**Use of Thermoelectric Generators in Self Sustaining Wireless Sensor Networks for Fire Monitoring**

by

**Armand Cassim Demitri C. De Castro**

**Isaac Daniel Q. Ilagan**

**Cid Franco A. Ordoñez**

**Jian Karlo R. Sta. Maria**

A Research Paper Submitted to the Mapúa Senior High School Department

in Partial Fulfillment of the Requirements for

**Research Project (RES04)**

Mapúa University

February 2019

**CHAPTER 1**

**INTRODUCTION**

Philippine forests have experienced a drastic decline in forest coverage since the past century. The country’s forest cover is down to 24% of its original forest cover in the 1900s. This is because of the widespread logging, mining operations, agricultural fires, tourism facilities development, and rural population expansion. “Recovering the Philippines” (2018) posits that the Philippines is losing approximately 47,000 hectares of forest cover every year, according to the data provided by the Forest Management Bureau of the Department of Environment and Natural Resources. Philippine forests give home to its biodiversity which is considered as one the richest in the world. The need for environmental sensors such as fire detection and gas sensors are critical in saving Philippine forests.

Most forests are remote to people and are outside the power grid therefore, power management systems for technologies such as environmental monitors are hindrances in keeping Philippine forests safe from natural and human induced threats. Internet of Things (IOT) concern for this study is the insufficiency of power supplies in remote and rural areas, therefore the solution that the researchers suppose is to produce a self-generating or self-sustaining power source for wireless sensors. Thermoelectric generators (TEGs) are 19th century technology that has been overlooked and slept on since people have been more attracted in harnessing solar energy as a form of renewable energy. When a heat event, such as a machine starting, in this case, the use of environmental monitors, occurs, the temperature of the machine will change relative to the ambient surroundings. This temperature differential can be harvested by the use of a TEG to power the machine itself. Due to a principle known as the Seebeck Effect.  According to Campbell, B. et al “TEGs utilize the Seebeck effect to produce a voltage from a thermal gradient” (p. 1). Previous works of literature Hwang, Vorobyev, and Guo (2011) have tried measuring the efficiency of solar-driven TEG’s. Rizzon, Rossi, Passerone, and Brunelli’s (2013) literary work have applied using wireless sensors for environmental monitoring powered by microprocessors. Campbell, Ghena and Dutta’s (2014) study made use of harvesting energy through faucets.

However, there were little to no works of literature that pertained to the application TEG’s in environmental monitors. In this paper, the researchers report that IoT solutions regarding sustainable energy in remote places have not had much technological advancements. Therefore, environmental monitoring sensors are not usually found in remote and extreme locations especially in the Philippines.

Sensors have a lot of waste heat that can be harvested and generated into renewable energy. The use of TEG’s are means of integrating old technology to environmental problems. Stating these, this research aims (1) to implement TEG for self-sustaining environmental sensors to provide power; (2) measure the amount of energy being generated by heat coming from RPi as converted by TEG; (3) compute for the reliability of the system as implemented in the actual environment. (4) To create an IoT system that will measure smoke for possible forest fires and kaingin.

This study will focus alone on the development of the self-sustaining wireless sensor networks with a TEG that has enough conversion of heat energy to electrical energy, the sensor will be put on remote areas that are far from people to make better security of the environment. It will not cover the actual size of the product, the placement of the wireless sensor and the signal of GSM module for notifications. The only sensor that will be used for fire monitoring is smoke sensor which will detect smoke from forest fires.

This study aims to develop a wireless monitoring sensor with self-sustained energy; to reduce expenses on buying limited sources of energy; to implement environmental sensors for detecting forest fires and illegal burning of underbrush, known as “kaingin”. It will benefit the extent of forest resources and will be a great help in preserving its natural state and raising global awareness. This study is essential for forest fire prevention for it aims to give up to date information. Overall, this research study will change relative to the ambient surroundings with the use of this research “Use of Thermoelectric Generators in Self Sustaining Wireless Sensor Networks for Fire Monitoring.”

