

Educational kit experiment PELTIER module C-1100

This kit aims to initiate in the knowledge of thermoelectricity both students, as all restless and curious people through a fun and surprising experiment.

It's about seeing what happens when you fill a bucket with cold water and one with hot water and try to understand the thermoelectric process that transforms this temperature difference in the power to turn the propeller of an electric motor.

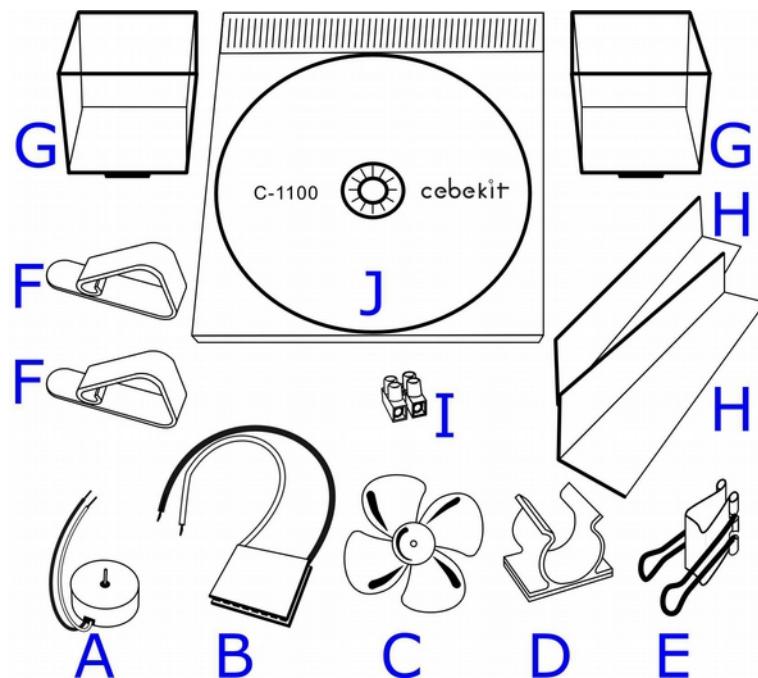
Is still largely unknown this energy source, which paradoxically has been in use for over 50 years in scientific applications. With the development of new semiconductor materials and currently is being used increasingly at consumer products and hopefully increasingly popular.

The heart of this kit is a Peltier module , they are usually used as electronic refrigerator , however for us will be an electric generator. In the same way as a battery converts chemical energy into electricity , a wind turbine converts wind energy into electricity or a solar panel converts sunlight into electricity , our special generator produces electricity from the temperature difference .

This manual contains a complete chapter with detailed theoretical explanations and technical data, including a data sheet of the thermoelectric modules , and details of construction, operation , current applications and future prospects.

The 10 proposed experiments address the following topics: **basic operation , thermal reversibility , reversibility electrical , thermal resistance, Zero Principle of thermodynamics, thermal bridges, thermal inertia , differential temperature and combination of Peltier modules.**

Kit Contents



(A) Motor C-6059	1 unit
(B) Peltier module C-1050	1 unit
(C) 4 blade propeller	1 unit
(D) Motor support	1 unit
(E) Grapple swing wing	1 unit
(F) Inclined feet	2 units
(G) Squares vessels	2 units
(H) Aluminum dissipators	2 units
(I) Terminal connecting two poles	1 unit
(J) CD with instructions and technical information	1 unit

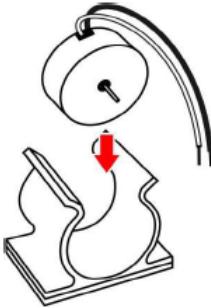
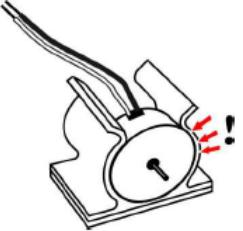
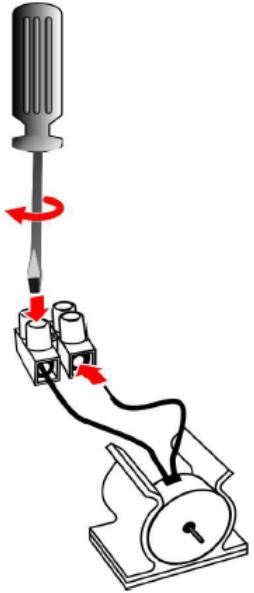
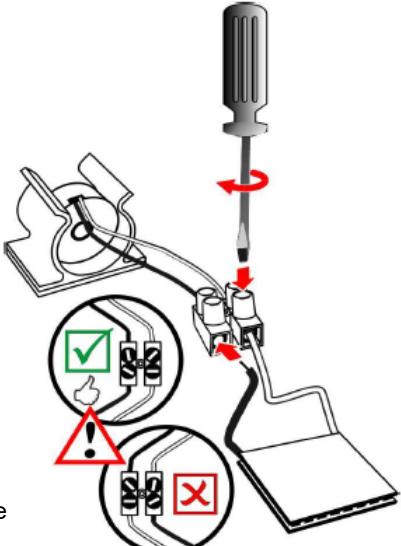
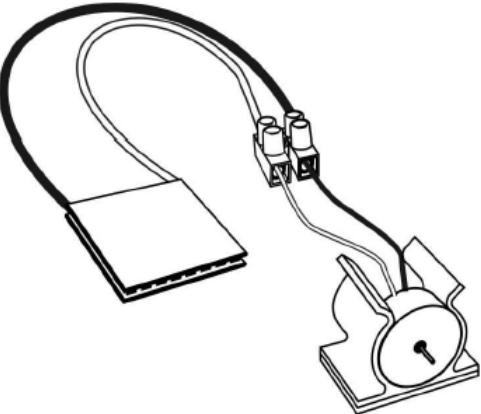
To make practical proposals also need:

- 1 small screwdriver for the screws on the terminal block
- Hot water
- Cold water / ice cubes
- buckets or jars suitable for hot and cold water

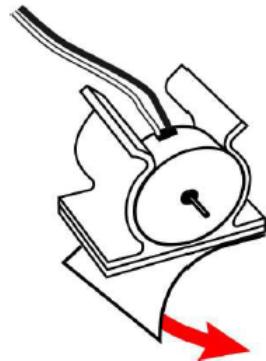
May optionally perform additional experiments if available:

- Multimeter
- Thermometer
- Peltier Module C-1050 (Supplementary)

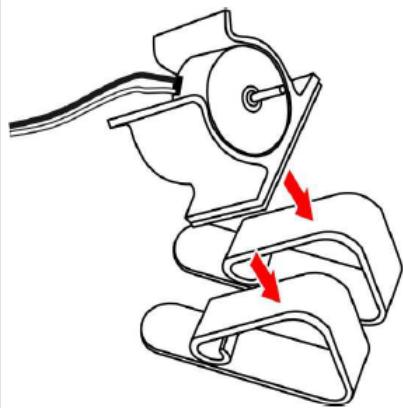
Mounting

<p>1 - Insert the pressure in the engine support. The output of the cables through the top.</p> 	<p>2 - The front of the engine has to be flush with the bracket.</p> 	<p>3 - Connect the motor leads to terminal</p> 
<p>4 - Connect wires to terminal Peltier module.</p> <p>Respect the polarity:</p> <p>Positive (red) engine, with the positive (red) module</p> 		<p>5 - Connected Group</p> 

