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A DESIGN AND ANALYSIS OF SELF REGENERATIVE LAMP ILLUMINATION-SOLAR ENERGY BASED HYBRID POWER GENERATION

R.JANAKIRAMAN[1], S.PARAMASIVAM[2], K.SASIKUMAR[3]
[1]Research Scholar, Dept. of Electrical and Electronics Engineering, JNTUH, Hyderabad.
[2] AGM(R&D), ESAB Engineering Services (India) Ltd, Irungattukottai, Tamilnadu.
[3]Assistant Professor, Sri Ramanujar Engineering College,
Dept. of Electrical and Electronics Engineering, Kolapakkam, Chennai-600127

Abstract –This paper proposes a model and design analysis of self regenerative lamp illumination-solar energy based hybrid power generation (SRLSHPG) system. This hybrid power generation system is possible through lamp illumination and solar energy; it is an alternative source of electrical energy, where ever the conventional power generation is not possible to install in practice. In this model consists of lamp illumination-solar energy based hybrid power generating system and storage battery system are combined together. This hybrid power generation system is a simple and cost effective control, and maximum power point tracking (MPPT) control has to extract more power. Also this hybrid system is developed through an experimental model

Keywords: Hybrid power generation; PV panel; maximum power point tracking (MPPT); wind energy

1. Introduction

The world's power demand concerned that increasing the necessity of electrical energy, the conventional energy systems is combined with renewable energy systems, and met the power demands. The new opportunities for utilization of renewable energy resources: particularly, solar energy and wind energy technologies have been increased, and their usage through PV panel and wind generator based hybrid configurations. In a hybrid energy system comprising three energy sources; namely PV panel, wind generator and fuel cells, has been integrated; and each of these three energy sources are controlled and to deliver the energy at optimum efficiency. A wind generator and PV panel based hybrid system is modeled, with MPPT controller, and blade pitch angle control strategies are applied and to improve the performance of the system under different environmental conditions has been presented [5].

The power fluctuation of hybrid system is lesser, when compared to the power generation of the individual WG and PV systems; such that the power fluctuation has been overcome by using battery storage has been presented [1]. In the Jordan country, there is a high electricity production cost, that is directly linked with the oil prices, and then they prefer the renewable energy systems, which are wind and solar electric power generation; and they installed wind farm in the mountainous area in the north, and the eastern desert are suitable to install solar power station are been discussed [2].

A solar -wind energy hybrid system, that can improve the power factor and quality power of electrical system. Whenever, a disturbance can occurs on load side, which can be minimized by using open loop and closed loop control systems have been presented [3] and [6]. A wind turbine and photovoltaic array based hybrid system has been controlled through error signal, which is fed to the controller, and to generate pulses for the dc-dc converter through VLSI based fuzzy logic controller; and then to provides a constant power has been presented [4].A hybrid system with buck/ boost converter, and the voltage control type feedback loop voltage (FLV); through the results of detailed simulations, and feasibility of the system are been studied [7]. In a wind-solar hybrid system, there is a bidirectional controller is connected to a DC-AC float charging-inverter system that provides charging current to a heavy duty storage bank of battery system has been investigated [8]. A search control approach is used in a steady state of drive and loss model during the transient state processes; it leads to reduce the power and energy losses of the systems have been presented [9]. A control system for the hybrid PV-Diesel energy system with battery storage was developed, and to coordinate, when the power should be generated by PV panels, and when it should be generated by the diesel generator and it is intended to maximize the use of renewable system while limiting the usage of diesel generator has been discussed [10]. An investigation presents an adaptive perturb and observe (P&O) – fuzzy control maximum power point tracking (MPPT) technique for photovoltaic (PV) based boost dc –dc converter has been presented [11].

2. PROPOSED MODEL OF SSRLSHPG

In this proposed model of SRLSHPG system is a smart-self regenerative power generation system through lamp illumination- solar energy based hybrid model, with a dual charging mode of batteries; charging from the PV panels: one is kept in the sunlight (outdoor PV panel) and other one is kept near the lamp illumination (indoor PV panel), both of them can be charging the batteries, simultaneously and independently. The outdoor PV panel can be charging the batteries, during the day time through sun light, and the indoor PV panel can charging the batteries during in night time by using lamp illuminations. The PV panels are made to capture maximum energy from the sun light and the lamp illuminations, through the Maximum Power Point Tracking (MPPT) technique. The MPPT control algorithm is that helps to get the maximum energy from the PV panels. In this hybrid system, the dual charging circuit that, charging the battery quickly and this has helps to recycling of the power from the lamp load.

