International Journal of Engineering Inventions
e-ISSN: 2278-7461, **p**-ISBN: 2319-6491
Volume 2, Issue 3 (February 2013) PP: 59-62

Design and Simulation of DC-DC Converter Used in Solar Charge Controllers

Arjyadhara Pradhan[1], Dr S.M Ali[2], Chitrlekha Jena[3], Puspapriya Behera[4]
School of Electrical Engineering, KIIT University, Patia, Bhubaneshwar-751024, Odisha, India

Abstract:- With the increasing Energy demand Conservation and effective Utilisation of Energy are very essential. Solar Charge Controllers helps in increasing the efficiency of the solar power transferred to the Battery. It consists of mainly Dc-Dc Converters. These Converters are mostly Dc Choppers which converts fixed Dc voltage to a variable Dc source. These Regulators are used in case of Solar Charge Controllers to increase or decrease the PV panel voltage to as that required by Battery. The DC voltage from the PV panel varies with the light intensity which depends on time of day and temperature. Similarly on the Battery side the voltage varies depending on the load connections. Thus for optimal charging of battery it is important that the voltage of the PV panel and the current matches the battery charging state at any instant. There are various types of Dc-Dc Converter of which Buck Boost Converter is taken into consideration. This paper shows all the Design calculations and simulation results of a Buck-Boost converter as depending on the weather condition the Solar Charge Controller will take the voltage input from the Solar PV panel and convert it to that required for optimal charging of battery.

Keywords:- Controller, Buck-Boost, Regulators, MPP, PWM

I. INTRODUCTION

DC-to-DC regulators are also known as Switching Regulators which uses power switchs like an inductor, a capacitor and a diode to transfer power from input to output. The switches are generally passive or Active type. Passive switches consists of a diode, where as the active switches are like MOSFET transistor. MOSFET transistors are an efficient and fast way to allow a pulse width modulation (PWM) signal to control the frequency and duty cycle of the ON and OFF time of the "switch". More power is transferred from input to output when Duty cycle is high. One of the advantages of the PWM is that the signal remains digital from the source i.e. from the Microcontroller to the MOSFET's so that any analog-to-digital signals conversion is no more needed. Digital signals are very rarely affected from outside noise, unless the noise is large to change the signal from one to zero or vice versa. There are many DC-to-DC converters so far studied .Some are like Buck, Boost, Buck-Boost, CUK, and Sepic. These regulators do not produce power. In fact some of the input power according to their efficiency is consumed by these Regulators. Therefore considering ideal case to maintain the same power level the adjusted voltage level affects the current level. Since current and voltage are both directly proportional to power therefore in buck mode the voltage is reduced as the current increases. While in boost mode the voltage is increased as the current decreases. The Solar Charge controller consists of various components like Dc-Dc Converter, Microcontroller, LCD, Temperature sensors, Voltage sensors, Current sensors, Irradiance Sensors. The Dc- Dc Converter is one among the major component of the controller which receives the input voltage from the PV panel and converts the voltage without use of transformer and gives the desired output as that required for various charging stages of Battery.

II. BUCK-BOOST CONVERTER

Buck-Boost Converter is a Dc Converter in which the output voltage can be increased or decreased than the input voltage. One of the striking features of this regulator is that it provides output voltage polarity reversal without the use of transformer. It is also called an Inverting Regulator. It has high efficiency and the output short circuit protection can be easily implemented. However it shows discontinues input current and high peak current flows through the switch. Buck Boost Converter consists of a switch which may be Mosfet or a Transistor, Inductor, Diode, Capacitor and Load may be resistive or any other.

