REPUBLIQUE ALGERIENNE DEMOCRATIQUE ET POPULAIRE

MINISTERE DE L'ENSEIGNEMENT SUPERIEUR ET DE LA RECHERCHE SCIENTIFIQUE

Université de Mohamed El-Bachir El-Ibrahimi - Bordj Bou Arreridj

Faculté des Sciences et de la technologie

Department d'Electronique

Rapport

Projet de Fin de Cycle (PFC)

MCIL 3

FILIERE : **Electroniques.**

Spécialité : Industries Electroniques.

- **Par : ABIDI Amani**

Intitulé

New vehicles air conditioning system using solar energy based on Peltier effect.

Présenté le : 14/06/2023

Devant le Jury composé de :

Nom & Prénom	***Qualité***	***Etablissement***
M.SID AHMED Soumia	***President***	***Univ-BBA***
M.FlISSI Moustafa	***Examinateur***	***Univ-BBA***
M.BENTOUHAMI Larafi	***Encadrant***	***Univ-BBA***
M.ATOUI Aissa	***Co-Encadrant***	***Univ-BBA***

Année Universitaire 2022/2023

THANKING

First of all, I thank Almighty God for giving me the strength and the courage to undertake this humble act which allowed me to live a beautiful experience**,** After the grace of God, I would like to thank my mother, who supported me in all its forms throughout my education and believed in my abilities. No matter how much I thank you, I will not repay you.

I would like to thank my supervisors, Mr. BENTOUHAMI LARAFI and Mr. ATTOUI AISSA, for monitoring my work and for the encouragement continuous that it never ceased to lavish on me throughout this work.

After that, I extend my warm thanks to the teachers of the Department of Electronics without exception, for their continuous support and good treatment, which encourages us to work harder.

DEDICATION

To my dear Mother Sihem

Who merit, sacrifices and human qualities

Made me live this day.

To my dear sister Nour el houda

And all the people who encouraged me and wished me success

Thank you.

ملخص

تناقش مذكرتنا بعنوان "نظام جديد لتكييف المركبات يعمل بالطاقة الشمسية بالاعتماد على تأثير peltier"نظام تكييف المركبات المعتاد وعناصره بالإضافة الى التبريد الكهرو حراري والخطوات المتبعة لتنفيذ النموذج الاولي للجهاز.

يتم التحكم في نظامنا من خلال لوحة اردوينو بحيث تمكننا من التحكم في قطع peltier بالإضافة الى ملتقط حرارة مع شاشة تمكننا من معرفة درجة الحرارة التي بلغها الجهاز بعد الاختبارات العديدة للجهاز اعطى لنا ما يقارب 40 بالمائة من توقعاتنا حيث يمكن تحسين هذه النتائج والتوصل لدرجة حرارة اقل خلال مدة أقصر.

Résumé

Notre étude intitulée "Un nouveau système de climatisation des véhicules alimenté par l'énergie solaire basé sur l'effet Peltier" aborde le système de climatisation automobile usuel et ses composants en plus du refroidissement électrothermique en plus des étapes utilisées pour mettre en œuvre le prototype de l'appareil.

Notre système est contrôlé par une carte Arduino qui nous permet de contrôler les parties Peltier, en plus d'un capteur de température avec un écran qui nous permet de connaître la température atteinte par l'appareil ; Après de nombreux tests de l'appareil, il nous a donné environ 40% de nos attentes, car ces résultats peuvent être améliorés et une température plus basse est atteinte.

Abstract

Our study entitled "A new vehicles air conditioning system using solar energy based on peltier effect " discusses the usual vehicle air-conditioning system and its components in addition to thermoelectric cooling in addition to the steps used to implement the prototype of the device.

Our system is controlled by an Arduino board that enables us to control the Peltier parts, in addition to a temperature sensor with a screen that enables us to know the temperature reached by the device.

After numerous tests of the device, it gave us about 40 percent of our expectations, as these results can be improved and a lower temperature is achieved.

SUMMRAY

GENERAL INTRODUCUTION 2

CHAPTRE I AUTOMOTIVE AIRCONDITIONING SYSTEM, SOLAR ENERGY AND THERMOELECTRIC COOLING

I.1 Introduction 3
Part 1: Automotive air condoning system 3
I 1.1 Air conditioning defined 3
I.1.2 Basic theory of cooling 4
I.1.2.1 Enthalpy 4
I.1.2.2 Pressure 4
I.1.2.3 Critical temperature and pressure 5
I.1.2.4 Conduction, convection and radiation 5
I.1.2.5 Heat 6
I.1.2.6 Temperature 6
I.1.3 Automotive air conditioning system operating 7
I.1.3.1 How Automotive air conditioning system works? 7
I.1.3.2 Air conditioning circuit 8
I.1.4 Automotive air conditioning components 9
I.1.4.1 Compressor 9
I.1.4.2 Condenser 9
I.1.4.3 Hoses and Lines 10
I.1.4.4 Expansion device 10
I.1.4.5 Evaporator 11
I.1.4.6 Storage vessel 12
Part 2 : Solar Energy And Thermoelectric Cooling 13
I.2.1 Different types of solar energy 13
I.2.1.1 Photovoltaic solar energy 13
I.2.1.2 Thermal Solar energy 15
I.2.1.3 Thermodynamic solar energy 15
I.2.2 Definition of Thermoelectric cooling 15
I.2.3 Thermoelectric effects 15
I.2.3.1 Seebeck effect 15
I.2.3.2 Peltier effect 16
I.2.3.2 Thomson Effect 18
I.2.4 Thermoelectric coefficients 18
I.2.4.1 Seebeck coefficient 18

I.2.4.2 Peltier Coefficient 19
I.2.4.3 Thomson Coefficient 19
I.2.4.4 Kelvin's connections 19
I.2.5 Applications in thermoelectricity 19
I.2.5.1 Peltier effect modules 19
I.2.5.2 Design of a Peltier element 20
I.2.5.3 Thermoelectric generator 21
I.6 conclusion 22

CHAPTRE II IMPLEMENTATION AND PRATICAL RESULTS

II.1 Introduction 23
II.2 Preliminary design of the project by hfss program 23
II .3 Project components 24
II .4 Principle of certain project components 26
II .4.1 Temperature and humidity sensor 26
II .4.1.1 DHT11 sensor 26
II .4.1.2 I2C LCD16×2 principle 27
II .4.1.3 Arduino Uno R3 27
II.4.2 Pump automatic operation system 28
II.4.2.1 SRD 5V Relay 28
II.4.2.2 DC Pomp 29
II.4.3 Peltier modules 30
II.4.3.1 Characteristics 30
II.4.3 Heat sink 31
II.4.4 Aluminum Box with spiral tube 31
II.4.5 Pcb card 32
II.4.5.1 Proteus 32
II.4.5.2 Stages of creating pcb card 32
II.5 Explanation of system operation 34
II .6 Final results of the system 35
II .7 Conclusion 36
GENERAL CINCLUSION 37
FIGURES LISTE
REFRENCES

GENERAL INTRODUCUTION

This study summarizes the design of the new vehicles air conditioning system using solar energy based on peltier effect.

The investigated vehicles air conditioning system in this project is mainly based on Peltier modules, which generate low heat that is eventually delivered to the radiator via stages in the system. The system is controlled by an Arduino board that sends and receives signals, whether peltier modules or pomp.

This device contains a screen to show the temperature inside the radiator, in addition to switches in order to control the peltier.

The thesis is divided into two main parts :

- In the first, we presented an overview of the current and widespread vehicle air-conditioning system and detailed its various elements. We also touched the many forms of solar energy. Finally, we covered thermoelectric phenomena such as : Seebeck, Thomson and peltier effect.

- The second part, we presented the different stages of creating this project, starting with the initial design of the project, choosing the electrical elements, simulation, creating the PCB card until assembling the device and testing its results.

CHAPTRE I

AUTOMOTIVE AIRCONDITIONING SYSTEM, SOLAR ENERGY AND THERMOELECTRIC COOLING

I.1 Introduction

Since the dawn of time, humans have attempted to exert control over their surroundings. It was only natural that a passenger comfort heating and cooling system would be required after the automobile became popular. As a result, the hunt for vehicle passenger compartment temperature control began in 1940. Air conditioning has grown in popularity year after year since then. Among the other things that man wanted to control is his use of energy, and accordingly he searched for other sources of it, such as Solar energy can be utilized through photothermal, photovoltaic and photocatalytic approaches. Photoelectrochemical conversion of solar energy into chemical energy and fuels, by means of artificial photosynthesis and photocatalytic chemical synthesis, could realize the application of solar energy in a variety of fields. This themed issue on advances in solar energy conversion brings together experts in this field to describe current research and future prospects in this area. The topic of the issue focuses on, but is not limited to, the rational design, fabrication, and advanced characterization of components of photo conversion systems, materials, processes and technologies.

