

RESEARCH ARTICLE



ISSN: 2321-7758

## AUTOMATION OF TEMPERATURE VARIATION SETUP FOR IMPEDANCE ANALYZER USING LABVIEW

**RAHUL GUNDE, KRISHNA KANTH KONDA, T.SATYANARAYANA**

Department of EIE, Lakireddy Bali Reddy College of Engineering, Mylavaram, Krishna, Andhra Pradesh, India



**RAHUL GUNDE**



**KRISHNA KANTH**



**T.SATYANARAYANA**

### ABSTRACT

Temperature is most often measured with a mercury thermometer up to a particular range. But in industrial purpose, product generation requires very high temperatures. For measuring and controlling the temperature, normal thermometers are not sufficient. In such cases, temperatures of materials can be measured and controlled by using LabVIEW and temperature measuring devices. Merging of LabVIEW programming with the temperature interfacing devices provides a flexible platform for creating sophisticated measurement and control systems. The present project is mainly focused to develop an experimental setup for measuring and controlling the temperature of the impedance analyzer using LabVIEW and thermocouple.

Keywords: - Eurotherm, GPIB Cable, Kethley, NI VISA, etc.

©KY PUBLICATIONS

### I. INTRODUCTION

The temperature is the measure of warmth or coldness of an object or substance with reference to some standard value. Several methods of temperature measurement and control have been developed over the years. Industrial process control usually requires that the temperature sensing device must be remote from the measuring or controlling instrument [4]. Of the various thermal sensing devices, the thermocouple is most commonly used, offering the best compromise of cost, accuracy and reliability. Control system can be found almost anywhere you look. They are used in automobiles, factories homes and businesses, and are found in equipment used by any industry you can name[1].

The job of a typical control system is to maintain something that is variable or changeable in a prescribed area. The human body for example has control system that regulate heartbeat, maintain body temperature, and provide balance.

Another common example is the temperature control system found in almost all homes. A control system keeps the temperature constant in heaters and glazers with respect to time and they heat it again when the temperature reduces. It maintains the constant heat with different intervals of time. This paper describes a project that involves designing, building, and demonstrating measuring and controlling the temperature of the impedance analyzer using

LabVIEW and thermocouple[5]. Another goal is to incorporate a PC-based data acquisition system (DAQ) along with LabVIEW [6], a graphics-based programming by national instruments. LabVIEW has been used in many applications.

## II. MATERIALS AND METHODS USED

### A. DAQ system

This system uses a data acquisition system (DAQ) that is connected to a PC in the lab. It gathers input from the process and passes output signals to the heating element.

A control algorithm is implemented in software on the PC that is connected to the DAQ system. The LabVIEW software package from National Instruments is used to develop the custom data acquisition and control program. The program measures the temperature from the process, compares it to a desired set point, and issues the proper control signal to the final control element[6].

### B. National Instruments SCXI

The I/O system is the signal conditioning extensions for instrumentation (SCXI) system from national instruments.

This is a molecular data acquisition system that has the ability to connect to a PC. This system include an input module, output module, and terminal blocks that are houses in a classis. The SCXI system provides a basic I/O interface along with signal conditioning. It is designed to connect to a DAQ card which is located in the PC. The DAQ card performs A/D and D/A conversion as well as signal timings and multiplexing.

### C. Thermocouple

The type k is the most common type of thermocouple. It's inexpensive, accurate and reliable. K-type thermocouple (chromel-alumel) in the standard thermocouple measurement configuration. The measured voltage  $v$  can be used to calculate temperature  $T_{sense}$ , provided that temperature  $T_{ref}$  is known[5]. The standard configuration for thermocouple usage is shown in the figure. Briefly, the desired temperature  $T_{sense}$  is obtained using three inputs—the characteristic function  $E(T)$  of the thermocouple, the measured voltage  $V$ , and the reference junctions' temperature

$T_{ref}$ . The solution to the equation  $E(T_{sense}) = V + E(T_{ref})$  yields  $T_{sense}$ . These details are often hidden from the user since the reference junction block (with  $T_{ref}$  thermometer), voltmeter, and equation solver are combined into a single product.

