Solar Powered Automatic Cabin Cooling System

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Abstract

The day to day increase in the atmospheric temperature leads to the need for better cooling as well as the energy systems. While considering the case of an automobile for example a car being parked outside in the sun, the temperature will gradually increase and humans cannot afford to be in such high temperatures. So for maintaining the ambient temperature inside the cabin the engine have to be operated just to provide the ambient temperature. Here the system implements an effective system to maintain an ambient temperature inside the cabin even when the engine is turned off. This utilizes the solar power extracted using a solar panel and given a separate storage space to power a system which controls the temperature inside the cabin. It utilizes the TEG (thermo electric generators) to provide the cooling inside the cabin. These TEG modules are given power supply from the solar energy extracted and the operation is controlled by a control circuit. Which senses the temperature inside the cabin continuously and TEG is operated whenever needed.

Keyword- PV System, Air Conditioning System, TEG (Thermo Electric Generators)

I. INTRODUCTION

Due to the increasing demand for refrigeration in various fields led to production of more electricity and consequently more release of harmful gas like co_2 all over the world which is a contributing factor of global warming on climate change. Thermoelectric refrigeration is a new alternative method. The thermoelectric modules are made of semiconductor materials electrically connected in series configuration and thermally in parallel to create cold and hot surfaces. Although they are less efficient than the vapour compression system, they are very light, low in cost, silent in operation, and are environmentally friendly.

The objectives of this project is to design and develop a working thermoelectric cooler that Utilizes the Peltier effect to refrigerate and maintain a temperature between 28^0C to 35^0C. The design Requirements are to cool the volume to a temperature within a short time and provide retention of at least next half an hour. And a Thermo syphon cooling system is used for cooling the hot side of TEG module. It will be used in automobiles where a solar panel charger is added for battery charging.

A thermoelectric module thus uses a pair of fixed junctions into which electrical energy is applied causing one junction to become cold while the other becomes hot. Because thermoelectric cooling is a form of solid-state refrigeration, it has the advantage of being compact and long lasting. It uses no moving parts except for some fans, employs no fluids, and do not require bulky piping and mechanical compressors used in vapour-cycle cooling systems. Such sturdiness favour thermoelectric cooling over conventional refrigeration in certain situations. The compact size and weight requirements, as well as portability in the design, rule out the use of conventional refrigeration.

Thomas Seebeck in 1821 discovered that a continuously flowing current is created when two wires of dissimilar materials are joined together at the ends and heated at one end. The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. When heat is applied to one of the two conductors or semiconductors, heated electrons flow toward the cooler one. If the pair is connected through an electrical circuit, direct current (DC) flows through that circuit.

The voltages produced by Seebeck effect are small, usually only a few microvolts (millionths of a volt) per kelvin of temperature difference at the junction. If the temperature difference is large enough, some Seebeck-effect devices can produce a few millivolts (thousandths of a volt). Numerous such devices can be connected in series to increase the output voltage or in parallel to increase the maximum deliverable current. Large arrays of Seebeck-effect devices can provide useful, small-scale electrical power if a large temperature difference is maintained across the junctions. This phenomenon is known as the Seebeck Effect.

II. LITERATURE REVIEW

1) S Rațiu, Laza, V Alexa and V G Cioată , "Practical studies on car air conditioning systems", Materials Science and Engineering 393, (2018)

Car manufacturers have attempted to introduce a number of additional auxiliary equipment to provide substantial improvements to passenger comfort in the interior of the passenger compartment while increasing vehicle performance, thereby achieving reliability and quality/price ratio. The development of air conditioning systems over time and the reduction of production costs

have led to an increasing demand from customers. Thermal comfort is the condition of the mind expressing the degree of general satisfaction with the surrounding environment" is understood. Thermal comfort sensation, i.e. neutral temperature sensation, is defined by the human body's thermal balance equation.

$$Q_H - Q_D - Q_T - Q_R - Q_L = Q_{RA} + Q_C$$

Where;

Q_H – internal heat due to metabolism;

Q_D – heat lost due to vapour diffusion through the skin; Q_T – heat lost due to perspiration;

Q_R – latent heat lost due to breathing; Q_L – heat lost due to dry breath;

Q_{RA} – heat lost through radiation to the surface of the dressed up human body; Q_C – heat lost through convection to the surface of the dressed up human body.

$$PMV = (0.33.\ e^{-0,036M} + 0,028)\ (QH- QD - QT - QR- QL - QRA – QC)$$

Where M – is the metabolism of the human body [met] (1met = 58.15 W/m^2, without physical activity). The following situations occur:

PMV=0 - total thermal comfort. There is, however, a percentage of 5% of people not satisfied with thermal comfort;

$0,85 < PMV < + 0,85$ - the maximum percentage of 20% of people not satisfied with thermal comfort. Humans control their body temperature by sweating and shivering. Thermal Environmental Conditions for Human Occupancy, which recommends keeping relative humidity between 30% and 60%, with below 50% preferred to control dust mites. At high humidity sweating is less effective so we feel hotter; thus the desire to remove humidity from air with air conditioning in the summer. In the winter, heating cold outdoor air can decrease indoor relative humidity levels to below 30%, leading to discomfort such as dry skin and excessive thirst. From a theoretical point of view, the operating principle of air conditioning systems and, in general, refrigeration systems, are based on the reversed Carnot cycle - heat transfer from the cold source to the hot source - with energy input Experimental research in this article focuses on determining how functional parameters of the air conditioning installation affect air quality by modifying its relative humidity. It is also intended to establish a correlation between these parameters. The variation of average values of the temperatures inside the condenser and evaporator is monitored by means of thermometer mounted on the stand. Also, the pressures in the low and high pressure circuits are determined by the stand's own instruments. Additionally, air relative humidity, air temperature and air velocity in front of the ventilation grilles are measured with the Testo Smart Probes - VAC SET measuring equipment.

2) Dauta, M. Adzriea, M. Irwantoa, P. Ibrahima, M. Fitraa, "Solar Powered Air Conditioning System" Energy Procedia 36 (2013). The demand of air conditioning is increasing due to the effect of climate change and global warming. If we still rely on the conventional electric air conditioning but electricity is generated form fossil fuels, the greenhouse gas emission would continuously worsen global warming, in turn the demand of air conditioning would be further increasing. The system, which has simpler capacity control, mechanism, easier implementation, high reliability, silent operation, long life and low maintenance cost was a genuine candidate for efficient and economic use of solar energy for cooling applications. But in this project concentrates on development and improvement of a normal air conditioner unit in order to operate using electricity generated from the PV system. Utilizing solar energy to run the air conditioning system is a practical technique to replace conventional electricity. In order to obtain a feasibility of the air conditioning system using solar, a lot research and testing have been initiated to learn and discover the design and operation of the air conditioning and solar system which is consist of PV system.

The purpose of this paper is to design and construct a direct current air conditioning system besides describe the component and characteristics of the system including its advantages and limitations. The actual performance of the system will be studied based on operational view and commercial applications.

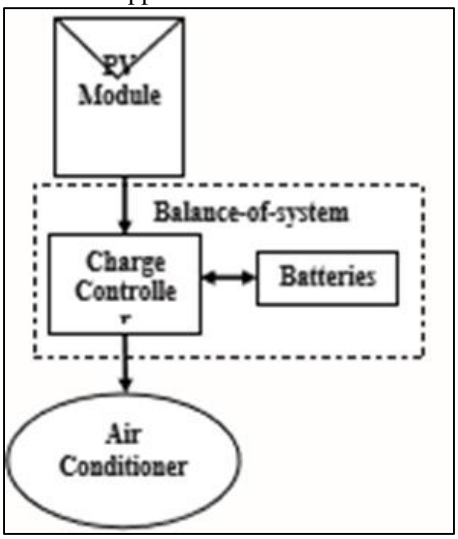


Fig. 1: Block diagram of PV System and Air Conditioning System

This paper concludes that the system design needs to consider both air conditioner and PV system in order to achieve the space cooling. There are several characteristics that are needed to know either on the PV system or air conditioning system. Electrical equivalent, IV characteristic curve and factors affect the output of PV cell is an important characteristic in photovoltaic. As for the air conditioning, cooling capacity must be determined first as it will give a rough idea on how to design and construct the system with enough electrical energy supplied to it. With considering of these several factors, it will help to improve the stability and efficiency of the system for greener solutions to the world's energy needs.

