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Design and Implementation of a Temperature Control and Monitoring System

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Abstract

This paper aims to constructive and functional knowledge of an automatic control and temperature monitoring system for a thermal enclosure equipped with a Brainchild BTC-9100 temperature controller. The thermal enclosure is designed for preserving the food at a controlled temperature falling within a range of 63-66 °C, heating enclosure achieved by free convection. This system is implemented in Measurement Laboratory in our University.

Key words*: temperaturecontrol system, fuzzy PID controller, solid state relay.*

Introduction

It is known that keeping a proper climate for food can bring positive changes as a result of the action of certain internal and external factors, but their negative effects too, where storage conditions are inadequate.

Convection heat is the primary heat transfer phenomenon that occurs in the fluid medium and the surface of separation of the phases. It is characteristic of moving averages; heat is transported by fluid particles moving. In general, the convection is accompanied by the conduction, given the fact that the particles are moving and in direct contact with each other.

Basic law of convection is Newton's law that says that the intensity of the heat flux on the surface of a solid body moving him transfer fluid is given by:

$$q = \alpha(Ts - T\infty), \tag{1}$$

where T_s – thermodynamic temperature of the surface of the solid body; T_∞- thermodynamic medium temperature of the fluid; α - convective heat transfer coefficient witch is determined experimentally.

Convective heat flux intensity is influenced by various factors such as cause fluid motion, fluid flow regime, the shape and position of the solid body, the circulating fluid space (open or closed).

Temperature Control System Configuration

The configuration of a temperature control system is presented in Fig. 1 [1]. This system is implemented in Measurement Laboratory in our University.

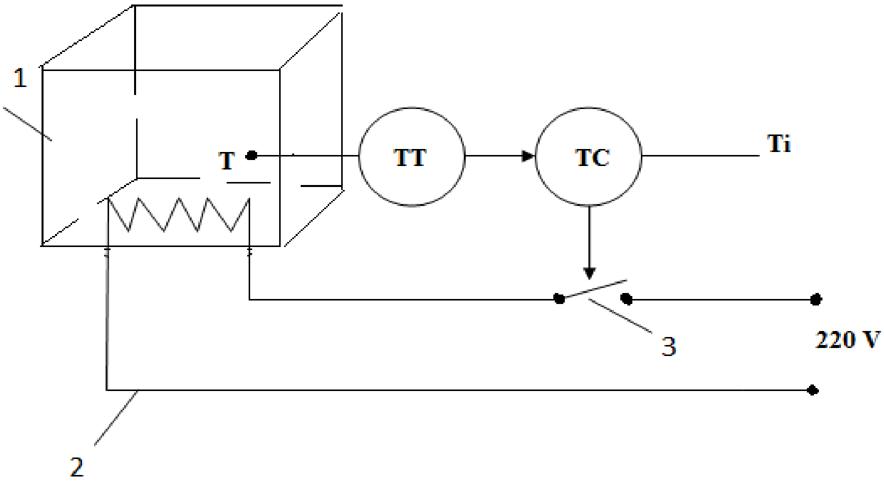

Fig. 1. Temperature control system configuration:
TT – temperature transducer; TC –Brainchild BTC-9100 temperature controller;
1- thermal enclosure; 2 – heating resistance; 3 – solid-state relay SSR

The thermal enclosure is made of stainless steel thermal food (fig. 2**)**. This option was chosen because stainless steel is low carbon steel, which contains chromium proportion of 10%. The addition of chrome steel gives it its unique properties and corrosion resistance. This allows the formation of film hard chromium, chromium oxide invisible to the steel surface, the film that is capable of self reface in the case of mechanical or chemical deterioration. Enclosure walls are lined with wool to lessen heat loss, which leads to a decrease in electricity consumption. Thermal heating chamber there are three resistors connected in parallel.

The Brainchild BTC-9100 temperature controller [3], used for temperature control, is part of fuzzy PID controllers with microprocessor; it has two posters of 4 digits with very bright LEDs that provide easy reading from a distance. Fuzzy logic technology enables the achievement of the desired process in the shortest time possible. Also, the overshoot at startup and load the external disturbance is minimal.

The Brainchild BTC-9100 is a controller with panel mounts 1/16 DIN. It can also be mounted on DIN rail using a DIN rail mounting kit. It is powered from 11 to 26 or 90-250Vcc/ca and is standard control relay 2A. The second output can be used as a control command for cooling or alarm function. The both outputs can be selected in the following variants: output triac, 5V logic output and linear current or voltage output for controlling an external device. The alarms can be configured in six ways and the third output can be configured as a timer.

