Power Generation by Solar Energy Based with Improved Controller of Proportional Resonance

T. Sundar
Assistant Professor
Department of Electronics and Instrumentation Engineering
Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya, Enathur, Kanchipuram – 631561, Tamil Nadu, India

Abstract— Novel methodology in power generation using renewable source such as solar energy with an improved controller of proportional resonance applying interleaved buck boost converter and inverter is designed. The designed model is analyzed with the existing models and simulation is done. Introduction of parallel arrangement of buck boost converter and inverter is applied to reducing the rippling source. A closed loop model in the resonance controller is applied to get an optimal result. A parameters such as steady state error, setting time and rise time are done with the existing model and tabulated.

Keywords: Solar Energy, Improved Proportional Resonance, Parallel arrangement, Interleaved Buck Boost Converter, Proportional Integral Controller, Sim Power Systems

I. Introduction

In the recent years, the emphasis of power generation in the growing society structure is a necessary need because of the variations in the supplies and demands requirement of energy. The produced amount of the power cannot grasp sufficient level of the demand so as to balance the insufficiency condition present in the recent years based on this gap there is a necessity of designs to enhance the generation of power using some methodologies. The new technologies were used in the power generating system by designing various types of converters. The existing models do not support the maximum generation of power due to its complexity made in the design with controllers and in series connection of operators provides a low power generation.

Renewable energy process of power generation acts as a major key in the energy production. Mostly, industries and academic companies apply the source of renewable energy like the solar, wind and hydrogen as micro grid or nano grid process used in order to generate clean power energy. The power system energy generator uses alternatively the source of renewable energy, since the renewable energy sources like the solar and wind are non constant energy. To overcome the complexity present in energy generation many algorithms are introduced with the application of new developed power generating system with the use of photovoltaic device.

Design Modelling Control and Simulation of DC/DC Power Buck Converter. is given by Abaali, H [1]. A design of Modified P&O Maximum Power Point Tracking Method with Reduced Steady-State Oscillation and Improved Tracking Efficiency is given by Ahmed, J [2]. A Novel Two Switch Non-inverting Buck-Boost Converter based Maximum Power Point Tracking System is given by Ahmed, K.T [3]. Cascaded Control System Design for a Cuk Converter via Singular Perturbation Approach is given by Aksenov, E.A [4]. Single and Interleaved Split-pi DC-DC Converter is given by Alzahrani, A [5]. Modeling and Simulation of Closed Loop Controlled Parallel Cascaded Buck Boost Converter Inverter Based Solar System is given by Sundar T [6]. Bond Graph Modelling and Dynamic Study of a Photovoltaic System Using MPPT Buck-Boost Converter is given by Andouisi, R [7]. A single switch DC-DC converter for photo voltaic-battery system is given by Anooj, A.S [8]. Input current ripple cancelation by interleaving boost and Cuk DC-DC converter is given by Arias-Angulo, J.P [9]. Modelling & Simulation of Photovoltaic system to optimize the power output using Buck-Boost Converter is given by Arora, S [10]. Modeling and implementation of a new ZCS interleaved bidirectional buck–boost DC–DC converter for energy storage systems is given by Aylapogu, P.K [11]. High voltage gain multiphase interleaved DC-DC converter for DC micro grid application using intelligent control is given by Babu, A.R [12]. An intelligent MPPT approach based on neural-network voltage estimator and fuzzy controller, applied to a stand-alone PV system. is given by Bendib, B [13].

The comparison of the controllers as applied to closed loop interleaved buck boost converter with Proportional Resonance controller was not covered in the above literature. The simulink model introduced has an application of closed loop in Proportional Resonance controller as an interleaved buck boost converter inverter based solar system.

The Block Diagram of Proportional Resonance Controller interleaved buck boost converter inverter based solar system as shown in Fig. 1. DC output of PV system is stepped up using ILBBC. The output of ILBBC is converted into AC using an inverter and the output of inverter is fed to the AC load. The output voltage of ILBBC is compared with the reference voltage and the error is applied to a Proportional Resonance controller.