3) Y.P.B.Yeung , K.W.E.Cheng ,W.W.Chan,C.Y Lam,w.f.choi,T.W.NG "Automobile hybrid air conditioning technology" 3rd International Conference on Power Electronics Systems and Applications, 2009.

This paper deals with the air condition compressor. The air condition compressor is driven by an internal combustion engine of the vehicle when the engine is running. When the engine is not running, the compressor is driven by a brushless DC machine powered by a 24 V lead acid battery. The concept of this air conditioning system is combining the technology of electric and traditional automobile air conditioning systems. The compressor of this system is driven by the internal combustion engine when the engine is running as a typical automobile air conditioning system. When the engine is shut down, the A/C compressor of this system is driven by an electric machine powered by a 24V rechargeable battery. When the battery voltage level is low, it is recharged by the electric power generated from the same electric machine driven by the engine. Since the speed of the electric machine is under control, the A/C temperature can be controlled with much less temperature fluctuation.

4) Law Choon Chuan, Herman Wahid, Leow Pei Ling "A Charge Pump-based Power Conditioning Circuit for Low Powered Thermoelectric Generator (TEG)"10th Asian Control Conference (ASCC) 31 May-3 June 2015

This paper deals with the power generation of TEG module. Power generation of TEG is directly proportional to temperature gradient. Paper focused on the power conditioning system for a low powered thermoelectric generator, it also determines the viability of TEG application in human portable device by adapting body temperature as source of energy conversion. It reveals the feasibility of signal conditioning method for a regular TEG module using charge pump. Here charge pump was selected as the power management approach for portable devices. As charge pump is familiar in the application of very-large-scale integration (VLSI) power management, it is suitable for the case of resolve low generated power for TEG system. At the same time, the results of application notes from Maxim Integration also indicated charge pump is more efficient than boost converter in terms of power management approaches today. Charge pump is proposed to be an ideal solution for low power devices in which voltage can be multiplied accordingly to sustain the process of electronic devices.

By having an input voltage of 4.5 mV to be step up to 3.3 V, it is taking five phase of four-stage charge pump. This resolves the problem of TEG with low output voltage generation when dealing with low temperature gradient. The idea of charge pump increased feasibility of TEG modules to harvest energy that can sustain operation of a portable handheld device. The idea can be performed practically in order to investigate other possible parameters such as current and power ratings to produce a better and stable energy harvesting system.

5) Hasan U. Zaman, Chowdhury Erfan Shourov, Abdullah Al Mahmood and Noor E Alam Siddique",Conversion of Wasted Heat Energy into Electrical Energy Using TEG" 2017

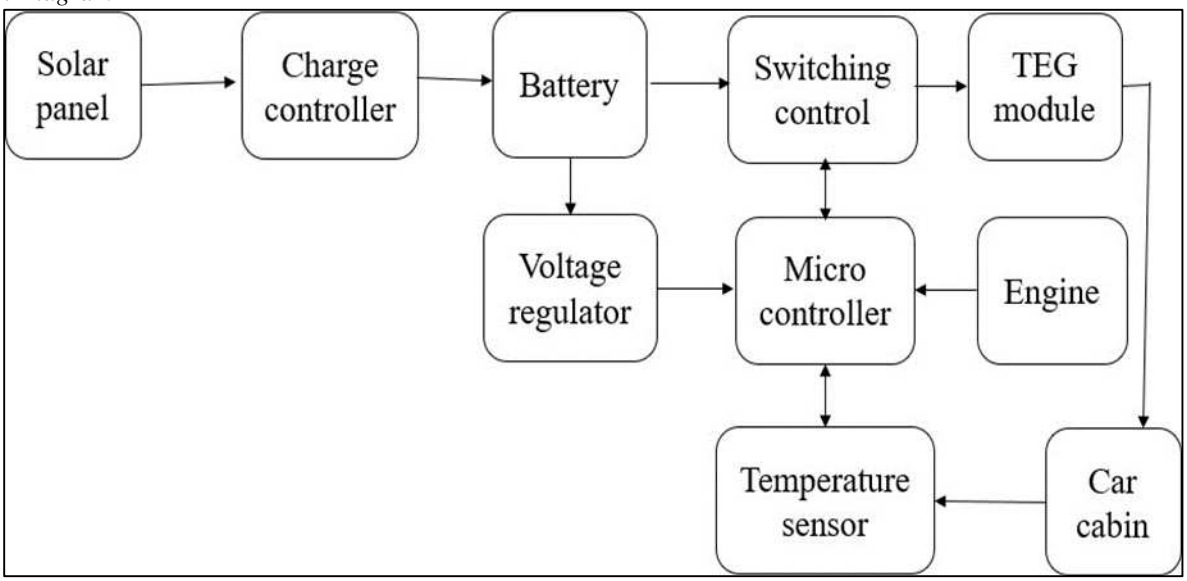
This paper deals with the conversion of the heat into electrical energy and the output is amplified to at least 5 Volts. This paper discusses extensively how the system functions and what are the components used to design it. The theory behind the function of the system and the possibility of implementing this design in the third world countries are also discussed. The impact of this growing technology can have in the third-world countries is ground-breaking. It involves the renewal and recycling of wasted heat into additional electric power. This is a growing technology and this paper describes the future scopes of this design being implemented at the industrial scale as well as the option of storing the electrical energy from the wasted heat and therefore making it portable. The designed system amplifies the negligible voltage generated by the TEG using a dc-dc step-up converter to produce a voltage high enough to charge up cell phones. The design of the system is simple and the cost of the system is much less than the comparable existing products.

A. Objectives

- Design an effective and inexpensive system to reduce the temperature inside the vehicle.
- Increase the air flow rate and decrease the steady state temperature inside the car cabin
- Minimum or zero fuel consumption for cabin cooling during the vehicle is on idle condition.
- Higher efficiency
- Reduced environmental impacts
- Conservation of conventional energy resources.

III. PROPOSED SYSTEM

A. Block Diagram



B. Block Diagram Description

From the block diagram the various components of the project are shown. It consists of a solar panel of 12 volt, 5 watts which is used for powering the auxiliary battery. Then this power is feed to the battery for charging it. This stored power is used for driving the microcontroller and for the working of the TEG module. The microcontroller used is a PIC16F874A/877A it is programmed in the desired conditions; it provide the switching pulses to the TEG module by sensing the temperature inside the car cabin. The temperature sensor is LM35.There is a loop between the TEG module the temperature sensor and the microcontroller. This system operate only when the engine is in off condition.

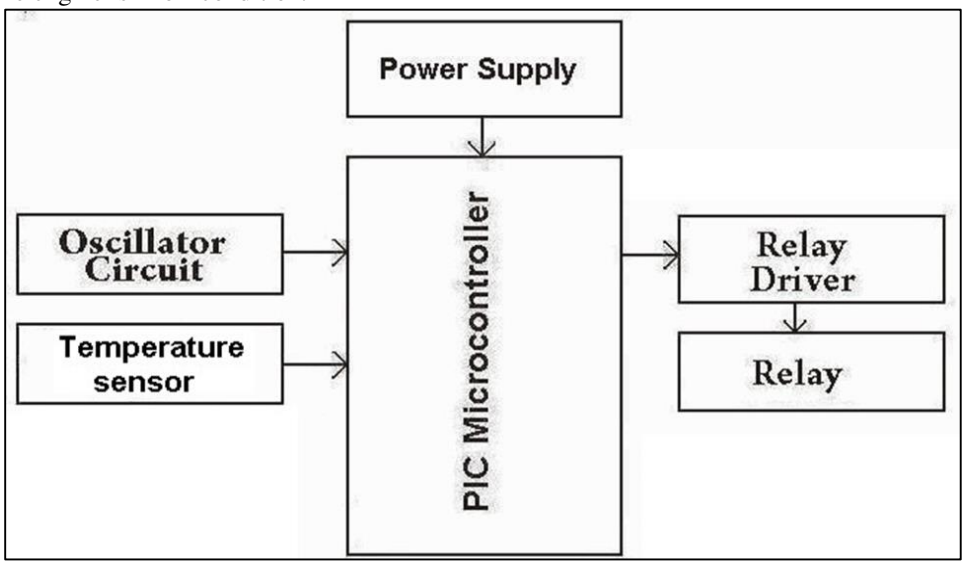


Fig. 2: Block diagram of proposed system

C. Components and Description

The components that are used in the project Solar Powered Automatic Cabin Cooling System are as follows,