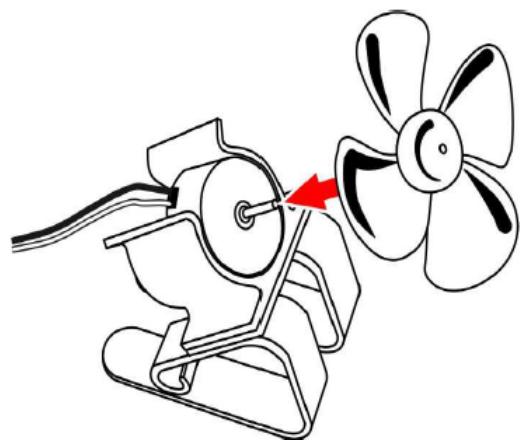
6 - Remove the protector
the adhesive pad



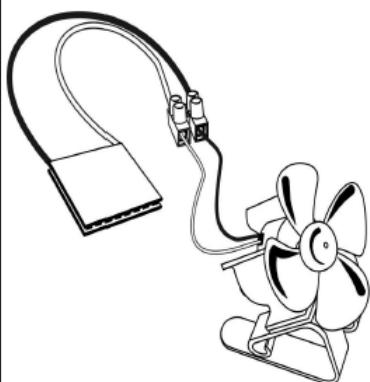
7 - Secure motor with its support at
the top of the feet inclined



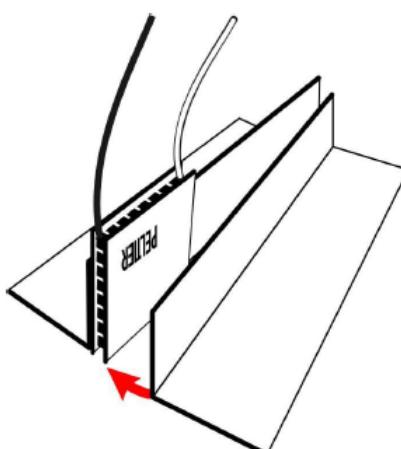
8 - Attach the propeller to the motor shaft.
Make sure you can turn freely without
brush holder and feet



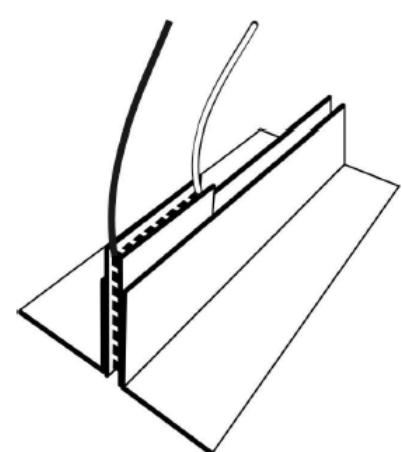
9 - Assembled group



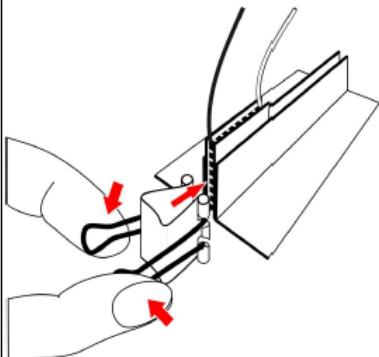
10 - Place the module between the
two aluminum heatsinks in the
position shown in FIG.
The red and black wires equal
as Figure



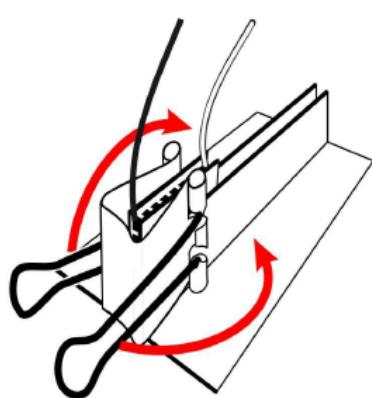
11 - Correct Position



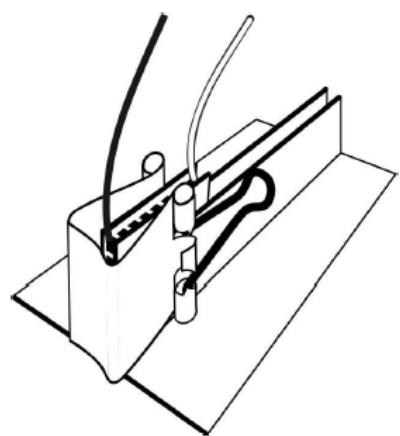
12 - Attach this assembly with the clamp. The two aluminum must be in constant contact with the surface of each of the faces of the Peltier module.



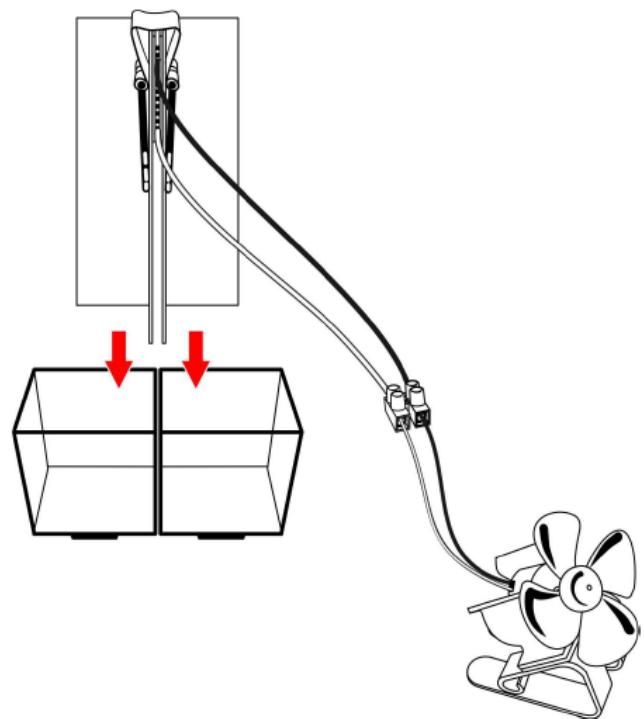
13 - Dual clip blades until they are completely blasted against aluminum



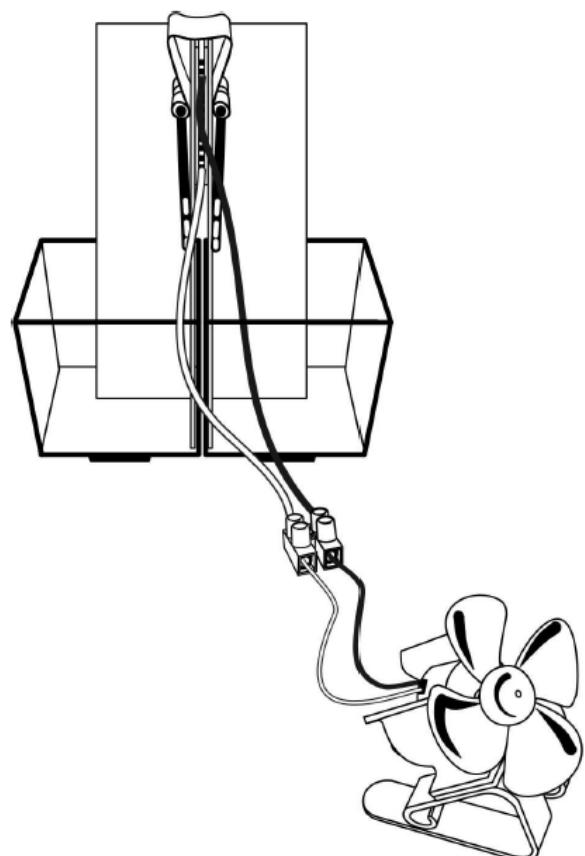
14 - Correct Position



15 - Put together the two square containers laterally. Insert the whole assembly earlier in the trays, as shown in Figure



16 - The assembly is now ready.



