A new proposal of three-step dc-dc converter scheme for solar power system

Hee-Chang Lee and Sung-Joon Park*, *Member, KIMICS*

Abstract—We report on a new type dc-dc converter design that combines the advantage of dc ripple noise elimination and high efficiency. As potential low cost solar cells, DSC module and the panel's system efficiency and stability are still critical problems to the way of marketing. In this study, a new three-step dc-dc converter scheme with the phase-shift-carrier technology is proposed to apply for solar power system. We have achieved power conversion efficiency around 94.88%.

Index Terms—DSC module,solar power system, phase-shift techniaue

I. INTRODUCTION

Due to excessive consumption of fossil fuels, supplying 80% of all energy consumed worldwide, during the past half century, we have been confronted environment pollution. And we are facing rapid resource depletion. To overcome these problems, development of renewable, clean cnergy technologies which include photovoltaic, solar thermal, wind turbines, hydropower, wave and tidal power etc. are imperative common challenges for mankind to live in the future [1]~[3].

This growing emphasis on renewable energy combined with utility deregulation has increased the possibilities for distributed generation. A variety of small scale dispersed photovoltaic(PV) power conditioners are used widely in various power applications such as MP3 player, lighting, home power appliances and calculating machine[10]. In the most PV power applications, a compact, efficient and low cost power conversion (dc-dc converter and dc-ac inverter) processing has been required practically. In this study, the utility-connected phase-shifter solar power system is schematically classified into three different types an alternative three-phase full bridge switching, an isolated high frequency transformer DC link and a transformer-less direct AC link. The topologies of three-step shifter dc-dc converter are advantageous for safety and reliable viewpoint due to the function of exact gate signal.

This paper presents a high frequency transformer utility-connected three-step shifter technique using FPGA interface to personal computer for the residential PV power generator system, which delivers the single-phase 2 wire type 60Hz AC output into the utility AC power grid. This paper also describes the whole system configuration of a new utility interactive DC modulated converter for solar PV power system with a high efficient solar power generation. Its operating principle as well as its related RTOS(real time operating system) computer control scheme is proposed from an experimental point of view.

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*Corresponding author Sung-Joon Park is with the Department of Electrical Eng, Pusan National University, Busan, 609-735, Korea (Tel: +82-51-510-2770, Fax:+82-51-510-0212,
Email: co2laser@chol.com)

II. CIRCUIT TOPOLOGY

The basic circuit configuration of the three-step shifter power system which is developed for small-scale solar power generation system in high efficient appliance is depicted in Fig. 1.

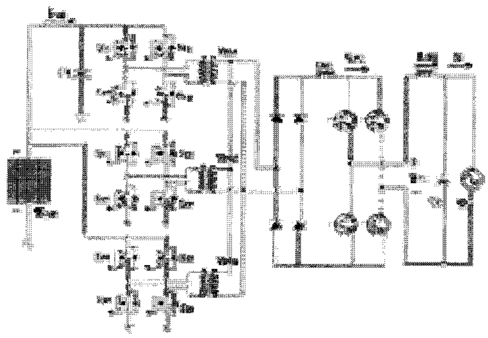

Fig. 1 DSC power system based on three-step shift modulated full-bridge converter

Fig. 1 shows the circuit configuration of the proposed three-step power system. The main circuit consists of the three-step full bridge dc-dc converter, specially designed high frequency transformer and high frequency voltage rectifier circuit and the synchronized polarity switching bridge inverter.

As it can be observed, the converter, which is made up of full bridge, S11~S34, is supplied by means of unstable DC solar source.

The high frequency transformer provides an equivalentseries inductance component to achieve fast switching. Isolated three-step dc-dc converters can be parallels connected to create a high- voltage string connected to a DC-AC inverter. The advantages are utilizations without the frequency limit.

To best assess the relative merits of the converter presented, a design for a string of 60W PV modules connected to 220Vdc in considered. The choice of 220Vdc(average) is based on a mains voltage of 195Vac+15%, or 200Vac+10%.

Three parallel connected per-DSC module three-step dc-dc converter design will be considered: preciously gate time, sequential process, shutdown feedback current.

The basis switching frequency chosen was 120kHz. This converter was built, and output voltage and current were adjusted by switching frequencies.

In order to derive a general rule for the three-step shifter technique between the gate signals of the adjacent FETs, in the connected full bridge converter of Fig.1, the criterion for the repetition of the rectifier output voltage pattern has to be identified.