The inputs of controller is signals from Pt100 or thermocouples type J, K, T, E, B, R, S, N, L. A/D conversion of the input signal is made with an 18 bits resolution. High sampling rate allows rapid process control.

Brainchild BTC-9100 temperature controller is composing by a numeric analog CAN and two LED displays Fig. 2.

Digital communication RS-485 or RS-232 is available as an option and allows the integration of devices in the control system overseen by the computer [3]. The presence of a communication port helps the automatic configuration, the calibration and the testing without using the front keys. The following diagram compares the behavior of controlled system with and without Fuzzy technology (fig. 3).

Fig. 2. Implementation of the temperature control system
(the thermal enclosure and theBrainchild BTC-9100 controller)

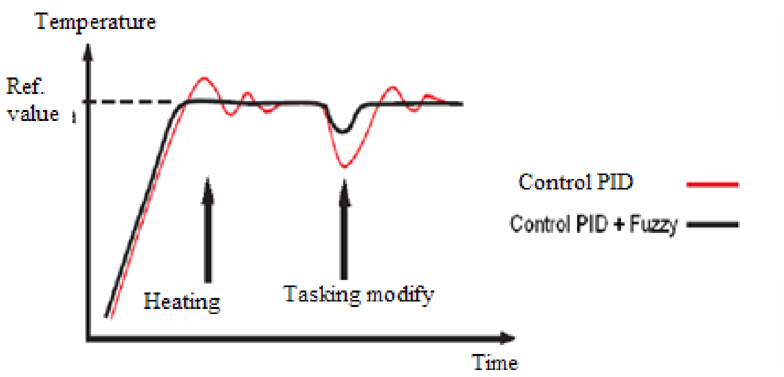

Fig. 3. PID and fuzzy control diagram

The temperature transducer is a Pt100. Depending on the temperature inside, the thermoresistance change their resistance, which is sent to the controller via the electrical connections positioned on the rear.

The actuators are devices that can change the controlled flow of matter or energy flow in a process. As actuators on use a solid state relay SSR (fig. 4). **A solid-state relay** (SSR) is an electronic switching device in which a small control signal controls a larger load current or voltage. It consists of a sensor that responds to an appropriate input, a solid-state electronic switching and a coupling mechanism to activate this switch without mechanical parts.

Fig. 4. Solid state relay (SSR)

Connection diagram of the system is designed and shown in Fig 5.

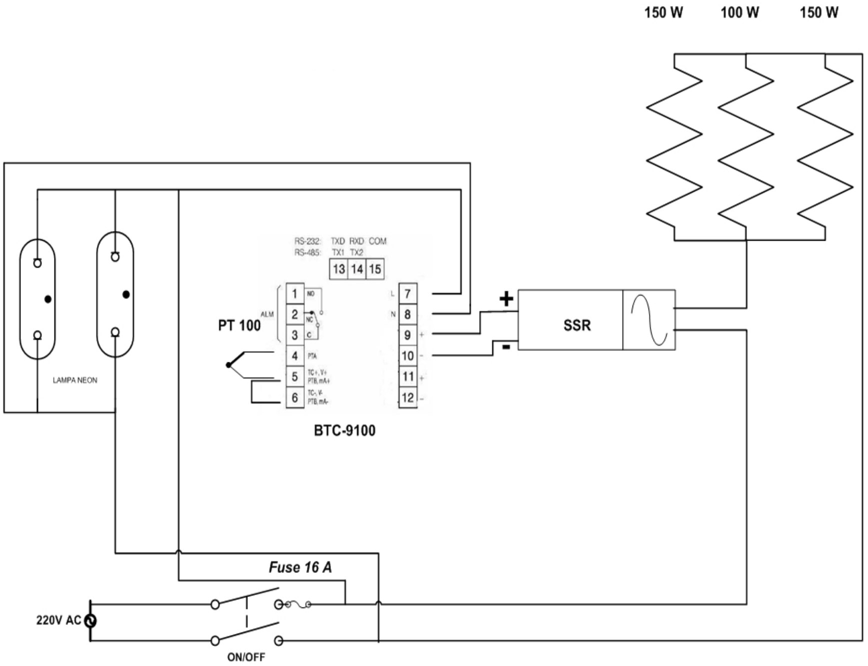

Fig. 5. Electrical connections of the temperature control system

Controller Monitoring Application

Monitoring program can be optionally purchased from the controller manufacturer. We can edit the various settings of the monitoring program individual per controller. The program supports four behaviors to specific setpoints set: Generates alarms / events, perform optional logging event / alarm, send email to different people directly responsible, automatically adds a comment to the choice of the 50 available (editable) (fig. 6) [3].

