International Journal of Engineering & Extended Technologies Research (IJEETR)

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

Intelligent Water Heater with Temperature Monitoring and Control

Dr. G. Sundar [1], Deva Nandhini S [2], Gangadurai K [3], Karthik T [4], Sivarajan K S [5]

Professor, Department of Electrical and Electronics Engineering, Sri Shakthi Institute of Engineering and Technology, L&T Bypass Road, Coimbatore, Tamil Nadu, India[1]

Students, Department of Electrical and Electronics Engineering, Sri Shakthi Institute of Engineering and Technology, L&T Bypass Road, Coimbatore, Tamil Nadu, India[2,3,4,5]

Publication History: Received: 25.02.2026; Revised: 20.03.2026; Accepted: 25.03. 2026; Published: 28.03.2026.

ABSTRACT: Traditional water heaters often rely on manual temperature control, which may lead to overheating, energy wastage, and potential safety hazards. To overcome these limitations, efficient and automated temperature monitoring systems are required to ensure safe and optimized water heating. This project focuses on the design and implementation of an intelligent water heating system that monitors and controls water temperature in real time. The proposed system is built using an Arduino Uno microcontroller and a waterproof temperature sensor to continuously measure the temperature of water inside the heater. The temperature sensor collects real-time data and sends it to the microcontroller for processing and analysis. Based on the measured temperature values, the microcontroller automatically controls the heater using a relay module to maintain the desired temperature range. When the water temperature exceeds the predefined limit, the relay switches off the heater to prevent overheating. Similarly, when the temperature falls below the set threshold, the system activates the heater to maintain the required temperature. This automated approach improves safety, energy efficiency, and user convenience compared to conventional water heating systems. The integration of microcontroller-based control and real-time monitoring ensures optimal heating performance while reducing human intervention. The proposed system demonstrates the potential for developing smart and energy-efficient water heating solutions suitable for residential and industrial applications.

KEYWORDS: Smart, Safety, Advanced Technology

I. INTRODUCTION

Water heaters are widely used in homes, industries, and commercial buildings to provide hot water for various daily activities such as bathing, cleaning, cooking, and other industrial processes. In many places, water heaters play an important role in improving comfort and convenience for users. However, most traditional water heating systems operate with simple manual controls and do not include advanced monitoring or automatic regulation features. Because of this limitation, users have to manually switch the heater ON and OFF, which is not always efficient or safe. In conventional systems, there is no proper mechanism to continuously monitor the temperature of the water. Due to the absence of automatic temperature control, the heater may continue heating even after the required temperature is reached. This can result in overheating of water, which may create safety issues and discomfort for users. In addition, when heaters remain ON for a longer period than necessary, it leads to unnecessary energy consumption and increases electricity usage. Another important drawback of traditional water heaters is the lack of a proper monitoring system. Users cannot easily know the exact temperature of the water in real time. Because of this, it becomes difficult to maintain the desired temperature level. These limitations highlight the need for a smarter and more reliable water heating system that can operate automatically and safely. To overcome these problems, an intelligent water heater system is developed in this project. The system uses a temperature sensor, microcontroller, and relay module to monitor and control the water temperature automatically. The temperature sensor continuously measures the water temperature and sends the data to the microcontroller for processing. Based on the temperature value, the system controls the heater through the relay module. By automatically regulating the heating process, the system helps maintain the required temperature level without manual intervention. This improves safety by preventing overheating and also reduces energy wastage by switching the heater OFF when the desired temperature is reached. As a result, the intelligent water heater system ensures safer operation and more efficient use of electrical energy.

International Journal of Engineering & Extended Technologies Research (IJEETR)

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

II. METHODOLOGY

The proposed intelligent water heater system is designed to automatically monitor and control water temperature through a microcontroller-based setup, ensuring safe and efficient heating. A waterproof temperature sensor continuously measures the water temperature inside the container and sends real-time data to the Arduino Uno microcontroller, which processes the readings and compares them with the user-defined temperature setting. Based on this comparison, the microcontroller controls a relay module to switch the heater element ON or OFF, maintaining the desired temperature and preventing overheating. Users can easily set their preferred temperature using a 4×4 keypad, while a 16×2 LCD display provides continuous updates on the current temperature and system status. Additionally, a mini-MP3 player module delivers voice alerts to notify the user when the target temperature is reached or when the heater's status changes, enhancing convenience and awareness. The system operates on a regulated power supply, converting 230V AC to 5V DC, and integrates all components to achieve automated, energy-efficient, and user-friendly water heating. This methodology combines real-time temperature sensing, automated relay control, and interactive feedback to offer a smarter, safer, and more efficient alternative to conventional water heaters.

