Design of Medicine Refrigeration for Rural and Flood Affected Areas- Fast Chilling Solar Based Refrigerator with Dual Mode Battery Charging to Preserve Antitoxin for Treatment

P. Vijaya Kumari

Senior Lecturer in Mechanical Engineering, Govt.Polytechnic, Rayadurg, Anantapur (Dt), India
perumallavijayakumari[at]gamil.com

Abstract: ***For the last few centuries, fossil fuel has been considered and utilized as the main source of energy. However; the negative impacts of burning fossil fuel on the environment have forced the energy research continuity to seriously consider renewable sources of energy. Solar energy, in particular, has been the main focus in this regard because it is a source of clean energy and naturally available. Solar energy applications include solar photovoltaic and solar thermal. Solar thermal systems are used to power absorption refrigeration and air-conditioning systems. In Today's world global warming is being increasing year by year. There are many reasons like pollution, deforestation, water contamination, etc...In coming years the major problem before us is depletion of ozone layer which is caused by the release of CFC's. Some of the equipment which cause this effect are refrigerators and A/C's. Here I am designing a mini solar based refrigerator for preserving injections, vaccines & Medicines to the remote areas where power supply is not possible which is cheaper as well as eco-friendly. Here I am using Micro controller (AT89S52) allows dynamic and faster control. Liquid crystal display (LCD) makes the system user-friendly. In this project Iam using solar panels for charging a Lead Acid Battery (12V, 1.2 Amp hrs), a pelteir thermoelectric device when connected to battery generates cool effect and hot effects depending on the mode required by the user. Since I am using this fridge for only cool mode, a peltier thermoelectric device is connected to the battery to generate cooling effect. I need to display the voltage for that I am using ADC0808 which is given to the controller. For this ADC Iam giving a clock pulses through 555 timer to perform its operation. This project uses regulated 5V; 500mA power supply. A 7805 three terminal voltage regulator is used for voltage regulation. Bridge type full wave rectifier is used to rectify the ac output of secondary of 230/12V step down transformer.***

Keywords: Solar panel, Peltier plate, Lead Acid Battery, rectifier, Heat sink, CFC's, Cooling fan & Thermoelectric Refrigerator etc.

1. Introduction

In the recent years, we all are facing electricity crisis. It's time to harness the renewable energy resources of the nature. This project utilizes the solar energy to run cooling system. In this project I have fabricated a thermoelectric system using solar energy. It is an eco-friendly project, made by using thermoelectric module. The thermoelectric devices used in thermoelectric refrigeration (or thermoelectric coolers) are based on the Peltier effect to convert electrical energy into a temperature gradient .The project has various applications like, military or aerospace, medical and pharmaceutical equipment etc. Thus it proves to be very helpful.

Solar-powered refrigerators are most commonly used in the developing world to help mitigate poverty and climate change. By harnessing solar energy, these refrigerators are able to keep perishable goods such as meat and dairy cool in hot climates, and are used to keep much needed vaccines at their appropriate temperature to avoid spoilage. The portable devices can be constructed with simple components and are perfect for areas of the developing world where electricity is unreliable or non-existent. Other solar-powered refrigerators were already being employed in areas of Africa which vary in size and technology, as well as their impacts on the environment. The biggest design challenge is the intermittency of sunshine (only several hours per day) and the unreliability (sometimes cloudy for days). Either batteries (electric refrigerators) or phase-change material is added to provide constant refrigeration.

In developed countries, plug-in refrigerators with backup generators store vaccines safely, but in developing countries, where electricity supplies can be unreliable, alternative refrigeration technologies are required. Solar fridges were introduced in the developing world to cut down on the use of kerosene or gas-powered absorption refrigerated coolers which are the most common alternatives. They are used for both vaccine storage and household applications in areas without reliable electrical supply because they have poor or no grid electricity at all. They burn a liter of kerosene per day therefore requiring a constant supply of fuel which is costly and smelly, and are responsible for the production of large amounts of carbon dioxide. They can also be difficult to adjust which can result in the freezing of medicine.

