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Thermoelectric Based Dual Processing Control Using Embedded Controller

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ABSTRACT— The aim of this project is to produce the thermal energy based upon the thermoelectric module (TEM), which is made up of two semiconductor metal junctions are used for heating and cooling process. The semiconductor element is made up of bismuth and tellurium. This process is carried out on the principle of peltier effect, which is the reverse process of see-back effect. Heating and cooling process is achieved by changing the current direction of semiconductor element. High power DC source is used to supply the power to semiconductor element. The whole process is carried on using MSP430 controller. It is a 16bit RISC microcontroller. It has 4k inbuilt EPROM to store the monitoring program by using four 16 bit ports. We can read and write the data for external interface. It has inbuilt ADC. We plan to extend such thermoelectric module in various applications such as commercial and industrial process. This technology sought to provide energy saving method and reduce the size of the product.

KEYWORDS—TEM, Peltier effect, Bismuth tellurium, MSP430 Controller.

I.INTRODUCTION

Thermal management has become significant issue over the past few years because of increased power density and use in harsh environments. Processor must operate below its safe design temperature which is typically 100^0[1]. Beyond which permanent failure may occur and shorten its life time [2]. The most common cooling method is extended surfaces of fins, or so-called heat sinks, serve to enhance the thermal capability of convective cooling with air. The use of fan driven forced air cooling facilitates effective thermal management of high performance, but at the cost of a substantial material stream, manufacturing complexity, pumping power and entropy generation [3]. The next common cooling method, vapor compression has remained practically a predominant technology for well over 100 years. The fundamental principle is to use liquid-vapor and vapor-liquid phase transitions to transfer heat from a low temperature state. It is desirable to have these phase transitions occurs at room temperature. The ideal vapor compression system should be non-toxic, non-corrosive, efficient, cost effective and importantly environmentally benign. This eventually lead to the increase in related co_2emissions. These type of thermal management have more number of element are needed. It is not a life time product [4]. The alternatives for vapor compression technologies are magnetic cooling, thermionic cooling, thermo acoustic cooling method [5].Magnetic method is an emerging technology that exploits the magnetocaloric effect [MCE] [6].The major challenges faced in the magnetocaloric technology, which include scarcity of magneto caloric materials, high cost of materials and magnets, limitations of physical properties of materials and time delay required to reach the required temperature lift [7]. In thermionic method, voltage is applied across the two materials with a gap or barrier thickness. When it is less than an electron mean free path, the high energy electrons will leave one surface for the other while being replacing by average energy electrons. The result is a lowering of the temperature of the first surface and corresponding heating of the second surface [8].It is unlikely for thermo tunneling to be an energy saving technology. The requirement including the development of cost effective low work function surfaces [9].In addition, the requirement for extremely small inter-electrode spacing (Nano-meter sized gaps) presents a unique challenge for large-scale manufacturing. In thermoacoustic method provide cooling using acoustic work to provide pressure waves, which expand and compress a gas inside a resonator. These pressure waves also cause displacement of the gas. The time phasing between pressure and displacement correct the gas can be made to pump heat from a cold heat exchange to hot exchange across a component [10].The major difficulties in acoustic method have been the relatively low power density [11], low cooling capacities, large physical size, heat conduction between the heat exchanges and hence poor performance of the heat exchanges [12].Design and control of compact heat exchanges in oscillating flow presents a unique challenge for thermoacoustic units with large capacities.

The proposed work of this paper is to develop a system that can be produce the heating and cooling process is based on the thermoelectric module and control by the MSP430 embedded controller.

II.METHODOLOGY

A.Thermoelectric module

A thermoelectric module is also called as a thermoelectric cooler or peltier cooler. It is a semiconductor-based electronic component that functions as a small heat pump.Thermoelectric devices can convert electrical energy in to a temperature gradient phenomenon which was discovered by peltier in 1834[13]. Thermoelectric module may be used for both heating and cooling there by making it suitable for precise temperature control application.

B. Thermoelectric materials

A typical thermoelectric device is composed of ceramic substrates that serve as a foundation and electrical insulation for N type and P type. Today's TE cooler is an alloy of Bismuth Telluride (Bi_2Te_3) that has been suitably doped to provide individual blocks or elements having distinct "N" and "p" characteristics. In addition to Bismuth Telluride (Bi_2Te_3), there are other thermoelectric materials including Lead Telluride (PbTe), Silicon Germanium (SiGe), and Bismuth-Antimony (Bi-Sb) alloys that may be used in specific situations. Figure (1) describe the relative performance or figure-of-merit of various materials over a range of temperature. The performance of Bismuth Telluride peaks with in a temperature range that is best suited for most cooling application. N type, P type Bismuth Telluride Thermo element that are connected electrically in series and thermally in parallel between ceramics. Shown in fig(2 & 3)