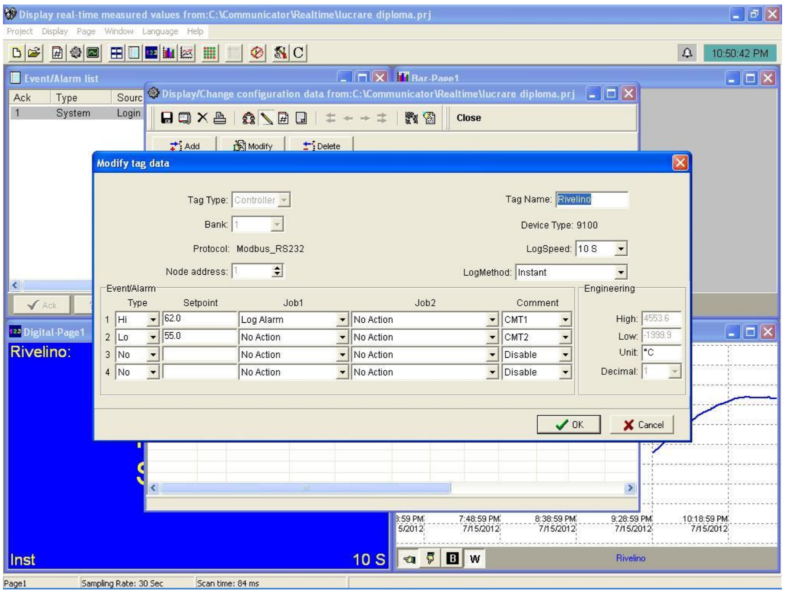

Fig. 6. Interface page

The main page includes four windows [3]: events / alarms; digital display of process temperature and set point; display column and display temperature alarm set point site; graphical display of process (Fig. 7).

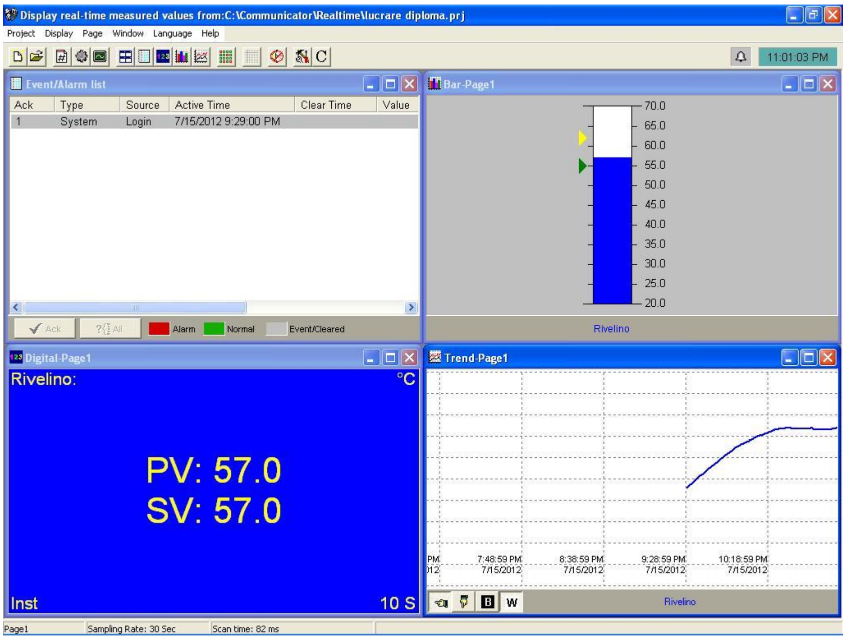

Fig. 7. Main dialog page

In Fig. 8 is shown the general parameterization window of a controller for our application.

