

Regeneration of Wastage Heat Energy from Vehicle Engine Heat-Up

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ABSTRACT: To meet the increasing world demands for energy, the rate of depletion of non-renewable energy sources must be reduced while emerging alternative renewable energy sources. Renewable Energy (RE) is a clean energy that produces no harm to earth and this can be done by increasing the overall thermal efficiency of conventional power plants. Thus a study is conducted to harvesting energy by using a renewable energy such as waste heat. Most of the techniques currently available recover waste heat in the form of thermal energy which is then converted to electricity in a conventional steam power plant. Another approach which has received a little attention so far is direct conversion of thermal waste energy into electricity. The objectives include determining the method of harvesting electricity from car engine heat, investigating the operational of Thermoelectric Generator (TEG), correlating the TEG with circuit to drive a load and analyzed the method through Matlab / Simulink software. The study will present the summary correlated particularly to car engines heat recovery systems, introducing the key parameters, components and methods to determine the performance of such systems.

KEYWORDS: Renewable Energy (RE), harvesting energy, waste heat, Thermoelectric Generator (TEG), car engine heat and Matlab / Simulink.

I. INTRODUCTION

As we know, a car uses quite a lot of electricity to work the ignition and others electrical equipment. The power source comes from rechargeable battery to keep the system running well. The battery, starting and charging systems are interrelated by a continual cycle of converting chemical energy to mechanical energy and then back again. The starter motor uses mechanical energy to crank the engine and once the engine is running, it's really a merry-go-round sort of relationship. The rotation of the engine drives the alternator, forcing electrical energy (current) into a battery, where it's stored as chemical energy. The chemical energy of the battery is then changed back to electrical energy when it supplies current to the starter motor and accessories. The cycle repeats itself as the engine's mechanical energy again drives the alternator to recharge the battery so it can supply more current to the starter when needed. The car engine produces waste heat when the car is moving. To recycle the waste heat, Thermoelectric Generator (TEG) is used to converting it to electrical energy.

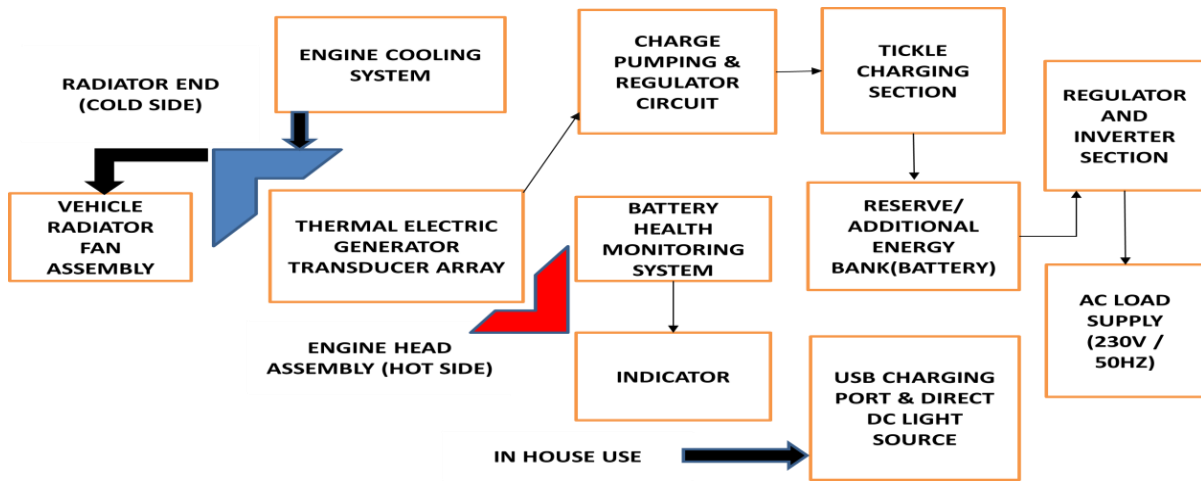


Fig No.1 Overview Block Diagram

Layout of the main components harvesting energy from car engine heat by using TEG

