

The Analysis of the TEG Peltier Heat Collecting Device in the 1.5 HP Split Unit Air Conditioning System

Sindhu Kumar¹, Rone², Manish Kumar^{3,*}

Abstract

Energy recycling is a different approach to creating a green environment in the modern world. Global energy usage is highest for air conditioning. Commonly air conditioning used to maintain indoor temperature. Split unit air conditioning systems are well-known for their small-area applications in Malaysia. Nevertheless, the condensing unit's heat discharge results in environmental waste. As a result, in this experiment, one peltier device employing a thermoelectric generator (TEG) module was developed. This paper's goal is to describe the creation of a peltier device that collects heat from a condensing unit and turns it into electricity. The Peltier gadget was positioned between copper plates measuring 120 mm by 60 mm by 2 mm. The copper plate was brazed at the compressor's output pipe, and its other side was attached to the heat sink, which allowed condensed water from the evaporator to pass through. Six peltiers were arranged in different configurations between copper plates. Three cases were monitored based on the condenser temperature and the cooling coil's ΔT . Case 1's maximum ΔT was noted, and each peltier's voltage output was concurrently examined. After operating the split unit air conditioner for 30 minutes at a temperature of around 9–10°C, the maximum 1.61V was recorded. The potential alternative for heat recovery is demonstrated by the use of TEG to capture heat and convert it into power. The produced current could be helpful for small-scale home electrical use.

Keywords: TEG, energy conservation, heat transformation, split air conditioner, seebeck effect

INTRODUCTION

Because of our dependence on energy resources, there has been a rise in energy consumption. Due to the limited supply of oil, the quantity of energy derived from current sources will decline. The price of power has risen to historically high levels throughout time due to a mix of political and monetary factors as well as the limited availability of oil. Since renewable energy will also leave a better environment for future generations, it is a more enticing alternative than producing power.

There are many different ways to produce renewable energy, including nuclear energy, solar energy,

wind energy, and hydro energy. In the modern world, producing electricity would require significant energy and resource expenditures as well as increased disruption of natural resources [1]. Recycling energy would be an additional way to attain green environment technology of renewable energy in order to minimise energy consumption. In order to maintain human comfort, air conditioning has recently consumed 50% of all energy consumed [2]. Heat recovery thus presents a viable avenue for the use of renewable energy. Using a thermoelectric generator, waste heat from the split unit air conditioning system's condenser was converted to electrical power (TEG). Nevertheless, not much

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Received Date: December 04, 2025

Accepted Date: December 07, 2025

Published Date: December 23, 2025

Citation: Sindhu Kumar, Rone, Manish Kumar. The Analysis of the TEG Peltier Heat Collecting Device in the 1.5 HP Split Unit Air Conditioning System. Journal of Refrigeration, Air Conditioning, Heating and Ventilation. 2025; 12(3): 14–21p.

study has been done to examine how well home split unit air conditioners can produce power [3–6]. The aim of this project is to create a gadget that can measure the current produced in relation to the waste heat collected from split unit condensers and used to generate power.

LITERATURE REVIEW

Air Conditioning System

Generally for maintaining indoor air quality and ensuring thermal comfort inside the conditioned room are the general Purpose of air conditioning systems. Installing air conditioning systems in homes improves the comfort of residents, particularly in countries with warm climates like Malaysia. Split unit systems are widely used in small-scale applications, particularly in homes [7]. The two types of air conditioning systems that are commonly recognised are unitary refrigerant systems and centralised systems. Because they rely on the vapour compression cycle, these two systems are referred to as traditional air conditioning systems [8].

However, the condenser's waste output was not completely used. There are two primary components of a split air conditioner: the interior unit and the outside unit.

Installing the outdoor unit outside the room or area you want to cool involves placing it on or next to a wall. The unit contains the capillary tube or expansion coil, condenser coil, and compressor. The cooling coil, a long blower, and an air filter are all housed in the stylish interior unit. The purpose of this experiment is to create electricity using the heat from the compressor's output pipe [9].

Thermoelectric Generator

All thermo-electric generators (TEGs) are solid state devices that convert heat into electricity. These gadgets don't need any moving parts to transform heat energy into electricity [10]. Figure 1 shows the design of a single thermoelectric generator.

