Automation System of Temperature Calibrator for Room Thermostat Using Arduino Mega256

Prisma Megantoro[1, a)] Albertus Ade Bagus[1, b)] Hafidz Faqih Aldi Kusuma [2, c)]
Sinta Adisti Reina [3, d)] Marwan Fadhilah [4.]

Author Affiliations
[1]*Faculty of Advanced Technology and Multidiscipline, Universitas Airlangga*
[a)]Vocational School, Universitas Gadjah Mada, Indonesia[1]

Author Emails
[a)] Corresponding author: prisma.megantoro@ftmm.unair.ac.id
[b)] [c)]
[d)] marwan.fadhilah-2021@ftmm.unair.ac.id

Abstract. Room temperature is one of the basic requirements for experimental laboratories that require temperature stability. Community efforts in incubating eggs, the incubator requires a stable room temperature with temperature monitoring on a calibrated thermometer and many other examples. With these needs, an automatic thermostat device has been devised as a thermometer chamber for calibration. The system used in this device is very concerned about the value of temperature homogeneity in the thermostat chamber. The sensor used is LM35, temperature control means using dimmers and relays to control the calorific value emitted by an incandescent lamp. In this device using Arduino MEGA As a microcontroller, the output of this device is the read temperature value and the value of standard deviation to be displayed on the 16x2 LCD. The reading range of the temperature value inside the thermostat is in the temperature range 21˚C – 30˚C, the average relative error of the instrument's room temperature reading the thermostat is -1.72%, and the maximum error is xz 1˚C.

Keywords Automation system, Arduino, Manufacturing innovation, Process innovation, Thermostat

1. INTROUDUCTION

The process of any work or activity inside or outside the room has a monitoring device, especially a room thermometer that is useful as a monitoring device for the surrounding room temperature. A room temperature is critical as a technical requirement in carrying out specific jobs, taking into account the maximum and minimum room temperature ranges required—applied to do the work [1, 2]. With the many types and forms of temperature measurement devices, in this case, a room thermometer (room temperature) where each measuring instrument must have a varying value of deviation. Sometimes the deviation is large or small; therefore, each temperature measuring instrument must have a temperature value by traceable standards [3] [5]. That way, each thermometer has a minimal deviation value between

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them and is recognized as a measuring instrument that has been calibrated with applicable standards [6]–[10].

The number of companies and state agencies must comply with the requirements set according to the applied standards (ISO). One of these requirements is the maintenance of the room system by monitoring the room temperature value of the room [11]–[13]. In addition, this room temperature thermometer must be calibrated every six months or a year to equalize or compare the reading of temperature values with traceable standards.

Asriani (2012) made a room temperature monitoring and control device. They are designed to make it easier for users to monitor room temperature automatically via a PC. The system design uses an LM35 temperature sensor, ATMega32 Microcontroller, 16x2 LCD, relay, with Visual Basic 6.0 program, and MySQL software as a database. The sensor will detect the input in the form of voltage and convert it by the microcontroller into temperature data. Users can define maximum and minimum temperature limits to turn the fan on and off automatically.

In general, temperature regulation uses an integrated control system [14]–[17]. The air temperature detected by a sensor is compared with a desired temperature setting value [18]–[23]. Suppose the air temperature entering the incubator is lower than the set temperature. In that case, the heater will work (on) to increase the temperature level in the incubator room so that the temperature in the incubator is always in the range tolerance according to the setting value [24, 25].

2. METHOD

2.1 System Design for Temperature Monitoring

The design of a monitoring system for measuring room temperature, a thermometer calibration device, requires several components, including a temperature sensor (LM35). This sensor will be read on the Arduino MEGA, and the results will be displayed on the 16x2 LCD screen. Fig. 1. Block Diagram System illustrates the components involved in the design of a monitoring system for measuring room temperature using a thermometer calibration device.

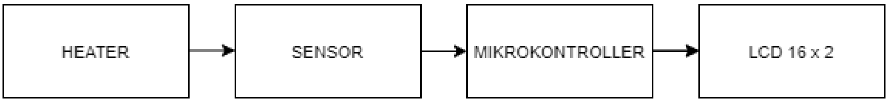

Fig. 1. Block diagram systems

The system block diagram explains that first, the sensor will read the temperature generated by the heater and provide convection energy in the form of heat, which will be received or read by the LM35 sensor. Then the temperature sensor will convert the received signal into a voltage which the Arduino MEGA microcontroller will read. Then the Arduino will change the ADC to a temperature unit value of ˚C.

Through a laptop or PC (Personal Computer), a program will be created for Arduino, which will contain the program interface for sensors to Arduino. In addition, on Arduino, a viewer program will also be created, which will be displayed on the 16x2 LCD.