OPERATION

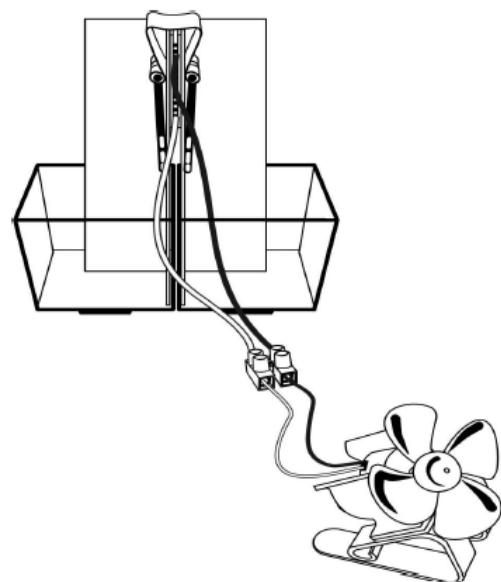
To perform the experiment will need:

Bowl of hot water

Bowl of cold water

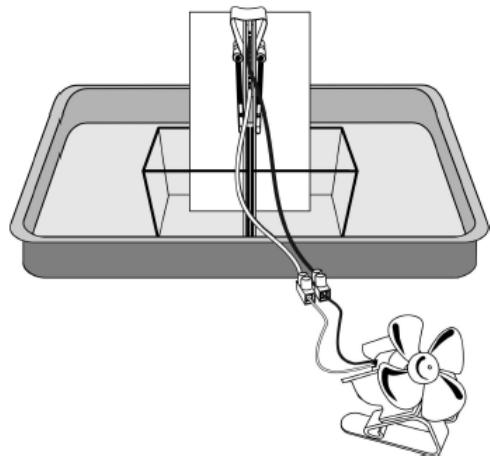
Ice cubes

1 - Check the assembly.
 Must be properly aligned and stable I can not dump to fill with water.
 By turning the propeller should not touch or rub anywhere.
 The terminal block and cables must be outside both containers.
 The vessel is to the right of the student be the cold water.

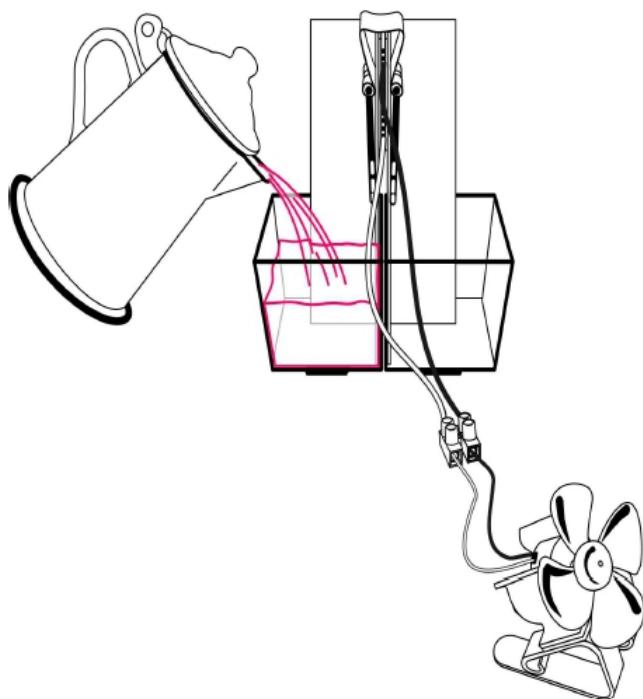


Council:

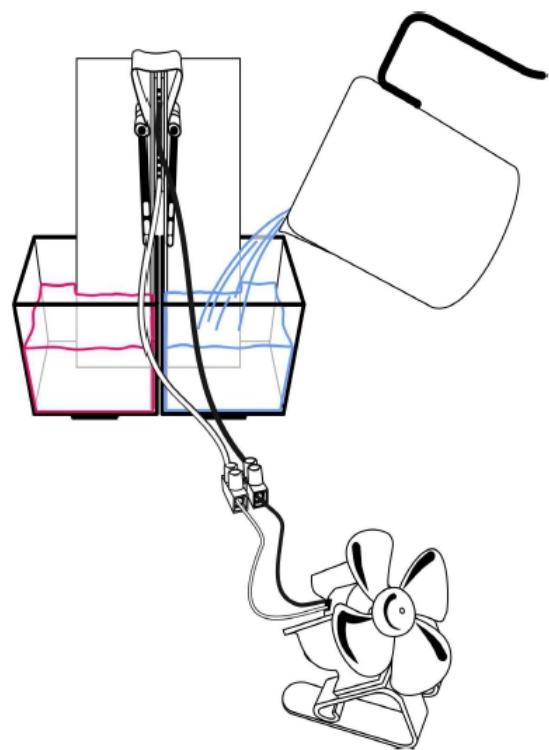
To avoid trouble caused by overturning of containers, water spills or splashes, it is recommended to place the whole of the two containers inside a plastic bucket that will collect water that may be shed.
 For clarity in the drawings, the bowl is not illustrated in the following images.



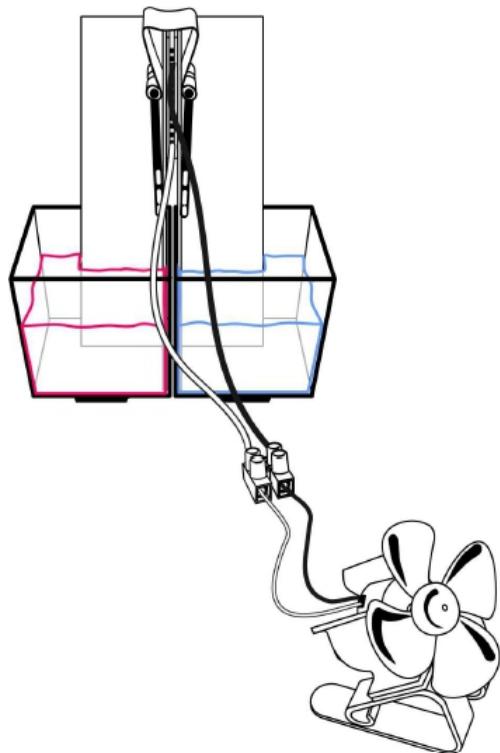
2 - Taking the necessary precautions, pour water hot in the container on the left, to fill 3 / 4 about parts.



