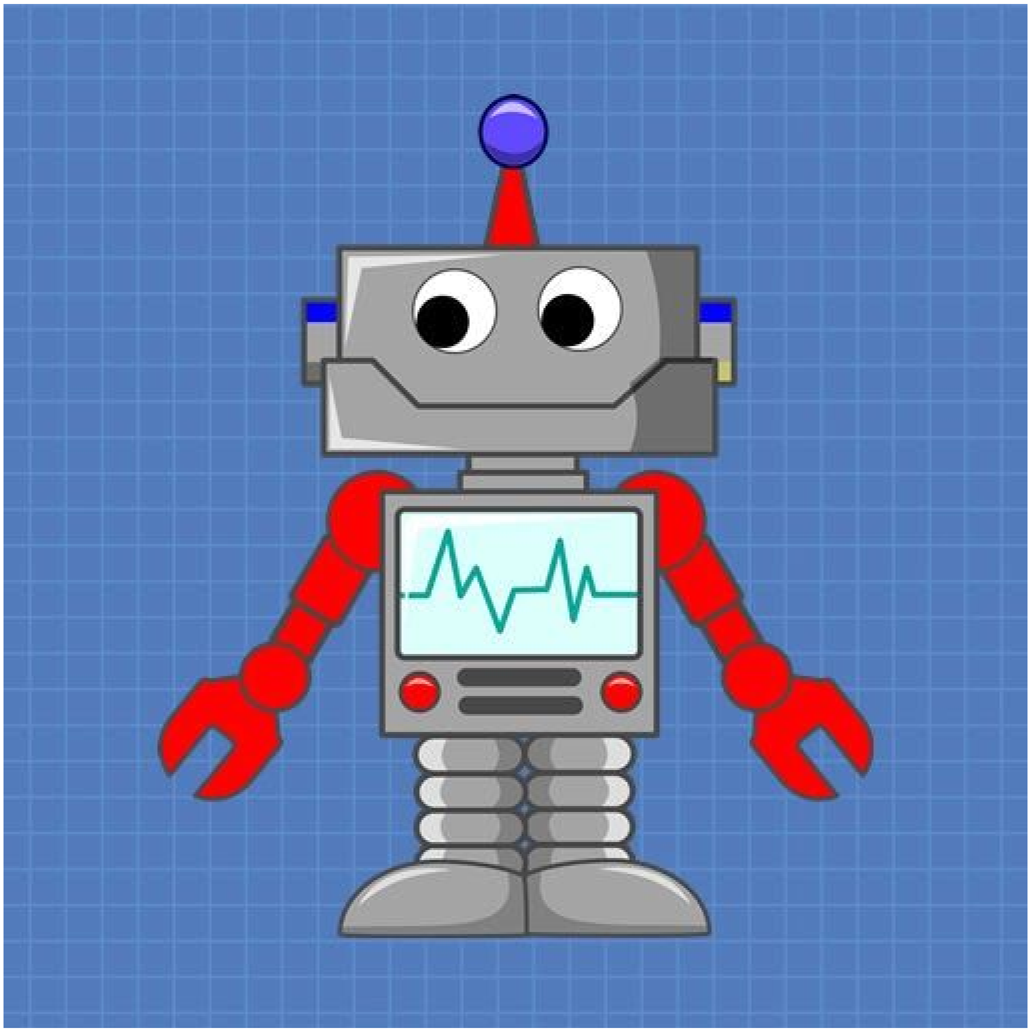
Peltier Effect Cooling Experiments



DroneBot Workshop Tutorial

https://dronebotworkshop.com

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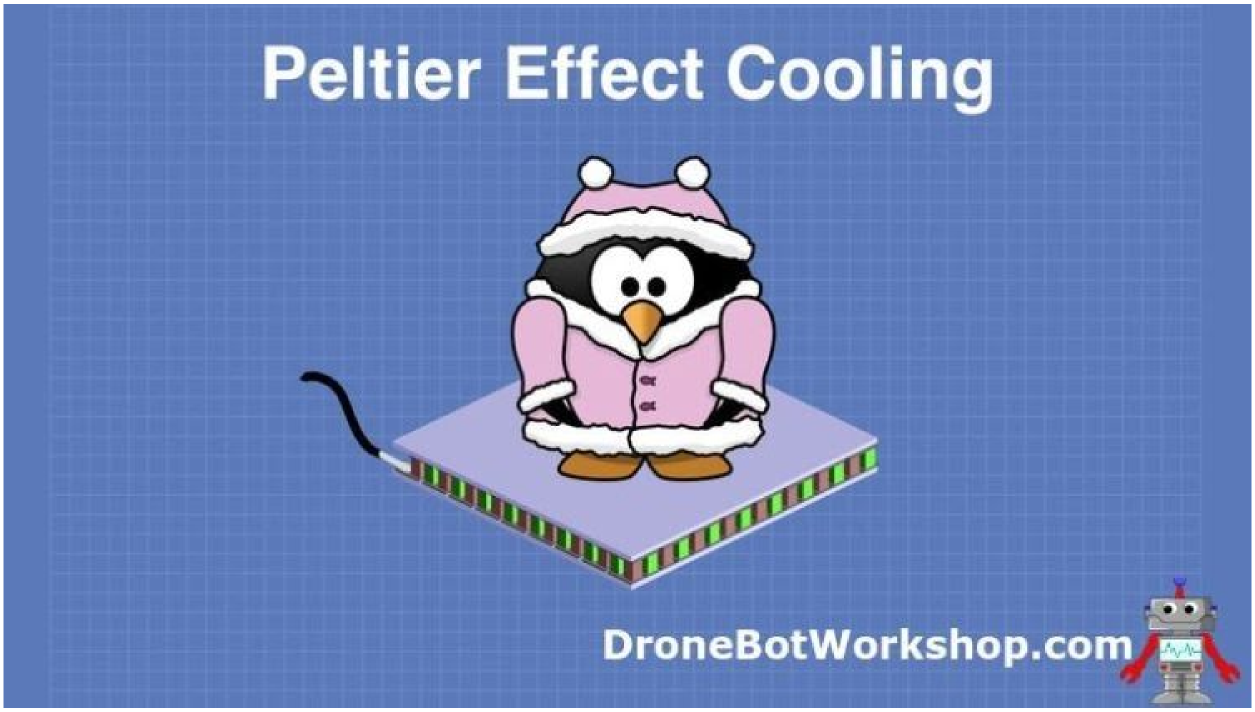
A Peltier cooling device is a thermoelectric semiconductor component that can provide cooling with no moving parts. It's very easy to use and it can get very cold – and also very hot!

Today we will conduct a few experiments with a common and inexpensive Peltier cooling device.

Introduction

The ability to cool air or exchange heat is critical in many situations. From computer chips that need to keep from overheating to spacecraft that need to withstand temperature extremes the design of cooling systems is big business.

Most of us are familiar with air conditioning. By reducing temperatures and humidity they allow us to live and work in environments that would otherwise be uncomfortable or even unbearable. Even in cool climates air conditioners are used in data centers to keep equipment (and personnel) at a comfortable operating temperature.



Conventional air conditioning employs a refrigerant or coolant which is circulated through pipes, pumps, evaporators, and condensers to remove heat and dispense it outside. It is efficient and effective, but it also takes up a lot of space.

There are also applications where conventional air conditioning is not practical or even possible.

Enter the Peltier device. This semiconductor component can perform heat exchange without any moving parts. It is ideal for cooling down computer chips, as well as for building small cooling devices for personal use. It also is used in spacecraft as conventional air conditioning won't operate in a low-gravity environment.

We won't be building any spacecraft in the workshop, at least not today. But we can use inexpensive Peltier devices top provide cooling for small projects, or just for some interesting and fun experiments.

The Peltier Effect

In 1834 a French physicist named Jean Charles Athanase Peltier discovered that passing current through two dissimilar metals could create either a rise or fall in temperature at the junction of the two metals.

Peltier experimented with wires made of copper and bismuth. He found that when current flowed from copper to bismuth heat would be generated at the junction. He also found that the reverse was true, when the current flowed between bismuth and copper the junction grew colder.

This phenomenon became known as the *Peltier Effect*.

The Seebeck Effect

An effect closely related to the Peltier Effect is the *Seebeck Effect*.

The Seebeck Effect is named after German physicist Thomas Johann Seebeck who discovered the effect in 1821, however, it had actually been observed as far back as 1794 by Italian scientist Alessandro Volta. In case that name sounds familiar Volta is indeed the gentleman who the Volt is named after.