A thermocouple assembly generally has four major components:

- **Element:** Two wires of dissimilar alloys joined at the tip. When the ends are exposed to a temperature gradient, and electromotive force (EMF) is generated. The EMF is very small, amounting to microvolts per degree.
- **Protection Tube:** A metal or ceramic tube, usually closed at the end that protects the element from the environment of the process.
- **Head or Cold End Termination :** The head is a terminal block/protective enclosure assembly provided for connection to thermocouple extension wire. In lieu of this, an integrated extension assembly may be provided.
- **Extension Wire:** Although not a portion of the thermocouple assembly itself, the extension wire is a critical part of the total circuit. The wire must be manufactured from alloys compatible with the element.

### D. Shielded GPIB cable

General purpose interface bus. It was created as a standard interface for communication between instruments and controllers from various vendors. It uses the ANSI/IEEE Standard 488.1. GPIB has the ability to send data through a system controller, usually a computer, and receive data from up to 14 different additional instruments organized in a linear, or serial, fashion.

The GPIB card can receive data from these 14 different instruments at speeds up to 1 mByte/s.

### GPIB 24pin connection (2/2)

- Pin 1 to Pin 4 Data input/output bit.
- Pin 5 EOI End-or-identify.
- Pin 6 DAV Data valid.
- Pin 7 NRFD Not ready for data.
- Pin 8 NDAC Not data accepted.
- Pin 9 IFC Interface clear

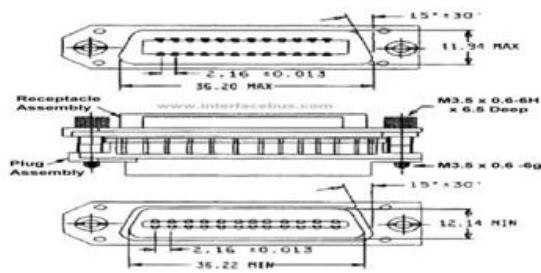


Fig 1. GPIB 24 pin connection (2/2)

- Pin 10 SRQ Service request.
- Pin 11 ATN Attention.
- Pin 12 SHIELD
- Pin 13 to Pin 16 DIO8 Data input/output bit.
- Pin 17 REN Remote enable.
- Pin 18 to Pin 23 Ground for pin 6 to pin 11
- Pin 24 Logic ground

### III. SOFTWARE

Perhaps the most important piece of the system is the software. The software is the controller. It analyzes the input from the process and decides on an output action based on a control algorithm. The software is also the instrumentation. It displays data on the PC screen that a human operator can use to understand how the system is behaving. The software also enables an operator to control the process by entering a set point or by manually controlling the final control element.

#### A. National Instruments LabVIEW 7 Express

We can use LabVIEW to communicate with hardware such as data acquisition, vision, and motion control devices, and GPIB, PXI, VXI, RS-232, and RS-484 devices. It has built-in features for connecting your application to the Web. Also we can create test and measurement, data acquisitions, instrument control, data logging, measurement analysis and report generation applications.

LabVIEW is a graphics-based software development package that incorporates data acquisition, measurement, analysis, presentation, and control. Programs are written in the form of Virtual Instruments, or "VI's" that can execute alone or can be used as "sub- VI's" in larger programs.

The programming style is much like the C programming language, however, actual code input is done graphically rather than typed with a text

editor. This makes it easy for non-programmers to quickly create and debug applications.

The software integrates seamlessly with data acquisition and measurement products from National Instruments. When used with the SCXI system, the result is very quick development of powerful measurement and control applications. Perhaps the biggest benefit of the LabVIEW system is that it includes hundreds of VI's that are ready to use in a custom program. In the development of this project I took full advantage of ready-made VI's for control, acquisition, and analysis.

#### B. LabVIEW Software VI's

The software is perhaps the most important component of the system. It acts as the controller and also as instrumentation. The main routine, or VI, provides a front panel interface that allows the operator to control and monitor the system. It calls sub-VI's to perform functions that gather analog input, send analog output, and implement a PID control algorithm.

- Front panel: The front panel is what allows the operator to control and monitor the process. It includes software controls and indicators that mimic physical controls such as buttons, sliders, LEDs, and charts. Shown below as Figure 2 is a screenshot of the front panel.

The temperature of the process is displayed in a thermometer-style indicator as well as recorded on a strip chart. Also on the strip chart is the set point value. By showing both set point and measured values on the strip chart, one can easily see how the system responds to changes in set point.