III. PROPOSED SYSTEM

The proposed intelligent water heater system operates by continuously monitoring the water temperature using a temperature sensor, which sends real-time readings to the Arduino microcontroller. The user sets the desired water temperature via a keypad, and the microcontroller continuously compares the actual temperature with this set value. If the water temperature falls below the desired level, the microcontroller activates the heater through a relay, turning it ON, and once the temperature exceeds the set value, the heater is switched OFF to prevent overheating. The current temperature and system status are displayed on a 16×2 LCD for user reference, while a mini-MP3 module provides voice alerts to notify the user of changes in the heater's operation, ensuring safe, efficient, and convenient water heating. The intelligent system ensures precise temperature control, preventing energy wastage and water overheating.

S.No	Component	Purpose
1	Arduino Uno	Main controller
2	16x2 LCD (I2C - PCF8574)	Display output
3	4x3 Matrix Keypad	User input
4	DS18B20 Sensor	Temperature measurement
5	Relay Module	Control external devices
6	DFPlayer Mini (optional)	Audio output (not used in code)
7	Power Supply (5V)	Provide power
8	Jumper Wires & Breadboard	Circuit connections
9	4.7kΩ Resistor	Pull-up for DS18B20

TABLE- 1 Components and its Function

International Journal of Engineering & Extended Technologies Research (IJEETR)

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

This system uses an Arduino Uno as the main controller to manage all operations. **In Table 1** displays temperature and system status, while the keypad allows user input.The DS18B20 sensor measures temperature, and the relay controls the heater accordingly. Power supply and supporting components ensure proper connections and stable operation.

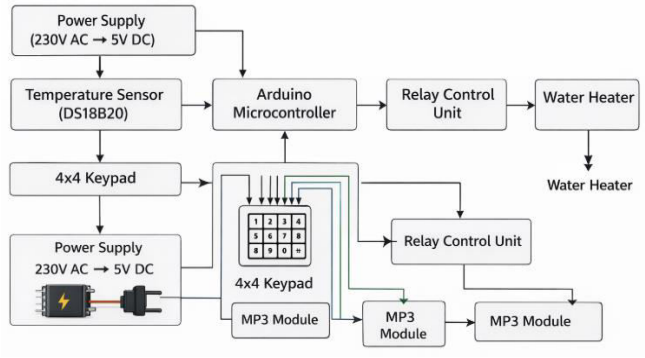

Figure 4.1 Intelligent Water Heater with Temperature Monitoring and Control

IV. BLOCK DIAGRAM FOR PROPOSED SYSTEM

The Block Diagram represents the overall structure and working of the intelligent water heater system. In this system, the power supply unit provides the required electrical energy to operate all the components such as the microcontroller, temperature sensor, relay module, keypad, LCD display, and other modules. The Arduino Uno microcontroller acts as the central control unit that coordinates the functioning of all the connected components in the system. The temperature sensor continuously measures the temperature of the water and sends the measured data to the Arduino microcontroller. In **Figure 4.1,** the desired temperature using the 4×4 keypad, which acts as an input device for the system. The microcontroller reads both the sensor data and the user input, processes the information, and determines whether the heater should be turned ON or OFF based on the set temperature value. Based on the processed data, the Arduino sends control signals to the relay module, which switches the heater ON or OFF accordingly. The LCD display is used to show important information such as the current water temperature and system status. In addition, the speaker and MP3 module provide audio alerts to notify the user when the water reaches the required temperature or when any system condition changes. Thus, the block diagram illustrates how all the components interact to achieve automatic temperature monitoring and control in the intelligent water heater system.

