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Temperature Stability Measurement of a Microwave Oven by Using PID Based Controller

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Abstract: In a nutshellfood cooking industry uses microwave, conduction or convection based system for making dishes. Proposed system is used to make a universal cooking system, with microwave and conduction methodology; here two shelves are available for users. One shelf is for microwave and other one is for conduction oven. In conduction compartment desired system uses PID based controller and thermocouple based feedback system for maintaining constant temperaturefor cooking with less response time and better stability Control. Desired system is User interaction product, provided with LCD and keypad modules to select different temperature and timing based operation. Thus the developed system is more reliable.

***Key Words* - Microwave, Conduction Oven, PID Controller, Temperature, Thermocouple, Feedback system, Set Point, Overshoot, System, Heater, Arduino, MATLAB Simulink.**

I. INTRODUCTION

PID control allows a system to accurately adjust for load or set point changes. Implementing a PID controller, however, requires that it be 'tuned or adjusted for the system for which it is installed [1, 2]. One apparatus for heating the samples is an electric kiln. This kiln is powered by 120 VAC and draws 16 amps. It is capable of producing temperature of 400 degrees F. The kiln is fitted with an infinite heat switch. The switch acts as a duty cycle switch. The higher the setting the longer the heater is on and the less time it is off. Visual feedback of the temperature is provided to the operator via an analog temperature meter. As the temperature approaches the desired amount, the operator must use his judgment to adjust the rheostat. If the temperature is rising at a fast rate, it will probably overshoot the desired set point and the operator must turn down the setting. This project involves retrofitting the kiln with an automatic control using a small microprocessor based PID controller. The controller accepts a K type thermocouple and switches the heater on and off through a solid state relay. The process variable is acquired by a data logger and transmitted to a computer for storage, processing.

1.1 System Diagram

System uses Arduino nano controller. Arduino nano is interfaced with thermocouple temperature sensor, Keypad and LCD is interfaced for guiding users. Upon selecting desire temperature from keypad, system turns on the relay and continues to supply power till system reaches at desired level. Then PID controller is made by applying PID rules to Arduino controller and then system gives stable output using heating coil.

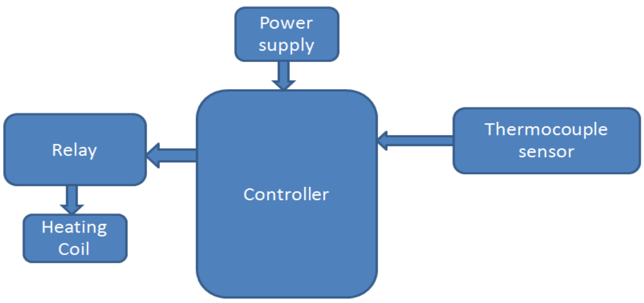

Figure 1: Arduino nano pin out
Table 1: Arduino Nano Specifications

Microcontroller	Arduino nano
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	7
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	128 KB of which 4 KB used by boot loader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

1.2 Reason for selecting the project

The reason for selecting and implementing this project was to get better food quality and vitamin rich food. Also to get stable constant temperature form oven.

It is the simplest methodology to make the system stable by implementing PID algorithm to a controller.

1.3 Objective of project

- The main objective in proposed system is to make system temperature constant.
- Another objective of obtaining a stable system (Oven) is to obtain vitamin rich food.
- Stability control using PID algorithm for food making temperature.
- To develop a Keypad and LCD based system.

II. Methodology And Implementation

PID stands for Proportional-integral-derivative. PID controller continuously calculates an error value e(t) as the difference between a desired set point (SP) and a measured process variable (PV) and applies a correction based on proportional, integral, and derivative terms (denoted P,I, and D respectively), hence the name. PID controller maintains the output such that there is zero error between process variable and set point/desired output by closed loop operations.