It was found that recycling heat is quite common in Europe. Denmark gets roughly half of its electricity from recycled heat, followed by Finland at 39 percent, and Russia at 31 percent. In the U.S., it's just 12 percent. Thermoelectric generator is the new alternative energy that will produce electricity by using waste heat as a source. Thermoelectric generator consists of two sides which is cool side and hot side of the plate. When there is temperature different at both side of the plates, the electricity will produced. This method known as Seebeck Effect and its operation is described using Fig. 2. In this technique, the voltage is produced by a heated junction of two wires that is directly proportional to the temperature. But the output voltage that produces from the plate is unpredictable and inconsistent due to the temperature different at the plate. Besides, the small value of output voltage that produced from the thermo plate is insufficient to run a load. So, this paper will study on how to maintain the temperature so the output voltage will constant and maintain. To maintain the temperature of the plate is depends on the type of heat sink and the types of plate at hot side use either aluminum, copper, zinc, iron and etc. While to increase the small value of output voltage that being generated by thermo plate; is using a boost circuit.

II. OBJECTIVES

- To study a methods of generate electricity using car engine heat.
- To prove the thermoelectric generator is being able to run a load.
- To developing the concepts of inverter by converts the DC output to AC output.
- To analyzed the method through the simulation using Matlab / Simulink software.

III. METHODOLOGY

Shows the overall steps of project and analyze the findings of each experiment following the sequential of flow chart

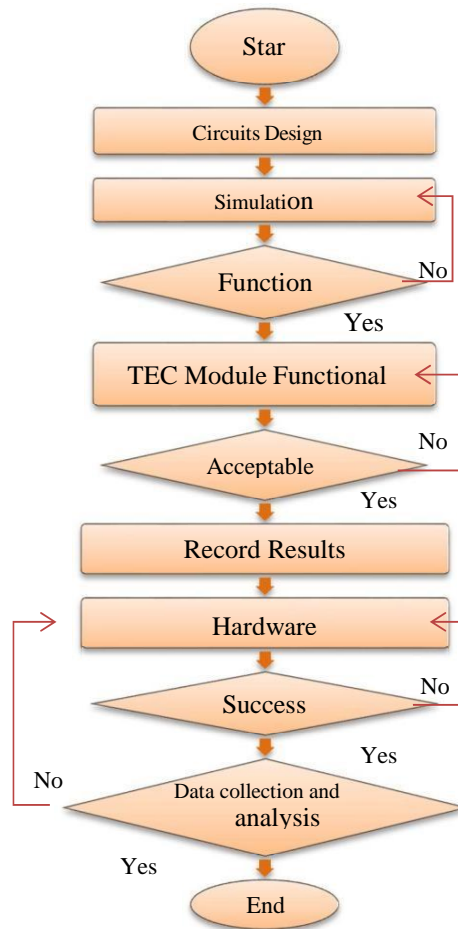


Fig No.2 Design Flow Chart

● **Thermoelectric Module**

TEG modules as shown in Fig. 4 are designed to provide DC power to a wide range of devices with high reliability and are particularly useful in remote areas where grid power is not readily available. TEGs utilize unique construction techniques to survive a high number of thermal cycles and temperature up to 200°C. When heat is applied to the hot side of a TEG, electricity is produced. Almost any heat source can be used to generate electricity, such as solar heat, geothermal heat and even body heat. In addition the efficiency of any device or machine that generates heat as a by-product can be drastically improved by recovering the energy lost as heat.

● **Thermoelectric Module**

The full block diagram of project design as depicted in Figure 5 was used to express the configuration of equipment from car engine heat source until load.

● **DC-DC Booster Circuit**

The circuit diagram as shown in Fig. 6 was used as DC- DC booster circuit that using IC of MAX756 as driver to boost up small input voltage starting from 0.7V up to 5V.

Meanwhile, the circuit diagram as illustrated in Fig. 7 was used as DC-DC booster circuit that using IC of LM2577-12 as driver to boost up small input voltage starting from 5V up to 12V.

● **Inverter Circuit**

Inverter circuits that using IC of CD4047 as Low Power Monostable / Astable Multivibrator to invert Direct Current

(DC) to Alternating Current (AC) from 12V DC to 230V AC.

IV. SIMULATION RESULTS

The simulations for this experiment are being analyzed by using Matlab / Simulink software. The purposed by doing this simulation are to proof that simulation result of circuits and hardware used in this experiment are the same. The figure below shows the display result and graph for all three circuits used.

The circuit of 1.3V to 5V circuit was constructs using Simulink software. It proves that the voltages are successfully step up from 1.3V to 5.117V.

The voltage and current output that obtained from scope in simulation. The graph at bottom shows the voltage output of boosting circuit. It can be seen that voltage starts increase from 1.3V until 5V.