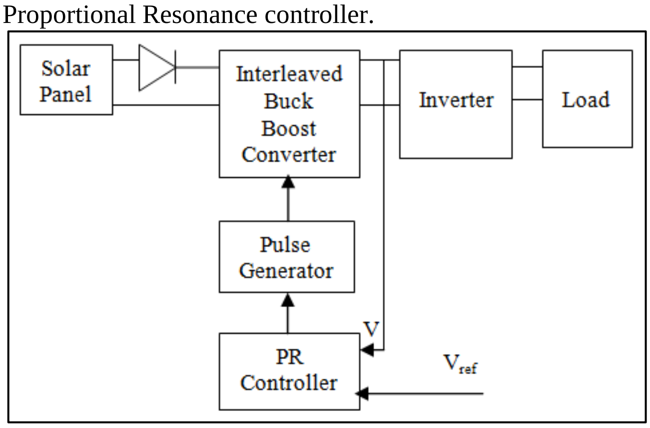

Fig. 1: Photovoltaic ILBBCI system Using Proportional Resonance controller

II. ANALYSIS

The equations used for design of interleaved buck boost converter and Proportional Resonance controller is as follows:

$$C = \frac{I_0 K}{fC} V\Delta \qquad (2.1)$$

$$L = \frac{(1-K)R}{2f} \qquad (2.2)$$

$$I_p = \left(\frac{I_s}{K}\right) + \left(\frac{I}{2\Delta}\right) \qquad (2.3)$$

The output of PR controller in S domain is

$$V_{0(s)} = V_{1(s)}\left(K_1 + \left(\frac{K_2}{(S^2 + W^2)}\right)\right) \qquad (2.4)$$

The Fig. 2 is shows the design of Proportional Resonance controller Flow chart.

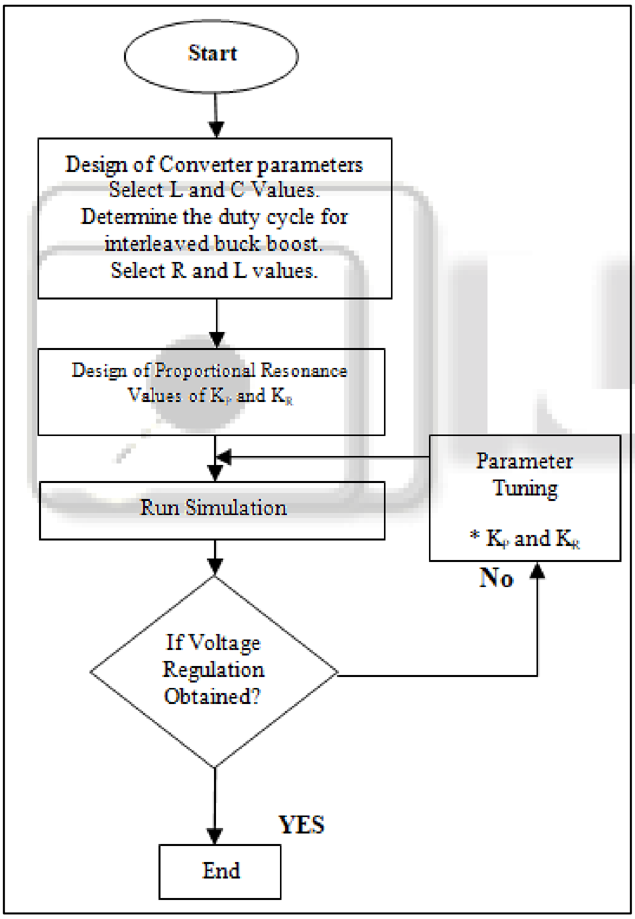

Fig. 2: Flow Chart for Design of Proportional Resonance controller

III. SIMULATION RESULTS

The results of open loop ILBBCI system, closed loop PR controlled ILBBCI systems are presented in this section.

A. *Open loop ILBBCI system*

The Fig. 3 is the system of open loop with input change of ILBBC. In Fig. 3a the increase of solar energy got by step change input is shown. Fig. 3b shows the buck boost converter output voltage where the voltage is increased by 70V as the increase in output voltage is from 320V to 390V.The Fig.3c and Fig. 3d shows the voltage output and current load respectively. Finally it was viewed that the voltage was increased due to boost operation.

