International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Cyclic Temperture Heating and Cooling Control System

Prathik Jain, Saroj Anand Tripathy, Rajesh R

ABSTRACT: This paper on the cyclic temperature heating and cooling control system proposes a method to control and adjust to the suitable temperatures for the rooms. The system is utilised to control the temperature in various real-time environments. This where the paper on the cyclic temperature heating and cooling control system comes in by making the use of the peltier effect in the thermoelectric module, which is trying to solve the above problem. The temperature sensor detects the change in temperature as the difference between the set-point temperature which is used to execute the fan or the heater. The error in the system is reduced by the Proportional-Integral-Derivative (PID) controller which is around 80%-90%, which is often created by the Pulse Width Modulation (PWM) which generates square wave responsible for switching 'ON' and 'OFF' the thermoelectricmodule. These then switch between the Metal-Oxide Semiconductor Field Effect Transistor (MOSFETS) using the H-bridge circuit causing to change the flow of Direct Current (DC) current which in turn, is responsible for controlling the temperature of the surroundings. It can be used in precise temperature control and rapid thermal cycling in a micromachined DNA polymerase chain reaction chip.It also can be used in temperature control for PCR thermo-cyclers based on peltier effect thermo-electric. It can be used in an automotive cabin climate control system.Help in improving solar cooling technologies.Also, improve in the accuracy of the thermal testing of equipment.

***Keywords:** Peltier effect, PID controller, Thermoelectric module, Pulse Width Modulation (PWM), MOSFET,H-bridge circuit, DC current.*

I. INTRODUCTION

This paper is going to become one of the most important topics since the environment is going through a major change of climate. It won't be able to survive if any other ice age like event occurs which can wipe-out life. So, to solve the existing situation it is required to maintain certain temperatures to survive. Hence, by using this simple method of temperature control, this problem is solved. Certain habitats can be saved by using this technique.

Many efforts like the one in equivalent model optimization with cyclic correction approximation method considering parasitic effect for thermoelectric coolers paper[1]where the model was refined by intrinsic parameters and parasitic thermal conductance here the error is only 1.6 kelvin as an experimental data but also 0.13 kelvin when heat is absorbed equal to 80% this was because thermoelectric coolers have become highly integrated in high-heat-flux chips and high-power deviceswhich increases the parasitic effect between component layers. Temperature control for Polymerase Chain Reaction(PCR) thermo-cyclers based on peltier effect thermoelectric [2], which proposes a method to reduce the time taken by a PCR model-based hybrid control configuration which can detect thermal cycling which is actually based on feedforward control model which can be identified by the step-data response which was due to effect of high ramp rates and short temperature hold. Temperature control system [3] where it proposes a method to control the temperature by using basic principles and thermostat mostly programmable with many error variations. Precise tempering temperature control system of mining of chain with bi-sensors [4] used two infrared detectors to obtain the temperature of non-contact-based workpiece circular chain reaction which had a precision of ±1°C

Two-stream parallel-flow heat exchanger equation [5] studies the with the boundary using two temperature measurements. When initial values and inputs, exact observability was obtained which was used to measure one fluid temperature which usually becomes unobservable.

Temperature control [6] uses temperature control for concrete by trying to limit the heat generation potential of the binder in the mixture which was changed with precooling mix constituents. Research on temperature control with numerical regulators in electric resistances furnaces with indirect heating [7] discusses the analysis of two position regulators and by utilising the self-tuned PID controller and PID controller for temperature used for indirect heat resistance furnaces. The temperature sensor used for this is numerical temperature regulator AT-530 type. It utilises three tuning methods of Ziegler-Nichols step response, Cohen-Coon tuning rules and Ziegler-Nichols tuning rules. This increased the efficiency of the machine and gave a temperature control response when it used Cohen-Coon tuning rules than that of Ziegler-Nichols step response method and Ziegler-Nichols tuning rules method.