- TEG module
- Temperature sensor
- Solar panel
- Fan
- Frame
- Battery

D. Thermo Electric Generator (TEG)

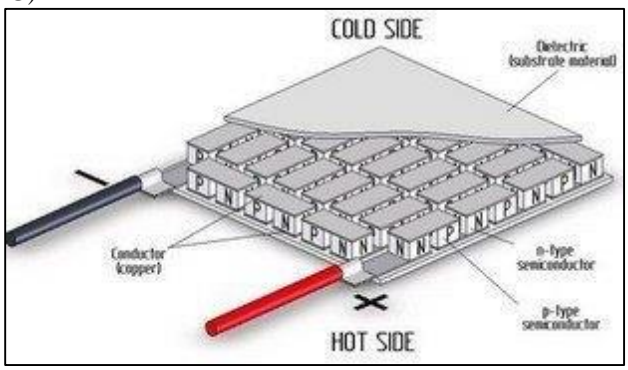


Fig. 3: Thermo Electric Generator

A thermoelectric generator (TEG), also called a Seebeck generator, is a solid state device that converts heat (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect). Thermoelectric generators function like heat engines, but are less bulky and have no moving parts. However, TEGs are typically more expensive and less efficient. Thermoelectric generators could be used in power plants in order to convert waste heat into additional electrical power and in automobiles as automotive thermoelectric generators (ATGs) to increase fuel efficiency. Another application is radioisotope thermoelectric generators which are used in space probes, which has the same mechanism but use radioisotopes to generate the required heat difference.

E. LM35 Temperature Sensor

The LM35 is an integrated circuit temperature sensor. It can measure temperature more accurately than a thermistor. The sensor circuit is sealed and hence not subjected to oxidation. The LM35 generates a higher output voltage than a thermocouple and it does not need an amplifier. It has an output voltage proportional to the Celsius temperature. The scale factor is .01V/°C. The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 °C at room temperature and +/- 0.8/°C over a range of 0oC to +100 °C. Another important characteristic of the LM35DZ is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1/°C temperature rise in still air.

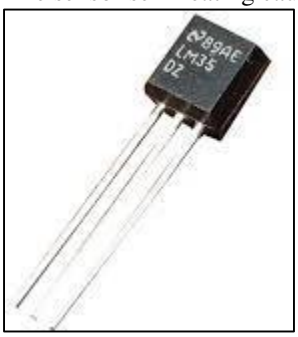


Fig. 4: LM35 Temperature sensor

F. Solar Panel

The most useful way of harnessing solar energy is by directly converting it into electricity by means of solar photo-voltaic cells. Sunshine is incident on Solar cells, in this system of energy Conversion that is direct conversion of solar radiation into electricity. In the stage of conversion into thermodynamic from is absent. The photo-voltaic effect is defined as the generation of an electromotive force as a result of the absorption of ionizing radiation.

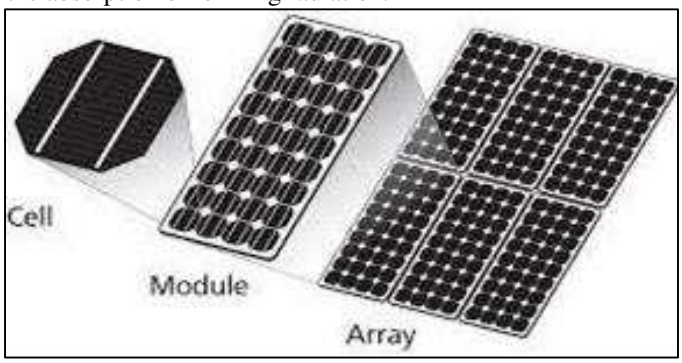


Fig. 5: Solar panel

Energy conversion devices, which are used to convert sunlight to electricity by use of the photo-voltaic effect, are called solar cells. In recent years photo-voltaic power generation has been receiving considerable attention as one of the more promising energy alternatives. The reason for this rising interest lie in PV's direct conversion of sunlight to electricity, the non-polluting nature of the PV widespread are of PV generation has been hampered by economic factors. Here to force, the low cost of conventional energy sunlight has obviated the development of a broad-based PV technology. At the present time, PV generation can be justified only for special situations mostly for remote sites where utility lines on other conventional means of furnishing energy may be prohibitively expensive and is one of the most attractive non-conventional energy sources of proven reliability from the micro to the Mega-watt level.

G. Cooling Fan

Fig .6: Cooling fan

A fan is any fan inside, or attached to, a case used for active cooling, and may refer to fans that draw cooler air into the case from the outside, expel warm air from inside, or move air across a heat sink to cool a particular component. Generally these are found in axial and sometimes centrifugal forms.

H. Frame

This is made of mild steel material. The whole parts are mounted on this frame structure with the suitable arrangement. Boring of bearing sizes and open bores done in one setting so as to align the bearings properly.

I. Battery

In isolated systems away from the grid, batteries are used for storage of excess solar energy converted into electrical energy. The only exceptions are isolated sunshine load such as irrigation pumps or drinking water supplies for storage. In fact for small units with output less than one kilowatt.

Batteries seem to be the only technically and economically available storage means. Since both the photo-voltaic system and batteries are high in capital costs. It is necessary that the overall system be optimized with respect to available energy and local demand pattern. To be economically attractive the storage of solar electricity requires a battery with a particular combination of properties.

- Low Cost
- Long Life
- High Reliability
- High Overall Efficiency
- Low Discharge
- Minimum Maintenance
- Ampere Hour Efficiency
- Watt Hour Efficiency

We use lead acid battery for storing the electrical energy from the solar panel for lighting the street and so about the lead acid cells are explained below.

J. Lead - Acid Wet Cell

Where high values of load current are necessary, the lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulphuric acid (H_2SO_4). In the application of battery power to start the engine in an auto mobile, for example, the load current to the starter motor is typically 200 to 400A. One cell has a nominal output of 2.1V, but lead-acid cells are often used in a series combination of three for a 6-V battery and six for a 12-V battery.

The lead acid cell type is a secondary cell or storage cell, which can be recharged. The charge and discharge cycle can be repeated many times to restore the output voltage, as long as the cell is in good physical condition. However, heat with excessive charge and discharge currents shortens the useful life to about 3 to 5 years for an automobile battery. Of the different types of secondary cells, the lead- acid type has the highest output voltage, which allows fewer cells for a specified battery voltage.