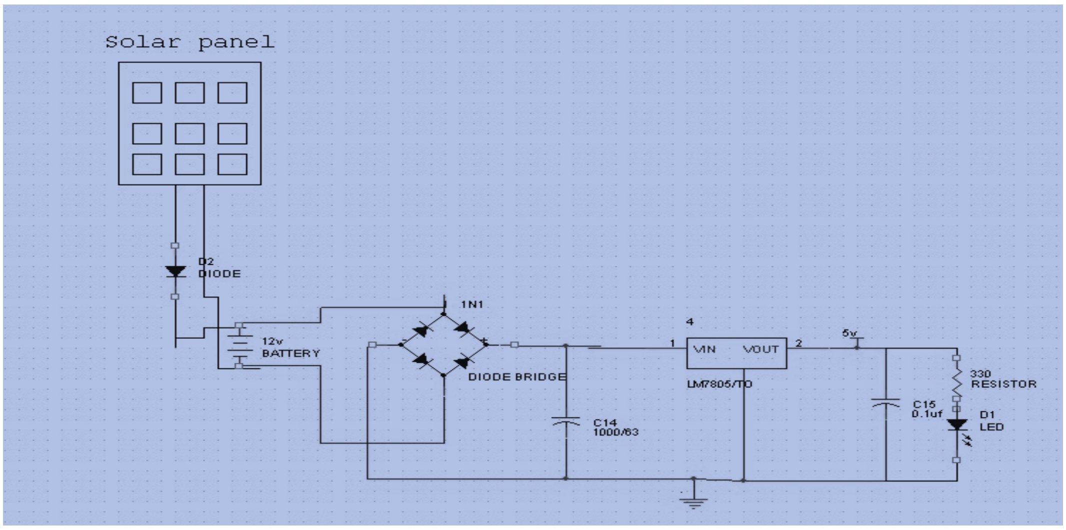
2. Objectives

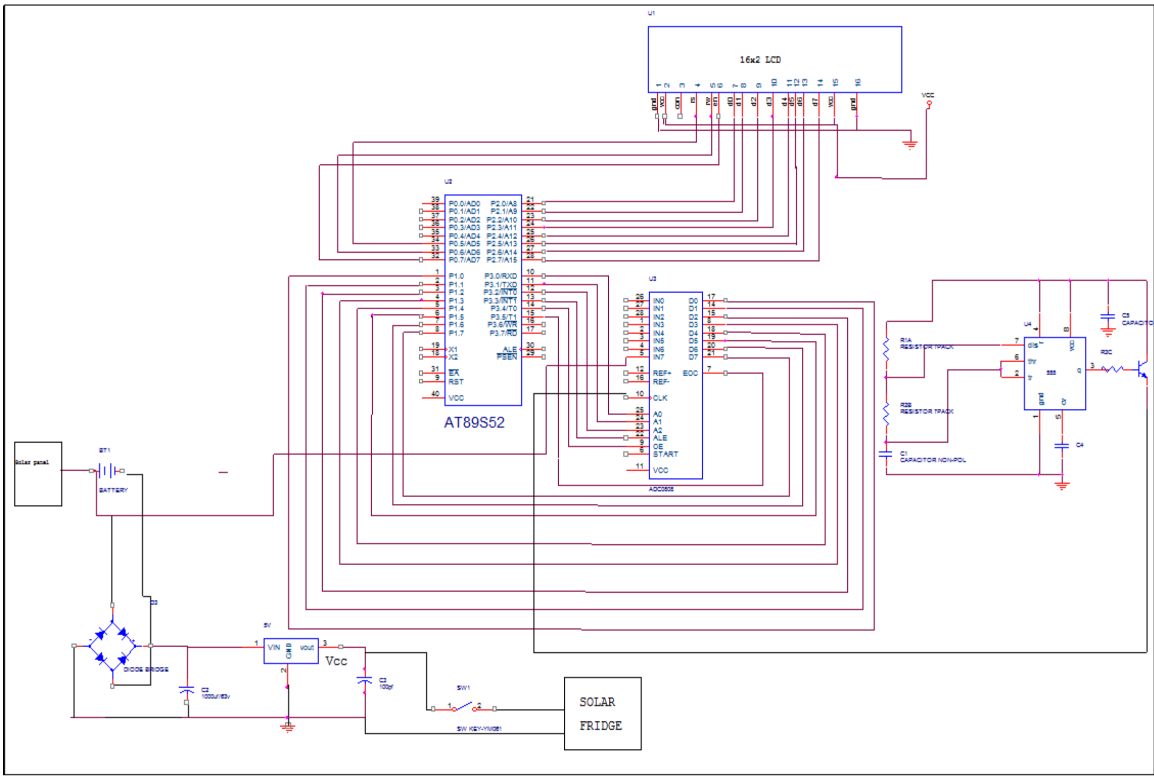
In recent years, with the increase awareness towards environmental degradation due to use of CFCs and HCFCs refrigerants in conventional refrigeration systems has become a subject of great concern. Besides, these kinds of refrigeration systems having limitation of use of grid power and same cannot be utilised for remote applications.

