Solid State Room Heater that Generates Electric Energy

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***Abstract—* In winter, especially in chilled cities like Shimla & Kashmir, room heaters are essential and these devices equipped with hot air blowers, entire room temperature will be raised to a certain level depending up on the heater and blower capacity. Construction of hot air blower is very simple, but producing electric energy from the room heater is the new technology. Here, the heat produced by the hot air blower is also used to generate electric energy through the Thermo-Electric-Generators (TEG). The main purpose of this system is, without any additional power source, using the same heat produced by the hot air blower to warm-up the room, another important talented feature of generating electric energy is created by which the required light source for the room will be created without additional power source. Means the waste heat produced by the body of room heater can be converted in to electric energy.**

***Index Terms—* Conversion, Electric Energy, Hot Air Blowers, Light Source, Room Heaters, Thermo-Electric-Generators (TEG), Waste Heat, Warm-up**

I. INTRODUCTION

The proposed project work is aimed to generate electric energy through waste heat produced by the room heater box. Often room heater boxes are made with metal and hot air blower or heating element will be arranged inside the box to deliver the hot air in to the cold room. In this process, the metal box will be heated and the heat produced by the box can be converted in to electric energy using TEG modules. Heat energy to Electric Energy or waste heat from the room heater is the process of generating electricity. An electric heater is an electrical device that converts an electric current in to heat. The heating element inside heater is an electrical resistor and an electric current passing through a resistor will convert electrical energy in to heat energy. Now some of the heat will be wasted because the metal box absorbs the heat and this waste heat will be converted in to electric energy using thermo electric generators attached to the metal body.
The main intention of this project work is to learn the subject of thermo electric devices, what are the devices and how they work is the main motto of this project work. A Thermoelectric generator or TEG is a solid-state device that converts heat directly into electrical energy, this device contains a circuit containing of thermoelectric materials that generate electricity from heat directly. A thermoelectric module consists of two dissimilar thermoelectric materials joining in their ends to generate DC which will flow in the circuit when there is a temperature difference between the two materials. Now the portable power generating mechanism is constructed in such a way so that it maintains temperature differences between hot and cold body temperatures of the TEG modules, as the difference is more, more electricity will be produced. To prove the concept practically, here with the help of a room heater, TEG modules are heated by attaching its hot body to the room heater body aside from where hot air is delivered through vent. The colder side bodies are cooled with heat sink mechanism, here rectangular type of aluminium pipe which is filled with water is used and it is attached over the colder bodies of TEG modules.

As each TEG module generates very less voltage, here 4 such devices are used and are connected in series to boost the voltage to around 6 to 8v. This voltage is sufficient to glow a bunch of around 15 to 20 high-glow LED's. if required, this voltage can be used to charge the cell phone also. Since it is a prototype model, small size TEG devices are used, but for real time applications, big size higher rating devices can be used to generate more electric energy which can be used to charge a high-power rechargeable battery and this stored energy can be used for many applications.
This kind of system can be used for waste dump yards where debris is burned through a large metal furnace. By which a waste-to-energy plant is a waste management facility that combusts wastes to produce electricity. This type of power plant is sometimes called a trash-to-energy, municipal waste burning, energy recovery, or resource recovery plant. Modern

waste-to-energy plants are very different from the trash incinerators (an apparatus for burning the waste) that were commonly used until a few decades ago. In olden days, steam turbines are energized by burning the waste in waste yards, but this very painful activity, lot of maintenance is required every day. But the one which is designed here is maintenance free. The above said design can be can be altered for some other useful applications, for example; if the top of the room heater is modified using stove-top mechanisms, cooking activities can be carried out in addition to producing hot air and producing electricity.

Now coming to the project work, the main function of the system is to generate electricity by producing hot air. For demo purpose, one small metal rectangular type of box will be constructed using mild-steel metal plates. At one side of the box, 4 TEG modules are used and are attached to the hot body of box to generate DC voltage. Since it is a prototype module, only 4 TEG modules are used to prove the basic concept, but for real time applications, huge quantity of such modules can be used to generate huge amount of power. As these TEG modules are attached to the hot body at one side, heat energy will be converted in to electric energy. The energy produced here can be utilized to energize the mini-LED light.

The TEG modules used here are some sort of commercial devices which are used for demo purpose, they cannot be used for real time applications and hence it is recommended not to heat these devices continuously. In our trail runs we found that these 4 devices together connected in series can generate nearly 6 to 8V DC at 200 to 250 milliamps current. This power is obtained when the box temperature was nearly 70^0 C. Since the TEG modules are costliest devices, it is recommended not to burn heavily and continuously. The detailed description of these devices is provided in following chapters.

Now coming to the electronic part of the project work, here the system is designed to display the important parameter value of hot box temperature. Means when the hot air blower is energized how much voltage it is generating at what temperature. This data acquired from the hot box through sensor is converted in to digital through internal ADC of processing unit. The processing unit constructed with PIC16F676 which is having built-in-with ADC and it is programmed to display the temperature value in degree centigrade through an LCD.

The temperature measuring cum display unit is constructed with PIC series microcontroller chip, for this purpose PIC16F676 is used. This is a 14 pin IC and it is built with internal ADC such that additional A to D converter is not required for converting the analog data generated by the temperature sensor. The temperature sensor used here is LM 35 which is intended to measure and display the hot body temperature of hot air blower box. This chip is programmed to display the temperature value in digital through LCD interfaced with PIC controller.

