A Survey of PV Based Solid State Transformer for Storage and Distribution Applications

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Abstract: Multi-port dc-dc isolated converter has emerged recently as very important in the case of PV based storage and distribution application. A new front end converter is introduced for efficient PV generation and Common solid state transformer to improve the converter op-erating speed. Half bridge non-isolated dc-dc converter introduced for battery storage and Controller is implemented based on BESS (battery energy storage system) for high power grid distribution proposed in secondary of transformer. Front end converter (FEC) plays a major role and its switching operation is per-formed by MPPT based pulse genera-tions.Theoverall converter performance is verified through MATLAB (Simulink).

Keywords: Front end converter,HT transformer, MPPT, Half bridge dc-dc converter

I. Introduction

Recent days the growth in peak demand for electricity and the increasing of distributed and deregulated energy systems require an optimized grid control unit. The advances in computing and communication technologies[2] allow transforming the traditional power network into a smart grid, capable of real-time remote monitoring and control. Smart grids are particularly well- suited for renewable energy sources; power is utilized, depending upon the availability of natural resources. Three port converters for interfacing multi power sources and storage devices are widely used in recent years. Instead of using individual power electronic converters for each of the energy sources, multiport converters have the ad- vantages including less components[3], lower cost, more com-pact size, and better dynamic performance. In the electric vehicle application, the regenerative energy occurs during acceleration or startup. Therefore, it is very important for the port connected to the energy storage to allow bidirectional power flow.

This paper is proposed three port dc-dc converter operation. Efficient PV generation done through front end converter. Battery storage process through half bridge AC-DC converter. Half bridge converter having bidirectional capability. Grid interface con-nected in secondary side of one port.

II.PV Source

Photovoltaic's (PV)is a method of generating electrical power by converting solar radia-tion into direct current electricity using semiconductors that exhibit the photovoltaic ef-fect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Photovoltaic are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. The term photovoltaic denotes the unbiased operating mode of a photodiode in which current through the device is entirely due to the transduced light energy. Virtually all photovoltaic devices are some type of photodiode.

Shih-ming Che, Tsorng-Juu Liang in 2013[2] andYen-mo Chen, Alex q. Huang, Xunwei yu in 2013 presents [3]presents the grid-connected AC module is an alternative solution in photovoltaic (PV) generation systems. It combines a PV panel and a micro-inverter con-nected to grid. These features improve the energy-conversion efficiency. Therefore, the control scheme of the proposed converter provides maximum utilization of PV power most of the time.

This paper[12] investigates the issues of ensuring global power optimization for cascaded dc–dc converter architectures of photovoltaic (PV) generators irrespective of the irra-diance conditions. The individual MPPTs have been implemented by an extreme-seeking control, a robust and less knowledge-demanding perturb-and-observe method. The paper presents [11] reliably operating solar-energy systems composing of solar arrays and their interfacing converters are of prime importance to maximize the solar-energy harvesting. Known as negative resistance oscillation. Practical evidence is provided based on a coupled inductor super buck converter.

The presented [1] system consists of two sets of a PV array and Buck-Boost type chopper circuit .The implementation of an interleaved boost converter using SiC diodes for PV applications is presented in this paper [13]. This paper presents also an optimization study of the size and efficiency of the interleaved boost converter. Based on 1) the steady-state characteristic of the topology,

2) the static and dynamic characteristics of the switching cells,

3) the loss model of the magnetic components and 4) the cooling system design.

Toshihisa Shimizu, Masaki Hirakata, Tomoya Kamezawa, and Hisao Watanabe .In 2011[5] presents Photovoltaic modules must generally be connected in series in order to produce the voltage required to efficiently drive an inverter. However, if even a very small part of photovoltaic module (PV module) is prevented from receiving light, the generation power of the PV module is decreased disproportionately. This greater than expected de-crease occurs because PV modules which do not receive adequate light cannot operate on the normal operating point, but rather operate as loads. As a result, the total power from the PV modules is decreased if even only a small part of the PV modules are shaded. In the present paper, a novel cir-cuit, referred to as the generation control circuit (GCC), which enables maximum power to be obtained from all of the PV modules even if some of the modules are prevented from re-ceiving light. The proposed circuit enables the individ-ual PV modules to operate effectively at the maximum power point tracking, irrespec-tive of the series connected PV module sys-tem. Toshihisa Shimizu, Osamu Hashimoto, and Gunji Ki-mura in 2003 [6] and Soeren Baekhoej Kjaer, John K. Pedersen, Frede Blaabjerg in 2005 [7] presents a novel photovoltaic in-verter that can not only syn-chronize a sinusoidal ac output current with a utility line voltage, but also control the power generation of each photovoltaic module in an array and in-verter technologies for connecting photovoltaic (PV) modules to a single-phase grid. Various inverter topologies are present-ed, compared, and evaluated against demands, lifetime, com-ponent ratings, and cost. Finally, some ofthe topologies are pointed out as the best candidates for either single PV module or multiple PV module applications. The paper presents [8] a novel fly back-type utility interactive inverter circuit topology suitable for ac module sys-tems when its life time under high atmospheric temperature is taken into account. The proposed inverter circuit also enables realization of small volume, lightweight and stable ac current injection into the utility line.