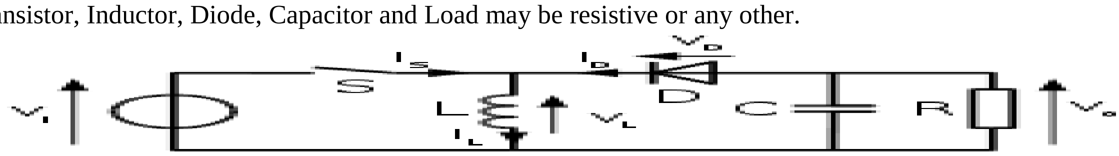

Fig 1: Diagram of a Buck Boost Converter

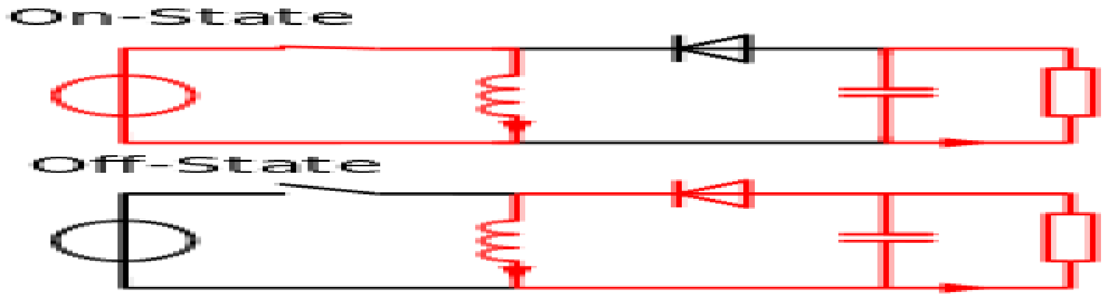

Fig. 2: The two operating states of a Buck–Boost Converter:

The principle of operation of the buck–boost converter is simple (see figure 2):

- While in the On-state, the input voltage source is directly connected to the inductor (L) resulting in accumulating of energy in L. In this stage the output load is supplied with energy from the Capacitor.
- While in the Off-state, the output load and capacitor are connected with the Inductor, so energy is transferred from L to C and R via Diode D.

The characteristics of the buck–boost converter comparing to Buck and Boost are mainly:

- The output voltage polarity is opposite of the input voltage polarity.
- In case of an Ideal Converter the output voltage can vary continuously from 0 to $-\infty$. The ranges for a buck and a boost converter are respectively 0 to V_i and V_i to ∞.

III. SOLAR CHARGE CONTROLLER

Solar Charge Controllers are the controllers which regulate the power output or the Dc output voltage of the solar panels to the batteries. Thus we can say these controllers take the Dc output voltage as the input voltage converts it into same Dc voltage but as that required for Battery charging. These are mostly used in off grid scenario and uses MPP i.e. Maximum Power Point Tracking scheme which maximizes the output efficiency of the Solar Panel. In Battery charging the output voltage Regulation plays an important factor as batteries require specific charging method with various voltage and current levels for specific stage. These charging processes enhance battery performance and battery life. Standard Charge controllers are used where the solar panel voltage used as input are higher than the output voltage. Thus keeping the current constant the voltage will be reduced by the controller. This results in loss of power. MPPT based solar charge controllers use smart technologies such as microcontrollers to compute highest possible power output at any given time i.e. voltage will be monitored and regulated without power loss. The Controller will lower the voltage simultaneously increase the current, thereby increasing the power transfer efficiency.

IV. DESIGN PARAMETER CALCULATION OF BUCK-BOOST CONVERTER

In this paper Buck-Boost Converter is used for resistance matching to achieve the optimum output by maximum power point tracking. The PV panel used as a source of input for the DC-DC converter has the following characteristics: Maximum power P_{max}= 20 watt, Maximum voltage V_{max} = 17 volt, Maximum current I_{max}=1.18 Amp, Open circuit voltage V_{OC}=21volt, Short circuit current I_{sc}=1.30amp. The design of Buck-Boost Converter starts with the selection of one Inductor and one Capacitor with a resistive load.

Input voltage 12-16volt

Output voltage 12v, 1.2amp

By using the output equation Vo = - (D*Vs)/(1-D), where D is the Duty cycle D is calculated to be 0.48.

D > 0.5 ------Boost mode

D < 0.5 ------Buck mode

Is = source current, 1.3 Amp

Similarly by using this formula $I_s = I_o*D/(1-D)$, output current is calculated, Io = -1.27Amp

The value of Inductance as calculated is given as $L = (D*V_s)/(F_s*\Delta I)$, L= 200µH

And the value of Capacitance is taken as $C = D*I_a/(\Delta V*Fs)$, C= 350µF

The switching frequency is chosen as Fs = 10 KHz with Time period T = 0.1*10e-3.