There are some of the advantages, while this model has to be using in practice: only the initial cost is required to install this PV power system and there is no maintenance cost is required. The energy utilization of the lamp illuminations is possible; and no wastage of energy, no noise and CO_2 emission pollutions are created in this PV power generation system, and also, the usage of PV energy reduces global warming.

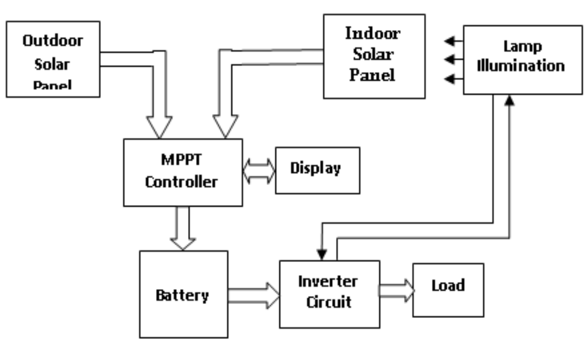

Fig.1. Block diagram of proposed SSRLSHPG system

Fig.1 shows the block diagram of model and design analysis of a self regenerative lamp illumination-solar energy based hybrid power generation (SRLSHPG) system. This proposed model consists of two numbers of photovoltaic (PV) panels: one is outdoor PV panel and other one is indoor PV panel, maximum power point tracking (MPPT) system, seven- segment display unit, inverter circuit, lamp illumination system, battery storage system and load. One of the PV panel has been kept in the sunlight and the other one has been placed near the lamp illumination inside the room. The outputs of both the PV panels have been connected to a MPPT controller, in order to capturing the maximum power, and enhance the efficiency of system. The inverter circuit has been provided to convert the battery stored DC source to the AC source, and supplying the conventional loads. Both of the PV panels have been connected to a seven- segment display unit, in order to display the amount of power generated by each panel. A controller is provided, in order to control the intensity of the lamp, and the load connected**.**

2.1 Photovoltaic (PV) - Panel

A PV panel consists of set of photovoltaic cells; this module is electrically connected altogether and mounted on a supporting structure. This solar- panel module size is decided by the capacity of load requirements. For the experimental analysis, the PV panel specification has given in table.1.

Table.1 Solar panel specifications

Specifications	Ratings
Number of panels	2
Maximum power (P_{max})	10 watts
Voltage at max power (V_{mp})	17 Volts
Current at max power (I_{mp})	0.59 Ampere
Open circuit voltage (V_{oc})	20 Volts
Short circuit current (I_{sc})	0.7 Ampere

PV panel current generation is given as:

$$I_p = I_L - I_D - I_{Rsh} \quad (1)$$

Or

$$I_p = I_L - I_o \left\{ \exp\left[\frac{V - R_s}{V_T} I\right] - 1 \right\} - \frac{V - R_s}{R_{sh}} I$$

Where,

I_L = Photo current
I_D = Diode current
I_{sh} = Shunt current
R_s = Series resistance
R_{sh} = Shunt resistance

2.2 Storage Battery System

A storage battery unit is consisting of one or more electrochemical cells that, converts the stored chemical energy into electrical energy. This battery storage system can store the electricity, while the PV panel generating the power. For the experimental analysis of the storage battery unit specification has given in table.2.

Table. 2 Battery specifications

Specifications	Ratings
Type	Lead-acid battery
Anode	Lead
Cathode	Lead oxide
Electrolyte	H_2SO_4
Capacity	7 Ampere-Hour
Charging current	1.5 Amperes
Number of battery used	1

2.3 Inverter Circuit

The inverter circuit is an electronic circuitry, which converts the direct current (DC) from the battery storage in to the corresponding alternating current (AC). The inverter circuit has designed by using MOSFET switches, logic gates, and other components. A free-wheeling diode is providing to protect the circuit, from damage, in case of over voltages and abnormal currents. A filter is provided to filter the harmonic components of the generated power.

2.4 Lamp Illumination

Laws of Inverse squares is defined as, illumination at a point is inversely proportional to square of its distance from the point source and directly proportional to the luminous intensity of the source of light in that direction.