PIC (usually pronounced as *"pick"*) is a family of microcontrollers made by Microchip technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to Peripheral Interface Controller, and then it was corrected as Programmable Intelligent Computer. The first parts of the family were available in 1976; by 2013 the company had shipped more than twelve billion individual parts, used in a wide variety of embedded systems.

Early models of PIC had read-only memory (ROM) or field-programmable EPROM for program storage, some with provision for erasing memory. All current models use flash memory for program storage, and newer models allow the PIC to reprogram itself. Program memory and data memory are separated. Data memory is 8-bit, 16-bit, and, in latest models, 32-bit wide. Program instructions vary in bit-count by family of PIC, and may be 12, 14, 16, or 24 bits long. The instruction set also varies by model, with more powerful chips adding instructions for digital signal processing functions. The following is the general and brief introduction of microcontroller chips.

Microcontrollers are increasingly being used to implement instrumentation system. It is therefore important to understand Microcontroller based systems well. Today, microcontrollers have become an integral part of all measuring instruments. Dedicated system that use microcontrollers, have certainly improved the functional, operational and performance based specifications. The architectural changes in instrumentation and control systems where and are due to the computing and communication capability of the Micro controller devices. Micro controller must be treated as a tool for computing and communication; Knowledge of microcontrollers is meaning full and very rewarding if it is applied to design a product that is useful in the industry or for the society in general. This is a subject, which has direct relevance to industrial product development and automation. In this project work, microcontroller chip is programmed to display the hot body temperature in degrees centigrade.

Any Micro-controller, that functions according to the program written in it. Here the program is prepared in such a way, so that the system performs the function of displaying the cold body temperature of TEC module. The program is nothing but an instruction set, this is often prepared in binary code, & are referred as machine code, there by this software is called as machine language. Writing a program in such a code is a skilled and very tedious process. It is prone to errors because the program is just a series of 0's and 1's and the instructions are not easily comprehended from just looking at the pattern. An alternative is to use an easily comprehended form of shorthand code for the patterns 0's and 1's. Micro controller can read and it can store the information received from the remote-control unit. Micro-controllers are dedicated to one task and run one specific program. The program is stored in ROM (read-only memory) and generally does not change. If there are any modifications in the function, or errors in the software, the existing program must be erased from the chip & again modified program must be loaded in the chip through chip burner.

II. FUNCTIONAL DESCRIPTION OF CIRCUIT

Regarding temperature monitoring cum display unit, the process starts with the temperature sensor. For this purpose LM35 is used and it is attached to the hot body of room heater box by which temperature can be measured and displayed accurately. The output of the sensor is fed to the PIC controller chip, as this chip is having built-in-with ADC, the analog data generated by the sensor will be converted in to digital internally. Based on this digital value, the controller chip is programmed to read and display the temperature value in degree centigrade. LCD is used to display the temperature value in digital.

A. Temperature sensor

The most frequently measured environmental quantity is "Temperature" This might be expected since most of the systems are affected by temperature like physical, chemical, electronic, mechanical, and biological systems. Certain chemical effects, biological processes, and even electronic circuits execute best in limited temperature ranges. Temperature is one of the most frequently calculated variables and sensing can be made either through straight contact with the heating basis or remotely, without straight contact with the basis using radiated energy in its place. There is an ample variety of temperature sensor on the market today, including Thermocouples, Resistance Temperature Detectors (RTDs), Thermistors, Infrared, and Semiconductor Sensors.

Usually, a temperature sensor is a thermocouple or a resistance temperature detector (RTD) that gathers the temperature from a specific source and alters the collected information into understandable type for an apparatus or an observer. Temperature sensors are used in several applications. Here in this project work LM35 is used.

LM35 is an analog, linear temperature sensor whose output voltage varies linearly with change in temperature. LM35 is three terminal linear temperature sensors from National semiconductors. It can measure temperature from*-55* degree Celsius *to* +150 degree Celsius. The voltage output of the LM35 increases 10mV per degree Celsius rise in temperature. LM35 can be operated from a 5V supply and the stand by current is less than 60uA. LM35 is an integrated analog temperature sensor whose electrical output is proportional to Degree Centigrade. LM35 Sensor does not require any external calibration or trimming to provide typical accuracies. The LM35 temperature sensor can be used to detect precise centigrade temperature. The output of this sensor changes describes the linearity. The o/p voltage of this IC sensor is linearly comparative to the Celsius temperature

LM35 is an analog temperature sensor. This means the output of LM35 is an analog signal. Microcontrollers don't accept analog signals as their input directly. We need to convert this analog output signal to digital before we can feed it to a microcontroller's input. For this purpose, here PIC controller is used which is having built in with ADC (Analog to Digital Converter). Modern day boards like Arduino and most modern day micro controllers come with inbuilt ADC.

B. A to D Converter

A-D converters are among the most widely used devices for data acquisition. Computers use binary (discrete) values, but in the physical world everything is analog (continuous). The most important parameter of an ADC is resolution. The higher resolution ADC provides a smaller step size, where step size is the smallest change that can be discerned by an ADC. In addition to resolution, conversion time is another major factor in judging an ADC. Conversion time is defined as the time it the ADC to convert the analog input to a digital number.

The ADC chips are either parallel or serial ADC. In parallel ADC, we have 8 or more pins dedicated to bringing out the binary data, but in serial ADC we have only one pin for data out. Here the controller used to display the temperature is having built in with ADC and there by the data delivered through A to D converter is directly fed to the controller internally. Based on this data, the PIC 16F676 microcontroller chip displays the temperature through LCD.

