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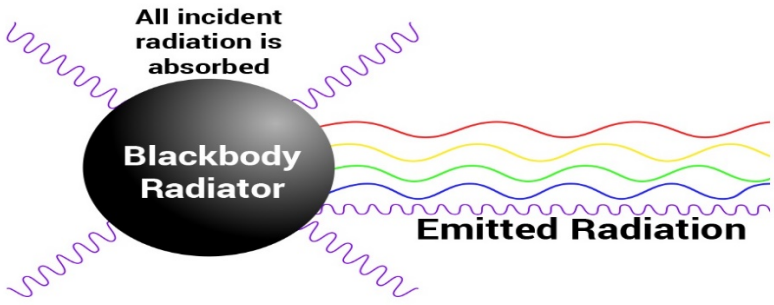
THERMOELECTRIC POWER GENERATION USING BLACKBODY RADIATION

Abstract

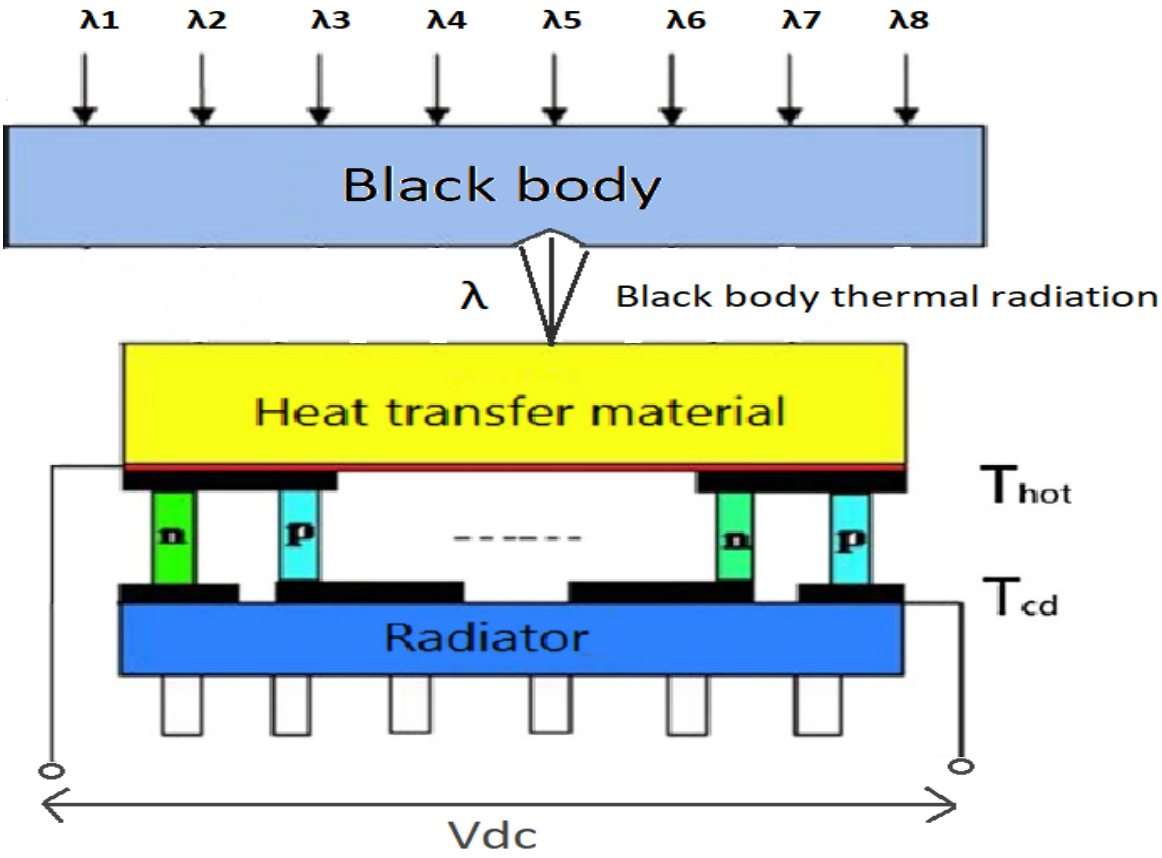
In the recent decades, the development of PV cells is phenomenal in the field of energy generation but there is a large amount of heat that is being wasted and has to be exploited. By using blackbody material which absorbs radiations irrespective of wavelengths. We are building an integrated thermoelectric generator that can even serve as an alternative for PV cells and also harvests waste heat. Previous studies have done this using solar tubes and air as a thermoelectric medium and temperature gradient is created w.r.t to the earth's surface which leads to the generation of electric potential. But we are building a module having blackbody as a perfect absorber so that no heat is being atrophied and water as a thermocouple coolant. The main amenity of this is we get large temperature difference for a constant colder side (high seebeck coefficient). Due to increasing demand for the fuel efficiency and stringent emission regarding carbon, the government has uplifted the market for thermoelectric generator. From this we can have a sustainable, economical and compact devices that can be inverted for domestic purpose. From this we can implicate that the thermoelectric generator can standalone in place of solar thermal cells with better conversion efficiencies. And also it manifest that it will be going to replace alternators in hybrid vehicles.