Part 1: Automotive air condoning system

I 1.1 Air conditioning defined

Before exploring its past and how it applies to automobiles, it is important to first study the concept of air conditioning. By definition, air cooling refers to the process of : The air is cooled, heated, cleaned, filtered, humidified, dehumidified, circulated, or recirculated. Additionally, the conditioned air's amount and quality are under control. This implies that the air's temperature,

Figure I.1.1 : Old and new vehicles air conditioning system.

humidity, and volume can all be adjusted at any time and in any circumstance. In the best-case scenario, air conditioning should be able to complete each of these duties simultaneously. Recognizing that refrigeration is a part of the air conditioning process is crucial (cooling by removing heat).

I.1.2 Basic theory of cooling

An air conditioner is a device that keeps the air in a specific space at a comfortable temperature and humidity level. To accomplish this, an air conditioner must include a heater, cooler, moisture controller, and ventilator. An HVAC system's fundamentals are :

- Heater – adding heat by transferring it;
- Cooler – removing heat by transferring it;
- Humidity – removing or adding moisture;
- Purification – by filtration;
- Ventilation – air movement through the vehicle.

I.1.2.1 Enthalpy

The enthalpy of a substance is a measure of its useful energy content. The enthalpy of a liquid rises in proportion to its temperature. When a liquid turns into a vapor evaporative latent heat Temperature does not rise due to the increase in internal energy, however enthalpy does.

I.1.2.2 Pressure

A force on a unit area is defined as a solid, liquid, or gas exerting pressure. The Pascal is the SI unit for pressure (Pa). Additional pressure units include atmospheres (atm), kilograms of force per centimeter squared (kgf/cm2), pounds per square inch (psi), and millimeters of mercury (mmHg) (mmHg). At sea level, atmospheric pressure is 101.325 kPa (14.6 psi). If the gauge does not monitor atmospheric pressure, this is frequently displayed as 0 (gauge pressure). When atmospheric pressure is added to gauge pressure, the result is absolute pressure.

- **A pressurised liquid :** When the tap is closed and a liquid that easily evaporates at atmospheric pressure is placed inside the box, pressure builds up, causing the boiling point of the liquid to rise. When the tap is opened, the pressure drops abruptly, and the liquid quickly evaporates, lowering the temperature (by absorbing the heat from inside the box)

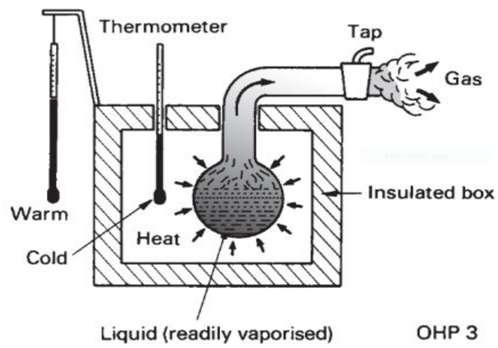


Figure I.1.2 : Liquid removing heat by changing state. [1]

I.1.2.3 Critical temperature and pressure

The critical temperature is the highest temperature at which a gas can condense and a liquid can vaporize as pressure increases.

-Pressures and temperatures that limit the maximum pressure and temperature to which they can be subjected.

- Subcritical systems are air conditioning devices that run below a refrigerant's critical thresholds.

I.1.2.4 Conduction, convection and radiation

I.1.2.4 .1 Conduction

Epacts how heat is directly transferred within a matter by conduction; for example, if heat is applied to one end of a steel bar, the temperature at the other end gradually rises. Although aluminum and copper are both good heat conductors, polymers act more like insulators (plastics).

I.1.2.4.2 Convection

Convection is the transfer of heat across a medium, such as a liquid in a saucepan When there is convection, heat and media move indefinitely. As the medium, whether liquid or gas, travels, heat is released into the environment. When a liquid or gas heats up, it expands, making some of the substance lighter than other parts that have less heat in them. Natural convection currents develop in any material that is not uniformly heated.

I.1.2.4.3 Radiation

Heat can move from one location to another via heat rays without warming the surrounding air. One example is ultraviolet light emitted by the sun. A warmer object, such as the sun's surface, can radiate heat to a cooler object, such as the Earth's surface.

I.1.2.5 Heat

Heat is a basic form of kinetic energy that can only be converted into or out of other forms of energy. Heat will always transfer from a hot surface to a cold surface until the temperatures are equal, according to scientific principles. The speed at which heat migrates is determined by the temperature difference between a hot (more energetic molecular movement) and cold (less energetic molecular movement) location.

I.1.2.6 Temperature

The following presents the two types of temperature :

- **Dry bulb temperature :** Is the temperature indicated by a standard thermometer used to measure air temperature.
- **Wet bulb temperature** : In a wet bulb thermometer, the heat-sensitive bulb of a glass tube thermometer is wrapped in gauze and suspended from one end of a water container, allowing

water to be drawn up by capillary action and moisten the bulb. Moisture steals some of the heat generated by the bulb, depending on how quickly it can evaporate. The temperature that is recorded is referred to as wet bulb temperature. Some equipment vendors sell as an accessory a probe with a wet sock temperature.

I.1.3 Automotive air conditioning system operating

I.1.3.1 How Automotive air conditioning system works ?

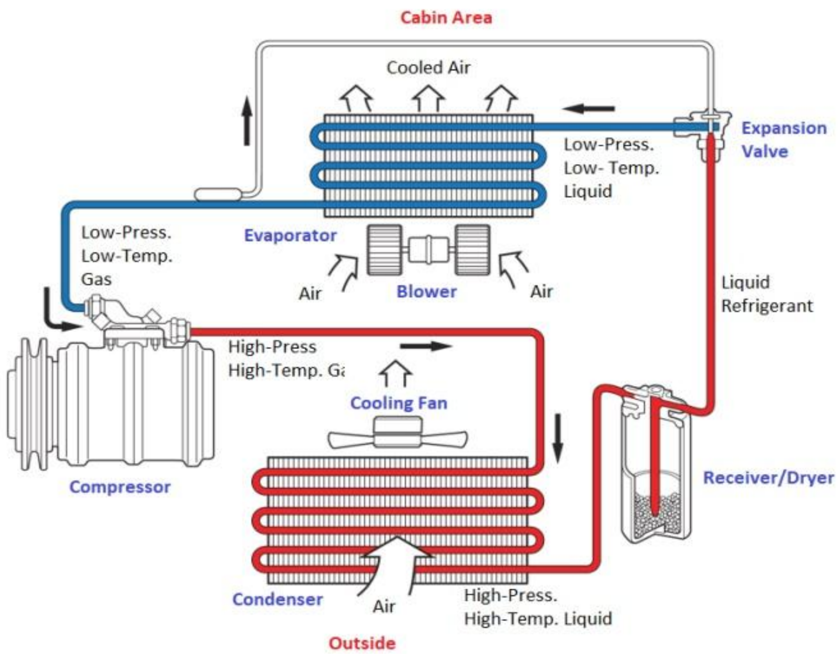


Figure I .1.3 : The vehicle air conditioning system. [2]

The physical principle of gas pressure, according to which temperature rises when a gas is compressed but falls when pressure is reduced, was the basis for the air conditioning system. Refrigerant gas is charged into the high-pressure air conditioning system circuit after passing through an engine-driven compressor. High pressure (20 to 30 bar) and a temperature of around 80 °C are applied to the gas. It then transfers into liquid form after passing through a condenser, a chiller, near the front of the vehicle to reduce its temperature. This liquid then flows through a pressure reduction valve, where the pressure elevates the liquid's temperature by around 10 degrees Celsius. The pressure reduction valve traps water, preventing the formation of ice in the circuit. It then passes through a vaporizer, which is now responsible for chilling the outside air, which then enters the vehicle's ventilation circle and mixes with the surrounding air at a temperature of 5 to 10 degrees Celsius. The temperature and air flow buttons allow you to manage the temperature of the passenger compartment manually or automatically (depending on your vehicle model).

I.1.3.2 Air conditioning circuit

To better understand the function of an automotive air-conditioning system, it is helpful to know the physical state of the refrigerant in the various sections of the system. Actually, there are only six such states to be considered (Following is a brief overview of each of these states. For component location, refer to callouts (A through F) in Figure 4 for an expansion valve system) :

Low-Pressure Vapor : The refrigerant is a low-pressure vapor in the section of the system from the evaporator outlet to the compressor inlet (A). This includes any devices found in the suction line, such as a suction-line drier, muffler, or accumulator.