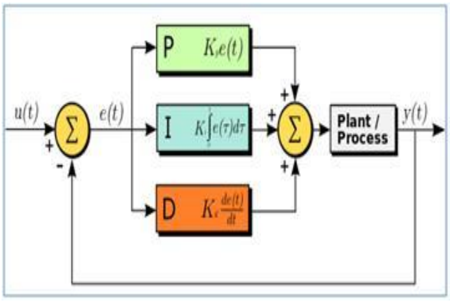

Figure 2: Feedback system developed using a PID Controller

PID Output Graph

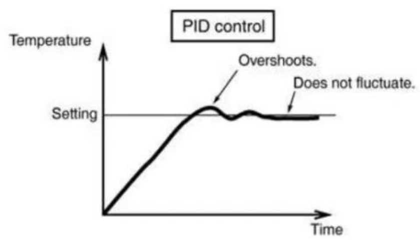

Figure 3: PID waveform

P controller eliminates the stay state error through the interval term. But we also made it clear that neither the p term nor I term can contribute to actively dampening the overshoots. This is where the derivative comes into play. Let's look at how this new term handles the error signal the job of the derivative term is to take the rate of change of the error as its control signal. The proportional term decreases the rise time the interval term eliminates a steady state error and the derivative term reduces the overshoots and ringing.

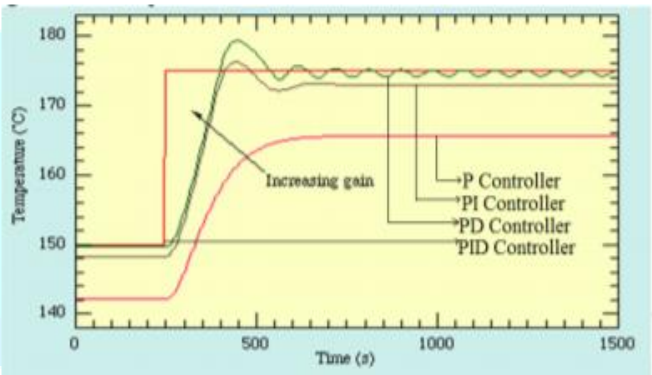

Figure 4: PID response of temperature system

III. Component Details

A. ARDUINO NANO

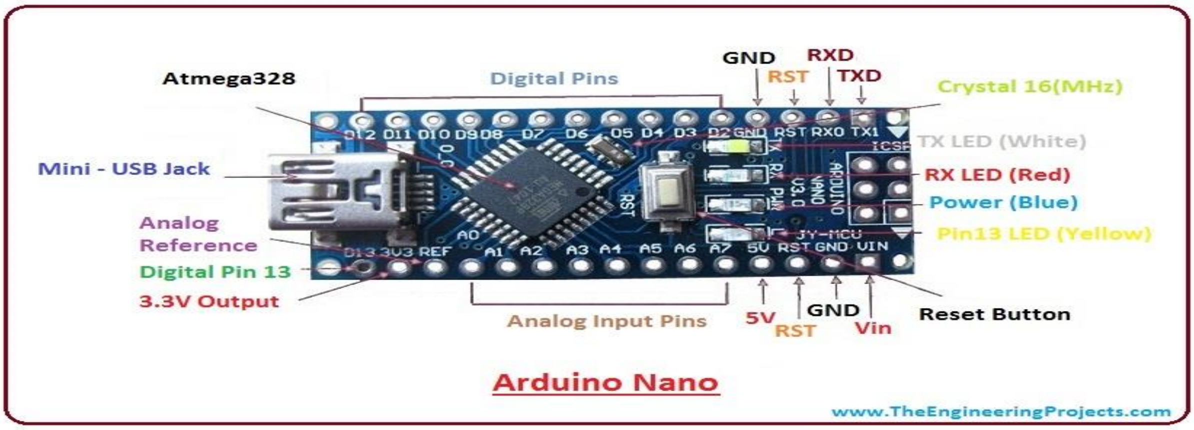

Figure 5: Arduino Nano pin out

Pin Functions

- Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX). Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the FTDI USB-to-TTL Serial chip.
- External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2). These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt () function for details.