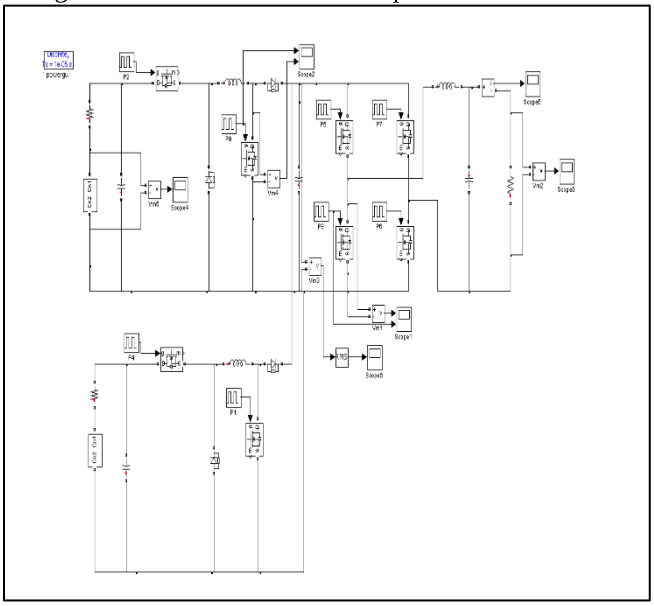

Fig. 3: Open loop Controlled system with step change in input

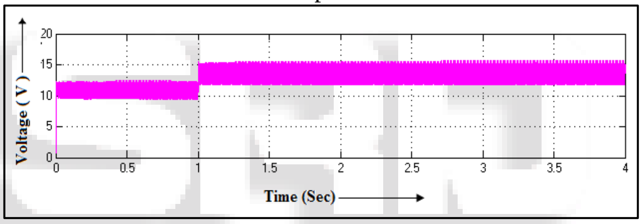

Fig. 3a: Input Voltage to ILBBC

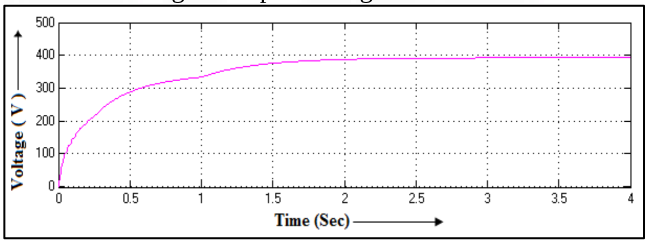

Fig. 3b: Output Voltage of the Buck - Boost Converter

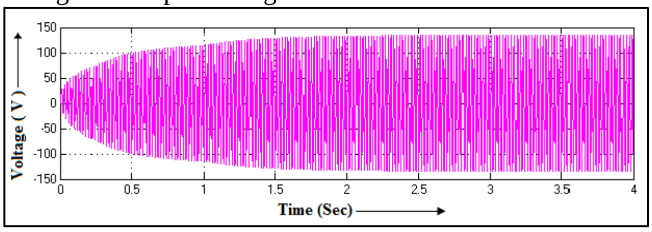

Fig. 3c: Output Voltage of the Inverter

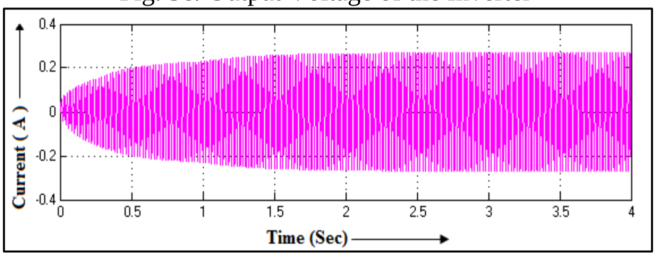

Fig. 3d: Output Current of the Inverter

B. Closed Loop ILBBCI with Proportional Resonance Controller

Fig. 4 represents the Proportional Resonance controller with the system of closed loop in ILBBCI of Proportional Resonance controller is implemented .Fig. 4a shows the developed input due to the insolation increased in the process. An addition of 2V from 12V to 14V in the input voltage is given. The Fig. 4b gives the result of the buck boost converter. The Fig. 4c and Fig. 4d represents the output voltage and current of the