10th Eco-Energy and Materials Science and Engineering Symposium


On December 5-8, 2012
Sunee grand hotel,
Ubon-ratchathani

Organized by

Co-organized by
PREFACE:
Message from the President of
Rajamangala University of Technology Thanyaburi

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This international conference is not only giving an opportunity for Thai and foreign researchers to present and discuss their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Our program consists of six research tasks: (1) Energy Technology, (2) Environmental and Social Impact, (3) Nanotechnology and Materials Science, (4) Energy Economics and Management, (5) New Energy Technology, and (6) Nuclear Technology.

I would like to take this opportunity to express our sincere gratitude to our two distinguished Plenary Speakers for kindly accepting our invitation. I deeply appreciate the very strong support given by Kyoto University. Thanks to the tireless works of the Organizing Committee, the Technical Program Committee, the invited speakers and paper and poster contributors, and excellent program been assembled to cover a broad spectrum of interesting topic.

We warmly welcome you to the 10th EMSES on December 5-8, 2012, Ubon Ratchathani, Thailand.

Numyoot SONGTHANAPITAK, Ph.D.
President of Rajamangala University of Technology Thanyaburi andConference Chairman of 10th EMSES 2012
PREFACE:
Message from the Director of
Institute of Advanced Energy, Kyoto University

It is my great pleasure to have the 10th Eco-Energy and Materials Science and Engineering Symposium (EMSES) with Rajamangala University of Technology Thanyaburi (RMUTT) under the long-term collaboration between RMUTT and Kyoto University. The 1st EMSES was held in 2001 in Thailand and the symposium has been expanded in its scientific contents as well as the academic network. I believe that the 10th EMSES gives a good opportunity to all participants to exchange their knowledge and idea to realize eco-friendly energy system in society. I would like to express my welcome to all participants and sincere thanks to the 10th EMSES organizing committee and all supporting organizations to make us having this symposium. I hope that the symposium will be successful and lead to further progress in energy science and technology and also in friendships of participants.

Professor Yukio Ogata, Ph.D.
Director of Institute of Advanced Energy, Kyoto University
PREFACE:
Message from the Former Dean of
Graduate School of Energy Science, Kyoto University
Program Leader,
Global COE “Energy Science in the Age of Global Warming”

I want to express my hearty welcome to all participants of Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This symposium is aiming the realization of importance of energy and materials technology through the academic, science and technology network among the world communities. The symposium gives an opportunity for researchers to discuss their research works and also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the further cooperation work will be developed.
I would like also extend my sincere thanks to all who made the meeting possible, including the 10th EMSES organizers, the SEE forum committee members, and the Japanese Government, JSPS, for their kind support. I am looking forward to seeing you in Ubon Ratchathani, Thailand.

Professor Takeshi YAO, Ph.D.
Former Dean of Graduate School of Energy Science, Kyoto University
and Program Leader, Global COE “Energy Science in the Age of Global Warming”
Message from the Chairperson of 10th EMSES Organizing Committee

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES).

RMUTT has a major mission on encouraging and supporting all areas of research. One of the key reasons is to assist in developing capability in science and technology in order to cope with recent rapid change in this field. We have jointly set up an academic symposium on the 10th EMSES with the perception on the significance of exchanging knowledge and research experiences between researcher in the field of energy, materials technology and environmental science. This symposium is not only giving an opportunity for Thai and foreign researcher to present and discussion their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the closer future cooperation incorporate with joint-research works will be developed. Thus, to support the aforesaid role, the symposium working committee would like to invite you to participate in this academic symposium.

I would like to express our sincere thanks to the organizing committee, participants and contributors for your kind corporation to this symposium. I wish this symposium proceeding will be a useful reference for future scientific research development.

