Simulation and Analysis of DC-DC Converter for Solar PV System to Connecting Mobile Charging Bank

Sunny Kumar Kashyap[1] Dr. Manju Khare[2]
[1]M.Tech. Student [2]Head of Department
[1,2]Department of Electrical Engineering
[1,2]LNCT, Bhopal, India

Abstract— With the expansion of technology in the 21st century, the demand for DC power has increased in urban and rural areas. A DC-DC converter is an efficient way to meet the electricity need from the local solar energy and helps in improving the system efficiency. This paper presents simulation results of a buck boost converter, MPPT algorithm (P & O method) for solar PV system that is MATLAB/simulation module and closed loop PI control system for obtaining constant 12 (V) and 24 (V) DC output voltage at DC bus to Connecting mobile charging bank. In addition, much research is focused on increasing the poor efficiency of the power processing and improving the power yield of the overall system.

Keywords: Photovoltaic Stations, Maximum Power Controller, DC–DC Buck Converter, MATLAB/Simulink Sampling Time, Mobile Charging

I. INTRODUCTION

Photovoltaic (PV) is one of the most promising technologies for the production of electrical energy in the increasing energy demand in the 21st century, which has shown the greatest development in the past few years compared to other types of renewable energy sources. The installed capacity of photovoltaic system in 2017 reached 408 GW investments in renewable energy. Now most of the equipment's are working on DC voltage supply. Normally, the supply coming in power station to the homes, offices and industries etc. In AC supply it is needed to convert AC supply into DC supply to makes useful for the equipment which in works on DC supply. Nowadays the energy generate in form of clean, efficient, and environmentally friendly sources has been becomes one of the major challenges for engineers and scientists. In case of addressing the poor efficiency of solar PV system, some methods are proposed for improving an efficiency of solar PV system among by implementing new concept is known as "maximum power point tracking" (MPPT). The DC-DC converter is responsible for transferring the maximum power from the solar PV module system to the load. A "MPPT" is used for extracting the maximum power in the solar PV module and transferring those power to the load.

A. The Maximum Power Point Tracking (MPPT) Method: -

Maximum Power Point Tracking (MPPT) techniques are used to maintain the Photovoltaic (PV) array system operating point at its maximum power point (MPP) and extract the maximum power available in PV arrays. These techniques vary in complexity, cost and speed of convergence, sensors required, hardware implementation, and effectiveness Photovoltaic (PV) solar systems have varying relationships to inverter systems, external grids, battery banks, and other electrical loads such that mobile charging bank.

B. DC–DC Power Converter:

A DC-to-DC power converter is an electronic circuit or electromechanical device that converts a source of direct current (DC) from one voltage level to another. It is the type of electric power converter. Power levels range from very low (small batteries) to very high (that is high-voltage power transmission). And

DC–DC power converter is nothing but there is a DC chopper which is a static device (switch) used to obtain variable DC voltage from a source of constant DC voltage, therefore chopper may be thought of as DC equivalent of an AC transformer since they behave in power, the DC chopper offers greater efficiency, faster response, lower maintenance, small size, smooth control, and for many applications, lower cost, than motor-generator sets and the gas tubes approaches.

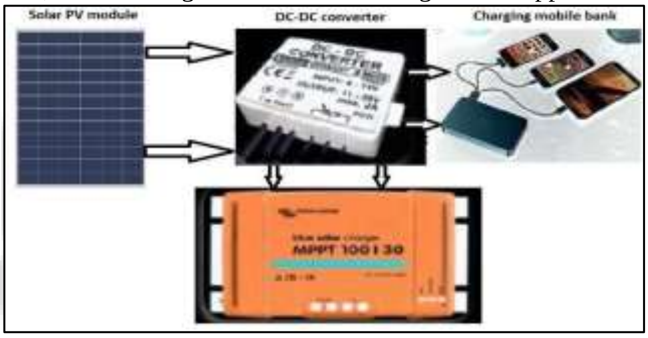

Fig. 1: Block diagram of DC-DC converter in solar PV system to connecting mobile charging bank

