

Power Management System with PV/Battery Hybrid System for Remote Areas

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ABSTRACT

This paper presents a energy management system for electrification to the rural areas where the grid is not available. The required demand information is suitable to improve the sizing and management of battery energy storage system. The energy management system includes the power electronics circuits to charge the battery from PV and it works as a current source when the battery is charging and working as a voltage source when it is supplying power to the loads.

The proposed optimization will increase the battery life from over charging and over discharging cycle. The energy management system will coordinate the battery and PV source and matches the critical and noncritical loads with available supply.

KEYWORDS: PV System, Battery, Energy Management System, critical and noncritical loads

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1. INTRODUCTION

These days interest for control all through the world increments and these requests can't meet by traditional sources (like warm and hydro age) in view of restricted accessibility of coal and water. Henceforth whole world foot forward to the sustainable power sources like breeze and sunlight based vitality they never going to be vanish, and these are the most encouraging other options to supplant customary vitality sources [1], [2]. Be that as it may, successful use of inexhaustible sources and for getting greatest power yield requires quick acting force electronic converters [3]. For three-stage applications, two sorts of energy electronic setups are normally used to exchange control from the sustainable power source asset to the network: 1) single-stage and 2) twofold phase

change. In the twofold phase change for a PV framework, the primary stage is generally a dc/dc converter and the second stage is a dc/air conditioning inverter. In first stage the DC-DC converter gives most extreme power following from PV module and furthermore delivers fitting DC voltage for organize 2 reversal. In stage2 (reversal arrange) inverter produces 3- ϕ sinusoidal voltages or streams and it exchanges energy to stack associated or to the framework [4].The framework structure is extremely adaptable. PV modules are the principle building obstructs; these can be orchestrated into clusters to expand electric vitality generation. Ordinarily extra hardware is essential with a specific end goal to change vitality into a helpful shape or store vitality for sometime later. The subsequent framework will in this manner be dictated by the vitality needs (or loads) in a specific

application. PV frameworks can be extensively characterized in two noteworthy gatherings [12].

1) Stand-Alone: These frameworks are disengaged from the electric conveyance matrix. Figure.1 portrays the most widely recognized framework setup. The framework portrayed in Figure.1 is really a standout amongst the most perplexing; and incorporates every one of the components important to serve AC apparatuses in a typical family or business application.

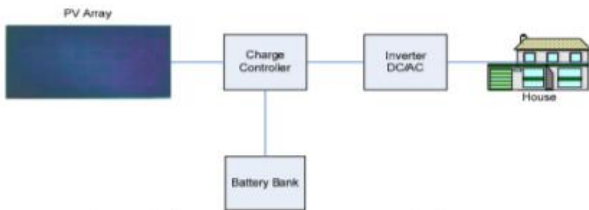


Figure.1. Stand-Alone Photovoltaic System

2) Grid-Tied: These frameworks are straightforwardly coupled to the electric dissemination arrange and don't require battery stockpiling. Figure.2. depicts the fundamental framework setup. There are many advantages that could be acquired from utilizing network tied PV frameworks rather than the customary remain solitary plans.

These advantages are: Smaller PV clusters can supply a similar load reliably. • Less adjust of framework segments are needed. • Comparable emanation diminishment potential taking • preferred standpoint of existing foundation. Disposes of the requirement for vitality stockpiling and the costs • related to substituting and reusing batteries for singular customers. Capacity can be incorporated if wanted to improve dependability for the customer. Exploits the current electrical infrastructure. • Efficient utilization of accessible vitality. Adds to the • required electrical network age while the customer's request is underneath PV yield.

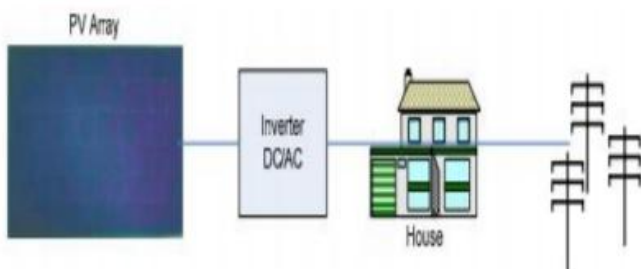


Figure.2. Grid-Tied Photovoltaic System

Highly sophisticated frameworks might be conceivable were battery stockpiling or a generator (or both) can be joined with a lattice association for

extra dependability and planning adaptability (at extra cost). [13] Most of the introduced private, commercial and focal scale frameworks utilize pre-manufactured level plate sunlight based modules, since they are broadly accessible.

