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Efficient Low Power Indoor Solar System

Sandesh[1], K.Vasudev Shettigar[2]

PG Scholar, Department of Electrical and Electronics, NMAMIT, Nitte, India[1]

Associate Professor, Department of Electrical and Electronics, NMAMIT, Nitte, India[2]

Abstract: The electrical power harvesting from environmental energy such as thermal , light, wind, vibration permits low-power devices, few of which are conventionally powered by batteries. Low-power devices are used in variety range of industrial applications. Battery replacement or recharging is generally unattractive inside the devices because cost and difficulty of getting access to the built in embedded devices. Solar energy is most widespread form of energy and Photovoltaic (PV) technology is thus very useful in energy harvesting. The choice of appropriate PV module like size and conditioning circuit for output power is essential for effective operation. To improve efficiency commonly used technique is maximum power point tracking (MPPT) and good response is obtained for changing irradiation. At low light levels in indoor systems control and tracking circuitry itself may consume most part of the generated power which is not feasible. This paper shows the circuit which can work in indoor and outdoor applications but without having controller in it.

Keywords: PV panel, MPPT.

I. INTRODUCTION

For decades, electricity is a key driver of socio-economy development. Now a days in the context of competition there is a direct relationship between electricity generation and development of the country. The Paper[1] presents distinct use of a Photovoltaic array offering great potential as source of electricity. The energy that comes from the solar panel has to be utilized properly, for this MPPT technique is used. MPPT refers to the maximum power point tracking. Microcontroller are used in such circuits which is very power hungry and it uses constant supply power for its functionality. In low power applications this may be the biggest burden over the supply source. The proposed model is an alternate to the microcontroller method. The paper[3] presents a two-phased tracking where PI-INC (Power increment aided Incremental Conductance) is used to get maximum power point tracking (MPPT) which improves the tracking behaviour of the conventional. In all the above mentioned models microcontrollers are used.

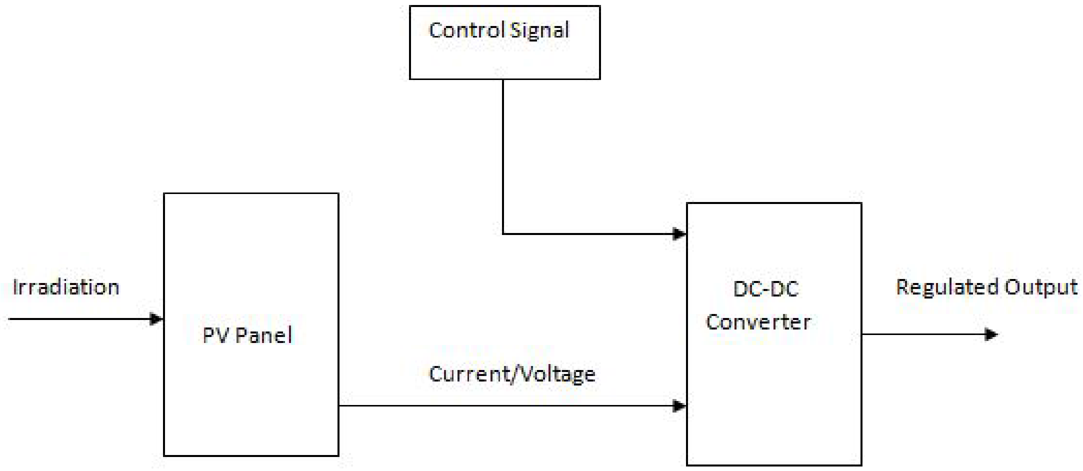

Fig 1: Block Diagram of the proposed model

II. SYSTEM BLOCK DIAGRAM

As shown in Fig.1 the PV panel generates the energy. This signal is given to the buckboost converter which regulates the input signal to the required level. The block diagram shows that there are mainly
3 important parts

- PV Panel
- Buckboost Converter
- Controller

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III. SYSTEM DESIGN

An infinite source of clean energy is solar energy and it is the most abandon source. Photovoltaic system is one of the renewable source of electric power which is in forefront because it can generate direct current without any heavy environmental impact.