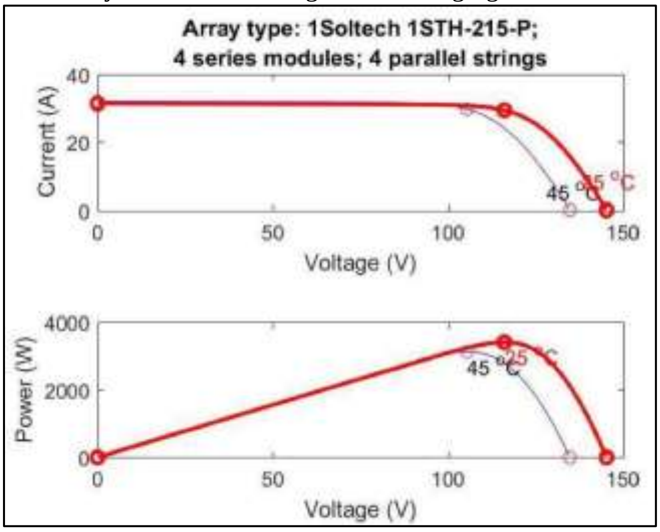

Fig. 2: Characteristics of PV Array

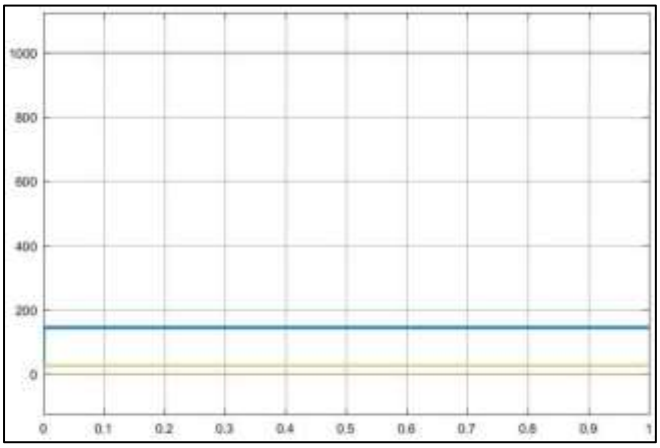

Fig. 3: Waveforms of PV Array

II. LITERATURE REVIEW

The literature review in this research work is focused on the Simulation and analysis of DC-DC converter for solar PV system to connecting mobile recharging Bank.

In the purpose of the research was to develop the methodology for the selecting the parameters of the main components of an autonomous solar PV system modal providing the most efficient conversion of solar energy. To test and verify the results obtained by simulation modeling of a dynamic regimes of the solar PV system were used in the MATLAB/Simulink® software package. this works of literature do not evaluate the MPPT tracking performance in terms of tracking time and tracking efficiency. These are also no discussion on how this 'MPPT' can be integrated with a battery charge controller. On the battery charge controller side, there are literatures solely present on multi-stage charging strategies [9], comparative study of various multi-stage charger [10], solar PV charge controller [11] In summary, the above literatures presented models that are lack of completeness didn’t present MPPT and overall charging the mobile bank. This paper presents the complete modeling of the solar PV MPPT as well as mobile charging Bank in Simulink and its performance analysis in the following sections.

III. MATHEMATICAL MODELS

The overview of the solar photovoltaic MPPT mobile bank battery charge controller model developed in MATLAB/Simulink environment is shown in Fig. 4 consists of a solar PV array, DC-DC converter, mobile bank battery and subsystem of mobile charging bank as shown in Fig. 5.

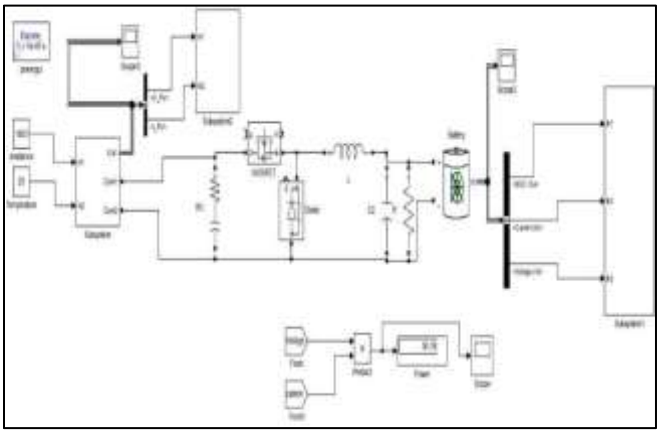
Fig. 4: Overview model of DC-DC converter in solarPV system to connecting mobile charging bank

