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Optimization Of Solar Power Using Super Capacitor

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Abstract: The growing energy demand and environmental concerns have increased interest in renewable sources like solar power However, solar energy is intermittent due to changing weather conditions. This project integrates supercapacitors into solar systems to stabilize power output Supercapacitors provide high power density, fast charge-discharge rates, and long lifespan, making them ideal for storing excess solar energy and supplying it when sunlight decreases. A boost converter regulates voltage, while an Energy Management System (EMS) optimizes charging and discharging cycles This setup ensures stable power delivery, improved efficiency, and system reliability Supercapacitors, known for the rapid charge-discharge cycles, high power density, and long lifespans, outperform conventional batteries in handling quick energy fluctuations and minimizing downtime By connecting supercapacitors in parallel with solar panels and using real-time monitoring for voltage and current, it is possible to smooth out energy supply variations, ensuring a more reliable and optimized solar power output. Such systems enhance energy buffering, enable efficient energy utilization, and improve overall system resilience, making them highly beneficial for both off grid and grid-connected solar installation. This study examines the variation of solar radiation which effect on storage performance, supporting application such as off-grid systems, EV charging.

Index Terms- Solar photovoltaic system, Supercapacitor, Inverter, Energy storage system, Power management, Optimization, solar panel efficiency, microcontroller based control , Relay switching method DC-DC converter.

I. INTRODUCTION

The self-sustainability is important for successful data processing within the field. Complete wire-free field systems possess robust economic competitiveness to their simple installation and maintenance. Self-sustainable systems also are environmentally friendly by not mistreatment the fossil-fuel based mostly green-house gas manufacturing power and by requiring a little physical presence within the field. Specifically, a field node must live on ambient energy sources (e.g., solar cells) and energy storage. By using the supercapacitor based solar energy buffering , a system that we call supercapacitor[1],[2]. Therefore, it is necessary to design a device that can set the direction of solar panel it always follows the sun position.

Fig.1.Flow chart of optimization of solar power using supercapacitor

The primary motivation behind this project is to enhance the reliability and efficiency of solar power systems. While solar energy holds great promise as a renewable source, its instability due to varying sunlight conditions limits its widespread application. By integrating supercapacitors with solar power. Advantages of optimization of solar power using supercapacitor: Very high rates of charge and discharge, little degradation over hundreds of thousands of cycles, good reversibility, low toxicity of materials used, high cycle efficiency[3].

II. RESEARCH METHODOLOGY

The photovoltaic panel is connected with supercapacitor which initially gets charged and then system gets energy directly from photovoltaic panel [4]. After the solar radiation is reduced the super capacitor will supply voltage that will be sent to the system and it will give 100% efficiency to photovoltaic panel. Three electromechanical relays are used in system which is used between solar and supercapacitor, and bus, solar and microprocessor which are used for protection and switching as per need of the system. Microcontroller is a system brain which control most of the functioning of components of the system i.e., display, driver IC and indirectly relays as shown in fig.2.

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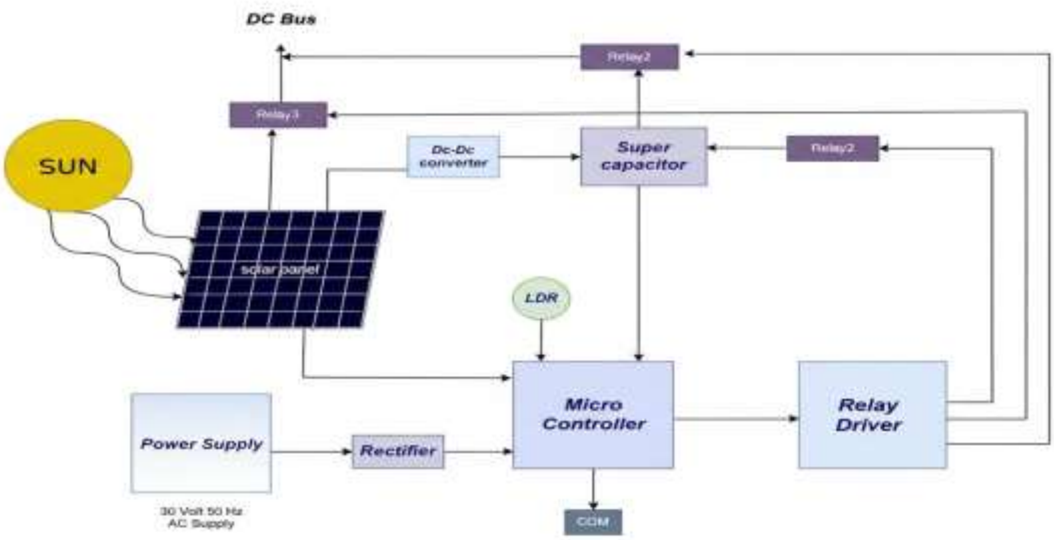