V. SIMULATION DESIGN

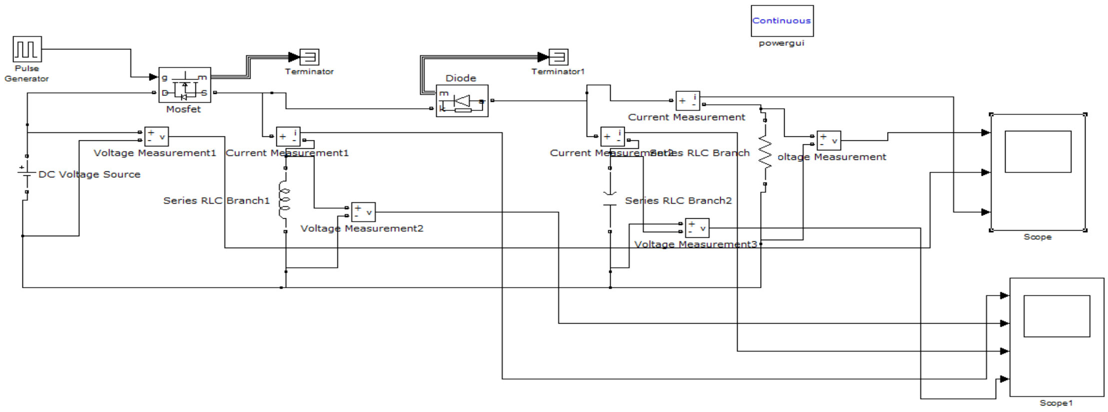

Fig 3: Shows the Simulation Design of Buck-Boost Converter performed using MATLAB

