Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 1, No.1, January : 2025

SMART POWER GENERATION FROM WASTE HEAT BY THERMOELECTRIC GENERATOR IN ELECTRONICS DEVICES

Anurag Patel,
Dr. Sanjay K Sharma, Head of Dept. of Electronics and Communication Engineering, of University Institute of Technology Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (M.P.)

ABSTRACT
One of the biggest problems facing Electronic Communication Device is the energy dissipation of devices at high data rates. The heat generated by these devices can impact the performance as a result of a new type of outage called power-consumption outage. Based on the heat transfer model in smartphones, Laptop & candle the power-consumption outage probability is analyzed.The main aim of this project is to develop a cleaner noise less cost effective way of power generation, which will help to reduce the global warming, as well as reduce the power shortages, load shed and also we can transfer. Keywords Thermometric generator as a renewable energy source Using in TEG , Space exploration and satellite power using in TEG using in TEG ,Remote power generation in off-grid locations using in TEG , Waste recovery and industrial applications using in TEG , Eco-friendly This project uses a generator to convert waste heat into electricity .A waste heat can be used as a input source to generate electricity and can be charged directly mobile battery and also stored in a rechargeable lead acid battery for further usage.

***Keywords**: Thermometric generator, Seebeck effect, waste-heat recovery, alternative green technology, direct energy conversion, thermocouple, thermal shield, thermoelectrimaterials, thermo electric module.*

I. INTRODUCTION
TEG is used to convert thermal electricity (heat) into energy primarily based on Seebeck effect immediately. In 1821, J. T. Seebeck (1770-1831) located that dissimilar metals which might be related at one-of-a-kind locations (junctions) will develop a micro-voltage if the two junctions are held at one-of-a-kind temperatures. This effect is referred to as the "Seebeck Effect".

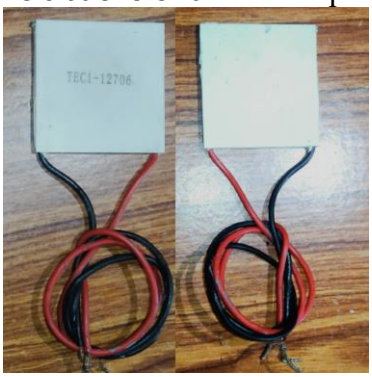


FIGURE 1: THERMOELECTRIC GENERATOR-12706 (Front & Back)
The waste heat to generate energy by means of the use of this thermometric electricity era (TEG) TEC12706 devices proven whenever heating of one floor (waste heat example fridge outer surface warmness, PC warmness, ion field heat, sun radiation warmness, even human) is likewise an enter of thermometric powered generator.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 1, No.1, January : 2025

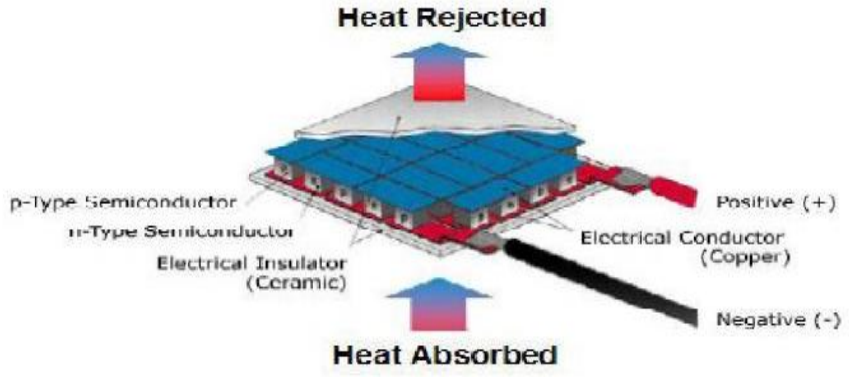


FIGURE 2: Schematic diagram of a thermometric generator

whist warmness is implemented one facet there will be anon-stop electron or holes will waft continuously based at the temperature of warmth. If the temperature is will increase the sort of manner that the other facet of thermometric generator is bloodless due to the fact warmness rework is uniform then only electron will go with the flow and voltage is developed at the output facet of the thermometric generator Fig, block diagram Voltage regulator (manipulate circuit) in this part voltage from the TEG is regulated with the aid of required voltage for mobile charge