Introduction

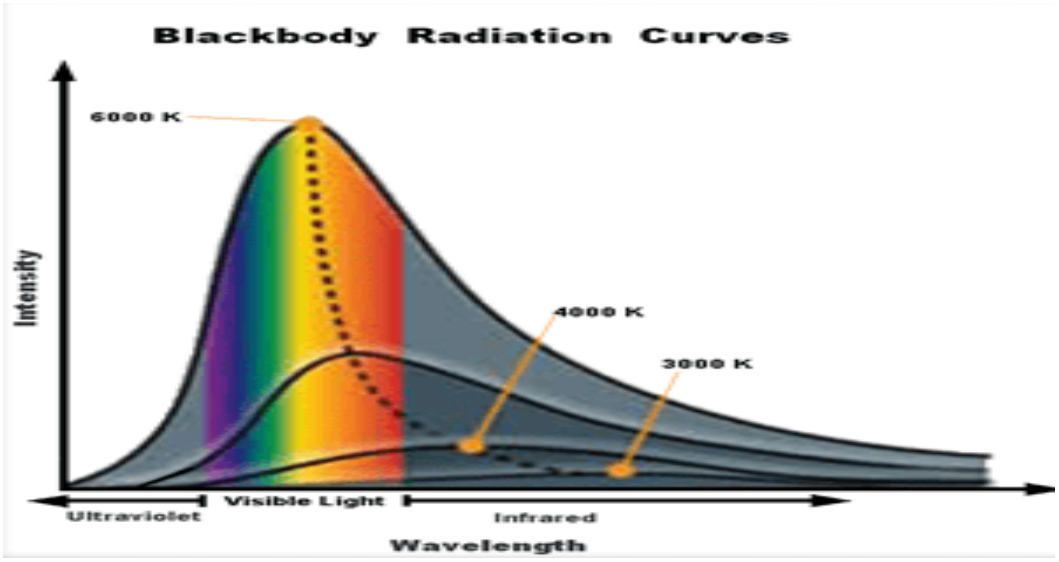
In this model black body used as a absorber/collector which absorbs electromagnetic radiation of all wavelengths. A black body neither reflects nor transmits radiations, but it emits thermal radiation/blackbody radiation which is a function of temperature (of black body). The emission is independent of incident radiations wavelength as it obeys wein's displacement law, which states that as the temperature of the blackbody increases the wavelength of the emitted radiation decreases i.e. frequency increases. This thermal black body radiation emitted is focused on temperature sensitive materials whose properties changes as the temperature changes. When thermal black body radiation is focused on one side of the temperature sensitive thermo electric material with radiator (i.e. cold water) setup for creating temperature gradient then voltage is produced this effect is called the Seebeck effect. It is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage. This Voltage produced is D.C therefore for distribution purposes it is inverted then step-upped using a transformer.