2.2 Calibrating Room Thermometer Based on LM35 and Arduino Mega

Planning a device, "Calibrating Room Thermometer Based on LM35 and Arduino Mega," starts with designing the structure of this measuring instrument and its operational system. This device will have a system where the temperature sensor serves as the input, processed through the Arduino. The output from the Arduino is programmed to display the temperature value, in °C, on a 16x2 LCD screen, along with the calculated Standard Deviation. Additionally, it is programmed to activate a green LED lamp. This LED acts as an indicator when the readings of the six temperature sensors are relatively uniform, showing a Standard Deviation of less than 0.5 ˚C, signifying homogeneity in the readings.

Fig. 2. Thermometer Calibration Device Schematic illustrates the electrical connections and overall design of the system. It shows the configuration of the LM35 temperature sensors connected to the Arduino Mega, which processes the sensor data. The figure also highlights how the output is displayed on the 16x2 LCD screen and how the green LED is triggered based on the Standard Deviation criteria. The schematic provides a clear visualization of the interactions between the components, ensuring the system works efficiently as designed.

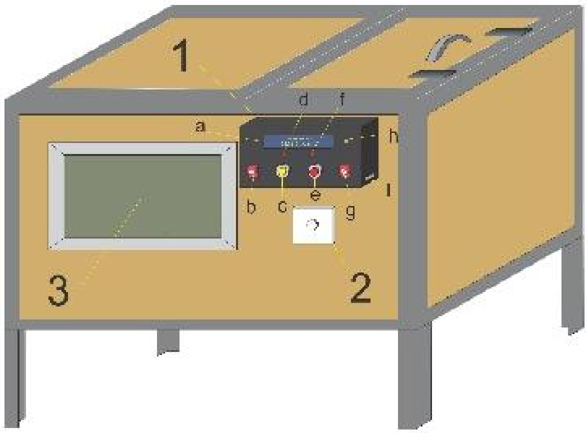

Fig. 2. Thermometer calibration device schematic

a) 16x2 LCD as displaying the value of temperature and Standard Deviation.
b) ON/Off button to turn on the microcontroller (Arduino MEGA).
c) Push Button to read measurement data, state, and re-measure.
d) Red LED as a sign for clicking the push button state.
e) Push Button to reset the process starting from the beginning.
f) Red LED as a sign for clicking the reset push button.
g) ON/Off button to turn on all systems to work.

h) Green LED as a marker that the temperature value measurement results are homogeneous.
i) Arduino USB port to be connected to a laptop/PC.

2.3 Design of Temperature Sensor Configuration on Arduino MEGA

The temperature sensor (LM35) is a sensor used in temperature measurement devices [26, 27]. This sensor will be directly connected to the Arduino MEGA board. Then the output of this sensor is analog data. In the design of the Arduino board, it functions to receive the output from the LM35 sensor as input. Fig. 3. Temperature Sensor Configuration Scheme with Arduino MEGA shows the wiring and configuration between the LM35 sensor and the Arduino MEGA. This schematic highlights the connection points for the sensor's data output, the power supply, and the ground, ensuring accurate temperature measurement and system functionality.

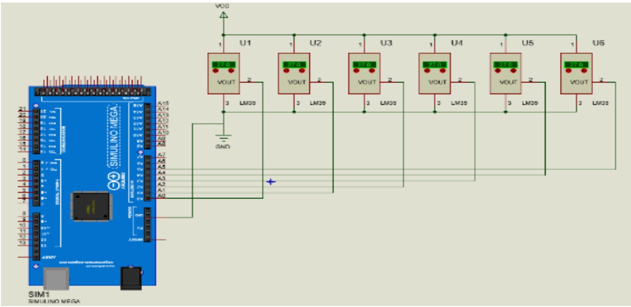

Fig. 3. Temperature sensor configuration scheme with arduino MEGA

Fig. 4. Flowchart of Sensor Readings with Arduino illustrates the step-by-step process of how the Arduino MEGA reads data from the temperature sensors (LM35) and processes it. This flowchart describes the operational process of a smart mailbox system. It begins with the initialization of the sensor port, which prepares the system to detect incoming mail or other events. Once initialized, the system collects data from the sensor, such as the presence or weight of the mail. The system then proceeds to calculate the mean and standard deviation of the input data, likely to detect patterns or anomalies in the mailbox's activity.

Next, the calculated values are displayed on an LCD screen. The system checks if the standard deviation falls within a ±0.5 threshold, which might signify consistent data readings or the arrival of new mail. If the standard deviation meets the threshold, LED 1 is activated as a visual indicator of new mail.

The system then checks if a button has been pressed. If so, LED 2 is turned on, potentially triggering a specific action such as sending a notification. The system also checks if another button is pressed to reset the system, which, if true, activates LED 3 and returns the system to its starting state. The process concludes with the end of the cycle, ready for a new set of events.

