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GSM Based Industrial Device Controlling

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Abstract: - ***The GSM-Based Industrial Process Monitoring and Control System is a microcontroller-driven embedded solution, built around the 8-bit AVR ATmega32 microcontroller, which offers 32KB of flash memory for program storage. The system integrates key components such as the LM35 temperature sensor, GSM modem, LCD display, relays (used as process control devices), and a matrix keypad, all interfaced with the microcontroller. An onboard regulated power supply ensures stable operation. The LM35 sensor continuously monitors the temperature of industrial processes, with real-time values displayed on the LCD screen and transmitted wirelessly via GSM to the operator's mobile device. Operators can control various industrial processes by sending password-protected SMS commands, with each device having a unique command code. The system also provides feedback by sending SMS notifications confirming the current status of the controlled devices.***

Keywords: industrial, process control, embedded system, GSM, microcontrolle

1 INTRODUCTION

Industrial monitoring and control refer to the application of sensor technology and computerized control systems to manage industrial machinery and processes. This approach minimizes the need for manual involvement, thereby improving operational safety and efficiency. In the broader context of industrialization, it marks an advancement beyond mechanization. While mechanization assisted workers with physical tasks, monitoring and control systems significantly reduce reliance on human sensory perception and cognitive effort.

These systems are capable of supervising and regulating a variety of industrial operations. Engineers aim to integrate automation with mathematical models and organizational principles to design sophisticated systems that address a wide array of industrial functions and human needs.

However, several human roles in industrial settings still fall outside the reach of full automation. Tasks requiring complex sensory interpretation—such as recognizing sounds or smells—or high-level decision-making, like strategic planning, remain best handled by humans. Additionally, where automation is technically possible, human involvement often remains more cost-effective.

To support precise process regulation, rugged specialized computers known as Programmable Logic Controllers (PLCs) are deployed. These devices coordinate the flow of inputs from physical sensors and match them with outputs to actuators, enabling accurate and tightly controlled operations.

Communication between operators and control systems is facilitated using Human-Machine Interfaces (HMI) or Computer-Human Interfaces (CHI), previously termed man-machine interfaces. These interfaces enable the monitoring and input of data such as temperature or pressure values, which is essential for automated responses or manual intervention during emergencies. Personnel responsible for managing these interfaces are typically referred to as stationary engineers.

In critical industries such as nuclear power, energy production, and oil and gas, precise and continuous monitoring of process devices—including sensors and actuators—is essential. Ensuring that sensor data is accessible across various locations simultaneously is crucial for informed decision-making. This is typically achieved by linking sensor networks to central servers through controllers. Many existing systems rely on web-server architectures that support wireless user authentication and dedicated port configurations for each application. However, the implementation and maintenance of such web-based systems are expensive and often complex. Moreover, maintaining reliable wireless connectivity presents additional challenges.

As a more feasible alternative, this project proposes the use of the GSM (Global System for Mobile Communications) network—a secure, readily available wireless communication platform. With advancements toward 3G and beyond, GSM offers a cost-effective solution. This project introduces a **GSM-Based Industrial Process Monitoring and Control System**, aimed at reducing maintenance costs and enhancing the reliability of critical industrial operations.

2. SYSTEM OVERVIEW

This section provides a detailed overview of current technologies and devices used for industrial process communication and control, along with an analysis of their limitations and a justification for the adoption of GSM-based systems.

2.1 Existing Technologies

In many developing countries, the majority of industries, especially small and medium enterprises, have yet to adopt industrial automation due to the high costs associated with modern automation infrastructure.

As a result, alternative wireless communication technologies are in use, though they often come with significant limitations:

- **Bluetooth**: A low-cost RF-based technology with a short communication range, typically around 10 meters, extendable to 100 meters with increased power. However, its limited range and one-to-one communication nature restrict broader industrial applications.
- **ZigBee (IEEE 802.15.4)**: This standard supports low power consumption and medium range communication (up to 30 meters) at lower data rates (up to 250 Kbps). Although it's more power-efficient than Bluetooth and supports up to 255 devices per network, it is still limited in range and may not reliably support large-scale industrial setups.
- **Wi-Fi (IEEE 802.11)**: Offers high-speed data transfer but requires expensive infrastructure, consumes significant power, and may not be reliable in noisy industrial environments.