This is very helpful when trying to determine the correct PID Constants. There is a slider for manually controlling the temperature and one to adjust the temperature set point for automatic control. A toggle switch allows the operator to switch between manual and automatic control. There is a dial control that sets the sampling rate. It controls how fast the software loop runs.

The PID values can be set in a numerical control box. Underneath the PID values box are two pushbutton switches.

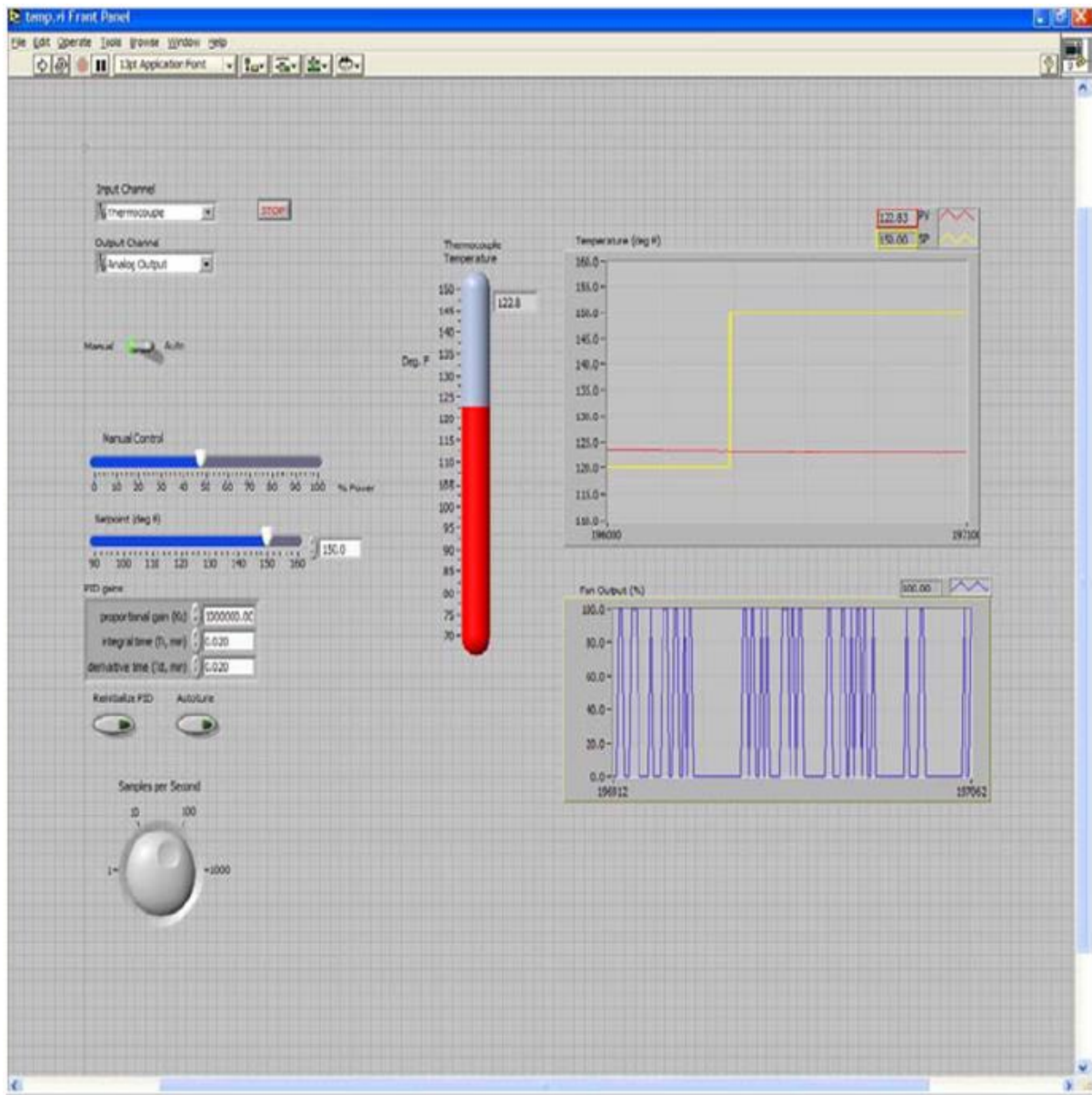


Fig 2. Controlling and monitoring the process by using LabVIEW.