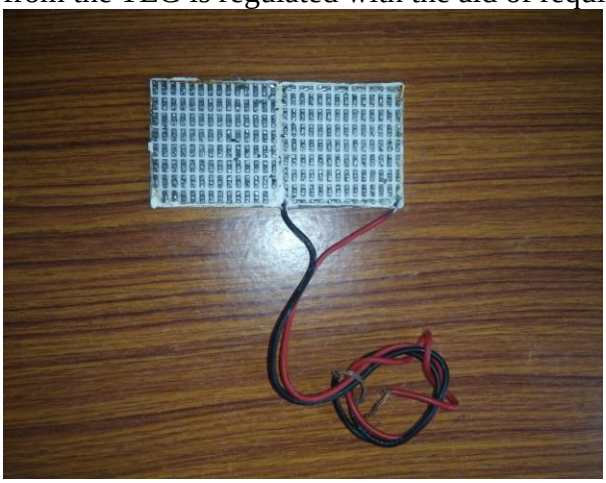


FIGURE 3: THERMOELECTRIC GENERATOR-12706 Fins

Thermoelectrical generator is consist of following parts-

1. Thermometric Module
2. Thermometric shield
3. Thermal Fin
4. Copper electrode

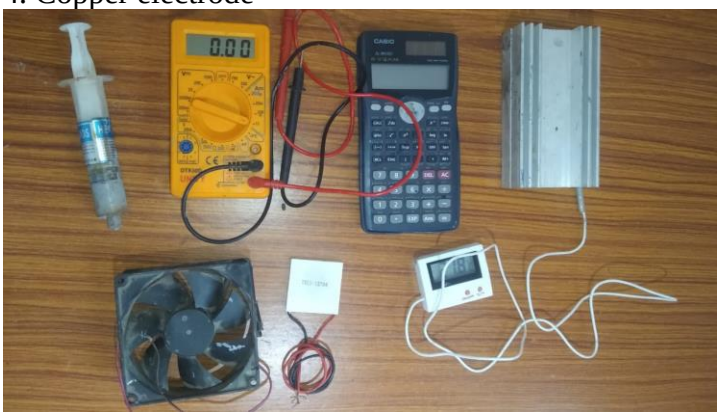


FIGURE 4:Using experiment component

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 1, No.1, January : 2025

PROPOSED METHODOLOGY

Seebeck effect turned into found in 1821 through the Estonian physicist Thomas Johann Seebeck. The phenomenon suggests that the temperature difference among two electrical conductors or semiconductors from awesome fabric nature produces a voltage among those two substances.

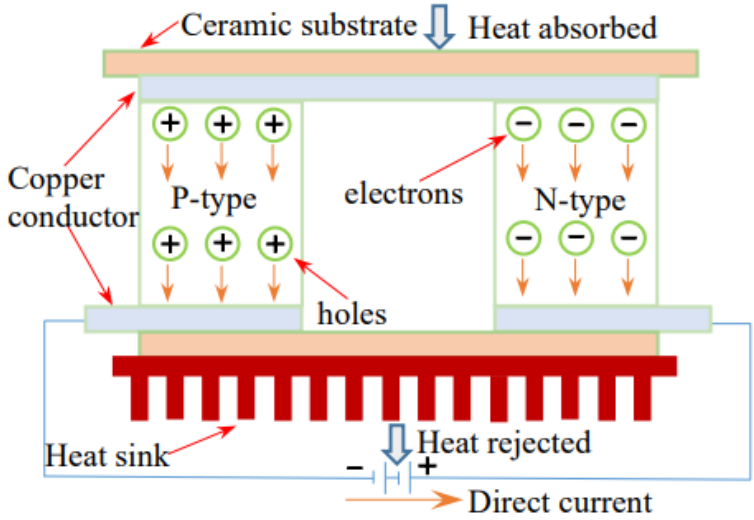


FIGURE 5: Heat flow through TEG module.

while warmth is implemented to one of the two conductors or semiconductors, the electrons became dynamic by means of the heat. considering the fact that only one side of the connection is subjected to warmth, the electrons begin to pass toward the cooler side of the two conductors. If the two conductors are related within the shape of a circuit, a right away modern will drift through the circuit.