As the peripheral signals usually are substantially different from the ones that micro-controller can understand (zero and one), they have to be converted into a pattern which can be comprehended by a micro-controller. This task is performed by a block for analog to digital conversion or by an ADC. This block is responsible for converting an information about some analog value to a binary number and for follow it through to a CPU block so that CPU block can further process it.

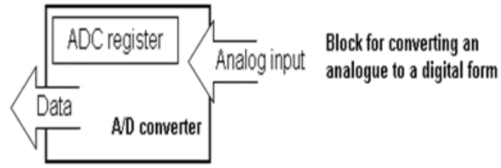

Fig 1. Block For Converting an Analogue to A Digital Form

This analog to digital converter (ADC) converts a continuous analog input signal, into an n-bit binary number, which is easily acceptable to a computer. As the input increases from zero to full scale, the output code stair steps. The width of an ideal step represents the size of the least significant Bit (LSB) of the converter and corresponds to an input voltage of $VES/2^n$ for an n-bit converter. Obviously for an input voltage range of one LSB, the output code is constant. For a given output code, the input voltage can be anywhere within a one LSB quantization interval.

An actual converter has integral linearity and differential linearity errors. Differential linearity error is the difference between the actual code-step width and one LSB. Integral linearity error is a measure of the deviation of the code transition points from the fitted line.

A good converter will have less than 0.5 LSB linearity error and no missing codes over its full temperature range. In the basic conversion scheme of ADC, the un-known input voltage VX is connected to one input of an analog signal comparator, and a time dependant reference voltage VR is connected to the other input of the comparator.

Most of the real world physical quantities such as temperature, voltage, current, pressure etc., are available in analog form and the microcontroller will not accept this analog information, therefore it is very much essential that this analog information should be converted into digital information. At such condition this A/D converter places a major role between the controller and the analog circuit. The most commonly used ADC's are successive approximation and the integrator type. The successive approximation ADC's are used in applications such as data loggers and instrumentation where conversion speed is important.

For ADC to start converting the data after selecting the channel by sending the address inputs, the start conversion signal is to be sent by Micro-controller. Then ADC starts converting the analog signals voltage into corresponding digital data.

Table I. The Digital Data Corresponding to Analog Input.

Voltage INPUT	D7	D6	D5	D4	D3	D2	D1	D0
0V	0	0	0	0	0	0	0	0
1.25V	0	1	0	0	0	0	0	0
2.5V	1	0	0	0	0	0	0	0
3.75V	1	1	0	0	0	0	0	0
5V	1	1	1	1	1	1	1	1

C. Display section

For displaying the temperature data in digital, here LCD is used and it is interfaced with PIC16F676 microcontroller at its output port. This is a 16 character x 2Line LCD module, capable of display numbers, characters, and graphics. The display contains two internal byte-wide registers, one for commands (RS=0) and the second for characters to be displayed (RS=1). It also contains a user. Programmed RAM area (the character RAM) can be programmed to generate any desired character that can be formed using a dot matrix. To distinguish between these two data areas, the hex command byte 80 will be used to signify that the display RAM address 00h is chosen.

This LCD contains 16 pins of which 8 are data pins and 3 are control pins. The following figure shows how the display unit is interfaced to the Microcontroller.

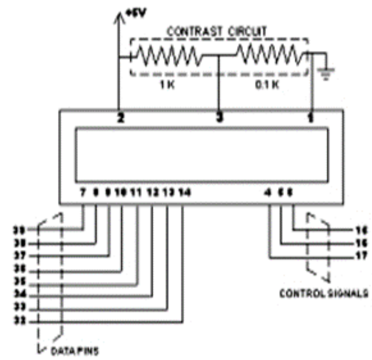

Fig 2. Display Unit Is Interfaced to The Microcontroller

As seen from the above figure, Pins from 7 to 14 are data pins used for the selection of a particular character and pins 4 to 6 are Control signal pins used for performing Register bank selection, Read / Write and Enable pins respectively. By adjusting the voltage at pin number 3 we can change the contrast of the display.

To display a particular character its associated logic sequence has to be placed on the data pins and write signal (Pin-6) has to be enabled. Microcontroller takes care of all these things based on the program loaded into it. As this display is used in the receiving end, Microcontroller places the logic sequence on the data pins based on the information obtained from the decoder output. The detailed description of the LCD panels and how it is interfaced with controller is explained in separate chapter.

D. Function of TEG Modules

Thermo-Electric Generator (TEG) 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 materials show the thermo electric effect in a strong or convenient form. The thermoelectric effect refers to phenomena by which either a temperature difference creates an electric potential or an electric potential creates a temperature difference. 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.

The array of TEG modules attached to the hot body of the mechanism is designed to deliver a maximum voltage of around 9v at no load condition, when the output is connected to the load, the voltage may fall down according to the power consumption of the load. Here the power produced by the mechanism is used to energize the LED light. As per the ratings specified by the device manufacturer, each TEG module is supposed to generate greater than 0.3amps at 4v, so all 4 devices together should able to generate 16v at 0.3amps current, but practically it is not proven may be due to the poor quality of the devices or due to the poor quality of the heat sink mechanism. The Led lighting system designed here is having 15 high glow LED's, each LED consumes nearly 15 milliamps current such that all LED's together consumes 225milliamps current. When this lighting load is connected to the array of TEG power source, and when the devices are heated at 100^0 C, it is observed that the voltage is fallen by 6V.

