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Solar Power Generation for Home Using MATLAB

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Abstract:

As the demand for sustainable and renewable energy continues to grow, solar energy is projected to be a key solution to cut the world's reliance on traditional sources of energy. This paper presents an effective model for solar energy production in domestic homes using MATLAB simulation and analysis. The research is centered on the optimization and design of the solar photovoltaic (PV) system with regards to the location, sunlight exposure, efficiency of the system, and load demand. MATLAB is utilized to simulate the solar panel performance, inverters, and storage systems and give precise details on energy production, cost of the system, and savings. Weather data is also incorporated into the model to forecast daily energy production under different environmental conditions. In addition, the analysis examines the inclusion of energy storage systems like batteries, which allow homes to retain excess energy created during peak sun hours for utilization at a later time. The results show that it is both feasible and economical to implement solar power in households, as well as show potential for long-term environmental and economic advantages. This paper adds to the body of research on solar integration at the residential level, providing informative input for homeowners, policymakers, and researchers toward a sustainable future.

Keywords: Solar Power Generation, MATLAB Simulation, Photovoltaic System, Energy Storage, Renewable Energy, Home Energy Management, System Optimization.

Introduction:

The growing energy demand, as well as the environmental issues that come with traditional power generation practices, has promoted a renewed interest in renewable energy options. Among them, solar power is an environmentally friendly and sustainable option, with immense prospects for decentralized power generation, especially at the residential scale. Solar photovoltaic (PV) systems, which convert sunlight directly into electricity, have gained widespread acceptance for home energy generation due to their scalability, low maintenance requirements, and the decreasing cost of solar panels and associated technologies.

Despite this, with increased adoption of solar power for home use, issues of maximizing performance, cost efficiency, and compatibility of solar systems remain. Such issues are generally due to concerns such as system design, solar irradiance, system sizing, energy storage, and compatibility with the existing grid. Simulation and modeling tools become very important here in maximizing solar power system design and operation.

MATLAB, a high-performance numerical computing platform, is extensively applied to model, simulate, and analyze renewable energy systems. It offers strong toolboxes for simulating solar energy, enabling researchers and engineers to forecast the performance of solar PV systems under different conditions. MATLAB-based models facilitate in-depth analysis of energload matching, system efficiency, and cost-benefit analysis, making it a perfect tool for designing residential solar power systems.

This paper is focused on formulating a MATLAB-simulation-based model for solar power generation specific to home use. The model takes into account the most important factors like solar irradiance, system layout, energy storage, and load requirement and provides an efficient methodology to design and assess solar power systems for residential applications. Through the process of simulating numerous scenarios, the paper discusses how different variables influence system performance

and offers suggestions regarding the ideal design and integration of solar power systems in dwellings. The work is a contribution to the emerging body of research that is making solar energy more affordable, efficient, and cost-effective for homeowners, further propelling the movement towards a cleaner and more energy-efficient future.

Technical characteristics of solar energy

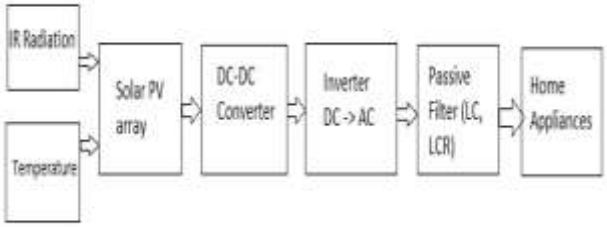
The fundamental knowledge necessary to understand the economics of solar energy is given by a short description of its technical characteristics.

The primary building components of solar cells are semiconductor materials like silicon and germanium. In these, sunlight releases the charge carriers (electrons) and generates an electric field. As an electric source, the field causes a direct current. This phenomenon is referred to as the photovoltaic effect. Generation of power based on this effect is feasible not only from direct sunlight but from its diffused component as well, and solar cells produce electricity even during clouded weather. The solar cell is integrated into the solar cell system. The inverter (for the conversion of direct current from the solar panel to alternating current), transformer, electrical protection device, wiring and monitoring device are collectively referred to as the balance of the system "BOS". Among his BOS is a sun tracking system that orients the panels towards the sun to maximize yield. There are three main forms of photovoltaic technology: monocrystalline cells, polycrystalline cells, and thin solid-state cells, with his first two responsible for more than 95% of module production worldwide.