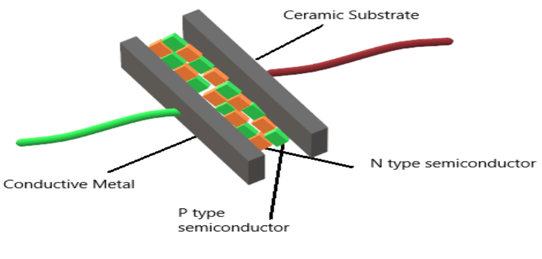

Fig.1: Thermoelectricmodule

Revised Manuscript Received on December 30, 2019.
* Correspondence Author
Prathik Jain*, UG Student, School of Electronics Engineering (SENSE), Vellore Institute of Technology, Vellore, Tamil Nadu, India.
Saroj Anand Tripathy, UG Student, School of Electronics Engineering (SENSE), Vellore Institute of Technology, Vellore, Tamil Nadu, India.
Rajesh R, Assistant Professor (Senior), School of Electronics Engineering (SENSE), Vellore Institute of Technology, Vellore, Tamil Nadu, India.

The cyclic temperature control system uses peltier element based cyclic thermoelectric heating and cooling system with accurate temperature control using a proportional integrator differentiator controller with the microcontroller. When a solid-state semiconductor device made up of semiconductor elemental substances like(p and n-type) are affixed perfectly between two substrates connected in series(electrically) and parallel (thermally) then a thermoelectric device shown in Fig. 1 is formed. So, when it appliesvoltage in a direction it generates heat on one side and absorbs heat on the opposite side. The phenomenon of peltier effect creates temperature difference using electric current, i.e., when a DC current is passed over the various other materials (like conductors/semi) connected at two intersection, it either sucks up or generates heat which depends on direction of DC current, if direction of DC current is reversed, the junction with higher and lower temperature junctions get reversed. The thermoelectricmodule is used as thermoelectricgenerator. The temperature gradient when applied to both planes of the thermoelectricmodule, DCcurrent generated varies directly with the temperature gradient. This is thermoelectricgenerator works on the principle of seebeck effect. Thermoelectricmodules have advantages like temperature regulation with the highest precision and greater stability, response time is very low and suitable temperature range. Thermoelectricdevices are very small in size, lightweight, noise independent, environmentally friendly. The power delivered by the thermoelectricmodulevaries directly with the measure of the thermal effect of heating/cooling. Voltage regulation in thermoelectricmodule is done using the PWM technique. The key for PWM function is a MOSFET and to vary the charge (+ to– or – to +) of DC current flowing through the thermoelectric device MOSFETS and transistors are combined together to work as H-bridge circuit. The power can be switched instantly from ‘ON’ to ‘OFF’ and ‘OFF’ to ‘ON’, on a fixed frequency with the help of PWM which leads to the creation of wave pulse shaped as a with constant power with afixed time period. The variation in the duty cycle creates a mean voltage output which is used by the thermoelectric device to regulate the temperature range as shown in Fig.2.

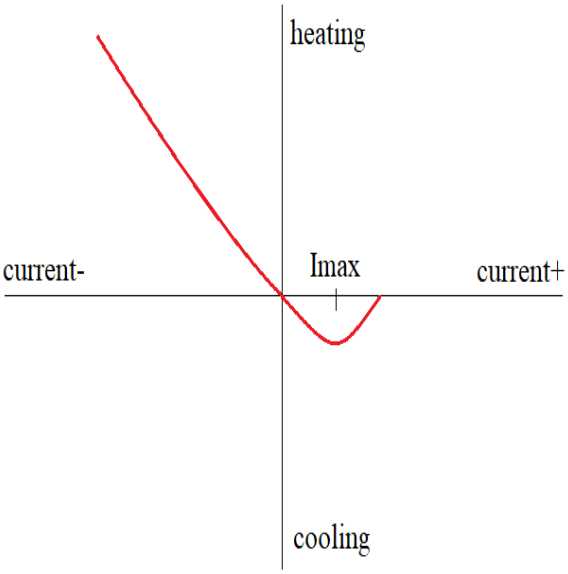

Fig.2: Thermoelectric characteristics

II. COMPONENTS AND USES

As shown in Fig. 3, the heart of the circuit controlling all the functions is the arduino board. The output voltage of the precision integrated circuit (LM35) is directly proportional to celsius temperature. The range of its operation varies