II. OPERATING PRINCIPAL OF TCDIC

The schematic graph of the TCDIC is portrayed in Fig. 3. From this figure, it can be noticed that no devoted converter is utilized for guaranteeing the MPP operation of the PV cluster, which prompts the enhanced usage of the converters included.

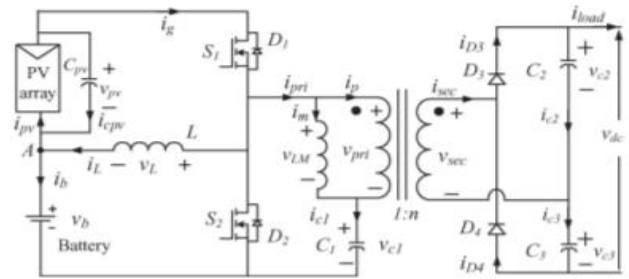


Figure. 3. Schematic circuit diagram of TCDIC

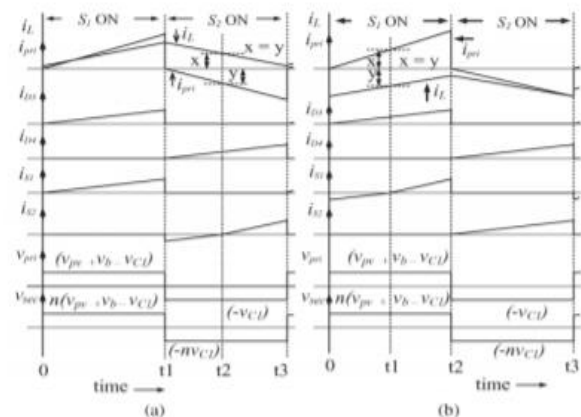


Figure. 4. Waveforms of currents flowing through and voltage across different key circuit elements of TCDIC when (a) i_L is positive and (b) i_L is negative
Operation of the Converter When Inductor Current is Positive

The waveforms of the streams moving through and voltages crosswise over various key circuit components of TCDIC, while the present coursing through the inductor L is certain, are appeared in Fig. 4(a). The different conceivable exchanging modes amid this condition are dissected in this segment.

a) Mode I (0 to t_1 ; S_1 and D_3 conducting): At the point when S_1 is turned on; the PV exhibit voltage v_{pv} is inspired crosswise over L , and the inductor current i_L increments. Amid this period, the voltage awed over the essential twisting of the transformer is $v_{pri} = (v_{pv} + v_b -$

vC1), wherein vb is the battery voltage and vC1 is the voltage over the capacitor C1. Thus, the essential current of the transformer, ipri, increments, and the capacitor C1 gets charged.

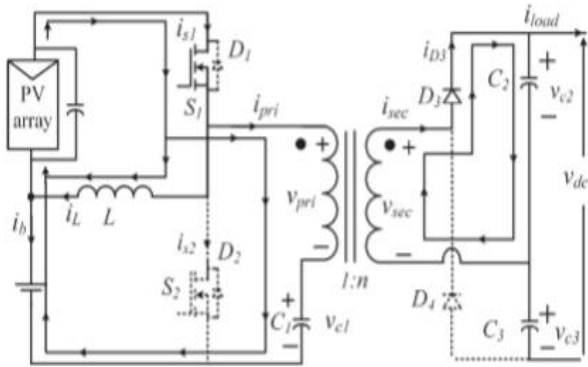


Figure.5. Equivalent circuit diagram of TCDIC when operating in mode I and inductor current is positive

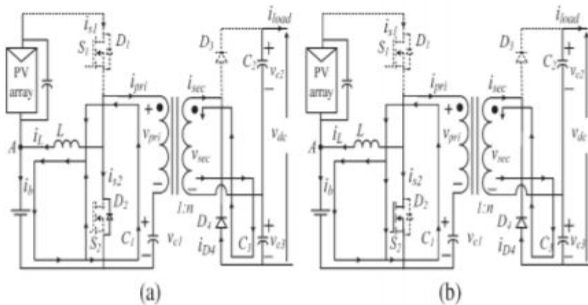


Figure. 6. Equivalent circuit diagram of TCDIC when inductor current is positive: (a) Mode II and (b) mode III

The present coursing through the auxiliary twisting of the transformer, isec, likewise increments. The diode D3 is forward one-sided, and the capacitor C2 gets charged. The voltage crosswise over C2 is given by vC2 = n(vpv + vb - vC1), wherein n is the turns proportion of the transformer. The comparable outline of TCDIC amid this mode is appeared in Fig.5.