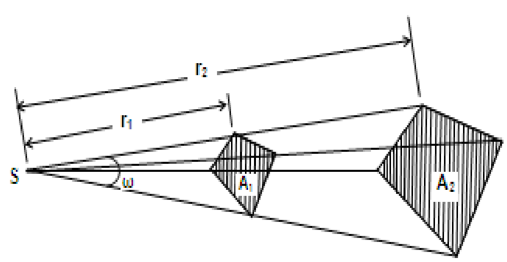

Fig.2. Inverse square law for light source

Fig.2. shows the diagramatic representation for the inverse square law of light source. Let, I be the luminous intensity of a point source of light expressed as lumens (Steeeradian), the diagraω be the solid angle considered.

Total light flux in ω steradians = I. ω
Area of surface at radius, r_1, $A_1 = r_1^2\ \omega$
Area of surface at radius, r_2, $A_2 = r_2^2\ \omega$
Illumination at surface of radius, $r_1 = E_1 = \frac{I\omega}{r_1^2} = \frac{I}{r_1^2}$ (3)

Illumination at surface of radius, $r_2 = E_2 = \frac{I\omega}{r_2^2} = \frac{I}{r_2^2}$ (4)

$$\frac{E_1}{E_2} = \frac{r_2^2}{r_1^2} \quad (5)$$

Here from equation "(5)", the illumination of surface is inversely proportional to the square of the distance between the surface and the light source, which provides, that the distance between the surface and the source is sufficientely large, so that the source can be regarded as a point source. Lamp efficiency is measured by lumens/watt. For analysis, an incandescent bulb has chosen for this application, which consists of an air-tight glass enclosure (the envelope, or bulb) with a filament of tungsten wire inside the bulb, through which an electric current is passed. The bulb is filled with an inert gas such as argon (93%) and nitrogen (7%) to reduce evaporation of the filament and prevent its oxidation at a pressure of about 70 kPa (0.7 atm). An incandescent lamp bulb is an electric light, which produces light with a filament wire heated to a high temperature by an electric current passing through it, until it glows.

3. Maximum Power Point Tracking Controller

There are different types of maximum power point (MPPT) technique are available: (i) Perturb and observe method; (ii) Incremental Conductance Method (INC); (iii) Constant Voltage Method; (iv) Current Sweep Method. Among these four techniques, perturb and observe method is the more suitable for the photovoltaic applications. This MPPT technique is suitable for capturing maximum power from the sun light.

4. Experimental model of model of SSRLSHPG System

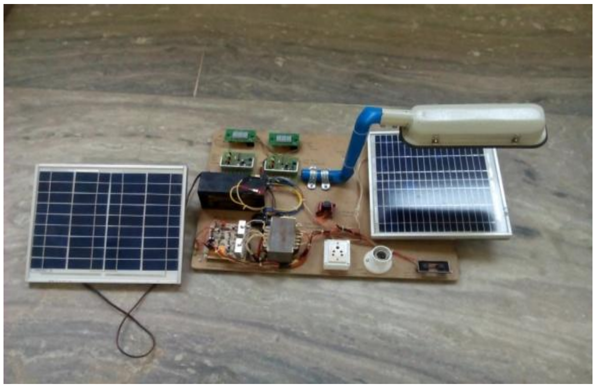

Fig.3. Experimental model of SRLSHPG

Fig.3. shows the experimental model of SRLSHPG system, consists of two photovoltaic panels; one is installed away from the room, as an outdoor panel, and other one is placed inside the room, as an indoor panel. Both of the PV panels are connected to the MPPT controller, which to capture the maximum power from the sun light and the lamp illumination. A compact flourecent lamp (CFL) is linked with the circuit, and illuminate from the conventional AC supply, which provides close to the indoor PV panel, and to generate power from the lamp illumination. The outdoor panel has to capture the power from the sun light. A battery charging circuit is provided for getting charge of battery unit from the PV panels simultaneously or independently. A seven segment display unit is provided to show the power generation output of the system.

In this model of SRLSHPG is a dual mode photovoltaic power generating system. It can generate electricity from both of the PV panels simultaneously. Also, this model generates electricity from the independent PV panels; either from sun light during the day time, or from the lamp illumination during the night time. The MPPT controller has to taken care of sustainable power generation from the suitable solar power tracking system. The power generation is displayed from the seven segment display unit.

5.1 Experimental Results and discussions

In this experimental setup, the electric power generation is obtained as shown in table.4.