**CHAPTER 2  
REVIEW OF RELATED LITERATURE**

**Wireless Sensor Nodes**

Wireless Sensor Nodes (WSN) has been around for a couple of decades now and these wireless sensor nodes is used for applications as diverse as earthquake measurements, wireless sensor nodes can be used to forecast and detect natural activity in places like forests. WSN consists of autonomous devices with inbuilt sensors for monitoring various environmental and physical conditions at various places and times. WSN is thus becoming increasingly widespread these days for monitoring and recording parameters like temperature, humidity and pressure at diverse locations. The main challenge is that these sensor nodes has ultra-low power, since they can be placed anywhere, where main sources of electricity are not available and changing battery may be costly, impractical, or even impossible.

WSN can benefit the country’s environmental health. An example for the use of wireless sensor nodes to help us and the environment is when. [1] Used the wireless sensor nodes for agricultural applications. Stamenković stated that it is necessary to use these types of measures due to the fact that there is now limited farming capacity, climate changes and various stress factors affecting agricultural production, increasing the quality and yield of feed and food will only be possible by using advanced agro-meteorological measures and wireless sensor nodes are the most promising information technology for agricultural applications. [2] Presented a wireless sensor network paradigm for real-time forest fire detection. Their goal was to detect and predict forest fire promptly and accurately to be able to reduce the risk of losing the forests, wild animals, and people in these unpredictable forest fires. Yu planned on densely deploying large amounts of sensor nodes in a forest. They used neural networks (a computer system modeled on the human brain and nervous system) to prolong the lifetime of the sensor networks. Yu made a wireless sensor network that can detect and forecast forest fire more promptly than the long-established satellite-based detection approach.

In our study, WSN is a method that can be applied together with the power of the thermoelectric generator (TEG) to monitor the environment and keep the environment to obtain a healthy and safe status from any hazards or threats.

**Renewable Energy and Sustainable Energy**

Renewable Energy and Sustainable Energy Renewable Energy is replenished through the human timescale. It will not deplete because of its abundance in Earth. Types of renewable energy are solar energy, wind power, electric energy, biomass, hydrogen (fuel cells), geothermal and other forms. These energies can provide electricity through different energy conversion. This sustainable energy meets the demand of energy without depleting resources because these can be used repeatedly.

According to [3], on their study on renewable energy most conventional energy are based oil, coal, and natural gas are highly effective drivers of economy but at the same time its damages our environment which can possibly be a risk to human health. Renewable energy can be an alternative way of producing electric energy that are abundant. Their study focused only on the energy sources. Waste heat energy is from the heat of machine because of the done work by it or other process that uses energy, it may be common to some type of production process. Waste heat recovery is very important because it can reduce the consumption non – renewable energy.

Relating this to the research, the researchers will convert waste heat coming from the wireless sensor to sustain its energy. Instead of using nonrenewable energy, waste heat coming from the environmental wireless sensor can be converted through the use TEG’s.

**Internet of Things**

[4] Stated that Internet of Things (IoT) data analytics is underpinning numerous applications, however, the task is still challenging predominantly due to heterogeneous IoT data streams, unreliable networks, and the ever-increasing size of data. Many Internet of Things applications enable smart city initiatives all over the world by leveraging ubiquitous connectivity, big data, and analytics. An IOT ecosystem consists of web-enabled smart devices that use embedded processors, sensors, and communication hardware to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed locally. Sometimes, the devices do most of the work without human intervention, although people can interact with the devices – for instance, to set them up, give them instructions or access the data. (Rosencrance, et al) (n.d.).

The Philippines is the fastest growing smartphone nation in Southeast Asia. All over the world, smartphones have become tools for tracking things and people. Companies such as Uber have built business models based on this. Additionally, more and more cloud-based applications are being connected to mobile phones. Smartphones essentially serve as Filipinos’ gate passes to the IoT (Yamio, 2017). Buildings and other infrastructures that are equipped with IoT use their own network to communicate (VPN) e.g. – computer shops, schools, banks, firms, and etc.