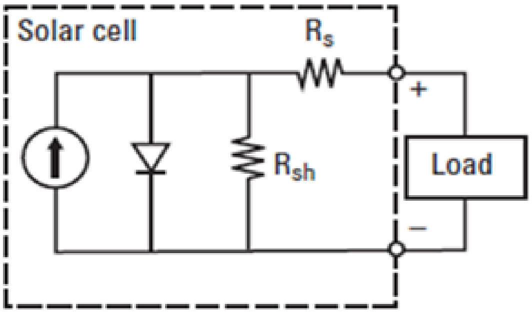

Fig 2: Single Diode model of the PV cell

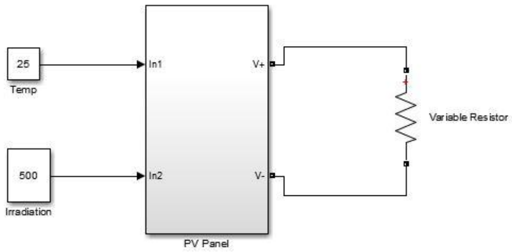

Fig. 3 Simulink model of the PV Panel

Fig.2 shows the single diode model of the PV panel. Below mentioned formulas are used to for the modelling of PV panel which is shown in the Fig.3. Fig. 4 & 5 gives the IV and PV characteristic of the PV panel.

$$i_{cell} = i_{ph} - i_d - i_{sh}$$

$$i_{cell} = i_r + [\alpha \frac{g}{g_r}(t_c - t_{cr}) + (\frac{g}{g_r} - 1)\, i_{sc}]$$

$$v_{cell} = -\beta(t_c - t_{cr}) - r_s \Delta i + v_r$$

$$\Delta i = [\alpha \frac{g}{g_r}(t_c - t_{cr}) + (\frac{g}{g_r} - 1)\, i_{sc}]$$

$$v_m = n_{sc} * v_{cell}$$

$$i_m = n_{pc} * i_{cell}$$

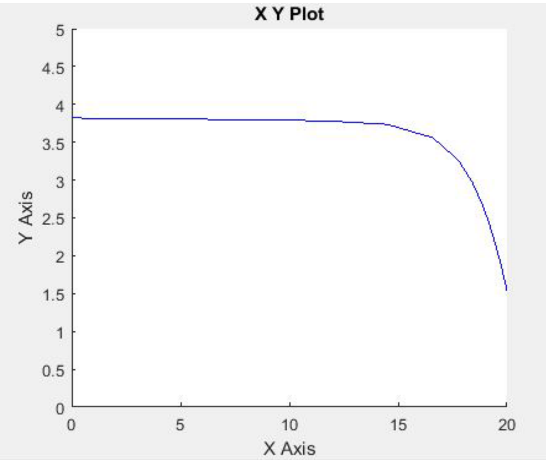

Fig. 4 Current Versus Voltage Graph

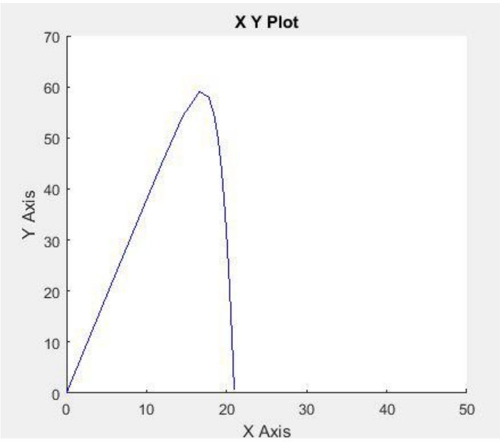

Fig. 5 Power Versus Voltage Graph

Model shown above in Fig.3 is replica of the formulas mentioned above. Output of photovoltaic panel is given to a variable resistor to plot the characteristics as shown in the Fig.4 and Fig.5 . In current characteristic Y-axis refers to current and X-axis refers to voltage. Current is constant initial and slops down after a cut off. In Power characteristic Y-axis refers power and X-axis refers to voltage. Fig.5 shows that there is a peak operating point for particular voltage level. MPPT will search that peak point and offers to work nearer to that operating point. If we observe the fig.5 the graph shows a peak power of approximately around 60Watts, this is for one particular irradiation. Similarly we can get the graph for different range of irradiations for particular PV Panel which will help us in getting the peak power. MPPT controller will search automatically peak point and keeps the device to operate around that point.