- The main aim of this project is to provide refrigeration for preserving injections, vaccines & Medicines to the remote areas where power supply is not possible. This project utilizes the solar energy for its operation. Solar energy is free of pollution.

- This project does not need any kind of refrigerant and mechanical device for its operation.

Line diagram:

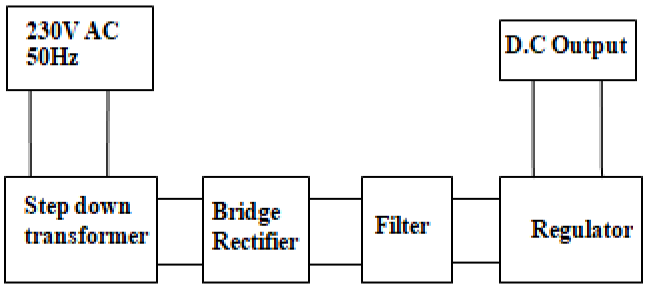




Explanation of each block:

Power Supply:

The input to the circuit is applied from the regulated power supply. The a.c. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating d.c voltage. So in order to get a pure d.c voltage, the output voltage from the rectifier is fed to a filter to remove any a.c components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage.



Transformer:

Usually, DC voltages are required to operate various electronic equipment and these voltages are 5V, 9V or 12V. But these voltages cannot be obtained directly. Thus the a.c input available at the mains supply i.e., 230V is to be brought down to the required voltage level. This is done by a transformer. Thus, a step down transformer is employed to decrease the voltage to a required level.

Rectifier:

The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification. The Bridge rectifier is a circuit, which converts an ac voltage to dc voltage using both half cycles of the input ac voltage.

Filter:

Capacitive filter is used in this project. It removes the ripples from the output of rectifier and smoothens the D.C. Output received from this filter is constant until the mains voltage and load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

Voltage regulator:

As the name itself implies, it regulates the input applied to it. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, power supply of 5V and 12V are required. In order to obtain these voltage levels, 7805 and 7812 voltage regulators are to be used. The first number 78 represents positive supply and the numbers 05, 12 represent the required output voltage levels.

Solar Cell Description

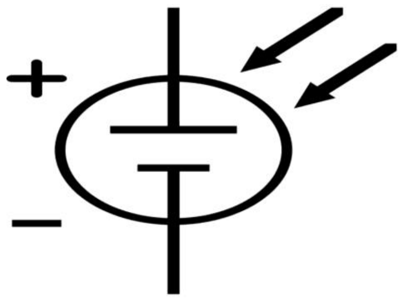
Solar Panel:

Photovoltaic Cells: Converting Photons to Electrons

The solar cells that we see on calculators and satellites are also called photovoltaic (PV) cells, which as the name implies (photo meaning "light" and voltaic meaning "electricity"), convert sunlight directly into electricity. A module is a group of cells connected electrically and packaged into a frame (more commonly known as a solar panel), which can then be grouped into larger solar arrays.

Photovoltaic cells are made of special materials called semiconductors such as silicon, which is currently used most commonly. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the semiconductor. The energy knocks electrons loose, allowing them to flow freely.

PV cells also all have one or more electric field that acts to force electrons freed by light absorption to flow in a certain direction. This flow of electrons is a current, and by placing metal contacts on the top and bottom of the PV cell, we can draw that current off for external use, say, to power a calculator. This current, together with the cell's voltage (which is a result of its built-in electric field or fields), defines the power (or wattage) that the solar cell can produce.



The schematic symbol of a solar cell

1) Photons in sunlight hit the solar panel and are absorbed by semi conducting materials, such as silicon.
2) Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity. Due to the special composition of solar cells, only allow the electrons to move in a single direction. The complementary positive charges that are also created (like bubbles) are called holes and flow in the direction opposite of the electrons in a silicon solar panel.
3) An array of solar panels converts solar energy into a usable amount of direct current (DC) electricity.

Solar energy:
Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar radiation, along with secondary solar-powered resources such as wind and wave power, hydroelectricity and biomass, account for most of the available renewable energy on earth Only a minuscule fraction of the available solar energy is used.

