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DESIGN OF A SOLAR MPPT CHARGE CONTROLLER USING ARDUINO MICROCONTROLLER

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Abstract — *Solar energy has become a very popular source of energy in recent days because of its eco-friendly behavior and never-ending amount in the nature. However, in practical case, the I-V and P-V characteristics of a solar panel contain a huge amount of ripples which actually affect the performance of the system. Therefore, to utilize solar energy efficiently, at a particular irradiance and temperature, Maximum Power Point (MPP) has to be determined and this maximum power must be extracted. In Proteus 8.3 Professional software, a simulation model of a MPPT based solar charge controller is designed using Arduino UNO, a multi-tasking programming platform based on AVR microcontroller. At different irradiance, MPP changes, and the maximum power point voltage (Vmp) also changes. The proposed model successfully tracks the Vmp at different irradiance. As finally charge controller circuit charges a dc battery, hence, after extracting maximum power from the solar panel, buck converter feeds it to a buck-boost converter to regulate the voltage.*

Keywords- *Maximum power point, Arduino UNO, Proteus, solar panel, buck-boost.*

I. INTRODUCTION

Due to exponential decay of the conventional energy sources, use of non-conventional energy sources has become a topic of interest in recent few decades. For example, solar, geothermal, biomass, ocean and wind energy are becoming significant sources of commercial power gradually [1, 8, 3]. Although, solar energy is one of the most significant renewable energy sources on the earth because of its eco-friendly behavior and never-ending amount in the nature [2, 8, 12], efficiency of this energy source is very low because of two reasons. Firstly, output power of a solar PV panel is much less as compared to its cost, and secondly, power is varying at every instant due to constantly changing solar irradiation and temperature [5, 6, 13]. But by tracking the maximum power point of the working solar PV modules at a certain instant, and by implementing various Maximum Power Point Tracking (MPPT) algorithms, we can increase the efficiency of the PV system by extracting the maximum available power form the module [5, 6, 13, 14]. Although, there are a number of MPPT algorithms, such as Perturb & Observe Method, Incremental Conductance method, Voltage Based Peak Power Tracking Method, Current Based Peak Power Tracking Method and many more, in our work, we have opted for Perturb & Observe Method because despite of oscillation around the maximum power point, it is one of the most efficient MPPT algorithms as it can even increase the system efficiency up to 97% [11, 13]. In this algorithm, change in power (ΔP) is calculated with respect to change in voltage (ΔV) at every instant [9]. Theoretically this value is zero at MPP. Graphically, the magnitude of this calculated value is positive on the right side and negative on the left side and slope of the maximum power point. So if the value is calculated at every instant, and finally at one instant, the magnitude comes to zero, it's assured that the maximum power point has been reached. Afterwards, maximum power extracted from the panel is fed to a buck-boost converter and finally a rechargeable battery is charged [8]. In our work, we have designed a microcontroller based programmable MPPT charge controller. The controller efficiently converts photovoltaic energy to electrical energy in the form of DC current and charges a 12 volt battery.

II. SIMULATION MODEL IN PROTEUS 8 PROFESSIONAL

A. Configuration of 250 watt solar panel interconnecting 36 solar cells

A 250 watt solar panel is designed in Proteus 8 Professional. To this end, specifications of a standard 250 watt solar panel of Sunmodule Pvt. Ltd. are taken as references. Since, there is no in-built solar module in Proteus 8 Professional, 36 single solar cells each with current sources of 8.28 ampere, shunt & series resistances of 100 kΩ & 0.5 mΩ respectively are interconnected in series. This entire configuration of 250 watt solar panel with short-circuits current (Isc) and open-circuit voltage (Voc) of 8.28 ampere & 37.8 volts respectively, designed as per the data sheet, is encapsulated within a module-like structure.