The voltages derived from the Seebeck effect are reduced. The voltage range produced is typically inside the order of micro volts (millionth of volt) with the aid of temperature unit.

If the temperature distinction is tremendous sufficient, a few devices might also produce a few millivolt. numerous devices can be connected in parallel to increase the power deliver ability. these devices were proven to provide a small-scale stage of electrical electricity if a massive temperature difference is maintained among the junctions.

II. LITTERATEUR REVIEWED

Thomas Jon Seebeck (1934) invented that a temperature formed between assorted conductors produces a voltage and present day. on the heart of the thermometric generator effect is the fact that a temperature difference in a undertaking material outcomes in warmth drift among one aspect to any other facet

Hrutika Karpe studies to meet the global warming and the alternative approach of those purpose. Thermometric era package is one the first-class technique to achieve this .It use TEG plate to play this role. TEG direct converts warmth powerinto electric energy. The software of this technology also can improve the overall performance the of strength conversion structures feasible energy generation is viable because of waste warmness emitted from the automobile this approach involve the methods like seeback effect and thermometric impact. in line with Seebeck effect in case you generate a temperature gradient across the junctions of varied conductors, electrical contemporary might go with the flow.

M Akif Kunt research about the TEG module structure TEG module in exhaust gadget. In his examine, thermoelectric generator which turned into aircooled was designed to recycle waste warmth power of exhaust systems of ICengines and its performance became examined. The consequences acquired effects were as compared with the results of analysesand experiments. most voltage fee at RI = 45O load resistance became acquired as 11.03 V (experiment) andeleven.22 V (evaluation), and maximum cutting-edge price at RI = 5O load resistance as zero.42 A (test) at Th = 250 C, DT= 40

Mohd. Quasim Khan , S Malarmannan , G Manikandaraja centered their have a look at on warmth exhaust fron the automobile engine, how much we will use or how a good deal strength we misplaced within the surroundings inside the form of global warming and all but ourundertaking is specifically centered on the two wheelers and there exhaust system and heat used but the concept is aproxmatily equal . . The IC engines which might be utilized in vehicles have most .25 to 0.30 efficiency and rest of the heat strength which is burned in combustion chamber transferred to the exhaust and then to the environment. The installation function and thermoelectric materials also has a critical position in enhancing the performance

III. TEST ANALYSIS OF TEG

1. TEST AnalysisTEG-12706 Heat source from candle
2. Flexible thermometric device to harvest waste heat from the laptop
3. Flexible thermometric device to harvest waste heat from the Mobile Device

3.1: Test AnalysisTEG-12706 Heat source from Candle

INTRODUCTION

The TEG-12706 is a thermometric generator (TEG) module, which can convert heat into electricity based on the Seebeck effect. Here's a general guide on how to harvest waste heat using the

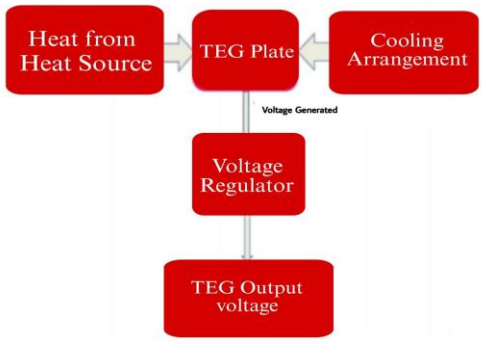


FIGURE 6: Block diagram Basic TEG Working

Materials Needed:

TEG-12706 module
Heat source (heat from Candle .)
Heat sink (to create a temperature gradient)
Thermal interface material (e.g., thermal paste, grease)
Electrical connections (wires, connectors)
Load or battery (to store or use the generated electricity)

WORKING

Identify the Heat Source: Identify a waste heat source such as an engine, exhaust, or industrial equipment. The TEG-12706 operates best with temperatures between 25°C and 150°C on the hot side. This time I have using CANDLE as a heat source .

Prepare the Heat Sink: A heat sink is necessary on the cold side to create a sufficient temperature difference. Common heat sinks include metal fins, liquid cooling systems, or simply a cooler surface.

Apply Thermal Interface Material: Apply thermal paste or grease to both sides of the TEG-12706 to ensure efficient heat transfer. This minimizes thermal resistance and ensures the module captures the maximum amount of heat.