IV. CIRCUIT DIAGRAM

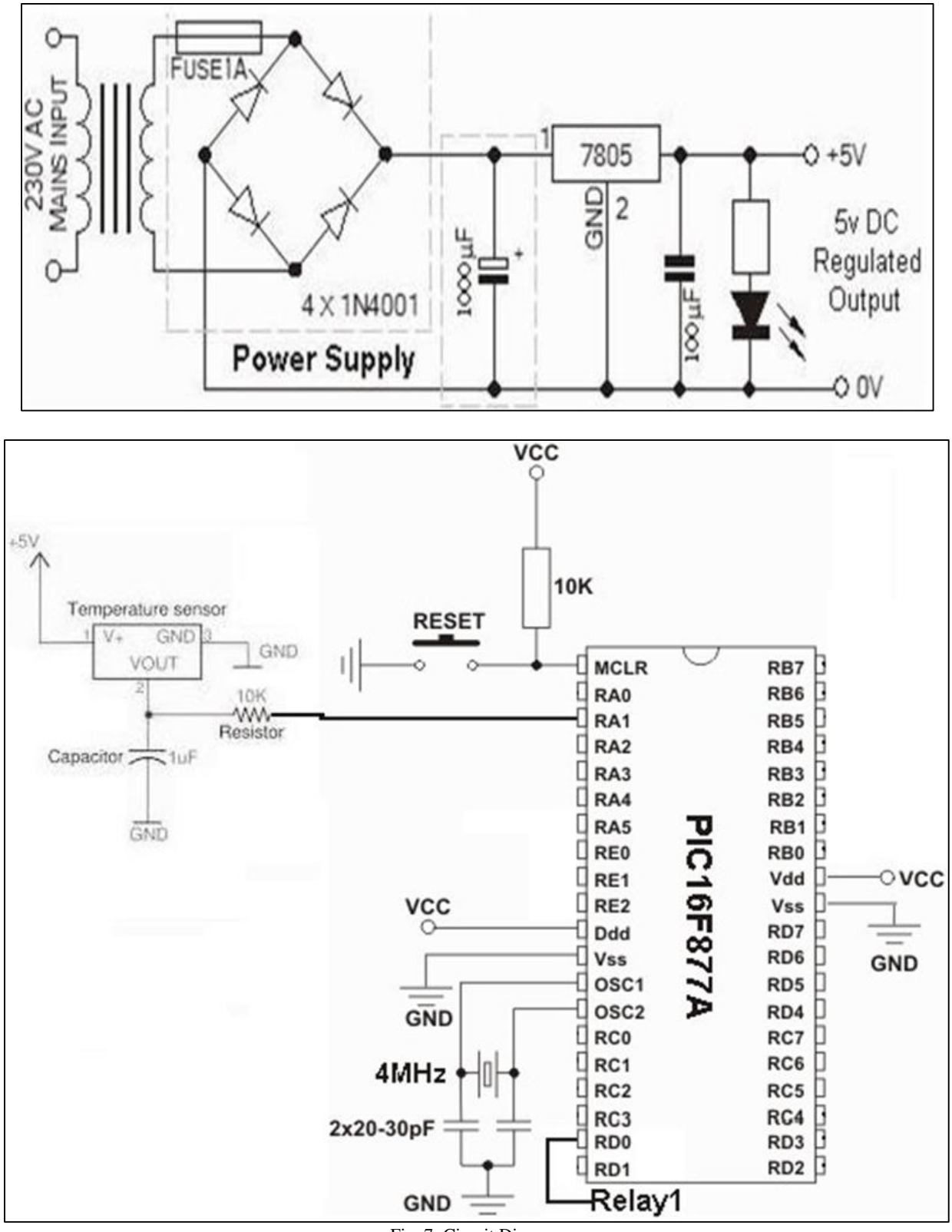


Fig. 7: Circuit Diagram

A. PIC Microcontroller

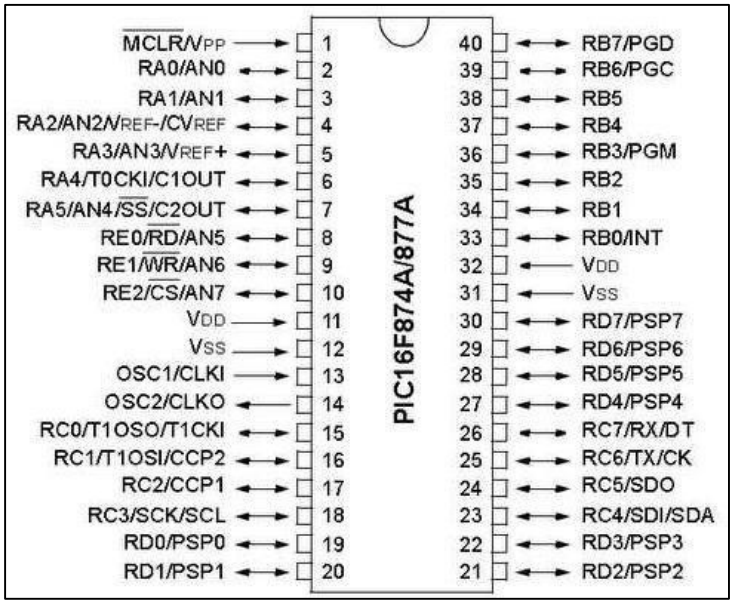
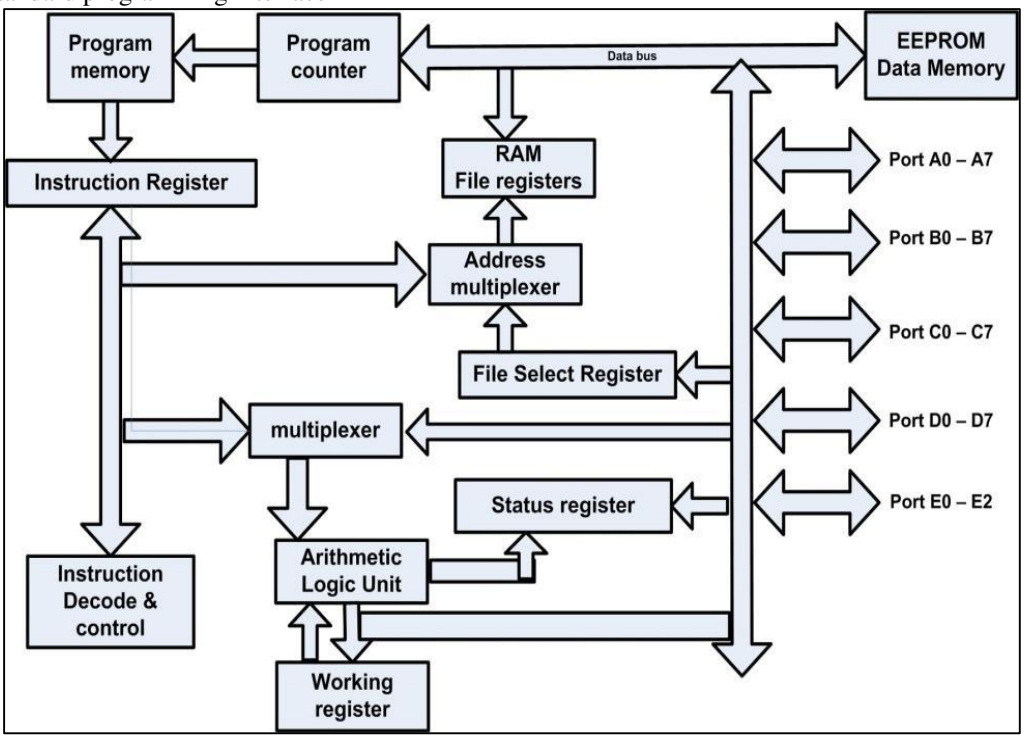


Fig. 8: Block diagram of PIC Microcontroller

The PIC Micro is one of the most popular microcontrollers and in case you were wondering the difference between a microprocessor and a microcontroller is that a microcontroller has an internal bus within built memory and peripherals.
In fact the 8 pin (DIL) version of the 12F675 has an amazing number of internal peripherals. These are:

- Two timers.
- One 10bit ADC with 4 selectable inputs.
- An internal oscillator (or you can use an external crystal).
- An analogue comparator.
- 1024 words of program memory.
- 64 Bytes of RAM.
- 128 Bytes of EEPROM memory.
- External interrupt (as well as interrupts from internal peripherals).
- External crystal can go up to 4MHz.
- ICSP: PIC standard programming interface



Microcontrollers give you a fantastic way of creating projects. A PIC microcontroller is a processor with built in memory and RAM and you can use it to control your projects (or build projects around it). So it saves you building a circuit that has separate external RAM, ROM and peripheral chips.
What this really means for you is that you have a very powerful device that has many useful built in modules e.g.

- EEPROM.
- Timers.
- Analogue comparators.
- UART

1) Frequency Counter - using the internal timers and reporting through UART (RS232) or output to LCD.
2) Capacitance Meter - analogue comparator oscillator.
3) Event Timer - using internal timers.
4) Event Data Logger -capturing analogue data using an internal ADC and using the internal EEPROM for storing data (using an external I2C for high data storage capacity.
5) Servo Controller (Control through UART) - using the internal PWM module or using a software created PWM.