The simulation for boost converter for both boost circuit are the same. The input voltages of 5V are successfully increased to 12V. Even by using the same circuit, the value of parameters for pulse generator are different for both circuit. Percentages of pulse width for circuit as figure above are lower than circuit.

The voltage and current output that obtained from scope in simulation. The graph at bottom shows the voltage output of boosting circuit. It can be seen that voltage starts increase from 5V until 12V.

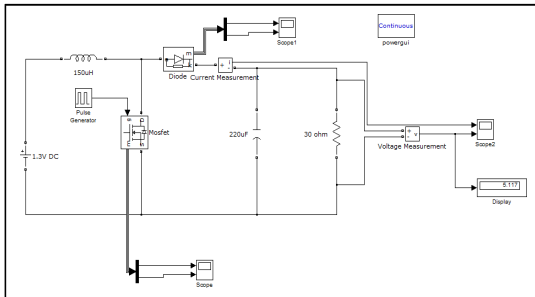


Fig No.3 Simulation of 1.3V-5V Boost converter

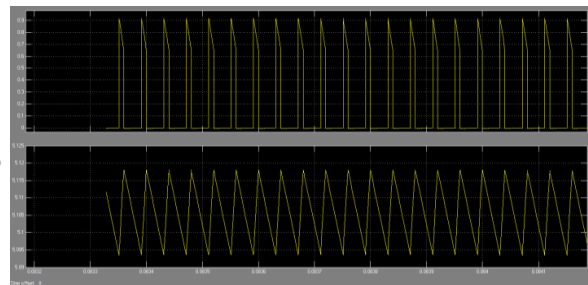


Fig No.4 Output of 1.3V-5V Boost converter

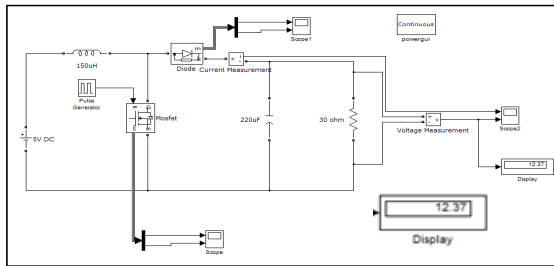


Fig No.5 Simulation of 5V-12V Boost converter

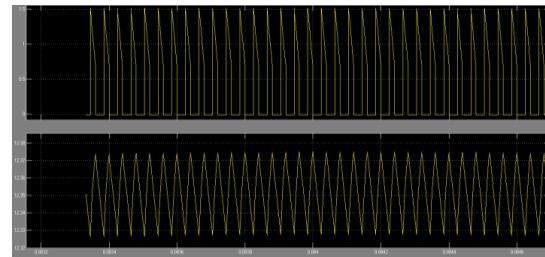


Fig No.6 Output of 5V-12V Boost converts

V. DESIGN KIT

The design and development of thermoelectric generator kits are design in a portable way so it can easily to be carried at anywhere, light and safe. The inputs are from thermoelectric generator and there are two outputs provided which are in 5V dc and 230V ac. The 5V output are in USB port which can be used for charging hand phone battery, LED lamp, fan and any application that requires 5V. There are two switches as shown in figure 16 which labeled as 5V and 12V. When the 5V switches are pushed on, it will boost to 12V. When a user requires 230V ac output, the 12V switch must be pushed on.

The design and development of thermoelectric generator kit was completed 100%. But there are problems occur at input current of TEC-12706 due to small current, the LED was not successfully light up.



Fig No.7 Thermoelectric generator kit

VI. EXPERIMENTAL RESULTS

The output from thermoelectric modules that using candle as a heat source. The experiment was use single TEC1-12706 modules in between aluminum plates and aluminum heat sink. By using multimeter that connected in parallel with TEG output, the output voltage is obtained. However, the output current is too small which is 0.003mA. The TEC module output voltage is not consistent, after a few second, the voltage start to drop due to decrease in temperature different between two sides because when current start to flow in TEC circuit, the heat from hot side will be transferred to the cool side by current.

The output current from five TEC1-12706 modules and connected in parallel. The output current is 7.46mA and it is larger than output current for one module.