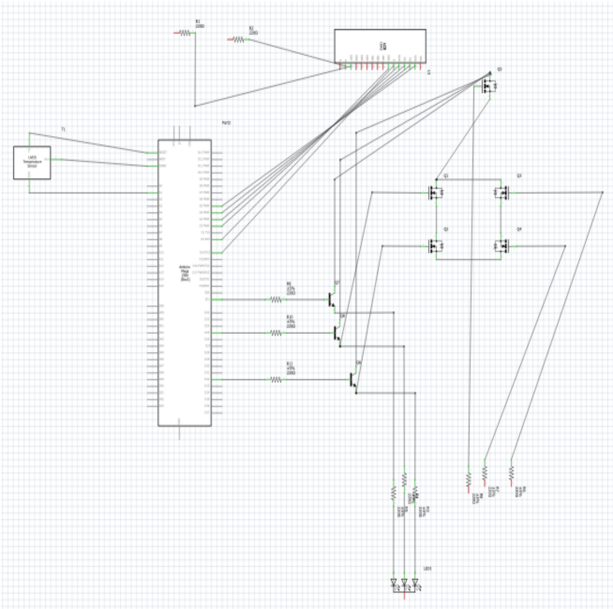

Fig.3: Schematicrepresentation

from -54°C to 151°C temperature scale and has a linear scale factor of +10mV/Celsius.

To assess and simplify suitable and required range of temperature observing challenges, i.e., a temperature integrated circuit working over a range of -54°C to +151°C is required this work of sensing temperature is done by LM35 temperature sensor which is converted into electrical (analog) signals, which is passed through to the microcontroller unit through an analog and digital converter(ADC).This analog function is converted into digital function by the use of ADC.

The arduino board is interfaced with LCD and keyboard devices and the MOSFETS and transistors are incorporated together to make the driver circuit. The values of temperature and the desired temperature of the thermoelectricdevice are sensedand then displayed on the LCD. The keyboard is used to enter the required temperature setpoint & the required heating and cooling cycle times.

The PWM regulation of temperature is done by MOSFET Q5 which function as a thermoelectric cooling/heating device. Bridge circuit is used to change the direction of DC current passing through thethermoelectric device.

MOSFET Q5 is driven by transistor T1, MOSFET Q1 &Q4 by transistor T2, MOSFET Q2 &Q3 by transistor T3. Heating by LED, cooling by fan.

Retrieval Number: B7082129219/2019©BEIESP
DOI: 10.35940/ijitee.B7082.129219
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

WORKING

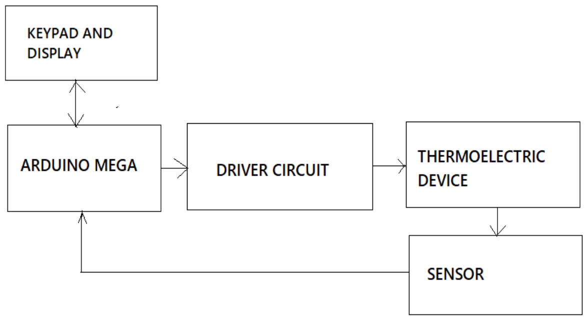

Fig.4: Block diagram of the temperature control system.

The basic block diagram for the working of this system is as shown in Fig .4**.** While connecting 12V 5A DC power supply to the driver circuit and 15V battery to Arduino board it is required that the system switches ON and then the keyboard is used ininputting the suitable values of temperature, heat generation, and heat absorption period.
Press A to enter temperature setpoint which prompts microcontroller to display "enter temperature setpoint", after entering temperature setpoint press "#" to validate the value. Press B to enter heating time in seconds and then press "#" to validate. Similarly, press C for cooling time in seconds and then press "#". To start operating the system press"*".
Arduino pin 8 is activated and transistor T2 is to be switched ON which will switch ON the MOSFETS Q1 &Q4 for heating cycle. transistor T1 and MOSFET Q2 & Q3 is in OFF state when arduino digital output pin 7 is deactivated, which results in the flowing of DC current through V_{cc}-Q5-Q1-thermoelectric device-Q4-ground, resulting in the heating to the required temperature of the top surface of the device where the sample is placed for a time period validated by the microcontroller.
In the cooling process, the transistor T1 is switched on by the pin 7 of Arduino activated by writing high by the arduino board which is responsible for the operation of MOSFETS Q2 &Q3. MOSFET Q1, Q4, and transistor T2 are in OFF state because arduino digital pin 8 is deactivated, allowing the current to be transmitted through V_{cc}-Q2-thermoelectric device-Q3-ground which means the direction of DC current is definitely reversed, resulting in the cooling of the top surface while the other side starts getting hot. Which can be continuously sensed by the temperature sensor LM35 connected to the analog pin A0,sending feedback to arduino.