Solar powered electrical generation relies on heat engines and photovoltaic. Solar energy's uses are limited only by human ingenuity. A partial list of solar applications includes space heating and cooling through solar architecture, potable water via distillation and disinfection, day lighting, solar hot water, solar cooking, and high temperature process heat for industrial purposes. To harvest the solar energy, the most common way is to use solar panels.

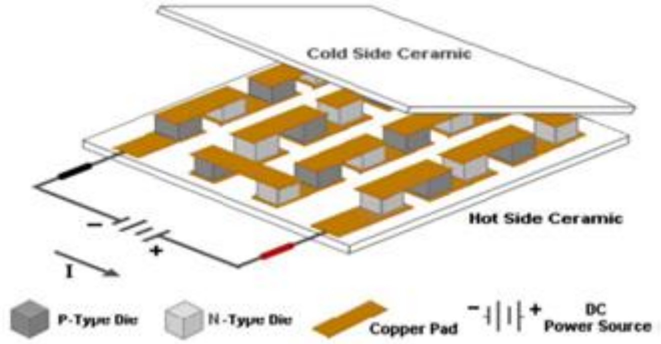
12V DC Battery:

Batteries are all over the place in our cars, our PCs, laptops, portable MP3 players and cell phones. A battery is essentially a can full of chemicals that produce electrons. Chemical reactions that produce electrons are called **electrochemical reactions**.

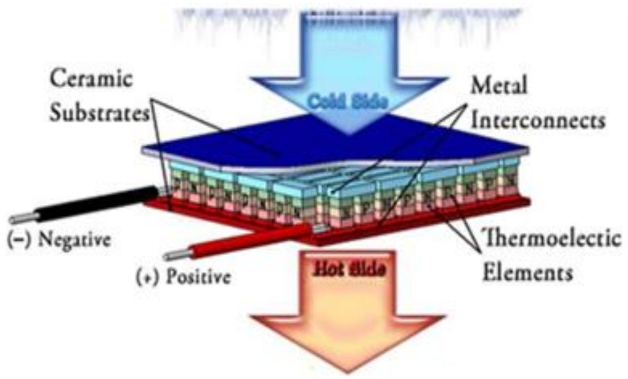
Thermo Electric Cooler

Peltier Plate
A typical thermoelectric module is composed of two ceramic substrates that serve as a foundation and electrical insulation for P-type and N-type Bismuth Telluride dice that are connected electrically in series and thermally in parallel between the ceramics. The ceramics also serve as insulation between the modules internal electrical elements and a heat sink that must be in contact with the hot side as well as an object against the cold side surface. Electrically conductive materials, usually copper pads attached to the ceramics, maintain the electrical connections inside the module. Solder is most commonly used at the connection joints to enhance the electrical connections and hold the module together. Most modules have and even number of P-type and N-type dice and one of each sharing an electrical interconnection is known as, "a couple." While both P-type and N-type materials are alloys of Bismuth and Tellurium, both have different free electron densities at the same temperature. P-type dice are composed of material having a deficiency of electrons while N-type has an excess of electrons. As current (Amperage) flows up and down through the module it attempts to establish a new equilibrium within the materials. The current treats the P-type material as a hot junction needing to be cooled and the N-type as a cold junction needing to be heated. Since the material is actually at the same temperature, the result is that the hot side becomes hotter while the cold side becomes colder. The direction of the current will determine if a particular die will cool down or heat up. In short, reversing the polarity will switch the hot and cold sides.

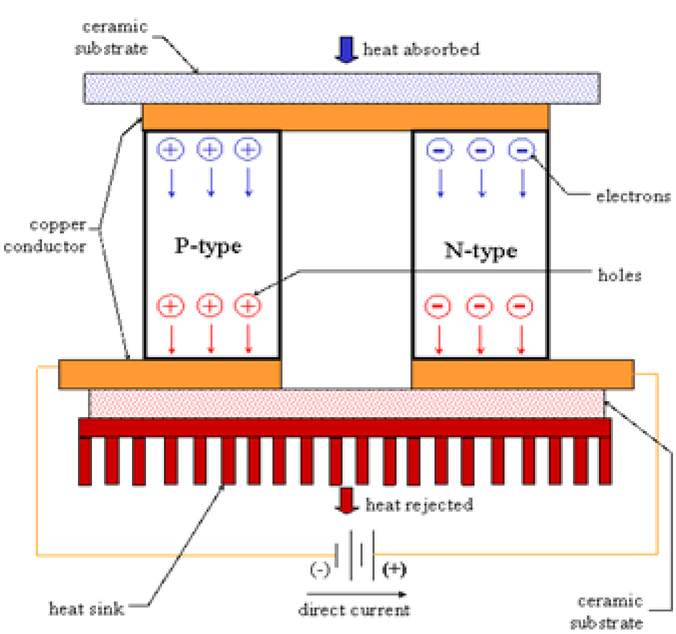
Working of thermoelectric module
Thermoelectric modules are solid-state heat pumps that operate on the Peltier effect. A thermoelectric module consists of an array of panel n-type semiconductor elements that are heavily doped with electrical carriers. The elements are arranged into array that is electrically connected in series but thermally connected in parallel. This array is then affixed to two ceramic substrates, one on each side of the elements (see figure below). Let's examine how the heat transfer occurs as electrons flow through one pair of p- and n-type elements (often referred to as a "couple") within the thermoelectric module:

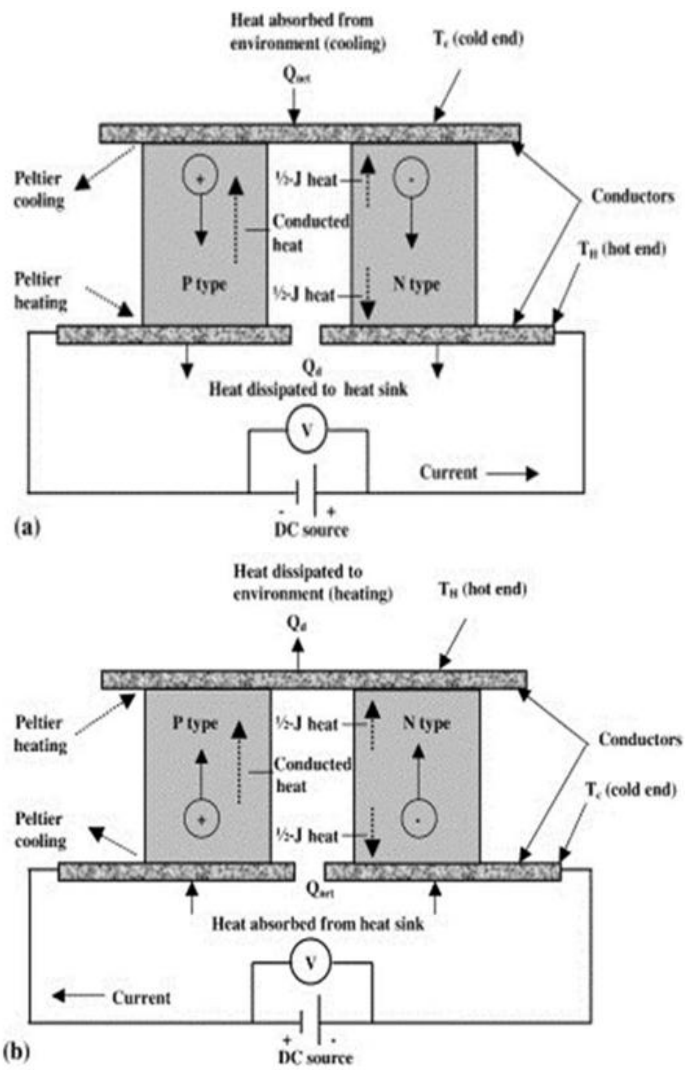


Operating Principle of the Thermo-Electric Module
The TEM operating principle is based on the Peltier effect. The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material. One of the TEM sides is cooling and the other side is heating. When a TE module is used, you must support heat rejection from its hot side. If the temperture on the hot side is like the ambient temperature, then we can get the temperature on the cold side that is lower .The degree of the cooling is depended from the current value that is leaking through a thermoelectric module. In a thermo-electric heat exchanger the electrons acts as the heat carrier. The heat pumping action is therefore function of the quantity of electrons crossing over the p-n junction.