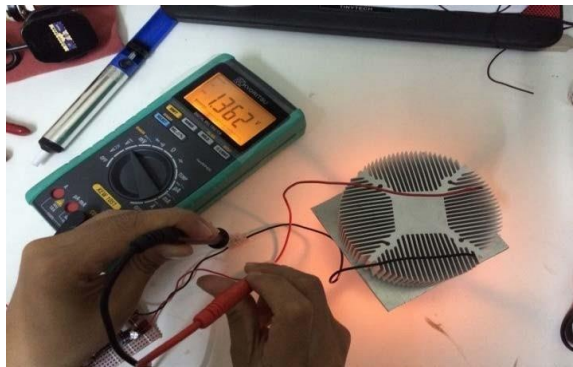


Fig No.8 Experiment TEG module using candle as a heat source



Fig No.9 Output Current from TEG module

VII. TESTING RESULTS

A testing circuit is required to make sure the functionality of the circuit that being used in this study. The testing is done by using power supply as an input and the output power of all circuits used in thermoelectric generator kits in terms of voltage and output. It can be seen that the current output for all circuit are very low due to TEC-12706 characteristic and disability.



Fig No.10 Output 230VAC Load

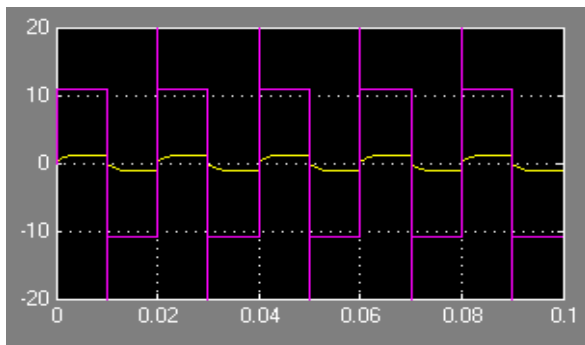
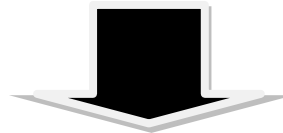


Fig No.11 Graph of voltage and current output for inverter

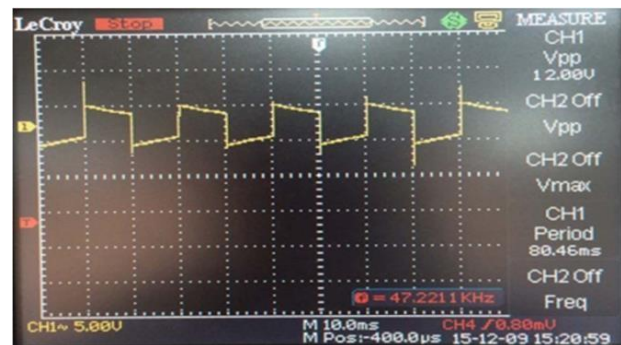


Fig No.12 Square Wave Waveform of Inverter Circuit

The waveform as shown in Fig. is a square wave waveform from an output of inverter circuit. The waveform is not smooth because the inverter circuit is not connected with the capacitor. As seen, the testing circuit and simulation circuits are not the same because the components that been using in simulation are hardly to find in market. Otherwise, the component that used for testing mostly new made component and rarely found in simulation software library. So that, the components used are different, the methods and results obtained are the same for both testing. Additionally, as shown in Fig; the inverter circuit is successfully run an AC load such as lamp.

Types of Circuit	Vin(V)	Vout(V)	Iout(A)
Boost Circuit 1.5V-5V	0.7	5.01	0.02m
Boost Circuit 5V-12V	05	12.12	0.02m
Inverter Circuit	12	236.0	0.5m

Table No.1 Input and Output Power of all Circuit



VIII. CONCLUSION

As the conclusion, the design and development of thermoelectric generator kit was successfully done. The kits are functioning well while testing it using supply. Some of the objectives of this project are achieved. Thermoelectric generator is proved to be able to generate electricity from heat. Unfortunately, the inputs current are too small so it cannot able to run any load. Sources of heat can be found everywhere and anywhere and the most places it can be found is at home. Mostly housing appliance produce a heat either at low temperature or high temperature including heat from car engine. Temperature difference is directly proportional with the output voltage that produced by TEG. The small output voltage that produces from the TEG will step up by boost circuit. But the output current from TEG is very small around 0.02mA. It is because only one TEG is used in this project. So it is unable to run any load due to small value current. Besides, these projects are conducting on hardware and simulation. The simulation that has done by using Simulink shows that the performances of the kits are the same results with hardware testing.

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