3 - Pour now cold water in the container of the right



4 - Wait a while and observe what happens



We recommend reading the technical information of the different sections to have the knowledge needed to help us understand what happens in the experiments.

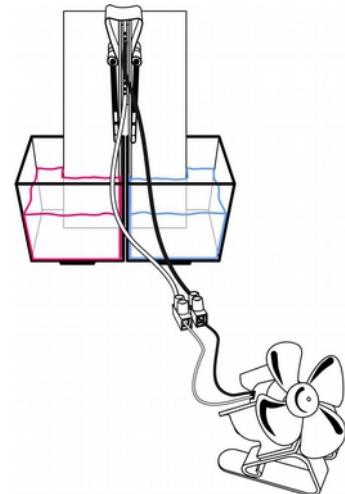
At the discretion of the teacher, you can first raise the experiment and then introduce the theoretical explanation.

Experiment 1 First Test

Fill two containers with tap water.

What is it?

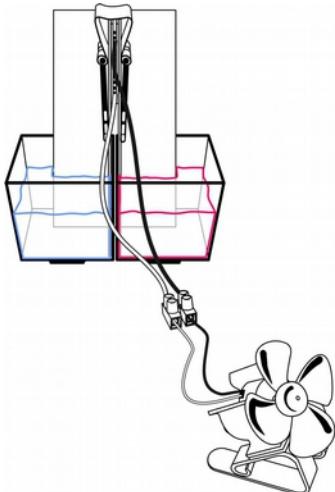
You know explain why?

**Experiment 2 Basic Operation**

We fill our container with hot water from left hot tap water (about 50 ° C) and the right to water We have previously cooled with ice.

What is it?

You know explain why?

**Experiment 3 Thermal Reversibility**

Fill the container with water to our left we have cooled previously cubes and right with hot water from the hot tap water (approx. 50 ° C).

What happens now?

Compare to the previous experiment and looking for an explanation

Experiment 4 Electrical Reversibility

With the help of the two or Screw screwdriver will loosen the strip that secure the motor wires.

Now we'll fix them so that the engine is red cable

Black wire connected to the Peltier module and the motor cable Black

Red wire is connected to the Peltier module.

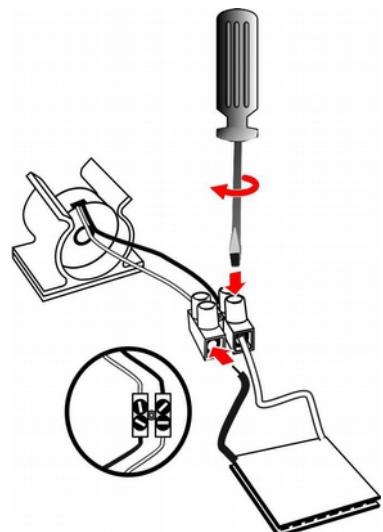
Then fill the container with water to our left

hot from the hot water tap (approx. 50 ° C) and the right to water have previously cooled with ice.

What happens now?

You know explain why? Compare to experiments 2 and 3

At the end of the experiment connects the motor cables as they were before.



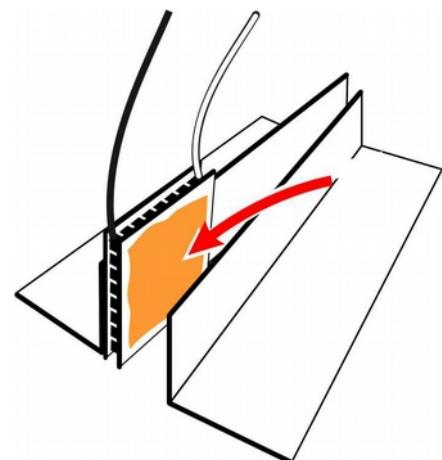
Experiment 5**Thermal Resistance**

The aluminum planes have to be well and playing the Peltier module over its entire surface, to achieve good thermal contact and get a proper heat transfer.

Try to improve the thermal contact decreasing thermal resistance, for this, we will apply on both sides of the Peltier module a little silicone grease, the electronics used to improve the thermal conductivity or what is the same, reducing the thermal resistance between the semiconductor power and cooling. Optionally you can use a drop of mineral oil (to grease the used sewing machines and mechanisms bike)

What has improved?

In computers silicone grease is also used you know where and for what purpose?

**Experiment 6****Zero Principle of Thermodynamics**

You'll notice that the duration of the experiment is a few minutes.

What you think may be the cause?

Several causes that cause. But all of them are related to the zero law of thermodynamics, since when contacting a cold object with another hot, both evolve until their temperatures are equalized.

Obviously the first cause is the reduced volume of water containers and the second can be the temperature of the room where the experiment is performed.

Think about why and whether it is better to stay very hot, very cold, or an average temperature.

You can perform this experiment by varying the temperature of the room. Heater or air conditioning on or off, open or closed windows and doors, and see if the duration of the experiment is longer or shorter.

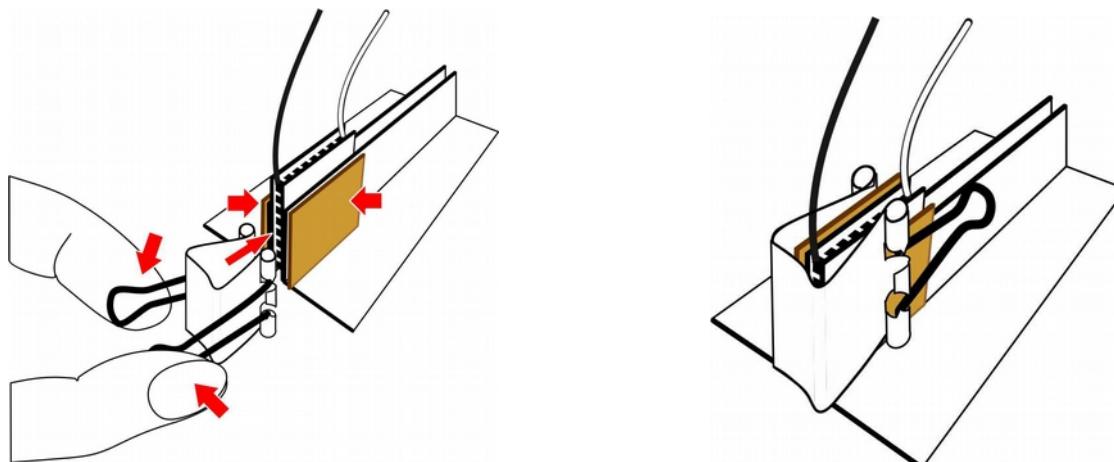
Experiment 7**Thermal bridges**

After making experiment 6 has identified some causes of the duration of experiments, but possibly has not fallen into a very important detail, this assembly has a thermal bridge between the "hot" aluminum "cold" aluminum. This thermal bridge behaves like a short circuit that discharges the thermal energy of our stack (the two basins with hot and cold water).

Find the similarity to an electrical circuit and the zeroth law of thermodynamics.

Let us now eliminate the thermal bridge of the clip, rather, to increase its thermal resistance.

This will place thermal insulation between the clamp and both aluminum. We can use two lengths of approximately 2 x 4 cm thick cardboard (1mm). If you can use heavy paper thin card folded on itself several times.