FIGURE 7: Apply Thermal Interface Material

Mount the TEG-12706: Attach the hot side of the TEG to the heat source.

Attach the cold side to the heat sink or a cooler surface. Make sure there is a sufficient temperature difference between the two sides.

Electrical Connections: Connect the output terminals of the TEG-12706 to an appropriate load or a power storage device (like a battery). The TEG-12706 typically generates low voltage, so you might need a boost converter to increase the voltage for practical use.

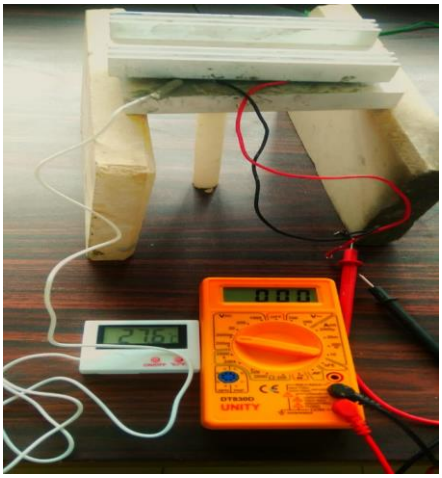


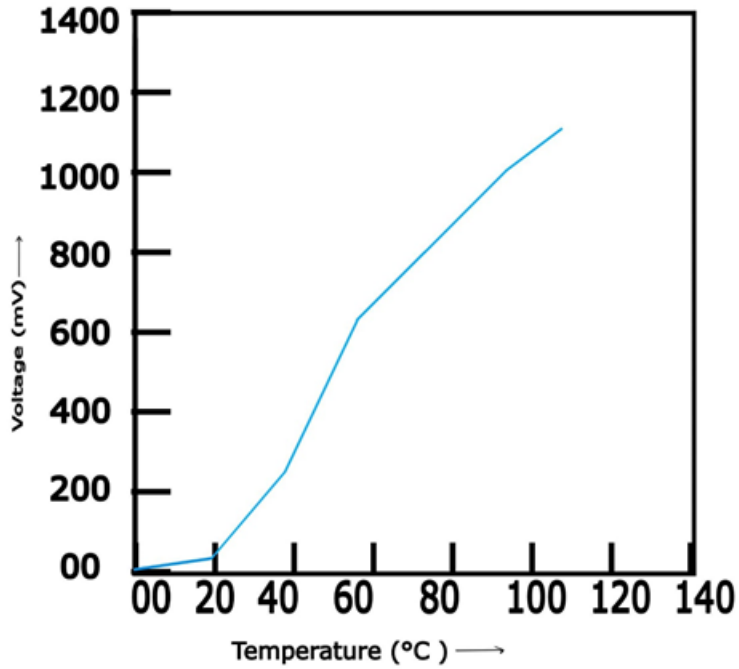
FIGURE 8: Test AnalysisTEG-12706 Heat source from Candle at room temperature (25°C)

Optimize the Temperature Difference: The greater the temperature difference between the hot and cold sides, the more electricity will be generated. Use a good heat sink to ensure the cold side stays as cool as possible

Monitor the Output: Measure the voltage and current output from the TEG-12706. For the TEG-12706, the open-circuit voltage can go up to about 00- 1050 (mV) depending on the temperature gradient 25-100 degree centigrade

FIGURE 9:Test AnalysisTEG-12706 Heat source from Candle at temperature (98°

GRAPHS 1: Variation Temperature (in Celsius) with Voltage (in Millivolt) using CANDLE in TEG-12706



3.2: Flexible thermometric device to harvest waste heat from the laptop

INTRODUCTION

The trouble with majority of laptops is they produce dangerous amounts of waste warmness which can damage the computer as an entire. If a TEG tool (thermometric generator) is inserted in between the CPU and CPU cooler, then it will produce a voltage that may be trickled charged again into the battery of the computer. To do that the CPU can be inserted in among the CPU cooler and the real cpu. Then have to be stressed in order that the voltage made from the TEG could be trickle charged again into the battery. This permits for the capacity of the TEG to provide voltage by means of sincerely the usage of the computer. This does in truth paintings and has been tested on different laptops, one in every of which has a single CPU, the opposite is a twin CPU system with two separate TEGs included into the layout. If a TEG device is inserted in among the CPU and CPU cooler, then it does in reality produce voltage that may be trickle charged lower back into the battery.

which means the greater a laptop is used (if the TEG is nicely applied into the system's design) it's going to produce voltage by using harnessing the dangerous byproduct of warmth, which could in flip rate the battery through certainly the usage of the pc. future paintings on this will consist of finding a manner to make the dangerous byproduct of warmth greater extreme to consequently produce extra power, with out overheating the system.