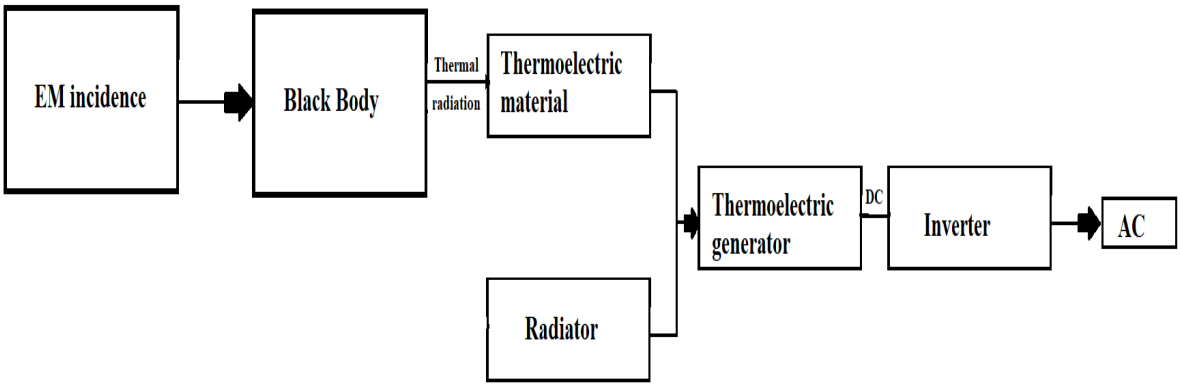
Methodology



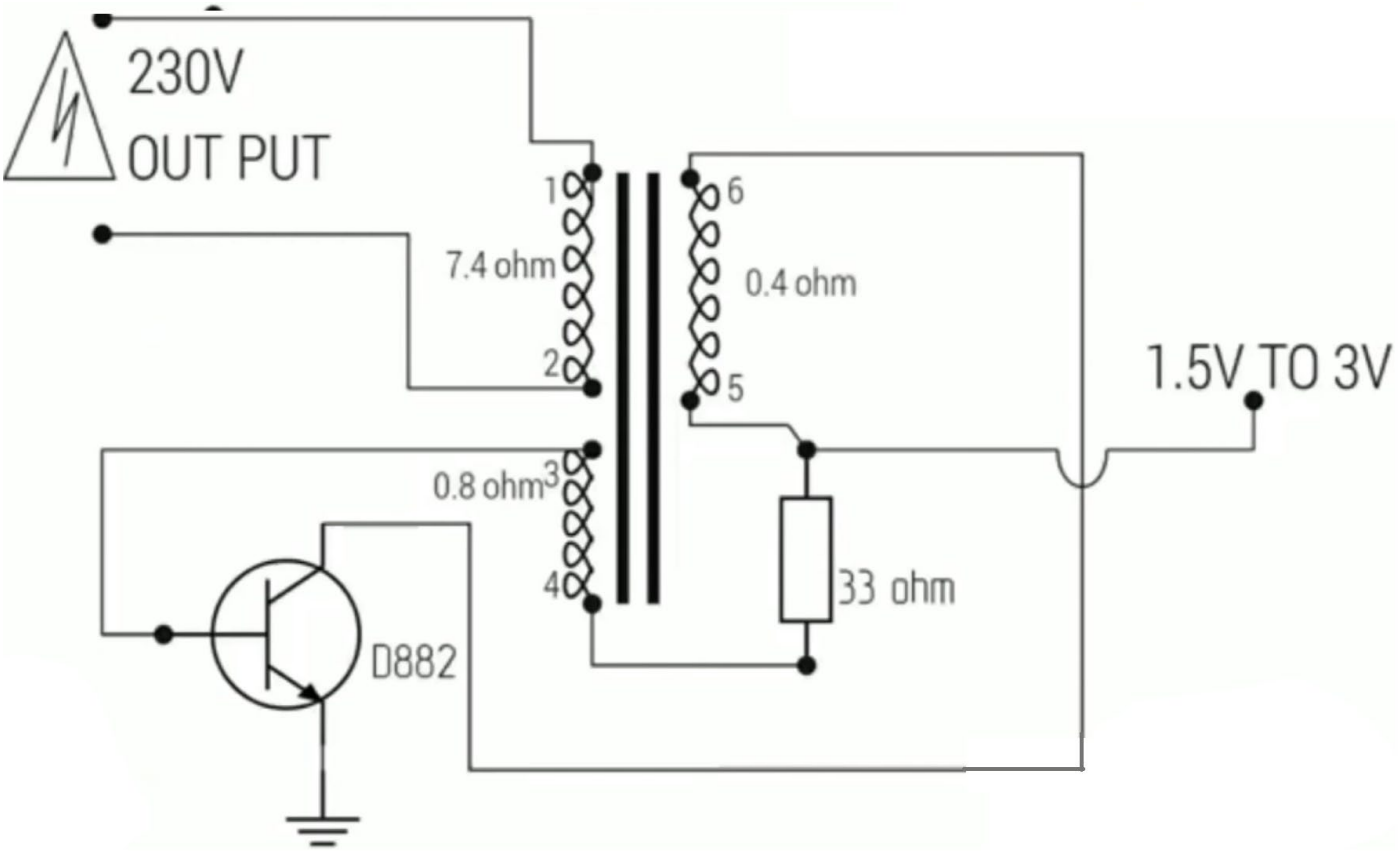
Dependence of Intensity on wavelength



Block diagram representation of the model



Inverter/Transformer Circuit



Motivation

Compared with other electrical generation methods, the thermoelectric power generation method in this paper has multiple advantages. The location advantage is significant, as the thermoelectric power generator designed and characterized in this study is suitable for placement in remote and complex natural environments (with varying temperature, no human existence, no water, no wind, large distances from urban areas, and difficult access to electricity), where other methods of

electrical generation, such as fossil electrical generation, nuclear electrical generation, wind electrical generation and hydro electrical generation, are not regularly available.

As energy waste has become one of the main reasons for energy crises, the application of thermoelectric technology plays an important role in alleviating the arrival of the energy crisis. Finally, the cost of one thermoelectric power generation device is much lower than other electrical generators.

Materials	**ZT (figure of merit)**
Bi_2Tc_3	0.8-10
PbTc	1.5 at 773K
Sodium doped PbTc	1.4 at 750K
$Ba_8Ga_{16}Si_3o$	0.87 at 870K
LM_4X_{12} L – rare earth metal M – Transition metal X - milalloid	>1.0
$Ca_3Co_4O_9$	1.4 – 2.7 at 900K

***ZT:** Figure of merit is used to determine the efficiency of thermoelectric generators

Nasa is developing a multi-mission Radioisotope thermoelectric generator in which the thermocouples would be made of “Skutterudite” that would generate 25% more power than the current designs.

Social Impact

1.There are used in Solar power plants in order to convert waste heat into additional power

2. Thermoelectric generators increases fuel efficiency of the automobiles by making use of waste heat produced by it.

3. Thermoelectric generators are commonly used on gas pipelines for power consumption up to 5KW.

4. Many space probes, including the Mars Curiosity rover, generate electricity using a radioisotope thermoelectric generator whose heat source is a radioactive element.