Low-Pressure Liquid : Immediately after the metering device, the entrance to the evaporator (B) is the only part of the system that may contain low-pressure liquid. Even this section contains vapor, called flash gas, having just passed through the metering device.

Low-Pressure Vapor and Liquid : In the evaporator (C), low-pressure liquid refrigerant boils as it picks up heat and is changed to low-pressure vapor.

High-Pressure Vapor : The refrigerant is at high pressure in a vapor state in the line from the compressor outlet to the condenser inlet (D). This includes any devices that may be in the discharge line, such as a muffler.

High-Pressure Liquid : The high-pressure liquid refrigerant section extends from the condenser outlet to the metering device inlet (E). This includes any devices in the liquid line, such as receiver, drier, and sight glass.

High-Pressure Liquid and Vapor : In giving up its heat, the high-pressure refrigerant vapor is changed to liquid in the condenser (F). [3]

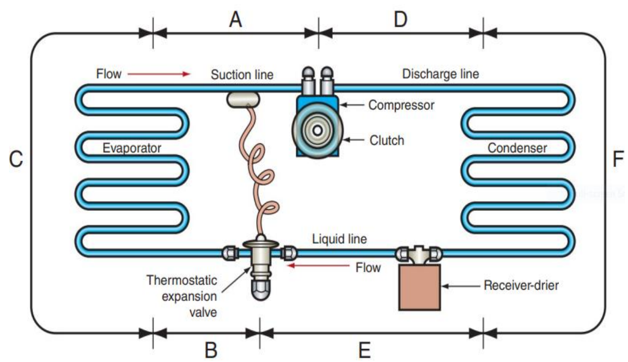


Figure I.1.4 : Refrigerant cycle and components in the expansion value air-conditioning system. [3]

I.1.4 Automotive air conditioning components

The basic automotive air-conditioning system components consist of these :

I.1.4.1 Compressor

The compressor is a mechanical device that circulates and compresses the refrigerant gas, increasing its temperature and pressure. This guarantees that heat is removed efficiently at the condenser. In most automobiles, three to four pounds of refrigerant are used to fill the system.

Figure I.1.5 : A typical air conditioning compressor.

I.1.4.2 Condenser

The condenser's function is to chill the refrigerant, which causes it to either condense or change from a gas to a liquid. This occurs when hot, gaseous refrigerant is forced across the condenser coil, which is exposed to heated external air. Due to the cooler exterior air, heat can pass from the refrigerant to it, where it is then rejected into the atmosphere.

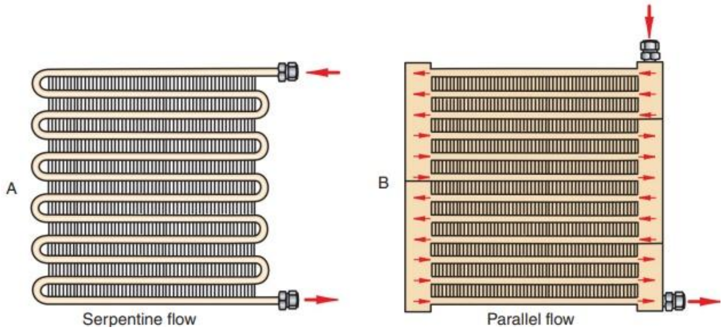


Figure I.1.6 : Two common flow paths through air conditioning condensers.

I.1.4.3 Hoses and Lines

Steel or aluminum can be used to make the vapor and refrigerant lines. The inside lining of hoses is typically made of nylon to ensure integrity and to create a barrier wall to stop refrigerant leakage. Hoses are typically comprised of synthetic rubber coated with nylon braid for strength. All R-134a refrigerant systems use a hose with this barrier-type classification. Older R-12 systems employed hoses with inner liners commonly made of Buna "N", a synthetic rubber. R-134a systems cannot use Buna "N", which is unaffected by R-12. Systems using R-134a and R12 may both use barrier hoses lined with nylon.

I.1.4.4 Expansion device

I.1.4.4.1 Thermostatic Expansion Valve

Figure I.1.7 : Thermostatic expansion valves: (A) internal equalized and (B) external equalized.

The TXV, which is located on the evaporator's input side, serves as the system's metering device. The TXV separates the system into two parts: high and low. The thermostatic expansion valve is designed to serve two primary functions :

-The expansion valve meters the flow of refrigerant into the evaporator in accordance with different heat loads and compressor power.

-The refrigerant pressure decreases as high-pressure liquid enters the valve through a restriction and quickly expands and vaporizes into a low-pressure mist.

I.1.4.4.2 Orifice Tube

The liquid refrigerant enters the evaporator via the orifice tube, which acts as a calibrated restrictor. Its aim is to meter high-pressure liquid refrigerant as a low-pressure liquid into the evaporator. At the limitation, the orifice tube creates a pressure difference between the low-pressure liquid line and evaporator on one side and the high-pressure liquid line and condenser on the other.

Figure I.1.8 : A typical fixed orifice tube (FOT).

I.1.4.5 Evaporator

The evaporator is a heat exchanger that removes heat from the car's cabin air or from incoming fresh air pumped through the coil. The evaporator is usually situated in the passenger compartment.

The air conditioning evaporator, which cooled by absorbing heat from the atmosphere, can perform two roles at once when placed very close to the vehicle's dashboard. It gathers heat from the air that flows through it as well as heat from within the automobile to maintain the required temperature.

Figure I.1.9 : Air conditioning

I.1.4.6 Storage vessel

I.1.4.6.1 Receiver-drier—used with expansion valve

On the high-pressure side of the air conditioning system. The architecture of the drier separates refrigerant vapor from liquid to ensure that only liquid is available to the metering device. The receiver-drier has 5 primary purposes. First, it serves as a reservoir for liquid refrigerant collected from the condenser. Second, it maintains a liquid column free of vapors in the TXV under a variety of heat loads. In contrast to any vapor that may be present, the liquid refrigerant will sink to the bottom of the container and rise to the top. In addition to absorbing moisture, the receiver also serves as a filter to get rid of solid impurities. A constant flow of refrigerant is also ensured by the receiver-drier, which reduces compressor pulses.

Figure I.1.10 : Receiver drier.

I.1.4.6.2 Accumulator-used with orifice tube

The accumulator, which looks like a tank, is located at the evaporator's outflow. It must be present in any system that uses orifice tubes for air conditioning. The orifice tube may meter more liquid refrigerant into the evaporator than can be evaporated under certain conditions. Without the accumulator, surplus liquid refrigerant escaping from the evaporator would enter the compressor and damage it.

Figure I.1.11 : AC Accumulator.

Part 2 : Solar Energy And Thermoelectric Cooling

I.2.1 Different types of solar energy

I.2.1.1 Photovoltaic solar energy

Solar photovoltaic (PV) energy is created when photons, a component of solar radiation, are directly transformed into electrical energy using sensors made of materials sensitive to visible wavelengths (also known as PV cells). When several PV cells are coupled in series or parallel and exhibit a nonlinear static current-voltage characteristic I(V) with a maximum power, the result is a generator photovoltaic (GPV). The temperature, amount, and age of the cell all have an impact on this attribute. The extreme extremes at which the GPV's point operating time can alter are represented by the current short-circuit voltage Icc and the open-circuit voltage Voc.

Figure I.2.1 : A solar panel, consisting of many photovoltaic cells.

I.2.1.1.1 Discovery of the photovoltaic effect

The technology known as photovoltaics produces direct current (DC) electrical power, which is measured in watts (W) or kilowatts (KW), from semiconductors when they are illuminated by photons. As long as light is shining on the solar cells, electrical power will be produced. Solar cells never require recharging like batteries do because when the light goes out, the electricity also goes out. For more than 30 years, some have operated outside continuously on Earth or in space.

I.2.1.1.2 Photovoltaics cells

A photovoltaic cell is based on the scientific phenomena known as the photovoltaic effect, the photovoltaic cell is composed of two layers of crystalline silicon, which is a conductor. This means that, despite being bound to atoms, electrons can separate and circulate with the help of light energy, allowing the passage of a current as in an electrical conductor.

There are four electrons in the silicon atom. Doping two layers will result in polarization. To make it one of the layers, many Boron atoms are added to the P layer, which is one electron positive compared to silicon atoms (3electrons). The other negative layer (N layer), composed of many phosphorus atoms, contains one more electron (5 electrons) than silicon atoms, forming a potential barrier. When the two types of layers are superimposed, the two separate charges (+ and -) remain in their respective fields because they cancel each other out and produce an electric field that repels the other charges. Bore and phosphorus atoms are not movable, unlike silicon atoms, which define only one layer.