inverter. The Table – I gives the detail of the Proportional Resonance controller systems. The settling time and steady state error are very much reduced using Proportional Resonance Controller. The rise time is reduced from 1.1 Sec. The Peak time is reduced 0.9 Sec. The Settling time is reduced 1.7 Sec. The steady state error is reduced 1.3 Volt.

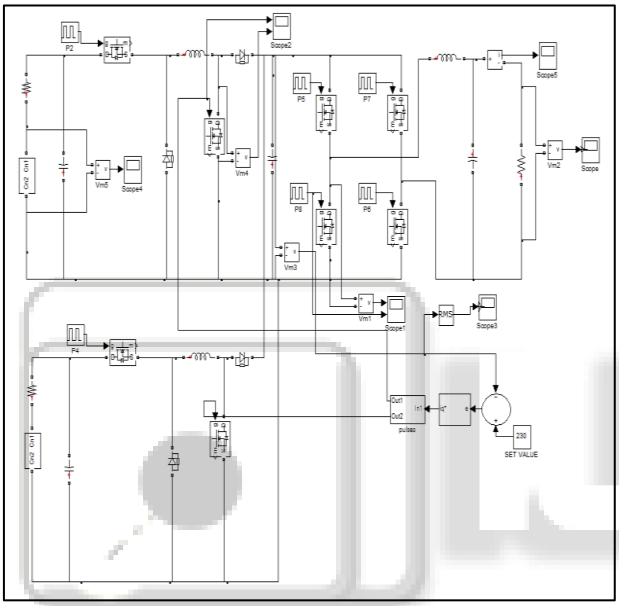

Fig. 4: Simulink model of the closed loop ILBBCI system with PR Controller

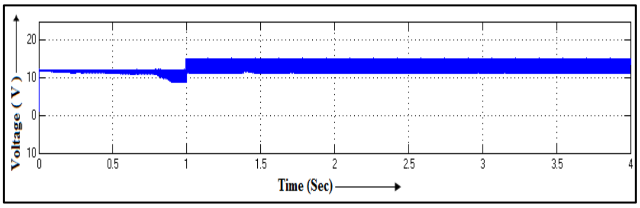

Fig. 4a: Input voltage waveform

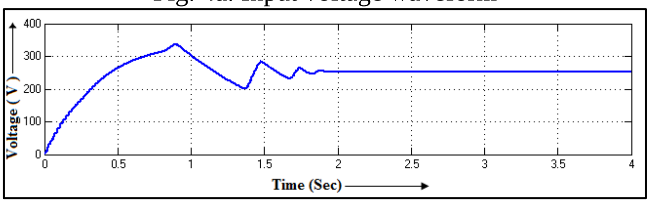

Fig. 4b: DC link voltage waveform

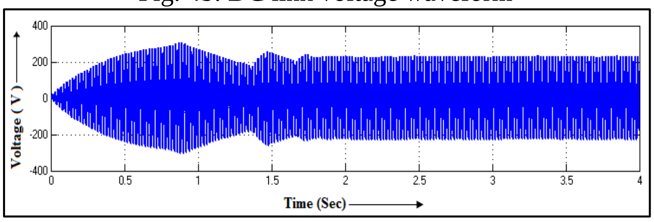

Fig. 4c:Output voltage of inverter with PR controller

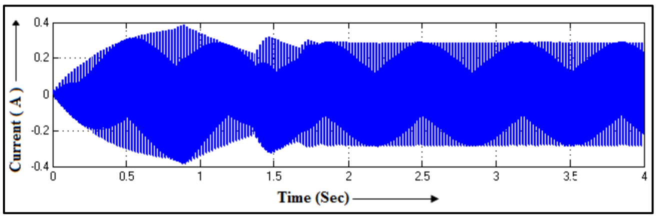

Fig. 4d: Output current of Inverter with PRC

Type of Controller	Rise time (s)	Peak time (s)	Settling time (s)	Steady state error (v)
Proportional Resonance	1.1	0.9	1.7	1.3