The one marked Auto tune starts an automatic tuning routine. This routine attempts to find the best values for P, I, and D using the Zeigler-Nichols ultimate gain method. Upon completion, the new PID values are automatically entered into the control box.

- **Block Diagram:** The block diagram is a graphical representation of the underlying software program. It consists of icons that represent typical programming elements such as constants, variables, subroutines, and loops. Figure 3 below is a screenshot of the block diagram for this system.

#### IV. IMPEDANCE ANALYZER

An impedance analyzer is a computational device that measures opposition to current in alternating current (AC) systems. Impedance refers to how physical or chemical properties interact with current & voltage. In other words, impedance is how well a material or component passes current.

This resulting ratio of voltage to current is measured in ohms ( $\Omega$ ). The equipment connects via input cables or uses a small handheld terminal probe for spot checking.

**V. TEMPERATURE SENSOR**

A temperature sensor is attached to the surface of the heating element. It is what provides feedback to the control system. The sensor is a J-type thermocouple sensor which sees much use in industry. It is capable of sensing temperatures from 32-900 degrees Fahrenheit. It is well suited for use with the SCXI system because the signal conditioning system takes care of the cold junction compensation as well as the scaling necessary to get an accurate temperature reading in degrees Fahrenheit.

**VI. BUILDING THE SYSTEM**

**A. Experimental Circuit.**

Firstly we done an experiment by using Lm35 which is a temperature sensor ,by using a Lm35 we can measure more accurately than a thermistor ,it can be able to measure high A. Experimental Circuit.

Firstly we done an experiment by using Lm35 which is a temperature sensor ,by using a Lm35 we can measure more accurately than a thermistor ,it can be able to measure high output voltage than thermocouple .the circuit diagram and the LabVIEW front panel and block diagrams are shown below.

In the above figure the 5v pin of analog pins is connected to positive ground and ground pin to the

negative ground. A3 pin is connected to the Vout. To measure the temperature change.

A light dependent resistor is placed so that if the temperature is low, moderate and high was shown by glowing different lights. Digital 8,9,10 pins are connected to the 1, 3, 4 pins of LDR. The 2 pin of the LDR is connected to ground.to the third pin of digital pins a fan is connected the fan will rotates if the temperature is high.

After performing with the Lm35 sensor we did the experiment by using the k-type thermocouple but this k-type thermocouple is interfaced with Arduino using Arduino software and the max31855chip.

**VII. WRITING AND DEBUGGING THE SOFTWARE**

Since the LabVIEW environment uses a graphical programming language, it is very easy to write and debug the software. You don't have to memorize code because each code element and structure can be picked from a menu and dragged into your program. The program can be run and debugged in the same window. This makes it very quick to troubleshoot and fix problems. There is an "Execution Highlighting" option that acts as a debugger by slowly stepping through your program. The slow action allows you to see how the code is behaving.

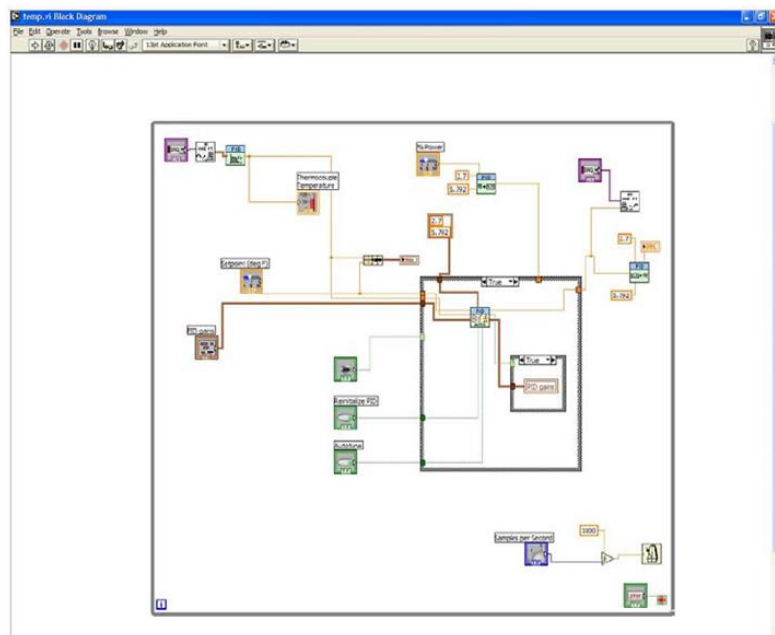


Fig. 3. Programming of LabVIEW in graphical form.