III. METHODOLOGY

To adjust the average DC power delivered to the thermoelectric device by varying the duty cycle generated by the low-frequency PWMsignal (a MOSFET is usually used here). This is where the PID controller eq. (1) comes in use by modulating or varying the duty cycle created by PWM.

$$u(t) = K_p\, e(t) + K_i \int_0^t e(t')dt' + K_d \frac{de(t)}{dt} \quad (1)$$

(equation use for reducing the error caused in temperature reading created by the PWM)
This function is usually provided with arduino. The sensor provides it with the input parameter referring to it as setpoint and then calculating & combiningthe proportional, integral and derivative responses resulting in computation of the output for the thermoelectric device.
The difference of measured temperature and the desired temperature causing the PID controller eq. (1) generating the output to the MOSFET switch represented as PWM signal which depends on the combination of proportional, integral and derivative response which minimize errors by tuning the parameters. The loop created is implemented by the microcontroller which provides analog output in the form of a PWM signal which in turn is given to the driver circuit. This value is continuously read by microcontroller and then compared to the desired value which is actually based on error. Then the control value computed by PID suitably changes the duty signal. for example, when error value is less than a certain value, the microcontroller gives fixed tuning parameters to the PID or when it is greater than that value it gives coercive tuning parameters to the PID to gain control quickly.

IV. RESULT& DISCUSSIONS

The paper shows the output as the temperature measurements as shown in Fig.5 on the thermal processing camera with a temperature range of -1.5 to 1.5 degrees in 50 seconds of heating and cooling time.
Given below Fig.6 shows the simulation of the circuit when the set-point temperature is greater than the measured temperature by LM35 sensor which turns the heater "ON". Fig.7 shows the simulation of the circuit when the set-point temperature is less than the measured temperature by LM35 sensor which turns the cooling fan "ON" whereas the heater is "OFF".
The set-point temperature value can be changed by pressing the '*' button for 5 seconds which in turn again directs you through the series of steps to set the temperature which again can be used for the simulations.

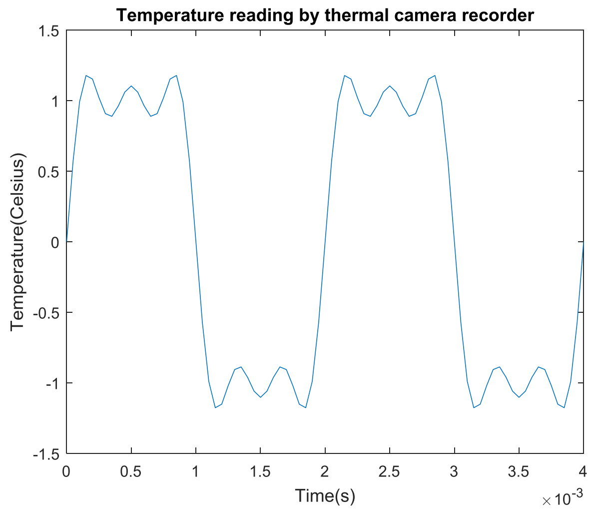

Fig.5: Temperature reading by thermal camera recorder.

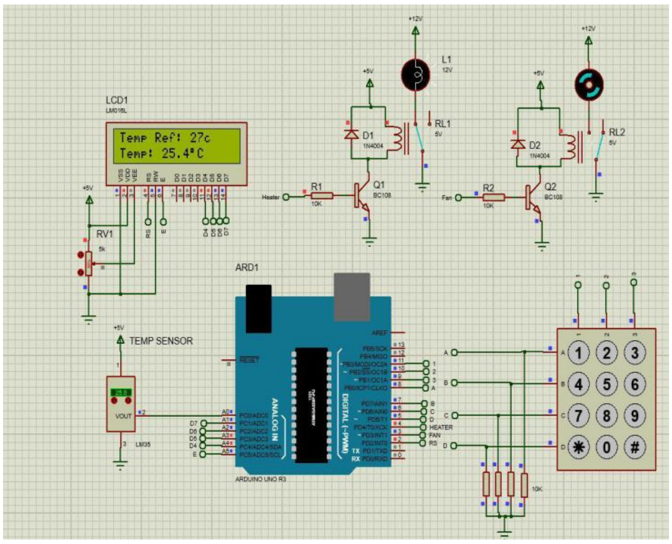

Fig.6: Simulation of temperature control system (working of heater)