Each of these technologies suffers from constraints in either range, reliability, complexity, or cost. Moreover, they often fail to provide synchronized information access across multiple nodes in a large industrial environment.

2.2 GSM Technology

Global System for Mobile Communications (GSM) is a second-generation (2G) digital cellular system that offers a reliable and cost-effective alternative to the technologies mentioned above. Key features include:

- Operates in 900 MHz or 1800 MHz frequency bands using Time Division Multiple Access (TDMA).
- Supports digital voice and data services, including SMS, with maximum data speeds of 9.6 Kbps.
- Enables full mobility and global roaming, backed by standardized international protocols.
- Cost-effective due to wide availability and public infrastructure.

GSM Network Architecture

The GSM system is divided into three main components:

- **Mobile Station (MS)**: The user's mobile device.
- **Base Station Subsystem (BSS)**: Manages communication with the mobile station via the air interface.
- **Network Subsystem**: Includes the Mobile Switching Centre (MSC), which handles call routing, mobility management, and communication with fixed networks.

2.3 Comparison: GSM vs SCADA

While SCADA (Supervisory Control and Data Acquisition) systems are traditionally used in centralized industrial automation, they rely heavily on wired infrastructure (e.g., fiber optics, leased telephone lines). This makes SCADA unsuitable for remote or temporary installations such as prefabricated substations due to high installation and maintenance costs.

Feature	**GSM**	**SCADA**
Advantages	- Utilizes public mobile networks (no cabling) - Low cost - Mobile control possible via SMS - Easily expandable	- High reliability - Well-established centralized control systems
Disadvantages	- Communication quality depends on GSM traffic - Needs improved centralized management	- High setup cost - Not suitable for mobile monitoring
Applications	Ideal for small, widely-distributed substations	Better suited for large, centralized systems

GSM's SMS-based communication is particularly effective for small, intermittent data transfers and allows mobile-based control, which is not feasible with most SCADA systems. The decreasing cost of GSM modules further enhances its practicality.

2.4 GPRS Enhancement

General Packet Radio Service (GPRS), often considered a stepping stone to 3G, enhances GSM by offering:

- Packet-switched data transfer with speeds up to 115–117 Kbps (typically ~56 Kbps).
- Improved spectrum efficiency and continuous internet connectivity.
- Support for modern internet-based applications over existing GSM networks.

2.5 Overview of Devices Used

LM35 Temperature Sensor

The LM35 is a precision IC temperature sensor with an output voltage linearly proportional to Celsius temperature. It offers the following features:

- Calibrated directly in °C.
- Linear output of +10.0 mV/°C.
- Accuracy of ±0.5°C at 25°C.
- Full operational range: −55°C to +150°C.
- Suitable for remote applications due to low power consumption (less than 60 µA).
- Minimal self-heating and high accuracy without external calibration.

These attributes make LM35 ideal for real-time industrial temperature monitoring.

Figure 2: Plastic package LM35 DZ

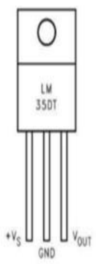

Figure 3: Pin layout

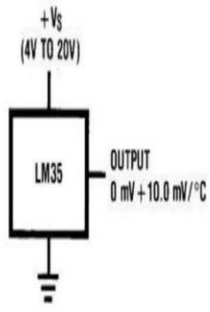

Figure 4: Voltage outputs

LCD JHD162A

The JHD162A is a 16x2 alphanumeric LCD module that utilizes the light-modulating properties of liquid crystals. Unlike LEDs, liquid crystals do not emit light directly but instead manipulate ambient light. It functions based on two polarizing sheets with a liquid crystal solution between them. When an electric current is applied, the orientation of the crystals changes, either allowing or blocking light passage. Each segment of the display behaves like a shutter, enabling it to show characters effectively.

This module operates within a temperature range of -10°C to 60°C and has a typical operational lifetime of over 50,000 hours at room temperature without direct exposure to sunlight.

