Components Specifications:

PV panels
Electricity performance of solar panel:
Condition: 1000W/sq-m AM1.5
Temperature: 25iæ
Model: MS1250, 50W

Table 1: Specifications of PV panels

Specifications	Ratings
S/C current **Isc**	3.285
O/C voltage **Voc**	22.298
Max power **Pm**	54.106
Max current **Im**	2.966
Max voltage **Vm**	18.241
Form Factor (**FF**)	73.87
EFF (%)	15.62
Series resistance **Rs**	0.740
Shunt resistance **Rsh**	123.52

Hall Effect current sensors

Table 2: Specifications of Hall Effect current sensors

Specifications	Ratings
Model name	Wcs2210
Amp ratting	10 amps
Voltage	60v
Type	Non contact Hall's

Micro controller

Table 3: Specifications of Micro controller

Specifications	Ratings
Model name	Arduino Nano
Controller name	Atmega 328p
Voltage	5v
I/O pins	22
Inputs	8 ADC 1024
Outputs	14 Digital
Memory	32Kb
SRAM	2KB

Relay circuit

Table 4: Specifications of Relay circuit

Specifications	Ratings
Model name	Hrs4h s dc 12 V
Amp rating IN	100 amp
Voltage IN	12V
Amp rating OUT	10 Amp
Voltage OUT	24 DC /230V AC
Type	EM Coil (non-solid state)

LCD display

Table 5: Specifications of LCD display

Specifications	Ratings
Model name	20×4 Alpha numeric
Operating voltage	5 – 5.5 V
Operating mode	8 bits

Alarm

Here piezo buzzer is used for alarm with operating voltage of 3 – 15 V. Here 5V is applied.

4. Operation of Hotspot detection Scheme

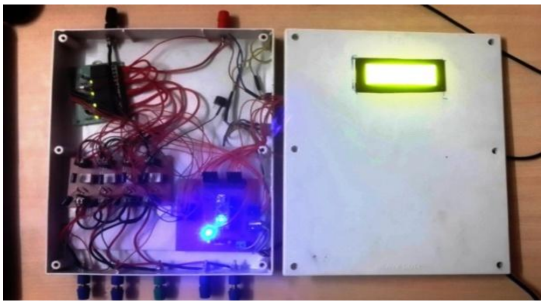

Figure 6: Circuit board of hotspot detection and isolation

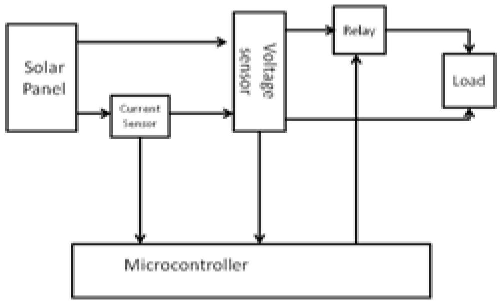

Figure 7: Schematic diagram for single panel

When the PV panels are generating the power, the current of the panels are sensed by the Hall Effect current sensors, due to Hall Effect they give equivalent voltage signals to the micro controller [11]. The micro controller converts analog signal to digital values, then the voltage and current values of four panels are displayed in the LCD. Whenever the shading occurs on a cell of any PV module the cell is reverse biased and starts dissipating power [2],[3], then the micro controller gives the signal to an alarm and a relay circuit of respected panel [12]. Alarm is on and relay circuit trip the corresponding panel from the grid. LCD displays which panel is affected (the panel current is zero) and that panel starts working automatically after the hotspot is removed. This is all done by the micro controller by giving the related programs to the micro controller.

5. Results

It is implemented and validated the proposed hotspot detection and isolation for 3A of load; the three observations are given below fig 8, fig 9 and fig 10. Fig 8 is observed when there is no partial shading. At this time four panels shared the load equally (0.75 each), fig 9 is observed when partial shading occur on panel 4 without isolation, the reverse current is clearly observed in the 4^{th} line of the LCD, and fig 10 is observed at same partial shading conditions with isolation on the same panel, it is clear that, the current from that panel is isolated so that the panel is protected from the hotspot.

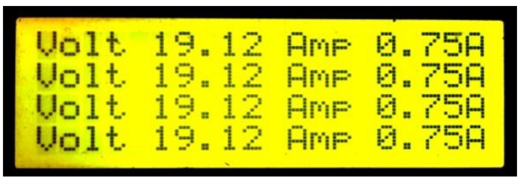

Figure 8: Without any partial shading condition

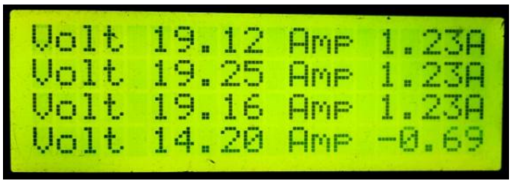

Figure 9: With partial shading without isolation

Figure 10: With partial shading with isolation

The experiment is conducted at 3A load, the result with isolation (fig 10) shows that, load draws 1amp from 3 panels without any excess current. The partially shaded panel (4th) is completely isolated, and then the current is zero in that panel. Whereas in fig 9 (without isolation) we can observe the excess current of 0.23 amps from each panel which is responsible for 0.69 amps reverse current in 4th panel. In this case, the 4th panel is not isolated which can cause permanent damage of the solar panel. Our hotspot detection and isolation project will help to improve the solar panel life and performance.

6. Conclusion

The following conclusions were drawn from the experimental work. Under partial shading condition the reverse currents are observed clearly. These reverse currents can cause the temperature increase; if the temperature reaches critical value (Hotspot) the cell is permanently damaged.

A model is proposed to detect hotspot and isolate panel which is under hotspot by using relay circuit. That panel starts working automatically after shading is removed. The panel parameters are observed for three conditions they are, (i) without any partial shading, (ii) with partial shading without isolation (iii) With partial shading with isolation. This helps to protect the solar panel from permanent damage and improve the reliability and performance of solar plant.

7. Acknowledgement

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