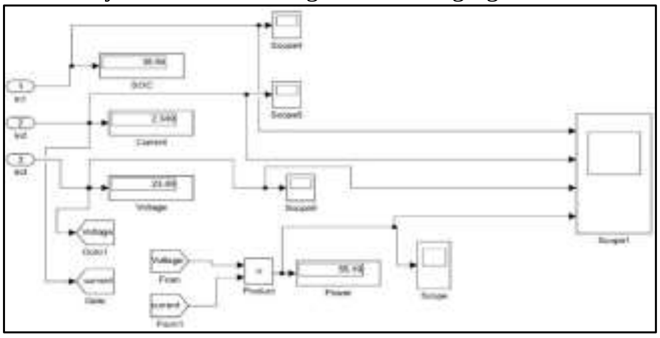
Fig. 5: Subsystem1 of mobile charging bank

Photovoltaic cell is an electrical device such that converts the energy of light directly into electricity by this photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device those electrical characteristics, such that current, voltage, and resistance, there are vary when exposed to light. First of all, we select the powerguin and set the simulation type is discrete and the solver type is Tustin/Background Euler (TBE) and again select the sample time is 50e-6s. The PV array is the parallel string is four and series connected modules per string is four and the Display I-V and P-V characteristic as shown in Fig. 2.

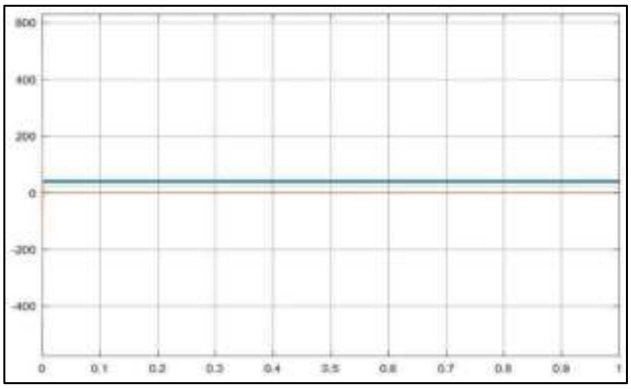

Fig. 6: waveforms of charging of mobile bank battery only

The PV array is input terminal are connected to simultaneously irradiance and temperature that is irradiance is 1000(W/m^2) and temperature is 25(deg C). And output terminal like as a subsystem and bus selector are selected voltage (V_PV) and current is selected (I_PV) and then the bus selector is connected to unite Delay the sample time is 1e-4 as well as initial condition is zero. And bus selector is also selected to scope and in this we will get the webform which is shown in the Fig. 3. And other output terminal is connected to RC- branch like resistance is 0.001(ohms) and capacitance of a capacitor is 100e-6(F) and again connected to MOSFET Internal diode resistance Rd is 0.01(ohms)

We know that P = V*I (1)

And diode is connected to parallel to each other and its Resistance Ron is 0.001(ohms) Along with this there is an inductor connected in series which has inductance is 0.869e-3(H)and along with this capacitor connector in parallel whose capacitance is 569.79e-6 (C). And the last one is register connected which is acting as load whose resistance is 10(ohms) Mobile charging bank is connected to the output load such that Nominal voltage is 24(V), Rated capacity is 100(AH) Initial state-of-charge in percentage is 100% and Battery response time is 1(S). When the battery of the mobile charge bank is discharged then Maximum capacity is 104.1667(AH), Cut-off Voltage is 18(V), Fully charged voltage is 26.1316(V) Nominal discharge current is 20(A), Internal resistance is 0.0024(ohms), Capacity (Ah) at nominal voltage is 31.0278(AH) and its Characteristic of discharging of mobile bank battery shown in Fig. 7.