- b) Mode II (t1 to t2; D2 and D4 conducting): This mode starts when S1 is killed and S2 is turned on. At the beginning of this mode, iL is sure, and as S1 is killed, ipri is zero. Since iL > ipri, the diode D2 begins directing. The proportionate circuit graph of TCDIC amid this mode is appeared in Fig. 6(a).
- c) Mode III (t2 to t3; S2 and D4 conducting): At the point when iL ends up noticeably littler than (-ipri), the diode D2 is turn around one-sided, and the switch S2 begins directing. Whatever is left of the operation continues as before as that

of mode II. The proportionate circuit chart of TCDIC amid this mode is appeared in Fig. 6(b).

When Inductor Current is Negative

The waveforms of the streams moving through and voltages crosswise over various key circuit components of TCDIC, while the present coursing through the inductor L is negative, are appeared in Fig. 6(b). The different conceivable exchanging modes amid this condition are examined in this segment.

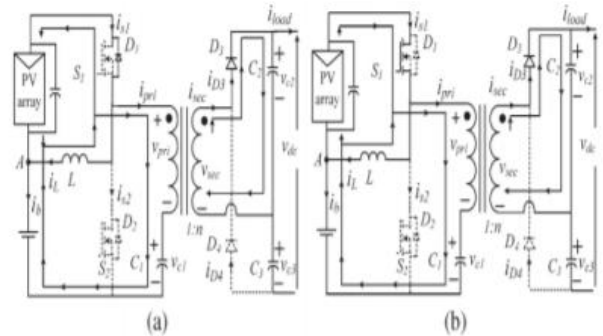


Figure. 7. Equivalent circuit diagram of TCDIC when inductor current is negative: (a) Mode I and (b) mode II

III. PROPOSED ENERGY MANAGEMENT SYSTEM

A power hardware based vitality administration framework (EMS) was utilized to altogether lessen fuel utilization in a power framework including two diesel generators and a BESS; notwithstanding, the examination did not consider the BESS condition of charge (SOC), lifetime, cost, or the expansion of PV sources as of late presented in FOBs. In this paper, an advanced EMS (OEMS) is introduced where a basic however hearty calculation deals with the diesel generators, the BESS, and PV source as appeared in Fig.

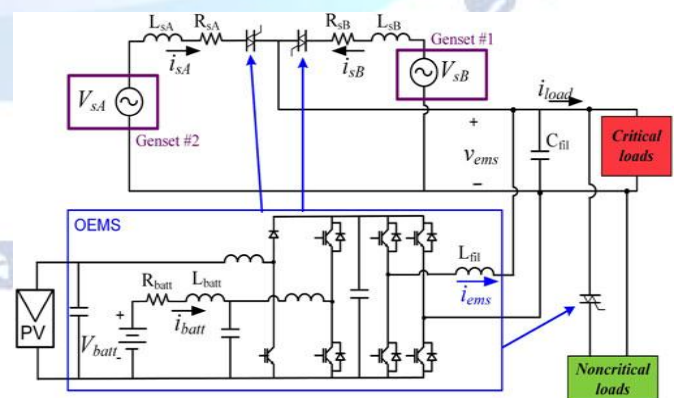


Fig 8: Proposed EMS Block Diagram

Critical loads in the schematic are those electrical devices that must be powered at all times to ensure the success of the military operation. The

optimization strategy includes lifetime and economic considerations for the BESS; thus, managing the cost of the microgrid while reducing fuel consumption. They are applied not only to microgrids, but also to assess the impact on bigger energy system. Although some of these papers deal with critical load service and fuel consumption, none of them addresses remote military microgrids and their key issues.

In this paper, Optimized Energy Management is proposed for the OEMS. The new contribution of this paper includes the overall optimization procedure which uses SOSs for the semicontinuous function handling, and integrates economic evaluations by properly taking into account how the measure of BESS influences its charge/release cycle; in this manner, the battery lifetime. Another new commitment is the equipment usage of the improved control framework; in a research facility model the OEMS arranges the vitality sources and BESS to benefit basic and noncritical burdens utilizing the outcomes from the proposed advancement. It ought to be noticed that the utilization of microgrid innovation to FOBs is once in a while found in the writing, in this manner this paper is likewise new in the application that it presents. One vital variable that must be considered in a FOB is that basic burdens must be overhauled constantly, regardless of whether this outcomes in shedding of noncritical burdens when a blame happens. With the proposed calculation, we work to keep away from the shedding. Two streamlined situations, with and without a PV source, show fuel funds of $\approx 30\%$ - half, separately, contrasted with past work.