When photons with sufficient energy are absorbed by this semiconductor, a valence bond, or the relationship between an electron and an atom, is ruptured for each silicon atom, resulting in the liberation of an electron from each silicon atom. The voltaic effect is the difference in potential between these two layers. Due to the electric repulsion field, this electron will unavoidably move to the negative side, whereas silicon atoms that have gained an electron (Si+) will move to the positive side. By connecting these layers, we can transport electrons from one layer to the next, resulting in an electric current. After employing this method, silicon atoms that have lost an electron (Si+) are connected to by "non-energy" electrons.

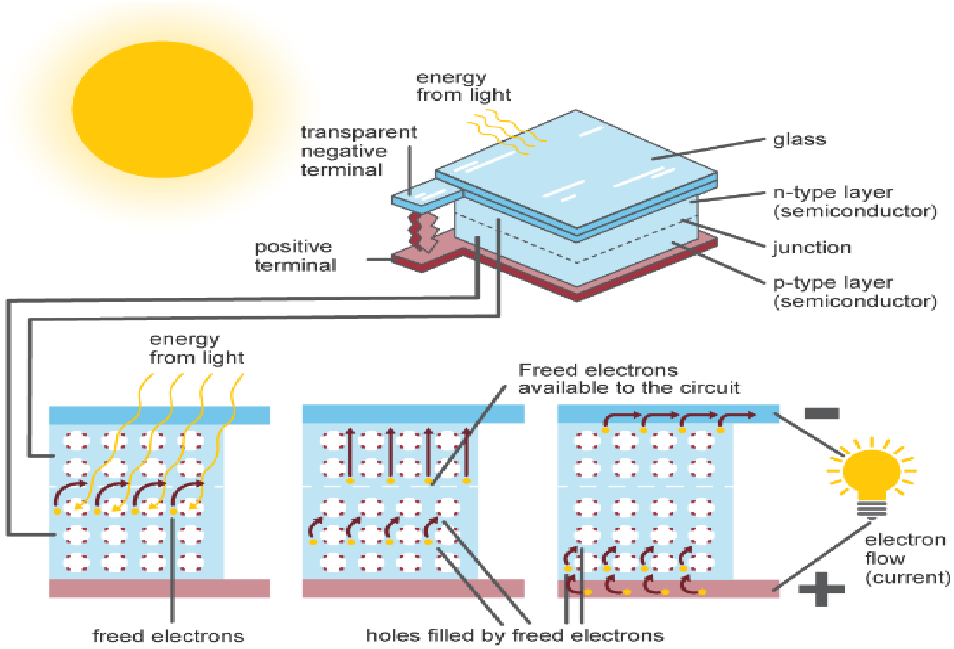


Figure I.2.2 : Inside a photovoltaic cell. [4]

I.2.1.2 Thermal Solar energy

Solar thermal energy is created by converting solar radiation into heat and primarily recovering it by heating water. Although it can be used as a complement for habitat heating, its primary application is to provide residential hot water. If the temperature is high enough, electricity can be generated using a thermodynamic cycle (and heat). This industry deals with concentrated solar systems, often known as thermodynamic solar power plants.

I.2.1.3 Thermodynamic solar energy

Thermodynamic solar energy is a method for concentrated solar power plants to generate electricity while storing the thermal energy needed to do so for several hours after sunset. The basic concept is to direct sunlight through mirrors to heat a fluid to a high temperature (a few hundred degrees), which will then generate steam via heat exchange and power via a turbine. Because the fluid used can retain heat for several hours after sunset, it is possible to generate electricity in the early evening, when consumption is at its peak.

I.2.2 Definition of Thermoelectric cooling

Thermoelectricity is the process of converting heat into electricity. Seebeck, a German physicist, made the discovery in 1821. The thermoelectric effect is phenomena that connects a material's ability to conduct heat and current. The Seebeck, Peltier, and Thomson effects are mentioned. This effect should not be confused with the pyroelectric effect, which emerges after a temperature change and disappears after the dielectric relaxation time.

I.2.3 Thermoelectric effects

I.2.3.1 Seebeck effect

I.2.3.1.1 Explanation of the phenomenon

When a metal is exposed to a temperature gradient T, the average electron energy on the hot side is greater than on the cold side, an energy gradient forms. As a result, a force will emerge that causes electrons to diffuse from the heated to the cold side. As a result of this diffusion, the material becomes polarized as a result of the accumulation of mostly negative carriers on the cold side and mostly positive carriers on the hot side, creating an electric field E that aids in the diffusion of cold electrons towards the hot side.

I.2.3.1.2 Principle

A temperature gradient (dt) applied at the ends of a conducting bar spontaneously generates a potential difference (dV) proportional to the temperature difference. The constant of proportionality constitutes the Seebeck coefficient :

$$\alpha_{ab}=\frac{dV}{dt} \quad (1)$$

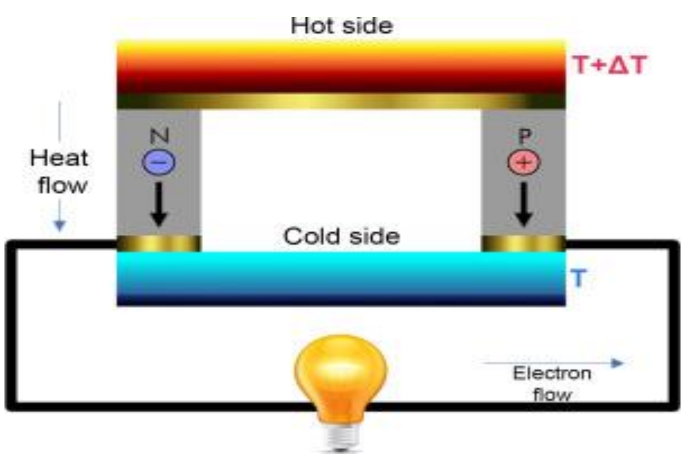


Figure I.2.3 : The Seebeck effect. [5]

I.2.3.2 Peltier effect

I.2.3.2.1 Explanation of the phenomenon

The system with which they interact provides energy to load carriers when they transition from a low energy level to a higher energy level, for as when moving from type p material to type n material. However, the only system capable of containing them is the crystalline network in which they collide. As a result of the Peltier effect, the crystalline network transfers energy to the load carriers and the junction cools. Load carriers, on the other hand, traverse a junction by going from a high-energy level to a low-energy level, and the energy lost is passed to the grid, and the junction is heated by the Peltier effect. The type of material a and b, as well as the direction of the current flowing through them, cause a temperature gradient in the sample.

The interaction of electrical and thermal phenomena allows for two possible applications: refrigeration and electrical generation. Refrigeration is made possible by the flow of heat that occurs after an electric current is applied to the terminals of a material. This flow allows heat to be evacuated from a body to be refrigerated and dissipated into the surrounding environment. Current generation can occur when external heat causes a temperature difference at the material's ends. A voltage is established, which can then be used to generate current in a load resistor.

I.2.3.2.2 Principle

In the Peltier effect, the amount of heat absorbed (Q) or generated is proportional to the electric current (I). The proportionality constant μ is the Peltier coefficient :

$$\mu = \frac{Q}{I} \quad (2)$$

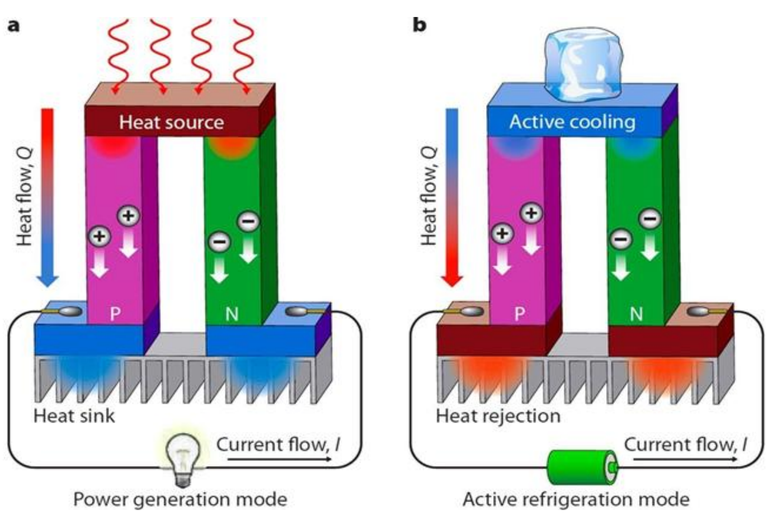


Figure I.2.4 : Principle of the Peltier and Seebeck effect. [6]

I.2.3.2.3 Applications

This effect's most intriguing applications are in low-power micro refrigeration, particularly in electronics and astronautics. Thermoelectric refrigerators have many appealing characteristics, including long life, accuracy, dependability, and silence. However, their profits are pitiful. However, a few companies make portable coolers that run on cigarette lighters.