III. CONTROLLER DESIGN

We developed a three-step solar power system for DSC. The three-step shifter dc-dc converter performs 1/6 duty cycle control based PFM control in synchronization with the utility input inverter voltage. It delivers high quality sinusoidal output power from the solar array panel modules as the DC input power source. Fig.2 shows a sequence of the proposed three-step-shifter method.

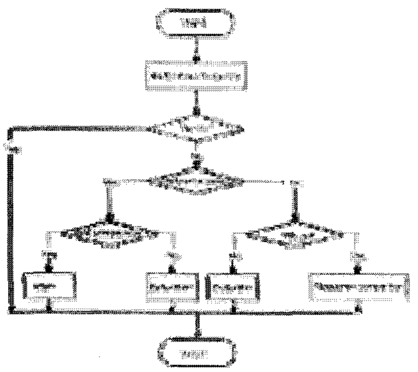

Fig. 2 Sequence of three-step dc-dc converter

The main elements of the full-bridge stepping signal are designed with the aim of attenuating saturation energy.

The three-step shifter technique control loop is shown in Fig. 3.

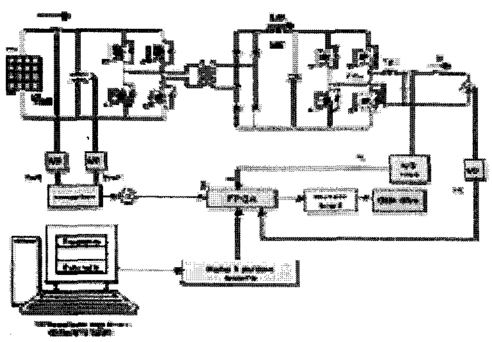

Fig. 3 Power circuit and control algorithm

The three-phase-shifter DC-DC converter controls the output frequency of DSC source line signal.

The block diagram representation of the control system is shown in Fig.3. The controlled voltage E(out) through the inductance of the filter circuit is feedback and compared with the sinusoidal reference voltage. The switching frequency is adjusted by the Vout and DC converter out voltage. The comparator generates a signal to ROM in FPGA. The interval for each dc-dc step converter module of operation is determined by the signal in which the reference value is compared with the DC voltage. The appropriate frequency from that is also sent to the FPGA.

Fig. 4 shows the controller circuit for three-step dc-dc converter. This controller is digitally implemented on the FPGA (ACEX-EP1K 100_208PQFP type) and interfaced with PC parallel port.

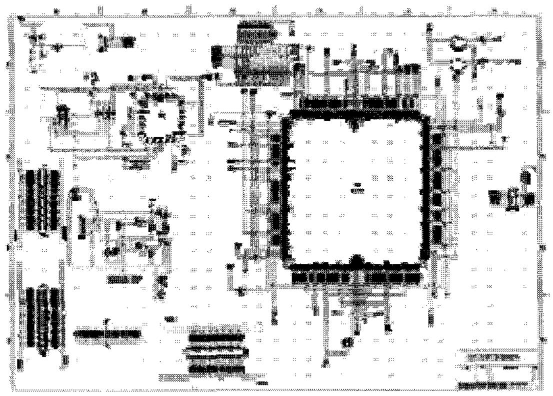

Fig. 4 Controller circuit for three-step dc-dc converter

Due to the unstable power source of the DSC input current control, it can be considered as a variable transfer function. In order to exactly simulate the gate turn-on time and duty-ratio, we used ModelSim simulation tool.

Fig.5 shows the software program for three-step shift dc-dc converter system. We used verilog HDL(Hardware description language) for three-step dc-dc converter. And, we used Borland C++ for PC interface software.

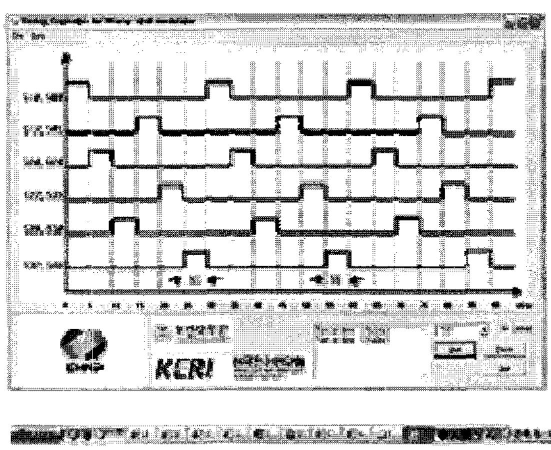

Fig. 5 Controller program for three-step de-dc converter

We developed a three-step dc-dc power system that allows frequency to select freely in PC monitor.