Description table

S.No.	Name of th Element	Value
1.	IR Radiation	1500 W/m^2
2.	Temperature	25^0C
3.	Inductor	0.02 H
4.	PWM Generator Modulation Index	0.8
5.	Pulse Generator amplitude	1
6.	Parallel strings for PV array	20

Fig.1: Flowchart



This flowchart provides the preliminary idea of our project we have created a power system using different components like infrared radiations, temperature, solar photovoltaic panel, boost converter, inverter, passive filter and the house where supply is given. we have delineated the different component for each and every component using component editor. We have identified the waveform with the assistance of scope and we have identified that our house needs 240 volts of ac supply but from the solar panel we are receiving near about 120-150 volts of dc supply so the dc supply is converted into ac supply here with the assistance of different components. We have applied the capacitor also between the boost converter and the solar panel so that with the assistance of capacitor we can prevent the ripple factor here. Rather than applying the inverter here we can apply the transformer also but the sole reason for applying inverter is that the transformer will need more space and the transformer's cost is very expensive. Another diagram illustrates the simulation of all the components which are selected altogether from the component editor and all the components are brought together through MATLAB simulation. And the waveform graph is provided through the scope. Benefits of the solar power system:

•Solar power is a renewable resource and all can make use of it.

Keeping on utilizing the sun's energy will decrease fossil fuel use. Combustible materials are needed to produce modules that capture sunlight, but present-day manufacturing technologies can cut net greenhouse gas emissions in five years. The sun does not carry the same deadline as oil, natural gas and coal.

• It imposes less environmental harm than other means of energy production. Solar power's use comes with much less environmental harm in comparison to other sources, such as those on the renewable energy side.

•\tSolar power renders the world energy independent. The sun shines on our planet daily. The extreme north and south of Antarctica are the only exceptions to this benefit, but there are periods of the year when sunlight is available.

MATLAB Software

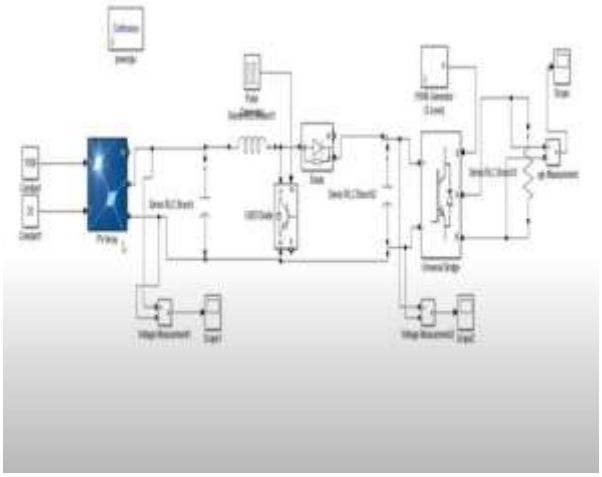
MATLAB is an interactive system whose fundamental data elements are dimensionless arrays. This makes many technical computational issues, particularly those that have matrix and vector forms, possible to solve in a fraction of the time it would take to code in a scalar, non-interactive language like C or

FORTRAN. MATLAB is an abbreviation for Matrix Laboratory. MATLAB was first designed to grant simple access to the LINPACK and EISPACK group's developed matrix software, which collectively represented the state of the art in software for matrix computation. MATLAB has changed over time with input from numerous users. In academic environments, it is a routine teaching tool for first-year and graduate courses in mathematics, engineering and science. In the industry, MATLAB is the go-to tool for efficient research, development, and analysis. MATLAB offers a collection of application-specific solutions known as toolboxes. Notably to most of her MATLAB users, the toolbox enables her to learn and implement specialized technology. A toolbox is an extensive set of her MATLAB functions (M-files) that enhance the MATLAB environment to solve a particular class of problems. Fields where toolboxes exist include signal processing, control systems, neural networks, fuzzy logic, wavelets, and simulation