Key Features of LCD JHD162A:

- **Display Mode:** TN/STN
- **Data Interface:** 8-bit parallel
- **Display Type:** Positive Transflective
- **Backlight:** LED (5.0V)
- **Viewing Direction:** 6 o'clock
- **Operating Environment:** Indoor
- **Driving Voltage:** Single power supply
- **Mounting Type:** COB (Chip On Board)
- **Connector Type:** Pin
- **Driving Method:** 1/16 duty, 1/5 bias
- **Display Format:** 16 Characters × 2 Lines

Figure 5: 16X2 LCD

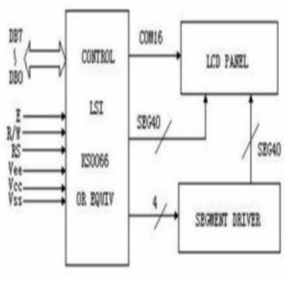

Figure 6: LCD and LCD Block Diagram

SIM300 GSM Module

SIM300 is a tri-band GSM/GPRS module operating at EGSM 900 MHz, DCS 1800 MHz, and PCS 1900 MHz. It supports GPRS multi-slot class 10 and coding schemes CS-1 to CS-4, enabling SMS, data transfer, and remote control applications. It interfaces with host systems through a 60-pin board-to-board connector, and provides flexible options including keypad and SPI LCD support.

The module features two serial ports and two audio channels (dual mic input and speaker output), all programmable via AT commands.

Key Features of SIM300:

- **Supply Voltage:** 3.4V – 4.5V
- **Power Consumption (Sleep Mode):** 2.5 mA (typical)
- **Frequency Bands:** EGSM 900 / DCS 1800 / PCS 1900
- **Operating Temperature:** -20°C to +55°C
- **SMS Storage:** On SIM card
- **Antenna:** External (via 50Ω connector or pad)
- **Interfaces:** Dual serial ports
- **Timers:** Programmable via AT commands

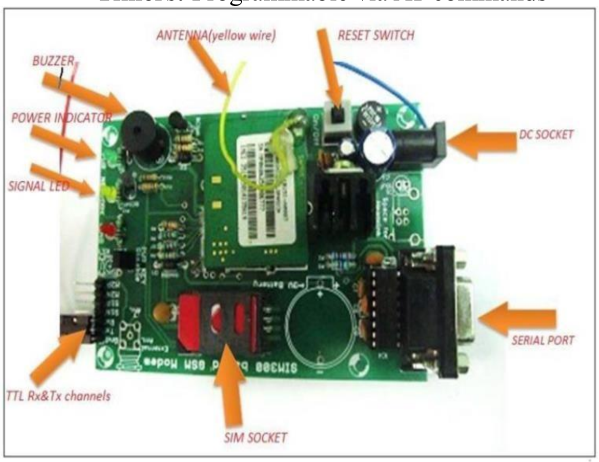

Figure 7: Overview of SIM300

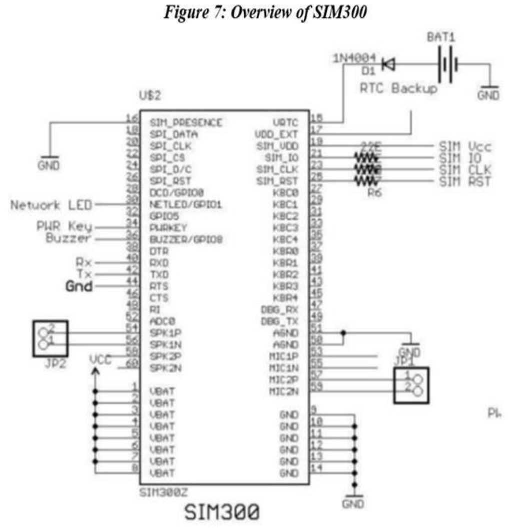

Figure 8: Block diagram & pin configuration of SIM300

ATmega32 Microcontroller

ATmega32 is an 8-bit AVR microcontroller based on the enhanced RISC architecture, offering high efficiency by executing most instructions in a single clock cycle. It delivers performance up to 1 MIPS per MHz, allowing optimized power and speed balance.

Used on a double-sided PTH PCB for durability, the ATmega32 board supports a wide input voltage range (7V–15V DC), includes reverse polarity protection, and features a 7805 voltage regulator with a heatsink to supply up to 1A current. Reset and power switches are also integrated.