B. Features

In fact a PIC microcontroller is an amazingly powerful fully featured processor with internal RAM, EEROM FLASH memory and peripherals. One of the smallest ones occupies the space of a 555 timer but has a 10bit ADC, 1k of memory, 2 timers, high current I/O ports a comparator a watch dog timer... I could go on as there is more!

C. Programming

One of the most useful features of a PIC microcontroller is that you can re-program them as they use flash memory (if you choose a part with an F in the part number e.g. 12F675 not 12C509). We can also use the ICSP serial interface built into each PIC Microcontroller for programming and even do programming while it's still plugged into the circuit.

We can program a PIC microcontroller using assembler or a high level language and I recommend using a high level language such as C as it is much easier to use (after an initial learning curve). Once you have learned the high level language you are not forced to use the same processor.

D. Input / Output - I/O

A PIC Microcontroller can control outputs and react to inputs e.g. you could drive a relay or read input buttons with the larger devices it's possible to drive LCDs or seven segment displays with very few control lines as all the work is done inside the PIC Micro Comparing a frequency counter to discrete web designs you'll find two or three chips for the microcontroller design and ten or more for a discrete design. So using those saves prototype design effort as you can use built in peripherals to take care of lots of the circuit operation. Many now have a built in ADC so you can read analogue signal levels so you don't need to add an external devices e.g. you can read an LM35 temperature sensor directly with no interface logic.

E. Peripherals

The PIC microcontroller has many built in peripherals and this can make using them quite daunting at first which is why I have made this introductory page with a summary of each major peripheral block. At the end is a short summary of the main devices used in projects shown on this site. The best way to start is to learn about the main features of a chip and then begin to use each peripheral in a project.

PIC microcontroller Feature	*PIC microcontroller feature description*
Flash memory	*Re-programmable program storage.*
RAM	*Memory storage for variables.*
EEPROM	*Long term stable memory: Electrically Erasable Programmable Read Only Memory.*
I/O ports	*High current Input/output ports (with pin direction change).*
Timers/Counters	*Typically 3.*
USART	*Built in RS232 protocol (only needs level translator chip).*
CCP	*Capture/Compare/PWM module.*
SSP	*I2C and SPI Interfaces.*
Comparator	*An analogue comparator and internal voltage reference.*
ADC	*Analogue to digital converter.*
PSP	*Parallel Slave Port (for 8 bit microprocessor systems).*
LCD	*LCD interface.*
Special features	*ICSP,WDT,BOR,POR,PWRT,OST,SLEEP*
ICSP	*Simple programming using In Circuit Serial Programming.*

F. Flash Memory

This is the program storage area and gives you the most important benefit for using a PIC microcontroller. Devices used in projects on this site can be re-programmed up to 100,000times (probably more) as they use Flash memory - these have the letter F in the part name.

G. ICSP

In Circuit Serial Programming (ICSP) is the next most important benefit. Instead of transferring your chip from the programmer to the development board you just leave it in the board. We can re-program the device while it's still in the circuit so once your programmer is setup we can leave it on the bench and test your programs without moving the chip around and it makes the whole process much easier.

H. I/O Ports

Input / Output ports let you communicate with the outside world so we can control led's, LCDs or just about anything with the right interface. We can also set them as inputs to gather information.

I. Pin Direction

Most PIC microcontroller pins can be set as an input or and output and this can be done on the fly e.g. for a dallas 1 wire system a pin can be written to generate data and read at a later stage. The TRIS register controls the I/O direction and setting a bit in this register to zero sets the pin as output while setting it as one sets the pin as input. This allows us to use a pin for multiple operations e.g. the Real Time clock project uses RA 0, the first pin of PORT A, to output data to a seven segment display and at a later point in the program read the analogue value as an input.

J. Current

The PIC I/O ports are high current ports capable of directly driving LEDs (up to 25ma output current) - the total current allowed usually ~200mA this is often for the whole chip (or specified for several ports combined together).

K. Timer / Counters

Each PIC microcontroller has up to three timers that we can either use as a timer or a counter (Timer 1 & 2) or a baud clock (Timer 2).

L. Timer 0

The original timer: Timer 0 was the first timer developed and you can find it in all the earliest devices e.g. 16F84 up to the most current e.g., 16F877A. It is an 8 bit timer with an 8 bit pre scaler that can be driven from an internal or external clock. It generates an interrupt on overflow when the count goes from 255 to zero. Timer 0 always synchronizes the input clock (when using external clock).

M. Timer 1

This is a 16 bit timer that generates an overflow interrupt when it goes from 65535 to zero. It has an 8 bit programmable pre scaler and you can drive it from the internal clock (Fosc/4) or an external pin. To eliminate false triggering it also has an optional input synchronizer for external pin input. This timer can be used in sleep mode and will generate a wakeup interrupt on overflow. Timer 1 is also read by the CCP module to capture an event time.

In addition it can be used to drive a low power watch crystal. This is something that sounds good but I don't recommend you do it as watch crystals are extremely difficult to drive correctly. You should only use it if you are going to make a pcb and follow all the guidelines in making it noise free. I used a DS1307 in the Real Time clock project which drives the crystal directly but even this is difficult to get operating accurately.

N. Timer 2

This is an 8 bit timer with an 8 bit prescaler and an 8 bit post scaler. It takes its input only from the internal oscillator. This timer is used for the time base of a PWM when PWM is active and it can be software selected by the SSP module as a baud clock. It also has a period register that allows easy control of the period. When timer 2 reaches the PR2 register value then it resets. This saves having to check the timer value in software and then reset the timer and since it is done in hardware the operation is much faster - so you can generate fast clocks with periods that are multiples of the main clocks.

O. USART

The USART is a useful module and saves having to code up a software version so it saves valuable program memory. You can find more information on RS232 here and how to make it work.

P. Baud Rates

We have to be careful using the baud rates as they depend on the main clock in use and normal oscillator values in general do not fit very well with 'real' baud rates. There is a table of baud rates in microchip data sheet DS33023A which indicates the expected percentage error for a specific clock rate and in general the higher the main clock the lower the error. We sometimes have to play around with the register settings to get a better fit with our clock rate and the baud rate we want. An example is for an 8MHz clock - if we use BRGH=1 and an 8MHz clock we get accurate baud rates up to 38.4kbaud. We have to force this to work e.g. in mikro the built in USART routines use BRGH=0 so at 8MHz the baud rate is only accurate to 9.6kbaud.If we want a super-accurate baud rate the best way is to use a clock crystal that ends up giving you that baud rate i.e. work back through the baud rate equations to find the crystal we need.

Q. CCP

The Capture/Compare/PWM module has three modes of operation:

- Capture - Capture the time of an event.
- Compare - Generate an output when Timer 1 reaches a value.
- PWM - Pulse Width Modulation

R. Capture

Capture mode is used to capture the value of Timer 1 when a signal at the CCP pin goes high (or low depending on how the CCP is set up). The CCP can accurately capture the arrival time of a signal at the CCP pin so it can be used for pulse time measurement.

S. Compare

Compare mode is used to generate an output when Timer 1 reaches a value you put into CCPR1. One special event trigger mode lets you start the ADC when the compare mode triggers.

T. PWM

PWM gives you one Pulse Width Modulation output with 10 bit resolution and with no software overhead - once started it operates all by itself unless you want to change the duty cycle. It uses Timer 2 to define its operation using Timer 2 period register to define the frequency of the PWM.

U. SSP

The comparator is module that has two analogue comparators which can be set up in one of 8 different ways. Either digital or analogue inputs can be compared to reference voltages. In one mode an internally generated voltage reference is used as an input to both comparators and in the same mode multiplexing lets you monitor up to four different input pins. We can even send the output of the comparator to a pin so that it is used independently from the microcontroller e.g. in a circuit where you need a comparator you don't need an extra chip! The analogue level must be between Vdd and Vss as protection diodes won't allow anything else. The module will generate an interrupt if the comparator output changes. We can use it in sleep mode and the interrupt will wake it up. The source impedance of the analogue signal must be smaller than 10k.

