HIGH EFFICIENCY RIDGE CONCENTRATED PHOTOVOLTAIC POWER GENERATION USING MPPT & ULTRA CAPACITOR

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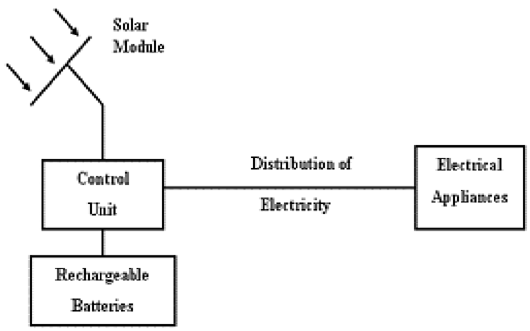
Abstract - In the present scenario, high proportion of electric power generation is done with the help of non-renewable sources like fossil fuels, nuclear reactions, etc. But it causes greenhouse effect which leads to global warming. So, the efficient power generation using the abundantly available energy resources, without polluting the environment, is the need of the hour. India being a tropical country, power generation using the solar energy is the best choice. Average sunshine hour in India is about 7 hrs annually also the sun shine shines in India for about 9 months in a year. This paper gives an overview about the efficient power generation using ridge concentrator photovoltaic cells, maximum power point tracker and ultra capacitor.

Keywords- ridge concentrator, maximum power point tracker (MPPT), Ultra Capacitor/ Super Capacitor

I. EXISTING SYSTEM

The existing system of Solar power generation uses the components as shown below in the block diagram. Here, the Solar panel converts the solar energy into a DC electric energy. The generated dc voltage from the solar module is fed to the Battery through a Control unit, which comprises of a Bidirectional DC/DC Converter. The stored energy from the battery is fed to the DC load through this DC-DC converter unit which is in-built inside the control unit. In case of an AC load, the DC current must be converted into AC by using an Inverter (DC/AC Converter).



II. LITERATURE SURVEY

Sun Jian, Shi Mingheng (2009) proposed an experimental Study on A Concentrating Solar Photovoltaic/Thermal System, which uses double-trough compound parabolic concentrator model**.** It shows how a single-pass photovoltaic/thermal solar system with compound parabolic concentrator (CPC) and fins is designed and its electric-thermal performance over arrange of local conditions. CPC is used here to increase the intensity of solar radiation incidence on the PV/Thermal setup.

Hui Yang, Laiure Luo, etal (2011) introduced "A Photovoltaic Generation Heating System Based on Double Parabolic Reflector Focusing and Hybrid Tracking Technology". This study explains the model in which double parabolic reflector is used to strengthen the solar radiation and to improve the efficiency. In addition, Hybrid Tracking technology is being used to improve efficiency using the Hill climbing method.

Anthony M Cree and Francis VP Robinson (2013) analysed the Lifetime Extension of a Battery in a Small-Scale Wind-Energy System Using Supercapacitors. This analysis explains the efficient charging of the Super Capacitor during the sudden voltage hike and the corresponding rapid discharge during the peak demand conditions. This, in turn, extends the lifetime of the Battery, which is proved in the paper with the help of simulations.

Shih Ming Chen, Tsorng-Juu Liang and Ke-Ren Hu (2013) implemented a Solar Power Optimizer for DC Distribution System. They proposed that high step-up solar power optimizer (SPO) that efficiently harvests maximum energy from a photovoltaic (PV) panel then outputs energy to a dc-microgrid. Its configuration is based on a high step-up dc–dc converter with an MPPT control circuit. The proposed converter has many advantageous features such as increased voltage conversion ratio, reduced voltage spike on the active switch, etc.,

III. MODEL OF THE PROPOSED SYSTEM

The Ridge Concentrated Solar panel consists of two reflectors each on one side. The sun light which is incident on the reflectors get reflected onto the panel, thereby the strength of the solar light incident on the panel is increased. This increases the net power output. Here, we have arranged the setup so as to compare the results between the differently concentrated panels. In the prototype, we have used three panels: one with two reflectors (2x Concentrated), other with only one reflector (1x

Concentrated) and the last one with no reflectors (No Concentrated). The output power from all the three panels are measured separately and compared to analyze the efficiency of the ridge concentrated panel. Now, this generated dc voltage from the solar-panel is given to the maximum power point tracking system. For Maximum power point tracking, three methods are available, among which Perturb & Observe Algorithm is found to be the best choice. The voltage and the current sensor circuits used for sensing the panel-output.