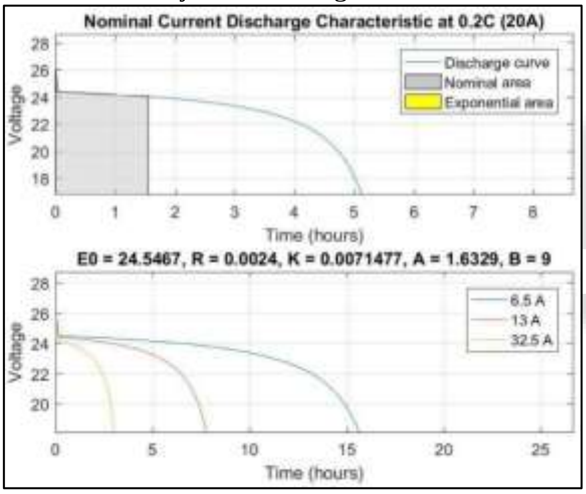

Fig. 7: Characteristic of discharging of mobile bank battery

The subsystem1 is connected to the output of the bus selector across the battery bank charging as shown in Fig. 5. Firstly, if the mobile is not connected to the battery bank, then its current is zero as shown in Fig. 8. But voltage will be present in it as shown in Fig. 9

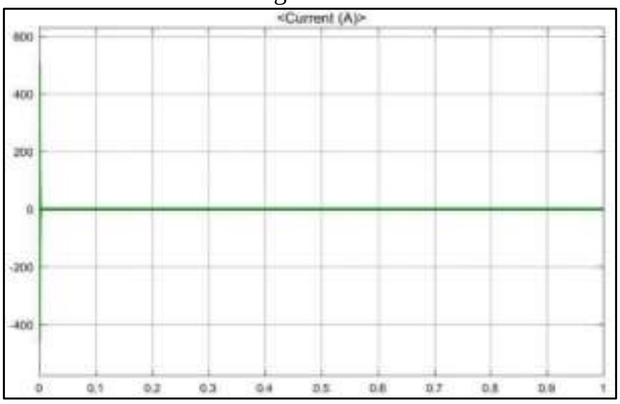

Fig. 8: Waveforms of current battery bank not connecting in mobile

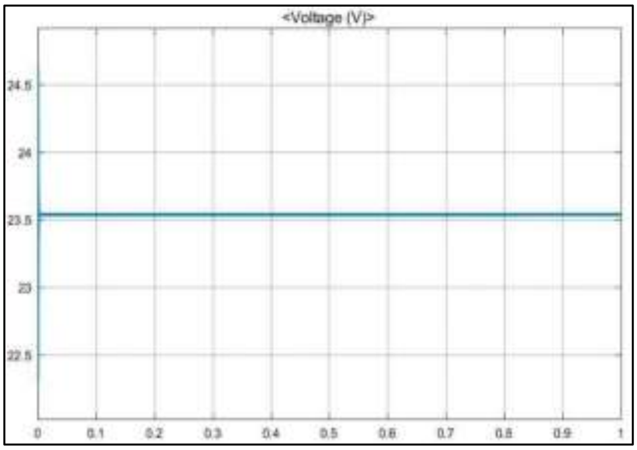

Fig. 9: Waveforms of voltage battery bank not connecting in mobile

Find out the output voltage of DC-to-DC converter it definedas below.

$$V_{out} = -\frac{V_{in} * K}{(1-K)} \quad (2)$$

Where,

V_{out} = output voltage of buck boost converter (V)

V_{in} = input voltage of buck boost converter (V)

K = duty cycle

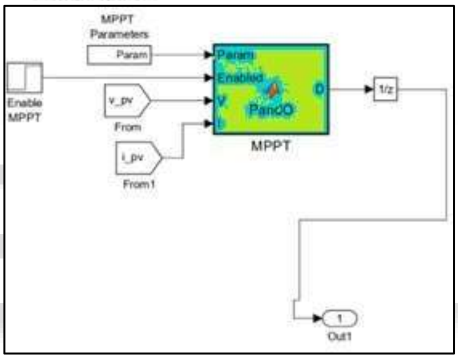

Fig. 10: Simulink diagram of subsystem2 in MPPT to connectDC-DC converter.

Power delivered by in this module depends on the load connected to the module. In MPPT algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltagein which solar PV module can produce maximum power is called 'maximum power point' or peak power voltage. Here MPPT is most effective under such that cold weather, cloudy and hazy days.