Power system design and simulation

Atmospheric temperature is not constant and changes from morning to evening. Of maximum temperatures are attained during the afternoon. Power declines at night. He has to feed the load with a constant power supply of 240 volts 24 hours a day. But with the solar panel, you have maximum power during the afternoon but not precise power during moving/evening/cloudy days, so you must boost the voltage for other uses. In order to receive that much voltage from the solar panel for cloudy or rainy days, a boost converter is implemented since the grid and load may not receive exactly the voltage needed. Hence, a boost converter needs to be added to carry the load. Once converted to pure AC, you can add a transformer to increase the voltage. When you add a transformer, there is no need to add a boost converter. The function remains the same, i.e., it increases the voltage. Comparing transformer and boost converter, transformer is highly expensive and require more space, but in boost converter we are using only one diode and one inductor with the assistance of switch Hence, the structure of a boost converter can be extremely simple as compared to a transformer. The step-up transformer is not coupled, but the voltage has to be stepped up at the output. The boost converter contains a switch and the inverter also contains a switch, so it requires a pulse to turn it on and off. So, we use the first generation for both the inverter switch and the boost converter switch. These are the required components for photovoltaics and a capacitor must be used between the solar panel and the boost converter. When I execute the system, I receive 110-120 V DC, but at home I require 240 V, and by putting a boost converter in between provides 240 V DC. Here in this project, we used the infrared and temperature falling on the photovoltaic panel for designing the system, and a capacitor is inserted between the PV panel and the boost converter in order to eliminate the ripple factor. A boost converter is utilized to increase the voltage. Inverters are also used to transform DC form to AC form power. LCR type passive filters can be used to achieve a pure type of AC power. A

configuration of boost converter needs an inductor, diode, and switch, and therefore I employed an IIGBT diode in place of a switch. Upon execution of the model, three waveforms are shown on the oscilloscope. The first waveform is designed to deliver a DC voltage of 120-150 volts, the second waveform is designed to deliver an AC voltage of 220-240 volts, but not in pure form. But if we use a passive filter, then we obtain a pure AC domestic voltage of 240V.



The material employed in the power system are:

(i) Infrared Radiation: The light we see everyday is a negligible part of the electromagnetic spectrum. The electromagnetic spectrum consists of all forms of radiation, from X-rays utilized at hospitals to radio waves utilized in communication.

(ii) Photovoltaic Panel: Solar PV panels transform the energy of the sun into electrical energy. Although the initial energy (solar irradiation) is free, PV panel conversion efficiency is a critical factor in their development, market penetration, and energy share.

(iii) Boost Converter: A boost converter is one of the simplest forms of mode converters. As the name indicates, it accepts an input voltage and increases or boosts it.

(iv)Inverter: A power electronic device or circulatory that convert direct current into alternating current.

(v) Passive Filter: A passive filter installed between a nonlinear load and series-connected active line filter has a significant function to compensate for load current harmonics. With the passive filter installed, the series connected active power supply filter becomes a harmonic isolator.

Here there are receiving the dc supply close to around 120150Volts. But our house needs ac voltage i.e. 240Volts. The power system was interfaced by the solar panel on which we are providing temperature and infrared radiations and that is interfaced with the boost converter which is utilized to increase the voltage and the capacitor is utilized between solar panel and boost converter to boost converter to prevent the ripple factor. There is an inverter that converts the dc voltage to ac voltage and that is again connected to the passive filter because we are receiving the ac but that is not pure so passive filer is connected to receive the pure form of ac. And here we are receiving the supply for 240Volts for the home.