WORKING PROCESS

Complete setup to converting the waste heat emitted from the laptop into electric Energy or power by Thermometric Generator complete setup to harvesting wast heat in pc is proven in fig while warmness is carried out to the recent aspect the TEG get absorb the warmth from any frame (ex-refrigerator warmth, pc warmness, warmth from the car, solar heat, or even human frame is likewise a waste warmth supply for TEG).

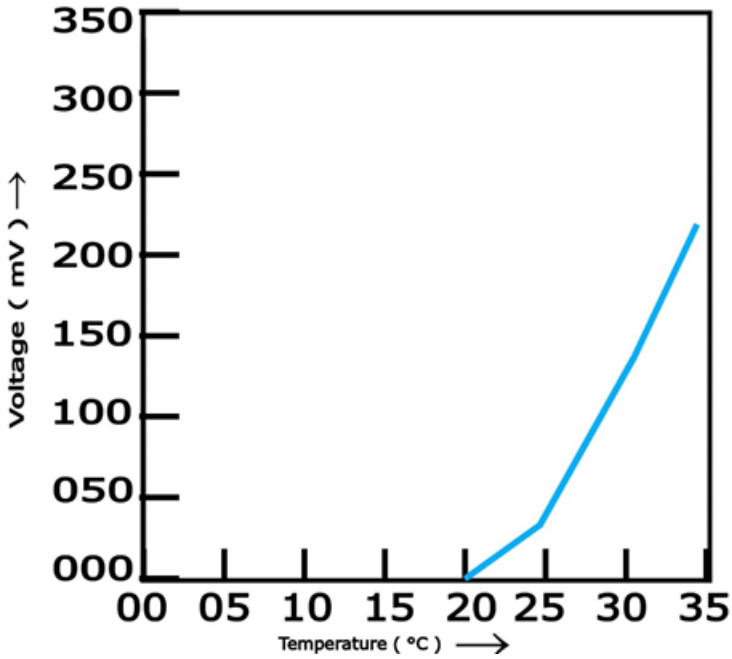
First of all we take laptop, thermometric generator, thermometer, voltmeter, and heat sink and prepare a good setup in which we keep thermometric generator on top and heat sink below it and connect voltmeter to thermometric generator (positive end to positive end of thermoelectric generator & voltmeter and negative end to negative end) after this we keep laptop on top which is shown in the figure, after keeping laptop we keep using it so that heat starts generating from it and temperature keeps increasing and when temperature keeps increasing .

below this whilst warmth absorbs one facet it rejected at the other aspect (bloodless side) heat transfer take region from warm surface to cold floor. in order that the electron will flow to thru copper conductor to the whole. circuit so voltage can be regulated on the circuit.then our output additionally keeps growing like if the temperature goes up to 35 °C then our output comes up to 243 (mV), so in this way we harvest the waste heat of laptop and convert into electric energy

FIGURE 10:Working Process in Flexible thermometric device to harvest waste heat from the laptop

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 1, No.1, January : 2025

GRAPHS 2: Variation Temperature (in Celsius) with Voltage (in Millivolt) using LAPTOP in TEG-12706



3.3: Flexible thermometric device to harvest waste heat from the Mobile Device

INTRODUCTION

The cause of the research is to build a TEG(Thermometric Generator) kit which the cell cellphone the usage of the waste warmth . till now in India there is no any mobile telephone to be had in which provision for cellular cellphone charging is available with the assist of waste warmness. our device works on the principle of Seebeck impact. in line with seeback impact whilst one aspect of the TEG plate is hot and the opposite is cold, the temperature difference outcomes in the conversion of voltage distinction. This task makes a speciality of the use of the waste heat of bike exhausts and changing the warmth strength into electrical strength with the help of TEG(Thermometric powered Generator). The package accommodates of TEG modules that are made up of semiconductors. Bismuth tellurium(Bi2Te3), lead telluride(PbTe), and silicon germanium(Si Ge) are generally used semiconductors. This package takes the warmth electricity from the mobile smartphone and the cooling is completed through the loose convection with the assist of fin attached on the alternative facet of the TEGmodule. This temperature difference is converted into voltage difference by way of TEG module. This voltage distinction is in addition regulated through voltage regulator and ultimately can be used for cell telephone charging. it's miles best option for cellular telephone charging because it makes use of the waste warmth and additionally now not affect the environment as it isn't causing any kind of pollution. This mission is ordinary value saving and environment pleasant