IV. SIMULATION RESULTS

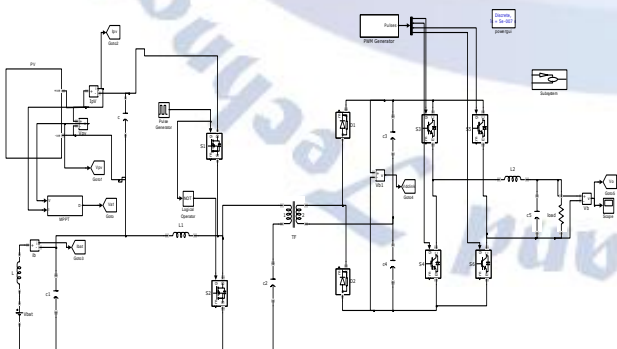


Figure : Simulated circuit under steady-state operation in MPPT mode

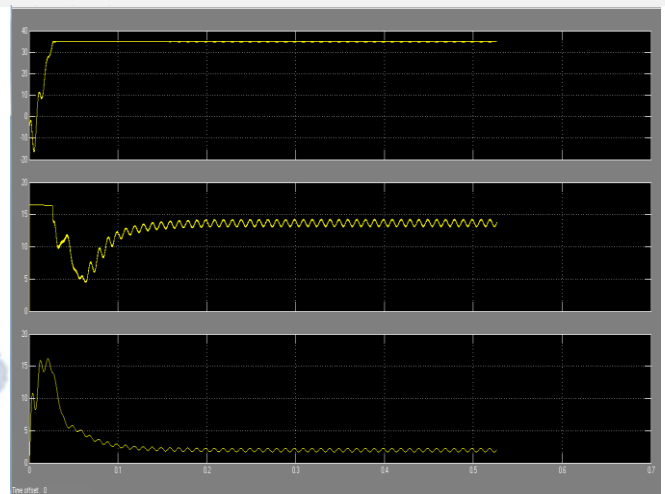


Fig: Simulated response of the system under steady-state operation in MPPT mode V_{pv} , I_{pv} , I_{bat}

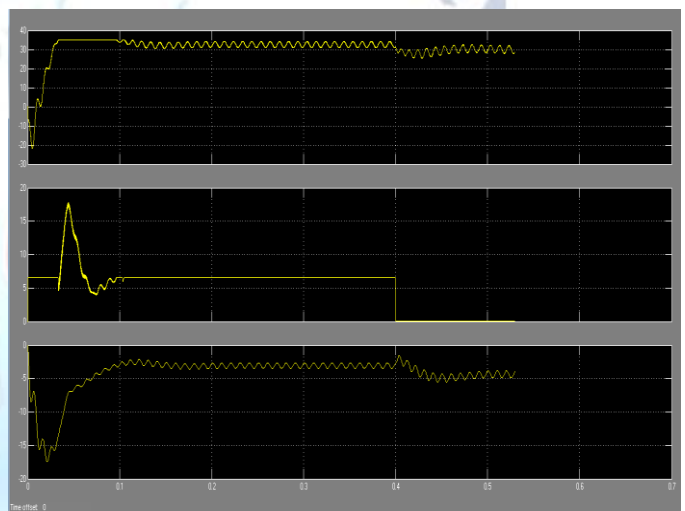


Fig: Response of the simulated system during mode transition between MPPT and BO modes V_{pv} , I_{pv} , I_{bat}

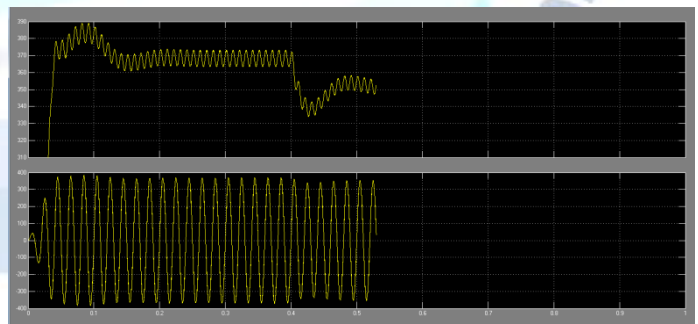


Fig: Response of the simulated system during mode transition between MPPT and BO modes V_{dc} and Load Voltage