As described above, the output of the power source is not stable, it varies based on many factors, the first reason is that at what degrees the TEG module is heated, the second and most important reason is that weather the temperature difference between hot and cold bodies of the TEG modules are maintained or not. Power source is depended based on these two reasons, if the temperature difference is maintained properly and modules hot bodies are heated at specified ratings, than maximum output can be obtained from the power source.

E. Design of LED light

As described above, the LED light is constructed with 15 high glows Led's and each led is having a current limiting resistor connected in series with the Led. A current limiting resistor is a resistor that is used to reduce the current that is passed through the junction of LED. In order to determine the value of current limiting resistor, we need to know three values, i.e.

I = LED forward current in amps
Vf = LED forward voltage drop in volts
Vs = Supply voltage

According to the data sheet of LED, I = 15 milliamps. I,e, 0.015A. Vf = 1.5V, means drop across the diode junction will be 1.5V. Vs = 6V, this is the approximate value getting from the power source. Now these are the three known values and the following is the equation to determine the value of current limiting resistor.

R = Vs – Vf / I, according to this formula, the value of the current limiting resistor must be 300 ohms. If the source voltage reduces, value of the resistor also will be reduced accordingly.

Another important task is to find out the power rating of the resistor which will be measured in wattage. Depending up on power consumption of the LED or a bunch of LED's connected in parallel, as the current consumption increases, power rating of the resistor also increases. The purpose of the resistor is to limit the current by which voltage will be dropped across the terminals of the resistor. The equation for the power is P = I V

F. Description About Room Heaters

With temperatures dipping below 10 degrees on a regular basis in some parts of the country, and cold winds only making things worse, winter can become harsh for a lot of people. Irrespective of the number of layers you are wearing, staying warm can become difficult. To remedy this situation, the most apt solution is to get an electric room heater. But how exactly do you pick one that's right for you? Let's look at the factors involved while purchasing an electric heater, so that you can also make an informed choice!

III. TYPES OF ELECTRIC ROOM HEATER

Let's talk about the top four types of electric heaters in brief to obtain an idea about what these are.

A. Fan-Forced Room Heaters – They are a type of convection heaters that include an electric fan to pass air over a heat source. The biggest advantage of this type of room heater is that they are extremely portable and budget-friendly.

B. Radiant Heaters – They use a heating element usually enclosed behind glass resembling a light bulb. They evenly warm the room and are perfect for spot heating as it directly warms the body. Using the principle of radiation to heat the room, these are also noiseless.

C. Convection Heaters – In this type of heater, the heating element directly warms the air in contact by thermal conduction. This makes them perfect for small closed areas.

D. Oil-Filled Heater – In this type, the heating element is a sealed oil reservoir. It warms up which then releases heat into the room. They are considered to be energy efficient as well as perfect for providing consistent levels of heat over a longer period of time

IV. DESCRIPTION ABOUT TEG MODULES

Thermoelectric generators are devices that convert temperature differences into electrical energy, using a phenomenon called the "Seebeck effect". Their typical efficiencies are different depending up on the quality and ratings. These are solid-state devices, and have no moving parts.

The Seebeck Effect in TEGs; The Seebeck effect involves a temperature differential across the module by heating one side of the module and cooling the opposite. A Seebeck Module is a thermoelectric generator TEG and a Peltier Module is a thermoelectric cooling module TEC. Since we regret TEC technology here, it is concentrated about TEG technology only. To produce meaningful electric power from TEG we need to expose the hot side to temperatures well above 150°C range. As the heat transfers from the hot body to cold body, if proper technology is not implanted to maintain the cold side to remove heat and maintain temperatures, we will not get effective output from the TEG module.

Thermoelectric Generators and Temperature Differentials

Thermoelectric Generators work on temperature differentials. The greater the temperature delta of the hot side compared to the cold side, the greater the amount of power will be produced.

Two critical factors control Thermoelectric TEG power output

a. Temperature Delta: the temperature of the hot side less temperature of the cold side.

b. The quantity of heat that can be moved through the module.

Great effort must be placed on both the heat input design and especially the heat removal design. The better the TEG Generator construction is at moving heat from the hot side to the cold side and dissipating that heat once it arrives to the cold side, the more power will be generated. Thermoelectric Seebeck Effect modules are designed for very high power densities, if a high quality device is used, as in the case of photovoltaic module, when compared with the space occupied by a panel, more electric energy can be acquired from the TEG module. Thermoelectric Generators using cooling liquid technology at colder body creates huge temperature differences and performs better than any other method of green energy sources.

Thermoelectric materials

Thermoelectric materials generate power directly from heat by converting temperature differences into electric voltage. These materials must have both high electrical conductivity (σ) and low thermal conductivity (κ) to be good thermoelectric materials. Having low thermal conductivity ensures that when one side is made hot, the other side stays cold, which helps to generate a large voltage while in a temperature gradient. The measure of the magnitude of electrons flow in response to a temperature difference across that material is given by the Seebeck coefficient (S). The efficiency of a given material to produce a thermoelectric power is governed by its “figure of merit” $zT = S^2\sigma T/\kappa$.

For many years, the main three semiconductors known to have both low thermal conductivity and high power factor were bismuth telluride (Bi_2Te_3), lead telluride (PbTe), and silicon germanium (SiGe). These materials have very rare elements which make them very expensive compounds.

Today, the thermal conductivity of semiconductors can be lowered without affecting their high electrical properties using nanotechnology. This can be achieved by creating nano-scale features such as particles, wires or interfaces in bulk semiconductor materials. However, the manufacturing process of nano-materials is still challenging.

