Thermoelectric Generator

AJIT KUMAR MISHRA[1], MRITUNJAY SHUKLA[2], SHIKHAR SHARMA[3], PROF. RAHUL DESAI[4]
[1, 2, 3, 4] *Department of Electrical Engineering, Bharati Vidyapeeth Deemed University, College of Engineering, Pune*

Abstract- ***In today's environment we are more focused and interested in deploying sustainable and renewable energy that produce less carbon emission and eco-friendly energy. Energy users are continuously asking for instruments that can gives us required amount of energy for their domestic and other uses, at the time when power is unavailable as well as addition to their normal usage. The most prominent difficulties coming with these devices are there designs are complex, bulky and expensive. In addition to that energy sources for these type of renewable energy generators is not available in ready to use form. What we needed is to design a generator that will be low in cost, storable and easy to use that provides supplemental energy to the home or emergency backup electricity if there is power cut. We are believing to design a thermoelectric generator that can use waste heat energy produce by machinery works and other process that produce thermal energy. The major advantage of this generator is that the electricity produced is clean, safe and user friendly.***

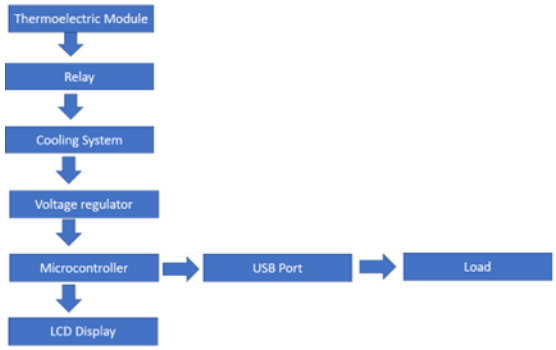
Indexed Terms- ***THERMOELECTRIC GENERATOR, ECOFRIENDLY ENERGY, THERMOELECTRIC MODULE, VOLTAGE REGULATOR.***

I. INTRODUCTION

The project is to design a low cost, storable, easy to use thermoelectric generator that will provide us supplemental electrical energy to the home and backup electricity if there is power cut. The generator that we are designing will utilises the waste heat produce in mechanical machine operation like silencers and combustors as input energy source. The TEGs answers the need for a sustainable, small, simple home energy source. The design of the TEGs went through following main stages. Each stage was defined by the breakthroughs or changes in the method of heat transport. In the first stage, heat is collected directly by thermoelectric module which converts heat into electrical energy by the phenomenon of Seebeck effect. This approach is simple and little effort of the part of the user. The second stage is voltage regulation with the help of voltage regulator named LM78XX series voltage regulator to control the output voltage given by thermoelectric module. The third stage is microcontroller and liquid crystal display part that is for automatic control and digital interface that helps to understand the working conditions of the TEG.

II. WORKING

A TEM is composed of many thermoelements like bismuth telluride in series electrical link for increasing operating voltage and also in parallel thermal connection to improve the thermal conductivity. Thermoelectric module convert heat energy to electrical energy on the basis of Seebeck effect when there is temperature difference occurs. The electrical equivalent circuit of thermoelectric generator is a voltage V and an internal resistance R, which is similar to a battery. Thermoelectric modules are placed directly on the top of surface and mounted uniformly over the available surface of the heat exchanger. The cold-side temperature of the modules is maintained by the coolant system.



Block Diagram of TEG

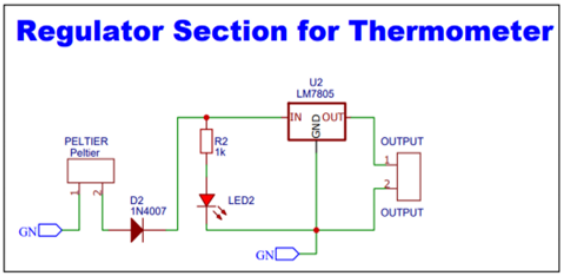
III. MAIN COMPONENTS

3.1 THERMOELECTRIC MODULE

A thermoelectric module is used for both heating and cooling purposes. A TEM also used for power generation purpose where we need to apply a temperature difference across the module to generate a current. It mainly contains n and p-type doped semiconductor materials which are connected thermally in parallel and electrically in series. They are mounted between two ceramic layers that keep the overall structure together mechanically. It insulate the individual elements from one another electrically and from external mounting surfaces. Most TEM comes in size of approximately 2.5-50 mm (0.1 to 2.0 inches) square and 2.5-5mm (0.1 to 0.2 inches) in height. Both of these types that is N-type and P-type Bismuth Telluride thermoelectric materials are used in a TEG. N-type material is highly doped so that it will have an excess of electrons and P-type material is doped so that it will have a deficiency of electrons. By varying temperature we can control the output current generate across the module.