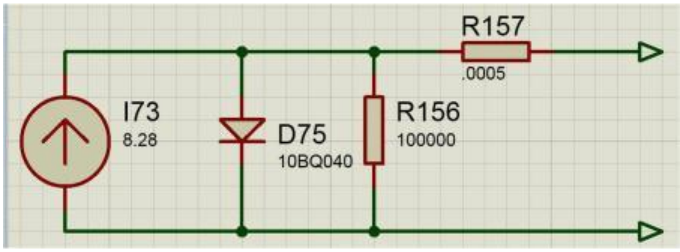

Fig.1. Single Diode Model of a Solar Cell in Proteus 8.3 Professional

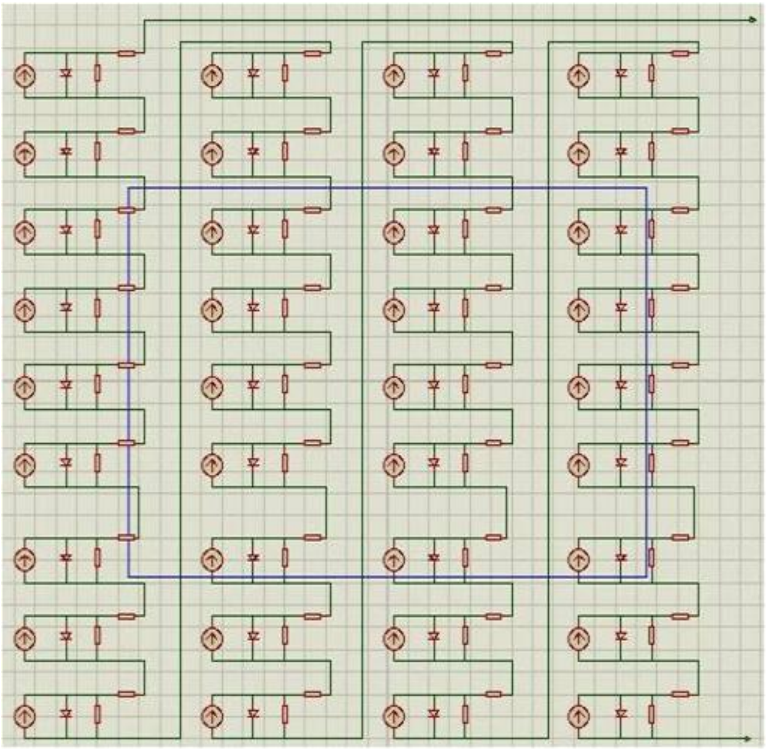

Fig.2. Configuration of 250 watt solar panel interconnecting 36 solar cells

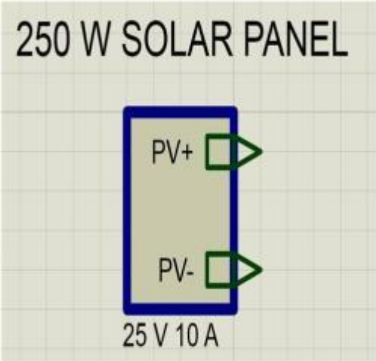

Fig.3. Encapsulated 250 watt solar panel

B. Configuration of 250 watt solar panel interconnecting 36 solar cells

Output voltage from the aforesaid 250 watt solar panel is fed to a buck converter which is again series connected to a buck-boost converter and finally to storage battery. Two power electronics switches of buck and buck-boost circuits, MOSFETs IRF9520, which are P-channel power MOSFETs, are triggered by two separate dedicated PWM pins of Arduino UNO.

C. Arduino UNO

Arduino is basically a family of multitasking programmable platform based on AVR microcontroller. By default, its clock speed is 16 MHz, however, in this work, it is made to operate at 50 kHz frequency. UNO has 6 analog input pins and 14 digital I/O pins of which 6 are dedicatedly PWM pins.

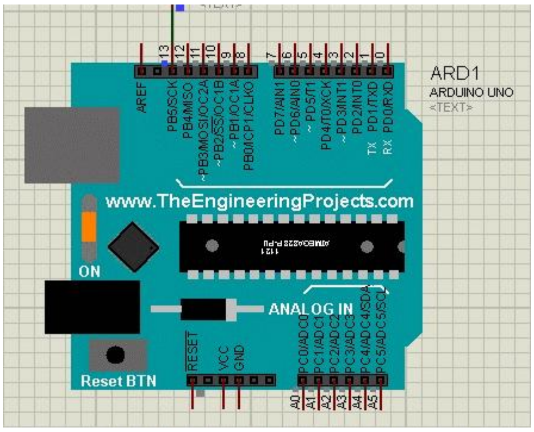

Fig.4. Arduino UNO in Proteus 8.3 Professional

D. Gate Triggering Circuit

A Gate triggering circuit is used to boost the voltage level of the PWM signal generated by the PWM pins of Arduino UNO up to the gate-threshold voltage (VTh) of the MOSFET switch IRF9520.

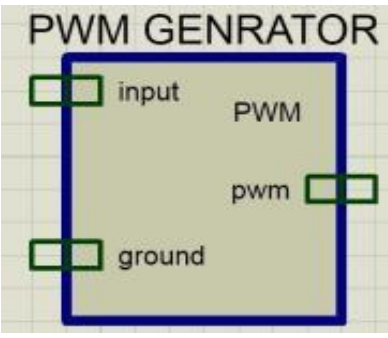

Fig.5. Gate Triggering Circuit

This gate triggering circuit consists of the optocoupler PC817. This PC817X is a series of optocoupler which efficiently isolates the control circuit and the power circuit and boosts the input voltage level.