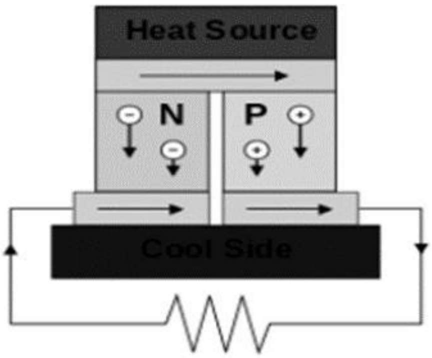

Fig 3. A thermoelectric circuit composed of materials of different Seebeck coefficient (p-doped and n-doped semiconductors), configured as a thermoelectric generator.

Thermoelectric module

A thermoelectric module is a circuit containing thermoelectric materials that generate electricity from heat directly. A thermoelectric module consists of two dissimilar thermoelectric materials joining in their ends: an n-type (negatively charged); and a p-type (positively charged) semiconductors. A direct electric current will flow in the circuit when there is a temperature difference between the two materials. Generally, the current magnitude has a proportional relationship with the temperature difference. (i.e., the more the temperature difference, the higher the current.)

Thermoelectric system:

Using thermoelectric modules, a thermoelectric system generates power by taking in heat from a source such as a hot exhaust flue. In order to do that, the system needs a large temperature gradient, which is not easy in real-world applications. The cold side must be cooled by air or water. Heat exchangers are used on both sides of the modules to supply this heating and cooling.

There are many challenges in designing a reliable TEG system that operates at high temperatures. Achieving high efficiency in the system requires extensive engineering design in order to balance between the heat flow through the modules and maximizing the temperature gradient across them. To do this, designing heat exchanger technologies in the system is one of the most important aspects of TEG engineering. In addition, the system requires minimizing the thermal losses due to the interfaces between materials at several places. Another challenging constraint is avoiding large pressure drops between the heating and cooling sources.

After the DC power from the TE modules passes through an inverter, the TEG produces AC power, which in turn, requires an integrated power electronics system to deliver it to the customer.

A. Materials for TEG

Only a few known materials to date are identified as the electric materials. Most thermoelectric materials today have a ZT, the figure of merit, value of around unity, such as in Bismuth Telluride (Bi_2Te_3) at room temperature and lead telluride (PbTe) at 500-700K. However, in order to be competitive with other power generation systems, TEG materials should have zT of 2-3 range. Most research in thermoelectric materials has focused on increasing the Seebeck coefficient (S) and reducing the thermal conductivity, especially by manipulating the nanostructure of the thermoelectric materials. Because the thermal and electrical conductivity correlate with the charge carriers, new means must be introduced in order to conciliate the contradiction between high electrical conductivity and low thermal conductivity as indicated.

When selecting materials for thermoelectric generation, a number of other factors need to be considered. During operation, ideally the thermoelectric generator has a large temperature gradient across it. Thermal expansion will then introduce stress in the device which may cause fracture of the thermoelectric legs, or separation from the coupling material. The mechanical properties of the materials must be considered and the coefficient of thermal expansion of the n and p-type material must be matched reasonably well. In segmented thermoelectric generators, the material's compatibility must also be considered. A material's compatibility factor is defined as when the compatibility factor from one segment to the next differs by more than a factor of about two, the device will not operate efficiently. The material parameters determining s (as well as zT) are temperature dependent, so the compatibility factor may change from the hot side to the cold side of the device, even in one segment. This behaviour is referred to as self-compatibility and may become important in devices design for low temperature operation. In general, thermoelectric materials can be categorized into conventional and new materials

B. Conventional materials

There are many TEG materials that are employed in commercial applications today. These materials can be divided into three groups based on the temperature range of operation

a. Low temperature materials (up to around 450K): Alloys based on Bismuth (Bi) in combinations with Antimony (Sb), Tellurium (Te) or Selenium (Se).

b. Intermediate temperature (up to 850K): such as materials based on alloys of Lead (Pb)

c. Highest temperatures material (up to 1300K): materials fabricated from silicon germanium (SiGe) alloys.

Although these materials still remain the cornerstone for commercial and practical applications in thermoelectric power generation, significant advances have been made in synthesizing new materials and fabricating material structures with improved thermoelectric performance. Recent research have focused on improving the material's figure-of-merit (zT), and hence the conversion efficiency, by reducing the lattice thermal conductivity.

C. New materials

Researchers are trying to develop new thermoelectric materials for power generation by improving the figure-of-merit zT. One example of these materials is the semiconductor compound ß-Zn_4Sb_3, which possesses an exceptionally low thermal conductivity and exhibits a maximum zT of 1.3 at a temperature of 670K. This material is also relatively inexpensive and stable up to this temperature in a vacuum, and can be a good alternative in the temperature range between materials based on Bi_2Te_3 and PbTe.

Beside improving the figure-of-merit, there is increasing focus to develop new materials by increasing the electrical power output, decreasing cost and developing environmentally friendly materials. For example, when the fuel cost is low or almost free, such as in waste heat recovery, then the cost per watt is only determined by the power per unit area and the operating period. As a result, it has initiated a search for materials with high power output rather than conversion efficiency. For example, the rare earth compounds $YbAl_3$ has a low figure-of-merit, but it has a power output of at least double that of any other material, and can operate over the temperature range of a waste heat source.

