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Millienium3 PLC Based Temperature Control Using LM 35

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Abstract

This paper presents the PLC based temperature control using LM35 sensor. Measurement of temperature and its control has become a major part of the control systems operating in an environment which is temperature sensitive. In this paper, LM35 sensor is being used for the measurement of temperature and is then controlled using Programmable Logic Controller (PLC). The system will get the temperature from the LM35 and this temperature is then compared with the desired temperature. According to the measured value of the temperature, either the fan or the heat will be switched on. For the purpose of achieving the above measurement and control PLC is used as the interface. Before implementing these ideas directly into making hardware design, software simulation is being done using PLC software. The result is obtained in the form of proportional electrical signal i.e voltage. This voltage is manipulated directly to give the temperature which is being measured.

Keywords: PLC, LM35, temperature sensor.

Introduction

Temperature is defined as a physical property of matter which expresses quantitatively the measure of hotness and coldness. Most of the physical properties of materials including solid, liquid, and gaseous or plasma, density, solubility, vapor pressure, and electrical conductivity depend on the temperature[1]. The rate at which a chemical reaction takes place is basically determined by the temperature. Temperature also determines the thermal radiation emitted from a surface[2]. The process temperature can be accurately controlled with the help of a controller without extensive operator involvement. The temperature controller accepts a temperature sensor such as a thermocouple or RTD or LM35 sensor as input. It compares the measured temperature to the desired control temperature or set point and provides an output to a control element. There are three basic types of conventional controllers: ON/OFF controller, Proportional and PID. Based on the application, any of these controllers is selected to control the temperature[3] recent advances in technology like PLC made it possible to have the temperature control included in the same instrument that is also controlling the other aspects of the equipment[4].

Transduction

Devices measuring various physical parameters are being used extensively throughout the world. The parameters may be force, pressure, temperature, displacement and other such quantities. This paper documentation is written with an intension to give you an overview of how to measure the temperature and control it. All this data is being obtained in the form of electrical signals. For this purpose, the transduction principle is being used in the form of sensors. i. Converting a signal in one form of energy to another form of energy is termed as the process of transduction. ii. An electrical transducer is a device which converts various signals to proportional electrical signal.

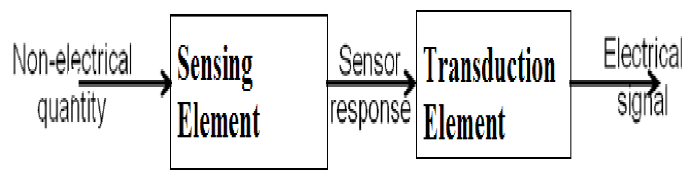

Figure-1
Transducer block diagram

Basically, an electrical transducer consists of two parts which are sensing or detecting element and transduction element. Commonly, the sensing or detecting element is known as sensor. The block diagram of the transducer is shown in figure-1.

A transducer is a device that receives energy from one system and transmits it to another in different forms. Basically there are two types of transducers: namely electrical and mechanical. The mechanical transducers are those primary sensing elements that respond to change in physical condition of a system and gives output in different form. For example, when a bimetallic strip is subjected to a temperature change then the output is the mechanical displacement of the strip. The mechanical transducers are distinguished from the electrical transducers on the basis of the output signal generated. The mechanical transducers generate output signal which is mechanical in nature. The electric transducers respond to non-electrical quantities but generate output signal which is electric by nature.

It is practically always possible to use either mechanical or electrical transducer for the measurement of any physical parameters. But it is observed that for each measured, electrical transducers are preferred over the mechanical transducers.

Temperature Sensor

For the measurement of temperature, an LM35 temperature sensor is being used. LM35, an integrated circuit sensor to measure temperature with an electrical output proportional to the temperature (in°C) is used in this paper. It operates for biasing voltage of +4 volts to +40 volts and has sensitivity of 10 mV/°C.

Characteristics of LM35 Sensor: i. An output voltage which is proportional to the Celsius temperature is obtained. ii. Sensitivity factor is .01V/°C iii. The sensor does not require any external calibration or trimming and maintains an accuracy of +/-0.4 °C at room temperature and +/- 0.8 °C over a range of 0°C to +100 °C. iv. LM35 sensor draws only 60 micro amps from its supply and possesses a low self-heating capability. v. Its self-heating cause's less than 0.1 °C temperature rise in still air.