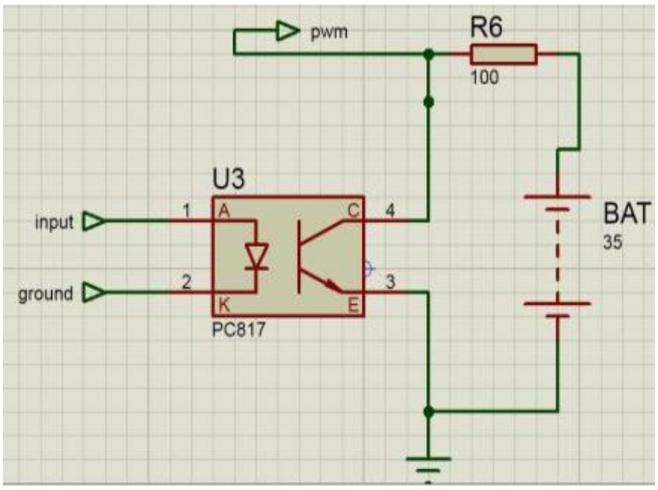

Fig.6. Gate triggering circuit consisting of PC817

E. Current Sensor ACS712

ACS712 is a Hall current sensor. Current from the 250 watt solar panel is fed to the IP+ terminal of the current sensor ACS712 and output signal from it is fed to A1 pin of Arduino UNO through a LC current filter.

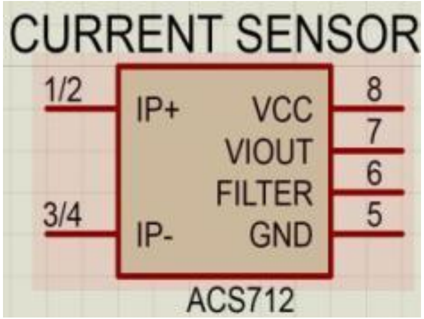

Fig.7. Current Sensor ACS712

F. Final Simulation model of the circuitry

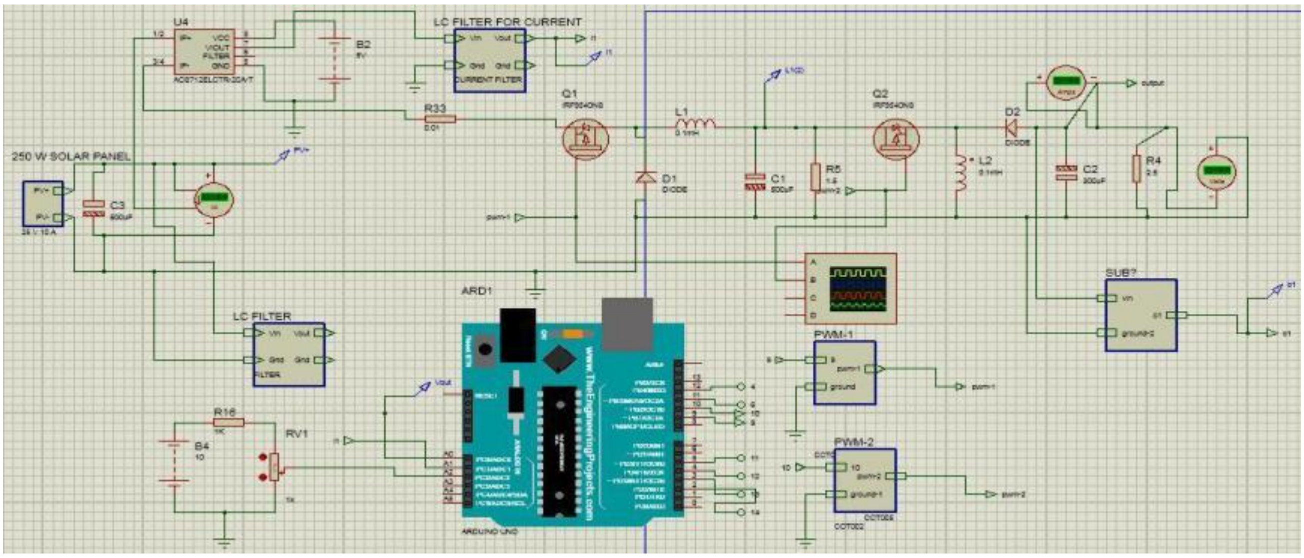

Fig.8. Simulation model of MPPT based charge controller circuitry

III. ARDUINO PROGRAMMING

In Arduino Programming software, pulses for desired buck and buck-boost operations are programmed. From Pin 9 and Pin 10, respectively, these two pulses are generated and fed to analog input pins A1 and A0 respectively of Arduino UNO.