Table 1: Time Domain Parameters Using Proportional Resonance Controller

IV. PROTOTYPE HARDWARE OF OPEN LOOP ILBBCI SYSTEM

The hardware for interleaved buck boost converter inverter system is fabricated and tested in the laboratory. The snapshot for hardware is shown in Fig. 5. The hardware consists of solar panel control board and power board. The output voltage of PV array is shown in Fig. 5a. The switching pulses for the IGBTs M1 & M3 are shown in Fig. 5b & Fig. 5c respectively. The Interleaved Buck Boost Converter Switching pulse is shown in Fig. 5d.The output voltage of interleaved buck boost converter is shown in Fig. 5e. The Output voltage of the inverter with filter is shown in Fig 5f. It can be seen from Fig. 3 and Fig. 5 that the experimental results follow the simulation results.

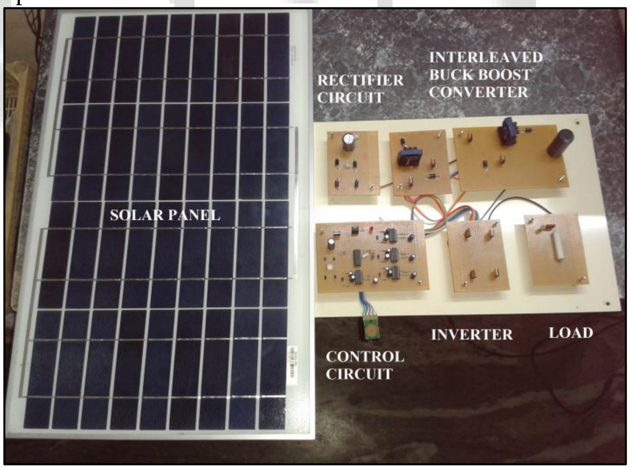

Fig. 5: Hardware Snap Shot

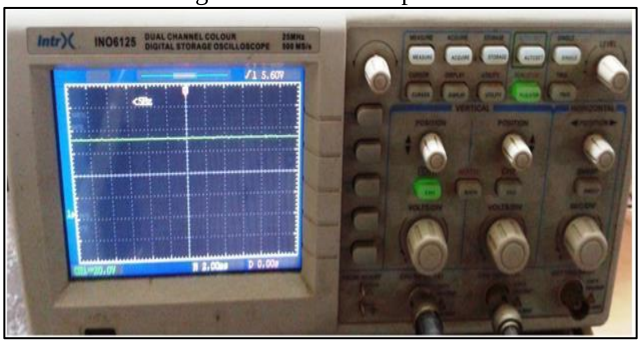

Fig. 5a: Output Voltage of the PV Array

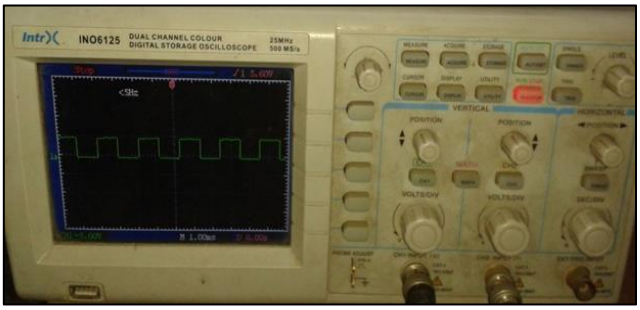

Fig. 5b: switching Pulse for the IGBT M1

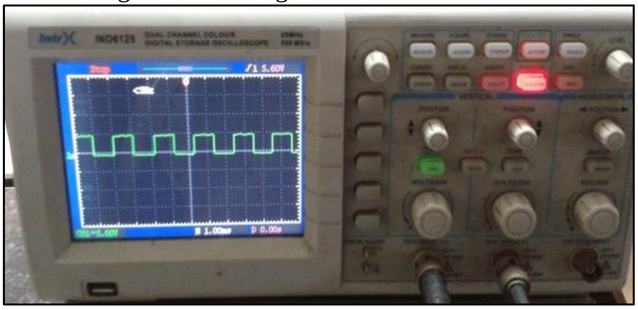

Fig. 5c: switching pulse for the IGBT M3

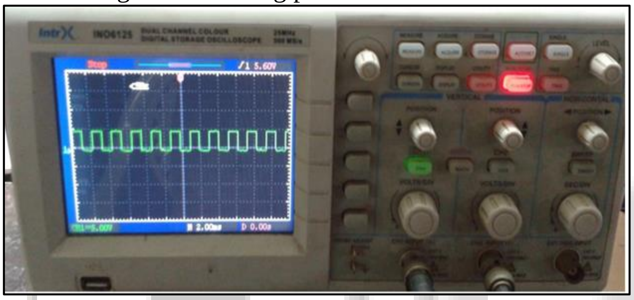

Fig. 5d: Interleaved Buck Boost Converter Switching Pulse

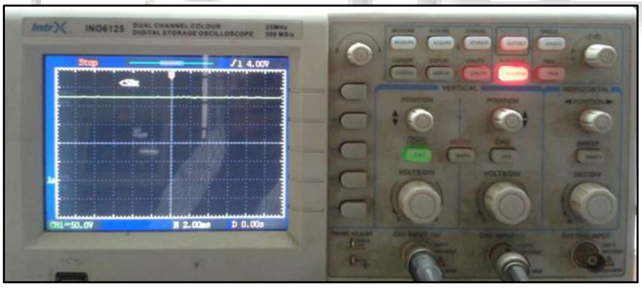

Fig. 5e: Output Voltage of the interleaved buck boost Converter

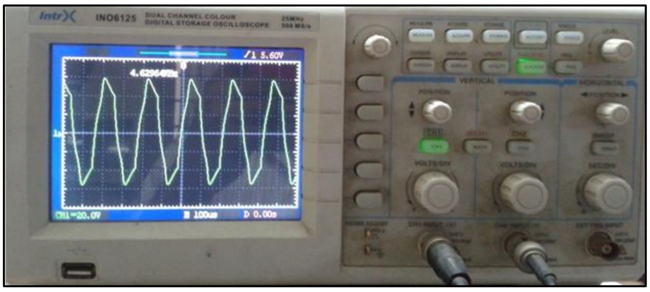

Fig. 5f: Output voltage of the inverter with filter