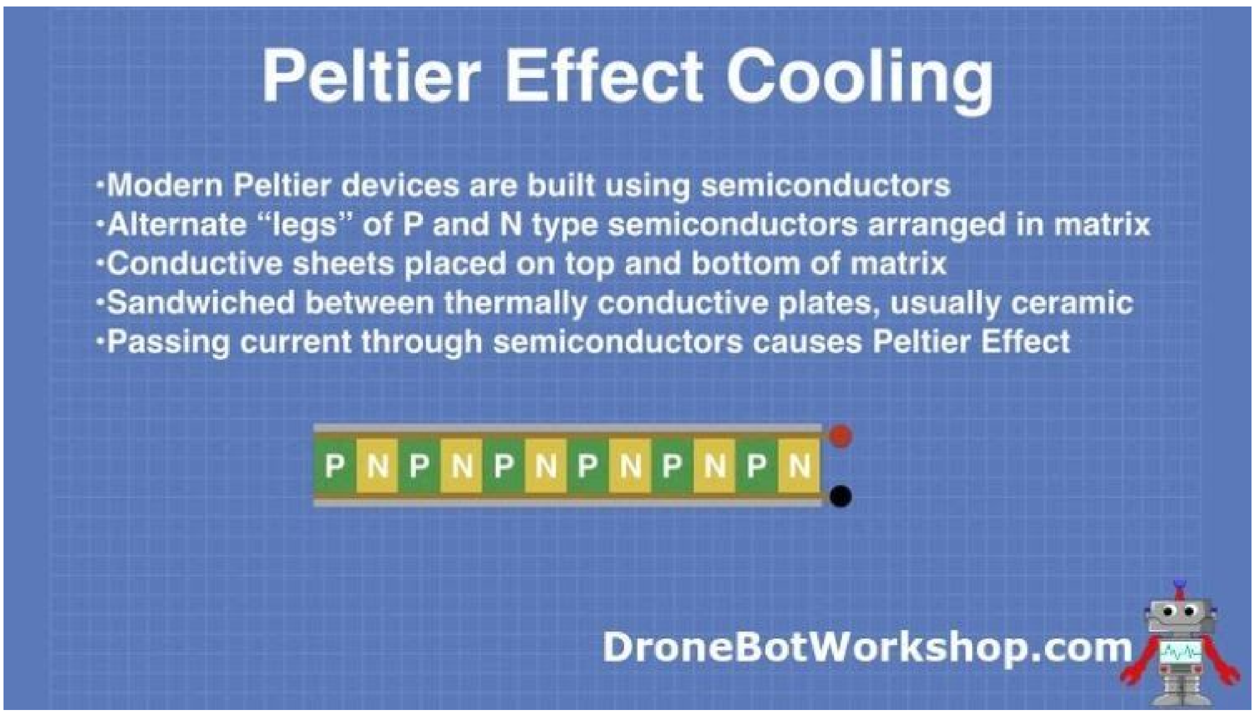
The Seebeck Effect is essentially the opposite effect to the Peltier Effect. The Seebeck Effect describes the conversion of heat directly into electricity at the junction of different types of wire.

A Peltier device can also be used as a Seebeck device and vice-versa, although the efficiency of both is limited. Both the Peltier and Seebeck effects fall into the category of *Thermoelectric Effects*.

Modern Peltier Devices

Instead of using dissimilar metals modern Peltier devices make use of semiconductors.

A semiconductor Peltier cooler consists of a collection of “legs” composed of P or N-type semiconductor material. A “leg” is constructed by creating several layers of substrate material, built up in order to have some height.



These “legs” are arranged in a matrix, with alternating P and N-type material.

A conductive sheet is placed below and above the matrix to provide electrical connections. The whole assembly is then sandwiched between a thermally conductive insulator, usually ceramic.

This is the type of Peltier device that we will be experimenting with today.

Issues with Peltier Modules

Peltier modules are very useful cooling devices, but they are far from perfect.