III.Front End Dc- Ac Converters

Domingo A. Ruiz-Caballero, Reynaldo M Ramos-Astudillo, Samir Ahmad Mussa Marcelo Lobo Heldwein in JULY 2010[15] andGautam Sinha, Thomas A. Lipo in 2000 [16] pre-sents novel symmetric hybrid multilevel topologies are intro-duced for both single- and three-phase medium-voltage high powersystems.Theproposed multilevel inverters are suited for high power drive applications due to their increased voltage capability. Simulation and experimental results are presented to demonstrate the link voltage balancing strategy and the performance of the four-level drive.

IV.DC Link Control

Farid Bouchafa, El Mad-Jid Berkouk andMohamed Seghir Boucherit in 2007 [17] proposed a serious constraint in a multi-level inverter is the capacitor voltage bancing problem Power converter. The results obtained are full of promise to use the inverter in high voltage and great power applications as electrical traction .

George Hwang, Peter W. Lehn Manfred Winkelnkemper [18] proposed due to the limited lifetime of electrolytic capaci-tors, use of film capacitors is gaining popularity in AC-DC converter applications. M.A. Brubaker, H. C. Kirbie, and T. A. Hosking [19] Richard Marschalko, Denes Fodor, Petre–Dorel Teodorescu and Mircea Bo jan 2011[20] presents the paper deals with some problems concerning the current stress of the smoothing capacitor connected on the DC part of the PWM AC to DC converters .Finally there are proposed modification in the control scheme of the rectifier with the proposes to prevent the negative effect of the capacitor aging. Bon-Gwan GU, Kwanghee Nam in 2006 [21] Zeliang Shu, Na Ding Jie Chen, Haifeng Zhu in 2013 [22] presents the con-verter side dc-link current is made equal to the inverter side dc-link current in a pulse width modulation (PWM) converter-inverter system, no current will flow through the dc- link ca-pacitor anda space vector pulse width modulation (PWM) (SVPWM) algorithm, the experimental results verify the bal-ancing algorithm and the system steady-state and dynamic performances.

V.High Frequency Transformer

TOMASZUK and A. KRUPA in 2011 [23],G. Ortiz, D. Bortis, J. Biela and J. W. Kolar [24] presents the renewable energy sources such as PV modules, fuel cells or energy storage de-vices such as super capacitors or batteries deliver output volt-age. Peak power is drawn from the input capacitor bank. The proposed full-bridge based topology results in a much higher efficiency and power density. Rongjun Huang, Sudip K.Mazumder in 2010[25] and Daisuke Tsukiyama, Yasuhiko Fukuda, Shuji Miyake,SaadMekhilef, Soon- Kurl Kwon and Mutsuo Nakaoka in 2011 [26] presen-tsoutlines aswitchingscheme to improve the energy efficiency for an isolated high-frequency multi-phasedc/pulsating-dc converter, which is the front end of a three- phase rectifier-type high-frequency-link inverter. Narendran, S. Harikrish-nan, K. C. Ramya Ashokkumar and R. Malathi in 2010[27], Sixifo Daniel Falcones Zambrano in 2011 [28] presents a Solid State Transformer (SST) that incorporates a DC- DC multiport converter to integrate both photovoltaic (PV) power generation and battery energy storage is presented in this dissertation. The DC-DC stage is based on a quad active-bridge (QAB) converter which not only provides isolation for the load, but alsofor the PV and storage. Milan Ilic, Dra-gan Maksimovic in 2007[29] presents a fullbridge converter-with reduced circulating current and a reduction of the switch conduction and turn-off losses achieved by an energy recovery secondary clamp circuit. The proposed clamp cir-cuit allows the converter to operate with wide input or output voltage range with mini-mum voltage stress across the output diodes.

VI.Half Bridge Rectifier

R.Seyezhai, G.Ramathilagam, P.Chitra, V.Vennila in 2013[30]V. Ravi kumar, PrasadYadav in 2013 [31], deals with the analysis and design of LLC resonant converter suited for photovoltaic applications and presents a novel, yet simple zero-voltage switching (ZVS) interleaved boost power factor correction (PFC) ac/dc converter used to charge the traction battery of an electric vehicle from the utility mains.

A. Salami and E. Rezaei in 2013 [32] presents a new bidirec-tional dc-dc converter for a fuel cell system is proposed that has a current Tripler rectifier in its low voltage side. R. Samuel

Rajesh Babu, Joseph Henry in 2013 [33] presents a comparison of half bridge and full bridge isolated, soft-switched, DC-DC converters for Electrolysis applica-tion.R.Madhusudhanan,Dr.S.Ramareddy in 2009 [34] presents a soft switching DC-DC conver-ter. Compared to the conven-tional bridge DC-DC converter for the similar applications, the new topology has the advantages over conventionalcircuit topology, soft switching implementation without additional devices, high efficiency and compact control.