- PWM: 2 to 13 and 44 to 46. Provide 8-bit PWM output with the analog Write() function.
- SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Duemilanove and Diecimila.
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- I2C: 20 (SDA) and 21 (SCL). Support I2C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I2C pins on the Duemilanove or Diecimila.

B. MAX 6675 K-TYPE THERMOCOUPLE

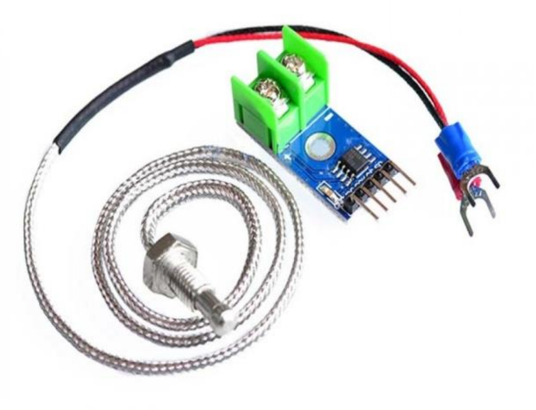

Figure 6: Max 6675 K-Type Thermocouple

Features

- Working voltage: DC-5V
- Operating Current: 50mA
- Temperature measuring range: -2°C to 800 °C [Test procedure for 2-800 °C]
- Temperature measurement accuracy: ± 1.5 °C
- Temperature resolution: 0.25 °C
- The output mode: SPI digital signal
- With a fixed mounting holes for easy fixed installation.
- Storage temperature: -20 ~ 80 °C
- Module weight: 4g approximately
- Module size: 25mm * 15mm * 13mm

C. LCD DISPLAY

Figure 7: Alphanumeric LCD display

Features

- Operating Voltage is 4.7V to 5.3V.

- Current consumption is 1mA without backlight.
- Alphanumeric LCD display module, meaning can display alphabets and numbers.
- Consists of two rows and each row can print 16 character.

IV. Results And Discussion

The temperature stability results are obtained and analysis of data acquisition system is done in MATLAB GUI software. Fig.5 and 6 show the Temperature stability result and analysis for the system.