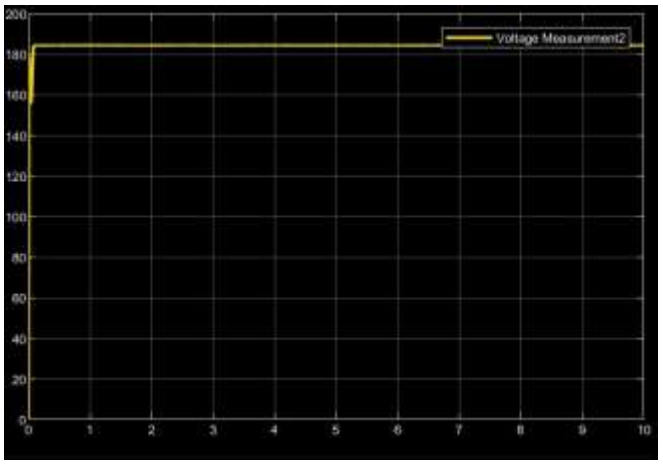


Fig.2 : waveform for dc voltage

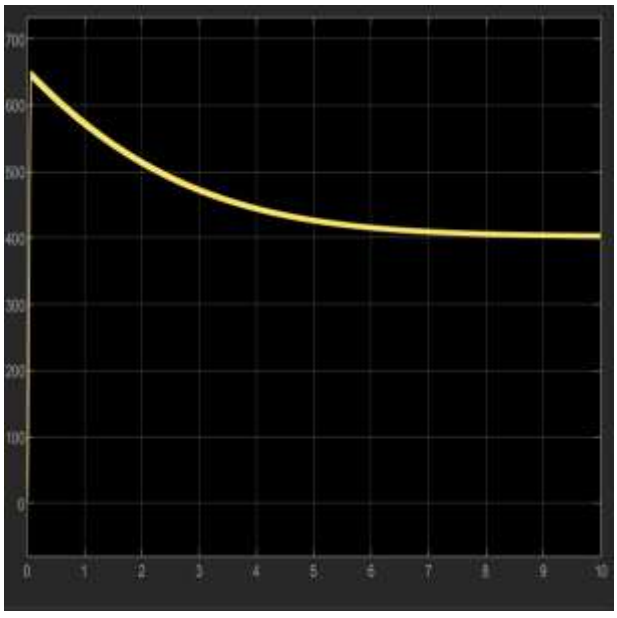


Fig.3 : waveform for boost converter

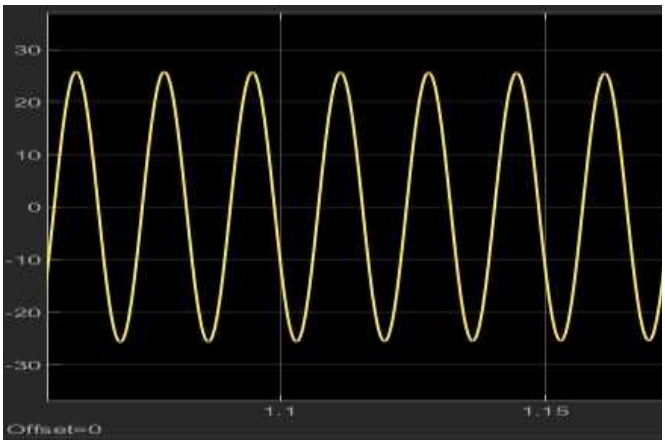


Fig.4 : waveform for pure ac signal

The above figure shows the transformation of the dc voltage from the solar energy to the pure form of ac voltage.

Conclusion

Solar power is a highly significant source of direct usable energy and generates another energy resources: biomass, wind, hydropower and wave energy. The majority of the earth surface get heat energy from the sun. Therefore, acquiring more popularity in recent years. Solar energy is abundant it has the highest availability than other sources of energy. The percentage of 20% solar energy is provided in the earth. The sun is adequate to supply the entire energy requirement of the world for a year. Solar energy conversion to electric energy has several application areas. Domestic, space and aircraft and naval applications are the primary solar energy fields. Solar energy simply the energy released directly by the sun and harnessed where, typically the Earth. The sun produces its energy by undergoing a thermonuclear process in which approximately 650,000 tons of hydrogen are converted into helium. Two enormous advantages of solar power over fossil fuels are :

The first is that it is renewable energy it is never going to be depleted. The second is the impact on the environment. Solar photovoltaic generation of energy consumes large area. Since the cost of the land are increasing day by day, there are some stringent requirements to utilise the available land as efficiently as possible. Because of the nature of, two elements must possess an operating solar energy generator. Such two elements are collector and a storage unit. Solar energy has witnessed dramatic growth in the last few years because of technological advancements that have led to cost savings as well as government policies supplies.

Future scope

The solar panels that are utilized for the conversion of sunlight to electric power typically last for several years and it is even easier to maintain them. The future of solar power in India is extremely bright due to the variety of ways solar power can be utilized. Now, we have solar-powered devices and appliances that can run with the assistance of solar power. These are lights, fans, inverters, cables, power conditioners, home appliances, solar road safety devices, and streetlights. The electrical energy gained from solar energy will be utilized to power electrical appliances independently without any reliance on the continuous supply of electricity. Solar energy can decrease electricity usage and electricity expense in domestic and industrial consumption. Currently, there are a few best solar projects in India and there are others on the anvil.

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