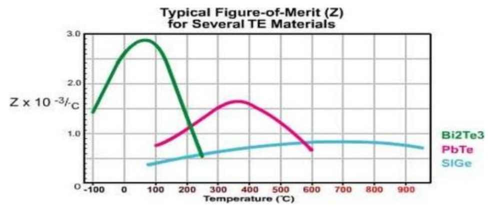

Fig.1 Relative performace or figure-of-merit of various materials

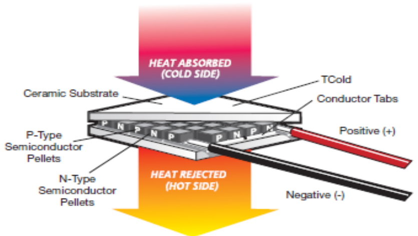

Fig.2 Complete Thermoelectric Module

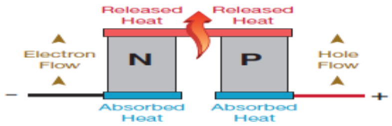

Fig.3 Semiconductors electrically in series and thermally in parallel

C.Process on thermoelectric module

The configuration circuit of TEM shown in figure(4) illustrates the phenomenon known as the peltier effect.

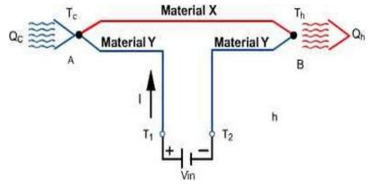

Fig.4 Process on peltier effect

If a voltage (v_{in}) is applied to terminals T_1 and T_2 an electrical current (I) will flow in the circuit. The result of current flow, a slight cooling effect (Q_c) will occur at junction, where heat is absorbed and a heating effect (Q_h) will occur at junction B where heat is expelled. The peltier effect can be expressed mathematically as

$$Q_C \text{ or } Q_h = P_{xy} \text{ x } I$$

P_{xy} is the differential peltier co-efficient beween the two materials x and y in volts. I is the electric current flow (TEM) in amperes. Is the rete of cooling and heating respectively in watts.

III. PROPOSED SYSTEM

Design of dual processing system based on thermoelectric module and embedded controller as shown in fig (5).

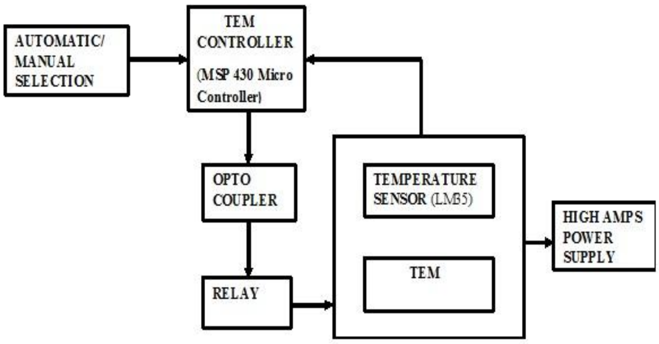

Fig.5 Proposed System

The most common method for measuring the temperature is by using LM35. Because LM35, output voltage is linearly proportional to a Celsius temperature. This sensor is used to measure the signals from the TEM. After measurement, these analog signals are converting in to digital signals and compared with the actual signals and set point signals. If any discrepancies occur the TEM produce. Thermoelectric module are constructed using dissimilar semiconductor, who main element of dual processing system. The TEM relies on peltier effect and its structure is schematically shown in fig 5.When a forward bias current flow in TEM, negative heat generation (heat absorption) occurs at the top cold junctions of the thermocouples conversely when the current is reversely biased, the opposite is true. TEM structure operates the high current, so high amps power supply are use in proposed architecture. The MSP430 (M430G2553) processor plays an important role in controlling the devices. It has an inbuilt A/D converter. The MSP 430 processor produce the control signal when temperature are varying depend upon TEM. In electronicsopto -isolator, also called an opto coupler, photo coupler or optical isolator. It transfers electrical signals between two isolated circuits by using light. Opto-isolated prevents high voltages from affecting the system receiving the signal.

IV. PROCESS FLOW

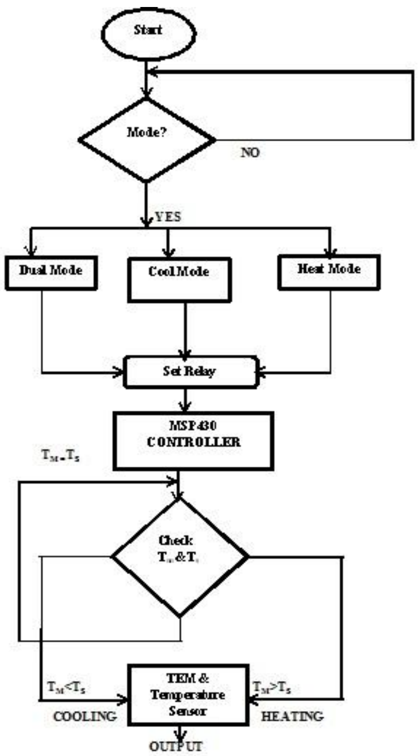

Fig.6 Process flow diagram

MSP –Mixed Signal Processor
T_m - Measured Temperature
T_s - Set Temperature
TEM –Thermo Electric Module