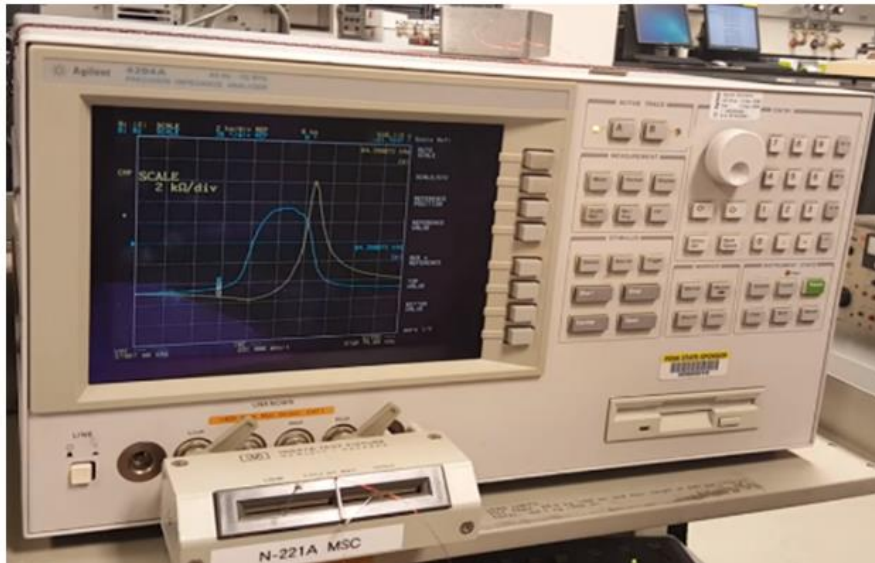


Fig. 4. Impedance analyzer

#### VII. TESTING THE SYSTEM

Testing of the system was done in sections. For example, each component of the PWM circuit was tested as it was built. The ability to send and receive signals using the SCXI system was tested separately from the software.

This approach makes problems easier to isolate when troubleshooting. Testing the complete system meant connecting the Impedance analyzer to the SCXI modules, and then running the LabVIEW VI. Testing the SCXI hardware is pretty straightforward. There is a software configuration tool from National Instruments called Measurement and Automation Explorer. Using this software, you can easily configure input and output channels and test them. Configuring and tested the input and output channels using this easy interface. When I was ready to use the channels in my LabVIEW program, I already knew they worked. Since the system is controlled with a graphical front-panel interface, it is very easy and intuitive to learn. The controls and instruments are modeled after their physical counter parts. They have the same mechanical action as one would expect. To run the system, first make sure that the hardware circuit is powered on and connected to the SCXI modules. Start the LabVIEW software on the PC and run the

VI. Everything can be controlled from the front panel[7-9].

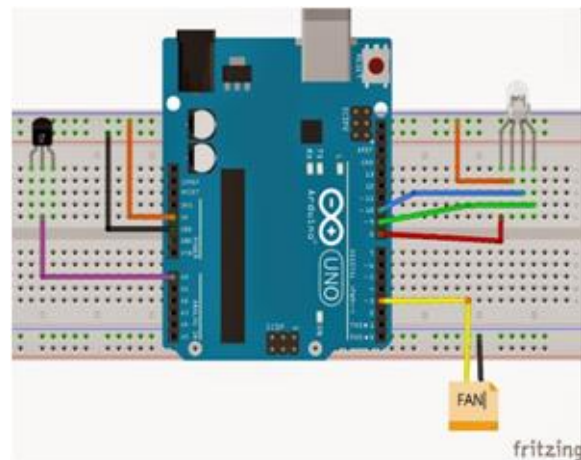


Fig. 5. Experimental Circuit diagram for LM35 using Arduino

#### XI. SETUP REQUIREMENTS

The system needs a power supply to operate the heater and impedance analyzer, a connection to the proper SCXI input and output modules, and a PC running the LabVIEW VI. One interesting thing is that the controlling PC need not be physically connected to the hardware circuit. As long as the hardware is connected to a networked PC via the SCXI system, the process can be monitored and controlled from any PC that can run the VI and communicate over the network.