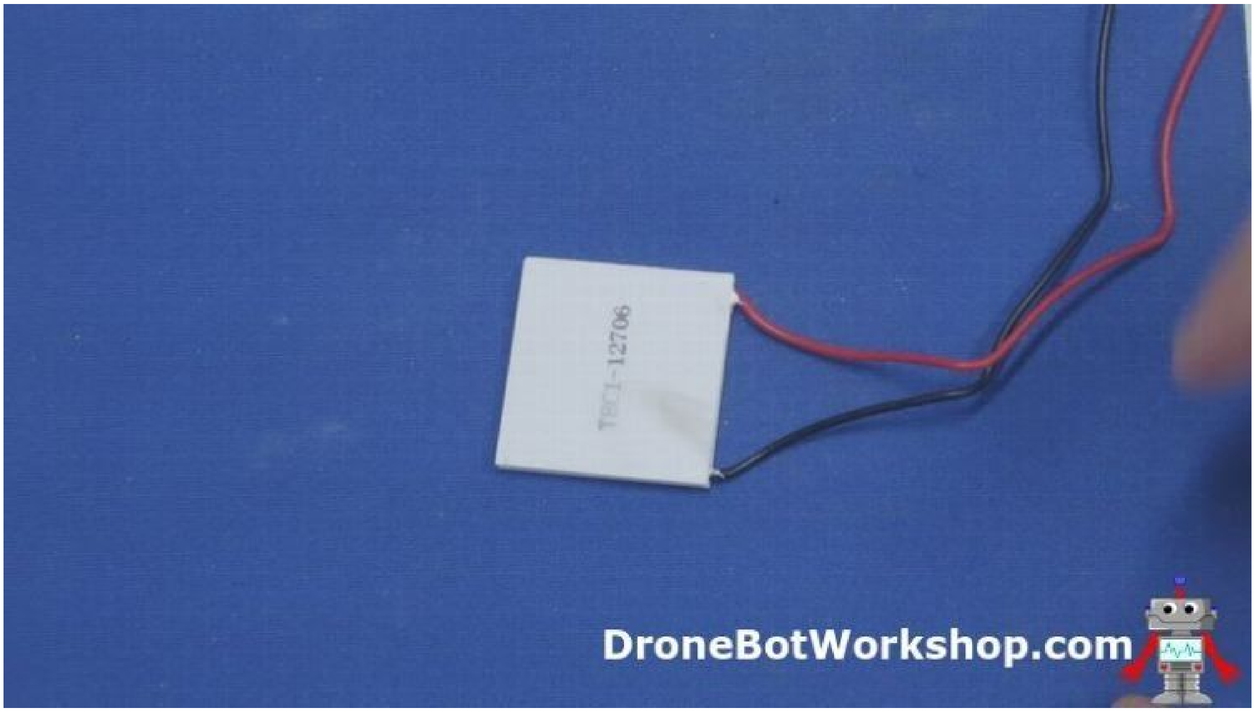
The biggest issue with a Peltier module is its inefficiency. A Peltier cooler is nowhere near as efficient as a conventional coolant-based device. While they can be used to create small air conditioning units it would be impractical to use them to cool down an entire building.

Another issue is lifespan. The Peltier module will not last forever, all thermoelectric coolers will experience decreased efficiency as they age. To be fair, conventional air conditioning systems also suffer the same drawback.

TEC1-12706 Peltier Cooler

The Peltier device we are going to be using is a very common module, the TEC1-12706 Peltier cooler.