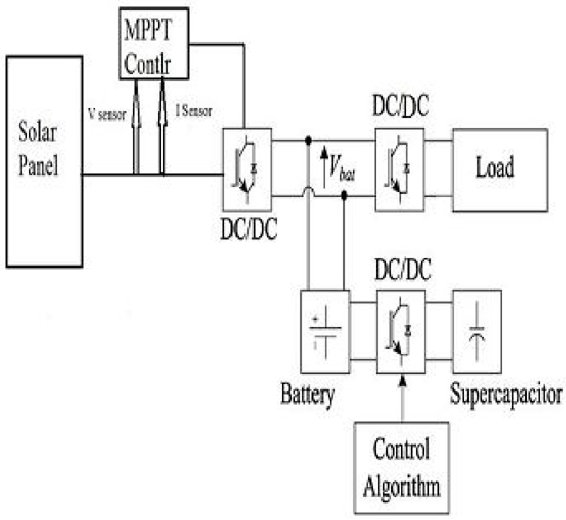


Fig 3.1 Block diagram of the proposed system

IV. COMPONENTS DETAILS

4.1 SOLAR PANEL:

A solar panel (photovoltaic module or photovoltaic panel) is a packaged, interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications.

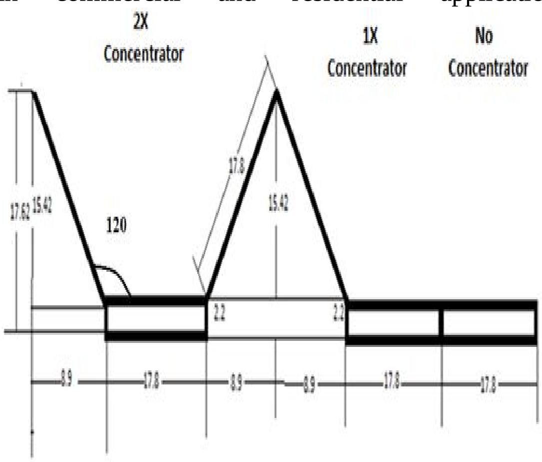
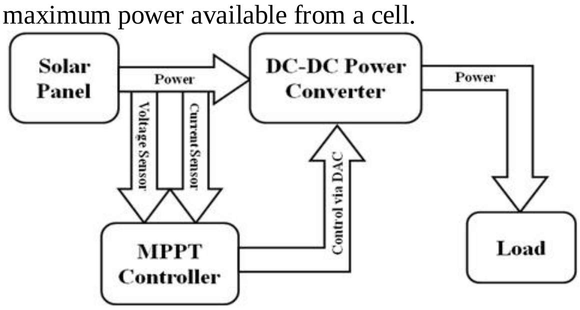


Fig4.1 Block Diagram of the concentrator – Side View

Because a single solar panel can produce only a limited amount of power, many installations contain several panels. A photovoltaic system typically includes an array of solar panels, an inverter, and sometimes a battery and interconnection wiring.

4.2 MAXIMUM POWER POINT TRACKER:

A maximum power point tracker (or MPPT) is a high efficiency DC to DC converter that presents an optimal electrical load to a solar panel or array and produces a voltage suitable for the load. PV cells have a single operating point where the values of the current (I) and Voltage (V) of the cell result in a maximum power output. These values correspond to a particular load resistance, which is equal to V/I as specified by Ohm's Law. The power P is given by $P=V*I$. A PV cell has an exponential relationship between current and voltage, and the maximum power point (MPP) occurs at the knee of the curve where $dP/dV=0$. At this point the characteristic resistance equals that of the load resistance. Maximum power point trackers utilize some type of control circuit or logic to search for this point and thus to allow the converter circuit to extract the maximum power available from a cell.