In order to create thermoelectric generators, thermocouples of the N and P kinds are linked electrically in series and thermally in parallel. When the TEG is heated on one side and cooled on the other, a seeback effect occurs [11], which causes voltage to be created [12].

Voltage is therefore produced [12]. There has been a lot of interest in the research of the seeback effect on heating, ventilation, and air conditioning (HVAC) equipment [13–15]. The technique of heat recovery mostly using condenser hot air and exhaust air [16]. As a result, this study presents the TEG Peltier device, which uses split unit air conditioning systems to generate electricity [17].

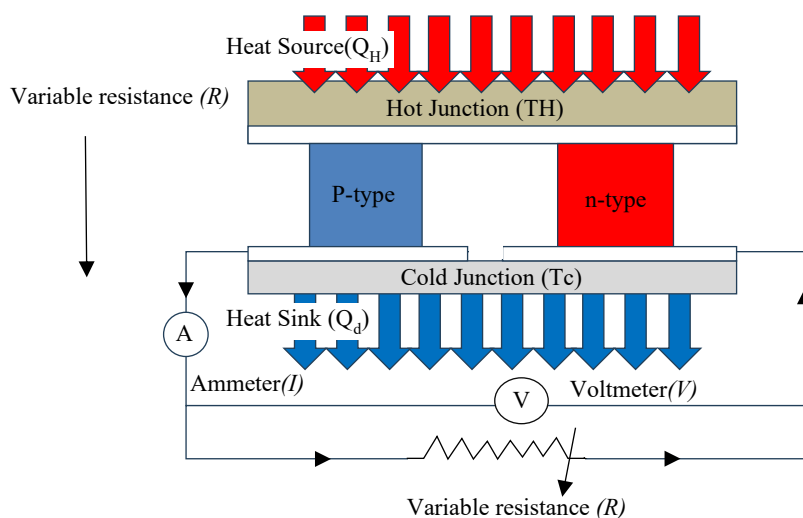


Figure 1. Schematic of thermoelectric generators working principle.

METHODOLOGY

For this project, a 1.5 horsepower (HP) split unit air conditioner with a 15,000 BTU/hr (non-inverter) cooling capability has been chosen. A Peltier module was designed to be attached to an outside unit, as seen in Figure 2, in order to ensure that the heat created could be captured and converted into electrical power.

This experiment was carried out at a laboratory located in Melaka, Malaysia, with a temperature range of 26 to 28°C and a relative humidity of 70%. R22 is the kind of refrigerant that is used in the cycle.

Development of the Peltier Module

The peltier module was installed near the compressor's discharge pipe. The copper plate is 120 by 60 mm and has a thickness of 2 mm. Because copper has a thermal conductivity value of 401 W/mK, it was employed to trap heat. As seen in Figure 3 [19], six TEG/peltier modules were organised and marked appropriately.

Subsequently, the front and rear of the Peltier module were sandwiched between copper plates, and then attached to the aluminium heat sink seen in Figure 4. While the other copper plate was joined to the heat sink, the first copper plate was brazed to the discharge pipe [20]. Thermal grease was then used to place TEGs between the heat sinks, increasing thermal conductivity by levelling off the uneven surfaces of the heat sinks. An evaporator's condensation water is collected in a water tank before being sent through the heat sink [21].

RESULTS AND DISCUSSION

This experiment produced a number of data, including temperature data monitoring and peltier development. The designed TEG peltier device is seen in Figure 5.

In the meanwhile, Figure 6 provides an overview of how the experiment is operating. The heat sink was the conduit through which condensation water from the evaporator passed [22]. Water temperature indicates that 5°C, 7°C, and 9°C flow through the heat sink, correspondingly, based on split unit set conditions [23].

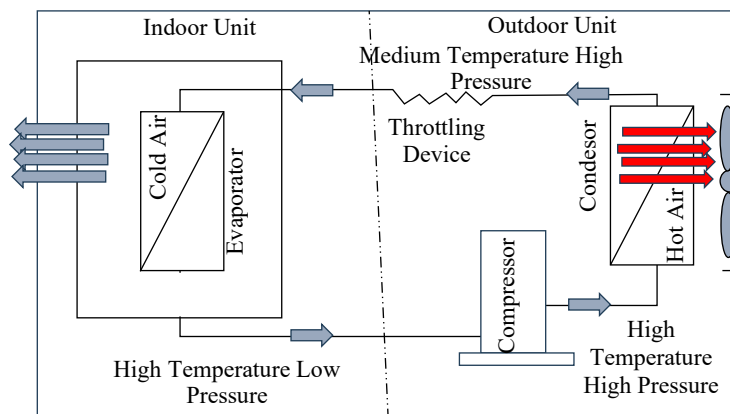


Figure 2. Outdoor unit.