Jaroslav Dudrik, Juraj Oetter in 2007 [35],Jaber A. Abu-Qahouq, HongMao, and Issa Batarseh in 2005 [36] presents soft switching PWM DC-DC converters using power MOSFETs and IGBTs. C. R. Sullivan, S. R. Sanders in 1997 [37] ,Zhong Ye [38]presents A constant-frequency zero-voltage-switched square-wave dc-dc converter is introduced, and re-sults from experimental half-bridge implementations are pre-sented. A. Faruk Bakan, İsmail Aksoy, Nihan Altintaş in 2012[39] presents half bridge DC-DC converters with trans-former isolation presented in the lit-erature are analyzed for high current and low-voltage applications under the same operationcon-ditions, and compared in terms of losses and efficiency.

VII.Full Bridge Rectifier

Mangesh Borage, Sunil Tiwari, Shubhendu Bhardwaj, and Swarna Kotaiah in 2013[40],R.samuel Rajesh Babu and Joseph Henry in 2011 [41],shubhendu Bhardwaj, Mangesh borage and Sunil Tiwari in 2008 [42] presents A new topology of full-bridge dc–dc converter is proposed featuring zero- voltage-switching (ZVS) of active switches over the entire conversion range. The aim of K.RajalakshmiMr.S.P.Karthick in 2013 [46] presents by adding a simple external commutat-ing aid circuit to the full-bridge dc/dc converter with phase-shift control and by reducing the magnetizing inductance, optimum perfor-mance (i.e.ZVS operation and high conversion eiliciency) can be achievedfrom full load down to almost zero load.

Milan Ilic, Dragan Maksimovic in 2007 [47] introduces a full bridge converter with reduced circulating current and a reduc-tion of the switch conduction and turn-off losses achieved by an energy recovery secondary clamp circuit. Zhe Zhang, Ole C. Thomsen, Michael A. E. Ander-sen and Henning R. Nielsen [48] presents a new two-input isolated boost dc-dc converter based on a distributed multi-transformer structure which is suitable for hybrid renewable energy systems is investigated and designed. Rugaju, M., Janse van Rensburg, J.F. and Pienaar H.C.vZ [49] presentTelkom and other critical service companies use batteries as the main source of energy for their inverters and uninterruptible power supplies (UPS). An alternative to the battery run inverter or UPS systems would be the use of a fuel cell as the source of en-ergy. Fuel cells provide the main advantage of refuel ability over battery operated systems.

VIII.Three Phase Inverter with Grid Connection

Eftichios Koutroulis, Frede Blaabjerg in 2011 [50] presents DC/AC inverters are used in grid-connected PV energy pro-duction systems as the power processing interface between the PV energy source and the electric grid. The energy injected into the electric grid by the PV in-stallation depends on the amount of power extracted from the PV power source and the effi-cient processing of this power by the DC/AC inverter. In this paper two new methods are presented for the optimal design of a PV inverter power section, output filter and MPPT control strategy. Erika Twining & Donald Grahame Holmes [51] present the first stage of a research program that aims to explore interactions between multiple power electronic con-verters connected to weak distribution networks.

Jaime Alonso-Martínez, Santiago Arnaltes [52] presents a three-phase grid-connected inverter designed for a 100kW photovoltaic power plant that features a maximum power point tracking (MPPT) scheme based on fuzzy logic. Bailu Xiao, Lijun Hang, Cameron Riley, Leon M.Tolbert, Burak Ozpinec [53] presents Athree-phase modular cascaded H-bridge multilevel inverter for a grid-connected photovoltaic (PV)system is presented in this paper. To maximize the solar energy yextraction of each PV string, an individual max-imum powerpoint tracking (MPPT) control scheme is applied, which allows the independent control of each dc-link voltage. PVmismatches may introduce unbaanced power supplied to thethree-phase system. To solve this issue, a control scheme withmodulation compensation is proposed. L.Hassaine, E. Olías, M. Haddadi and A. Malek in 2007 [54] ,Miss. Sangita R Nandurkar, Mrs. Mini Rajeev in2012 [55] presents the overall efficiency of grid- connected photo-voltaic power generation systems depends on the efficiency of the DC-into-AC conversion. M. Jamil, S. M. Sharkh, M. Abusara, R. J. Boltryk [56] also discusses the design of a repetitive feedback controller for a grid-connected two-level three-phase voltage source inverter connected between a DC source and the grid through an LCL filter Fritz Schimpf, Lars E. Norum in 2008 [57] presents a short overview of the state of the art for grid tied PV inverters at low and me-dium power level mainly intended for rooftop applications. The inverters are categorized according to the configura-tion of the PV system, the configuration of the conversion stages within the inverter and whether they usetransformers or not. Topologies without transformers have big advantages like lowweight, volume and cost. In addition they often reach higher efficiencies than topologies with transformers. There-fore they are important for future developments.

IX.Conclusion

This paper has provided a brief summary of three port dc-dc converter operation. The proposed-converter provided con-tinuous power flow to grid from PV generation and battery backup. Effi-cient PV generation and battery storage process done through front end converter. Battery sources gets to grid based on bidirectional power flow in half bridge converter. Battery storage and charge control is achieved by closed loop control and over all converter performance is veri-fied through MATLAB (Simulink).

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