4.3 DC-DC CONVERTER

The dc/dc converter under the proposed control strategy filters transient variations from the battery charge-profile in real time by diverting them to/from the supercapacitor module. The converter control strategy must therefore be capable of fast, dynamic bidirectional current tracking.

A boost converter is a DC to DC converter with an output voltage greater than the source voltage. A boost converter is sometimes called a step-up converter since it "steps up" the source voltage. Since power (P = VI) must be conserved, the output current is lower than the source current.

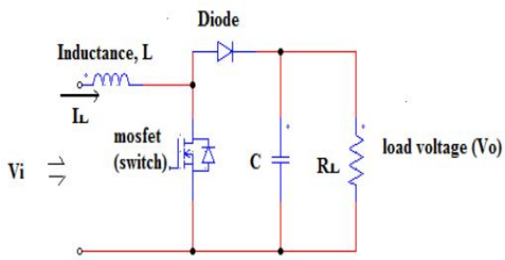


Fig 3.3 Step up DC/DC Converter

The designed DC-DC boost converter is connected between the photovoltaic module and the load so as to enable the module operates at maximum power at all time. Boost converter is made of up four elements; they include the inductance, diode, capacitor and MOSFET. The converter is control through the MOSFET which act as a switch. The ON and OFF of the switch (MOSFET) control s the output voltage by changing the voltage of the inductance so as to enable the photovoltaic module power the load at maximum voltage. The operation of the converter is analyzed in different operating condition. The operation of the converter is analysis in continuous conduction mode.

4.4 BATTERY:

The dynamic battery model was used to represent battery voltage and state of charge (SOC) variations. Electronic apparatus have described improvements in power quality, uninterrupted power supply (UPS), and memory backup.

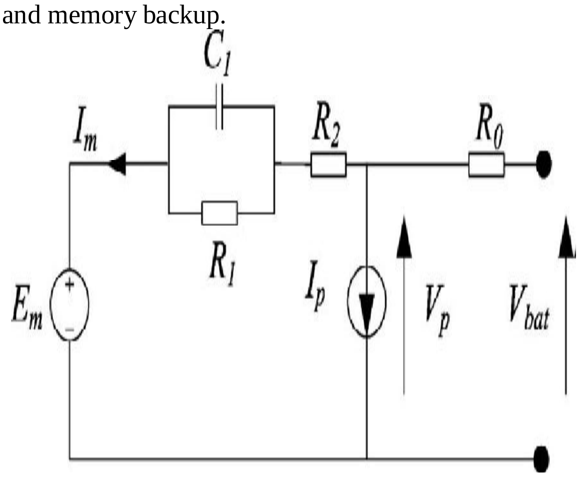


Fig 4.4 Dynamic battery model

4.5 ULTRA CAPACITORS:

Ultracapacitors otherwise known as electrochemical double layer capacitors (or Supercapacitors) perform mid-way between conventional capacitors and electrochemical cells (batteries). The charging and discharging capability of UC is fast. They are increasingly interesting because of their high-energy density (compared to conventional capacitors) and high-power density (compared to batteries and fuel cells). Reports of ultracapacitor applications in power distribution systems and in utility

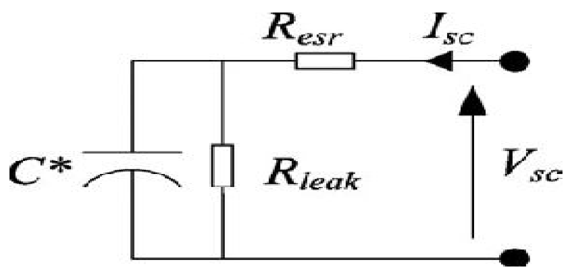


Fig 4.5Simplified Ultracapacitor model

The supercapacitor module was configured to give a maximum operating voltage of 120 V_{dc}. To ensure that the supercapacitor voltage is maintained at a higher level than the battery voltage at all times, a lower limit was placed on the supercapacitor operating voltage of 30 V_{dc}.