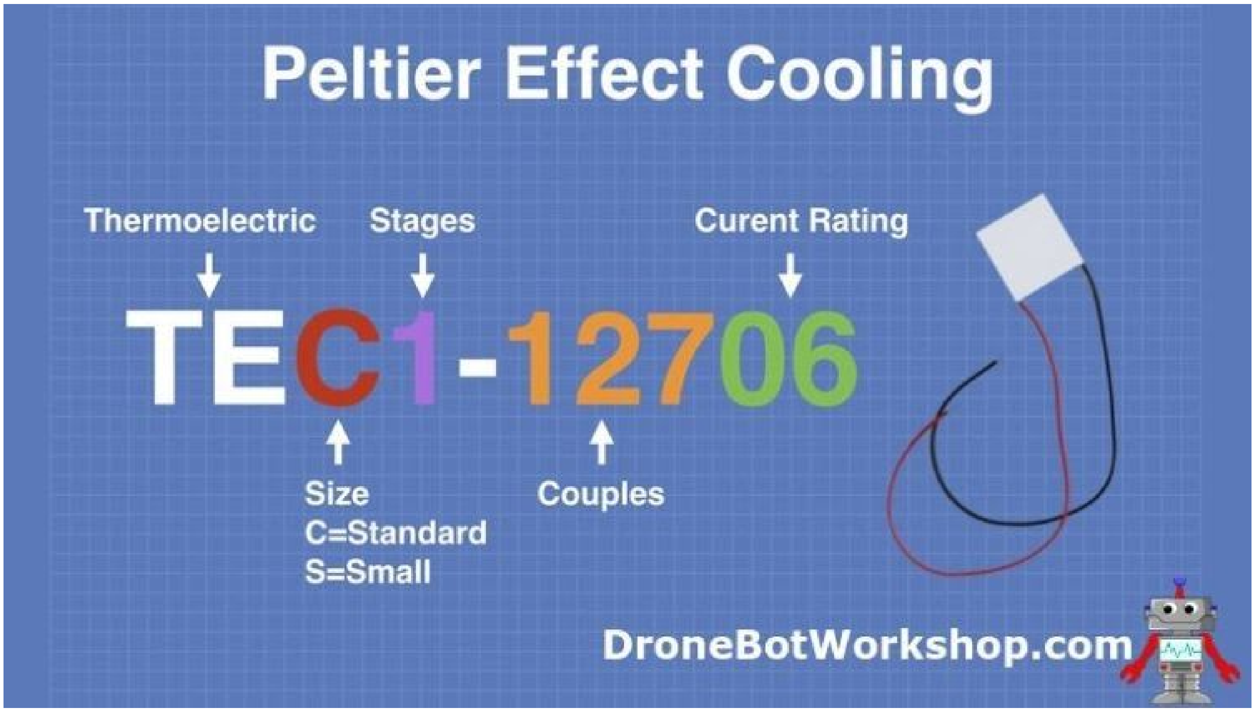
This is a small device measuring 40mm x 40mm, I measured the thickness of my module at 3.75mm. This is a Standard size Peltier module, and you'll find that 40mm x 40mm is also a standard heatsink size.



The module has two leads, a red one and a black one. These are for powering it, I used a 12-volt power supply for my module. As Peltier modules are not very efficient you'll need a good amount of current to drive this, I recommend using a power supply capable of 6 amperes.

Reading the Part Number

You can use other Peltier modules in the experiment as well. These modules have a standardized part number scheme, as illustrated below.



The part number for my device breaks down as follows:

- **TE** – This is an abbreviation for "Thermoelectric"
- **C** – This indicates the Size of the module. A "C" module is a Standard sized module whereas an "S" module is a smaller one.
- **1** – This indicates the number of Stages or layers of semiconductor material. In this series, most have only one layer, but Peltier modules are available with more layers.
- **127** – The number of Couples, a "couple" is a P-N junction pair.
- **06** – The amount of current the device is rated at in amperes. Note that these modules do not have a voltage rating.

TEC1-12706 Operation

On my module the side with the labeling on it is the side that gets cold, however, this may not be a standard so I advise you to test your module.

Incidentally, you can reverse the polarity of voltage you apply to the Peltier module. The result will be that the heat will be emitted from the other side of the module. This is a good trick to know if you happen to install your module backward.

One thing you will find out very quickly is that you MUST use heatsinking on the hot side, the module will burn itself out if you don't and the cold side won't get very cold at all.

Peltier modules are not rated for the temperature they cool down too. Instead, the module is rated for a temperature difference between the hot and cold sides. So the cooler you can keep the hot side, the colder the cold side will get.

Peltier Module Experiments

We are going to perform a few experiments with the Peltier module. While none of these experiments (except, perhaps the last one) are of any practical value they will give you a good idea as to the amount of cooling you can obtain from the Peltier module.

They will also show you the importance of using a good heatsink as well as a hefty power supply.

Quick Power-up

The first experiment is about a simple as it can get!

All we are going to do is to power up our module very briefly, to see how hot the hot side gets. I underlined "very briefly" and I mean it, a couple of seconds is all it takes with a suitable power supply.

First I measured the module temperature before powering it up. Note that I placed the module on a jig to hold it, you don't want to hold it in your hand when you do this experiment! As it can get VERY hot!

In my case, it measured 20.8 Celcius, which is about right for the ambient temperature in the workshop when I made the measurements.

Next, I applied power from my 12-volt bench power supply. This caused the modules hot side to immediately heat up, and I removed the power after only about 2 seconds. I then took another temperature measurement.

As you can see the temperature has increased dramatically in just a couple of seconds!

Because of the arrangement that I used to hold the module the “cold” side was not that cold at all, my jig conducts heat to both sides. And, as the Peltier module creates a temperature difference, it would not have been that cold even if I had used an arrangement to isolate the two sides.