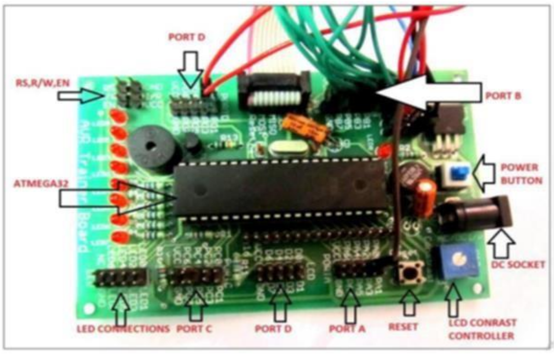

Figure 9: AVR Development Board

Key Features of ATmega32:

- 32KB ISP Flash memory (Read-While-Write support)
- 1KB EEPROM
- 2KB SRAM
- 32 general-purpose I/O lines and registers
- On-chip JTAG and debugging support
- Programmable Watchdog Timer with internal oscillator
- Timer/Counters with compare functionality
- USART, SPI, and TWI (I²C) communication interfaces
- 8-channel, 10-bit ADC
- 6 power-saving modes

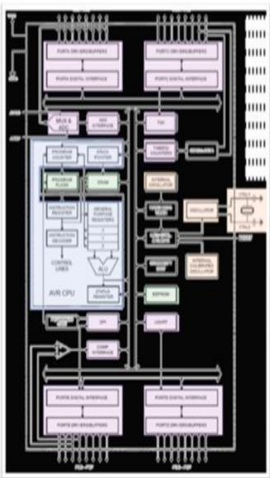

Figure 10: Architecture of ATMEGA 32

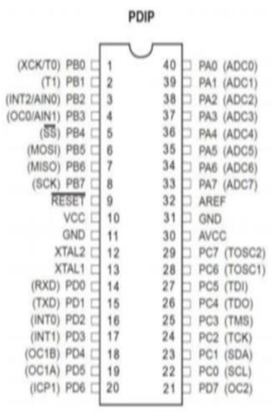

Figure 11: Pin configuration

Relay Module

A relay is an electromagnetic switch that controls high-power devices using a low-power signal. In this project, 12V DC relays are employed to manage industrial load switching.

Relay Terminal Labels:

- **COM (Common):** Moving part of the switch
- **NC (Normally Closed):** Connected to COM when coil is off
- **NO (Normally Open):** Connected to COM when coil is on\

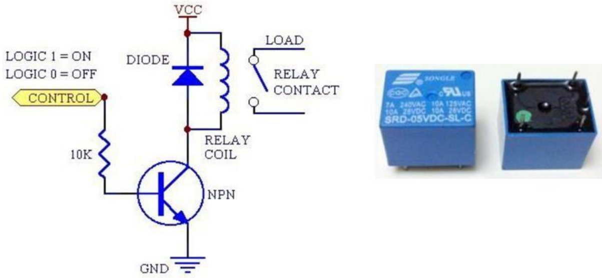

Figure 12: Relay and its Circuit Diagram

Matrix Keypad (4x4)

The matrix keypad consists of 16 tactile switches arranged in a 4-row by 4-column grid. It is used for user input, such as entering passwords or commands.

Figure 13: Matrix keypad

Buzzer

A piezoelectric buzzer is integrated to alert users during incorrect password entry or unauthorized access. Its advantages include low power consumption and compact size.

Figure 14: Buzzer

Power Supply System

The system is powered through a 12V DC non-regulated adapter. Voltage regulators such as 7805 and 7812 are used to derive stable 5V and 12V outputs for different components.

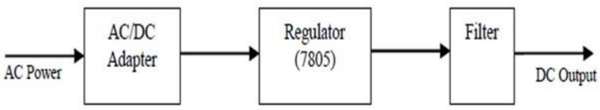

Figure 15: AC-to-DC Conversion

Software Module

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The embedded code for this project is developed in **Embedded C** using **AVR Studio 4**, an IDE for AVR microcontrollers on Windows platforms. The project is configured under the **AVR-GCC** environment. The source code is compiled into a HEX file using **WinAVR**, which is then programmed into the ATmega32 using **SinaProg v1.3.5.6**.

3. METHODOLOGY

This section outlines the architecture, system model, working principles, and interfacing details of the components used in the proposed GSM-based industrial process monitoring and control system.

System Model

This project focuses on designing a GSM-based system for real-time monitoring and control of industrial processes. The embedded system is capable of monitoring critical process parameters and controlling equipment locally using onboard I/O peripherals. Remotely, it enables authorized users to interact with the system via SMS through a GSM modem.

The GSM module serves as the communication interface between the remote user and the embedded system. SMS commands can trigger operations or request status updates. The control logic is implemented in embedded C.