	Ultracapacitors	**Batteries**
Charging time	Fraction of a second to several minutes	Several hours
Self-discharging	Hours to days	Weeks to several months
Power density	> 1000 W/kg	<500 W/kg
Energy density	< 5 Wh/kg	10 – 100 Wh/kg
Charging /discharging efficiency	85%-98%	70% - 85%
Cycle life	10^6 - 10^8	200 – 1,000

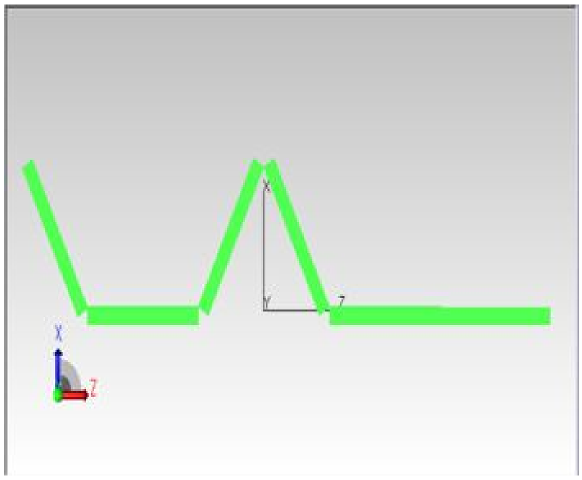
Table 1 Comparison of batteries and Ultracapacitors