V. IMPLEMENTATION AND WORKING

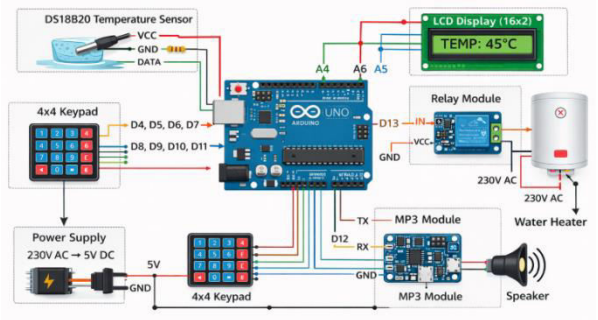

Figure 5.1 Circuti Diagram of Water Heater with Temperature Monitoring

The hardware connections of the intelligent water heater system using an Arduino Uno microcontroller. An AC to DC adapter converts the 230V AC mains supply into a regulated 5V DC power supply, which is used to power the Arduino board and other electronic components in the system. The temperature sensor is placed near the water container to continuously measure the temperature of the water.

The temperature sensor output pin is connected to one of the analog input pins of the Arduino, allowing the controller to read the temperature values as electrical signals. A 4×4 keypad is connected to the digital input pins of the Arduino

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

and is used by the user to set the desired water temperature. The system continuously compares the measured temperature from the sensor with the user-defined value to determine the heater operation.

A relay module is connected to the Arduino digital output pin to control the water heater. When the water temperature is below the set value, the Arduino sends a signal to activate the relay, which turns the heater ON. When the required temperature is reached, the relay is turned OFF to stop heating. A 16×2 LCD display is connected to the Arduino through an I2C interface using SDA and SCL pins, allowing the system to display the current temperature, set temperature, and system status.

VI. SOFTWARE IMPLEMENTATION

```
#include "Arduino.h"
#include "LiquidCrystal_PCF8574.h"
#include "Relay.h"
#include "Keypad.h"
#include "DS18B20.h"

#define DFPLAYER_PIN_TX 10
#define DFPLAYER_PIN_RX 11
#define RELAYMODULE_PIN_SIGNAL 12
#define KEYPADMEM3X4_PIN_ROW1 6
#define KEYPADMEM3X4_PIN_ROW2 7
#define KEYPADMEM3X4_PIN_ROW3 8
#define KEYPADMEM3X4_PIN_ROW4 9
#define KEYPADMEM3X4_PIN_COL1 3
#define KEYPADMEM3X4_PIN_COL2 4
#define KEYPADMEM3X4_PIN_COL3 5
#define DS18B20WP_PIN_DQ 2

#define LCD_ADDRESS 0x3F
#define LCD_ROWS 2
#define LCD_COLUMNS 16
#define BACKLIGHT 255

char keypadmem3x4keys[4][3] = {
  {'1','2','3'},
  {'4','5','6'},
  {'7','8','9'},
  {'*','0','#'}
};

LiquidCrystal_PCF8574 lcdI2C;
Relay relayModule(RELAYMODULE_PIN_SIGNAL);
Keypad keypadmem3x4(KEYPADMEM3X4_PIN_COL1, KEYPADMEM3X4_PIN_COL2,
KEYPADMEM3X4_PIN_COL3,
        KEYPADMEM3X4_PIN_ROW1, KEYPADMEM3X4_PIN_ROW2, KEYPADMEM3X4_PIN_ROW3,
KEYPADMEM3X4_PIN_ROW4);
DS18B20 ds18b20wp(DS18B20WP_PIN_DQ);

const int timeout = 10000;
char menuOption = 0;
long time0;

void setup()
{
  Serial.begin(9600);
```

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

```
 while (!Serial);

 lcdI2C.begin(LCD_COLUMNS, LCD_ROWS, LCD_ADDRESS, BACKLIGHT);
 keypadmem3x4.begin(keypadmem3x4keys);
 menuOption = menu();
}

void loop()
{
 if(menuOption == '2') {
  lcdI2C.clear();
  lcdI2C.print("Circuit");
  lcdI2C.selectLine(2);
  lcdI2C.print("Working");
  delay(1000);
 }
 else if(menuOption == '3') {
  relayModule.on();
  delay(500);
  relayModule.off();
  delay(500);
 }
 else if(menuOption == '4') {
  char key = keypadmem3x4.getKey();
  if (isDigit(key) || key == '*' || key == '#') {
   Serial.print(key);
  }
 }
 else if(menuOption == '5') {
  float tempC = ds18b20wp.readTempC();
  Serial.print("Temp: ");
  Serial.print(tempC);
  Serial.println(" C");
 }

 if (millis() - time0 > timeout) {
  menuOption = menu();
 }
}

char menu()
{
 while (!Serial.available());

 while (Serial.available())
 {
  char c = Serial.read();
  if (isAlphaNumeric(c))
  {
   time0 = millis();
   return c;
  }
 }
}
```