V. ADC

The single 10 bit Analogue to Digital Converter can have up to 8 inputs for a device multiplexed from input pins. The ADC can be used during sleep but you have to use the RC clock mode. One benefit of this is that there will be no digital switching noise so you will get better conversion accuracy. For the 16F877A you cannot just choose to use an analogue input if you feel the need as there are only a specific and limited number of ways that the analogue input pins can be enabled. It is best to start with AN0 and add more as necessary - see the datasheet for which analogue inputs can be enabled e.g. if you started a design using only AN5 you would find that you may have to enable a few more analogue inputs as well! The 16F675 can measure 4 analogue input pins.

W. PSP

The Parallel Slave Port lets you to connect the PIC microcontroller directly into a microprocessor system. It provides an 8 bit read/write data bus and RD (read) WR (write) and CS (chip select) inputs - all active low. This will let us add a PIC microcontroller to a system so that the PIC microcontroller can be treated as a memory mapped peripheral. It will let the microcontroller behave just as though it was another microprocessor building block e.g. some memory or ram but in this case we have full control over exactly what the building block is i.e. we can re-program the PIC microcontroller to do just about anything.

X. LCD

The LCD interface lets you directly interface to an LCD saving you having to use an LCD Module such as the HD44780. We have not used this feature as it is another commercial requirement where removing a chip (HD44780) saves money in a production run. We think it is capable of driving a graphic LCD.

Y. Special Features

ICSP	*In Circuit Serial Programming*	*(Jumps to ICSP section).*
WDT	*Watch dog timer*	*This is a software error protector.*
BOR	*Brown Out reset*	*This detects if the power supply dips slightly and resets the device if so.*
POR	*Power on reset*	*This starts Microcontroller initialization.*
PWRT	*Power up Time*	*A time delay to let Vdd rise.*
OST	*Oscillator start up timer*	*Wait for 1024 cycles after PWRT.*
SLEEP	*PIC microcontroller sleep mode*	*Enter low power mode.*

Z. WDT
If our software goes haywire then this timer resets the processor. To stop the reset the well behaved software must periodically issue the CLRWDT instruction to stop a resert. The WDT runs using its own oscillator. It runs during sleep and shares Timer 0 prescaler.

AA. POR
Power on Reset starts PIC microcontroller initialization when it detects a rising edge on MCLR.

BB. PWRT
If you enable this then 72ms after a POR the PIC microcontroller is started.

CC. OST
Oscillator Startup Timer delays for 1024 oscillator cycles after PWRT (if PWRT is enabled) ensuring that the oscillator has started and is stable. It is automatic and only used for crystal oscillator modes and is active after POR or wake from sleep.

DD. SLEEP
Sleep mode (or low power consumption mode) is entered by executing the 'SLEEP' command. The device can wake from sleep caused by an external reset, Watch Dog Timer timeout, INT pin RB port change or peripheral interrupt.

You may think that 1k or even 8k is so tiny that it won't be useful but each PIC microcontroller uses RISC (Reduced Instruction Set Computing) which simply means that it has a cleverly arranged instruction set that only has a few instructions. The mid-range parts have 35 instructions.

If you use the high level language as recommended in this site then you won't need to be too aware of the instruction set it just means you can do a lot with a small amount of memory. Most of the projects on this site although they are fully working projects fit within 2k words!

EE. PIC Microcontroller RAM and EEPROM Size
The PIC microcontroller RAM size is also important as it stores all your variables and intermediate data. For example don't use floating points alter it to use a different variable type e.g. you can use long integers with fixed point operation to avoid floating point.PIC microcontroller EEROM: Electrically Erasable ROM is used to store data that must be saved between powers up and power down. This area is readable and writable and has a much longer life than the main program store i.e. it has been designed for more frequent use.

V. WORKING

In this project "AUTOMATIC CABIN COOLING SYSTEM", three. Thermoelectric coolers operate by the Peltier effect (which also goes by the more general name thermoelectric effect). The device has two sides, and when a DC electric current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other gets hotter. The "hot" side is attached to a heat sink so that it remains at ambient temperature, while the cool side goes below room temperature. In some applications, multiple coolers can be cascaded together for lower temperature. In this project this system consists of a car setup, a radiator and a cooling fan. An effect whereby heat is given out or absorbed when an electric current passes across a junction between two materials.

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa via a thermocouple. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, heat is transferred from one side to the other, creating a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers.

The term "thermoelectric effect" encompasses three separately identified effects: the Seebeck effect, Peltier effect, and Thomson effect. The Seebeck and Peltier effects are different manifestations of the same physical process; textbooks may refer to this process as the Peltier–Seebeck effect (the separation derives from the independent discoveries by French physicist Jean Charles Athanase Peltier and Baltic German physicist Thomas Johann Seebeck). The Thomson effect is an extension of the Peltier–Seebeck model and is credited to Lord Kelvin.

Joule heating, the heat that is generated whenever a current is passed through a resistive material, is related, though it is not generally termed a thermoelectric effect. The Peltier–Seebeck and Thomson effects are thermodynamically reversible, whereas Joule heating is not.

A. Peltier Effect
The Peltier effect is the presence of heating or cooling at an electrified junction of two different conductors and is named after French physicist Jean Charles Athanase Peltier, who discovered it in 1834. When a current is made to flow through a junction between two conductors, A and B, heat may be generated or removed at the junction. The Peltier heat generated at the junction per

unit time is where πa and πb are the Peltier coefficients of conductors A and B, and I is the electric current (from A to B). The total heat generated is not determined by the Peltier effect alone, as it may also be influenced by Joule heating and thermal-gradient effects (see below).

The Peltier coefficients represent how much heat is carried per unit charge. Since charge current must be continuous across a junction, the associated heat flow will develop a discontinuity if a and πb are different. The Peltier effect can be considered as the back-action counterpart to the Seebeck effect (analogous to the back-emf in magnetic induction): if a simple thermoelectric circuit is closed, then the Seebeck effect will drive a current, which in turn (by the Peltier effect) will always transfer heat from the hot to the cold junction. The close relationship between Peltier and Seebeck effects can be seen in the direct connection between their coefficients: $\pi = TS$

A typical Peltier heat pump involves multiple junctions in series, through which a current is driven. Some of the junctions lose heat due to the Peltier effect, while others gain heat. Thermoelectric heat pumps exploit this phenomenon, as do thermoelectric cooling devices found in refrigerators.

VI. HARDWARE IMPLEMENTATION

A. Manufacturing Process

Manufacturing involves turning raw material to finished products, to be used for various purposes. There are a large number of processes available. These processes can be broadly classified into four categories.

1) Casting Processes
2) Forming Processes
3) Fabrication Processes
4) Material Removal Processes

B. Casting Processes

These processes only processes where the liquid metal is used. Casting is also the oldest known manufacturing process. Basically it consists of inducing the molten metal into a cavity of mould of the required form and allowing the metal to solidify. The object after solidification removed from the mould. Casting processes are universally used to manufacture a wide variety of products. Casting is the most flexible and cheapest method and given high strength of rigidity to the parts which are difficult to produce by other manufacturing processes. The principle process among these sand casting where sand is used as the raw material. The process is equally suitable for the production of a small batch as well as on a large scale.

C. Forming Processes

These are solid state manufacturing processes involve minimum amount of material wastage. In forming process metal may be heated to temperature which is slightly below. This solidify temperature and large force is applied such the material flows and act in desired shape. The desire shape is controlled by means of a set of tool ties and dies, which may be closed during manufacturing. These processes are normally used for large scale production rates. These are generally economical and in many cases improve the mechanical properties.

D. Fabrication Processes

These are secondary manufacturing processes where the starting raw materials are produced by any one of the previous manufacturing processes desired. Its assembly involve joining pieces either temporary or permanent. So that they would be perform the necessary function. The joining can be achieved by either or both of heat and pressure joining materials.

E. Material Removal Processes

These are also a secondary removal manufacturing process, where the additional unwanted material is removed in the form of chips from the blank material by a hard tools so as to obtain the final desired shape.

Material removal is normally a most expensive manufacturing process. Because more energy is consumed and also a lot of waste material is generated in this process. Still this process is widely used because it deliver very good dimensional accuracy and good surface finished. Material removal process are also called machining processes.