Table 3. Voltage at indoor PV panel

S. No	PV Panel Tracking Angle(ϕ)	D.C. Voltage (V)
1	0°	0.0
2	45°	4.0
3	60°	7.0
4	75°	12.0
5	90°	17.0
6	105°	13.0
7	120°	6.0
8	145°	4.0
9	180°	0.0

Table 3. shows the voltage generation with respect to PV panel tracking angle for indoor PV panel, which is located inside the room. The voltage generation is based on the PV panel tracking angle through MPPT controller. The voltage generation is gradually increases until the maximum power point is reached and then gradually reduces until the minimum value.

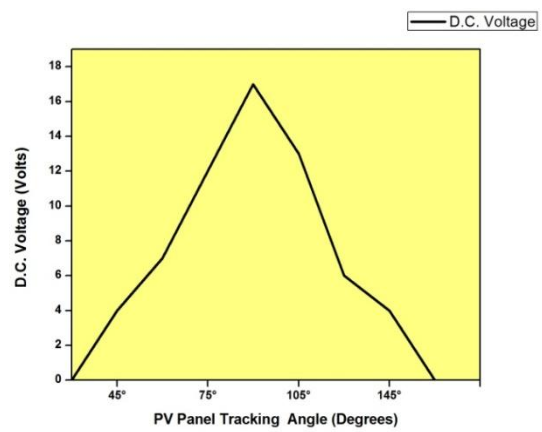

Fig.4. Characteristics of PV panel tracking angle- voltage

Fig. 4. Shows the PV panel tracking angle versus voltage generation characteristics for indoor PV system. The voltage generation is based on the PV panel tracking angle through MPPT controller, and the voltage generation is gradually increases until the maximum power point is reached i.e., 17 volts and then gradually reduces until the minimum value i.e., 0 volt.

Table 4. Voltage at outdoor PV panel

S.No	PV Panel Tracking Angle(ϕ)	D.C. Voltage (V)
1	0°	0.0
2	45°	5.0
3	60°	8.0
4	75°	16.0
5	90°	20.0
6	105°	15.0
7	120°	8.0
8	145°	6.0
9	180°	0.0

Table 4.shows the voltage generation with respect to PV panel tracking angle for outdoor PV panel, which is located away from the room. The voltage generation is based on the PV panel tracking angle through MPPT controller. The voltage generation is gradually increases until the maximum power point is reached and then gradually reduces until the minimum value.

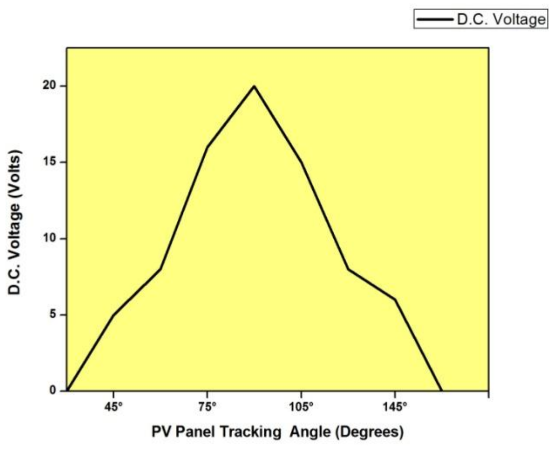

Fig. 5. Characteristics of PV panel tracking angle- voltage

Fig. 5. Shows PV panel tracking angle versus voltage generation characteristics for outdoor PV system. The voltage generation is based on the PV panel tracking angle through MPPT controller, and the voltage generation is gradually increases until the maximum power point is reached i.e., 20 volts and then gradually reduces until the minimum value i.e., 0 volt.

Table 5. Hybrid system voltages at indoor and outdoor PV panels

S.No	PV Panel Tracking Angle(ϕ)	D.C. Voltage (V)	D.C. Voltage (V)	Total D.C. Voltage (V)
1	0°	0.0	0.0	0.0
2	45°	4.0	5.0	09.0
3	60°	7.0	8.0	15.0
4	75°	12.0	16.0	28.0
5	90°	17.0	20.0	37.0
6	105°	13.0	15.0	28.0
7	120°	6.0	8.0	14.0
8	145°	4.0	6.0	10.0
9	180°	0.0	0.0	00.0

Table 5. shows the hybrid system voltage generation from both of the PV panels. In this comparison the outer panel voltage generation is more than the indoor panel voltage generation. The cumulative voltage generation of both of the PV panels are also been tabulated.