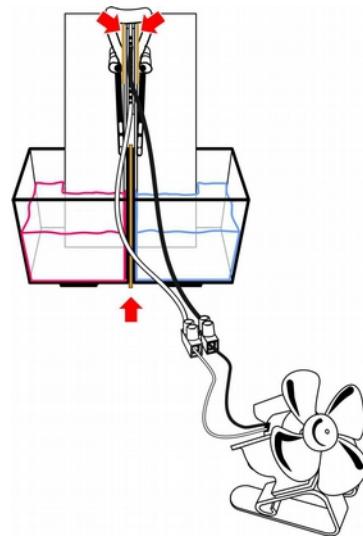


But there is another thermal bridge assembly.
Have you detected?

Indeed the two vessels almost touch each other, and although the plastic is not a good conductor of heat, the heat resistance is not high because the walls are thin. To increase the thermal isolation between the two containers will place a cut of approximately 4 x 4 cm 1 mm cardboard.

Make now the experiment, time of operation and compare it with that of the first experiments.

The thermal bridges are a serious problem for a good level of energy efficiency in homes. Thermal bridges can be caused by windows, doors, shutters and poorly insulated walls or ceilings. Searching for information on the energy certificates and how to improve them.



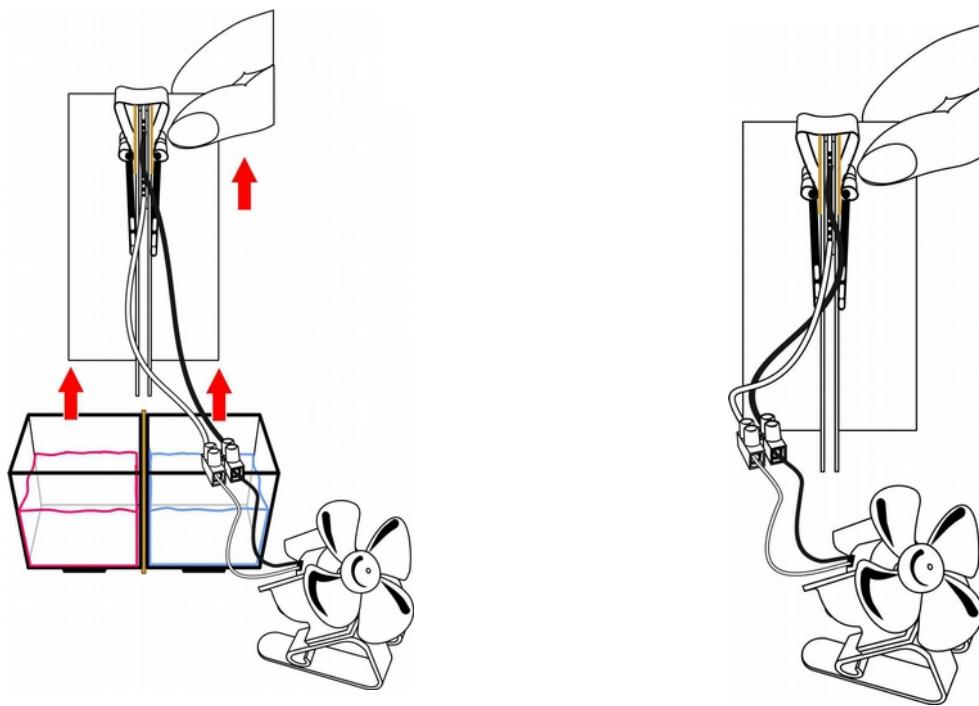
Experiment 8 Thermal inertia

Repeat the experiment 7.

As the propeller spins at speed trying to lift the Peltier-engine group and bring them out of the cups of water (be careful that water does not spill) and leave it on the table.

If you can control the terminal voltage with a voltmeter, lifts the group when the voltmeter to stabilize at its maximum reading.

Attention: To avoid burning your fingers must take the Peltier-powerplant by the cold aluminum.



Do you wonder what happens?
How long is maintained well?
You know explain why?

Repeat the same experiment but with the water of the two hottest and coldest respectively buckets and see if it stays more or less time than before.

The tension generated by a Peltier module is directly proportional to the temperature difference between the cold side and the warm side.

Perform the following tests with the experimental setup 7 and complete the table.

Warning: be careful when handling the heated water as its temperature can reach 100 ° C. Risk of severe burns! We recommend using a kettle or similar vessel.

If you have a thermometer suitable for measuring liquids, makes measurements in the table.

If you have a voltmeter to measure current, makes the stress in the strip. You can use the scales of 2 V or 20 V

Recipient left	Temperature recipient left	Recipient derecha	Temperature recipient right	Temperature differential (° C)	How to turn the engine? (slow, Normal, Fast, very fast ...)	tension in strip (V)	Time is rotating propeller
water faucet water hot		water faucet cold water					
water faucet water hot		water precooled with ice					
water heated		water precooled with ice					
water heated		water precooled and a ice cubes					

Do you know how to explain the results?

Experiment 10 Peltier modules combination

To perform this experiment you must purchase an additional C -1050 Peltier module.

When we need to increase the capacity of a battery to power an electric or electronic device , we associate several batteries in series or in parallel, as we want to increase the voltage or current respectively. We can also do the same with the Peltier modules.

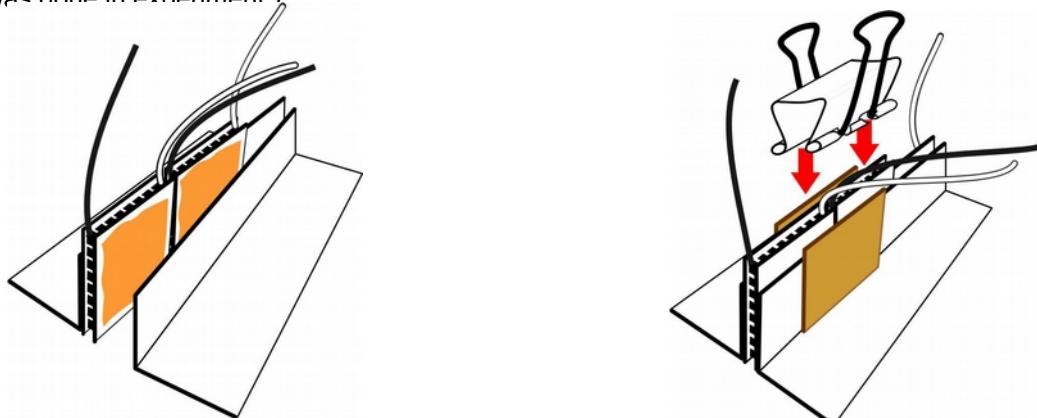
For this experiment, the current generated by the Peltier module kit is enough to power the motor . To increase the speed we need to increase the voltage , so connect the two modules in series.

First post the second module between aluminum, next to another module.