LinkLabs outlined 8 IoT environmental monitoring use cases: Monitoring air for quality, carbon dioxide and smog-like gasses, carbon monoxide in confined areas, and indoor ozone levels. Monitoring water for quality, pollutants, thermal contaminants, chemical leakages, the presence of lead, and flood water levels. Monitoring soil for moisture and vibration levels in order to detect and prevent landslides. Monitoring forests and protected land for forest fires. Monitoring for natural disasters like earthquake and tsunami warnings. Monitoring fisheries for both animal health and poaching. Monitoring snowfall levels at ski resorts and in national forests for weather tracking and avalanche prevention. Monitoring data centers for air temperature and humidity.

Monitoring forests and protected land for forest fires is one of the most useful yet ignored environmental use case Philippines need. From an online article published on Philstar, “Recovering the Philippines” (2018), the Philippines is losing approximately 47,000 hectares of forest cover every year. Therefore, it is ethically mandatory for Filipino citizens to take action.

Other works of literature have tried producing unique types of surfaces that absorb UV and visible light to generate significantly more power e.g - enhanced efficiency of solar-driven thermoelectric generator with femtosecond laser-textured metals by [5] but have not integrated such technology to IoT and environmental monitoring.

In India, [6] developed a customized design of an Internet of Things (IoT) enabled environment monitoring system to monitor temperature, humidity and CO2. Shah and Mishra (2014) discussed in their study “IoT enabled environmental monitoring system for smart cities” the services for which quality can be enhanced in a smart city are monitoring the strength of buildings, waste management, air quality management, weather monitoring, noise monitoring, traffic management, parking management, energy consumption management and automation buildings.

If we try to implement the same strategy of putting environmental monitors in Philippine forests reported of experiencing illegal logging and *kaingin*, forest rangers will be notified with up-to-date information, and perpetrators will be held to account. Mike Crismundo, a writer from Manila Bulletin, made an article entitled “DENR 13 admits having hard time going after illegal loggers”. According to Crismundo (2017) in the first five months of 2017, the DENR Enforcement Division have recorded 1,824,098 bd. ft. of illegal forest cut products which were confiscated in different parts of the Caraga Region.

**Thermoelectric Generation**

In sensor network, one of the most critical challenges for static and mobile pervasive regarded by energy. It discusses how recent developments in energy-harvesting technologies have raveled self-sustainable operation for low-power body sensor networks. These might not always be feasible solutions, however, and in some cases, could even prove prohibitive. A computational model has been refined in order to replicate the thermal and electric behavior of thermoelectric generators. The nonlinear system of equations of the thermoelectric, heat transfer equations and the equation system using the finite difference method and semi-empirical expressions for the convection coefficients solved by this model. The accuracy of the computational model is ordered to validate and determine the thermoelectric electric power generation test bench that has been built which have a maximum error of lower than 5%. [7] Stated that in order to settle the accuracy of thermal resistance of the dissipater, we made some tests in a standardized climatic room. The experimental data gathered from the test bench are correlated with the values from the computational model. With this contrast, we make a verification of the model to know the error between the experimental and the simulated values.

Thermoelectric power generation can help in utilizing such low-grade heat and improving the total efficiency of power plants. It can also propose the utilization of unused energy in condensers by means of thermoelectric conversion and to calculate a theoretical amount of energy retrieval in a heat exchanger. [8] Stated that in the cylinder wall, using the theoretical approach of heat conduction can reduce output power P by the mathematical function of thermoelectric. However, they are inappropriate in a big scale application because these alloys are composed with somewhat uncommon materials.