Schematic of a Thermoelectric Cooler





The p-type semiconductor is doped with certain atoms that have fewer electrons than necessary to complete the atomic bonds within the crystal lattice. When a voltage is applied, there is a tendency for conduction electrons to complete the atomic bonds. When conduction electrons do this, they leave "holes" which essentially are atoms within the crystal lattice that now have local positive charges. Electrons are then continually dropping in and being bumped out of the holes and moving on to the next available hole . In effect, it is the holes that are acting as the electrical carriers. Now, electrons move much more easily in the copper conductors but not so easily in the semiconductors. When electrons leave the p-type and enter into the copper on the cold-side, holes are created in the p-type as the electrons jump out to a higher energy level to match the energy level of the electrons already moving in the copper. The extra energy to create these holes comes by absorbing heat. Meanwhile, the newly created holes travel downwards to the copper on the hot side. Electrons from the hot-side copper move into the p-type and drop into the holes, releasing the excess energy in the form of heat. The n-type semiconductor is doped with atoms that provide more electrons than necessary to complete the atomic bonds within the crystal lattice. When a voltage is applied, these extra electrons are easily moved into the conduction band. However, additional energy is required to get the n-type electrons to match the energy level of the incoming electrons from the cold-side copper. The extra energy comes by absorbing heat. Finally, when the electrons leave the hotside of the n-type, they once again can move freely in the copper. They drop down to a lower energy level, and release heat in the process.

The Peltier Plate is a smart swap temperature control option providing a temperature range of –40 to 180 °C, with a maximum heating rate of 30 °C/min, and temperature accuracy of +/- 0.1 °C. A platinum resistance thermometer (PRT) sensor is positioned in the middle of the lower sample plate and ensures accurate measurement and control of sample temperature. It is the most common system for standard parallel plate and cone and plate testing of structured fluids. The open design facilitates easy sample loading and cleaning of geometries

Technical Specification

Thermoelectric modules withstand potentially detrimental environmental conditions operating without failure under the low temperature point being equal to 285 K (12°C) and the high temperature point being equal to 328 K (+55°C). Thermoelectric modules successfully meet the below specified conditions without failure: sinusoidal vibration, 10-50 Hertz, with vibroacceleration amplitude up to 20 m/s2 (2g). Unsealed thermoelectric modules withstand high humidity conditions with the RH level up to 88 % and 298 ° K (25°C) without any failure in operation. Thermoelectric modules withstand single mechanical shock with the peak shock acceleration being equal to 20G (200 m/s2) and 2-4 msec Collision Momentum without any failure.

Benefits:
- No chlorofluorocarbons
- Generate no electrical noise
- Durable and maintenance-free
- Capable of generating electricity when one side is kept cool and heat is applied to the other
- No moving internal parts to damage when in transit
- Makes absolutely no noise and does not vibrate
- Long life
- Slim and compact
- Excellent quality

Specifications:
- Type: TEC1-12726
- 400W
- 12V
- Couples: 127
- Imax (A): 20
- Vmax (V): 15.4
- QCmax (W) 177.8
- Tmax ˚C: 68
- Dimensions: 50 x 50 x 3.65mm (2 x 2 x 0.15")
- Wire length: 101mm (4")
- Fully sealed for protection against moisture

Advantages of mini thermoelectric Refrigerator:
- Solid state heat pumps have no moving parts
- No Freon's or other liquid or gaseous refrigerants required
- Noiseless operation
- Compact size and light weight makes TEMs well suited for miniature coolers
- High reliability
- No bulky compressor units
- Precise temperature control, Relatively low cost and high effectiveness
- Operation in any orientation
- Included LCD display with back-light for 24 hour display viewing
- High efficiency and outstanding energy harvest in a small modular design
- Eco-friendly C-pentane, CFC free insulation

Disadvantage

C.O.P. is less as compared to conventional refrigeration system.

Limitation

This project is based on solar energy, thus solar energy is very necessary for the working of this project. But in rainy season it cannot be possible to charge battery from solar .this is the limitation of this project but this problem can be solved by giving direct current supply.

Applications
- Medical and pharmaceutical equipment.
- It can be uses as remote place where electric supply is not available.
- Laboratory, scientific instruments, computers and video cameras.
- Industrial, consumer, scientific / laboratory, and telecommunications organizations.
- Uses range from simple food and beverage coolers for an afternoon picnic to extremely sophisticated temperature control systems in missiles and space vehicles.

3. Conclusion

The project is useful for the instant chilling/hot applications. Thus this project concludes that solar energy systems must be implemented to overcome increasing electricity crisis. In this work, a portable solar operated system unit was fabricated and tested for the cooling and heating purpose. The system was designed based on the principle of a thermoelectric module to create a hot side and cold side. The cold side of the thermoelectric module was utilized for cooling purposes whereas the rejected heat from the hot side of the module was eliminated using heat sinks and fans. And hot side of the thermo electrical module was utilized for heating purpose. In order to utilize renewable energy, solar energy was integrated to power the thermoelectric module in order to drive the system. Furthermore, the solar thermoelectric cooling and heating system avoids any unnecessary electrical hazards and proves to be environment friendly

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