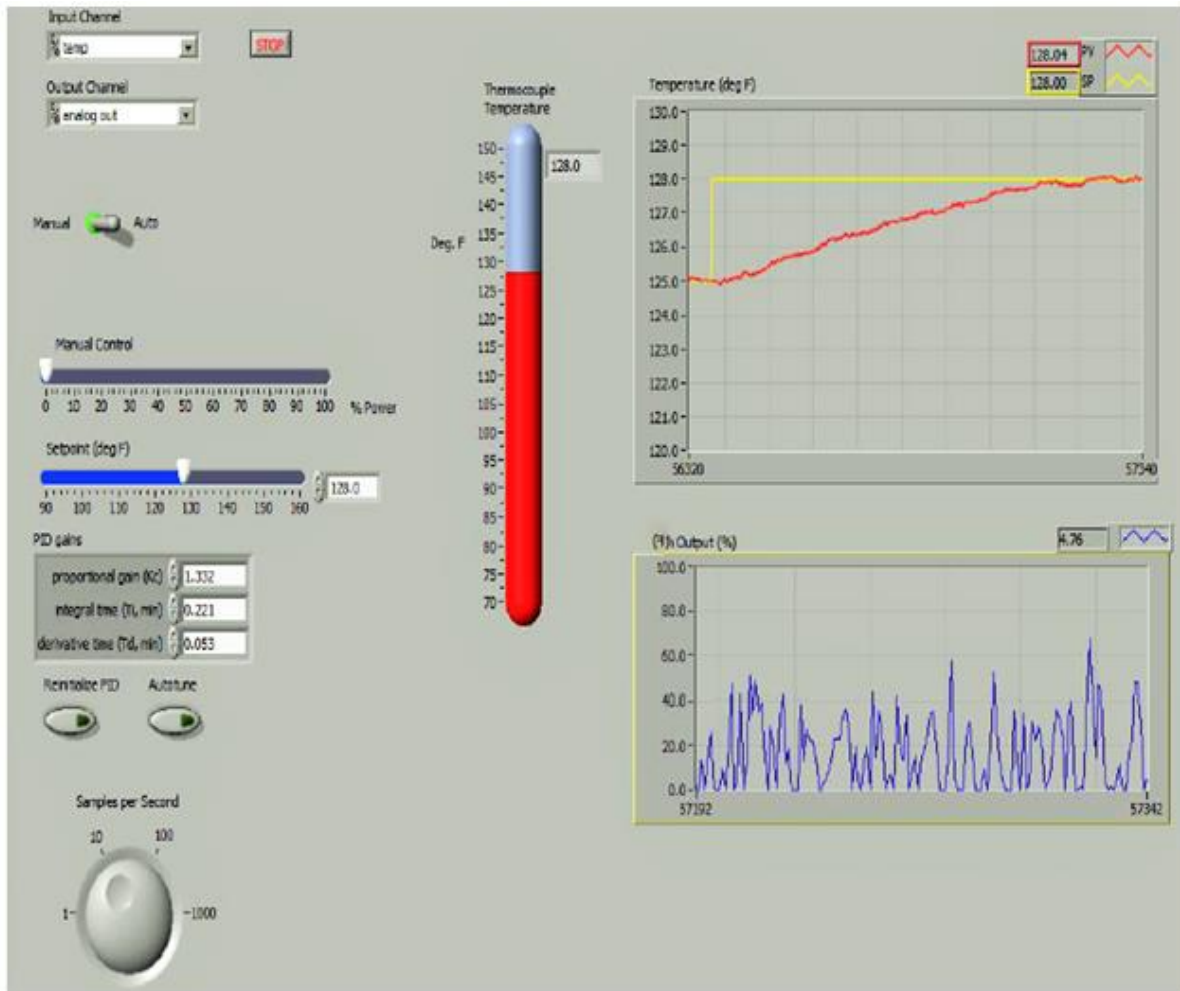


Fig.6. Controlling temperature output circuit by using LabVIEW.