Uses of LM35 Sensor: i. Temperature can be measured more accurately using this sensor than with any thermistor. ii. The LM35 generates a higher output voltage when compared with that of thermocouples and may not require the amplification of the output voltage

Process control loop: The Figure-2 shows the general arrangement of process control loop. It consists of four elements, i .Process, ii. Measurement, iii. Controller iv. Control element.

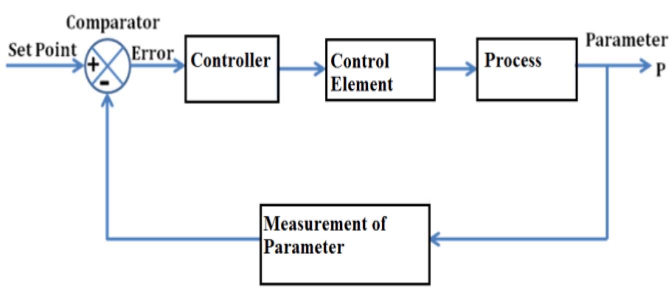

Figure-2
Process control loop

For the proper feedback it is necessary to measure the value of the actual parameter P. This is done using transducer. For process control i.e. control of the physical parameters, the parameter is measured first and then fed back to the comparator which compares this value with a desired preset value by the user as shown in figure-2. The difference which is the error is fed to the controller which reduces the error by minimizing it. The control element controls the parameter accordingly and it is then further processed to achieve the desired value.

Temperature controllers

The temperature of a process can be controlled with varying degrees of accuracy with a temperature controller. The input to the temperature controller is provided by a sensor such as a thermocouple, RTD, or thermistor which is present in the controller. The temperature controller compares the actual temperature with the preset temperature that the user has provided [5].

There are three basic types of controllers: i. On/Off Control, ii. Proportional Control and iii. PID Control

On/Off Control: An on-off controller is the basic type of temperature control device [6,7]. There are two settings for this controller. It can be either on or off as shown in Figure-3. If the actual temperature is below the preset point, the output will be on for heating control. In cooling it is on when the actual temperature is above the preset point. This is a typical heating and cooling thermostat. Often times the on off temperature controller is programmed with a differential. The differential will turn on or off the system after the actual temperature has exceeded either side or the on off set point for a period of time. On/Off temperature controllers are not as accurate or precise as needed in many operations. On/Off control has the simplest of control modes. This controller is usually used where a precise control is not necessary[8]. One special type of On/Off control used for alarm is a limit controller. A latching relay is used in this controller, which must be manually reset, to shut down a process when a certain temperature is reached [9].

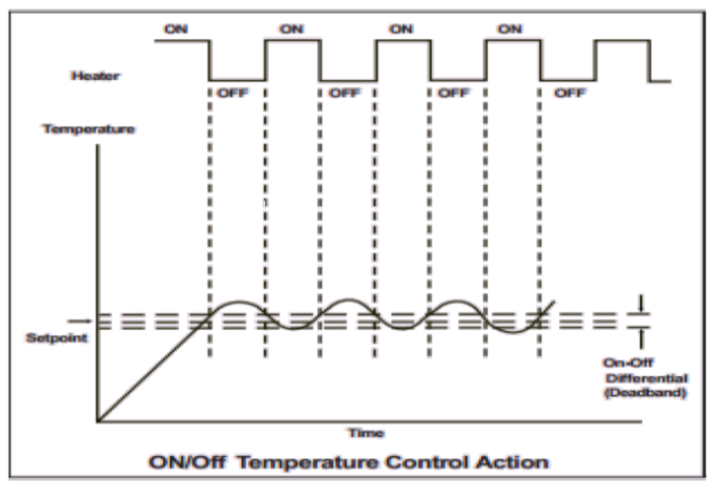

Figure-3
ON/OFF control

Proportional Control: A Proportional controller is an enhanced version of the On/Off temperature controller which gives the better performance. It keeps the temperature controller from cycling on and off constantly. This controller reduces the percentage of power supplied to the heater as the preset point is reached. It causes the unit to move beyond the preset point but remaining in the band. This type of controller will use less energy to maintain temperature. Proportional controls are designed to eliminate the cycling associated with On/Off control[10]. This has the effect of slowing down the heater so that it will not overshoot the preset point, but will approach the preset point and maintain a stable temperature[11].This proportioning action can be accomplished by turning the output on and off for short time intervals[12].