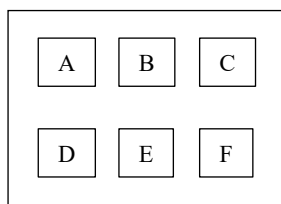


Figure 3. Six TEG peltier arrangement.

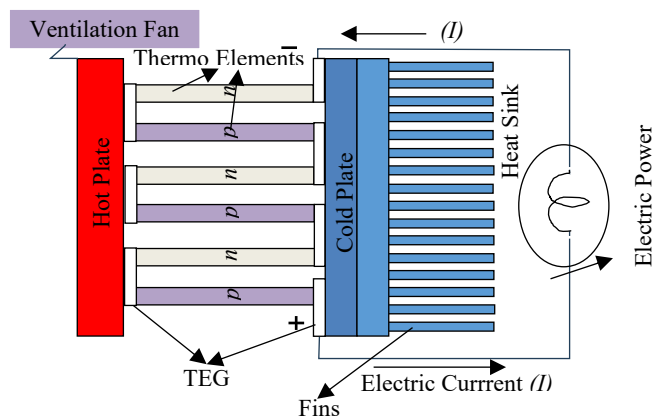


Figure 4. Side view of TEG peltier attach to the copper plate and heat sink.

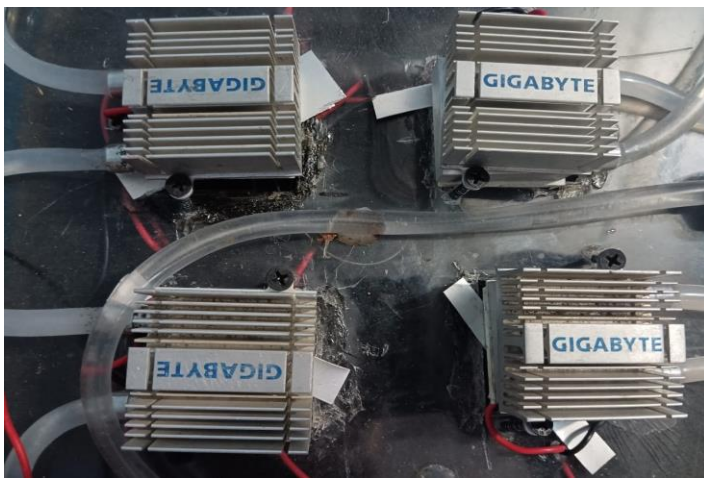


Figure 5. TEG Peltier device development.

We monitored the split unit air conditioner's current generation for the first thirty minutes of operation.

The experiment employed a Type K thermocouple and a Fluke data recorder to gather temperature readings. Additionally being observed is the temperature differential between the hot and cold plates. There were three different settings for the air conditioner.

The split unit utilised in this project's three differences scenario is shown in Table 1. Monitoring has also been done on the temperature differential between the hot and cold plates. Three distinct settings were selected for the air conditioner. The split unit utilised in this project's three differences scenario is shown in Table 1.

Five times were data were gathered. The voltage output from the peltier device was then maximised by placing the voltage output in parallel series and applying the Joule Thief technique. Additionally, a condensate water-based piping system that holds evaporator water was designed. The gadget module's changing temperature will produce and generate power [24].

A number of measurements were made based on three scenarios, each with varying evaporator and condenser temperatures. The evaporator and condenser temperatures have a considerable correlation with the temperature of the hot copper plate, as shown in Figure 7. Case 1 displays the lowest temperature of the evaporator along with a noticeable increase in the condenser temperature and ΔT . Consequently, benchmark case 1 data—which has the condenser temperature at 80°C and the evaporator temperature at 3°C —will be used to track the amount of power generated.

Table 1. Coil temperature refer to 3 case experiment.