Novel Processing

In order to increase the figure of merit (zT), a material's thermal conductivity should be minimized while its electrical conductivity and Seebeck coefficient is maximized. In most cases, methods to increase or decrease one property result in the same effect on other properties due to their interdependence. A novel processing technique exploits the scattering of different phonon frequencies to selectively reduce lattice thermal conductivity without the typical negative effects on electrical conductivity from the simultaneous increased scattering of electrons. In a bismuth antimony tellurium ternary system, liquid-phase sintering is used to produce low-energy semi coherent grain boundaries, which do not have a significant scattering effect on electrons. The breakthrough is then applying a pressure to the liquid in the sintering process, which creates a transient flow of the Te rich liquid and facilitates the formation of dislocations that greatly reduce the lattice conductivity.

Efficiency: The typical efficiency of TEGs is around 5–8%. Older devices used bimetallic junctions and were bulky. More recent devices use highly doped semiconductors made from bismuth telluride (Bi_2Te_3), lead telluride (PbTe), calcium manganese oxide ($Ca_2Mn_3O_8$), or combinations thereof, depending on temperature. These are solid-state devices and unlike dynamos have no moving parts, with the occasional exception of a fan or pump. For a discussion of the factors determining and limiting efficiency, and ongoing efforts to improve the efficiency, see the article Thermo-electric materials Device efficiency.

V. LCD Description

LCD Displays are dominating LED displays, because these displays can display alphabets, numbers and some kind of special symbols, where as LED's (seven segment display) can display only numbers. These LCD displays are very useful for displaying user information and communication. LCD displays are available in various formats. Most common are 2 x 16, is that two lines with 16 alphanumeric characters. Other formats are 3x16, 2x40, 3x40 etc.

In recent years LCD is finding widespread use replacing LED's, because of the ability to display

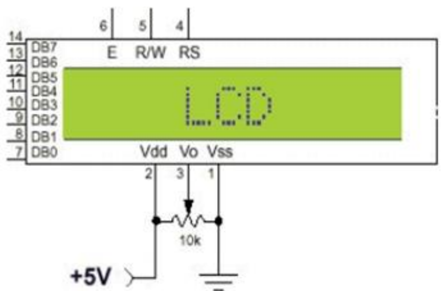

Fig 4. LCD Panel

numbers, characters, and graphics. Another advantage is, because of its compactness and ease of programming for characters and graphics, more information in the form of text message or graphics can be displayed. Generally, the LCD modules have an 8-bit interface, besides the 8-bit data bus; the interface has a few other control lines. The 8-bit data bus is connected to port '0' and the control lines are connected to port '2'. The default data transfer between the LCD module and an external device is 8-bits, however it is possible to communicate with the LCD module using only four of the 8-data lines. The R/W line is connected to ground and hence the processor cannot read any status information from the LCD module, but can only write data to the LCD

Vcc, Vss, and VEE: While Vcc and Vss provide +5V and ground, respectively; VEE is used for controlling LCD contrast.

RS - register select: There are two very important registers inside the LCD. The RS pin is used for their selection as follows. If RS = 0, the instruction command code register is selected, allowing the user to send a command such as clear display, cursor at home, etc. If RS = 1 the data register is selected allowing the user to send data to be displayed on the LCD.

R/W - read/write: R/W input allows the user to write information to the LCD or read information from it. R/W = 1 when reading; R/W =0 when writing.

D0 – D7: The 8 bit data pins, D0 – D7, are used to send information to the LCD or read the contents of the LCD's internal registers. To display letters and numbers, we send ASCII codes for the letters A – Z, a – z, and numbers 0 – 9 to these pins while making RS = 1. There are also instructions command codes that can be sent to the LCD to clear the display or force the cursor to the home position or blink the cursor.

VI. DESCRIPTION ABOUT TEMPERATURE SENSOR

In general, a temperature sensor is a device which is designed specifically to measure the hotness or coldness of an object. LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). With LM35, the temperature can be measured more accurately than with a thermistor. It also possesses low self-heating and does not cause more than 0.1 °C temperature rise in still air. The operating temperature range is from -55°C to 150°C. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It has its applications on power supplies, battery management, appliances, etc.

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). It can measure temperature more accurately. The sensor circuitry is sealed and not subject to oxidation. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. The LM35 has an output voltage that is 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°Cover a range of 0°C to +100°C.Another important characteristic of the LM35 is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The LM35 comes in many different packages such as TO-92 plastic transistor-like package, T0-46 metal can transistor-like package, 8-lead surface mount SO-8 small outline package.

Working principle of LM35

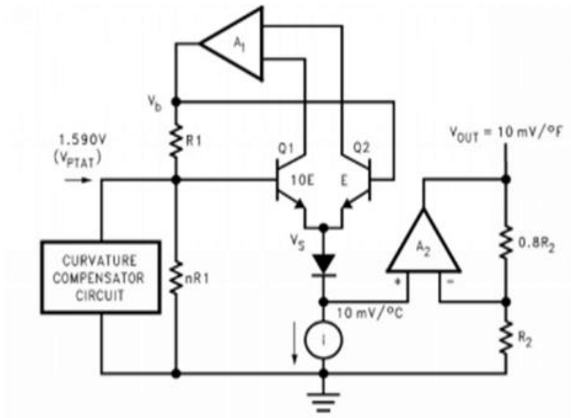

Fig 5. Circuit Diagram of LM35

There are two transistors in the centre of the drawing. One has ten times the emitter area of the other. This means it has one tenth of the current density, since the same current is going through both transistors. This causes a voltage across the resistor R1 that is proportional to the absolute temperature, and is almost linear across the range. The "almost" part is taken care of by a special circuit that straightens out the slightly curved graph of voltage versus temperature. The amplifier at the top ensures that the voltage at the base of the left transistor (Q1) is proportional to absolute temperature (PTAT) by comparing the output of the two transistors. The amplifier at the right converts absolute temperature (measured in Kelvin) into either Fahrenheit or Celsius, depending on the part (LM34 or LM35).The little circle with the "i" in it is a constant current source circuit. The two resistors are calibrated in the factory to produce a highly accurate temperature sensor. The integrated circuit has many transistors in it -- two in the middle, some in each amplifier, some in the constant current source, and some in the curvature compensation circuit. All of that is fit into the tiny package with three leads.