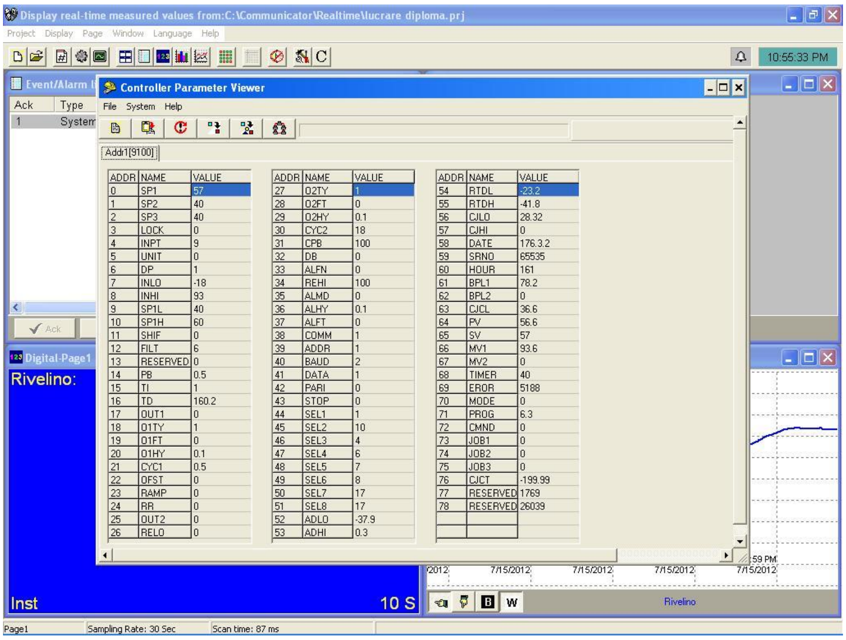

Fig. 8. General parameterization window [3]

The software controller included graphical displays option of the histogram process [3]. Data files can be printed, saved or exported in a .csv files (fig. 9).

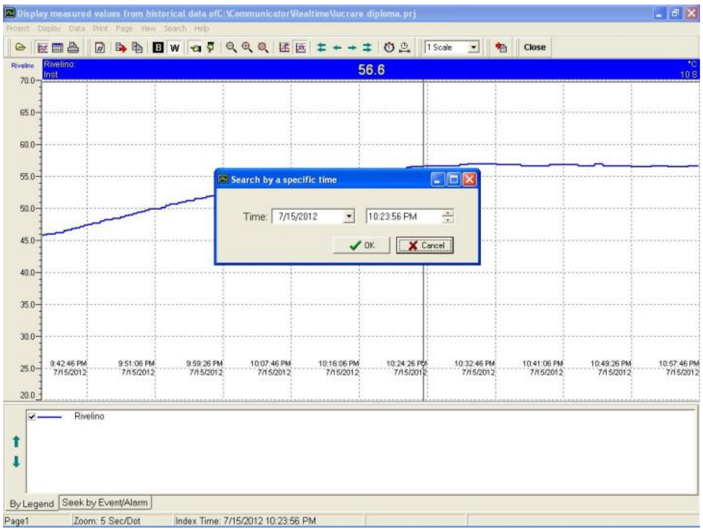

Fig. 9. Data graphical window for current application

Conclusion

This work aims to achieve a practical application that meets the objective of monitoring the temperature in a thermal enclosure. With this type of controller and small modifications, simple fact, it can be used in other applications such as temperature control in a house; controlling the temperature of refrigerators; control of water temperature in storage tanks. The advantages of using these fuzzy controllers in the automation of processes are relatively low cost and high reliability. Due to the scope of the system and the possibility of modifying the parameters of the controller, the system allows its use in many industrial and residential applications.

References

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3. * * * – *Brainchild BTC-9100Manual.pdf.*

Proiectarea şi implementarea unui sistem de reglare şi monitorizare a temperaturii

Rezumat

Lucrarea prezintă proiectarea şi implementarea unui sistem de reglare automată şi monitorizare a temperaturii utilizând un regulator numeric Brainchild BTC-9100. Procesul reglat este reprezentat de o incintă confecţionată din inox. Dispozitivul de automatizare cuprinde un traductor de temperatură Pt100, un regulator de temperatură Brainchild BTC-9100, elementul de execuţie fiind un releu solid-state SSR. Comunicaţia digitală de tip RS-485 sau RS-232 este disponibilă ca opţiune şi permite integrarea în sisteme de control supervizate cu ajutorul calculatorului. Programul de monitorizare generează alarme/evenimente, execută opţional logarea evenimentului/alarmei, trimite email către diferite persoane direct responsabile, adaugă automat un comentariu.