## X. RESULTS, DISCUSSION AND TESTING OF THE CIRCUIT

Temperature plays a very vital role for good crystallization of the materials. Initially the temperature is set when the mains supply is switched ON, Furnace becomes ON which increases the temperature. Also, various materials have different melting points, it is necessary to program different temperature profiles according to the materials chosen.

For this, Programming is done to get a constant rise in temperature at regular interval of time. Once the required temperature is achieved it is kept constant for few hours. Then again it is decreased for fixed time. The rate of rise and decay time is selected according to the requirement, it may be same or different. First individual circuit modules

were fabricated and tested. Once they found working satisfactorily, the furnace was connected to the Impedance analyzer via suitable relay and contactor circuit. Visual indication is also provided to check the status of the furnace. The performance of each module and reliability of the circuit was checked and measured and found working satisfactorily. Different materials were grown with different temperature profile. The results obtained were satisfactory.

The PID VI that was used includes an auto tuning function. With the loop tuned, the controller was able to keep the process temperature within  $\pm \frac{1}{2}$  degree of the set point. The response to a three degree step change is shown below as Figure 6.

In this screenshot, you can also see the P, I, and D in fig. 3. Shows gains that were set by the

auto-tuning function. Getting the loop perfectly tuned is not really an issue for this system because even the 1-degree variation of an un-tuned system is too small to matter for practical applications.

#### XI. CONCLUSIONS

A simple and reliable temperature controller was designed and tested successfully. The K-type thermocouple is used as a temperature sensor. The temperature of the furnace is controlled up to 1200oC with an accuracy of  $\pm 1$ oC. The working of the controller is found satisfactorily.

#### XII. ACKNOWLEDGMENTS

Authors are deeply indebted to Prof. K. C. James Raju, Hyderabad Central University for his valuable support and expert guidance rendered to us.

#### REFERENCES

- [1]. Narong Aphiratsakun , Virach Wongpaibool And Kittiphon Techkittiroj, A Review On Temperature Process Control : Case Study On Boiler, Department Of Mechatronics Engineering ,Bangkok , Thailand , July 2011.
- [2]. P. A. Saudagar , D. S. Dhote , D. R. Solanke, Microcontroller Based Intelligent Temperature Controller For Greenhouse, Volume 1, International Journal Of Engineering And Science, December 2012.
- [3]. Theophilus Wellam , Bhudi Stiaawan, A Microcontroller based Temperature Monitoring System, Volume 53, International journal of computer applications, September 2012
- [4]. A. Nagoorkani, "Control Systems, "First Edition, RBA Publications, 2002.
- [5]. Sheshera S. Petal, D.R.Petil, B.H. Brahmhatt " Design of a low cost temperature controller for high temperature furnaces used in crystal

growth" International Journal of Research in Engineering and Technology, eISSN: 2319-1163 | pISSN: 2321-7308

- [6]. Kishori Jadhav , Nisha Sarwade Development of 4/16-Channel Data Acquisition System Using Lab VIEW Electrical department, VJTI, Matunga, 400019
- [7]. <http://www.ni.com/LabVIEW> 2012
- [8]. <http://www.ni.com/NI-DAQmx> 9.8
- [9]. <https://www.ni.com/visa/>

#### ABOUT AUTHOR(s)

**Rahul Gunde**, final year graduate of Department of Electronics and Instrumentation Engineering at Lakireddy Bali Reddy Autonomous Engineering College. He has been working in the area of LabVIEW programming since two years. He done his Internship at Central University Hyderabad. He also attended and acted as coordinator for various LabVIEW&instrumentationworkshops.

**Krishna Kanth Reddy Konda**, final year graduate of Department of Electronics and Instrumentation Engineering at Lakireddy Bali Reddy Autonomous Engineering College. He has been working in the area of LabVIEW programming since two years. She has done her Internship at Central University Hyderabad and he has also attended and acted as coordinator for various workshops in relation with instrumentation and LabVIEW.

**T. Satyanarayana**, Associate Professor, received his Ph.D from Acharya Nagarjuna University in 2010, India. He has published 30 articles in highly reputed International Journals and presented papers in International Conferences at Japan, Portugal, Spain & Poland. He is also having two ongoing Govt. of India funded research projects. He also worked in DST &DRDO, Govt. of India funded projects.