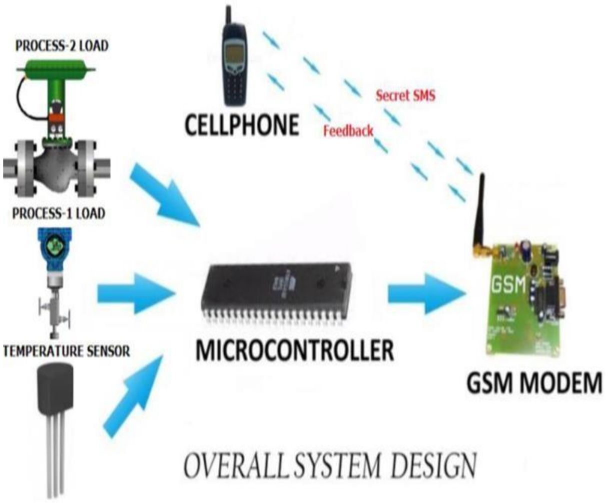

Figure 16: System Model

Basic Principle of System

- **Microcontroller**: ATmega32 is interfaced with sensors (e.g., temperature, smoke), actuators, an LCD display, and a GSM modem.
- **System Initialization**: Upon powering on, the controller sends a status SMS to pre-registered numbers.
- **Remote Interaction**: Users can update control logic, request status, and send operational commands via SMS.
- **Feedback Mechanism**: The GSM modem acknowledges command execution by sending an SMS reply to the user.

Working of the System

The microcontroller interfaces with temperature (LM35), IR, and smoke sensors to monitor industrial parameters. If a threshold (e.g., 50 °C) is crossed:

- The controller sends an SMS alert to the user.
- The user can reply with a corrective command.
- Upon receiving the command, the controller activates the relevant actuator to stabilize the condition.

Example: Overheating in a thermal plant's boiler can be detected using the temperature sensor, prompting an automated or user-initiated response to reduce heat input.

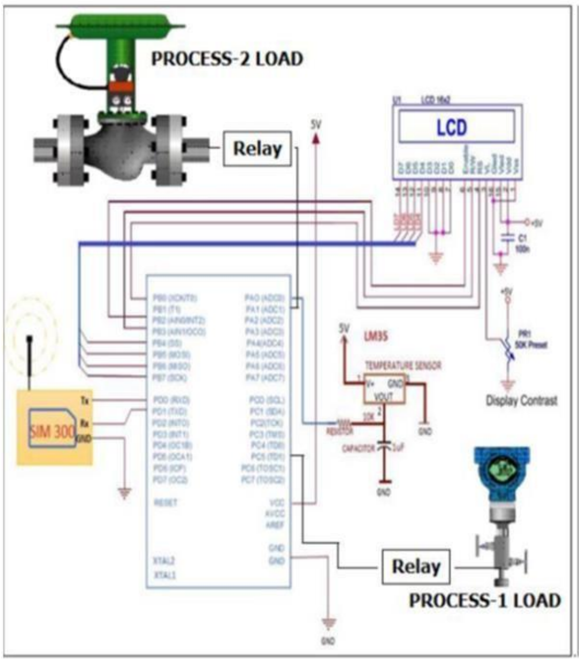

Figure 17: Total interfacing and circuit diagram

Interfacing of Devices

LM35 and ADC Interfacing

- **Signal Processing**: LM35 output varies at 10 mV/°C.
- **ADC Details**: ATmega32's 10-bit ADC converts analog voltage to digital value (0–1023).
- **Temperature Calculation**:

Temperature=ADC Value×510\text{Temperature} = \frac{\text{ADC Value} \times 5}{10}Temperature=10ADC Value×5

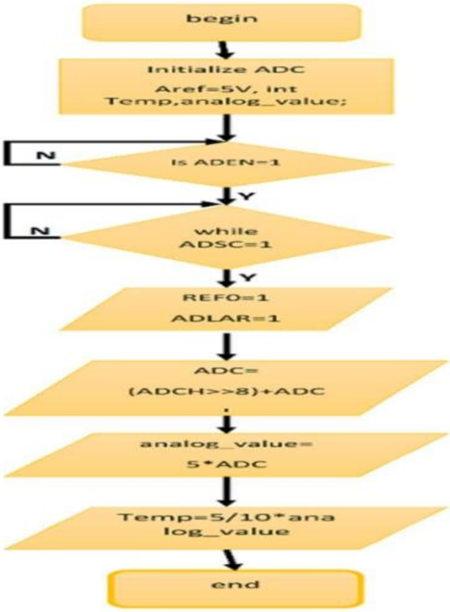

Figure 18: Flowchart for ADC Conversion

LCD Interfacing

- Operates in 4-bit mode due to hardware wiring.
- Initial command in 8-bit mode is followed by 4-bit configuration.
- Used to display system states and sensor values.

