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Thermoelectric Peltier Plate Based On DC-DC Convertor For BESS In Automobiles

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Abstract: As waste heat recovering techniques, especially thermoelectric generator (TEG) technologies, it is used in automotive industry. Useful electricity generation is possible due to the great amount of waste heat emitted from the internal combustion engine operation. This thesis proposes the innovative concept of thermoelectric-generator-based DC-DC conversion network. Thermocouple acts as Peltier plate due to its low cost and compactness, when electric current is passed through a circuit consisting of two dissimilar metals, heat is evolved at one junction and absorbed at the other junction. Peltier effect is the converse of Seebeck effect. This technique is used to run our vehicle by converting the exhaust heat from the automobiles into a useful electrical energy. This reduces the amount of fuel consumed for initial environment of vehicles.
Keywords—DC-DC conversion, Peltier effect, seeback effect.

I. INTRODUCTION

This thesis project is scheduled in two major phases. The work starts from definition and development of the concept of TEG-based DC-DC conversion network for automotive applications, followed by the development of a bottom-up design approach for this network. For the second phase, optimal solutions for DC-DC convertors utilized in the proposed network will be investigated. The discussion should base on comparison study and analysis, while the optimal solution should be refined and verified by modeling and simulation.

A. Thermoelectric generator:

Thermoelectric generator (TEG) is a device that converts thermal energy directly into electrical energy. Early TEG devices utilize metallic TE material, whereas more recently manufactured TEGs use alternating n-type and p-type semiconductor materials. The TEG structure is "sandwich like", with thermoelectric materials "sandwiched" by two heat exchanger plates at its two ends respectively. One of the two exchangers has high temperature, and hence, it is called the hot side of the TEG; while the other has low temperature and is called the cold side of the TEG. There are electrical-insulate-thermal -conductive layers between the metal heat exchangers and the TE material. The two ends of n- and p-type legs are electrically connected by metal. The thermal-electrical conversion is done by a phenomenon generally referred to as "Seebeck effect", which is named after one of the scientists who discovered it. TEGs are solid-state device, which means that they have no moving parts during their operations. Together with features that they produce no noise and involve no harmful agents, they are the most widely adopted devices for waste heat recovery.

B. Seebeck effect:

Seebeck effect is the conversion of temperature differences directly into electric ity. In the basic version of TEG, the conductor materials used to generate Seebeck effect are two different metals or semiconductors.

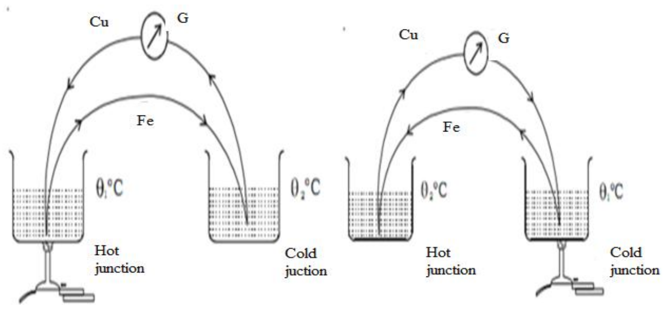

Figure 1: Seebeck Effect

The term thermopower, or more often, Seebeck coefficient of a material, is a measure of the magnitude of an induced thermoelectric voltage in response to a temperature difference across that material.

II. TECHNICAL DESCRIPTION

A. Peltier Effect:

When electric current is passed through a circuit consisting of two dissimilar metals, heat is evolved at one junction and absorbed at the other junction. This is called Peltier effect. Peltier effect is the converse of Seebeck effect.

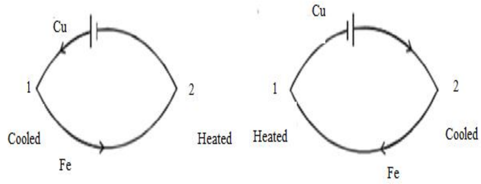

Figure 2: Peltier Effect

In a Cu-Fe thermocouple, at the junction 1 (Figure2.a) where the current flows from Cu to Fe, heat is absorbed (so, it gets cooled) and at the junction 2 where the current flows from Fe to Cu heat is liberated (so, it gets heated). When the direction of the current is reversed (Figure2.b) junction 1 gets heated and the junction 2 gets cooled. Hence Peltier effect is reversible.

B. Dc-dc convertors:

DC-DC convertor is a class of power convertors. It converts a DC source of a certain voltage level to another voltage level. In modern electronic systems, DC-DC convertors are needed to convert the voltage supply from the power source to the voltage level required by the target function block. Beside, DC-DC convertor can also regulate the output voltage. For TEG utilization ns in automotive applications, DC-DC convertor is commonly used for boosting up voltage supplied by the TEG converted power source, so as to reach the voltage levels required by different in-car electronics.

C .Principle of dc-dc convertors:

There are two major concerns in the design of DC-DC convertors: efficiency and regulation. The issue of efficiency arises since almost all circuit has resistive components or parasitic resistors, which are power consuming during the functioning of the convertor. That is to say, designers need to optimize the efficiency of the convertor, although efficiency can never reach 100%. The issue of regulation is caused due to the fact that all power sources are not absolutely constant; however, many electronics require a certain level of stability of power supply. Up until now, there are already various design techniques and optimized components addressing these issues.

The general principle of DC-DC convertors in volves the storage of electrical energy into components, such as capacitors and inductors, and the release of energy to loads.