Buckboost converter regulates the output voltage to the required level which takes the input from the PV Panel. Which controls the output based on the PWM input to it. Buckboost converter acts in buck mode if PWM has duty ratio less than 0.5 and acts in boost mode if the duty ratio is greater than the 0.5. This is the beneficial part of using the buckboost converter. In case of MPPT technology peak power is obtained by controlling the duty ratio for the converter. Controller continuously keeps monitoring the power through the feedback. Therefore it must be a closed loop system in some cases.

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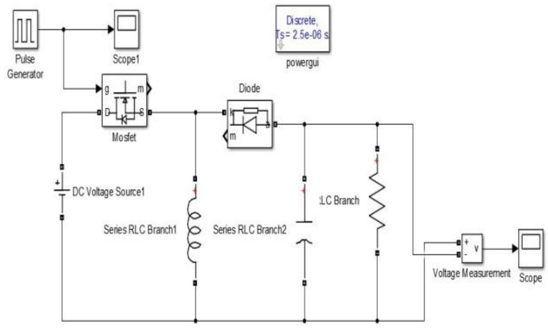

Fig.6 Buckboost Converter

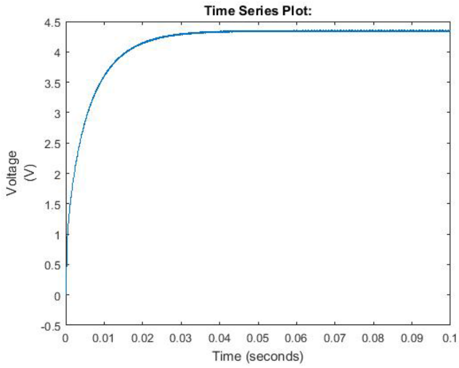

Fig.7 Output of Buckboost Converter

IV. SIMULATION AND RESULT

Controller is the part which handles the PWM input to the buck boost converter. The PWM is generated using 555 timer IC or an OPAMP and to set the duty ratio open circuit voltage(Voc) of Photovoltaic panel is used. Open circuit voltage will be different for different irradiation. Open circuit voltage is stored in the capacitor by disconnecting the load end by using switch and timer, and in the mean time connecting the capacitor which gets charged to its peak ie Voc. Therefore a sampling is required to connect and disconnect capacitor meanwhile disconnect and connect the converter. Large capacitor has to selected such that there should not be much variation in the capacitor value during its sampling. Sampling time must be appropriate such that charging of the capacitor should be maximum for the irradiation to which panel is operating at that particular time. Sampling time must be appropriate, it should not be too long or should not be too short. If it is too long even if the irradiation is changed the PWM will be according to the previous sample. If it is too short then much time will be wasted in sampling itself. Simulation is performed using the MatLab software.