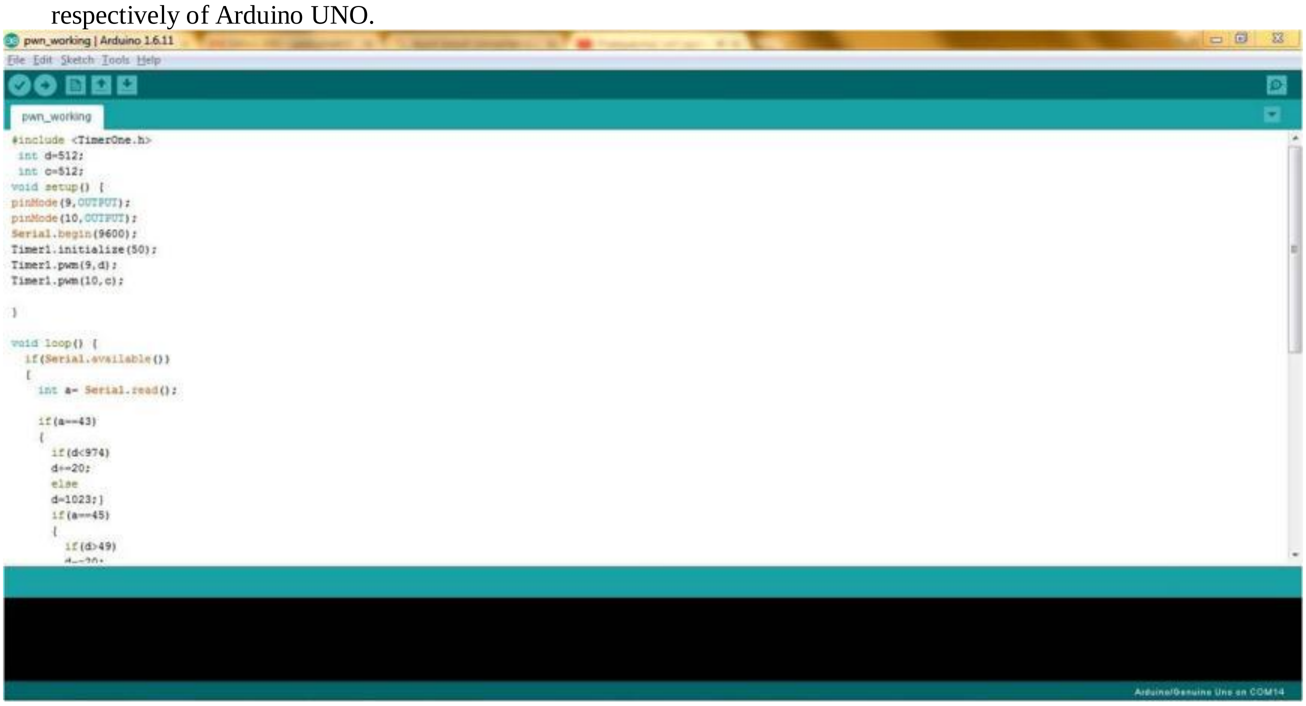

Fig.9. Arduino programming for buck and buck-boost pulses, Part I

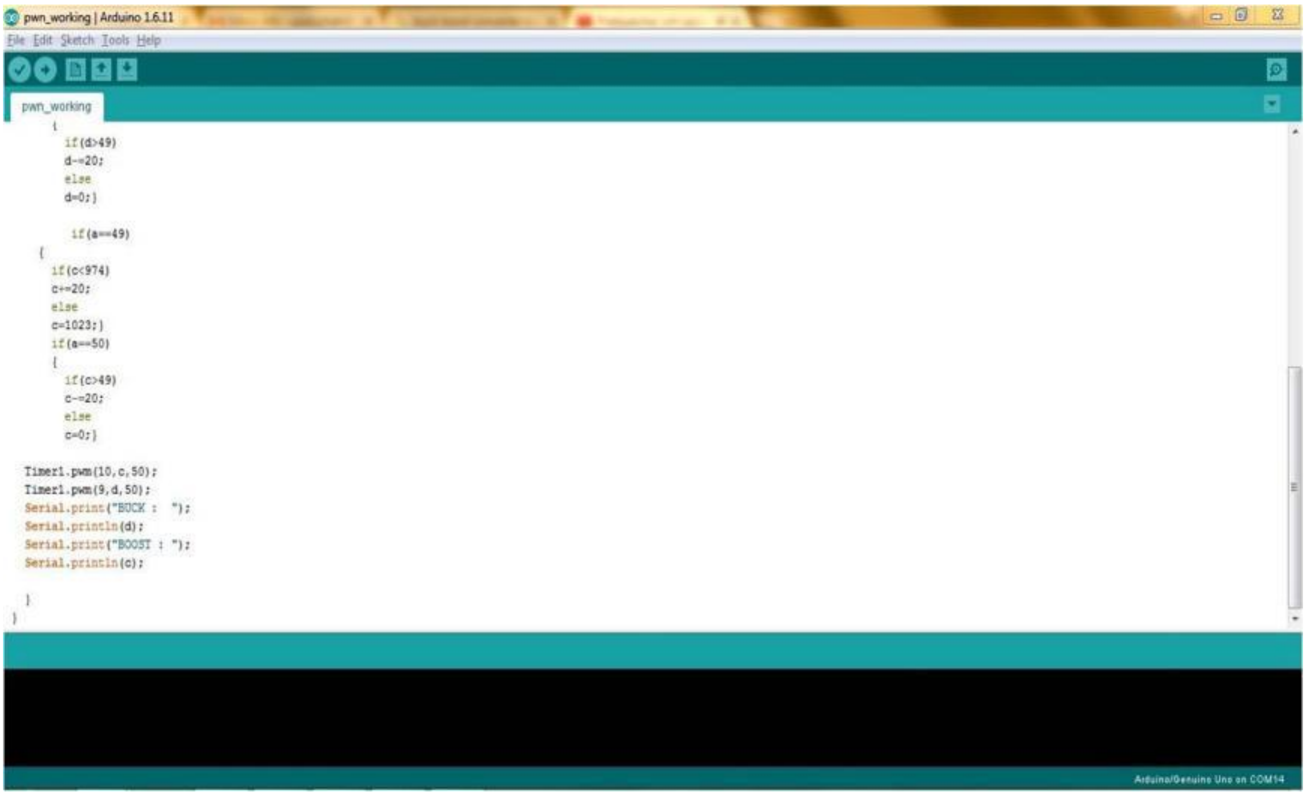

Fig.10. Arduino programming for buck and buck-boost pulses, Part II

IV. SIMULATION RESULTS

Perturb & Observe method of MPPT algorithm is compiled in Arduino programming language. As solar irradiance and temperature will be changing at every instant, for real time simulation, a potentiometer is varied to change the voltage from the solar panel abruptly. Maximum power point voltage (Vmp) is successfully traced at these different values of solar panel voltages. Since there is no in-built option in Proteus 8.3 Professional to vary the irradiance and