By controlling the time for energy storage and release, average voltage level appeared at the converter load can be controlled. The average load voltage level can thus be either higher or lower than the voltage level of the power source. DC-DC convertors utilize pulse-width-modulation (PWM) signal as the switching control signal for its advantage of linear control over the load power.

D. Boost convertor:

Boost derived convertors, both isolated and non-isolated versions, find many usage in the network proposed in this thesis. This boost convertor is designed to operate in continuous conduction mode (CCM) when the switching frequency is 25 KHz, the input voltage level is around 4.5 V, and the load resistance is 4 Ω.

Voltage levels generated by TEGs are usually at a relatively low level, which is not appropriate to directly serve as power Source for many electronics. Hence, it is practical and necessary to use DC-DC convertors to boost up the voltage to a desired level. Besides, DC-DC convertor can act as a regulator for the fluctuating TEG voltage under varying temperature conditions.

III. PROPOSED WORK

We are using ATMEGA8 microcontroller. During the running condition of engine, the heat is produced from the exhaust part of the vehicle. This heat is captured by the Peltier plate which converts the thermal energy into an electrical energy. Our suggested peltier plate having the capable of producing 5V as electrical output.

But all vehicles having the specification of 12V battery. So the output of peltier plate is given as input to the DC-DC booster convertor. The DC-DC booster convertor having the capability of converting the voltage from 5V to 12V. Our microcontroller plays a major role in the booster circuit. The microcontroller producing the continuous PWM pulse to the transistor (TIP122) present in the booster convertor circuit.

While programming the microcontroller, we used to give a small delay pulse. Hence the faster conversion of voltage (say 5V to 12V) takes place by receiving the continuous PWM pulse from the microcontroller. The 12V output from the booster circuit is stored in the 12V battery. Once the voltage reaches the particular level of battery which is programmed in a microcontroller, then the fuel from the tank is stopped its supply to the engine slowly and the motor of the engine automatically receives charge from the battery.

Also we use Cobalt arsenide in peltier plate, which does not allow escaping even the small amount of heat. Hence it gives continuous charge to the motor to rotate. Thus the motor rotates normaly as same as it runs by fuel. Only the starting condition of the vehicle requires fuel and the rest of the time, the vehicle uses charge from the battery for its running condition. By this method, we can improve the fuel economy upto 40%.

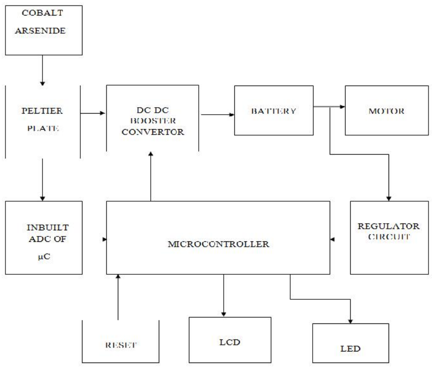

Figure 3: Block diagram of proposed method

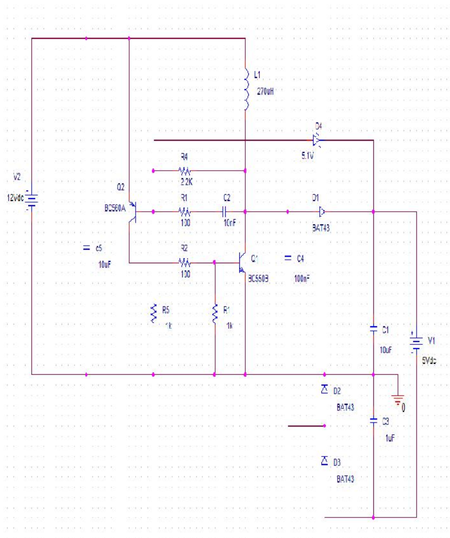

Figure 4: Circuit Diagram for Booster Amplifier

IV. EXPERIMENTAL RESULTS

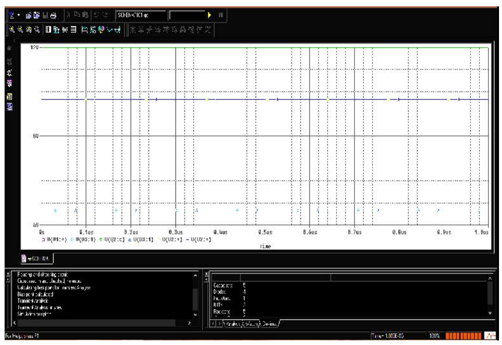

Figure 5: Simulation Output for 5volts to 12 Volts

Figure 5 provides the output current of 20 mA and maximum voltage of 12.6 volts while the input of 5 volts at current of 64 mA that is effective in the range of 87%. Switched DC to DC convertors offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing. The design specification of DC-Dc booster convertor (5V-12V) is given below.

Input & Output Range

Table 1: Testing of DC-DC Booster Convertor

INPUT (in VOLTS)	OUTPUT (in VOLTS)
5V	12V

V. CONCLUSION

The target of this thesis is to propose an innovative TEG system topology, together with improved DC-DC convertor solutions, for automotive application which can improve the conversion efficiency. The Proposed system can be able to reduce the fuel consumption to the maximum limit and also this system will help us the working environment. Our suggested Peltier plate having the capable of producing 5V as electrical output.

But all vehicles having the specification of 12V battery. So the output of peltier plate is given as input to the DC-DC booster convertor. The DC-DC booster convertor having the capability of converting the voltage from 5V to 12V.

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