IV. RESULTS

The Simulink model of a closed loop DC-DC converter for solar PV system to connecting mobile recharging Bank module is shown in Fig. 4. For the solar PV system to connecting mobile recharging Bank module is modelled using electrical characteristics for provide the output current, voltage and power of the PV module as shown in Fig.11. PWM signals are generate using combination of the output of MPPT duty cycle as well as output of PI controller. The output voltage of DC-DC converter is DC 23.5 (V), current is 2.349(A) and power is 55.19(W) shown in Fig.11

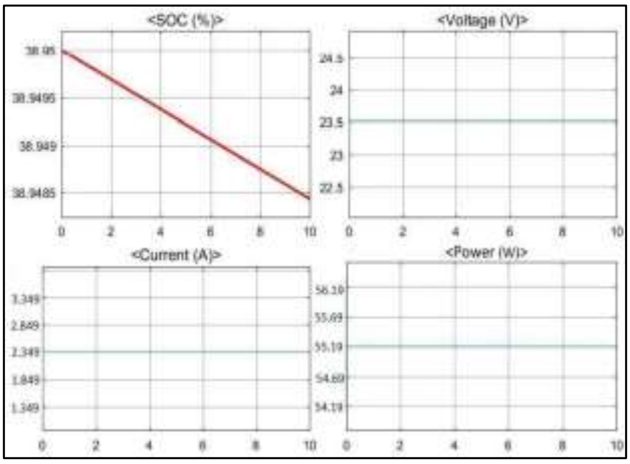

Fig. 11. Mobile charging bank simulation result

V. CONCLUSION

A detail circuitry modeling of a Solar PV MPPT mobile recharging Bank battery charge controller model in Simulink is presented. And these are fully reproducible. The MPPT mobile recharging Bank battery charge controller is capable to charge a 23.5(V) and mobile charging bank likeas lead-acid battery through tracking the maximum power from the 2(Kw) solar PV array power source and regulated the charging using a three-stage chargingstrategy. It achieved a DC power is 55.19(W) which matches many high ends commercial solar PV MPPTcharge controller product specification.

ACKNOWLEDGMENT

This research paper was supported by Engineering College LNCT Bhopal.

REFERENCES

[1] Renewables 2019 Global Status Report, Renewables Now (REN21), 40 (2019)
[2] B. N. Mohapatra, A. Dash, B. P. Jarika, Power Saving Solar Street Lights, International Journal of Emerging Technologies in Engineering Research, 5, 105-109 (2017)
[3] Noridzuan Idris, Ahmad Maliki Omar, Sulaiman Shaari, Stand-Alone Photovoltaic Power System Applications in Malaysia, The 4th International Power Engineering and Optimization Conference, (2010).
[4] A. Safari and S. Mekhilef, “Simulation for the Hardware Implementation of Incremental Conductance MPPT With Direct Control Method Using Cuk Converter”, IEEE Trans. Ind. Electron, vol. 58, no. 4, pp. 1154 – 1161, Apr. 2011.
[5] W. Xiao, W. G. Dunford, P. R. Palmer, and A. Capel, “Regulation of photovoltaic voltage,” IEEE Trans. Ind. Electron., vol. 54, no. 3, pp. 1365– 1374, Jun. 2007.
[6] T. Esram, P. L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques," IEEE Trans. On Energy Conversation, vol. 22, no. 2, pp.439-449, Jun. 2007.
[7] R. Faranda and S. Leva, "Energy Comparison of MPPT techniques for solar PV Systems," WSES Trans. on Power Systems, vol. 3, pp.446- 455, 2008.
[8] K. Y. Chen, T. J. Liang, J. F. Chen, “Novel maximum power- point tracking controller for photovoltaic energy conversion system” IEEE Trans. on Ind. Electro., vol. 48, no. 3, pp.594-601, Jun. 2001.
[9] E. I and O. Rivera, "Maximum Power Point Tracking using the Optimal Duty Ratio for such that DC-DC Converters and Load Matching in Photovoltaic Applications," IEEE, pp. 987- 991, 2008.