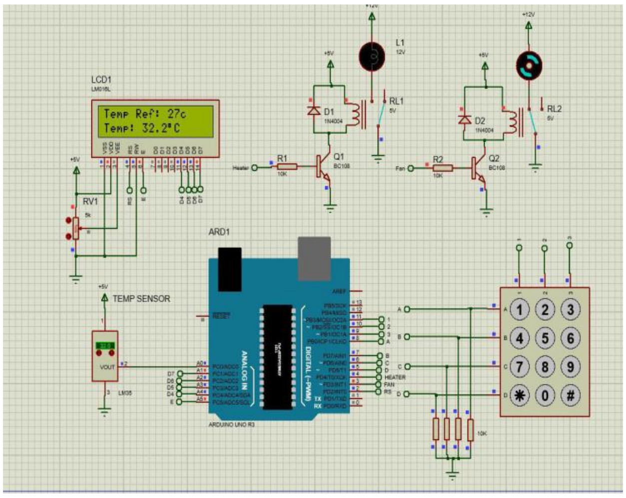

Fig.7: Simulation of temperature control system (working of the fan)

V. CONCLUSION

The problem addressed in the paper is solved using the basic PID controller to greater precision level of 80%-90%. This methodology is under development and the prototype can be made by using simple tools. This system is applicable for any system which requires temperature control. This is because the temperature sensor can detect temperature from -54 to 151 °C. This simplifies the previous models used to solve the above-mentioned problem. And the use of simple tools and machines make it cost-effective and used for various applications.

REFERENCES

1. Wang N[1], Chen J[1], Zhang K[1], Chen M[1], Jia H[2].Equivalent model optimization with cyclic correction approximation method considering parasitic effect for thermoelectric coolers.2017 Nov 21;7(1):15917. doi: 10.1038/s41598-017-16261-0.
2. Qiu X[1], Yuan JTemperature control for PCR thermocyclers based on peltier-effect thermoelectric.Conf Proc IEEE Eng Med Biol Soc. 2005; 7:7509-12
3. Ogu, Emmanuel & John, Ekundayo& Olumide, Oyetesu. Temperature Control System. (2011). Thesis for: BSc., Advisor: Ogunlere, S.O.
4. Gu, Deying& Wang, Jinkuan&Xue, Yanho. (2003). A Precise Tempering Temperature Control System of Mining Circular Chain with Bi-Sensors. IFAC Proceedings Volumes. 36. 213-215. 10.1016/S1474-6670(17)37631-0.
5. W. Lu and J. Chen, "Observability of the two-stream parallel-flow heat exchanger equation," in *IMA Journal of Mathematical Control and Information*, vol. 27, no. 1, pp. 91-102, March 2010. doi: 10.1093/imamci/dnq003
6. Azenha, Miguel &Sfikas, Ioannis&Wyrzykowski, Mateusz &Kuperman, Selmo&Jędrzejewska, Agnieszka. (2019). Temperature Control. 10.1007/978-3-319-76617-1_6.
7. C M Diniş, G N Popa and A IagărResearch on temperature control with numerical regulators in electric resistance furnaces with indirect heating Published under licence by IOP Publishing Ltd IOP Conference Series: Materials Science and Engineering, Volume 106, conference 1

AUTHOR PROFILE

Prathik Jain, currently pursuing B.TECH.(2nd year) in Electronics and Communication Engineering with specialization in the Internet of Things and sensors from Vellore Institute of Technology, Vellore. This is his first research paper which was completed in over a period of 3 months.

Saroj Anand Tripathy: currently pursuing B.TECH.(2nd year) in Electronics and Communication Engineering with specialization in the Internet of Things and sensors from Vellore Institute of Technology, Vellore. This is his first research paper which was completed in over a period of 3 months

R. Rajesh received B.E. degree in Electronics and Communication engineering from Mohammad Sathak college of Engineering, Kilakarai, India in 2002, the M.Tech. degree in Communication Engineering in 2005, and Ph.D degree in 2019 from VIT, vellore. He is now an associate professor in the School of Electronics Engineering, VIT, Vellore. His research interest includes signal processing in full-duplex relay assisted communication.