Case	Evaporator coil temperature	Case Condenser coil temperature	ΔT
1	3°C	80°C	77°C
2	6°C	76°C	67°C
3	9°C	71°C	62°C

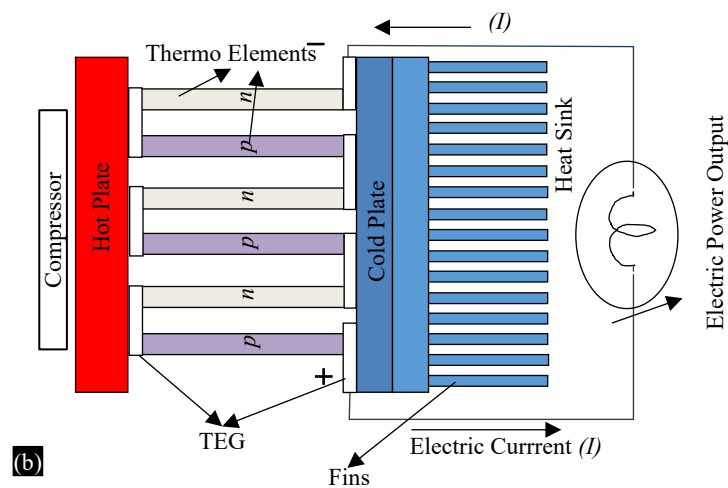
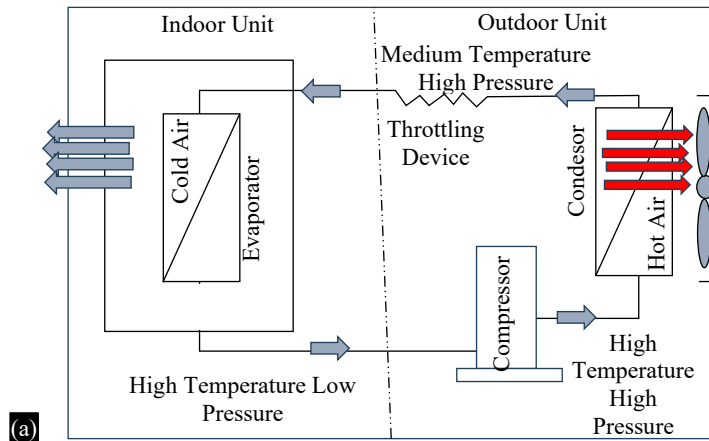


Figure 6. (a, b) Overall experiment layout.

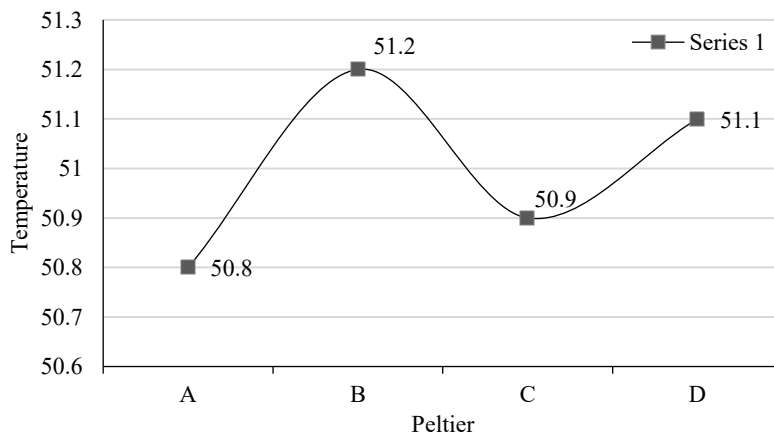


Figure 7. Hot copper plate temperature against set evaporator coil temperature.

The various temperature values for each peltier are shown in Table 2. There aren't any noticeable temperature differences across any peltiers. The average temperature range for all peltiers is between 9.7 and 9.9 degrees Celsius. Every plate exhibits consistent heat transmission when the temperature is measured for both hot and cold plates [18]. As a result, there is no significant difference in the voltage output of each TEG peltier when arranged in this manner. Table 2 displays temperature data that changes during the course of operation for each of the six peltiers. When compared to other peltiers, Figure 8's voltage output for Peltier B clearly demonstrates the greatest voltage output. According to the trend for all peltiers, the peltier device begins to produce voltage three minutes into the operation of the split unit. But, after six minutes of operation, the current started to rapidly grow again, and by twelve minutes, it had decreased for all the data. The compressor, which begins to completely compress after 12 minutes of operation, is somewhat responsible for this phenomenon [24].