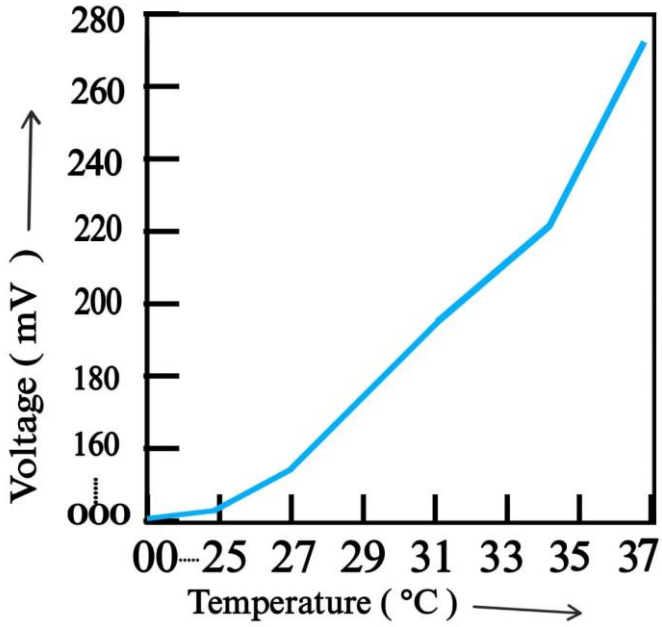
WORKING PROCESS

First of all we take mobile phone, thermometric generator, thermometer, voltmeter and heat sink and prepare a good setup in which we keep thermometric generator on top and heat sink below it and connect thermometer to it and connect voltmeter to thermometric generator (positive end to positive end of both and negative end to negative end) after this we keep laptop on top which is shown in the picture, after keeping mobile we keep using it so that heat starts getting generated from it and temperature keeps increasing and when temperature keeps increasing then our output also keeps increasing like if the temperature goes up to 31 degree centigrade then our output comes up to 230 mV, so in this way we harvest the waste heat of mobile and convert it into electric energy.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 1, No.1, January : 2025

FIGURE 12: Working Process in Flexible thermometric device to harvest waste heat from the Mobile phone

GRAPHS3:Temperature (in Celsius) with Voltage (in Millivolt) using MOBILE PHONE in TEG-12706



IV. CONCLUSION

The voltage generated by the TEG-12706 increases as the temperature difference cold sides grows.The TEG module typically produces around 10-15 mV per degree Celsius of temperature difference.The table reflects the relationship using typical temperature heat source.

Laptops produce variable heat depending on workload, which may cause fluctuations in voltage output. Light workloads generate lower heat and thus lower voltages, while heavy tasks produce more heat, increasing the voltage.Practical Application:While the TEG-12706 may not produce large amounts of energy, it can be useful for small-scale energy harvesting applications, such as powering low-energy electronics (e.g., sensors, small devices) or for charging small batteries using waste heat from laptops or other electronics.

The experiment confirms a linear relationship between the temperature difference (ΔT) acrosstheTEG-12706 and the voltage output (in millivolts). As the temperature difference increases, the voltage produced also rises, typically by 10-15 mV per °C.Voltage Output from Laptop Heat: laptop as the heat source, temperatures on the hot side of the TEG ranged from20°Cto45°C, depending on the laptop's usage (e.g., light browsing or heavy gaming). This resulted in a voltage

output ranging from 010 mV to 400 mV.The maximum voltage of 450 mV was recorded difference reached 45°C (with the cold side at 20°C and the laptop heat side at 45°C).
The TEG-12706 is capable of converting heat from a mobile phone into electricity, but due low heat output of phones, the voltage generated is generally lower (around010-280)mV depending on the usage and temperature difference). This shows that the TEG-12706canstillbe effective in energy recovery from mobile phone waste heat, though the scale of energy harvested will be smaller than from larger heat sources like laptops or other electronic devices. The TEG-12706 is capable of converting heat from a mobile phone into electricity, but due to thermometric low heat output of phones, the voltage generated is generally lower (around010-280mV depending on the usage and temperature difference). This shows that the TEG-12706canstillbe effective in energy recovery from mobile phone waste heat, though the scale of energy harvested will be smaller than from larger heat sources like laptops or other electronic devices.