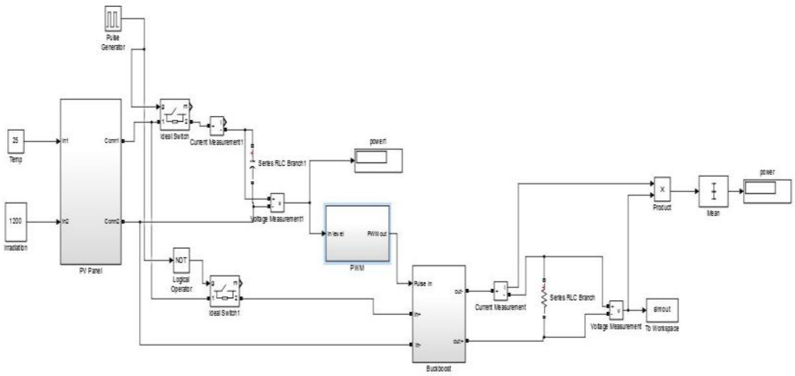

Fig. 8 Simulink Model of the System

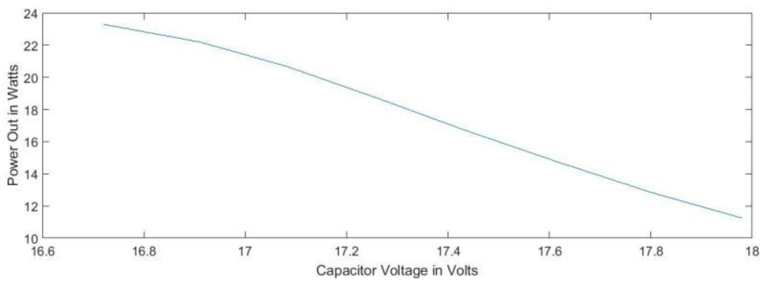

Fig. 9 Capacitor voltage versus output power

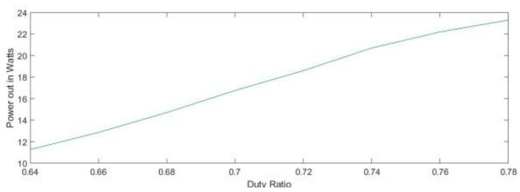

Fig. 10 Duty Ratio versus output power

Two figures fig.9 and fig.10 are drawn by the varying irradiation from 500 to 1200 keeping temperature constant at 25 degree Celsius. The graph shows a linier relationship between the irradiation, capacitor voltage and the Duty ratio. Fig.9 shows as we increase the irradiation, capacitor voltage is getting reduced linearly but output voltage is increasing. That is at irradiation 500 capacitor voltage is around 18 volts where as output power is 11.25 watt and at irradiation 1200 capacitor voltage is 16.72 where as output power is 23 watts. Similarly if we observe graph in fig.10 as we increase irradiation at regular interval of duty ratio we can get the near maximum power. That is for irradiation 500 for duty ration of 0.64 we have near maximum output where as for 1200 we have a near maximum out at duty ratio of 0.78. The linier relationship between of capacitor voltage, duty ratio and output power is utilized. A large capacitor is thus connected across the output of panel to hold the open circuit voltage which varies linearly for different irradiation level. Now the voltage this large capacitor is used to set the level in the PWM generation. Thus PWM generator has 2 inputs one from sawtooth wave generator and other from the capacitor. According to these two input it will generate a PWM which is appropriate to the near maximum power. PWM out is given t the buck boost converter which provides the supply for the entire load.

V. CONCLUSION

MPPT that uses microcontroller is not suitable for indoor systems, it is suitable only for outdoor applications where control of the system, normally necessitating the use of a microcontroller. From the above experiment it is verified that by without microcontroller we can vary the duty ratio of the converter. Hence as an alternate to the microcontroller a astable multivibrater to be designed. The width of the pulse has to be changed according to the open circuit voltage of the open circuit voltage of the PV panel. According to the FOCV the pulse width will vary.

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BIOGRAPHIES

Sandesh, received his B.E. (E&C) degree from Shri Jayachamarajendra College of Engineering,Mysore,India in 2012. He is pursuing his M.Tech.(Microelectronics and Control Systems degree) in Nitte Mahalinga Adyanthaya Memorial Institute of Technology, Nitte, Karkala, India. His area of interest includes Renewable energy research, Embedded systems & VLSI technologies.

K. Vasudeva Shettigar, received his B.E. (E & E) degree from SJCE, Mysore University, Mysore, India in 1986, and M.Tech. (Power Systems) degree in 1992 from National Institute of Engineering affiliated to Mysore University. Presently Mr. Vasudeva Shettigar is serving as Associate Professor, Dept. of Electrical & Electronics Engineering, Nitte Mahalinga Adyanthaya Memorial Institute of Technology, Nitte, Karkala,India. He is Life member of ISTE. He has published 10 technical research papers in various National and International conferences. He has chaired International conference held at NMAMIT Nitte during May 2011, 2013 and 2015. Mr. Shettigar has organized several National Conferences and National Workshops and Short term training programmes (STTP) in the college for the benefit of faculty (NMAMIT) and faculty of neighbouring Institutes. His areas of interest include power system & protection, power quality and High Voltage Engineering. He has a teaching experience of over 27 Years, and guided over 50 U.G & 24 P.G. Technical Project works.