5. TEG is an alternative method it acts as a backup for solar PV cells when solar panel is down, and the backup battery goes into deep discharge.

Advantages of Thermoelectric Generators

1. **Reliability** - Thermoelectric generators are solid-state devices. Having no moving parts to break or wear out makes them very reliable. Thermoelectric generators can last a very long time. The Voyager 1 spacecraft thermoelectric generator, as of this writing has been operational for 41 years. It has traveled over 13 billion miles without any maintenance or repairs.
2. **Quiet** - Thermoelectric generators can be designed to be completely silent.
3. **No Greenhouse Gases** - Thermoelectric generators do not require any greenhouse gases to operate. Some energy conversion technologies do.
4. **Wide Range of Fuel Sources** - Thermoelectric generators do not have restrictions on fuels that can be used to generate the needed heat. Many other energy conversion technologies do.
5. **Scalability** - Thermoelectric generators can be designed to output power levels smaller than microwatts and larger than kilowatts.
6. **Mountable in Any Orientation** - Thermoelectric generators operate in any orientation. Some energy conversion technologies are sensitive to their orientation relative to gravity.
7. **Operation Under high and Zero G-forces** - Thermoelectric generators can operate under zero-G or high-G conditions. Some other energy conversion technologies cannot.
8. **Direct Energy Conversion** - Thermoelectric generators convert heat directly into electricity. Many energy conversion technologies require intermediate steps when converting heat to electricity. For example, heat energy from fuel is converted in a turbine to mechanical energy, then mechanical energy is converted to electricity in a generator. Each energy conversion step adds losses in the form or waste heat. This makes thermoelectric generators less mechanically complex than some other energy conversion technologies.
9. **Compact Size** - Thermoelectric generators can be designed to be very compact. This leads to greater design flexibility.