F. Welding

Welding is a process of joining two metal pieces by the application of heat. Welding is the least expensive process and widely used now a days in fabrication. Welding joints different metals with the help of a number of processes in which heat is supplied either electrically or by mean of a gas torch. Different welding processes are used in the manufacturing of Auto mobiles bodies, structural work, tanks, and general machine repair work. In the industries, welding is used in refineries and pipe line fabrication. It may be called a secondary manufacturing process.

G. Drilling

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multipoint. The bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the workpiece, cutting off chips (swarf) from the hole as it is drilled.
In rock drilling, the hole is usually not made through a circular cutting motion, though the bit is usually rotated. Instead, the hole is usually made by hammering a drill bit into the hole with quickly repeated short movements. The hammering action can be performed from outside of the hole (top- hammer drill) or within the hole (down-the-hole drill, DTH). Drills used for horizontal drilling are called drifter drills.

H. PCB Designing

1) Printed Circuit Board (PCB)

Nowadays the printed circuit board hereafter mentioned as PCB's makes the electronic circuit manufacturing as easy one. In olden days vast area was required to implement a small circuit. To connect two leads of the components, separate connectors are needed. But PCB's connect the two leads by copper coated lines on the PCB board. PCB's are available in various types' namely single sided and double sided boards. In single sided PCB's the copper layer is one side.

I. Manufacturing

The circuit is drawn on a paper and it is modified or designed to reduce the space this designed PCB layout is to be drawn on the plain copper coated board. There boards are available in 2 types.

- Phenolic
- Glass Epoxy

Most computer PCB's are glass epoxy. To draw the circuit diagrams we can use the black colour paint. Before that the required size of the plane PCB board is determined from the roughly drawn PCB layout. Using black paint the desired circuit is drawn on the board.

J. CAD in PCB

First the PCB layout is designed by CAD. The print out is taken from the computer (of large size) for out clearance. This layer is given to the photography section to get the layout in its actual size. From this we can have the positive and negative images of the layout.
This photographic image is exposed in the following three methods.

- Polybluem
- Chrombin
- Five Star

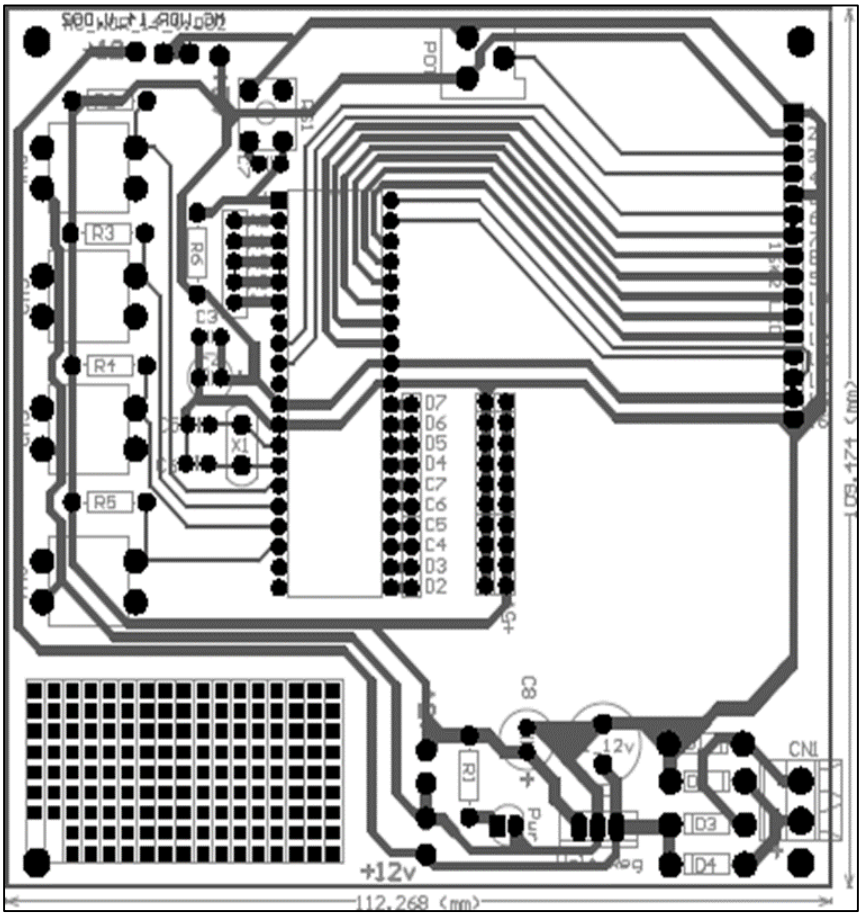
The exposed mesh is placed on plain copper coated board in correct alignment by using wooden clamps. Special paints are used to spread over the mesh. Paint flow through the board and the layout lines are made on the copper board. Finally, there are fine layouts on the copper board.

K. Etching

This can be done both by manual and mechanical ways by immersing the board in to a solution of formic chloride and hydrochloric acid and finally cleaning the board with soap.

L. Characteristics of Epoxy Resin

Term	*Definition*	*Range of Options*
Dielectric constant	*Relative capacitance to that of air vacuum or dielectric*	*3-6*
Dissipation factor	*Electrical efficiency of loss*	*0.33 to 0.03 (60 – 1000) Hz*
Dielectric strength	*Voltage that material can withstand prior to failure*	*300 – 450 V/min for 0.125 inch thickness*
Arc Resistance	*Resistance to electrical breakdown initiated by formation of conductive path or tracking*	*80 –100 sec.*
Surface resistivity	*Resistance to electric current along surface of 1 cm2 measurement*	-



M. Relay

Relays are essential for automation systems and for controlling loads. Relays are the best way for galvanic insulation between high and low voltage portions of a circuit. There are hundreds of different relay types.

N. Basic Relay Operation

1) The Contacts

Each relay has two mechanical parts inside. The first one is the contact(s) of the relay. The contacts operate similarly to the contacts of a simple switch or pushbutton.

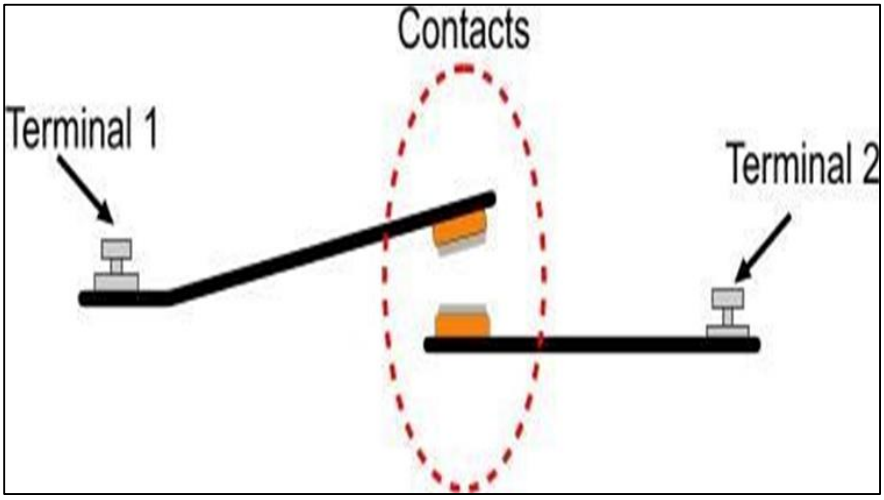


Fig. 9: Relay contacts

The two terminals operate as a switch. When the contacts are 'in contact' then the current flows from Terminal 1 to Terminal 2. There are two types of contacts: the NO and the NC. NO stands for Normal Open contact, while NC stands for Normal Closed contact. The Normal Open is a contact like the one showed in the previous illustration. When the contact is still, then no current

flows through it (because it is an OPEN circuit). On the other hand, a Normal Closed contact allows the current to flow when the contact is still. Bellow i illustrate both of these contacts:

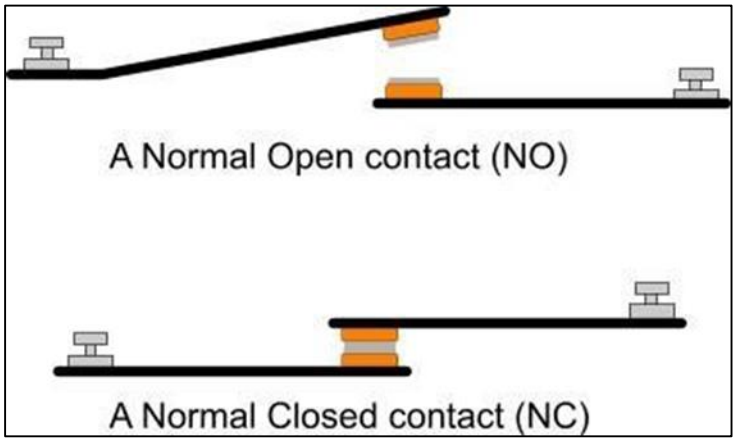


Fig. 10: Open and closed contacts of relay

It is noticed that the NC contact is turned upside-down compared to the NO contact. This is done in purpose. This way, both contacts (NO and NC) will change state if a force is applied to the left metal heading from UP to DOWN

O. OPTO Coupler

Transformers isolate the primary input voltage from the secondary output voltage using electromagnetic coupling by means of a magnetic flux circulating within the iron laminated core. But we can also provide electrical isolation between an input source and an output load using just light by using a very common and valuable electronic component called an Optocoupler.