Table 2. Peltier and temperature data.

Peltier	T (°C) Plate Hot	T (°C) Plate Cold	ΔT (°C)
A	50.8	40.7	9.8
B	51.2	40.5	9.7
C	50.9	40.5	9.9
D	51.1	40.4	9.7

Table 3. Voltage generated for each peltier against time.

S.N.	Time (m)	TEG A	TEG B	TEG C	TEG D	TEG E
1	3	0.21	0.22	0.21	0.19	0.16
2	6	0.19	0.21	0.22	0.21	0.19
3	9	0.2	0.27	0.19	0.2	0.16
4	12	0.18	0.24	0.18	0.18	0.14
5	15	0.2	0.24	0.2	0.2	0.18
6	18	0.22	0.31	0.2	0.19	0.21
7	21	0.21	0.29	0.25	0.25	0.22
8	24	0.29	0.35	0.29	0.27	0.28
9	27	0.23	0.36	0.25	0.27	0.23
10	30	0.27	0.33	0.26	0.26	0.22

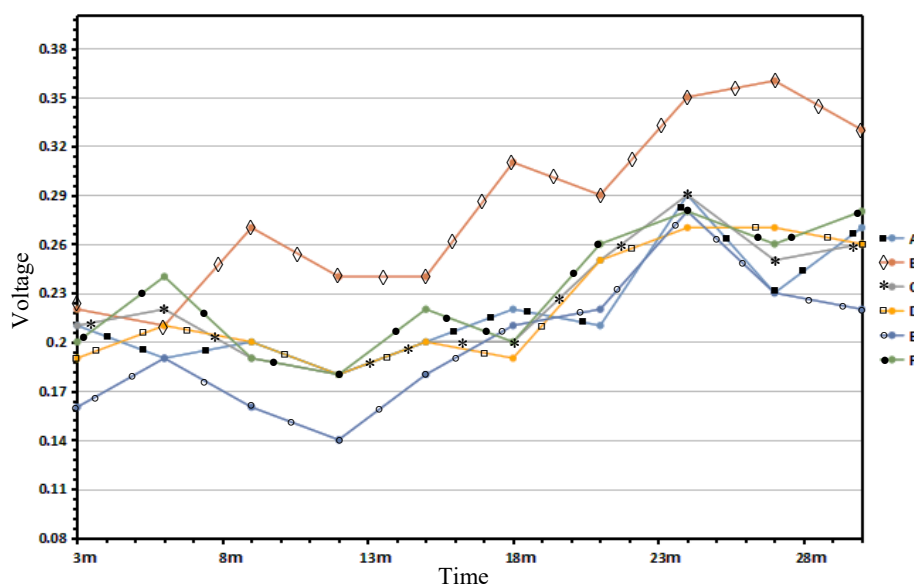


Figure 8. Voltage output for each peltier.

Six TEGs were electrically linked in series to form an array. TEG A, B, C, D, E, and F were used for electrical characterization; their relative voltages were 0.30 V, 0.27 V, 0.33 V, D 0.26 V, 0.26 V, and 0.22 V. Because it is brazed to the copper plate on top of the discharge pipe, Peltier B exhibits the greatest voltage output value. This result indicates the highest voltage output and represents the data when the split unit air conditioner and peltier device have already run for 30 minutes. The greatest voltage that can be obtained from these peltier devices, when the voltage from each peltier is added together, is 1.47 V.

CONCLUSION

The progress of this peltier device research yields encouraging results for producing voltage using the heat recovery technique. Between 9 and 10°C was the temperature differential between the hot and cold plates, which produced 1.47 V. The thermoelectric generator (TEG)-based Peltier device demonstrates the fundamentals of thermoelectric power and its appropriate use in waste heat energy recovery. It is possible to efficiently design thermoelectric frameworks to function with minimal heat sources and temperature gradients. These can suggest that TEG technologies are appropriate devices for split unit air conditioning systems' waste heat recovery.

Acknowledgments

The help provided by GLA University, Mathura, India in conducting this research is greatly appreciated by the Author.

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