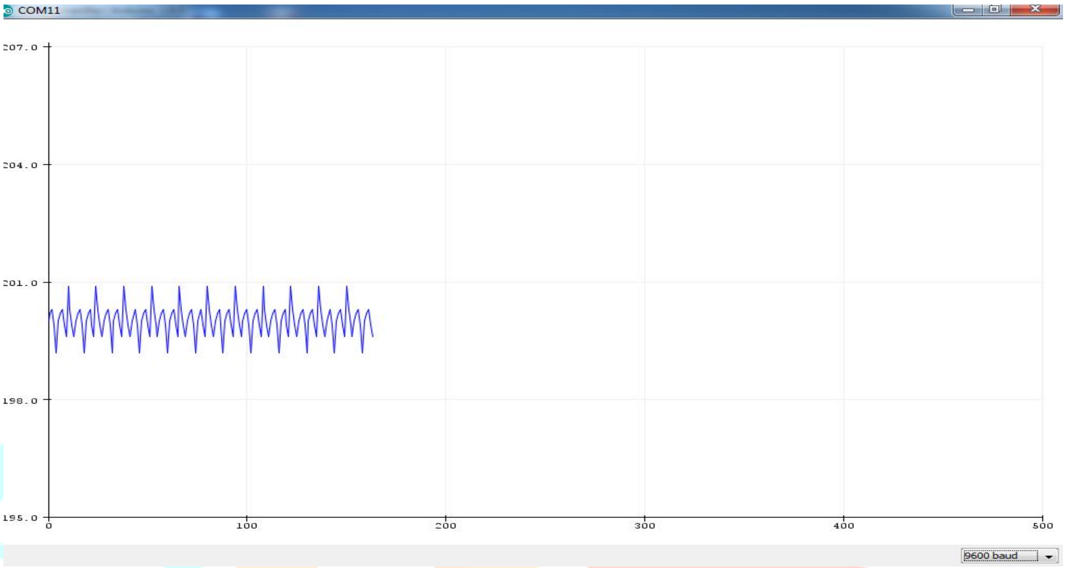

Figure 8: Arduino serial plotter graph for Set Temp. 200 *C

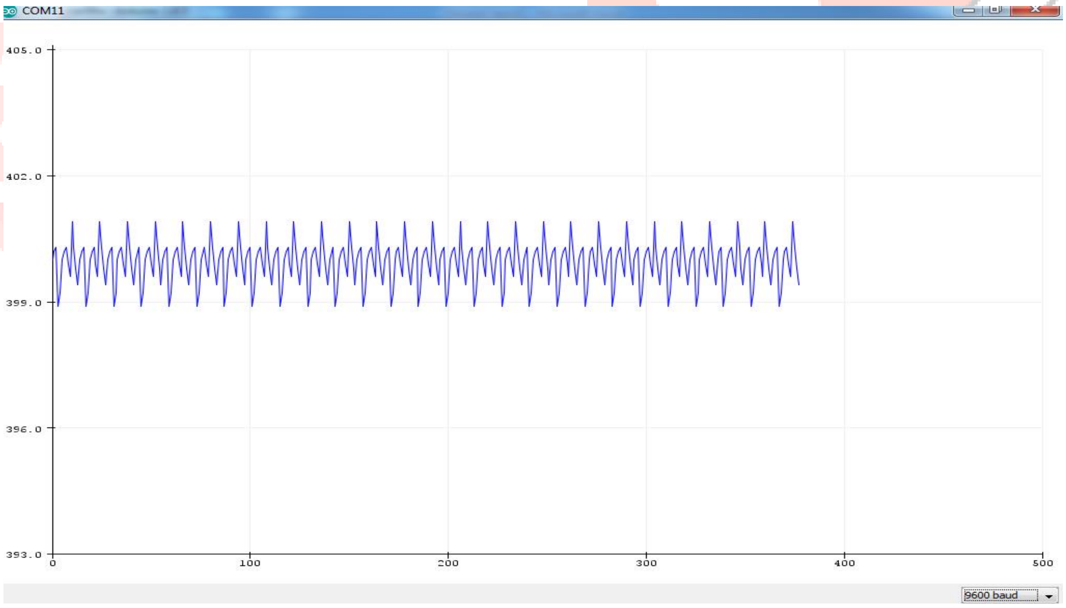

Figure 9: Arduino serial plotter graph for Set Temp. 400 *C

Fig.7 and 8 show the Temperature stability result and analysis in MATLAB GUI.