Sommai PIVSA-ART, Ph.D.
Dean of Faculty of Engineering, RMUTT
Director of CoE on Sustainable Energy System (Thai-Japan)
Organizing Chairman of 10th EMSES 2012
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<td>Assoc. Prof. Dr. Numyoot Songthanapitak, President of RMUTT, Thailand and Chairperson of 10th EMSES conference</td>
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<td>Prof. Dr. Kiyoshi Yoshikawa, Vice President of Kyoto University, Japan Co-Chairperson of 10th EMSES conference</td>
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<td>09:45-10:45 am</td>
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<td>Assoc. Prof. Dr. Wisanu Pecharapa</td>
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<td>Dr.Sorapong Pavasupree</td>
<td>Asst Prof. Dr. Warunee Anyawathian</td>
<td>Asst. Prof. Dr. Jakkree Srinonchart</td>
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| Poster Session |                   |                           |                           |                           |
# Conference Program of 10th Eco-Energy and Materials Science and Engineering

## 7th December 2012

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<td>Assoc. Prof. Dr. Thawatch Kerdsuwan</td>
<td>Dr. Seichi Aiba</td>
<td>Prof. Dr. Takeshi Yao</td>
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<td>Dr. Leong Yew Wei</td>
<td>Dr. Supaporn Tomson</td>
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<td>Prof. Dr. Hirokuki Hamada</td>
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<td>Asst.Prof.Dr. Boonrit Prasartkeaw</td>
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<td>03:15-04:00 pm</td>
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High Voltage Gain Interleaved DC Boost Converter Application for Photovoltaic Generation System

W. Khadmun and W. Subsingha
Department of Electrical Engineering, Faculty of Engineering, Rajamangala University of Technology Thanyaburi, Klong 6, Thanyaburi, Pathumthani 12110
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Abstract— This paper presents a novel high voltage gain interleaved DC boost converter. This converter is non-isolated boost converter, which can level up DC voltage from 24 Vdc input voltage to 130 Vdc output voltage. This is adequate suitable in order to develop and apply with any dc output renewable energy source, such as PV generation system and etc. The converter in this paper has power rating at 350W. The proposed converter has totally four modules of DC boost converter, which are connected in parallel. At the same purpose, these switching devices are controlled by 90 degree shifting to each other, due to an interleaving technique. This will leads to a smoother output dc current. Nevertheless, the High gain DC boost converter in this project was done by MATLAB / SIMULINK based Digital Signal Processing Board (here is TMS320F2812) implementation. The laboratory experiment shows that the converter works very well, and its result is in a good satisfaction.

Keywords— non-isolated boost converter, 4 phase Interleave technique, DSP implementation

1. INTRODUCTION

In general, Photo Voltnic cell (or Solar cell) can transform the energy form any light sources into an electrical dc power source. When the electromagnetic wave in light source impacts the semiconductor junction in the PV cells, energy will be transformed by causing a movement of electrons in PV's semiconductor junction. By connecting the external of the load side, the current will flows into an electrical circuit. However, there are some limitations on the PV's power rating. Due to the output voltage of such PV cell and PV panel is not high enough to provide to a customer in general, thus, the PV's output voltage has to be boosted up higher enough for providing any electrical appliances.

Therefore, DC boost converter is needed to boost up a dc voltage, then it will transforms to AC voltage using DC-AC converter (or Inverter). Normally, a traditional non-isolated DC boost converter has a significant disadvantage due to its low voltage. Thus, a high gain DC converter has to be proposed. However, such DC converter must have a good reliability in long time operation. In which, it also should be a small size in order to ease of installation, maintenance, power lossless and toughness [1]-[9].

2. DC BOOST CONVERTER TOPOLOGIES

Typical boost converter

High voltage gain DC converter that proposed in this paper is considered from a traditional non-isolated DC boost converter as shown in Figure 1. However, the difference between DC Converter in Figure 1 and 2 is the location of diode, but its operations of both circuits are the same.

Fig. 1 Boost converter with inductor and diode in positive side

Fig. 2 Boost converter with inductor and diode in negative side

Interleaved boost converter

There are two configurations of interleaving DC boost converter circuit in this project as shown in Figure 3 and Figure 4, respectively. An advantage of the interleaved technique is to reduce the converter size (especially inductor), reduce a ripple current and also increasing the converter's efficiency.

Fig. 3 Two phases interleaved Boost converter (inductor and diode in positive side)
3. HIGH VOLTAGE GAIN INTERLEAVED DC BOOST CONVERTER

High voltage gain DC boost converter that proposed in this paper is a combination of two 2 phase interleaved boost converter from Figure 3 and 4 together as shown in Figure 5.

Such circuit is called as 4 phase interleaved DC boost converter. The four switching devices (here is Power MOSFET IRF3415) are controlled in 90° phase delay to each others simultaneously (interleave technique method), in order to smooth output ripple current, raising power rating and efficiency as described above.