I.2.3.2 Thomson Effect

I.2.3.2.1 Principle

Absorption of heat from the outside environment when the current circulates in the opposite direction of the temperature difference, and a heat release when the current circulates in the direction of the temperature difference Conversely an electric current is generated if the material is subjected to a temperature gradient and a heat flow.

I.2.4 Thermoelectric coefficients

I.2.4.1 Seebeck coefficient

According to a change in temperature (dt) between two materials (a and b) at their junctions implies a difference in electrical pot ential (dV) :

$$S_{ab}=\frac{dV}{dt} \tag{3}$$

The Seebeck coefficient, also called "thermoelectric power", is expressed in V/K the Seebeck coefficients of the two materials are related to the Seebeck coefficient of the torque according to :

$$S_{ab}=S_a-S_b \tag{4}$$

I.2.4.2 Peltier Coefficient

The Peltier effect occurs when an electric current I is applied to a two-material circuit, causing heat to be released at one junction and absorbed at the other, as explained by :

$$\mu_{ab} = \frac{Q}{I} \qquad (5)$$

I.2.4.3 Thomson Coefficient

For a single material, the Thomson coefficient can be easily defined. Each material segment separately produces or absorbs heat when there is a temperature gradient and electrical current present. The material's internal thermal flux gradient is then determined by :

$$\frac{dQ}{dx} = I_{\tau} \times \frac{dt}{dx} \qquad (6)$$

I.2.4.4 Kelvin's connections

The three effects Seebeck, Peltier and Thomson are linked by Kelvin's relations following :

$$S_{ab} = \frac{\mu_{ab}}{t} \qquad (7)$$

$$\tau_a - \tau_b = t \times \frac{dS_{ab}}{dt} \qquad (8)$$

I.2.5 Applications in thermoelectricity
I.2.5.1 Peltier effect modules

As previously stated, a Peltier module is thus a P semiconductor assembly with N to create PN junctions on one side and NP junctions on the other.

When a current is passed through the module, the N electrons are pushed to the positive terminal and the P gap is dragged to the negative terminal. After leaving all 20 two-junctions, they move to the other side of the module, where the gap recombines with an electron and an electron with another gap, releasing heat in the process. As a result of the configuration of the NP and PN junction linkages and the properties of semiconductors N and P, a Peltier module will be heated on one side and cooled on the other when a current is applied to it.

Knowing that if one can maintain the temperature of its warm face at a level that is almost identical to the ambient temperature by extracting the heat produced continuously we can obtain very low temperatures of its cold face, we chose to use a single Peltier plate in order to reduce power consumption but also to make it simpler for us to maximize and take advantage of it.

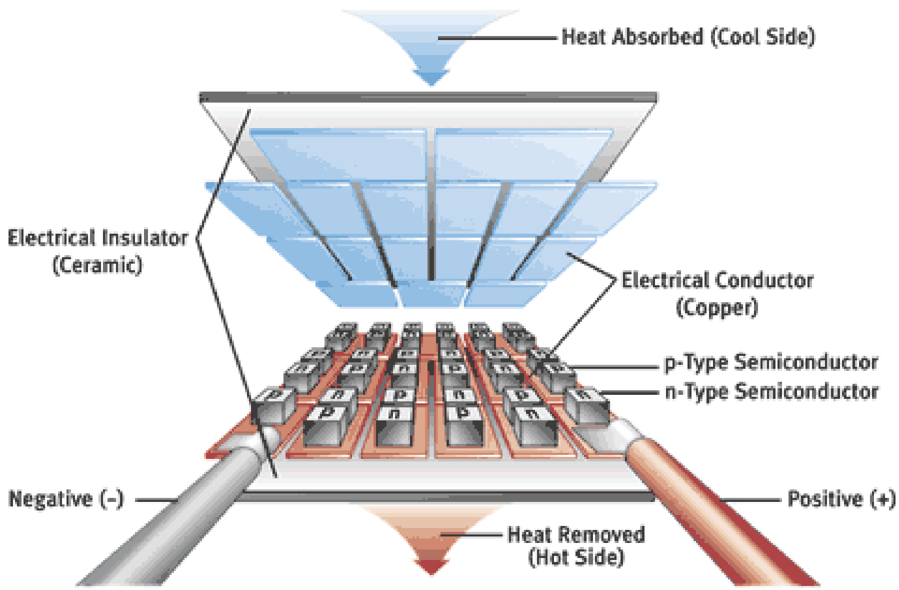


Figure I.2.5 : Illustration components of a Peltier module. [7]

I.2.5.2 Design of a Peltier element

I.2.5.2.1 Thermocouple

The thermocouple is the smallest component of a thermal element. It consists of two electrical conductors with significantly different Seebeck coefficients to produce the maximum possible thermoelectric voltage. The materials are typically semiconductor blocks with copper connections at their ends. Bismuth telluride (Bi2Te3) with doping of type n and p is currently the material that works best at room temperature.

I.2.5.2.2 Thermal element

Current Peltier elements are composed of a large number of thermocouples connected in series by copper bridges. On each side of a copper bridge, ceramic plates (often aluminum oxide) insulate it thermally but not electrically.

I.2.5.3 Thermoelectric generator

Thermoelectric power generator, any of a class of solid-state devices that either convert heat directly into electricity or transform electrical energy into thermal power for heating or cooling. Such devices are based on thermoelectric effects involving interactions between the flow of heat and of electricity through solid bodies.

All thermoelectric power generators have the same basic configuration, as shown in the figure. A heat source provides the high temperature, and the heat flows through a thermoelectric converter to a heat sink, which is maintained at a temperature below that of the source. The temperature differential across the converter produces direct current (DC) to a load (RL) having a terminal voltage (V) and a terminal current (I). There is no intermediate energy conversion process. For this reason, thermoelectric power generation is classified as direct power conversion. The amount of electrical power generated is given by I2RL, or VI.

A unique aspect of thermoelectric energy conversion is that the direction of energy flow is reversible. So, for instance, if the load resistor is removed and a DC power supply is substituted, the thermoelectric device shown in the figure can be used to draw heat from the “heat source” element and lower its temperature. In this configuration, the reversed energy-conversion process of thermoelectric devices is invoked, using electrical power to pump heat and produce refrigeration. [8]

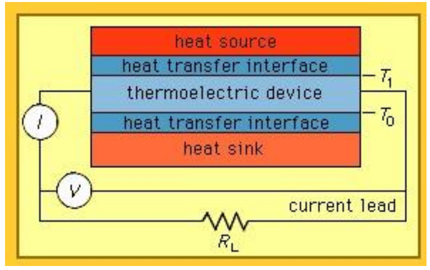


Figure I.2.6 : Thermoelectric power generator. [8]

I.6 Conclusion

In the first part of the chapter I, we provided an overview of the vehicle operating system as it is considered Mechanical systems that collaborate to circulate a refrigerant.

As we mentioned the most important elements in the vehicles air conditioning system, such as the compressor, the evaporator and the condenser.

In the second, we discussed the types of solar energy as well as thermoelectric effects which will help us understand and select the appropriate electrical elements for this project.

CHAPTRE II

IMPLEMENTATION AND PRATICAL RESULTS

II.1 Introduction

The project was designed in order to preserve the car battery as well as consuming less energy.

We used a set of Peltier pieces installed on an aluminum box for heat transfer, inside it a spiral tube to transfer the coolant to the radiator, as we used an Arduino board in order to control the Peltier modules, as well as the automatic start of the pomp, in addition to the LCD screen to display the temperature that DHT11 sensor sends from inside the radiator.

II.2 Preliminary design of the project by HFSS program

HFSS It is an acronym for Ansys High Frequency Structure simulator, which was developed by Professor Zoltan Sinds from Carnegie University with his talents, and it is considered one of the most famous programs in the field of high-speed 3D design used by companies and expert.

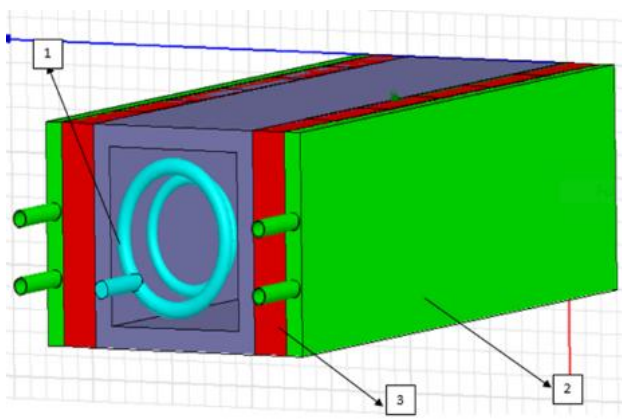


Figure II.1 : Aluminum box with a spiral tube immersed in coolant.