The LM35 IC has 3 pins, out of 2 for the power supply and one for the analog output. It is a low voltage IC which uses approximately +5VDC of power. The output pin provides an analog voltage output that is linearly proportional to the Celsius (centigrade) temperature. Pin 2 gives an output of 1 milli-volt per 0.1°C (10mV per degree). So to get the degree value in Celsius, all that must be done is to take the voltage output and divide it by 10-this give out the value degrees in Celsius.

VII. DESCRIPTION OF THERMO ELECTRICAL MATERIALS

Electrical power generated from a heat source, such as burning fossil fuel-coal, oils, indirectly through devices like steam turbines. The thermo-power or Seebeck coefficient of a material which governs its thermoelectric properties has units of voltage per unit temperature. A thermoelectric generator (TEG), also called a Seebeck generator, is a solid-state device that converts heat flux (temperature differences) directly into electrical energy through a phenomenon called the Seebeck effect (a form of thermoelectric effect). Seebeck effect applications are the foundation of thermoelectric generators (TEGs) or Seebeck generators which convert heat into energy. The voltage produced by TEGs or Seebeck generators is proportional to the temperature distance across between the two metal junctions.

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.

Thermoelectric materials can be used as refrigerators, called "thermo-electric-coolers", or "Peltier coolers" after the Peltier effect that controls their operation. As a refrigeration technology, Peltier cooling is far less common than vapor-compression refrigeration. Thermoelectric materials show the thermoelectric effect in a strong or convenient form. The thermoelectric effect refers to phenomena by which either a temperature difference creates an electric potential or an electric potential creates a temperature difference. These phenomena are known more specifically as the Seebeck effect (converting temperature to current), Peltier effect (converting current to temperature), and Thomson effect (conductor heating/cooling). While all materials have a nonzero thermoelectric effect, in most materials it is too small to be useful. However, low-cost materials that have a sufficiently strong thermoelectric effect (and other required properties) could be used in applications including power generation and refrigeration. A commonly used thermoelectric material in such applications is bismuth telluride (Bi2Te3). Thermoelectric materials are used in thermoelectric systems for cooling or heating in niche applications, and are being studied as a way to regenerate electricity from waste heat.

Thermoelectric materials have drawn vast attentions for centuries, because thermoelectric effects enable direct conversion between thermal and electrical energy, thus providing an alternative for power generation and refrigeration. This review summaries the thermoelectric phenomena, applications and parameter relationships. The approaches used for thermoelectric performance enhancement are outlined, including: modifications of electronic band structures and band convergence to enhance Seebeck coefficients. Several promising thermoelectric materials with intrinsically low thermal conductivities are introduced.

Thermoelectric materials generate electricity while in a temperature gradient. In order to be a good thermoelectric device, materials must have the unique combination of both high electrical conductivity and low thermal conductivity: a rare set of properties for one material to hold. Nanotechnology can now be used to lower the thermal conductivity of semiconductors whose electrical properties are excellent, but manufacturing nano materials is not trivial.

In order for a thermoelectric to establish a large voltage while in a temperature gradient, its thermal conductivity must be low. This ensures that when one side is made hot, the other side stays cold. For many decades, the only semiconductors known to have both low thermal conductivity and high-power factor were bismuth telluride (Bi2Te3), lead telluride (PbTe), and silicon germanium (SiGe): three expensive compounds using rare elements.

Today, low thermal conductivity can be achieved by creating nano scale features such as particles, wires or interfaces in bulk semiconductor materials. These nano scale features lower the thermal conductivity of the semiconductor and do not effect their strong electrical properties.

A thermoelectric module is a circuit containing thermoelectric materials that output usable electricity. There are several types of efficient thermoelectric materials, but not all are capable of operating in a power generation circuit, or "module," under typical waste heat recovery conditions. A thermoelectric module for power generation must operate in a very large temperature gradient and thus be subject to large thermally induced stresses and strains, for long periods of time. They must also be able to withstand a large number of thermal cycles, which cause mechanical fatigue. These two requirements represent some of the toughest thermal and mechanical environments that any electronic device must withstand. Furthermore, the geometrical design of a thermoelectric module will greatly effect its efficiency. The technology that goes into the design, joining and assembly of a thermoelectric module is copious.

A thermoelectric module requires two thermoelectric materials to function: one, an n-type (negatively charged) semiconductor; the second, a p-type (positively charged) semiconductor. This is so that a continuous circuit can be made whereby current can flow and power can be produced. With only one type of thermoelectric material, a voltage would be induced but current would never flow. These two n-types and p-type semiconductors form a thermoelectric "couple," but do not form a p-n junction. The two types of thermoelectric materials must be configured within the module such that they are electrically in series, but thermally in parallel. The module must therefore have internal wiring that accomplishes this, as well as junctions and materials that survive the harsh mechanical conditions it is subject to. A selection of materials that minimize thermal expansion coefficient mismatches and the technologies to fabricate them and their interfaces is of utmost importance in a thermoelectric module.