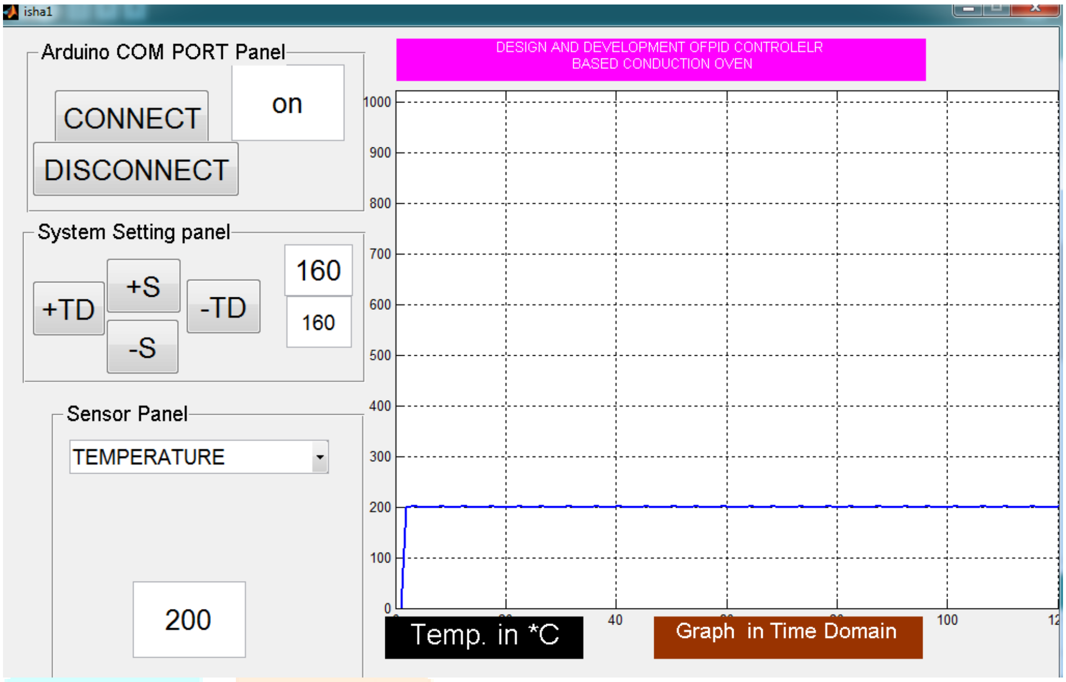

Figure 10: MATLAB GUI graph for Set Temp. 200 *C

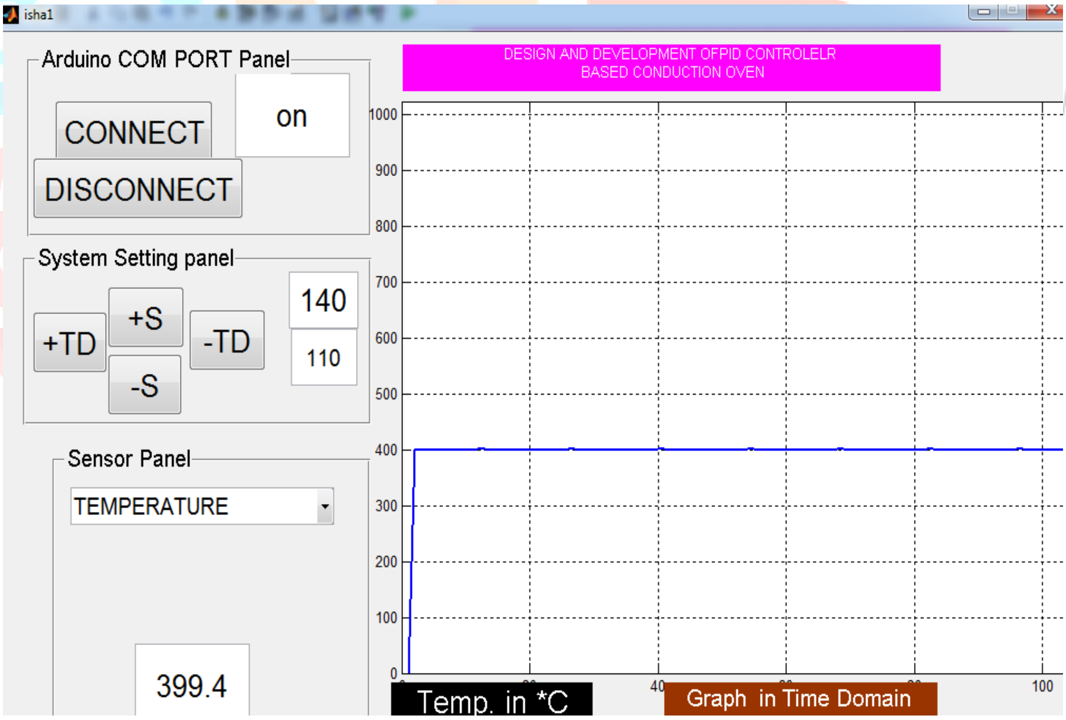

Figure 11: MATLAB GUI graph for Set Temp. 400 *C

Here, the results are obtained and analysis of data acquisition system is done in MATLAB GUI Software. Thus a stable temperature output is achieved using the PID controller. Also, the stability resolution is +0.5 degree to -0.5 degree *C.