VI. SIMULATION RESULTS

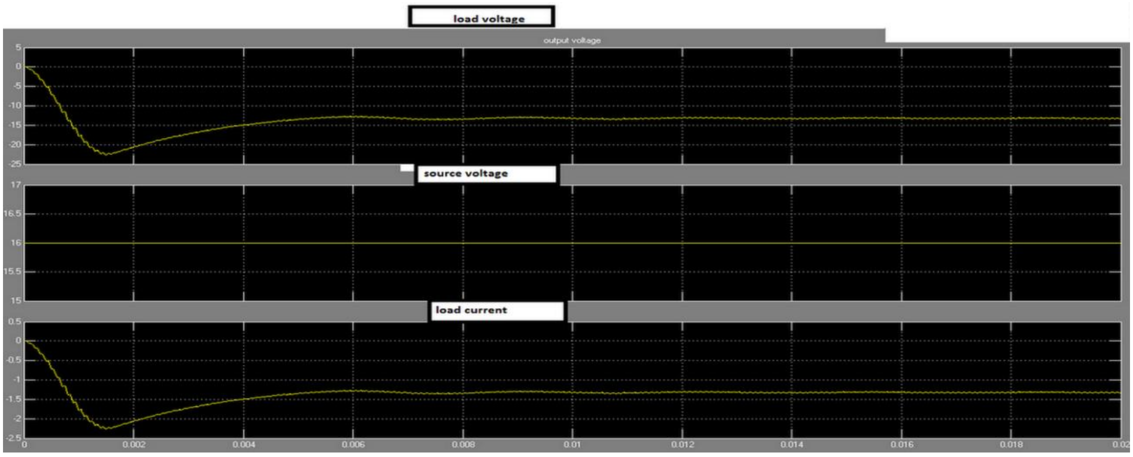

Fig 4: Shows the Converter output voltage, input voltage and Load current

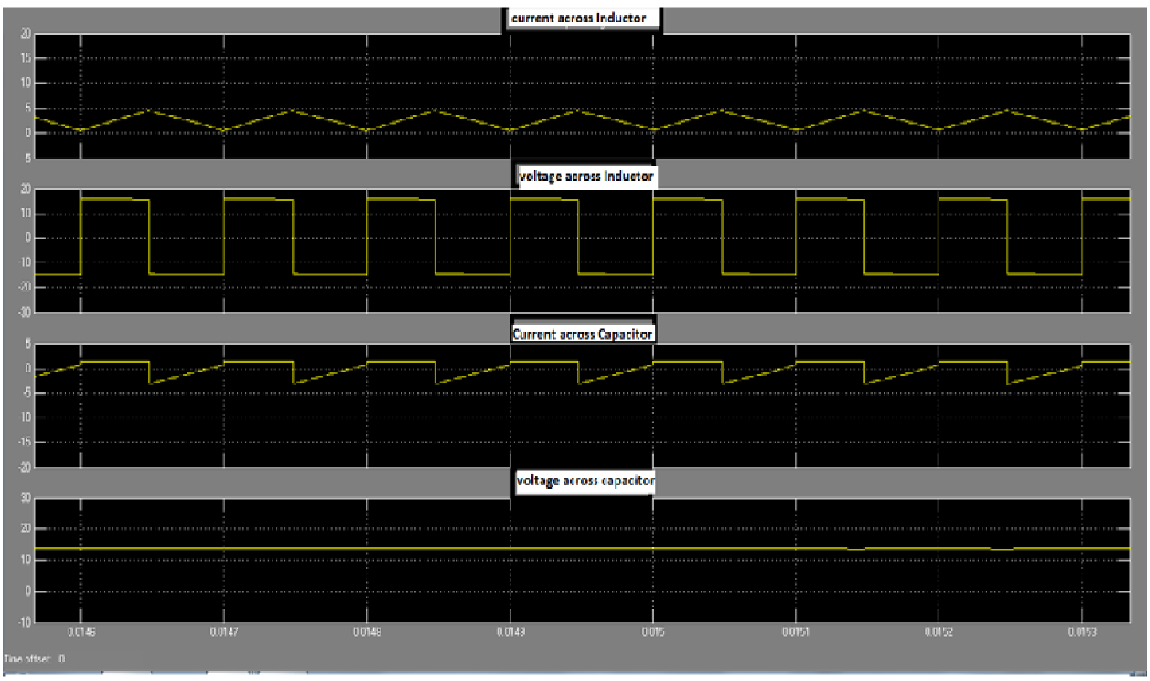

Fig 5: Shows the Simulation Results of Voltage and Current of both Inductor and Capacitor

VII. CONCLUSION

In this paper the design analysis of Buck Boost converter is presented. The Proposed system has been simulated in MATLAB SIMILINK environment. From the simulation results the output of the Dc-Dc Converter is checked which can be used as an input to the Battery. The most important feature of this Design is that it is very simple and easy to implement as it requires very less number of components. Further in the future work the same design can be implemented in the hardware.

Acknowledgement:

The authors wish to thank School of Electrical Engineering, KIIT University for providing necessary experimental platform and all computational facilities for Research and Analysis required for the completion of the paper.

REFERENCES

1) Non-inverting Buck-Boost Regulator" (p.9)
2) ST AN2389: "An MCU-based low cost non-inverting buck-boost converter for battery chargers"
3) http://en.wikipedia.org/wiki/Buck%E2%80%93boost_converter
4) Technical Manual for Sun Xtender Batteries, Concorde Battery Corporation, West Covina, CA, 2011.
5) W. S. Woodward (2008, Dec. 5) Solar-array controller needs no multiplier to maximize power. http://www.edn.com/article/4719
6) Ersuel Ago, Juan Sebastian Hidalgo, Steven Kobosko and Amber Scheurer "Photovoltaic MPPT Charge Controller (PMC^2).

Author's Biography

	**Ms Arjyadhara Pradhan** is working as Assistant Professor, in school of Electrical Engineering KIIT University, Bhubaneswar. She has done B.TECH from KIIT University in 2009. Presently she is continuing her Master degree in Power and Energy System under same University .Her area of Research and development is Renewable Energy mainly in solar energy. She has published about 12 papers in National and international conference and 13 International journals. She is the life member of Solar Energy Society of India, Indian science Congress Association and life member of Indian Society of Technical Education.
	**Dr S M Ali** is Associate Professor in Electrical Engineering of KIIT University Bhubaneswar. He received his DSc & Ph.D. in Electrical Engineering from International university, California, USA in 2008 & 2006 respectively. He had done M.Tech from Calcutta University. His area of research is in the field of Renewable Energy in Solar & Wind Energy. He had also guided five nos. of Ph. D students in his research area. He has also presented more than 50 papers in different National & International conferences in the field of Renewable Energy apart from around 20 nos of paper also published in National and International journals. He is Vice President of Solar Energy Society of India and Secretary of Institution of Engineers (India) , Odisha state centre.
	**Mrs Chitrlekha Jena** is working as Assistant Professor, in school of Electrical Engineering KIIT University, Bhubaneswar. She has done B.TECH from CET Bhubaneswar and has completed her Master Degree from KIIT University in Power Electronics and Drives. Her area of Research and development are Renewable Energy and Power Electronics. She has published about 3 papers in National and international conferences.
	**Puspapriya Behera** is continuing as 1st year M.Tech in Power Energy System, in KIIT University. She has published 5 papers in National and International conferences. She is having keen interest in the area of Renewable Energy.