This article discusses the thermoelectric materials that can generate electricity from waste heat will play an important role in the global sustainable energy solution. The metallic 1T phase MoS2 Nano sheets indicate their potential diverse applications not only as thermoelectric energy harvesting devices but also as self-powered gas sensors by revealing interesting moisture sensitive thermoelectric properties. [9] Stated that that the exfoliated layers of 1T phase MoS2 have high-performance thermoelectric energy harvesting properties. However, they didn’t use this to benefit the forest.

**Smoke Sensor**

A smoke sensor is a device typically used as an indicator of fire through the detection of smoke. Nowadays, smoke sensors are usually security devices used in buildings or households. However, they can also be used in the detection of fire in forests and fire prevention.

From many points of view, forest fire is an important problem. It damages the environment and reduces the overall quality of life, and it is also important from an economic point of view, since wood is a valuable resource. The researcher examined the problems of early fire/smoke detection by using shots at different part of the controlled forest. They based their approach image full segmentation, and subsequent isolation of segments with and without fire/smoke. [10]. [11] used remote sensing technologies such as: a remote controlled unmanned aerial vehicle (UAV) equipped with gas sensors and a thermal camera for fire detection and to reduce false alarms. Krüll went on to say that the UAV can be used as scouts for fire fighters. Krüll also used an unmanned blimp with gas and smoke sensors and a thermal camera to reduce the risk of re-ignition of the fire. The benefit of a blimp is a higher payload.

Relating to our study, Smoke sensors can be used together with our device, and powered by a TEG, to efficiently detect fire and prevent any forest fires from happening. If the researchers implement smoke sensors to their study, fire prevention rates can rise.

**GSM Module**

Nowadays, GSM network is the most used mobile network communication.A GSM module or a GPRS module is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a GSM or GPRS system (ElectronicsForu, 2016). Communication techniques of GSM networks include sending and reading of short messages (SMS), sending SMS to group users and etc.

In India, [12], B.D.S. made use of a GSM module to send notifications whenever there is human interference in their surveillance area. In their study, “Advanced Raspberry Pi Surveillance (ARS) system”, Vamsikrishna et al (2015) discussed that the notification process is done by sending short message service (SMS) through GSM Module.

Relating to this study, the researchers will be using a GSM module to notify the users in whenever something suspicious is detected by the environmental sensor. The GSM module’s real-time notification will be vital in safeguarding forests.

[1] Z. Stamenkovic, S. Randjic, I. Santamaria, U. Pesovic, G. Panic, and S. Tanaskovic, “Advanced wireless sensor nodes and networks for agricultural applications,” *24th Telecommun. Forum, TELFOR 2016*, 2017.

[2] Liyang Yu, Neng Wang, and Xiaoqiao Meng, “Real-time forest fire detection with wireless sensor networks,” *Proceedings. 2005 Int. Conf. Wirel. Commun. Netw. Mob. Comput. 2005.*, vol. 2, pp. 1214–1217, 2005.

[3] B. A. V Herzog, T. E. Lipman, J. L. Edwards, and D. M. Kammen, “RENEWABLE ENERGY : A VIABLE CHOICE,” vol. 43, no. 10, 2001.

[4] A. Akbar *et al.*, “{Real-Time} Probabilistic Data Fusion for {Large-Scale} {IoT} Applications,” *Ieee Access*, vol. 6, pp. 10015–10027, 2018.

[5] T. Y. Hwang, A. Y. Vorobyev, and C. L. Guo, “Enhanced efficiency of solar-driven thermoelectric generator with femtosecond laser-textured metals,” *Opt. Express*, vol. 19, no. 14, pp. A824–A829, 2011.

[6] J. Shah and B. Mishra, “IoT enabled environmental monitoring system for smart cities,” *2016 Int. Conf. Internet Things Appl. IOTA 2016*, pp. 383–388, 2016.

[7] H. B. Henninger, S. P. Reese, A. E. Anderson, and J. A. Weiss, “Validation of computational models in biomechanics,” *Proc. Inst. Mech. Eng. Part H J. Eng. Med.*, vol. 224, no. 7, pp. 801–812, 2010.