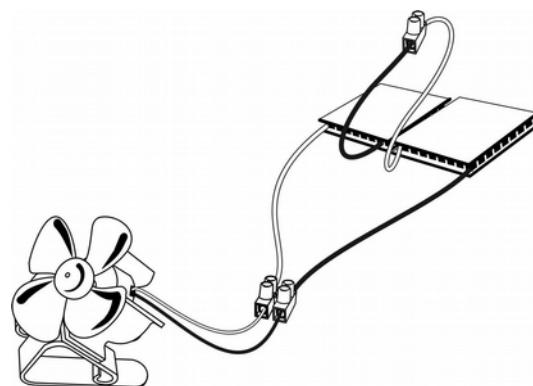
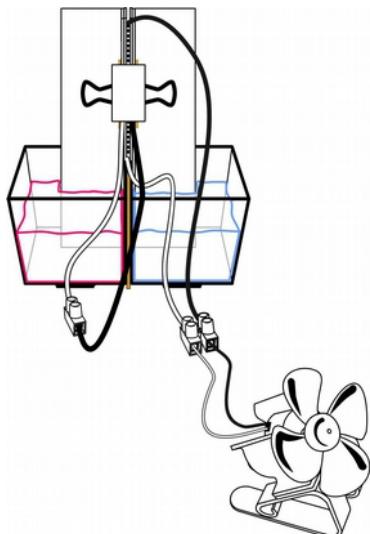
Please note the two modules must be placed with the hot faces resting on the same aluminum.

If you accidentally put an inverted relative to the other module, the system will not work.

It is necessary to apply silicone oil (or mineral oil) to both sides of the two Peltier modules and mounting the thermal insulation, as was done in experiment 7



For connecting the modules in series an additional strip is necessary. Look closely at the figure below that shows how you make the connection with the two engine modules in series. It is very important that you take notice of the polarity (wire colors).



Once you are ready the new group with the two Peltier modules connected in series with the thermal insulation, you must perform the following tests and measurements indicated in the table.

Warning: be careful when handling the heated water as its temperature can reach 100 ° C.
Risk of severe burns! We recommend using a kettle or similar vessel.

If you have a thermometer suitable for measuring liquids, makes measurements in the table.
If you have a voltmeter to measure current, makes the stress in the strip. You can use the scales of 2 V or 20 V

Recipient left	Temperature recipient left	Recipient derecha	Temperature recipient right	Temperature differential (° C)	How to turn the engine? (slow, Normal, Fast, very fast ...)	tension in strip (V)	Time is rotating propeller
water faucet water hot		water faucet cold water					
water faucet water hot		water precooled with ice					
water heated		water precooled with ice					
water heated		water precooled and a ice cubes					

Compare these results with experiment 9 and draw your own conclusions.
How could power a LED 1.5 V or a motor of the same voltage using Peltier modules?

Having come this far not the end of the experimentation with Peltier modules, on the contrary, the goal of these experiments is to open a new horizon of possibilities from the creative imagination of each person.

With proper installation, the motor should rotate clockwise helix.

If the engine does not work:

A) may be faulty cable connection on the terminal .

Maybe a cable has come loose , the screws are loose or do on the insulating plastic cable

B) Check that the propeller can rotate freely.

It may be locked due to friction are the motor bracket , with inclined legs or some cable.

C) The aluminum planes have to be well and playing the Peltier module over its entire surface , to ensure good contact and get a correct transmission of the temperature.

D) The transfer of heat from the water to the Peltier module does not occur instantaneously, so you need to wait a while until the aluminum equal to the temperature of the water and sends it to the module. According to room temperature and the water , it may take a few seconds to over a minute .

E) It is possible that the temperature difference between the hot and cold water is insufficient to generate the energy needed to drive the motor would spin the propeller.

If the motor runs in reverse:

A) Error in connecting cables. Reversed polarity. Reviewing instructions, section 4.

B) The Peltier module is mounted upside. Reviewing instructions, Item 10.

C) The module assembly and aluminum are mounted upside down in buckets. Reviewing instructions, point 15.

technical information

thermoelectric effect

The thermoelectric effect occurs at the junction of two non-metals alike, so if different temperatures on each side of the joint is applied, a voltage is generated. It also happens in reverse, applying a voltage to a temperature difference is created.

At the atomic level, the applied temperature gradient causes charge carriers to diffuse from the hot side to the cold side of the material.

This effect can be used to generate electricity, to measure temperature or change the temperature of objects. Because the side heater and cooler side are given by the polarity of the applied voltage, the thermoelectric devices can be used as temperature controllers.

The term "thermoelectric effect" encompasses three different effects:

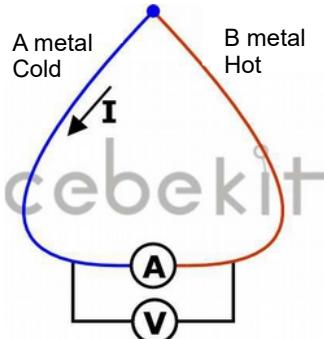
- 1) Seebeck effect
- 2) Peltier effect
- 3) Thomson effect (in some textbooks referred to as Peltier-Seebeck effect).

This separation is due to they were discovered independently by other scientists.

The Joule effect relates to heat that is generated each time an electric current flowing through a resistive conductive material. Although a thermoelectric effect is generally not so often called. The Seebeck, Peltier and Thomson effects are thermodynamically reversible, however the Joule effect is not

It is a thermal property discovered in 1821 by the physician and physicist Thomas Johann Seebeck Prussian, born in Reval (now Tallinn).

The Seebeck effect is that when applying a temperature difference at the junction of two dissimilar metals (thermoelectric device) a flow of electrons in the CONDUCTORS which creates a difference in electrical potential (voltage) which is proportional to the difference of induced temperatures. The flow starts in the area of higher temperature to the lower temperature.



Seebeck did not believe, or not reported, the heat applied an electric current generated. He used the term "termomagnetismo" to refer to the effect that he had discovered when welding two different metals (copper and bismuth) in a loop, since accidentally realized that heating of the metals while the other was kept cold, deviated the compass needle due to the generated magnetic field.

Each metal has a different Seebeck coefficient. Measured in mV / K (microvolt per Kelvin) and refers to the tension generated by each degree of temperature increase.

Peltier effect

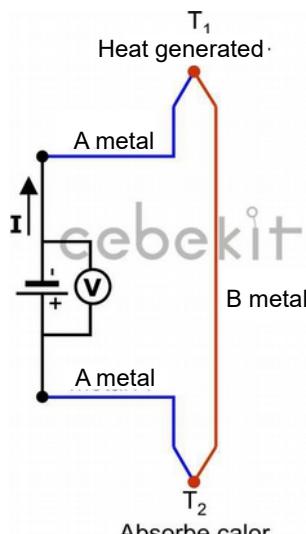
It consists of a thermoelectric property discovered in 1834 by French physicist Jean Charles Athanase Peltier , thirteen years after the discovery of the Seebeck effect by German scientist of the same name .

The Peltier effect refers to the creation of a temperature difference due to a difference in electrical potential . This occurs by circulating an electric current through a junction of two different metals or two different semiconductors (type P and type N). The flow of electrical current facilitates heat transfer at the junction between a metal and the other, while the other one cools heated.

To understand the phenomenon of cooling , we can think of the analogy of what happens to an ideal gas expands , it absorbs heat. Just as electrons could be expanded to move from a region of high density to low density another absorbing heat and cooling the area.

At the junction of two metals or different semiconductors is called a thermocouple . A group of several thermocouples in series are called a thermopile .

The circuit of the figure is composed of two different metals, Metal A and Metal B The current flowing through the circuit generates heat from thermocouple T1 while the thermocouple T2 absorbed .