The numbers 1, 2 and 3 in the Figure II.1 represent the following :

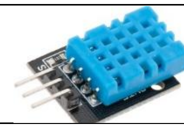
1. Spiral tube with coolant inside;
2. Cooling cases;
3. A group of peltier modules.

II .3 Project components

The following presents the components that we use in this project :

- DHT11 sensor;
- I2C LCD;
- Arduino Uno R3;
- 5×SRD 5V relay;
- DC water pomp;
- 4×Peltier modules;
- 4×Heat Sink;
- Radiator;
- Aluminum Box with spiral tube inside it;
- Connectors;
- 2 ×Switch;
- Engine coolant;
- Connecting thread.

Table II.1 : Project components.

Components	Pictures
DHT11 sensor	
I2C LCD16×2	
Arduino Uno 3	
SRD 5V Relay	
DC Water pomp	
Peltier modules	
Heat sink	
Radiator	
Aluminum box with spiral tube	

II .4 Principle of certain project components

II .4.1 Temperature and humidity sensor

The temperature and humidity sensor is an essential element in our project, as it shows us the temperature that the radiator has reached as temperature sensor is connected to it, and the results appear on the LCD screen. We also control the automatic stop or start operation of the pomp through the temperature recorded by the sensor.

The basic elements that we used in this system are :

II .4.1.1 DHT11 sensor

The DHT11 is a popular temperature and humidity sensor that contains a customized NTC for temperature detection and an 8-bit microcontroller for serial data output of temperature and humidity information. This table explains DHT11 pinout configuration :

Table II.2 : DHT11 pinout configuration.

No:	Pin Name	Description
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Provides serial data output for both temperature and humidity
3	Ground	Connected to the ground

DHT11 Specifications :

- Operational voltage : 3.5V to 5.5V;
- Operational current : 0.3mA (measuring) 60uA (standby);
- Temperature Sufficiency : 0°C to 50°C;
- Humidity Sufficiency : 20% to 90%;
- 16-bit resolution for both temperature and humidity;

- The PCF8574, an 8-bit I/O expander chip, is the brains of the adaptor. Its accuracy is 1°C and 1%. This device transforms the parallel data needed for an LCD display from the I2C data coming from an Arduino.

II .4.1.2 I2C LCD16×2

As the name implies, these LCDs work best for displaying only characters. An 8-bit I/O expander chip called PCF8574 is at the core of the adaptor, allowing a 16 by 2 character LCD, for instance, to show 32 ASCII characters across two rows. The I2C data from an Arduino is transformed into the parallel data needed for an LCD display by this chip.

The board also has a tiny trim pot for fine-tuning the display's contrast and a jumper for turning on the backlight. Remove the jumper and apply external voltage to the header pin labeled "LED" to alter the brightness of the backlight.

The I2C LCD Display has four pinouts :

• GND is a ground pin;

• VCC is the power supply pin. The power supply pin is VCC. Connect it to the Arduino's 5V output or an external 5V power source;

• SDA is the I2C data pin connected to A4;

• SCL is the I2C clock pin connected to A5.

II .4.1.3 Arduino Uno R3

The ideal board to start with when learning about electronics and programming is the Arduino UNO. The UNO board is the most durable one to may start with if this is first time working with the system. The UNO is the Arduino family's most popular and well-documented board.

An ATmega328P-based microcontroller board is the Arduino UNO. It contains 6 analog inputs, a 16 MHz ceramic resonator, a USB port, a power jack, an ICSP header, and a reset button. It also has 14 digital input/output pins, six of which can be used as PWM outputs. It comes with everything required to support the microcontroller; to get started, just use a USB cable to connect it to a computer, or an AC-to-DC adapter or battery to power it. You can experiment with your UNO without being too concerned about making a mistake; in the worst case, you can replace the chip for a few dollars and start over.

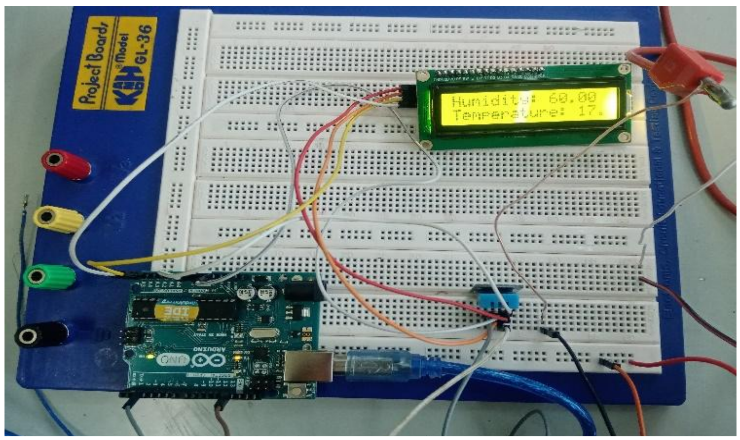


Figure II.2 : The final circuit test of the temperature and humidity sensor.

II.4.2 Pump automatic operation system

We added this automatic system in the project in order to provide the operation of the pump, as when the temperature reaches 15C in the radiator, the pump stops working and starts again when the temperature rises to 5. In order to achieve this system, we used two main elements :

II.4.2.1 SRD 5V Relay

Three high voltage terminals on the SRD-05VDC-SL-C relay (NC, C, and NO) are connected to the device you want to control. Three low voltage pins on the opposite side (Ground, Vcc, and Signal) connect to the Arduino.

NC: Normally closed 120-240V terminal;

NO: Normally open 120-240V terminal;

C: Common terminal;

Ground: Connects to the ground pin on the Arduino;

5V Vcc: Connects the Arduino’s 5V pin;

Signal: Transports the Arduino's trigger signal, which is used to activate the relay.

Inside the relay, an electromagnet is connected to a 120-240V switch. When the relay receives a HIGH signal at the signal pin, the electromagnet charges up, causing the switch contacts to open or close.

Normally open (NO) and normally closed (NC) electrical contacts come in two different varieties inside the relay. According to whether you want the 5V signal to turn the switch on or off, you can choose which one to use. In both arrangements, the common (C) terminal of the relay receives the 120–240V supply current. Use the NO terminal to operate the contacts that are ordinarily open. The NC terminal should be used to operate the usually closed contacts.

Figure II.3 : SRD 5V Relay.

II.4.2.2 DC Pomp

A small electric water pump motor is powered by a direct current power source such as a 24 volts, 12 volts, 5 volts, 6 volts, or 3volts battery, solar panel, or other electrical device. To pressurize, transfer, or circulate water or other liquids, it employs centrifugal force.

Table II.3 : DC Water pomp datasheet.

Model	Rated Voltage	Operating Voltage Rang	Rated Current	Max Flow	Max Heat
DC30A-1219	DC12V	5-12V	0.22A	210L/H	1.9M

Figure II.4 : DC 12V Water pomp.

II.4.3 Peltier modules

This thermoelectric Peltier module provides cooling up to a temperature difference of 67°C, simply by supplying it with 12 V and 6 A.

Its flat shape allows it to be stuck on any surface that needs to be cooled, where it reaches a temperature below zero only within 4 seconds.

In this project, we used 4 Peltier pieces so that they can be controlled by buttons, as the four pieces can be used together or only two.

II.4.3.1 Characteristics

Alimentation : 12 Vcc ;

Intensité : 6 A ;

Puissance : 51,4 W ;

Puissance Max : 72 W ;

Dimensions : 40 x 40 x 3,8 mm.

Table II.4 : Performance Specification Sheet.

Th(ºC)	27	50	Hot side temperature at environment
DTmax(ºC	70	79	Temperature Difference between cold and hot side of the module when cooling capacity is zero at cold side
Umax(Voltage)	16	17.2	Voltage applied to the module at DTmax
Imax(amps)	6.1	6.1	DC current through the modules at DTmax
QCmax(Watts)	61.4	66.7	Cooling capacity at cold side of the module under DT=0 ºC
AC resistance(ohms)	1.8to 2.2	2 to 2.4	The module resistance is tested under AC

Operation Cautions

● A heat sink is attached to the hot side of the module;

● working at a lower Imax or Vmax;

● Apply DC Voltage only.

II.4.3 Heat sink

Heat sinks are an essential component for a wide range of equipment and devices, including electronic devices, terminals, and systems, to properly manage heat. Understanding heat sinks will assist you in achieving effective heat removal, allowing you to maintain the proper temperature for your equipment while keeping it operational.