V.ARCHITECTURE OF MSP430

A microcontroller is a functional computer system on-a-chip. It contains a processor core, memory and programmable input/output peripherals. They consume relatively little power. As they are programmable, it programs must fit in the available on-chip program memory to reduce its cost, since processor interpret and process the digital data only. So an A/D converter is needed and it is used to convert the incoming data into a form that processor can recognize. Microcontrollers are now used in all automatically controlled products and devices. The Texas instrument's MSP430 (M430G2553) is a mixed-signal microcontroller family from Texas instruments. It built around a 16bit RISC CPU, It is a general purpose 16bit microprocessor. The MSP430 architecture is based on RISC (Reduced Instruction Set Computer) and its peripherals and flexible clock system combined by using a Von-Neumann common memory address bus (MAB) and memory data bus (MDB). MSP430 Controller has low power consumption and the operating voltages ranging from 1.8v to 3.6v. It contain on-chip A/D converter**.**

VI.CODE COMPOSER STUDIO

In the system built in code composer studio (CCStudio). It is an Integrated Development (IDE) for Texas Instrument (TI) embedded processor families. CCStudio comprises a suite of tools used to develop and debug embedded application. It includes compiles for each of TI's devices families, source code editor, project build environment, debugger, profiler simulators, real time operating system and many other features. Code composer studio is support running on both windows and linux pcs.

The compiler can handle in-line or separate functions, as well as parameter passing in re-usable registers. Transparent to the user, the compiler handles calls across pages automatically and analyzes program structure and call tree process to optimize RAM and ROM usage. It contains over 307 built while producing efficient and highly optimized code, TI embedded processors include a selection of hardware debugging capabilities.

VII.IMPLEMENTATION AND RESULT

In this paper the code composer studio used to debug and compile the specific program file. shown in fig (7) screen shot for code composer studio. Proto type model implementation diagram for proposed architecture shown in fig (8).

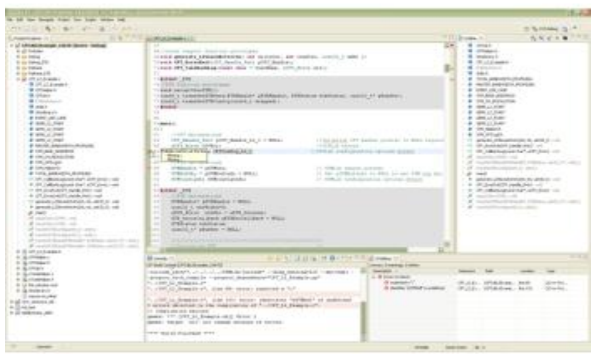

Fig.7 Screen shot for composer studio

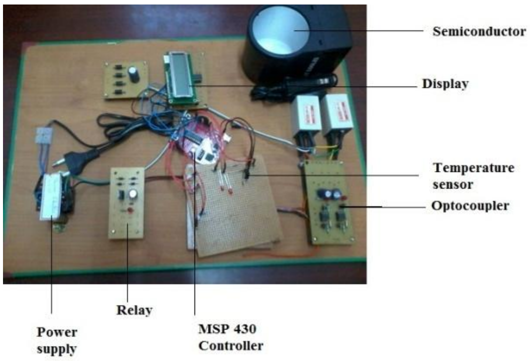

Fig: 8 prototype model for proposed architecture

VIII.COMPARISION AND RESULT

Thermoelectric technology has been presented in this paper, thermo acoustic and thermionic both have a poor efficiency, high technical risk and a long time to commercialize compare to thermoelectric. In magnetic and thermoelectric produce promise for efficiency, medium technical risks but, magnetic technology takes a long timeto commercialize compare to thermoelectric technology.

Table 1: Time taken to produce each mode of proposed system

Room temperature – 35.5^{0}c

Mode	Time
Stop to hot mode	1min(60sec)
Hot to cool mode	3min(180sec)
Cool to hot mode	1min(60sec)

IX.CONCLUSION

In this paper, whose design based on TEM and embedded controller architecture, has a building block structure and intelligent function modules. In terms of software design, code composer studio, support the controller. It measure, the temperature of TEM and compared with the set point temperature.If discrepancy occurs, TEM of semiconductor element produce the cool and heat. The advantages of such design are as follows, reliable energy converter and have no noise or vibration as there are no mechanical moving parts. One of the main impact of this project is size to be reduced because this fully based on the thermoelectric module. Thus, we plan to extend such TEM technology to various embedded application field are electronics, Bio-medical, missiles and space.

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