The variation of output voltage of converter and inverter with variation in solar irradiation is given in Table – II. The output of inverter varies from 51V to 176.5V when solar voltage varies from 12V to 48V. Comparison of simulation and experimental results is given in Table – III. Summary of Kp & K_R is given in Table – IV.

Sl.No	Solar Output voltage	Output Voltage of Converter	Output Voltage of Inverter
	Volts	Volts	Volts
1.	12	52	51
2.	15	58.7	58
3.	24	105.2	104.3
4.	48	177.3	176.5

Table 2: Variation of Output Voltage with Variation in Solar Irradiation

Sl.No	Description	Simulation	Experimental
	Solar Power PV Output	12V	12V
	IGBT	G4BC305	G4BC305
	Power Diode	IN4007	5408
	Inductor	2.0µH	2.0µH
	DC Capacitor	470µF/250V	470µF/250V
	Capacitor Filter	104µF	104µF
	Inductor Filter	70MH	70MH
	Output Voltage of Converter	52V	46V
	Output Voltage of Inverter	51V	45V
	Inverter Frequency	50HZ	50HZ

Table 3: Comparison Of Simulation And Experimental Result

Sl.No	Types of Controller	K_p	K_R
	PR	0.12	0.95

Table 4: Summary of K_P & K_R

V. Conclusion

Application of sim power system in modeling a parallel arrangement of an interleaved buck boost converter has a closed loop system used in Proportional Resonance Controller. A concluded report of both open and closed loop system with its output values and comparison were presented. The use of Proportional Resonance controller reduces the error in the steady state value of the closed loop system. The output using closed loop system based on the simulation were represented and tabulated. The simulation results are validated using experiment results of ILBBCI System. The proposed system is suitable for PV application since ILBBCI is good for low power application.