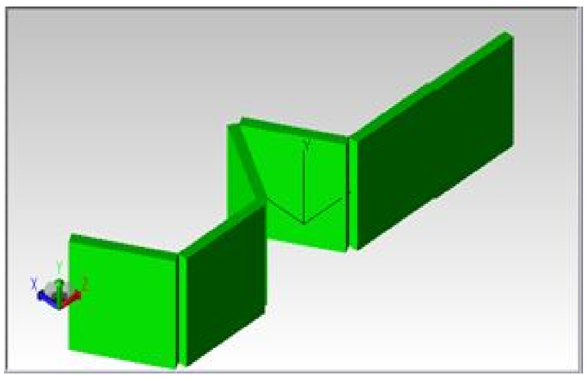
V. SOFTWARE USED

1. TracePro70
2. Matlab R2010b

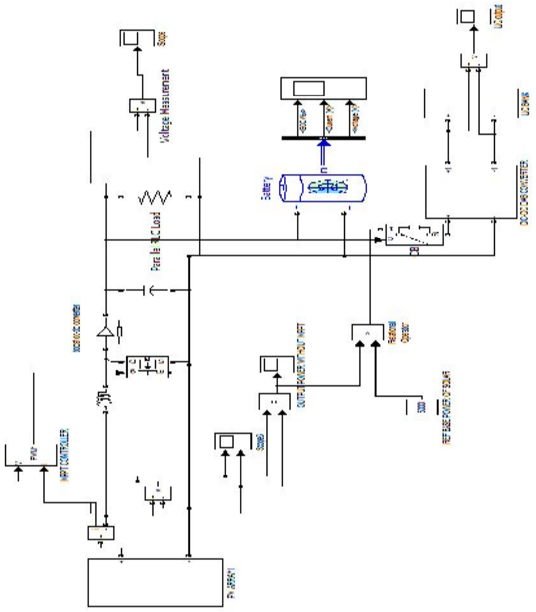
VI. SIMULATION

6.1 SIMULATION CIRCUIT FOR PANEL DESIGN





6.2 SIMULATION DIAGRAM OF THE PROPOSED SYSTEM – MATLAB



6.3 SIMULATION RESULTS

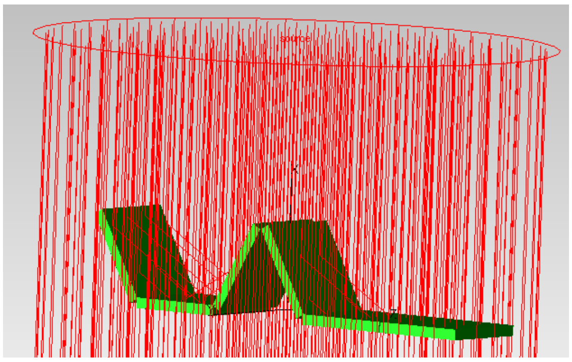
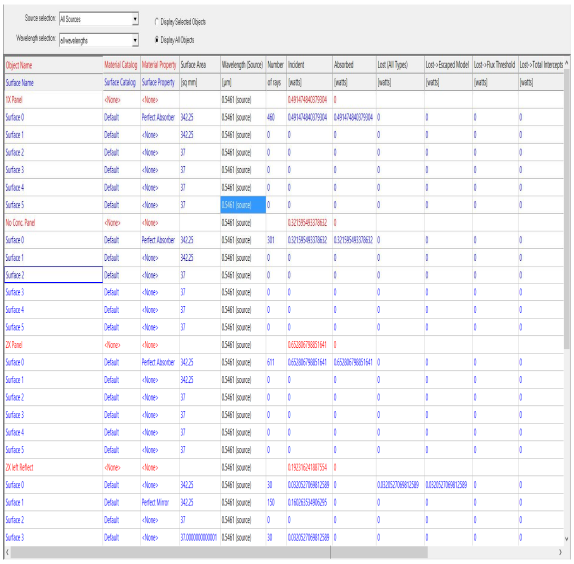


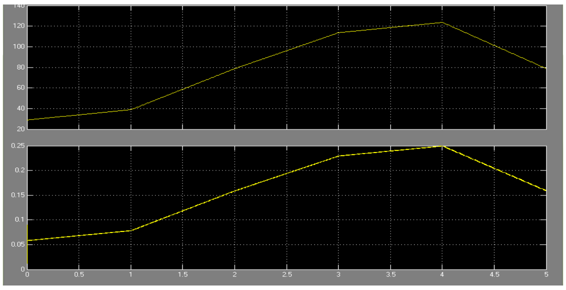
Fig 6.3 Simulation showing reflected sunlight from the reflectors when source is applied

6.4 INCIDENT LIGHT IN WATTS

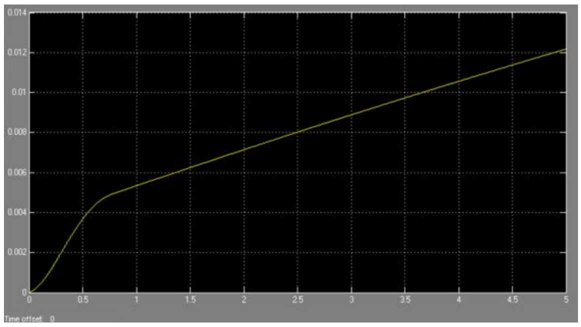


No Concentrated Panel: 0.3215954933
1x Panel: 0.491474840379307
2x Panel: 0.652806798851646
Hence 2x Panel is found to have the maximum incident light.

6.4 PANEL OUTPUT



6.5 UC OUTPUT



CONCLUSION

Performance of Ridge concentrator comparing to reference panel – With MPPT

- **Power Improvement** – 28.28 % (1X concentrator) & 38.54 % (2X concentrator)
- **Energy Improvement** (on connecting 3 W LED) - 26% (1X) and 35.4% (2X)
- **Temperature** – 40 deg cel (Reference), 50 deg cel (1X) & 57 deg cel (2X)
-

Comparison of all three

Improvement in Power compared to reference panel	1X	2X
Theoretical	54 %	65%
Simulation	35%	50%
Experimental – Normal	26.54%	36.56%
Experimental - MPPT	28.28%	35.54%

Conclusion based on Experimental Studies

WITHOUT MPPT

- **Power Improvement** – 26.54 % (1X concentrator) & 36.56 % (2X concentrator)
- **Energy Improvement (on connecting 3 W LED)** - 24.2% (1X) and 34.2% (2X)

WITH MPPT

- **Power Improvement** – 28.28 % (1X concentrator) & 38.54 % (2X concentrator)

- **Energy Improvement (on connecting 3 W LED) -** 26% (1X) and 35.4% (2X)

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