Table 5: LCD interfacing with AVR Board

LCD(JHD 162A)	AVR BOARD(PORT B)
Pin Number 1	GND
Pin Number 2	VCC(5V)
Pin Number 3	GND
Pin Number 4	PB0
Pin Number 5	PB1
Pin Number 6	PB2
Pin Number 7	Left Open
Pin Number 8	Left Open
Pin Number 9	Left Open
Pin Number 10	Left Open
Pin Number 11	PB4
Pin Number 12	PB5
Pin Number 13	PB6
Pin Number 14	PB7
Pin Number 15	VCC
Pin Number 16	GND

4. RESULTS AND DISCUSSION

The GSM-Based Industrial Process Monitoring and Control System is a microcontroller-based solution that integrates various components such as a temperature sensor (LM35) and process control devices. These components are connected to an ATmega32 microcontroller, which collects temperature readings and the status of industrial process control devices. These readings are then transmitted to a distant mobile station via a GSM modem. In parallel, the data is displayed on an LCD, allowing real-time monitoring by the industrial operator.

From the practical implementation and experimentation, it was observed that the temperature sensor data plays a crucial role in enabling the operator to monitor industrial process control devices. The data relayed through the GSM network allows the operator to make informed decisions and control the devices remotely.

5. CONCLUSION

This project provided valuable insights into various aspects of electronic equipment and communication technologies. It helped the authors gain practical knowledge about software analysis, designing, implementation, testing, and maintenance of embedded systems. One of the key challenges in industrial applications, such as in nuclear plants and power plants, is the need for secure sensor monitoring and robust authentication. This system successfully addresses the challenge by using a secret code for user authorization. The One-Wire protocol used for the temperature sensor enables temperature sensing over large areas, making it a highly efficient solution. The GSM network facilitates control from remote locations, and the ATmega32 microcontroller allows for seamless interfacing with various input/output devices, enhancing the versatility of the system.

This system's capabilities make it particularly appealing, as users can monitor and control industrial devices remotely using a simple cell phone. The end product is designed for ease of use, making it accessible to operators with minimal technical expertise.

REFERENCES

1. Manashti, M.J., Ghamarnia, H., Amirian, S., & Nezhad, R.M. (2012). *Design GSM-SMS based system for old, structured greenhouses with monitoring and logging network sensors*. International Research Journal of Applied and Basic Sciences, vol. 3, pp. 1497-1507.
2. Murugan, T., Periasamy, A., Muruganand, S. (2012). *Embedded based Industrial Temperature Monitoring System using GSM*, International Journal of Computer Applications, vol. 58, p. 0975 – 8887.
3. Raghu K. G., Fan Y., and Hui L. (2011). *Mobile Crowd sensing: Current State and Future Challenges*, IEEE Communications Magazine.
4. ATmega32 Datasheet, Atmel Corp., 2006. LM35 precision centigrade temperature sensors datasheet, National Semiconductors.
5. Subhani Sk. M., Sateesh, G. N. V., Chaitanya, Ch., and Prakash B. G. (2013). *Implementation of GSM Based Heart Rate and Temperature*

Monitoring System, Research Journal of Engineering Sciences, vol. 2, pp. 43-45.
6. "Hitachi HD44780 LCD controller," Hitachi, 1998. [Online]. Available at: Hitachi HD44780 LCD controller.
7. "SIM300 datasheet," [Online]. Available at: SIM300 Datasheet.
8. "Microcontroller to sensor interfacing techniques," BiPOM Electronics INC., [Online]. Available at: BiPOM Electronics.
9. Wellem, T. and Setiawan B. (2012). *A Microcontroller-based Room Temperature Monitoring System*, International Journal of Computer Applications, 53(1).
10. Ding, J. Z., Ma, B. (2009). *Remote monitoring system of temperature and humidity based on GSM*, 2nd International Congress on Image and Signal Processing, Tianjin, China, 2009, pp. 1-4.