Market Survey

In a paper published this week in the *Proceedings of the National Academy of Sciences*, the MIT researchers identify the underlying property that makes certain topological materials a potentially

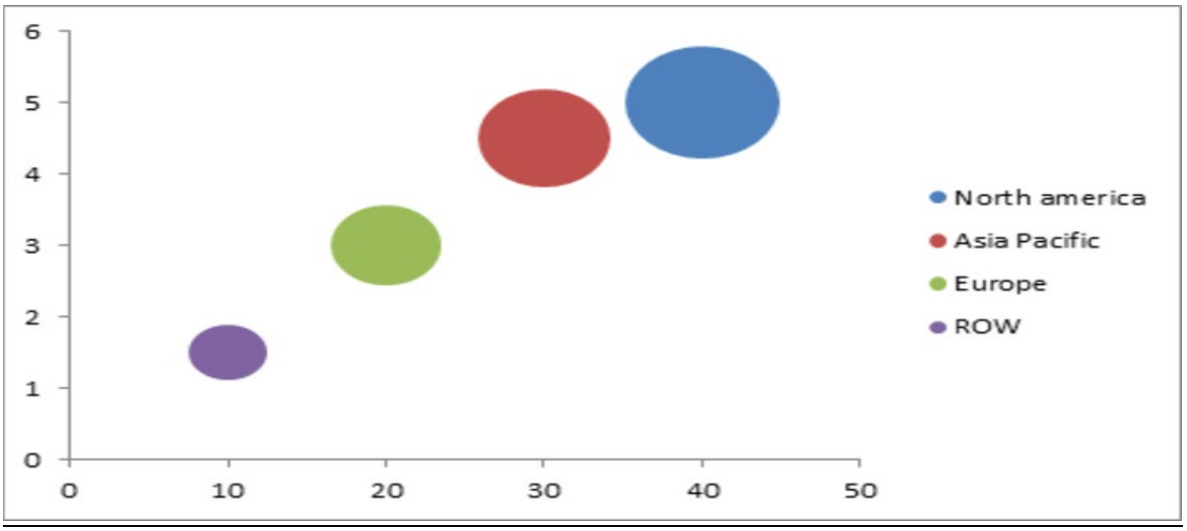
more efficient thermoelectric material, compared to existing devices. “We’ve found we can push the boundaries of this nanostructured material in a way that makes topological materials a good thermoelectric material, more so than conventional semiconductors like silicon,” says Te-Huan Liu, a postdoc in MIT’s Department of Mechanical Engineering. “I think topological materials are very good for thermoelectric materials, and our results show this is a very promising material for future applications,” Liu says.This research was supported in part by the Solid-State Solar Thermal Energy Conversion Center, an Energy Frontier Research Center of U.S. Department of Energy; and the Defense Advanced Research Projects Agency (DARPA).

The thermoelectric generator converts the heat into electrical energy. Increasing demand for fuel efficiency and stringent emission regarding carbon from the government has boosted the market for thermoelectric generator. Automotive segment has largest share in the thermoelectric generator market, due to increase in the automotive manufacturing across the globe. The growth in global thermoelectric generators market is likely to be challenged by factors such as high price and low efficiency of the thermoelectric generator. The global thermoelectric generator market is expected to show a growth at CAGR of about 14% from 2016 to 2021.

Market Segmentation

Regional Analysis of Global Thermoelectric generator Market North American region held the largest share of the global thermoelectric generator, followed by the Asia-Pacific. Asia-Pacific is expected to grow at highest CAGR for the thermoelectric generator market. Increased demand of thermoelectric generators by automotive industries to increase the fuel efficiency and increased industrialization in the region is expected to drive the thermoelectric generator market.

Thermoelectric generator Market, by Region (USD Million)



Key Players: The key players of Global Thermoelectric generator Market report include- Gentherm, Inc., II-VI Incorporated, Ferrotec Corporation, Laird PLC, Komatsu Limited, Yamaha Corporation, Evident Thermoelectrics, Tecteg, Alphabet Energy, and Tellurex Corporation.