temperature incident on the solar panel, a potentiometer is connected in the circuit at the output of the panel so that voltage coming out of it can be varied abruptly assuming the effect of different irradiance and temperature conditions. For different values of potentiometer, solar panel operating wattage is taken. As the potentiometer resistance gradually increases, i.e. irradiance incident decreases, wattage of the panel reduces. These five potentiometer values, at 0%, 25%, 50% & 75% and their corresponding solar panel wattages & Vmp are shown below:

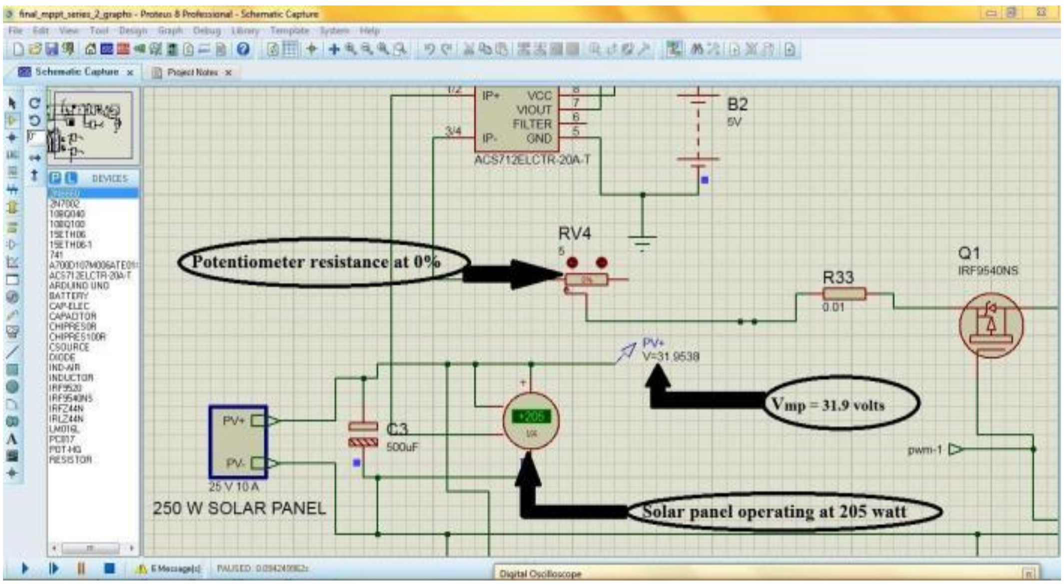

Fig.11. Potentiometer resistance at 0% & corresponding panel wattage and maximum power point voltage