Fig.2. Block diagram of optimization of solar power using supercapacitor

The LCD display which is 16×2 AMOLED display which show the ratings that are panel voltage, super capacitor voltage, current of supercapacitor and voltage of bus [5]. Some of the components like solar and supercapacitor are provided with resistance by KVL to limit the voltage to the microcontroller. The driver IC which is uln2003 that controls the three relays that are used for switching protecting for our system[6]. Resistor and capacitor are used for contract control for set and reset of microcontroller for storage of voltage of a regulated IC need extra voltage as presented in Table 1.

Table. 1. List of Component

Sr. No.	Components	Rating
1.	Solar panel	12V, 40W
2.	Supercapacitor	100F, 2.7V
3.	Relays	12V
4.	ATMEGA328	ESP-32
5.	7085 Regulator IC	
6.	16/2LCD Display	16*2
7.	ULN 2003 Driver IC	3.5A
8.	Resistance	1000Ω

III. HARDWARE IMPLEMENTATION

When the shadow falls on panel then the output of the panel is decreases, panel output give 11V is less than tolerance that's why the inverter will be off because it works only in allows tolerance voltage and MPPT only increases overall generated voltage its does not increase power efficiency[7]. So, we are used super-capacitor in parallel with solar panel. Super-capacitor charged with the help of solar panel. Solar panel gives sufficient output or not and super capacitor is charged or not with help of PIC-microcontroller. In normal condition solar panel supply to DC bus with the help of relay 1[8][9]. The Fig.3 illustrate the super-capacitor is discharge solar panel give power to the load using relay-1 is ON at the same time super-capacitor start charging using relay 2. When solar panel gives output is less than reference voltage then relay1 and relay 3 is OFF and supercapacitor gives power to load using relay 3. All output voltage is less than reference then all relays are OFF and then system will not work[10].

Fig.3. Prototype model of optimization of solar panel using supercapacitor.

IV. RESULTS AND DISCUSSION

There are four supercapacitor with voltage rating of 2.7V are connected in series to increase the voltage to the maximum voltage on which super capacitor to charged is 12.96V because, super capacitor can charge 20% greater than of its capacity. Load will be connected to super-capacitor until capacitor voltage falls up-to 11.0V to charge super-capacitor from 11V to 12.96V, at 500mA current, it took 3 minutes to charge completely. The solar panel output with supercapacitor charging using LED display as shown in the Fig. 4 (a) and (b).

(a) (b)

Fig. 4.(a) and (b) shows the solar panel output with supercapacitor charging using LED display.

V. CONCLUSION

The solar panel 12V, 20W generated the power and supply to the DC bus(12V) with help of relay 1, Here we used current transducer (CT) to measure the current of output of solar panel and supercapacitor. There are three relays (RL), relay 1,relay 2, and relay 3 operated at 12V respectively. That relays are operated by driver because we used 5V Pic-Microcontroller is not sufficient to operate 12V relays so we used driver. In that driver there are 7 outputs.

$$P=I*V$$

$$I= P/V=20/12=1.8Amp$$

We cannot measure solar panel voltage directly from the component, from PIC Microcontroller i.e. we used divider, it divides the voltage and gives 5V output to the Pic- microcontroller. By using voltage regulator to gives the constant 5V supply to the microcontroller from 12V DC bus. LCD display show all information of rating collected from the Pic- microcontroller.

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