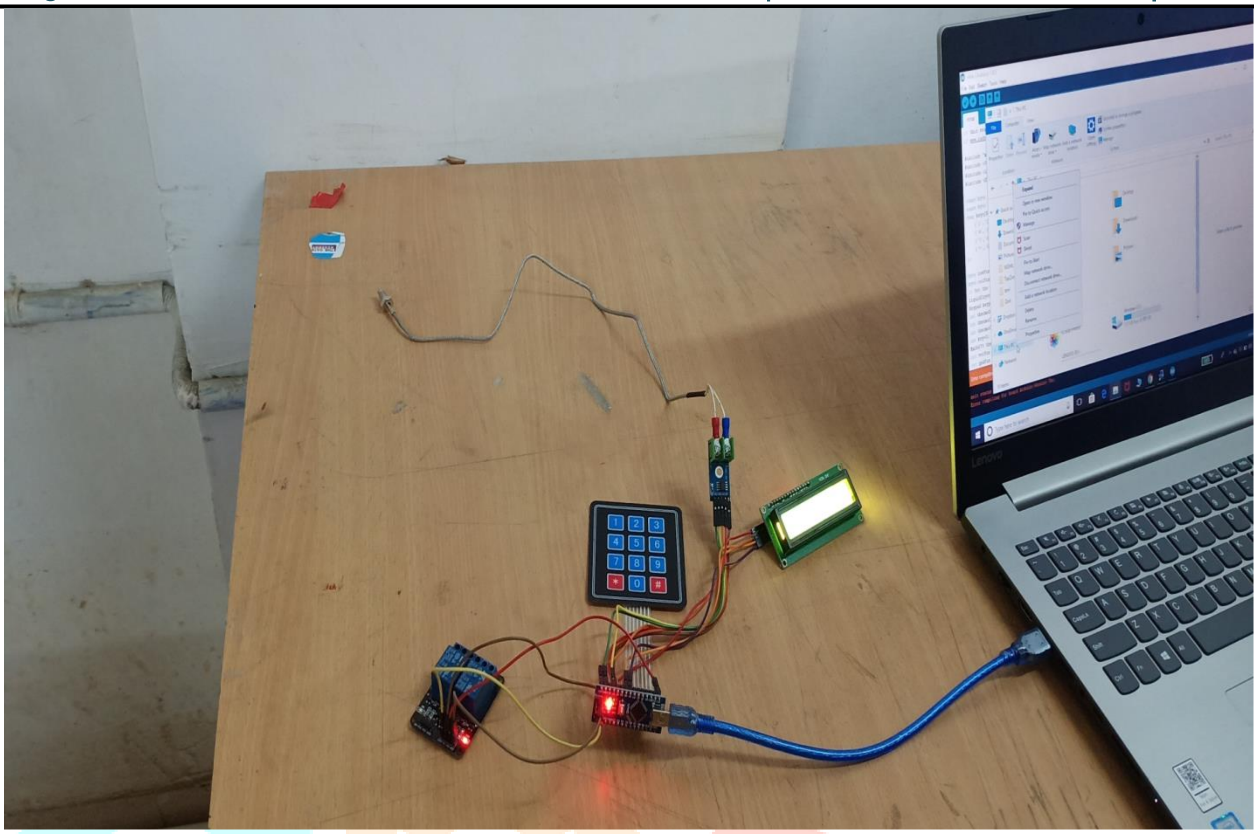

Figure 12: Set up showing the hardware accessories connected to the Arduino IDE

V. RESULTS AND DISCUSSION

It can be concluded that by applying mentioned methodology to the heating coil, a stable temperature can be achieved and the PID gives the most stable temperature output. And thus the food quality is maintained and vitamin rich food can be obtained. This project is user Interactive by applying it using keypad and LCD system. MATLAB GUI panel is useful to monitor the temperature of the system.

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