[8] T. Kyono, R. O. Suzuki, and K. Ono, “Conversion of Unused Heat Energy to Electricity by Means of Thermoelectric Generation in Condenser,” *IEEE Power Eng. Rev.*, vol. 22, no. 10, pp. 58–58, 2002.

[9] S. Jayabal, J. Wu, J. Chen, D. Geng, and X. Meng, “Metallic 1T-MoS2 nanosheets and their composite materials: Preparation, properties and emerging applications,” *Mater. Today Energy*, vol. 10, no. November, pp. 264–279, 2018.

[10] D. Asatryan and S. Hovsepyan, “Method for fire and smoke detection in monitored forest areas,” *CSIT 2015 - 10th Int. Conf. Comput. Sci. Inf. Technol.*, pp. 77–81, 2015.

[11] W. Krüll, R. Tobera, I. Willms, H. Essen, and N. Von Wahl, “Early forest fire detection and verification using optical smoke, gas and microwave sensors,” *Procedia Eng.*, vol. 45, pp. 584–594, 2012.

[12] P. Vamsikrishna, S. R. Hussain, N. Ramu, and P. M. Rao, “Advanced Raspberry Pi Surveillance ( ARS ) System,” no. Gcct, pp. 2–4, 1800.

**CHAPTER 3**

**ABSTRACT**

**I. Introduction**

Philippine forests have experienced a drastic decline in forest coverage since the past century. The country’s forest cover is down to 24% of its original forest cover in the 1900s. This is because of the widespread logging, mining operations, agricultural fires, tourism facilities development, and rural population expansion. “Recovering the Philippines” (2018) posits that the Philippines is losing approximately 47,000 hectares of forest cover every year, according to the data provided by the Forest Management Bureau of the Department of Environment and Natural Resources. Philippine forests give home to its biodiversity which is considered as one the richest in the world. The need for environmental sensors such as fire detection and gas sensors are critical in saving Philippine forests.

Most forests are remote to people and are outside the power grid therefore, power management systems for technologies such as environmental monitors are hindrances in keeping Philippine forests safe from natural and human induced threats. Internet of Things (IOT) concern for this study is the insufficiency of power supplies in remote and rural areas, therefore the solution that the researchers suppose is to produce a self-generating or self-sustaining power source for wireless sensors. Thermoelectric generators (TEGs) are 19th century technology that has been overlooked and slept on since people have been more attracted in harnessing solar energy as a form of renewable energy. When a heat event, such as a machine starting, in this case, the use of environmental monitors, occurs, the temperature of the machine will change relative to the ambient surroundings. This temperature differential can be harvested by the use of a TEG to power the machine itself. Due to a principle known as the Seebeck Effect. According to Campbell, B. et al “TEGs utilize the Seebeck effect to produce a voltage from a thermal gradient” (p. 1). Previous works of literature Hwang, Vorobyev, and Guo (2011) have tried measuring the efficiency of solar-driven TEG’s. Rizzon, Rossi, Passerone, and Brunelli’s (2013) literary work have applied using wireless sensors for environmental monitoring powered by microprocessors. Campbell, Ghena and Dutta’s (2014) study made use of harvesting energy through faucets.

However, there were little to no works of literature that pertained to the application TEG’s in environmental monitors. In this paper, the researchers report that IoT solutions regarding sustainable energy in remote places have not had much technological advancements. Therefore, environmental monitoring sensors are not usually found in remote and extreme locations especially in the Philippines.

Sensors have a lot of waste heat that can be harvested and generated into renewable energy. The use of TEG’s are means of integrating old technology to environmental problems. Stating these, this research aims (1) to implement TEG for self-sustaining environmental sensors to provide power; (2) measure the amount of energy being generated by heat coming from RPi as converted by TEG; (3) compute for the reliability of the system as implemented in the actual environment. (4) To create an IoT system that will measure smoke for possible forest fires and kaingin.