Proposed Simulation Circuit:

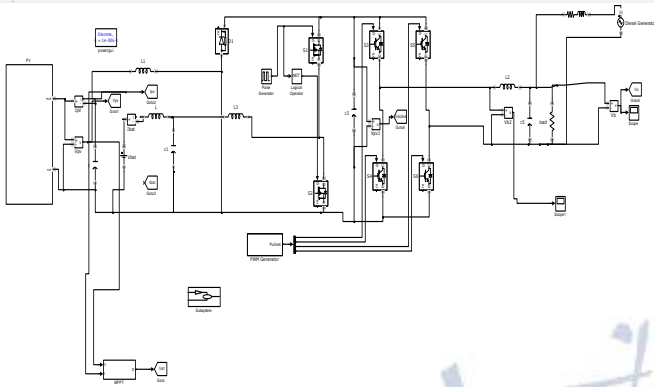


Fig: Proposed Simulation Circuit for during mode transition between MPPT and BO modes with Diesel Generator.

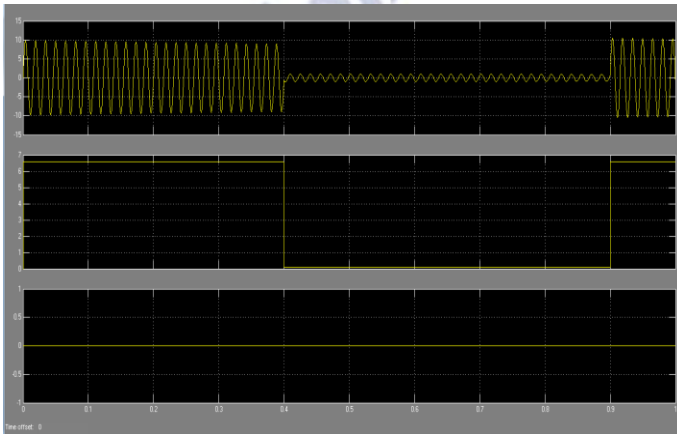


Fig: Response of the proposed simulated system during mode transition between MPPT and BO modes V_{pv} , I_{pv} , I_{bat}

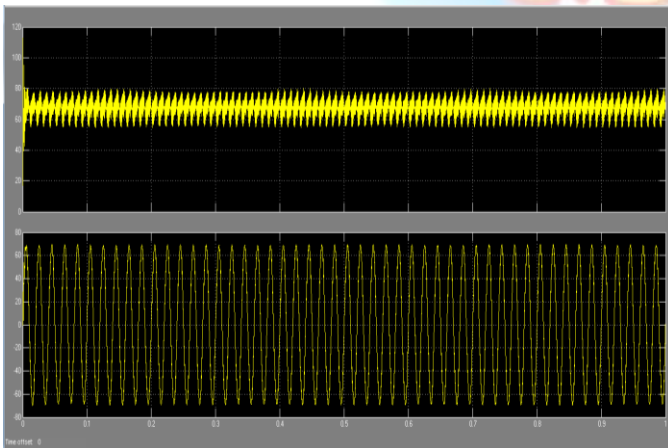


Fig: Response of the proposed simulated system during mode transition between MPPT and BO modes V_{dc} and Load Voltage

V. CONCLUSION

A sun oriented PV-based remain solitary plan for application in rural areas is proposed in this task. It is acknowledged by including once more proposed Optimized Energy Management System and existing TCDIC took after by a traditional full-connect dc to air conditioning inverter. The remarkable highlights of the proposed conspire includethe following: 1) The MPPT of the PV exhibit, charge control of the battery, and boosting of the dc voltage are accomplished in a solitary converter; 2)

necessity of devoted converter forensuring MPP task of the PV cluster is disposed of leadingto upgraded usage of energy converters; 3) improvement inbattery charging proficiency as a solitary converter is available in thebattery charging way; 4) lesser segment consider just twopower change stages are required; 5) separation is providedbetween input sources and the heap; and 6) straightforward and efficientcontrol structure guaranteeing legitimate working mode determination andsmooth progress between various conceivable working modes.The adequacy of the plan is checked by performing detailedsimulation thinks about. The reasonability of thescheme is confirmedthrough point by point test contemplates.

