Waste Heat Recovery from Automobiles

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Abstract

This paper deals about the waste heat recovery from automobiles using Thermo electric generator (TEG).Waste energy from automotive engine exhaust is converted into electrical energy to power a 12V batter using Thermoelectric Generator. There are three subsystems for this model the thermoelectric generator system, heat exchanger and power conditioning unit. The PCU consists of a buck-boost converter. The simulation results shows boost converter in Power conditioning unit is suitable for Thermoelectric Generator system.

Keyword- Boost Converter Heat Exchanger, Power Conditioning Unit, Seebeck Effect, Thermoelectric Generator Module

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I. INTRODUCTION

As the need for electricity is increasing it is necessary to generate electricity from other sources. India is the world's third largest producer and fourth largest consumer of electricity. There are some technologies which implement the harvesting of waste energy, by which the waste energy produced at the exhaust can be trapped and recycled into useful form. The heat energy getting wasted can be trapped and converted to useful electrical energy by the device called thermo-electric generator.[1]

This paper deals with the production of electric energy from waste heat using TEG from automobile. There are three units in the system, the heat exchanger, the thermoelectric module and the power conditioning unit. The power conditioning unit consist of a boost converter.[2] The voltage thus produced is sufficient for charging the battery. One of the factors taken into account while designing the TEG system is the impedance matching between the TEG and load.

II. THERMO ELECTRIC GENERATOR SYSTEM

The system mainly consists of three subsystems. The TEG module, heat exchanger, and the power conditioning unit. The gas to liquid HX transfers the heat to and from the TEM, taking heat from the exhaust to provide a hot side and taking heat away via the coolant loop to provide the cold side. TEG will generate energy using the hot and cold side given. The heat flow involves three effects such a Seebeck effect, the half of joule heating and thermal conduction of semiconductor material. The module absorbs heat energy and thus the electrons in the heat junction got excited and move towards cold junction. This movement induces emf.

III. HEAT EXCHANGER

Heat energy is available from many sources. One of the way to convert heat energy is using the TEG. A heat exchanger is a device used to transfer heat between a solid object and a fluid, or between two or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. The hot side of the thermoelectric generator module is kept in contact with exhaust pipe of the automobile. A heat ink is connected to the other side of the thermoelectric generator module. While the automobile is running the wind flow will help the heat sink to dissipate the heat faster.

IV. THERMOELECTRIC MODULE

TEG is used for the heat conversion. The TEG model requires the exhaust and coolant inlet temperature (Tai, Twi) and mass flow rate as inputs and outputs the voltage and current (V ,I) generated by then TEG.

A couple is formed using two dissimilar n-type and p-type legs. Several couples are joined together to form a module. Number of modules is taken according to the power requirement. The rechargeable batteries used in high power vehicles like SUVs can be charged using the heat produced in itself. With an engine temperature of around120^0, and a ΔT of 70^0, a voltage of 0.0628V can be produced. Another potential source of waste heat in automobiles is the exhaust pipe. About 70% of the fuel energy is wasted as heat through exhaust. This can be utilized. A highly efficient HZ-20 TEG module, at a ΔT of 50^0c, can give an output power of

1.8 W. But in actual operation, the output voltage is subjected to fluctuation due to the non-uniform heat gradient over the heat exchanger surface. This can be overcome by providing suitable thermal insulation.

V. POWER CONDITIONING UNIT (PCU)

This is the major part of the system comprises of the unstable heat source and loads. The output from this unit is connected to a DC-DC converter. Here we used a buck-boost converter for this. The output from the converter is connected to the 12V battery.[2]

A. Boost Converter

The voltage produced by the thermoelectric generator module is very low. It is not sufficient for powering the 12 V batteries in the automobile. Hence we use a boost converter. Boost converter is an inverting DC-DC converter with the output voltage greater or lower than the input voltage.[1] One of the drawbacks of this converter is that the switch does not connect to the ground; as a consequence, the driving circuitry is complex.