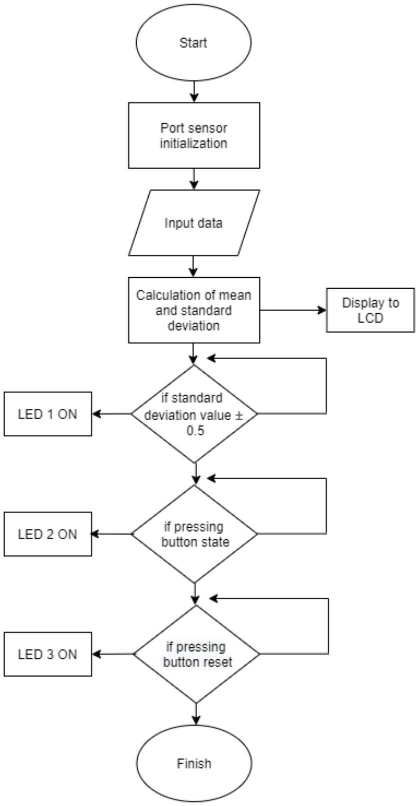

Fig. 4. Flowchart of sensor readings with Arduino

3. RESULT AND DISCUSSION

Hardware is a tangible form of system design. Therefore, hardware implementation must be considered because the hardware is a crucial component in determining the success of system performance. Some of the tests that will be carried out in hardware implementation, including serial communication and temperature Sensor (LM35). This test is carried out by comparing the sensor outputs that have ADC values in each sensor, where the placement of different sensors is, therefore each sensor needs to be tested to compare the results of each sensor with the standard temperature results. From testing each sensor, data is obtained and processed using excel software by paying attention to the results of the graphs obtained, especially the results of linear regression wherein processing the data the value of Y is obtained, which of the value of Y is used as the formula for measuring temperature in each sensor. Fig. 5. Thermometer Calibration LCD Device Display shows the output on the LCD screen from the hardware implementation of the system. The hardware is a crucial aspect of the system's design, as it directly affects the performance and accuracy of the calibration device.

Fig. 5. Thermometer calibration LCD device display

The first test is to find out the ADC value of the thermometer calibration device and compare it with the temperature listed on the standard device. Data collection is carried out when the temperature value listed on the standard is constant (does not change); therefore, every data collection is done hourly. The expected value The temperature inside the thermometer calibration device is stable, which means it is homogeneous. Testing obtained data will be shown in Table 1.

Table 1. Linearity Testing Device

Data each 3 hours	ADC (Desimal)						Standards temperature (PT-100) (˚C)
	Sensors 1	Sensors 2	Sensors 3	Sensors 4	Sensors 5	Sensors 6	
1	40	42	40	40	39	39	20,94
2	44	47	42	42	40	40	21,46
3	52	54	48	48	43	43	22,78
4	78	80	66	66	52	52	27,29
5	108	111	88	87	65	65	33,65

Table 2. Y and R values obtained by each sensor

Sensors	Y	R
Sensors 1	0.1867x + 13.199	0.9965
Sensors 2	0.1854x + 12.836	0.9973
Sensors 3	0.2634x + 10.265	0.998
Sensors 4	0.2683x + 10.037	0.9969
Sensors 5	0.4895x + 1.828	0.9999
Sensors 6	0.4895x + 1.828	0.9999

Data correlation coefficient (R) has an average of 0.998083 which means the device has fairly good linearity to changes in standard devices.

Table 3. Temperature sensor test data analysis results (LM35)

Standard Deviation Of Device Temperature	Average Temperature	Standard Temperature (˚c)	Relative Error (%)
0,248307605	21.958	21.87	-0.403902
0,603677618	25.103	25.6	1.9401042
0,361575257	28.161	27.8	-1.300959
0,354922527	29.72	30.3	3.7227723
	Average		0.9895038

The comparison of the value of the devices made is by direct comparison between the devices made and the standard (PT-100). The data above directly compares the device made with a temperature standard device where the reading of the temperature value listed must be correct. The value is generated when the temperature is constant. The resulting data is obtained by comparing the device made with the standard, whose measurements are carried out four times on each sensor.

This device has now been converted to C units, then compared with the standard device again to find the device vs. standard result. The comparison data is good with the difference between the device and the standard, less than 1˚C. However, after this device is as expected, the drawback of this device is the sensitivity that is not as sensitive as the standard thermometer temperature sensor. Then this device only has a measuring range between 21 to 50 ˚C while the standard is between 0 to 200 ˚C.

When using this device, it must be connected directly to AC power as a supply to turn on all systems. This device has also been tested for two days and obtained temperature data that still meet the regulatory threshold. Processing temperature data only looks for the standard deviation of the value per sensor, then the average temperature reading is calculated.

4. CONCLUSION

This device can measure temperature with a measuring range between 21˚C – 50˚C with a reading power of 0.1˚C. The relative error of the average result of the device is 0.9895038 %, and the maximum relative error is 3.7227723 %. In addition, this device can measure temperature with a device facility marked with a marker when it is suggested that the measured homogeneous temperature can be read in the form of an LED flame. This device has limited sensor sensitivity, but the results of the 90% reading are valid.

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