We use this heat sink because the TEC module transfers heat from the hot side to the cold side in order to function. During the cooling or heating phase, direct current flows from an n-type semiconductor material to a p-type semiconductor material. The Peltier Effect operates by absorbing heat energy from one junction of two dissimilar metals and releasing it in another.

II.4.4 Aluminum Box with spiral tube

We used aluminum because of its properties that allow us to maintain a low temperature, and we filled it with coolant for better effect.

II.4.5 Pcb card

II.4.5.1 Proteus

Proteus IP Solutions Inc. provided software-as-a-service communication capabilities to small and medium-sized businesses. Proteus, a privately held company headquartered in Ottawa, Canada, was created in 1997 and supplied services in sixteen countries. It has over 200 employees and over 500,000 subscribers worldwide.

Figure II.6 : Proteus software

II.4.5.2 Stages of creating pcb card

- In this project, we used Proteus software, and we tested the circuit before printing it, as shown in Figure II.7 :

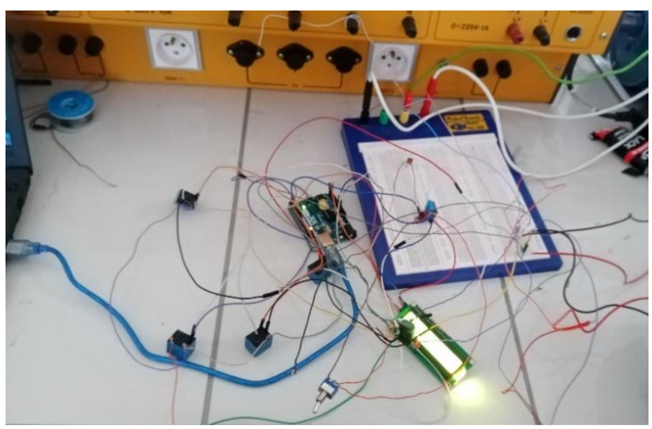


Figure II.7 : Circuit test before printing it.

- After testing the circuit, we design it on the software :

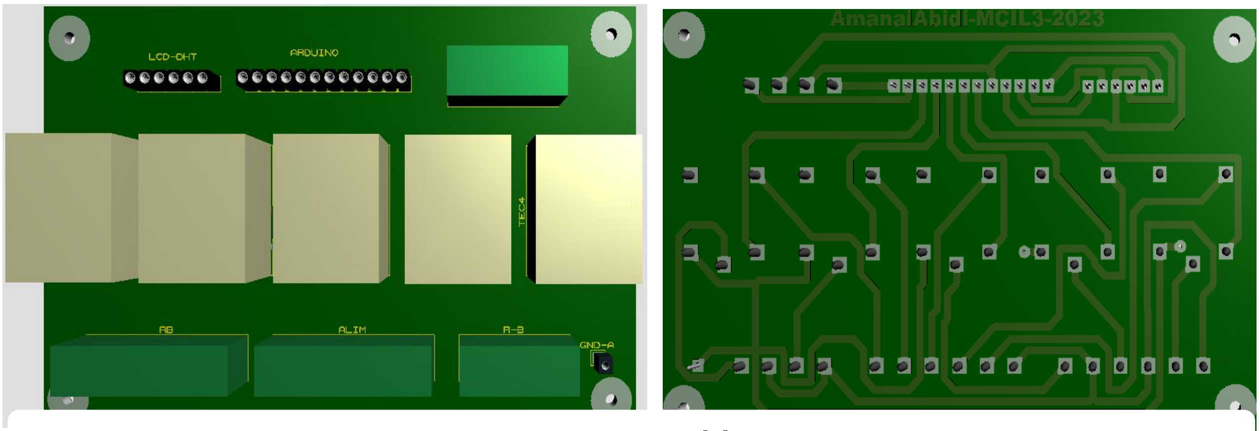


Figure II.8 : PCB card design.

- Then we printed the PCB card :

Figure II.9 : PCB card of the project.

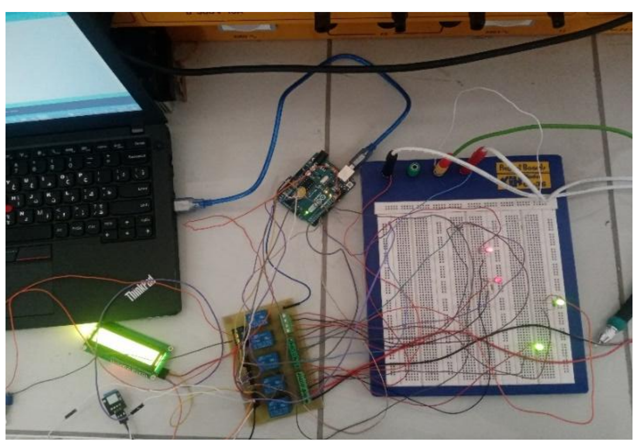


Figure II.10 : PCB testing.

II.5 Explanation of system operation

The new cooling system is primarily based on the peltier modules, which has two sides that differ in temperature when exposed to an electric current, one cold and the other hot.

The cold side of it used in the proposed new refrigeration system, so that it is installed on the surface of the aluminum box Inside it there is a spiral tube and the coolant passes through it and is immersed in a liquid that prevents the peltier from freezing and keeping the temperature as low as possible. As for the hot side of the peltier modules, we have added heat sink above it.

We also added a screen to display the temperature inside the radiator, and two circuit breakers, one controlling TEC1, TEC2 and the other controlling TEC3, TEC4 as for the pomp we made it work automatically to conserve energy so that it stops working when the radiator temperature reaches 15 degrees.

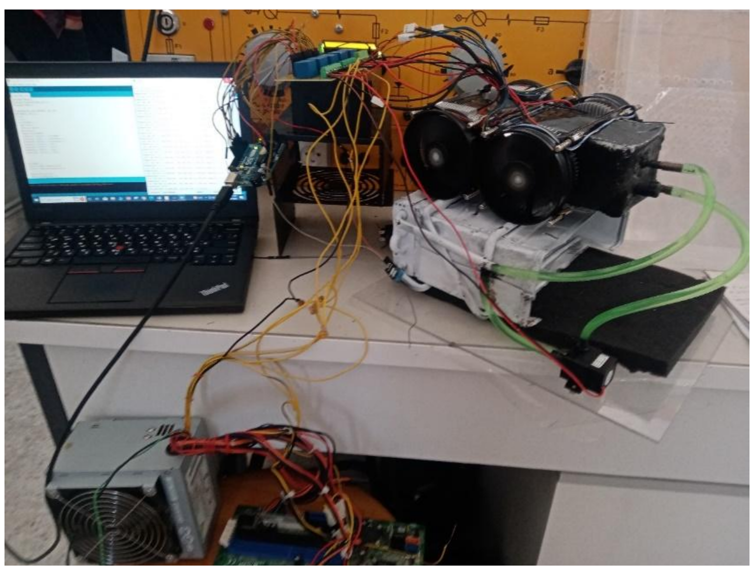


Figure II.11 : Vehicles air conditioning system on test.

II .6 Final results of the system

Table II.5 : Temperature changes inside the radiator during the initial trials of the project.

T(S)	1to25	26	27	28	29	30	31	32	33	34	35	36	37
T(C^O)	26	25.9	25.8	25.6	25.5	25.4	25.3	25.2	25.4	25.2	25.1	25	25.1
T(S)	38	39	40	41	42	43	44	45	46	47	48	49	50
T(C^O)	25	24.9	24.8	24.8	24.7	24.3	24	23.9	23.8	23.7	23.5	23.1	22.9