VII. ALGORITHM

International Journal of Engineering & Extended Technologies Research (IJEETR)

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

1. Start
2. Initialize Serial communication
3. Initialize LCD display
4. Initialize Keypad, Relay, and Temperature Sensor
5. Display menu options
6. Read user input from Serial/Keypad
7. Check selected option
   1. If option = 2 → Display message on LCD
   2. If option = 3 → Turn relay ON and OFF
   3. If option = 4 → Read keypad input and display
   4. If option = 5 → Read temperature from sensor
8. For temperature monitoring:
   1. Read temperature value
   2. Display temperature on Serial/LCD
9. Wait for some time (delay)
10. If timeout occurs → Return to menu
11. Repeat loop continuously
12. Stop

VIII. RESULT ANALYSIS AND DISCUSSION

The system maintains precise and steady temperature control in the water heater. The heater turns on and raises the temperature when the water temperature falls below the predetermined level; real-time readings are shown on the LCD. In order to prevent overheating, the system precisely turns off the heater. Appropriate sensor placement, and a steady power source are critical to performance. The outcomes verify that the microcontroller-based control system offers secure, and energy-efficient water heating along with efficient user communication.

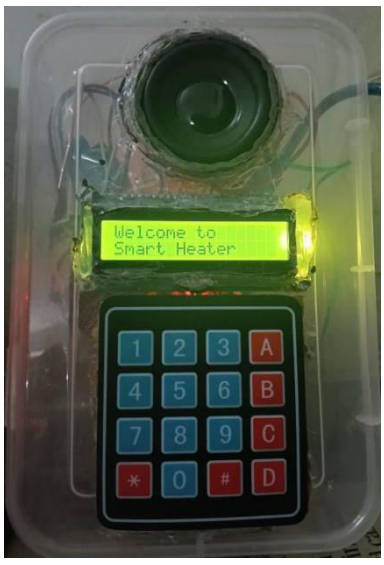

Figure 8.1: Initialization

This is a Smart Water Heater system built using an Arduino. In **Figure 8.1** represents the LCD displays system status, while the keypad allows users to set the desired temperature. A temperature sensor monitors water heat, and the controller operates the heater automatically.The setup ensures safe, efficient heating with user-controlled input and real-time feedback.

International Journal of Engineering & Extended Technologies Research (IJEETR)

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

Figure 8.2: Set the Temperature

The system allows the user to set the desired water temperature using the keypad. In **Figure 8.2,** displays the set temperature value for confirmation. An Arduino processes the input and compares it with the sensor reading.

Figure 8.3: Heating Status

The system begins heating once the temperature is set by the user. In **Figure 8.3** displays "Heating Start" to indicate activation of the heater. The Arduino controls the heating element based on the set temperature. Heating continues until the desired temperature is reached and maintained.

International Journal of Engineering & Extended Technologies Research (IJEETR)

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

Figure 8.4 Final Hardware Output

The system is connected to a water heater for automatic temperature control. **Figure 8.4** set the required temperature using the keypad, and it is shown on the display. The controller monitors temperature and manages the heating process accordingly. It ensures efficient heating with improved safety and user convenience.

IX. CONCLUSION

The intelligent water heater system effectively illustrates a micro controller-based, automated method for temperature monitoring and control. The system uses a sensor to efficiently measure the water's temperature and a relay module to automatically switch the heater to maintain the desired temperature. It lowers energy waste through controlled operation and guarantees safety by avoiding overheating. The incorporation of a keypad improves flexibility and user convenience by making it simple for users to adjust their desired temperature. While the audio alert system increases user awareness by indicating system status, the LCD display offers real-time monitoring. The system responds accurately to temperature changes and operates in a stable and dependable manner overall. System efficiency is further increased by appropriate sensor placement and calibration.