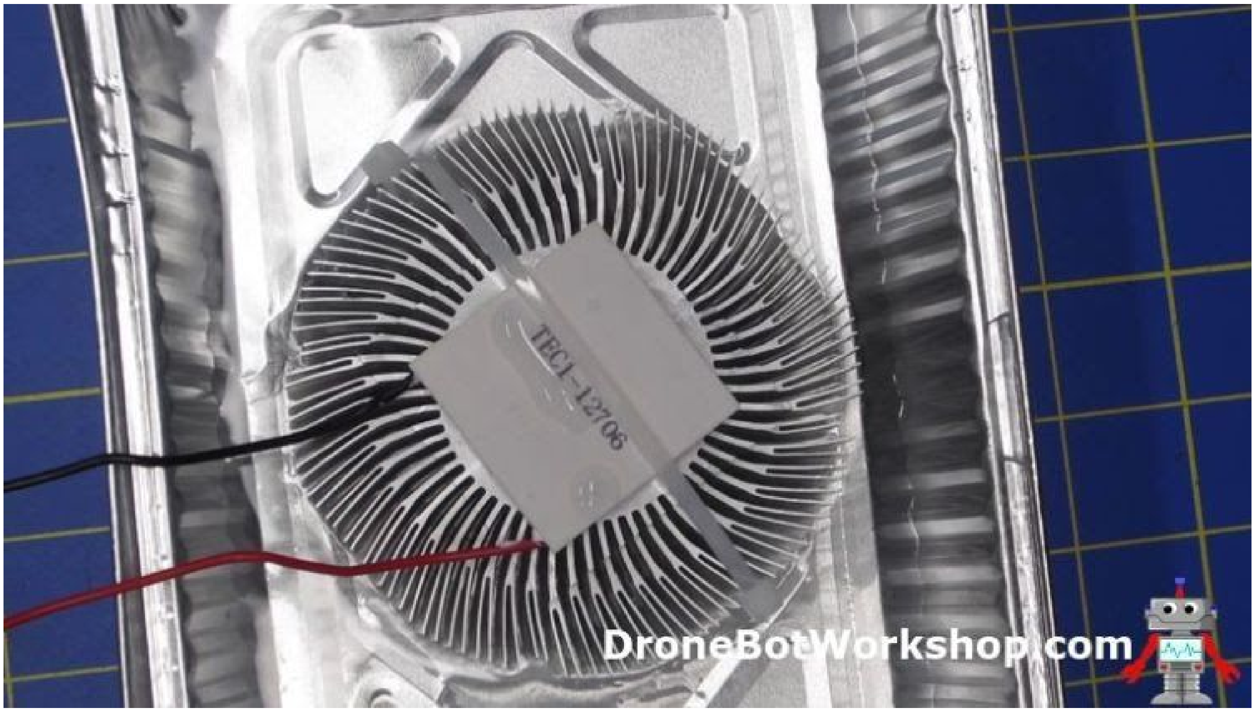
If anything this experiment illustrates how vital it is to have a heatsink on the hot side. Which is what we will do next.

Making Ice in the Workshop!

For this experiment, I mounted the Peltier module on a large heatsink, with the hot side against the heatsink. I used some thermal compound on the heatsink to make good thermal conduction between it and the Peltier module.

I then mounted the whole assembly in a pan of water, so that both the water and aluminum pan could extend the heatsinking capabilities.

I applied power to the Peltier module and observed that it immediately started getting cold. I then took a couple of drops of water and placed it on top of the module.



I waited a while and observed the water on the module.

After about 90 seconds I noticed that the water was starting to freeze. I let the experiment continue to run while I watched the freezing process.

After about three minutes the water had completely frozen!

To freeze water you need to drop the temperature to at least a minimum of zero Celcius. I suspect that since it froze so fast the actual temperature was lower than that.

This conclusively proves that the Peltier module does indeed get quite cold.

Generating Power

For the last Peltier module experiment, I am going to use the module for something it wasn't intended to do.

Remember the Seebeck Effect? This was the complementary effect of the Peltier Effect, it creates electricity out of heat.

It turns out that the Peltier Module can act as a Seebeck device, albeit a very inefficient one.

I tested out this theory by heating the “hot side” of my module with my heat gun while I observed the output voltage with a meter connected to the two leads.

