DMFC 시스템에 사용한 열전 변환기에 관한 연구

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A Study on Thermoelectric Converter Using DMFC (Direct Methanol Fuel Cell) System

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Abstract - This article describes a thermoelectric converter, which is powered by thermoelectric (TE) power modules. This system uses TE devices that directly convert heat energy to electricity to power a converter using direct methanol fuel cell (DMFC) system. The characteristics of the TE module were tested at different temperatures. A boost DC-DC converter was designed and controlled by a power-supply controller chip. Efficiency of about 80% can be achieved and because the thermoelectric converter system has not moving parts and has a small volume, the system can be carried about easily and conveniently to supply portable electric equipment and this is very important for some mobile equipment.
Keywords: Thermoelectric generator; DC-DC converter; boost; PWM

1. Introduction

The energies, such as petroleum, coal, coal gas, etc. will be exhausted one day, which makes environmental protection become very important recent days.

Renewable energy, such as solar energy, wind energy or hydropower is preferred, but it has limited use and is dependent on weather and topography.

The thermoelectric power generator (TEG) is a good candidate because of several advantages: silent, no pollution, and energy recycling, etc. It can make the unusable heat transform to the usable electric energy by thermoelectric effect.

In the past years, much work has been reported on the TE power generator. Killander [1] developed a stove-top generator using two TE power modules, model HZ-20. During the operating time, the output of the generator was about 10W and supplied the battery with a net input from 1 to 5 W. Rahman [2] developed the thermoelectric generator to supply portable electronic equipment or to charge a lap-top computer battery. The generator is powered from butane gas; it has a potential power output of about 13.5 W. Roth et al. [3] developed and tested a photovoltaic/thermoelectric hybrid system as a power supply for a mobile telephone repeater. The developed system supplies enough for 50 W permanent loads. All of the above research uses the thermoelectric generator to charge the battery and in this paper we will use thermoelectric generator to power a DC-DC converter [4] using DMFC system.

Two of the main issues for low output voltage power supplies are the power loss and be easy to carry about. This is especially true for portable electric equipments such as portable notebook computers. Because the thermoelectric converter system has not moving parts and has a small volume, the system can be carried about easily and conveniently for portable electric equipment and this is very important for notebook computers, because notebook computer is widely used nowadays. The objectives of this article are to study the principle of TE power generation and to design a TE powered converter that uses waste heat or another heat source as the direct portable electric equipment input power.

2. Theory

2.1.Thermoelectric powergeneration

Thermoelectric power generator is a class of solid-state devices that convert heat directly into electricity.

All thermoelectric power generators have the same basic configuration, as shown in the Fig.1. A heat source provides the high temperature, and the heat flows through a thermoelectric converter to a heat sink, which is maintained at a temperature below that of the source. The temperature differential across the converter produces direct current (DC) to a load (R_L) having a terminal voltage (V) and a terminal current (I). There is no intermediate energy conversion process. For this reason, thermoelectric power generation is classified as direct power conversion. The amount of electrical power generated is given by I^2R_L or VI.

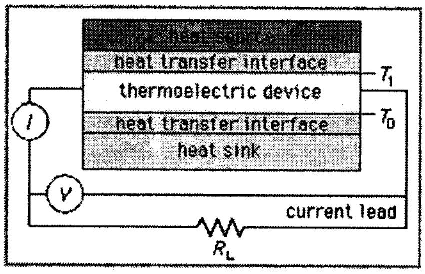
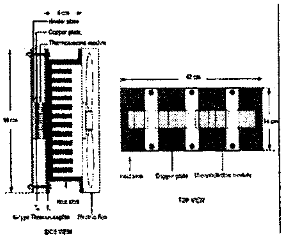
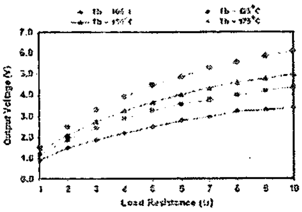


Fig.1 Configuration of TE generator

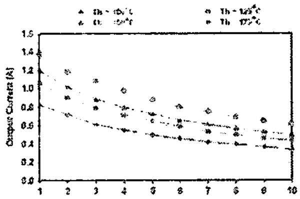
TE power modules TEP1-1264-1.5 were used in the experiment. The electrical characteristics were tested when the cold-side temperature was maintained at 40 degree which was shown in Fig.2.



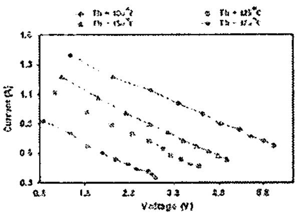
(a) The detail structure of a TEG



(b) Output voltage of single TEG



(c) Output current of single TEG

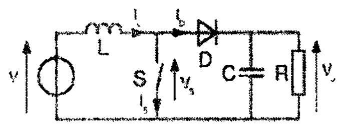


(d) V-I curve of a single TEG

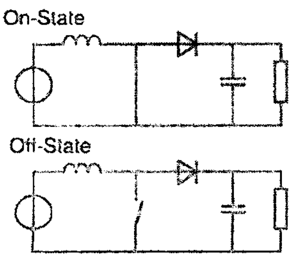
Fig.2 Characteristics of TE generator

2.2.DC-DCconverter

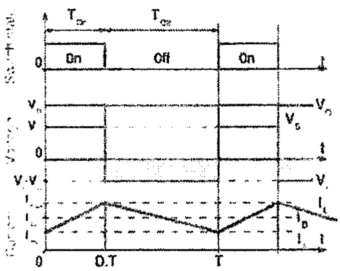
In a boost converter, the output voltage is greater than the input voltage. A boost converter circuit and waveforms are shown in Fig.3.