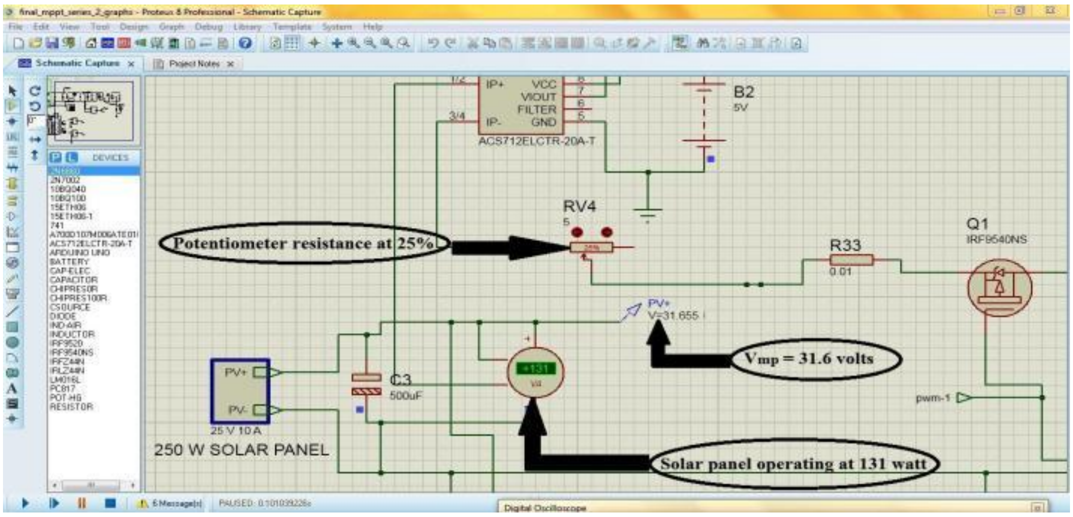

Fig.12. Potentiometer resistance at 25% & corresponding panel wattage and maximum power point voltage

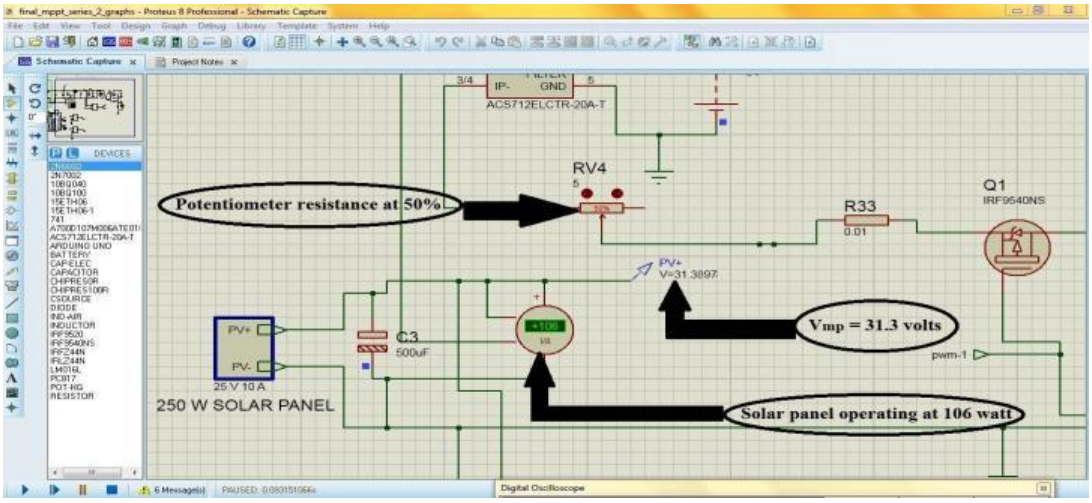

Fig.13. Potentiometer resistance at 50% & corresponding panel wattage and maximum power point voltage

Maximum Power Point Voltage (Vmp) is traced in a very precise range and plotted for these different values of potentiometer resistance and shown in the graph below:

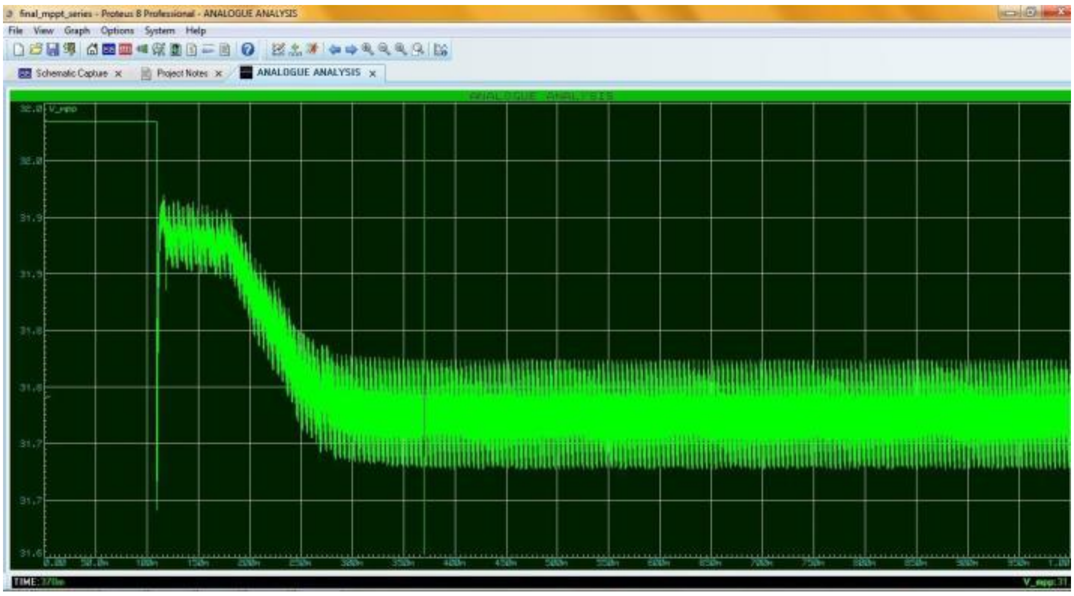

Fig. 12. Maximum Power Point voltage (V_mpp) characteristics

Output voltage of the buck-boost converter is stable at 12.1 volts and is traced in a graph and is shown below

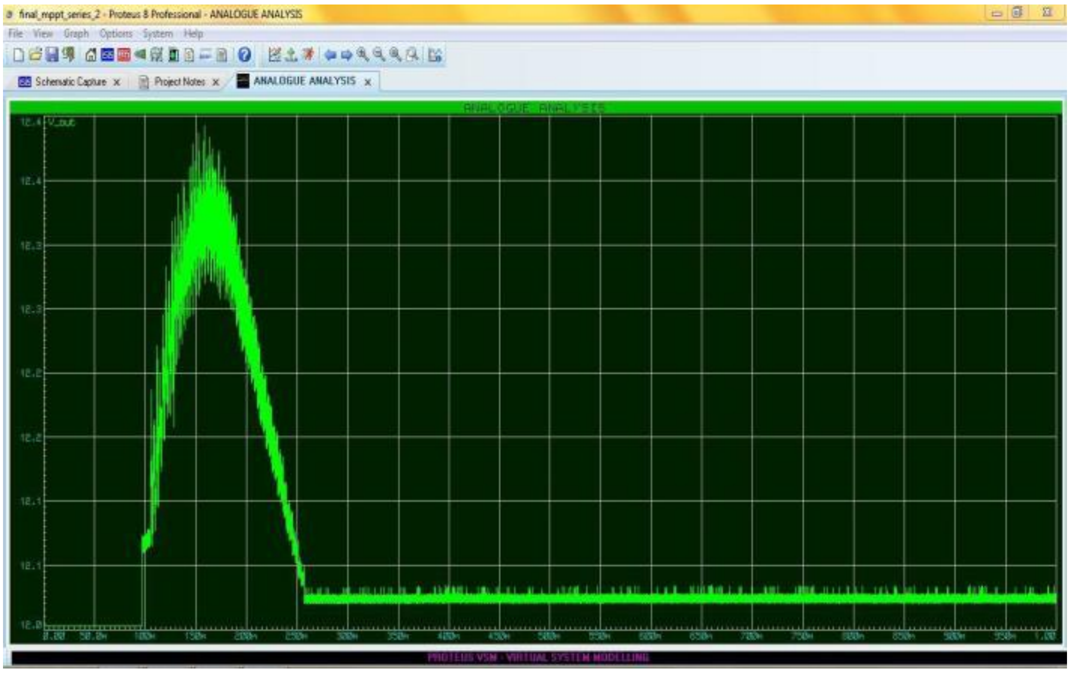

Fig. 16. Output voltage characteristics

Simulation results are summarized in the table below:

Table 1. Summary table of the simulation results obtained

Sr. No.	Potentiometer Resistance (%)	Irradiance (W/m^2)	MPP Voltage (volts)	Extracted Power (watts)	Charging Voltage (volts)	Charging Currents (Amps)
01	0	1000	31.9	205	12.45	5.67
02	25	750	31.6	131	12.23	4.18
03	50	500	31.3	106	12.10	2.12
04	75	250	30.9	90	12.10	1.29

V. CONCLUSION

A MPPT based charge controller circuitry model is proposed that can successfully track the maximum power points (MPP) at different irradiance values. Afterwards, the maximum power extracted from the panel at that particular irradiance and temperature condition is fed to a dc-dc buck-boost converter circuit to regulate it according to a fixed dc voltage and finally fed to a 12 volt battery.

REFERENCES

[1] J. Chang, Dennis Y. C. Leung, C. Z. Wu And Z. H. Yuan, "A Review on the energy production, consumption, and prospect of renewable energy in China", Renewable Sustainable Energy Rev., vol. 7, No. 5, pp. 453-468, October 2003.

[2] Furkan Dincer, "The analysis on photovoltaic electricity generation status, potential and policies of the leading countries in solar energy", Renewable Sustainable Energy Rev., vol. 15, No. 1, pp. 713-720, January 2011.Devendra Doda & Ankit Kumar Sharma, 'Advancement in solar PV Inverter' International Journal of Electronics and Computer Science Engineering 2192 Available Online at www.ijecse.org ISSN- 2277-1956.

[3] V. Salas and E. Olias, "Overview of the photovoltaic technology status and perspective in Spain". Renewable Sustainable Energy Rev., vol. 13, No. 5, pp. 1049-1057, June 2009.

[4] Roger Gules, Juliano De Pellegerin Pacheco and Hélio Leães Hey, "A maximum power point tracking system with parallel connection for PV stand-alone applications", IEEE Trans. Ind. Electron., vol. 55, No. 7, pp. 2674 – 2683, June 2008.

[5] Fan Zhang, Kary Thanapalan and Andrew Procter, "Adaptive Hybrid Maximum Power Point Tracking Method for a Photovoltaic System", IEEE Trans. Energy Convers., vol. 28, No. 2, pp. 353-360, April 2013.

[6] Frangui Liu, Shanxu Duan and Fei Liu, "A Variable Step Size INC MPPT Method for PV Systems", IEEE Trans. Ind. Electron., vol. 55, No. 7, pp. 2622-2628, June 2008.

[7] Hiren Patel and Vivek Agarwal, "Maximum Power Point TrackingScheme for PV Systems Operating Under Partially Shaded Conditions", IEEE Trans. Ind. Electron., vol. 55, No. 4, pp. 1689-1698, April 2008.
[8] Her-Terg Yau, Qın-Cheng Lıang and Chın-Tsung Hsıeh, "Maximumpower point tracking and optimal Li-ion battery charging control for photovoltaic charging system", Comput. Math. Appl., vol. 64, No. 5, pp. 822-832, September 2012.
[9] Yeong-Chau Kuo, Tsorng-Juu Lıang and Jıann-Fuh Chen, "Novel maximum-power-point-tracking controller for photovoltaic energy conversion system", IEEE Trans. Ind. Electron., vol. 48, No. 3, pp. 594-601, August 2002.
[10] Johan H. R. Enslin, Marıa S. Wolf, Danıel B. Snyam and Wernher Swıegers, "Integrated photovoltaic maximum power point tracking converter", IEEE Trans. Ind. Electron., vol. 44, No. 6, pp. 172-178, August 2002.
[11] T. Esram and P. L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", IEEE Trans. Energy Convers., vol. 22, No. 2, pp. 17-22, May 2007.
[12] Mazen M. Abu-Khader, Omar O. Badran and Salah Abdallah, "Evaluating multi-axes sun-tracking system at different modes of operation in Jordan", Renewable Sustainable Energy Rev., vol. 12, No. 3, pp. 864-873, April 2008.
[13] D. P. Hohm and M. E. Ropp, "Comparative Study of Maximum Power Point Tracking Algorithms", Prog. Photovoltaics Res. Appl. 2003, vol. 11, No. 1, pp. 47-62, November 2002.
[14] Azadeh Safari and Saad Mekhilef, "Simulation and Hardware Implementation of Incremental Conductance MPPT with Direct Control Method using CUK Converter", IEEE Trans. Ind. Electron., vol. 58, No. 4, pp. 1154-1161. Vol. 58, No. 4, April 2010.