PID Control: The Proportional Integral Derivative Controller combines proportional control with two additional adjustments, which helps the unit automatically compensate for changes in the system[13,14,15.] Time is the unit of measure which basically incorporates the integral and derivative features. The integral and derivative features in a temperature controller are called Reset and Rate respectively. The PID temperature controller provides the most accurate and consistent temperature control when compared with that of the other controllers. The proportional, integral and derivative gains must be individually tuned to a particular system using trial and error. It provides the most accurate and stable control of the three controller types, and is best used in systems which have a relatively small mass and for the systems that react quickly to changes in the energy added to the process. The limitation in this type of controller is the tuning of PID parameters or gains. Hence, in this paper a PLC is used to control the temperature which is basically used for automation applications.

PLC: A Programmable Logic Controller (PLC) is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, light fixtures etc. The functionality of the PLC has evolved over the years to include sequential relay control, motion control, process control, distributed control systems and networking. The data handling, storage, processing power and communication capabilities of some modern PLCs are approximately equivalent to desktop computers. Unlike general-purpose computers, the PLC is designed for multiple inputs and multiple output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-21 volatile memory

There are many benefits that can be obtained when equipment is controlled by a PLC. This is particularly true if all aspects of the equipment, including temperature control, are controlled by the PLC. PLCs are programmed using application software on personal computers. The computer is connected to the PLC through Ethernet, RS-232, RS-485 or RS-422 cabling.

The programming software allows entry and editing of the ladder-style logic or the function block diagram. The software generally provides functions for debugging and troubleshooting the PLC software during simulation. The PLC program will be uploaded and downloaded by the PLC software, for backup and restoration purposes. Some models of programmable controller have the feature that the program is transferred from a personal computer to the PLC though a programming board which writes the program into a removable chip such as an EEPROM or EPROM. In this paper, a millennium 3 PLC is used for the temperature control.

Hardware Design: The basic circuits which are being used in the hardware design of the controller are i. Amplifier circuit, ii. Power supply circuit, iii. *AMPLIFIER CIRCUIT*

In the amplifier circuit design, R_1 and R_f which are resistors and an op-amp µ741 are used as shown in figure-4. The connections are such that the feedback resistor Rf is connected between the output terminal (6) and the inverting terminal (2) of the op-amp. R_1 is connected between the inverting terminal (2) and ground.

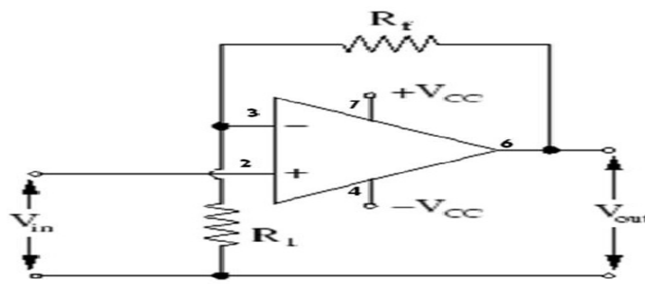

Figure-4
Noninvertingamplifier circuit

The biasing voltage is connected between the 7th and 4th pins of op-amp. The output which is to be amplified is connected to the non-inverting terminal (3). The output of the op-amp is obtained at the output pin (6) and is in the range of 0– 5 Volts.The output of the op-amp is given as:

$$V_o = V_i\left[1 + \frac{R_f}{R_i}\right] \quad (1)$$

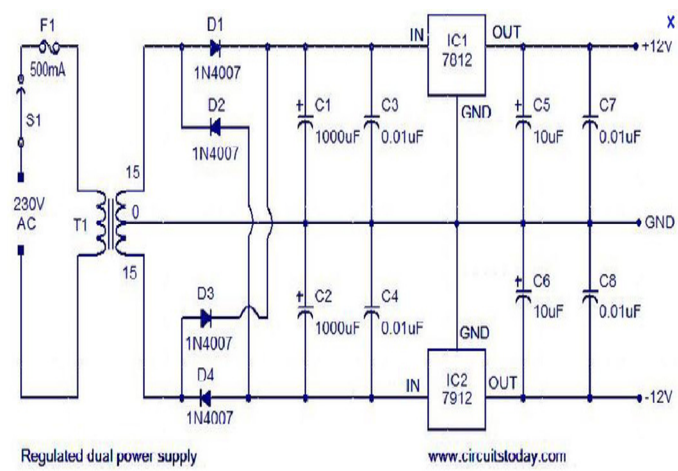

Figure-5
Power supply circuit

Power supply: The power supply circuit is as shown in figure-5.A single phase AC supply of voltage 230V is given to the 15-0-15, 0.5 A step-down transformer. The output of the transformer is given to the diode bridge rectifier. The output of the diode bridge rectifier is given to set of capacitors of rating 1000µF, 25 Volts and 10µF, 25 Volts to reduce ripples. The output of capacitors is given to 7812 regulator to obtain +12 volts and parallel to 7912 regulator to obtain - Volts.