This study will focus alone on the development of the self-sustaining wireless sensor networks with a TEG that has enough conversion of heat energy to electrical energy, the sensor will be put on remote areas that are far from people to make better security of the environment. It not will cover the actual size of the product, the placement of the wireless sensor and the signal of GSM module for notifications. The only sensor that will be used for fire monitoring is smoke sensor which will detect smoke from forest fire.

This study aims to develop a wireless monitoring sensor with self-sustained energy; to reduce expenses on buying limited source of energy; to implement environmental sensor for forest fires and illegal burning of underbrush, known as “kaingin”. It will benefit the extent of forest resources. It will be a great help in preserving its natural state and raising global awareness of what is happening. It could also help in detecting illegal burning of forest and it will give up to date information. This study is essential for forest fire prevention. Overall, this research study will change relative to the ambient surroundings with the use of the Use of Thermoelectric Generators in Self Sustaining Wireless Sensor Networks for Fire Monitoring.

**II. Methodology**

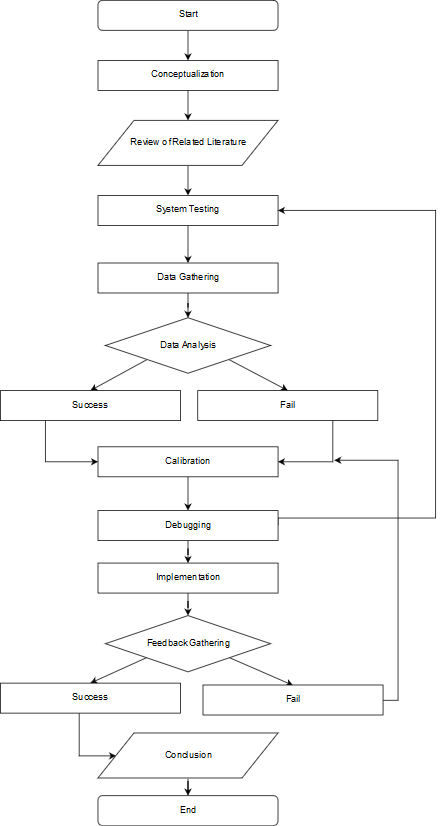
In this chapter, the procedures explained below must be taken after to reach the specific end goal and make the proposed prototype. Hardware components used in the system are discussed in this chapter.

The study was devised based on the conceptual framework presented below. The framework begins from the heat source, followed by the TEG, then the boost converter and ends in the Raspberry Pi. The basis of the steps is the specific objectives of the study. The conceptual framework is shown in figure 1.1.

A screenshot of a cell phone

Description generated with very high confidence

**Figure 1.1** Process Flow Chart



**Figure 1.2** Research Activity Flow

A close up of a map

Description generated with very high confidence

**Figure 1.3** Block Diagram

Experiments will be conducted to determine the range of energy values that can be generated by SP1848-27145 in accordance to the Raspberry Pi. In our experiment, we will be placing the SP1848-27145 on top of the sensor and will be measuring the generated current while the sensor runs. The hot side of the thermoelectric generator will be adhered a thermal conductive gel to secure a good thermal contact onto the hottest side of the sensor, while a heat sink (SK68-75-SA) will be placed on the cool side. This is to facilitate the heat dissipation and to keep a thermal gradient between the two sides. The temperature will be monitored by using a NTC thermistor placed on the hot side of SP1848-27145. The voltage will be measured through the reading of the voltage regulator. The room temperature will be measured by using a thermometer. The SP1848-27145 output voltage and current will be measured over a matched load with a 2 s period using multimeters2 controlled using a PC Software.

A DC to DC boost converter (DC to DC Step Up Boost Converter 0.9v – 5v DC to 5v DC 0.6A) will be added to the thermoelectric setup and the flow of the experiment will remain the same. The operation of the DC to DC boost converter module to be used is based on pulse frequency modulation (PFM) technique. Since PFM architectures have better low-power conversion efficiency, lower total solution cost, and simple converter topologies that do not require control-loop-compensation networks than their pulse width modulation (PWM) counterparts. Application of a boost converter to the thermoelectric setup is guaranteed to encourage a higher success rate.