3.2 LM78XX SERIES VOLTAGE REGULATOR

A voltage regulator is use to generate a fixed output voltage that remains constant regardless of changes to its input voltage or load conditions. A linear regulator employs controlled by a high gain differential amplifier. It compared the output voltage with precise set voltage and adjusts the pass device to maintain a constant output voltage. A switching regulator is use for converting the dc voltage into a switched voltage applied to a power MOSFET or BJT switch. The output voltage is then feedback to the circuit for controlling the power switch on and off times so that the output voltage remains constant regardless of input voltage or load current changes. The power dissipation of a voltage regulator is directly proportional to its output current for a given input and output voltage, which efficiencies can be 50% or even lower. Using the optimum components, a switching regulator can achieve efficiencies up to 90%. The linear regulator has much lower noise than a switching regulator with the same output voltage and current requirements. Typically, the switching regulator can drive higher current loads than a linear regulator

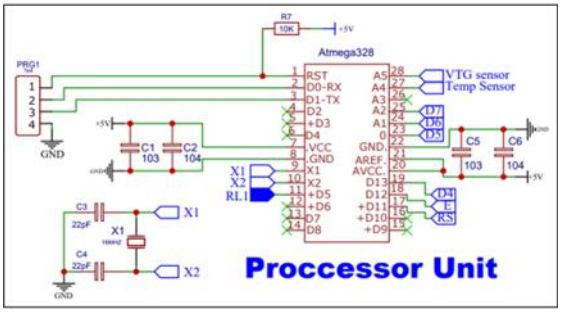


3.3 MICROCONTROLLER

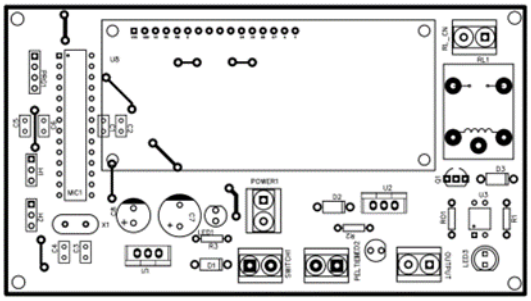
ATmega328P is one of the high-performance AVR technology microcontrollers with a large number of pins and features. It is designed with 8-bit CMOS technology and RSIC CPU which enhance its performance and its power efficiency get improved by auto sleeps and an internal temperature sensor.

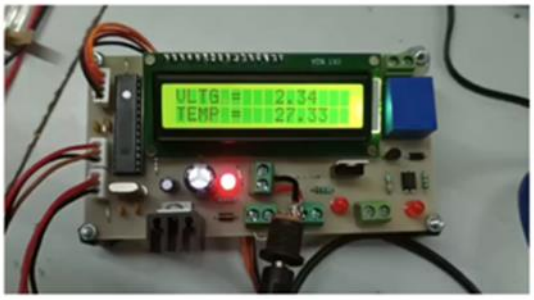
The IC allows multiple modern era communications methods for other modules and microcontrollers themselves, which is why the microcontroller ATmega328P usage has been increasing every day.

ATmega328P IC comes with internal protections and multiple programming methods which helps the engineers prioritize this controller for different situations.



Circuit Layout





3.3 Model Functioning

As we have seen we have three major components in our working model of TEG, i.e. Thermoelectric modules, Voltage regulator and Microcontroller (ATmega328P). We have attached a hot pan at on side of the module which result in temperature mismatched between two modules. This results in generation of power. We have also attached LCD to monitor the power generation and temperature of the Module. In attached picture, we can see that our working TEG model produce 2.34 volts at the temperature 27.33^ Celsius.

IV. RESULT

As we see efficiency of the generator is quite low because of their relatively low conversion efficiency. As for the convenience, we take the maximum temperature difference (68°C) which is a very modest value, higher temperature differences would result in higher efficiency. Generally thermoelectric devices requires temperature difference approximately up to 500°C to achieve an efficiency upto10%.

V. ADVANTAGE

- No moving parts
- Quite operation
- Longer life
- Low maintenance
- Environmentally friendly

VI. APPLICATION

- It can be used to charge mobile phones and tablets
- It can be used to feed cooling system of heavy machinery
- It can be used to light led bulbs

VII. CONCLUSION

This project determines the performance of the thermoelectric generator under mismatch conditions such as the limited working temperature and the inconsistent temperature distributions among the modules in series connection.

We have observed and record the data which highlights the effect on the electrical performance when there is temperature difference between two modules of thermoelectric modules. It can be concluded that a proper temperature difference applied between modules will improve the performance of the TEG. The experimental results shows that the power loss of the module in series connection is significant, 15% less than the theoretical value due to temperature mismatch condition. This situation can be improved from thermal insulation on the module and the power loss due to the inconsistent temperature distribution.

REFERENCES

[1] R. Ahiska, S. Dislitas Computer controlled test system for measuring the parameters of the real thermoelectric module
[2] C. Yu, K.T. Chau Thermoelectric automotive waste heat energy recovery using maximum power point tracking
[3] Yang jihui, R. Stabler Francis Automotive applications of thermoelectric material
[4] D.T. Crane, J.W. Lagrandeur Progress report on BSST Led US Department of Energy automotive waste heat recovery program
[5] Hongliang Lu, Ting Wu Experiment on thermal uniformity and pressure drop of exhaust heat exchanger for automotive thermoelectric generator