This +12 Volts acts as Vcc and -12 Volts acts as Vee for the amplifier circuit. The supply of +12Volts is then connected to 7805 regulator to obtain +5 Volts which is the supply voltage to the LM35DZ temperature sensor.

Block Diagram: The LM35 temperature sensor has three pins: one for giving input DC voltage of +5V (+4V to +30V), one for connecting to ground and one output pin. It gives the equivalent electrical output for the temperature which is to be measured.

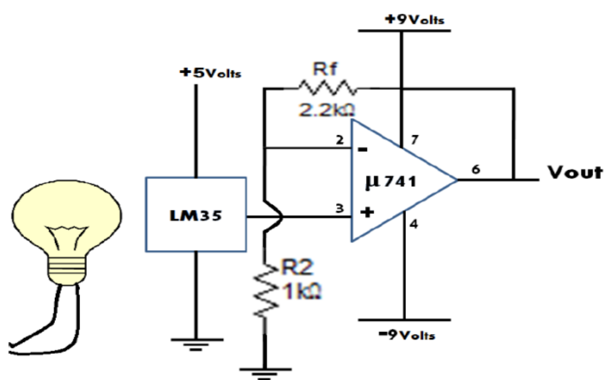

Figure-6
Circuit diagram of Temperature sensor

The scale factor of the LM35 is 10mV/°C and it can give a voltage equivalent for a maximum of 150°C temperature. So, the maximum voltage will be 1.5V i.e. the voltage obtained from LM35 will be in the range of few mV to 1.5V. Hence, we have to amplify the voltage to read it accurately. For this purpose an amplifier circuit is used as shown in figure-6.

Operating Modes of the Controller: There are several operating modes for the program to simulate and monitor in the workspace[16-18]. The various operating modes are listed below:

Edit Mode: Edit mode is used to construct programs in FBD mode, which corresponds to the development of the application.

Simulation Mode: In simulation mode, the program is executed offline directly in the programming workshop .In this mode, each action on the chart (changing the state of an input, output forcing) updates the simulation windows.

Monitoring mode: In Monitoring mode, the program is executed on the controller and , the programming workspace is connected to the controller**.**

In the present work, the program is developed in the Function Block Diagram Mode, since it has the components or the blocks which are pictorially understood and easy for verification.
The PLC block diagram is as shown in figure-7

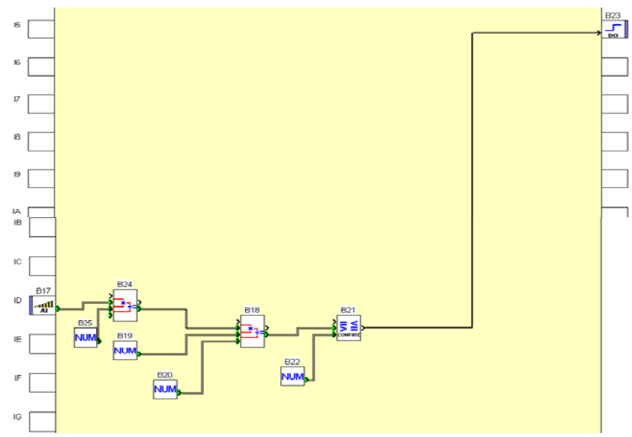

Figure-7
PLC block diagram

Conclusions

Temperature Controllers receive sensor signals and control heaters or other devices to maintain a preset temperature. These controllers are widely used for humidity, pressure, and flow rate control. So the measurement and control of temperature is very much necessary. In this paper, temperature is first sensed by LM35 sensor and then the electrical output (of few mv) is given to amplifier circuit containing µ741 op amp which amplifies the output so that its analysis can be done properly. The output of the amplifier circuit is then given to relay. Thereby controlling the temperature manually. This method of temperature control is very simple but does not produce accurate result. So temperature control is done in an effective manner by using PLC software. In this method, the system gets the temperature from the IC and this temperature is then compared with the preset temperature value. The results obtained in the proposed method of control using PLC are more effective than the conventional methods.

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