Since there is no assurance that SP1848-27145 with the DC to DC Step Up Boost Converter 0.9v – 5v DC to 5v DC 0.6A would produce an exact 5 v outputs at all times, a step-down voltage regulator (DC-DC 12V 24V to 5V 5A Converter Voltage Regulator Step Down) will be added to control fluctuating outputs and voltage. Voltage regulators are any electrical or electronic device that maintains the voltage of a power source within acceptable limits (Brittanica). Application of DC-DC 12V 24V to 5V 5A Converter Voltage Regulator Step Down will ensure a longer sensor lifespan for it will regulate fluctuating outputs that could be detrimental.

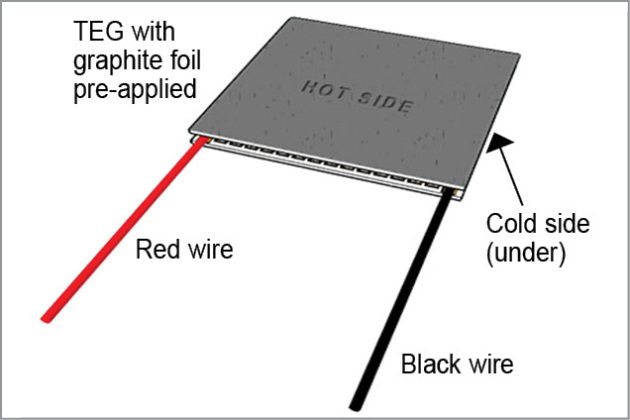
A smoke sensor (MQ2 MQ-29 Smoke / Gas Sensor Module) will be connected to the Raspberry Pi via an ADC Converter (ADS1115 16-Bit I2C ADC Development Board Analog to Digital Converter Module). A smoke sensor as defined by the National Fire Protection Association (USA) is a multi-station or single-station alarm that responds to smoke. Upon detecting smoke, the Raspberry Pi is programmed to notify forest rangers via text message by using a GSM module.

A GSM module is a chip or circuit used to communicate between a mobile device and a GSM system. It is similar to modems; however, GSM modules can be integrated within an equipment as an embedded piece of hardware. Application of the (SIM800L V2 5V Wireless GSM GPRS Module is absolutely necessary in keeping the system wireless.

With the specifications of the TEG that will be using, the researchers will be able to determine the efficiency for different kinds of heat sources that will be conducted throughout the experiment. Table 1 shows the specifications of the TEG that will be used throughout the  
experiment.

|  |  |
| --- | --- |
| Model: | SP1848-27145 |
| Temperature(C): | 150 degrees |
| Material: | Ceramic / Bismuth Telluride |
| Open-circuit voltage(V): | 4.8V |
| Current(MA): | 20/0.97/225; 40/1.8/368; 60/2.4/469; 80/3.6/559; 100/4.8/669 |
| Module weight: | 25g / 0.89oz |
| Module size: | 4 \* 4 \* 0.4cm / 1.6 \* 1.6 \* 0.2inch (L \* W \* H) |

**Table 1**



**Figure 1** SP1848-27145

Figure 1 shows the illustration of the TEG

|  |  |
| --- | --- |
| **TEMPERATURE DIFFERENCE** | **VOLTAGE OUTPUT** |
| * 20-degree temperature difference: | * open-circuit voltage 0.97V, generated current: 225mA |
| * 40-degree temperature difference: | * open circuit voltage 1.8V, generated current: 368mA |
| * 60-degree temperature difference: | * open circuit voltage 2.4V, generated current: 469mA |
| * 80-degree temperature difference: | * the open circuit voltage 3.6V, generated current: 558mA |
| * 100-degree temperature difference: | * open circuit voltage 4.8V, generated current: 669mA |
| * The above values are for reference only, the wiring in actual use, and the step-up board, there will be loss of current | |