The Peltier effect is the reverse of the Seebeck effect.
Peltier heat (Q) by the T2 binding absorbed per unit time is:

$$Q = (\Pi_B - \Pi_A) I$$

PA and PB being the Peltier coefficients of each material.

The P-type silicon has a positive Peltier coefficient at temperatures below 550 K and the N type silicon has a negative Peltier coefficient.

We can also say that the PAB Peltier coefficient on the union of two materials A and B, Q is equal to the heat released in a union or absorbed in the other, divided by the current I do travel on the circuit.

$$\Pi_{AB} = \frac{Q}{I}$$

Thomson effect

It was discovered by William Thomson (Lord Kelvin) in 1851, which showed that over a temperature gradient, a current flowing through a conductor may be used in a reversible manner such as refrigeration or cooling. In this case the amount associated heat is proportional to the thermal gradient and the current flowing through the Thomson coefficient. Thomson established formulas that relate the Peltier coefficient and the Seebeck coefficient:

$$\Pi = S T$$

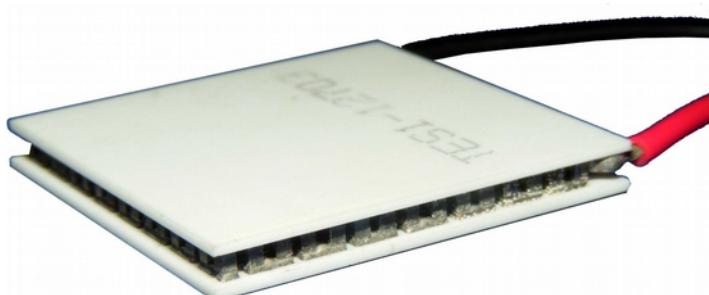
where P is the Peltier coefficient, S is the Seebeck coefficient and T is the absolute temperature

The Thomson coefficient m appears in the second Thomson relation:

$$\mu = T \frac{dS}{dT}$$

Peltier modules

A Peltier module, also called module or thermoelectric cooler TEC (Thermo Electric Cooler), is a semiconductor-based electronic component that functions as a small heat pump. It is based on the Peltier and Thomson effects.

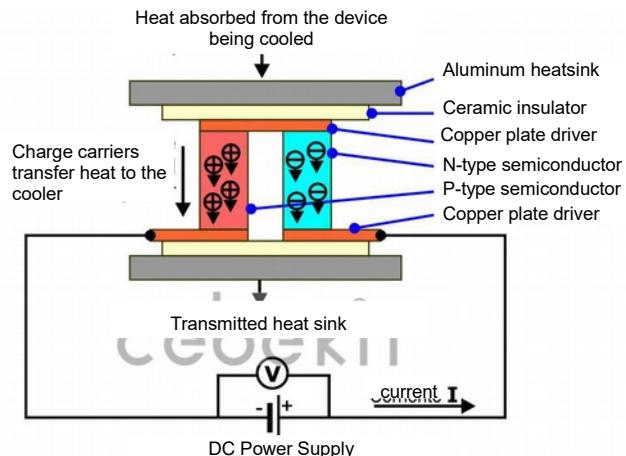


By applying a low voltage direct current to the TEC, heat flows through the semiconductor elements from one face to the other. Electrical current cools a heated face and the opposite face simultaneously. Accordingly, a particular aspect of the device can be used for heating or cooling if the polarity of the applied current is reversed. TEC features make it well suited for applications of precise temperature control and where the limitations of space and reliability are critical or where vibration refrigerants or compressors are unwanted.

A typical single stage refrigerator consists of two plates between which a number of ceramic thermocouples semiconductor P -type and N -type (alloys of bismuth telluride , Bi₂Te₃) are arranged . Importantly, the P and N bismuth telluride elements are loose and not forming semiconductor PN junctions are therefore not diodes .

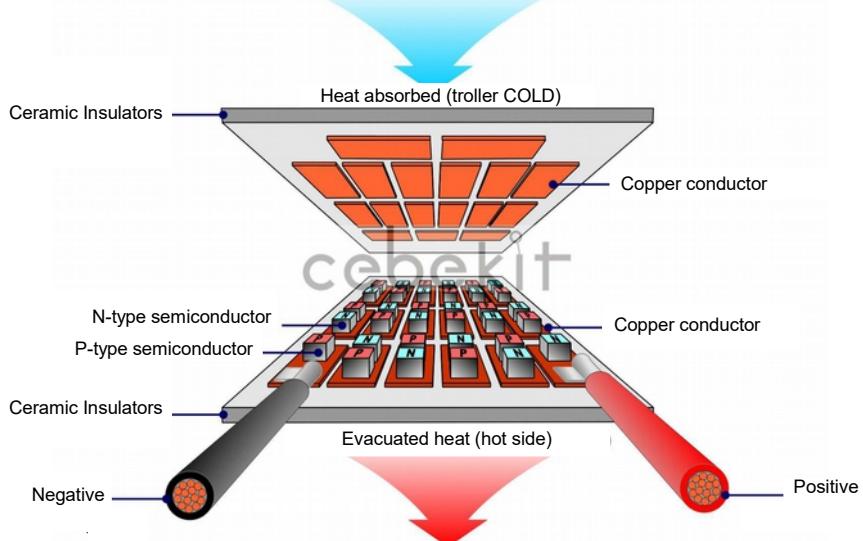
The following figure illustrates the operation of a Peltier thermocouple only:

C-1100



When a positive voltage is applied as shown, electrons pass from the elements to the P type to N type, and the cold-side temperature decreases as the electron stream absorbs heat, until it reaches balance. The absorption of heat (cooling) is proportional to the current, the Peltier coefficient of the material used and the number of thermocouples. This heat is transferred to the hot side of the module, where, through the heat sink is transferred to the surrounding environment.

The following figure represents an open TEC module, showing the internal distribution of various elements:



A TEC single stage as illustrated consists of an array of thermocouples, in which the semiconductor elements are electrically connected in series and thermally in parallel.

We have already seen that the thermodynamic effects are interrelated. The TEC modules are named (cooling device) for its main application, however, also produce the Seebeck effect if we work backwards, ie, to apply heat on one side and cold on the other, they behave as a generator electricity, being proportional to the temperature difference between both sides current produced. This effect is what we will explore in this educational kit.

Advantages and disadvantages

Some of the benefits of the Peltier modules are:

- No moving parts, virtually maintenance free and produce no noise or vibration
- Do not use chlorofluorocarbons
- The temperature control can be done with great accuracy to ± 0.01 °C.
- You may have a very small size and manufactured with different profiles
- Can be used in small spaces or in more severe environments than conventional cooling systems
- They have a long life. Mean time between failures (MTBF) of over 100,000 hours
- They are easily controlled via the voltage / current input
- You can produce "clean" electricity by exploiting differences in temperature and waste heat from other applications.

Some of the disadvantages are:

- They can only dissipate a limited amount of heat flow

With the development of the principles discovered by Seebeck, Peltier and Thomson, and thanks to new semiconductor materials introduced in the late 1950s, the thermoelectric cooling became a viable technology for small refrigeration applications.

Thermoelectric coolers are commonly used for applications that require heat removal ranging from milliwatts to several thousand watts. They can be used in as small as a beverage cooler or as large as a submarine or a railroad car applications.