REFERENCES

- [1]. "Electricity sector in India," Wikipedia, [Accessed: Nov. 3, 2014]. [Online]. Available: http://en.wikipedia.org/wiki/Electricity_sector_in_India#Demand
- [2]. "Access to electricity (% of population)," The World Bank, [Accessed:Nov. 3, 2014]. [Online]. Available: <http://data.worldbank.org/indicator/EG.ELC.ACC.S.ZS>
- [3]. M. Sechilariu, B. Wang, and F. Locment, "Building integrated photovoltaic system with energy storage and smart grid communication," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1607–1618, Apr. 2013.
- [4]. Y. M. Chen, A. Q. Huang, and Y. Xunwei, "A high step-up three-portdc-dc converter for stand-alone PV/battery power systems," IEEE Trans. Power Electron., vol. 28, no. 11, pp. 5049–5062, Nov. 2013.
- [5]. B. N. Alajmi, K. H. Ahmed, S. J. Finney, and B. W. Williams, "A maximum power point tracking technique for partially shaded photovoltaic systems in microgrids," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1596–1606, Apr. 2013.
- [6]. M. Miyatake, M. Veerachary, F. Toriumi, N. Fujii, and H. Ko, "Maximumpower point tracking of multiple photovoltaic arrays: A PSO approach," IEEE Trans. Aerosp. Electron. Syst., vol. 47, no. 1, pp. 367–380, Jan. 2011.
- [7]. J. T. Stauth, M. D. Seeman, and K. Kesarwani, "Resonant switched capacitor converters for sub-module distributed photovoltaic power management," IEEE Trans. Power Electron., vol. 28, no. 3, pp. 1189–1198, Mar. 2013.
- [8]. T. Shimizu, M. Hirakata, T. Kamezawa, and H. Watanabe, "Generationcontrol circuit for photovoltaic modules," IEEE Trans. Power Electron., vol. 16, no. 3, pp. 293–300, May 2001.
- [9]. H. J. Bergveld et al., "Module-level dc/dc conversion for photovoltaicsystems: The delta-conversion

- concept," IEEE Trans. Power Electron., vol. 28, no. 4, pp. 2005–2013, Apr. 2013.
- [10]. P. S. Shenoy, K. A. Kim, B. B. Johnson, and P. T. Krein, "Differential power processing for increased energy production and reliability of photovoltaic systems," IEEE Trans. Power Electron., vol. 28, no. 6, pp. 2968–2979, Jun. 2013.
- [11]. J. H. Wohlgemuth and S. R. Kurtz, "How can we make PV modules safer?" in Proc. 38th IEEE Photovoltaic Spec. Conf., 2012, pp. 3162–3165.
- [12]. W. Li and X. He, "Review of nonisolated high-step-up dc/dc converters in photovoltaic grid-connected applications," IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1239–1250, Apr. 2011.
- [13]. H. Wang and D. Zhang, "The stand-alone PV generation system with parallel battery charger," in Proc. IEEE ICECE, Jun. 2010, pp. 4450–4453.
- [14]. Y.-M. Chen, Y.-C. Liu, and F.-Y. Wu, "Multi-input dc/dc converter based on the multiwinding transformer for renewable energy applications," IEEE Trans. Ind. Appl., vol. 38, no. 4, pp. 1096–1104, Jul./Aug. 2002.
- [15]. C. Zhao, S. D. Round, and J. W. Kolar, "An isolated three-port bidirectional dc-dc converter with decoupled power flow management," IEEE Trans. Power Electron., vol. 23, no. 5, pp. 2443–2453, Sep. 2008.
- [16]. M. J. V. Vazquez, J. M. A. Marquez, and F. S. Manzano, "A methodology for optimizing stand-alone PV-system size using parallel-connected dc/dc converters," IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2664–2673, Jul. 2008.
- [17]. N. Mutoh and T. Inoue, "A control method to charge series-connected ultraelectric double-layer capacitors suitable for photovoltaic generation systems combining MPPT control method," IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 374–383, Feb. 2007.
- [18]. R. Chattopadhyay and K. Chatterjee, "PV based stand alone single phase power generating unit," in Proc. IEEE IECON, Oct. 2012, pp. 1138–1144.
- [19]. D. Debnath and K. Chatterjee, "A buck-boost integrated full bridge inverter for solar photovoltaic based stand alone system," in Proc. IEEE PVSC, Jun. 2013, pp. 2867–2872.
- [20]. T.-F. Wu, C.-H. Chang, Z.-R. Liu, and T.-H. Yu, "Single-stage converters for photovoltaic powered lighting systems with MPPT and charging features," in Proc. IEEE APEC, Feb. 1998, pp. 1149–1155.