REFERENCE

[1] V. Petrov et al., "Last Meter Indoor Terahertz Wireless Access: Perfor mance Insights and Implementation Roadmap," IEEE Communications Magazine, vol. 56, no. 6, pp. 158-165, 2018.
[2] M. Xiao et al., "Millimeter Wave Communications for Future Mobile Networks," IEEE Journal on Selected Areas in Communications, vol. 35, no. 9, pp. 1909-1935, 2017.
[3] X. Ge et al., "Joint Optimization of Computation and Communication Power in Multi-user Massive MIMO Systems," IEEE Transactions on Wireless Communications, pp. 1-1, 2018.
[4] X. Ge et al., "5G Ultra-Dense Cellular Networks," IEEE Wireless Communications, vol. 23, no. 1, pp. 72-79, 2016.
[5] J. Yang et al., "How Much of Wireless Rates Can Smartphones Support in 5G Networks?," IEEE Network, vol. 33, no. 3, pp. 122-129, 2019.
[6] J. Yang et al., "Power-Consumption Outage Challenge in Next Generation Cellular Networks," in 2019 IEEE Global Communications Conference (GLOBECOM), 2019, pp. 1-6
. [7] A. Goldsmith, Wireless communications. Cambridge university press, 2005.
[8] S. V. Garimella et al., "Electronics Thermal Management in Information and Communications Technologies: Challenges and Future Directions," IEEE Transactions on Components, Packaging and Manufacturing Tech nology, vol. 7, no. 8, pp. 1191-1205, 2017.
[9] E. Ungar and K. Stroud, "A New Approach to Defining Human Touch Temperature Standards," in 40th International Conference on Envi ronmental Systems(International Conference on Environmental Systems (ICES): American Institute of Aeronautics and Astronautics, 2010.
[10] Q. Ding and Y. Jing, "Outage Probability Analysis and Resolution Profile Design for Massive MIMO Uplink With Mixed-ADC," IEEE Transactions on Wireless Communications, vol. 17, no. 9, pp. 6293- 6306, 2018.
[11] B. M. ElHalawany et al., "D2D Communication for Enabling Internet of-Things: Outage Probability Analysis," IEEE Transactions on Vehicu lar Technology, vol. 68, no. 3, pp. 2332-2345, 2019. [12] K. J. Kim et al., "Outage Probability Analysis of Spectrum Sharing Systems With Distributed Cyclic Delay Diversity," IEEE Transactions on Communications, vol. 67, no. 6, pp. 4435-4449, 2019. [13] J. Cui et al., "Outage Probability Constrained MIMO-NOMA Designs Under Imperfect CSI," IEEE Transactions on Wireless Communications, vol. 17, no.
[12] M. C. Valenti et al., "The role of computational outage in dense cloud-based centralized radio access networks," in 2014 IEEE Global Communications Conference, 2014, pp. 1466-1472.
[13] D. Han et al., "Offloading Optimization and Bottleneck Analysis for Mobile Cloud Computing," IEEE Transactions on Communications, vol. 67, no. 9, pp. 6153-6167, 2019.
[14] M. Liu et al., "Cooperative Fog-Cloud Computing Enhanced by Full Duplex Communications," IEEE Communications Letters, vol. 22, no. 10, pp. 2044-2047, 2018.
[15] X. Li et al., "Measurement and analysis of energy consumption on Android smartphones," in 2014 4th IEEE International Conference on Information Science and Technology, 2014, pp. 242-245.
[16] P. K. D. Pramanik et al., "Power Consumption Analysis, Measurement, Management, and Issues: A State-of-the-Art Review of Smartphone Battery and Energy Usage," IEEE Access, vol. 7, pp. 182113-182172, 2019.