An Optocoupler, also known as an Opto-isolator or Photo-coupler, is an electronic component that interconnects two separate electrical circuits by means of a light sensitive optical interface. The basic design of an Optocoupler consists of an LED that produces infra-red light and a semiconductor photo- sensitive device that is used to detect the emitted infra-red beam. Both the LED and photo-sensitive device are enclosed in a light-tight body or package with metal legs for the electrical connections as shown.

An optocoupler or opto-isolator consists of a light emitter, the LED and a light sensitive receiver which can be a single photo-diode, photo-transistor, photo-resistor, photo-SCR, or a photo-TRIAC and the basic operation of an optocoupler is very simple to understand.

P. Phototransistor Optocoupler

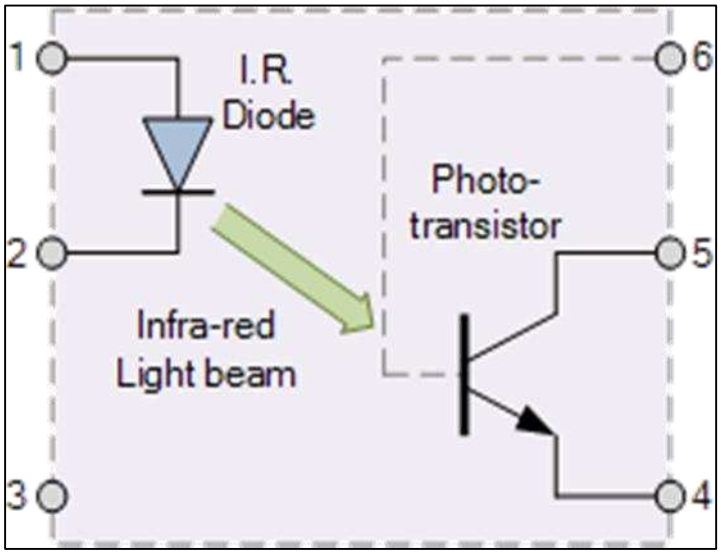


Fig. 11: Phototransistor Optocoupler

Current from the source signal passes through the input LED which emits an infra-red light whose intensity is proportional to the electrical signal. This emitted light falls upon the base of the photo-transistor, causing it to switch-ON and conduct in a similar way to a normal bipolar transistor. The base connection of the photo-transistor can be left open for maximum sensitivity or connected to ground via a suitable external resistor to control the switching sensitivity making it more stable.

When the current flowing through the LED is interrupted, the infra-red emitted light is cut-off, causing the photo-transistor to cease conducting. The photo-transistor can be used to switch current in the output circuit. The spectral response of the LED and the photo-sensitive device are closely matched being separated by a transparent medium such as glass, plastic or air. Since there is no direct electrical connection between the input and output of an optocoupler, electrical isolation up to 10kV is achieved.

Optocouplers are available in four general types, each one having an infra-red LED source but with different photo-sensitive devices. The four optocouplers are called the: Photo-transistor, Photo- darlington, Photo-SCR and Photo-triac as shown below.

Q. Optocoupler Types

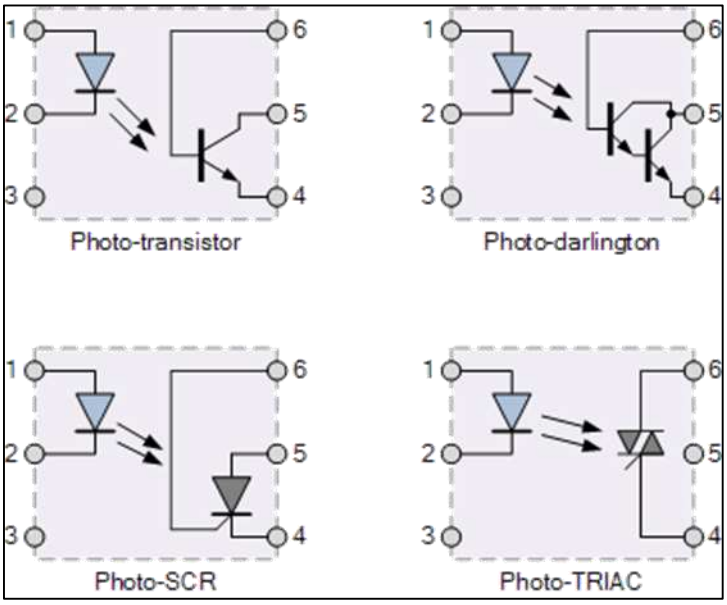


Fig. 12: Types of optocoupler

The photo-transistor and photo-darlington devices are mainly for use in DC circuits while the photo-SCR and photo-triac allow AC powered circuits to be controlled. There are many other kinds of source-sensor combinations, such as LED-photodiode, LED-LASER, lamp-photoresistor pairs, reflective and slotted optocouplers.

Simple homemade optocouplers can be constructed by using individual components. A Led and a photo-transistor are inserted into a rigid plastic tube or encased in heat-shrinkable tubing as shown. The advantage of this home-made optocoupler is that tubing can be cut to any length you want and even bent around corners. Obviously, tubing with a reflective inner would be more efficient than dark black tubing.

R. Optocoupler Applications

Optocouplers and opto-isolators can be used on their own, or to switch a range of other larger electronic devices such as transistors and triacs providing the required electrical isolation between a lower voltage control signal and the higher voltage or current output signal. Common applications for optocouplers include microprocessor input/output switching, DC and AC power control, PC communications, signal isolation and power supply regulation which suffer from current ground loops, etc. The electrical signal being transmitted can be either analogue (linear) or digital (pulses).

In this application, the optocoupler is used to detect the operation of the switch or another type of digital input signal. This is useful if the switch or signal being detected is within an electrically noisy environment. The output can be used to operate an external circuit, light or as an input to a PC or microprocessor.

VII. ADVANTAGES AND DISADVANTAGES

1) Advantages

- Simple in construction.
- Easy to fabricate.
- Low cost.
- Improved efficiency.
- Low fuel consumption.

2) Disadvantages

- Low performance compared to other refrigeration systems like vapour absorption.

- Heat is dissipated to environment.

VIII. APPLICATIONS

- Used to refrigerate beverages,
- Domestic Use,
- Small Scale Industries.

IX. CONCLUSION

A strong multidiscipline team with a good engineering base is necessary for the Development and refinement of advanced computer programming, editing techniques, diagnostic Software, algorithms for the dynamic exchange of informational different levels of hierarchy.

This project work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work.

We are proud that we have completed the work with the limited time successfully. The "SOLAR POWERED AUTOMATIC CABIN COOLING SYSTEM" is working with satisfactory conditions. We are able to understand the difficulties in maintaining the tolerances and also quality.

We have done to our ability and skill making maximum use of available facilities. In conclusion remarks of our project work. Thus we have developed a "SOLAR POWERED AUTOMATIC CABIN COOLING SYSTEM". By using more techniques, they can be modified and developed according to the applications.

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