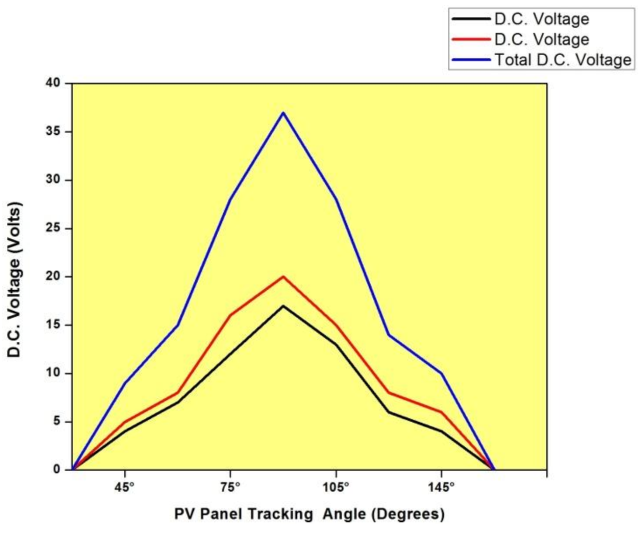

Fig.6. Characteristics of PV panel tracking angle- voltage of both the PV panels

Fig.6. shows the PV panel tracking angle versus voltage generation characteristics for indoor PV panel, outdoor PV panel, and both the panels. The voltage generation is based on the PV panel tracking angle through MPPT controller, and the cumulative voltage generation is gradually increases until the maximum power point is reached i.e., 37 volts and then gradually reduces until the minimum value i.e., 0 volt.

Table 6. Comparision betweet the existing and proposed system

S. No	Characteristics	Existing system	Proposed system
1	Charging time	6 hours	3 hours
2	Backup time	3 hours	4 hours
3	Charging technique	normal solar charger	MPPT technique
4	Initial cost	Medium	High
5	Applications	Emergency	Regular use of light
6	Running cost	Medium	Medium
7	Maintenance	Low	Low
8	Advantages	Battery life is less	Battery life increased

The comparison of existing system and proposed system are been tabulated. In thee proposed system the battery charging time is half of the existing system, and power charging capacity is twice that of existing model. Therfore, the proposed system is efficient than the existing system.

5. CONCLUSION

In this paper presented the smart self regenarative lamp-illumination- solar energy based hybrid power generation system, which has been designed, and experimentd. An experimetal model has been designed and experimented for different illumination levels. In this system involves the usage of renewable sources and the recycling of power is possible without wastage of illumination power from the lamp illumination. This PV model is efficient than the conventilonal PV power generating system, due to this model can be operated in dual mode of PV power generation. Both of the PV panels are connected with a MPPT controller, and to track the solar power generation for an effective charging. In future there is a possibility to develop, such type of model at commercal level, which could lead to the solution of compensation for the power demand.

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BIOGRAPHIES

R. Janakiraman received AMIE in Electrical Engineering from The Institution of Engineering (India) 1999, M.E. degree in Power Systems Engineering from College of Engineering, Guindy, Anna University, Chennai, India, in 2005.

Currently, he is with the position of Assistant Professor in the Department of Electrical and Electronics Engineering, of Sri Ramanujar Engineering College, Anna University Chennai, Tamil Nadu, India, pursuing Ph.D. in Jawaharlal Nehru Technological University, India. He is a life member of IEI. His research interests include renewable energy, power electronics, power systems and embedded systems.

S. Paramasivam received the B.E. degree from GCT, Coimbatore, in 1995, the M.E. degree from P.S.G. College of Technology, Coimbatore, in 1999, and the Ph.D. degree from College of Engineering, Anna University, Chennai, in 2004.

His interests include power electronics, AC motor drives, DSP- and FPGA-based motor controls, power-factor correction, magnetic design, fuzzy logic, neural networks, and controller design for wind energy conversion systems. He has published over 72 papers on various aspects of SRM and induction motor drives in international journals and conferences worldwide.

Presently he is working at ESAB Group, Chennai, as the R&D Head for equipments and cutting systems. He is the Editor-in-Chief of the International Journal of Power Electronics, and an Editorial Board Member of the International Journal of Adaptive and Innovative Systems and International Journal of Renewable Energy Technology. He is also a Reviewer for many IEEE journals, Acta Press, Inderscience journals, Elsevier journals, Hindwai journals, and IEEE conferences.