Consumer Products

Currently already being regularly applying the Peltier modules in consumer products .

We found examples of applications in camping , coolers , cooling electronic components and small measuring instruments.

The cooling effect of Peltier heat pumps are also used to extract water from the air in dehumidifiers completely silent . A cooler for camping car or can reduce the temperature to 20 ° C below the ambient temperature. With circuits feedback, Peltier modules are used to implement highly stable temperature controllers , maintaining control ± 0.01 ° C. Such stability can be used in laser applications , to avoid any drift of the laser wavelength due to changes in ambient temperature. Heated jackets are starting to use Peltier elements. Thermoelectric coolers are used to replace standard heat radiators for microprocessors , as heat radiators only provide passive cooling. Also important medical applications controlled to maintain the temperature during transportation of sensitive organs and drugs.

Scientific applications

The Peltier modules are also used in scientific devices , a common component being thermocycler (PCR thermal recyclers) , which are used for DNA synthesis by chain reaction of the polymerase, a common molecular biological technique which requires rapid heating and cooling the reaction mixture to the denaturation , primer annealing and enzymatic synthesis cycles .

One of its first applications , using the Seebeck effect , were used as thermoelectric generators in satellites and spacecraft , as everywhere is not possible to use photovoltaic panels. From 1961 , some drones (including Curiosity Mars rover vehicle) used radioisotope thermoelectric generators (RTGs) that convert thermal energy into electrical energy through the Seebeck effect.

Both photon detectors such as CCDs in astronomical telescopes , spectrometers , digital cameras or very high end , often are cooled with Peltier modules. This reduces dark counts due to thermal noise . A dark count occurs when a pixel records an electron due to thermal fluctuation and not receiving a photon. In the digital photos taken in low light effect "snow" , called "pixel noise " is displayed.

Thermoelectric coolers can also be used to cool the computer components to maintain the temperature within the design limits , or to achieve stable operation when overclocking . A Peltier cooler with a heat sink or cooling water can block a chip well below room temperature.

In fiber optic applications , where the wavelength of a laser or a component is highly dependent on temperature , Peltier coolers are used in conjunction with a thermistor in a feedback loop to maintain a constant temperature and thereby the wavelength stabilizing the device.

Some scientific electronic equipment for use in the field also are cooled with Peltier modules.

Future prospects

Future prospects are very encouraging, especially in the technology for generating and saving energy in a sustainable and non-polluting.

Back in the 20s of XX century, in remote areas of the Soviet Union, the Peltier effect is used to power the radio receivers. A long metal bar took advantage of the warmth of the fireplace while the other sucked the cold outside.

Most of the research in the field of thermoelectric applications sponsored by governments in the past 10-15 years has been in the area of thermoelectric power generation, looking for ways to improve the use of energy.

For any generator Peltier thermoelectric power, the voltage generated is directly proportional to the number of the pairs, the difference in temperature between the upper and lower sides and the Seebeck coefficients of the P and N materials employed.

Future prospects

Keep in mind that less than a quarter of the energy contained in gasoline cars used in useful work to move the vehicle . Most of the energy escapes into the atmosphere as heat , primarily through the vehicle exhaust and radiator.

The car companies Volkswagen and BWM , and the German Aerospace Center (DLR) are investigating thermoelectric devices for recovering the heat from the engine and exhaust , with getting a significant reduction in energy consumption of vehicles.

As for the industry, a third of the energy consumed is converted into heat losses directly heating the air or water cooling systems (rivers , lakes and seas) . Try to minimize this heat loss is a great opportunity for thermoelectric devices , to someday reduce national energy consumption , our dependence on fuel bought abroad and especially of fossil fuel pollutants , while minimizing environmental impacts posed by global warming.

Also heat recovery in a high influx of public (shopping centers, railway stations , airports, etc.) as well as in homes, are a good interesting field of research .

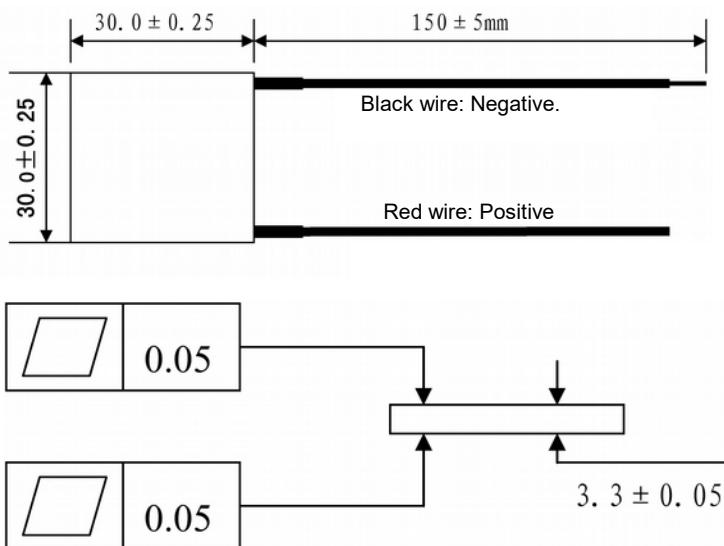
The thermoelectric waste heat recovery is the process that aims to recover this heat loss and turn it into electricity. This is the main focus of most investigations , both new materials and new energy generating devices . One of the fields is the future generation of clean electricity from temperature differences large bodies of water (lakes , rivers and seas) and certain collectors heated by the heat radiated by the sun.

The future is really hopeful because imagination has no limits.

Peltier Module Datasheet C-1050

technical Specifications

- Operating temperature: -156°C a 80°C
- Size: 30 x 30 x 3.3 mm
- Number of pairs: 127 pairs
- maximum current: Imax: 3,5A (15,4 VDC)
- Maximum voltage: Vmax: 15,4 VDC
- Maximum power: Qc max: 27 W (15,4 VDC)
- Resistance: AC-R: 2,95~3,15 Ohm (@Tempamb.: 20°C, 1kHz vacuum state)
- Maximum temperature: Tmax 363°C, Tmax-66°C (cooling capacity=0)
- Connection: 20AVG Cable, PVC insulated, tinned copper wire. L: 15cm
- Polarity: Black wire: Negative. Red wire: Positive
- Marked on the warm side





Safety Warnings

- Classroom activities for learning practices in educational settings made under the supervision of an adult instructor .
- This product is NOT A TOY.
- Not suitable for children under 3 years due to small parts which may be swallowed.
- Before starting installation and practices , it is necessary to have read and understood this manual.
- It is essential that children use it under the close supervision of an adult capable of doing so .
- Attention! For the performance of this kit will need to use HOT water. There is RISK OF SEVERE BURNS . This risk increases with younger students. You need to take all necessary precautions to prevent spills and burns during handling.
- Depending on the age of the students, and educator approach may be preferable to create temperature differences adding more ice cubes in the bowl of cold water instead of raising the temperature of hot water.
- It is recommended to protect the work surface (desk, table , etc.) to prevent damage in case of water spills .
- Take necessary safety precautions to avoid injury with a screwdriver or sharp edges that may have some of the components of the kit.
- When this product or its components are no longer in use , DO NOT DISPOSE OF TRASH . Store in a collection point for electrical / electronic equipment for recycling .

NOTE: This kit is recommended for children from 14 Always accompanied by an adult.



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