(a) Typical circuit of boost converter



(b) Topology sequence of the boost converter



(c) Waveforms of the boost converter

Fig.3 Characteristics of boost converter

3. Experiments and results

The configuration of the whole system is shown in Fig.4.

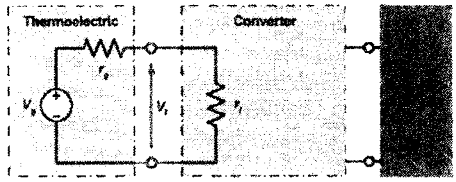


Fig.4 The configuration of the whole system

The specifications of the converter are shown in Table.1.

Input Voltage (Vi)	6.0V~8.0V
Output Voltage (Vo)	12V
Output Current (Io)	1.0A~1.5A
Switching Frequency (f)	33K Hz
Output Ripple Voltage	120mV

Table.1 The parameters of DC-DC converter

Fig.5 shows the configuration of the converter. The TL494 power-supply controller was used as the PWM control circuit.

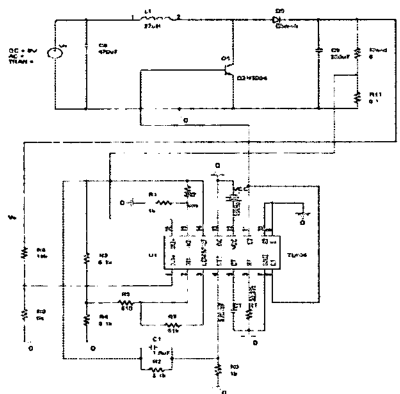


Fig.5 Circuit of the DC-DC converter

Open loop output voltage's characteristics(when input voltage is fixed in 7.5V). Variation of output voltage with duty cycle and the relationship $V_o - I_o$ were shown in Fig.6.

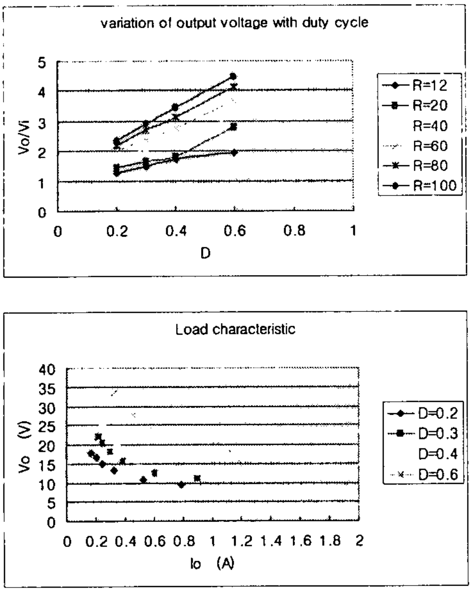


Fig.6 Open loop characteristics

Fig.7 shows the waveforms of output voltage and PWM control signal.

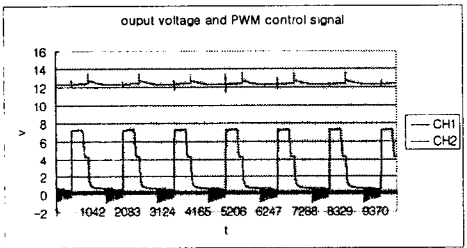


Fig.7 Waveforms of output voltage and control signal

Load and line regulation were shown in Fig.8 and Fig.9.

From the results we know that output voltage was well fixed in 12V no matter how the load or input voltage changes.

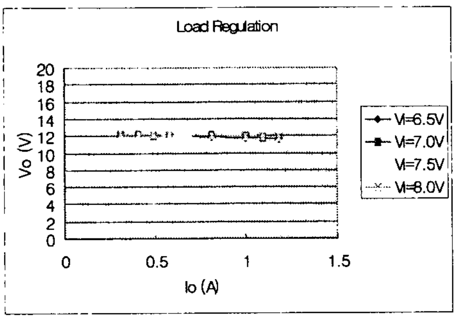


Fig.8 Load regulation

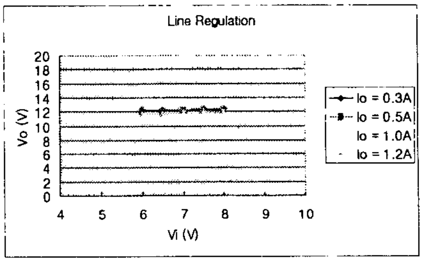


Fig.9 Line regulation

Fig.10 shows the efficiency of the system.

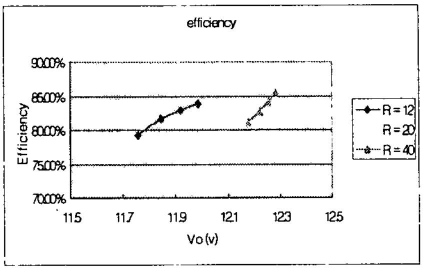


Fig.10 The efficiency of the system

4. Conclusion

The best power output of the system depends on the best dissipation of the heat sink. However, the system design may be improved by redesigning the heat exchanger (heat receiver and heat sink) appropriate to the ambient temperature.

Efficiency of 80% and higher can be achieved by using very low on-resistance MOSFET, and a small size is realized. To further increase the efficiency, use synchronous rectification. Synchronous rectification is achieved by simply replacing the free-wheeling diode with a MOSFET utilizing an additional gate drive circuit. In addition, use a low ESR capacitor for input and output filtering, reduce I^2R losses by using a low dc losses inductor and increasing the PCB copper track width on the high current path also can increase the efficiency of the system.

References

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