Also, it drives with PWM(pulse-width modulation) and PFM(pulse-frequency-modulation). The system is supplied by means of a 20V DSC. The maximum allowable ripple is set to 27.7mA, and it appears at a duty cycle D of 50%. The minimum ripple is set in order to limit the frequency in transient situation.

This FET gate signal time is limited 0.4μm.

IV. RESULTS

The proposed three-step-phase-shifted dc-dc converter photovoltaic generator system has been first simulated and then physically implemented. Fig. 6 shows the simulated signal of the FET.

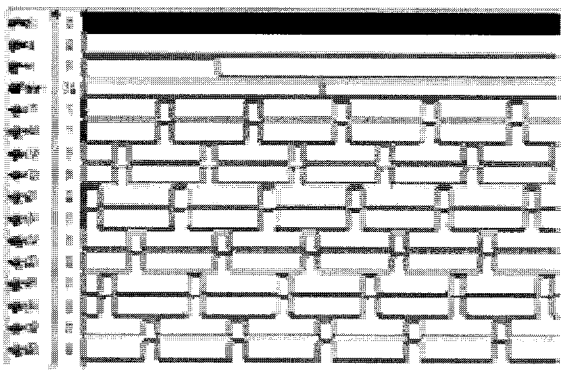

Fig. 6 Gate signal waveforms of the simulation

The frequency of the three-step dc-dc converter is 120kHz, it's adjusted freely, load is the utility power source 220V-60Hz. Fig. 7 is show the proposed three-step-phase-shifted converter performance. The results demonstrated the excellence of the proposed system.

We can be obtained that the load voltage waveform Vout is almost sinusoidal by the three-step system switching in spite of the unbalanced DC voltage. Also, Higher efficiency and lower acoustic noise at loads than boost converter were confirmed.

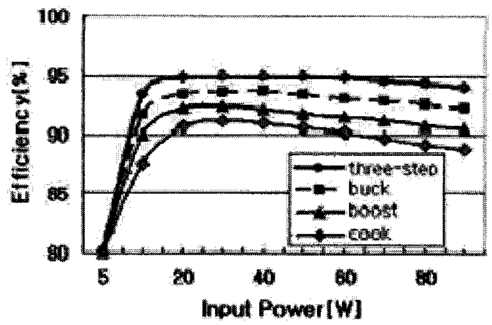

Fig. 7 The demonstration results of the three-step phase-shifted dc-dc converter for solar power system and its performance evaluation

A string of boost converters requires more DSC modules, but can always deliver any combination of DSC module power.

A downsized lightweight and three-step phase-shifted converter using the FPGA for a solar power system is performed for residential applications and evaluated from a practical point view. The 94.88% of power conversion efficiency is obtained at the 60W . Therefore, the solar power system is controlled on the maximum outputs by memorizing the duty ratio and switching frequency into the personal computer. At this configuration, a ripple current of 15mA is obtained.

Our system is improved in about 1.5% of the efficiency compared with the conventional one. The excell-ent performance of this solar power system isconcretely confirmed through the demonstration results. From now on, we will aim to obtain a 3kW prototype setup designed for small scale residential applications.

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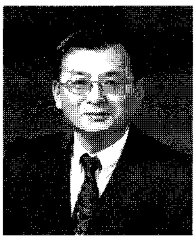

Hee-Chang Lee
Was born in Busan ,Korea ,in 1951 He received the B.S. and M.S. degrees in Electrical Engineering from pusan National University,Korea in 1974 and 1985 respectively, and the ph.D. degree in Mechatronics Engineering from Pusan National University, Korea in 2005. From 1977 to 1997, He was general manager at Engineering and Design Dept, LG electrionics.co. Ltd . After then, He was a professor of the Dept of Industrial Engineering, Yangsan College,Korea. From 1999 to 2002 And worked at Mechanical Technology Institute, Pusan National University, Korea. Since 2006he has been a professor in the College of Engineering, Tongmyong University.

Sung-Joon Park
He received his B.S. degree in Electrical Engineering from Dongeui University in 2000. He received his M.S. degree in Electrical Engineering from Pusan National University in 2002. He worked at the LG Electronics Institute of Technology as a research engineer(LG Elite). He is currently working toward a Ph.D. in Electrical Engineering at Pusan National University.