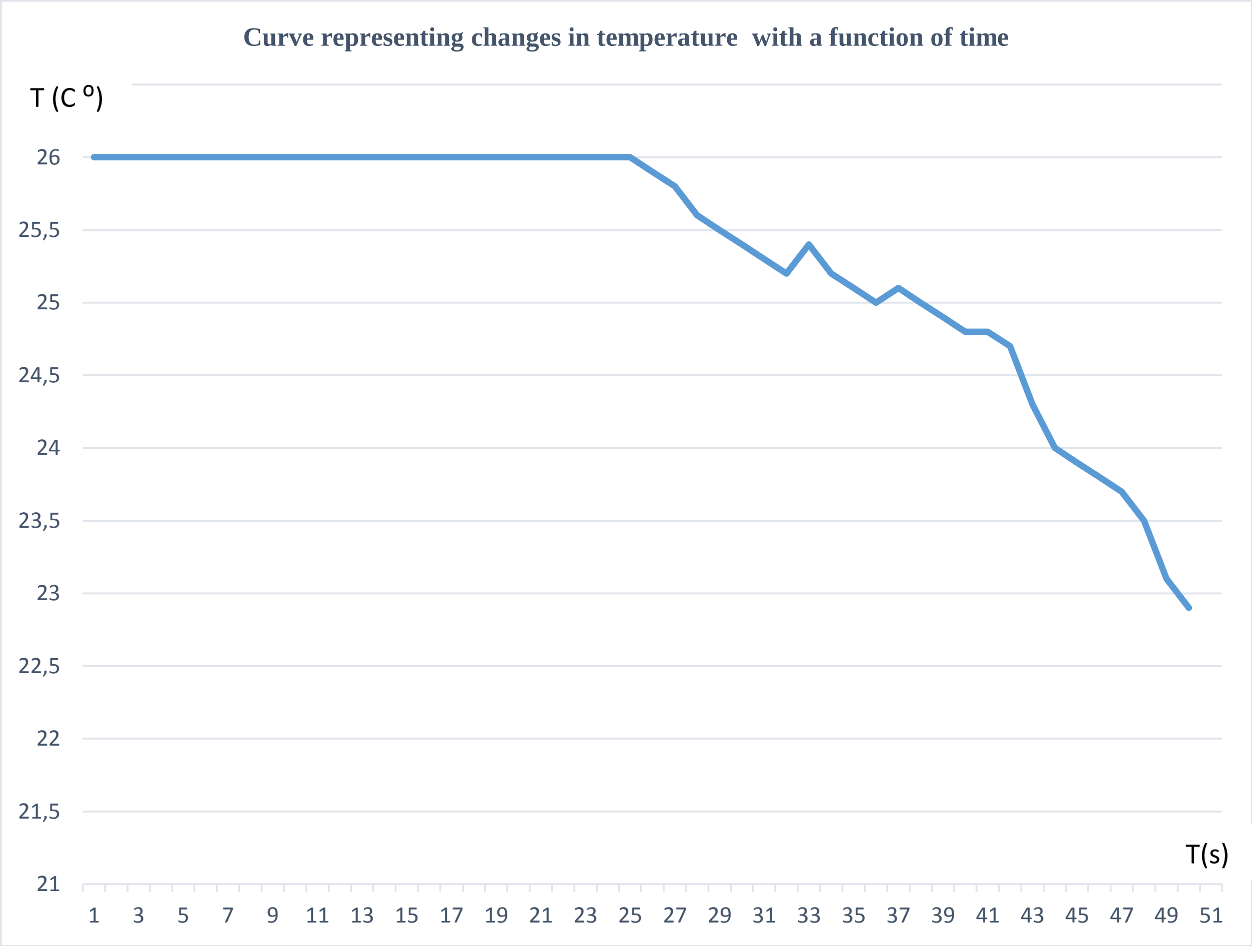


Figure II.12 : Curve representing changes in temperature with a function of time.

- We note that during the first 25 minutes, the temperature was constant and did not change, and this is due to the Peltier effect, which takes time.
- In the 26th minute, the temperature began to drop, but by a very small percentage.

- After that, the temperature began to decrease gradually over the next 25 minutes, as the temperature decreased from 25.9C^{O} to 22.9C^{O}.

After testing this system, it gave us approximately 40 of the expected results as shown in the diagram below, and these results can be improved considering this system is the initial version. Among the proposed improvements is adding a larger number of peltier modules and changing the size of the aluminum box so that it can be cooled faster.

Figure II.13 : Realization of vehicles air conditioning system finished product.

II.7 Conclusion

In this chapter, we discussed the various pieces that make up our practical reality, as well as their pinouts and modes of operation. In addition, we model the electrical diagram and create our device.

We completed our work by running tests in order to select the optimal parameters of the different elements of the project, and modify the final look to be more aesthetic.

GENERAL CONCLUSION

The air conditioner plays an important role in our lives, as it is considered an essential element, especially after the wave of development that has taken place, and it has become widely used, especially in vehicles.

Our topic is" New vehicles air conditioning system using solar energy based on peltier effect ", where we thought of creating a new system alternative to the usual car air-conditioning system while maintaining its effectiveness, due to the effect of the usual air-conditioning system on the battery and others and its large energy consumption. Therefore, in this project, we resorted to the use of the thermoelectric cooling principle through Peltier parts, in addition to controlling the device using Arduino board for ease of use. After application and testing, this model gave satisfactory results, especially as an initial version of the idea.

Later, we plan to develop this version and get better results in the following two years by adding Peltier components or changing some other pieces, as well as using solar energy panels as a source of energy. The idea and project's major goal was innovation and the quest for alternative solutions to the previous system that used less energy and produced good outcomes.

FIGURES LISTE

Figure I.1.1 : The old and the new vehicles air conditioning system……………………………………..……3

Figure I.1.2 : Liquid removing heat by changing state…………………………………………………..….5

Figure I.1.3 : The vehicle air conditioning system………………………………………………………….7

Figure I.1.4 : Refrigerant cycle and components in the expansion value air-conditioning system …………9

Figure I.1.5 : A typical air conditioning compressor………………………………………………………..9

Figure I.1.6 : Two common flow paths through air conditioning condensers……………………….……..10

Figure I.1.7 : Thermostatic expansion valves: (A) internal equalized and (B) external equalized …………10

Figure I.1.8 : A typical fixed orifice tube (FOT)……………………………………………………………11

Figure I.1.9 : AC Evaporator …………………………………………………………………………………11

Figure I.1.10 : Receiver drier …………………...…………………………………………………………12

Figure I.1.11 : AC Accumulator………..……………………………………………………………………..12

Figure I.2.1 : A solar panel, consisting of many photovoltaic cells………..………………………………13

Figure I.2.2 : Inside a photovoltaic cell. …………………….……………………………………………14

Figure I.2.3 : The Seebeck effect …………………………………………………………………….……16

Figure I.2.4 : Principle of the Peltier and Seebeck effect ………………………………………………….17

Figure I.2.5 : Illustration components of a Peltier module …..…………………………………………20

Figure I.2.6 : thermoelectric power generator ……………………………………………………………21

Figure II.1 : Aluminum box with a spiral tube immersed in coolant ………………………………………23

Figure II.2 : The final circuit test of the temperature and humidity sensor……………………………….28

Figure II.3 : SRD 5V Relay …………………………………………………………………………….29

Figure II.4 : DC 12V Water pomp ……………..…………………………………………………………29

Figure II.5 : Aluminum box contains a spiral tube filled with coolant ……………………………………31

Figure II.6 : Proteus software logo ……………………………………………………….……………..32

Figure II.7 : Circuit test before printing it …………………………….…..………………………………32

Figure II.8 : PCB card design ………..…………………………………………………………………33

Figure II.9 : PCB card of the project ………………………………………………………………..33

Figure II.10 : PCB testing ………………………………………………………………………………33

Figure II.11 : Vehicles air conditioning system on test …………………………………………………34

Figure II.12 : Curve representing changes in temperature with a function of time ………………………..35

Figure II.13 : Realization of vehicles air conditioning system finished product…..……………………..36

REFRENCES

[1] - Steven Daly ," AUTOMOTIVE AIR-CONDITIONING AND CLIMATE CONTROL SYSTEM". Butterworth-Heinemann is an imprint of Elsevier Linacre House, Jordan Hill, Oxford OX2 8DP 2006 .

[2] - Anuj Bhatia, "HVAC System for Cars and Automotive Vehicles". Continuing Education and Development, Inc. 22 Stonewall Court Woodcliff Lake, NJ 07677.

[3] - Mark Schnubel," Classroom Manual for Automotive Heating & Air Conditioning". Library of Congress Control Number: 201595668,2013-2017 sixth edition .

[4] - U.S. Energy Information Administration Last updated: May 26, 2023, with preliminary data for 2022 from the Electric Power Monthly, February 2023.

[5] - Sudip Paul;Angana Saikia;Vinayak Majhi and Vinay Kumar Pandey," Introduction to Biomedical Instrumentation and Its Applications", Copyright © 2022 Elsevier Inc. All rights reserved2022.

[6] - Tithi Sharma, Pratham Jain, Smit Patel, Nishyank Bhatt, Prof. Kunalsinh Kathia, " jraset Journal For Research in Applied Science and Engineering Technology" , Publisher Name : IJRASET Publish Date : 2022-03-16

[7] – Kaloyan Ivanov ; Anatoliy Aleksandrov and Ivaylo Belovski" Synthesis and Study on Waste Heat Thermoelectric Generator" Technical University of Gabrovo Faculty of Electrical Engineering and Electronics Gabrovo, Bulgaria 2022.

[8] - G. Ralph Strohl, Joseph W. Harpster. "thermoelectric power generator: Additional Information", The Editors of Encyclopaedia Britannica 2007.