VI. BLOCK DIAGRAM

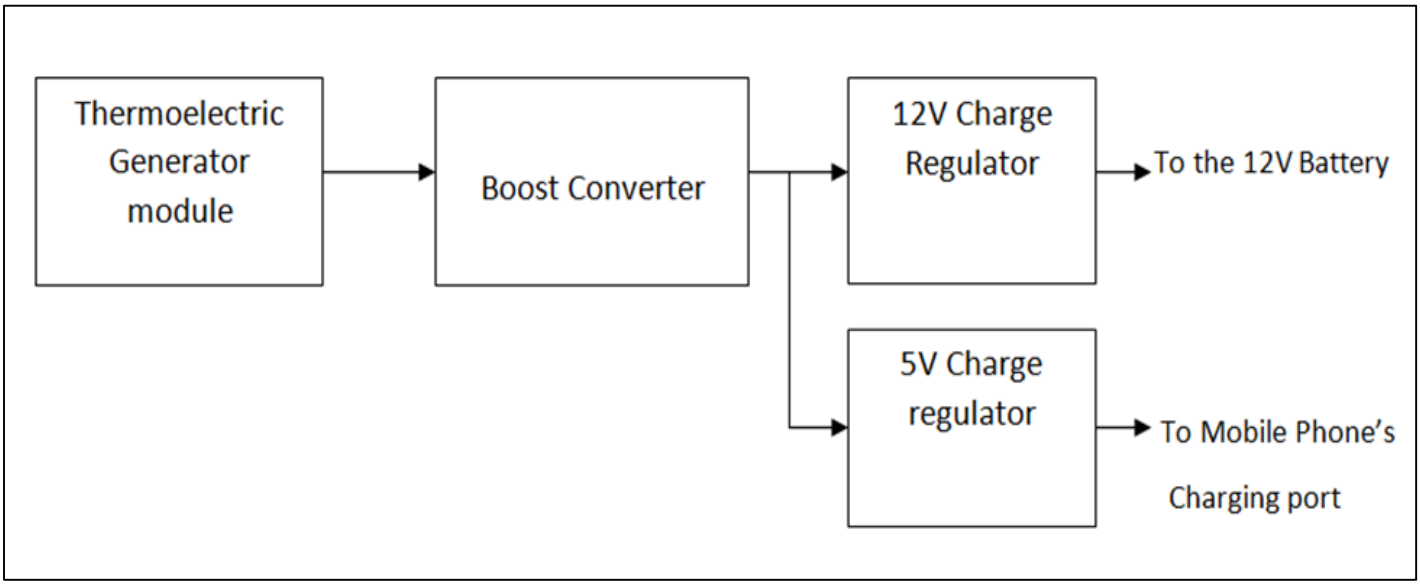


Fig. 1: Block Diagram of the Designed System

VII. SIMULATION RESULTS

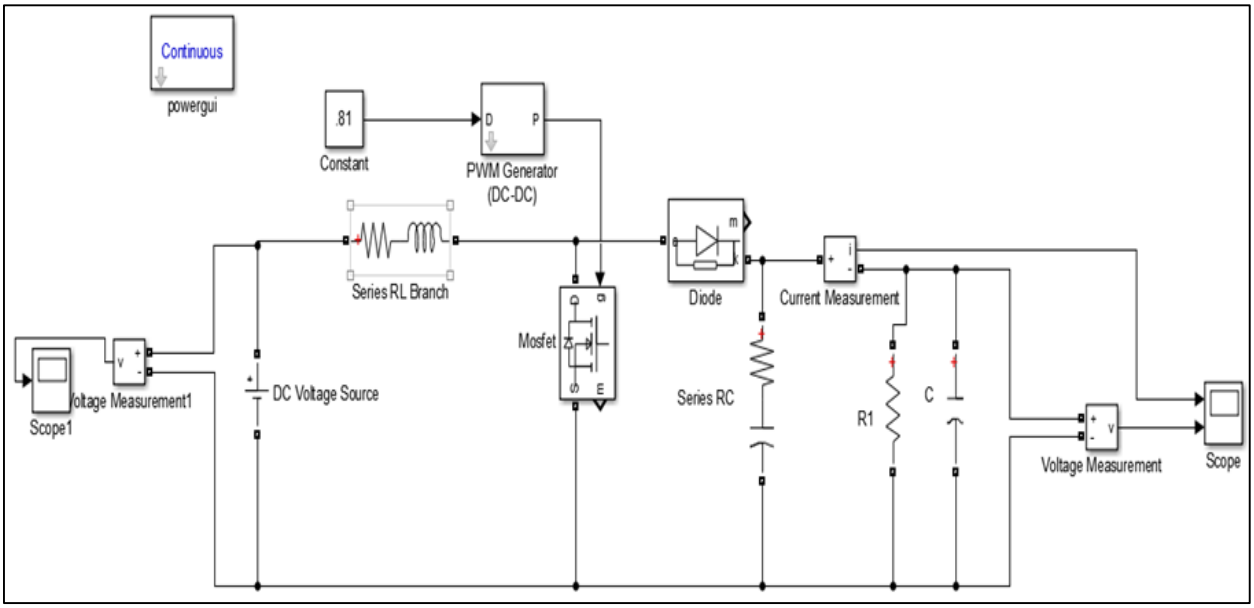
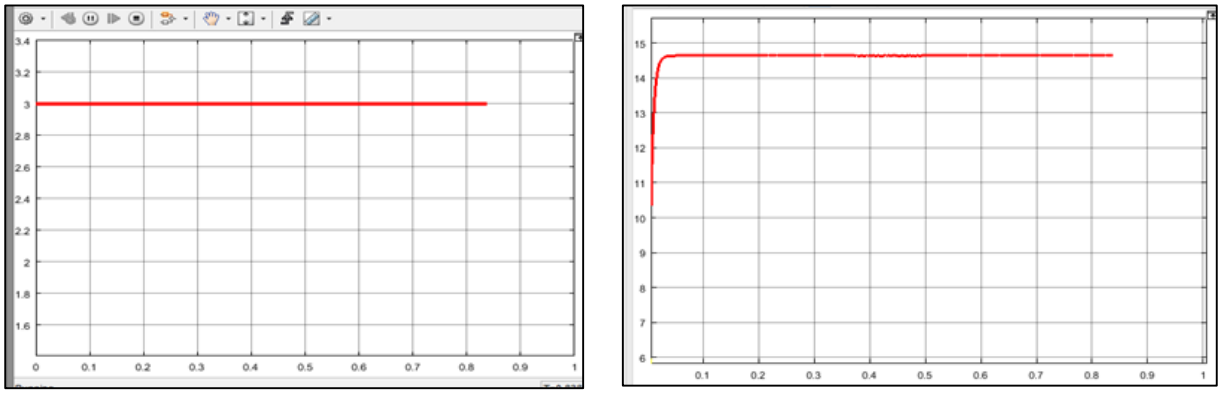


Fig. 2: Matlab simulation of the Boost Converter



(a) (b)

Fig. 3: Matlab simulation results (a) input (b) output

VIII. CONCLUSION

There is an increase in the demand for energy for our day to day activities, from simple devices to complex systems. All these systems depend on the electricity board or the power company for its operation. At one point of time, the scarcity for fuels occurs causing the scarcity in electricity. Hence, it is important to conserve energy. This project aims to conserve the electrical energy to some extent, by trapping the waste heat from the heat source in automobiles. This project can also be applicable in home appliances, where the heat from gas stoves can be trapped for producing electrical energy. By the efficient use of waste heat energy, we can save some amount of energy for operating appliances and auxiliary systems in vehicles.

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