The main aim is to regulate the output voltage by using Proportional Resonance controller with closed loop system in interleaved buck boost converter. In Future a Fuzzy logic system application of this closed loop system will be analyzed. The hardware may implement using hybrid source.

Acknowledgement

The authors would like to acknowledge the Mr.V.Swaminathan, HOD - EIE, Dr.G.Sriram, Dean (E&T) and Dr.S.V.Raghavan,Vice Chancellor, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya (SCSVMV) for providing the facilities to conduct simulation studies.

REFERENCES

[1] Abaali, H. (2015). 'Design Modelling Control and Simulation of DC/DC Power Buck Converter. World Academy of Science, Engineering and Technology', International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering, Vol. 9, Issue 10, pp 1229-1235.

[2] Ahmed, J. and Salam, Z., (2016) 'A Modified P&O Maximum Power Point Tracking Method with Reduced Steady-State Oscillation and Improved Tracking Efficiency', IEEE Transactions on Sustainable Energy, Vol. 7, pp 1506-1515.

[3] Ahmed, K.T., Datta, M. and Mohammad, N., (2013) 'A Novel Two Switch Non-inverting Buck-Boost Converter based Maximum Power Point Tracking System', International Journal of Electrical and Computer Engineering, Vol. 3, pp 467- 477.

[4] Aksenov, E.A. and Yurkevich, V.D., (2015) 'Cascaded Control System Design for a Cuk Converter via Singular Perturbation Approach', IEEE, pp 534-541.

[5] Alzahrani, A., Shamsi, P. and Ferdowsi, M., (2017) 'Single and Interleaved Split-pi DC-DC Converter', IEEE, pp 995-1000.

[6] T.Sundar and S.Sankar, "Modeling and Simulation of Closed Loop Controlled Parallel Cascaded Buck Boost Converter Inverter Based Solar System", International Journal of Power Electronics and Drive System (IJPEDS), Vol. 6, No. 3, September 2015, pp. 648~656, ISSN : 2088-8694.

[7] Andouisi, R., Mami, A., Dauphin-Tanguy, G. and Annabi, M., (2002) 'Bond Graph Modelling and Dynamic Study of a Photovoltaic System Using MPPT Buck-Boost Converter', IEEE, pp 1-6.

[8] Anooj, A.S. and Gopi, L., (2018) 'A single switch DC-DC converter for photo voltaic-battery system.' IEEE, pp 1-6.

[9] Arias-Angulo, J.P., Rosas-Caro, J.C., Haro-Sandoval, E., Valderrabano-Gonzalez, A., Mayo-Maldonado, J.C. and Valdez-Resendiz, J.E., (2018) 'Input current ripple cancelation by interleaving boost and Cuk DC-DC converter.' IEEE, pp 133-138.

[10] Arora, S. and Sharma, P., (2014) 'Modelling & Simulation of Photovoltaic system to optimize the power output using Buck-Boost Converter', International Journal of Information Technology and Electrical Engineering, Vol. 3, pp 23-28.

[11] Aylapogu, P.K., Bhajana, V.V.S.K., Drabek, P. and Jara, M., (2017) 'Modeling and implementation of a new ZCS interleaved bidirectional buck–boost DC–DC converter for energy storage systems', Electrical Engineering, Vol. 99, Issue. 4, pp 1283-1293.

[12] Babu, A.R. and Raghavendiran, T.A., (2017). 'High voltage gain multiphase interleaved DC-DC converter for DC micro grid application using intelligent control'. Computers & Electrical Engineering, Elsevier, pp 1-15.

[13] Bendib, B., Krim, F., Belmili, H., Almi, M.F. and Bolouma, S., (2014). 'An intelligent MPPT approach based on neural-network voltage estimator and fuzzy controller, applied to a stand-alone PV system.' IEEE, pp. 404-409.