REFERENCES

1. Horowitz, P., & Hill, W. (2015). Design and Analysis of Electronic Control Systems for Smart Heating Applications. Cambridge University Press.
2. Monk, S. (2017). Arduino-Based Automatic Temperature Monitoring and Control System. McGraw-Hill Education.
3. Blum, J. (2019). Development of Intelligent Embedded Systems Using Arduino Platforms. Wiley Publications.
4. Banzi, M., & Shiloh, M. (2022). Smart Home Automation and Temperature Control Using Arduino. Maker Media Inc.
5. Barrett, S. F., & Pack, D. J. (2016). Microcontroller-Based Heating System Monitoring and Control. Morgan & Claypool Publishers.
6. Ibrahim, D. (2021). Design of IoT-Based Temperature Monitoring System Using ESP32 and Arduino. Elektor International Media.
7. Mazidi, M. A., Naimi, S., & Naimi, S. (2017). Embedded Temperature Control System Using Arduino Uno. Pearson Education.
8. Margolis, M. (2018). Arduino-Based Smart Device Development for Automated Control Systems. O'Reilly Media.
9. Wilmshurst, T. (2018). Embedded System Design for Automated Water Heating Control Applications. Newnes Elsevier.
10. Monk, S. (2016). Practical Arduino Projects for Smart Temperature and Energy Management Systems. O'Reilly Media.
11. C.Nagarajan and M.Madheswaran - 'Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques'- Taylor &Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746

N: 2322-0163| www.ijeetr.com | A Bimonthly, Peer Reviewed, Scholarly Indexed Journal |

| Volume 8, Issue 2, March - April 2026 |

DOI:10.15662/IJEETR.2026.0802146

12. C.Nagarajan and M.Madheswaran - 'Experimental verification and stability state space analysis of CLL-T Series Parallel Resonant Converter' - Journal of Electrical Engineering, Vol.63 (6), pp.365-372, Dec.2012. DOI: 10.2478/v10187-012-0054-2
13. C.Nagarajan and M.Madheswaran - 'Performance Analysis of LCL-T Resonant Converter with Fuzzy/PID Using State Space Analysis'- Springer, Electrical Engineering, Vol.93 (3), pp.167-178, September 2011. DOI 10.1007/s00202-011-0203-9
14. S.Tamilselvi, R.Prakash, C.Nagarajan,"Solar System Integrated Smart Grid Utilizing Hybrid Coot-Genetic Algorithm Optimized ANN Controller" Iranian Journal Of Science And Technology-Transactions Of Electrical Engineering, DOI10.1007/s40998-025-00917-z,2025
15. S.Tamilselvi, R.Prakash, C.Nagarajan," Adaptive sliding mode control of multilevel grid-connected inverters using reinforcement learning for enhanced LVRT performance" Electric Power Systems Research 253 (2026) 112428, doi.org/10.1016/j.epsr.2025.112428
16. S.Thirunavukkarasu, C. Nagarajan, 2024, "Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," Journal of Electrical Engineering And Technology, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
17. C. Nagarajan, M.Madheswaran and D.Ramasubramanian- 'Development of DSP based Robust Control Method for General Resonant Converter Topologies using Transfer Function Model'- *Acta Electrotechnica et Informatica Journal ,* Vol.13 (2), pp.18-31,April-June.2013, DOI: 10.2478/aeei-2013-0025.
18. C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- *Springer, Frontiers of Electrical and Electronic Engineering*, Vol. 7(4), pp. 438-446, Dec.12. DOI 10.1007/s11460-012-0212-0.
19. C.Nagarajan and M.Madheswaran - 'Experimental Study and steady state stability analysis of CLL-T Series Parallel Resonant Converter with Fuzzy controller using State Space Analysis'- *Iranian Journal of Electrical & Electronic Engineering*, Vol.8 (3), pp.259-267, September 2012.
20. C.Nagarajan and M.Madheswaran, "Analysis and Simulation of LCL Series Resonant Full Bridge Converter Using PWM Technique with Load Independent Operation" has been presented in ICTES'08, a IEEE / IET International Conference organized by M.G.R.University, Chennai.Vol.no.1, pp.190-195, Dec.2007
21. Suganthi Mullainathan, Ramesh Natarajan, "An SPSS and CNN modelling based quality assessment using ceramic materials and membrane filtration techniques", Revista Materia (Rio J.) Vol. 30, 2025, DOI: https://doi.org/10.1590/1517-7076-RMAT-2024-0721
22. M Suganthi, N Ramesh, "Treatment of water using natural zeolite as membrane filter", Journal of Environmental Protection and Ecology, Volume 23, Issue 2, pp: 520-530,2022