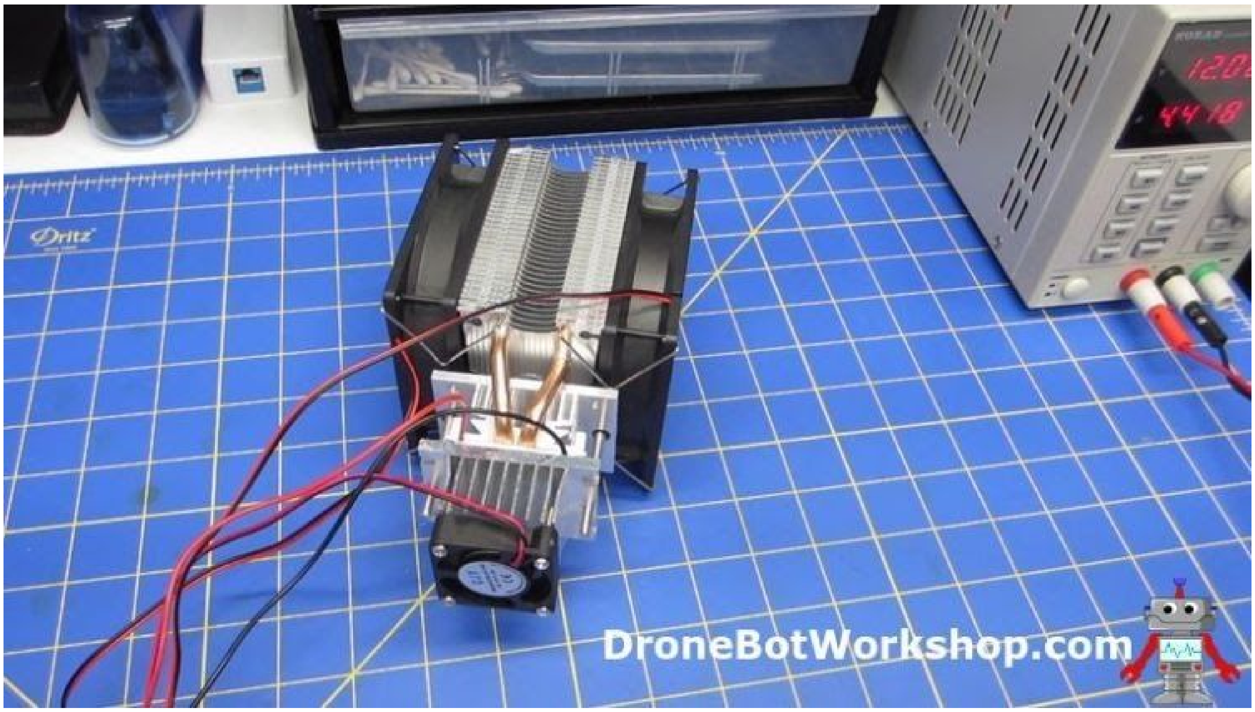
I managed to obtain about 1.5 volts from my module after I heated it up. Not enough to really do anything with, especially as I suspect it was very low-current.

Theoretically, you could probably hook up a number of modules in series to increase the voltage and in parallel to get more current. But for practical purposes, this is just a scientific curiosity.

If you really want to generate electricity from heat there are many better ways of accomplishing this!

Peltier Cooler Assembly

Peltier cooler assemblies are available on eBay and a number of other sources. They are very inexpensive and can be used for practical purposes such as building a tiny refrigeration unit or personal cooler.



If nothing else these assemblies are a great source of parts for a very low price. The one I obtained had three fans, a Peltier module, and several heatsinks and heat pipes. It even came with a new 12-volt 6-ampere power supply. A great deal when you consider it costs about as much as the power supply would by itself!

As everything on the assembly runs on 12-volts getting the device to work was very easy.

After hooking it up, I tried to obtain a temperature reading from the “cool side”, the end with the small fan.

It wasn't easy getting a reading but I got one eventually of 17.4 Celcius. In previous attempts, I managed to get a reading as low as 15 degrees.

One thing I did notice was that I was getting condensation on the "cool side" heatsink, which would have been caused by the moisture in the air condensing on the cold surface. So the device was also acting as a small dehumidifier as well!

These are great devices to experiment with, keep your eyes peeled on eBay to pick one up for yourself.

Conclusion

Peltier modules are very easy to use and, when heatsinked appropriately, can really reduce temperatures. They can provide cooling for semiconductors or for a frosty beverage, without any moving parts.

Hopefully, this article and the accompanying video will give you some ideas for some cool projects of your own!