How Thermoelectric Power Generator (Teg) Systems Work

A thermoelectric power generation system takes in heat from a source such as hot exhaust, and outputs electricity using thermoelectric modules. A thermoelectric module needs a large temperature gradient to generate electricity: something that is technically challenging to implement in real-world applications. In a power generation system, the heat for the hot side of this temperature gradient must be supplied efficiently from a heat source such as an exhaust flue. The cold side must be cooled by air, water, or another suitable medium. To supply this heating and cooling, technologies known as heat exchangers are used on both the hot and cold sides. A thermoelectric power generation system can be thought of as two heat exchangers, each of which have to move heat to (or from) the hot (or cold) side of the thermoelectric modules.

Maximizing the efficiency (or, conversely, the total power output) of a thermoelectric power generation system requires extensive engineering design. Trade-offs between total heat flow through the thermoelectric modules and maximizing the temperature gradient across them must be balanced. The design of heat exchanger technologies to accomplish this is one of the most important aspects of engineering of a thermoelectric generator.

In operation, the entirety of a thermoelectric power generator sits in multiple large temperature gradients. It also contains interfaces between materials at several places that require low thermal losses. The challenges of designing a reliable system that operates at very high temperatures are many. In addition, the system must not cause large pressure drops in the heating and cooling sources, another difficult engineering constraint. A thermoelectric generator produces AC power only after the original DC power from the thermoelectric modules passes through an inverter. An integrated power electronics system is necessary to deliver AC power to the customer.

VIII. BRIEF DESCRIPTION ABOUT HOT AIR BLOWERS

A heat gun is a device used to emit a stream of hot air, usually at temperatures between 100 and 550 °C (373 and 823 K; 212 and 1,022 °F), with some hotter models running around 760 °C (1,030 K; 1,400 °F), which can be held by hand. Heat guns usually have the form of an elongated body pointing at what is to be heated, with a handle fixed to it at right angles and a pistol grip trigger in the same pistol form factor as many other power tools.

Though it shares similarities to a hair dryer, it is not meant as a substitute for the latter, which safely spreads out the heat out across its nozzle to prevent scalp burning and has a limited temperature range, while heat guns have a concentrated element and nozzle, along with higher temperatures, which can easily scald the scalp or catch the hair on fire.

CONSTRUCTION: A heat gun comprises a source of heat, usually an electrically heated element or a propane/liquified petroleum gas, a mechanism to move the hot air such as an electric fan, unless gas pressure is sufficient; a nozzle to direct the air, which may be a simple tube pointing in one direction, or specially shaped for purposes such as concentrating the heat on a small area or thawing a pipe but not the wall behind; a housing to contain the components and keep the operator safe; a mechanism to switch it on and off and control the temperature such as a trigger; a handle; and a built-in or external stand if the gun is to be used hands-free. Gas-powered soldering irons sometimes have interchangeable hot air blower tips to produce a very narrow stream of hot air suitable for working with surface-mount devices and shrinking heat-shrink tubing.

Usage: Heat guns are used in physics, materials science, chemistry, engineering, and other laboratory and workshop settings. Different types of heat gun operating at different temperatures and with different airflow can be used to strip paint,[1] shrink heat shrink tubing, shrink film, and shrink wrap packaging, dry out damp wood, bend and weld plastic, soften adhesives, and thaw frozen pipes. Heat guns, often called hot air guns or hot air stations for this application, are used in electronics to de-solder and rework surface-mounted circuit board components. Heat guns are also used for functional testing of overheat protection devices, in order to safely simulate an overheat condition.

Household use of heat guns is common. Heat guns and lighter weight hair driers are sometimes used to remove paint splashes and wallpapers. Heat guns are also used to make plastics such as PVC piping pliable for the purposes of bending, to soften wax and adhesives such as that used in electronics, and to thaw out frozen copper pipes. There are also heat gun form factors friendly for food purposes such as melting hard candies, searing meats, or to start a charcoal fire or grill. Heat guns are sometimes used to upholster furniture and repair leather and vinyl goods.

CONCLUSION

The project work "Solid state room heater that generates Electric energy" is completed successfully and results are found to be satisfactory. During our trail runs we found that, when the room heater box is heated with hot air blower, all 4 TEG modules connected in series are generating nearly 9V DC at no load condition, when a load of 200milliamps is connected across the power source, the voltage is fallen to less than 6v. As per the specifications mentioned by the manufacturers of these TEG modules, each TEG modules is supposed to generate 4.5V 150^{0}C Temperature, but in fact they are not up to the mark and generating less voltage and there by 4 TEG modules are used and are connected in series to generate sufficient voltage to energize a mini light source. All modules attached to the hot body of the metal box must be heated up equally with hot air blower and for this purpose the hot air blower is moved continuously through and from where the TEG devices are attached. The current output of each module is also supposed to give 400 milliamps, but it is not giving, we found that each module is giving only 200milliamps at 2v, when devices are connected in series, only voltage will be increased but whereas current remains same and therefore finally we are getting 200milliamps current at 6v DC.

The concept presented here is very useful for the people staying in very cold areas near the Himalayas which serve by heating the room and at the same time the waste heat produced by the metal box can be used to light an electric light. Presently the mechanism is constructed as demo module, but when it is converted as cocking stove mechanism built with TEG modules attached with all sides of the stove, more power can be generated and it can be stored in to a rechargeable battery. The advantage of using battery is, the stored energy can be used to energize the important electrical devices like LED light when required.

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