**Table 2**

Table 2 shows the voltage per temperature differential.

|  |  |
| --- | --- |
| Wide Supply Range: | 2.0v to 5.5v |
| Low Current Consumption: Continuous Mode: | Only 150uA Single-Shot Mode: Auto Shut-Down |
| Programmable Data Rate: | 8sps to 860sps |
| I2C Interface: | Pin-selectable addresses |
| Size: | 2.8\*1.8cm/1.1\*0.7in |
| Weight: | 5g(approx.) |

ADS1115 16-Bit I2C ADC Development Board Analog to Digital Converter Module - intl

**Table 3** ADC Converter

USB DC To DC Step Up Boost Converter

|  |  |
| --- | --- |
| Input voltage: | 0.9-5V DC |
| Output voltage: | 5V DC |
| PCB size: | 34 (mm) x16.2 (mm) |

**Table 4** Boost Converter

Heatsink

|  |  |
| --- | --- |
| For Use With | TO-220 |
| Length | 75mm |
| Width | 46mm |
| Height | 33mm |
| Dimensions | 75 x 46 x 33mm |
| Thermal Resistance | 3.9K/W |
| Mounting | Screw |
| Colour | Black |

**Table 5** Heatsink

SIM800L V2 5V Wireless GSM GPRS Module

|  |  |
| --- | --- |
| FM: | International band 76 ~ 109MHz, 50KHz correction level. |
| Voltage: | : 4.1 ~ 5VDC |
| Operating Temperature: | -40 ~ 85 |

**Table 6** Gsm Module

MQ2 Combustible Gas Sensor

|  |  |
| --- | --- |
| Operating Voltage: | +5V |
| Can be used to Measure or detect : | LPG, Alcohol, Propane, Hydrogen, CO and even methane |
| Analog output voltage: | 0V to 5V |
| Digital Output Voltage | : 0V or 5V (TTL Logic) |
| Preheat duration: | 20 seconds |

**Table 7** Gas Sensor

L7805CV

|  |  |
| --- | --- |
| Output: | +5V, up to 1.5A with peak current of 2.2A |
| Input Voltage: | 7V Minimum, 25V Maximum |
| Voltage - Dropout (Typical) | 2V @ 1A |

**Table 8** Voltage Regulator

The following tables show the specifications of the material used in the prototype.

The experimental setup will take place in Mapua University while the implementation will take place in the remote areas of Tanay, Rizal.

**Statistical Treatment of Data**

To treat the data from the research, a one sample t-test will be conducted to determine whether the voltage output per temperature differential is enough to power the smoke sensors. As the temperature difference increases the voltage output increases as well. In the computation of the one sample t-test the researchers will be using the voltage output that is generated for every 20 degrees’ temperature difference (20-100 degrees). The one sample t-test is an appropriate analysis when the researcher compares the mean of a sample with a hypothesized mean to assess if differences occur. The assumptions of the one sample t test include: the data must be normally distributed within the population, the data should be independent, and the scores of one participant are not dependent upon scores of another participant. The null hypothesis for this research is 5 because that is the voltage required to power the smoke sensor.



The formula above will be used to determine the voltage output’s mean, after finding the voltage output’s mean, the formula below will be used to calculate the sample standard deviation.

Once the sample standard deviation is computed, the sample mean, sample standard deviation and the hypothesized value will be used in calculating for the test statistic. Below is the formula for the test statistic.



Once calculating for the test statistic is completed, calculate the probability of observing the test statistic under the null hypothesis. This value is obtained by comparing *t* to a *t*-distribution with (*n* − 1) degrees of freedom (*n* is the sample size)*.* This can be done by looking up the value in a t-test table. Once the assumptions have been verified and the calculations are complete, all that remains is to determine whether the results provide sufficient evidence to reject the null hypothesis in favor of the alternative hypothesis.