Voltage gain of the circuit can be determined by applying KVL in two separated circuits as follows

\[ U_0 + U_{ca} + U_{cs} - U_s = 0 \]  
\[ U_0 = U_{ca} + U_{cs} - U_s \]

when \( U_s \) is DC input voltage
\( U_0 \) is DC output voltage
\( U_{ca} \) is Capacitor voltage across \( C_a \)
\( U_{cs} \) is Capacitor voltage across \( C_s \)

Thus, voltage gain of the circuit is given in (3).

\[ \frac{U_0}{U_s} = \frac{(1 + D)}{(1 - D)} \] (3)

This means that the voltage can be raised over than a traditional non-isolated boost converter depend on the value of the duty cycle.

Inductance Design

Since the interleaving concept can reduces input current ripple also with inductance sizing, but the converters must be operated in continuous conduction mode (CCM). With a maximum current ripple (\( \Delta I_L \)), it allowed to use for determining an appropriate value of \( L \). And the current through the inducto inductance as follows [1]

\[ L = \frac{DU_s}{4.\Delta I_L . f_s} \] (4)

Capacitance Design

The output voltage ripple of the circuit depends the size of capacitor. However, there are two capacitors that connected in series, which effect to output voltage ripple (\( \Delta U_{bus} \)). The value of each capacitor depends on output current (\( I_{out} \)), duty cycle (\( D \)) and depends inversely with \( \Delta U_{bus} \), switching frequency (\( f_s \)) as follows [1].

\[ C_{bus} = \frac{I_{out}.D}{2.\Delta U_{bus} . f_s} \] (5)

<table>
<thead>
<tr>
<th>Devices</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inductances (L1, L2, L3, L4)</td>
<td>840μH, EE 42 core</td>
</tr>
<tr>
<td>Capacitances (C1, C2)</td>
<td>470μF 450V</td>
</tr>
<tr>
<td>Power switches (S1, S2, S3, S4)</td>
<td>IRF3415</td>
</tr>
<tr>
<td>Diodes (D1, D2, D3, D4)</td>
<td>RURG3020</td>
</tr>
<tr>
<td>Input voltage</td>
<td>24 Vdc</td>
</tr>
<tr>
<td>Output voltage</td>
<td>130 Vdc</td>
</tr>
<tr>
<td>Maximum power output</td>
<td>350 W</td>
</tr>
<tr>
<td>Switching frequency ( f_s )</td>
<td>25 kHz.</td>
</tr>
</tbody>
</table>

4. EXPERIMENTAL RESULTS

| Fig. 6 TMS320F2812 control model |
The proposed DC boost converter is built in a laboratory scale using TMS320F2812 DSP board. The DSP board is set for generating a suitable control signals for all four switching devices in the circuit. However, in order to controlling the essential data and some important control parameters, MATLAB/Simulink is used as a basis platform for managing the control model and such control data through TMS320F2812 DSP board.

The gate driving signals of switching devices generated from TMS320F2812 are shown in Figure 8. A phase angle of each gate driving signals is 0, 90, 180 and 270 degree.

The experimental results shown that the steady-state interleaved averaged inductor currents $i_{L1}$, $i_{L2}$, $i_{L3}$ and $i_{L4}$ were 3.4A, 3.8A, 3.4A and 3.2A respectively. The inductor current waveforms are shown in Figure 9.

The maximum output power of proposed converter is 350W. This output power is calculated by multiply output voltage 130Vdc and output current 2.8A. The output voltage waveform and output current waveform are shown in Figure 10.

The voltage of output capacitors $U_{c1}$ and $U_{c2}$ are the same as 78V. The capacitor voltage waveforms are shown in Figure 11.

5. CONCLUSION

This paper present DC-Boost Converter for applying to the photovoltaic generation system by using interleaves technique. This converter is non-isolated boost converter,
which can level up DC voltage from 24Vdc input voltage to 130Vdc output voltage at power rating of 350W. Four phase of each switching control signal are different at 90 degree. However, inductor currents in each phase in the experimental results are not exactly the same because of the inductors’ parasitic. High voltage gain interleaved DC boost converter in this paper could be applied to any renewable energy systems and some related applications. Further research is to analyze in balancing the inductor currents and feedback control scheme in order to stabilize the converter output voltage.

REFERENCES


