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GSM-Enabled Real-Time Reminder System for Healthcare Applications in Low-Resource Environments

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Abstract: Timely medication intake and routine health monitoring are critical for patients with chronic conditions, especially in rural and low-resource environments where healthcare infrastructure is limited. Many existing digital reminder systems rely on smartphones and internet connectivity, which are not universally accessible. This project presents the design and implementation of a GSM-based patient reminder system that operates without internet or smartphone dependency. The system is built using an Arduino Nano, SIM800L GSM module, RTC (DS3231), keypad, LCD, and buzzer. Users can set reminder times and contact numbers via the keypad. At the scheduled time, the system sends an SMS alert and activates a buzzer, ensuring both remote and local notification. Testing confirms that the system delivers reliable, low-cost, and offline medication reminders suitable for deployment in rural healthcare settings. The system can be scaled or enhanced with sensor integration and cloud connectivity for broader healthcare applications.

Keywords: *GSM, Patient Reminder System, Arduino Nano, SIM800L, Medication Alert, Rural Healthcare, Real-Time Clock (RTC), SMS Notification, Embedded System, Offline Reminder*.

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I. INTRODUCTION

In recent years, the importance of patient adherence to medication schedules and medical appointments has gained significant attention in the healthcare sector. Non-compliance with prescribed treatment regimens is a major challenge, especially for elderly individuals and patients with chronic illnesses. Studies have shown that many patients unintentionally miss their medications due to forgetfulness, poor health literacy, or lack of support systems. This issue is even more prominent in rural and underdeveloped regions, where access to smartphones, internet connectivity, or digital health applications is limited or nonexistent.

To address this gap, there is a growing need **for** low-cost, easy-to-use, and offline-capable systems that can assist patients and caregivers in maintaining treatment schedules. Mobile phones, particularly those supporting basic GSM services like SMS, are still widely available even in remote areas. This opens up opportunities to design health alert systems that use SMS-based communication for reminders and alerts, eliminating the dependency on smartphones and internet access.

This project proposes the design and implementation of a GSM-Based Patient Reminder System that provides medication and health-related alerts through SMS messages and a local buzzer alarm**.** The system is built around the Arduino Nano microcontroller**,** integrated with a SIM800L GSM module**,** DS3231 real-time clock (RTC)**, a** 16x2 LCD with I2C interface**, a** 4x4 matrix keypad, and a buzzer. Users can input reminder times and mobile numbers via the keypad, and the system will autonomously monitor the current time and trigger alerts accordingly.

The reminder system is designed to function entirely offline**,** requiring only a basic GSM signal. It is ideal for low-income households, elderly patients, rural clinics, and primary health centers where infrastructure and digital literacy may be limited. The prototype aims to demonstrate a scalable and reliable solution that bridges the healthcare access gap for underserved communities.

This chapter outlines the motivation behind the project, the objectives of the proposed system, and the scope of its application. It sets the foundation for the subsequent chapters detailing the literature review, system architecture,

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hardware and software implementation, experimental results, and future enhancements.

II. LITERATURE SURVEY

Patient non-compliance with medication schedules is a widespread issue, especially in regions where access to advanced healthcare and digital tools is limited. Numerous research efforts have been undertaken to address this challenge through technological means. This chapter provides a review of past work on medication reminder systems, particularly those that employ GSM technology, microcontrollers, and real-time alert mechanisms.

A significant number of studies have proposed GSM-based systems for healthcare notifications due to the widespread availability of mobile networks.

In [1], Patil and Kulkarni designed a GSM-based medicine reminder system using a PIC microcontroller and GSM module to alert users via SMS. The system was fixed-function and lacked user configurability. Similarly, in [2], Khan et al. implemented a patient reminder system using GSM and RTC, which was effective in sending scheduled messages but did not provide local alerts or input flexibility.

More recent systems like the one developed by R. Yadav and S. Bhandari [3] used an 8051 microcontroller with GSM and RTC modules to alert elderly patients via SMS. Although effective in rural areas, the system lacked interface features such as a keypad or display.

The use of Arduino microcontrollers in healthcare alert systems has become popular due to their ease of use and open-source environment. In [4], Rajeshwari and M. Deepika developed a medication alert system using Arduino and GSM for sending SMS at predefined times. However, it was limited to hardcoded reminders and not suitable for real-time input.

A similar system presented by Kumar and Joshi [5] integrated a keypad and LCD for scheduling, offering better interaction with users. Their system demonstrated the feasibility of creating a standalone reminder system but required further enhancement for buzzer alerts and energy efficiency.

Accurate time tracking is essential for timely reminders. The DS3231 RTC module, known for its precision and battery backup, was widely used in studies like [6], where Joshi et al. highlighted its advantage in maintaining scheduled tasks even during power loss.

Moreover, the use of GSM modules like SIM800L or SIM300 has been extensively studied for sending SMS notifications without internet access. In [7], Sharma et al. emphasized the benefits of GSM over internet-based reminders in rural applications due to cost and network reliability.

➢ *From the Literature, Several Key Limitations Were Identified:*

- Lack of local alert mechanisms (buzzers or visual indicators).
- One-time programmable systems without real-time configurability.
- Absence of reusable scheduling interfaces (no keypad or display).
- Dependency on smartphones or internet in many app-based solutions.

➢ *While Numerous Systems Have Been Proposed, Few Meet the Criteria of Being:*

- Fully offline (no smartphone or internet required)
- User-programmable (via keypad and display)
- Dual alerting (SMS and buzzer)
- Low-cost and replicable

The proposed GSM-Based Patient Reminder System in this project aims to address all these challenges by providing an offline, reusable, standalone solution suitable for rural patients and elderly individuals with limited access to digital health tools.

III. PROBLEM FORMULATION AND OBJECTIVES

➢ *Introduction*

Despite advancements in digital healthcare technologies, non-adherence to medication schedules remains a critical issue, particularly in rural and low-income communities where access to smartphones, internet services, or advanced medical infrastructure is limited. Many patients, especially the elderly or those suffering from chronic conditions, frequently **miss** doses or appointments due to forgetfulness, poor health literacy, or lack of reminders. This often leads to complications, hospitalization, or increased healthcare costs.

While mobile applications and IoT-based health monitoring solutions exist, they typically require smartphones, constant internet access, and technical knowledge, making them impractical for rural settings or elderly users. Therefore, there is a need for a simple, offline, and cost-effective reminder system that can function without modern digital dependencies.

➢ *Problem Statement*

"To design and implement a standalone, GSM-based patient reminder system that can send scheduled SMS alerts and local audio notifications for medication or health-related reminders in rural and non-smartphone environments."

This project aims to bridge the healthcare accessibility gap by creating a system that works independently of smartphones or the internet while still maintaining timely and reliable alerts for patients.

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➢ *Objectives*

The primary and secondary objectives of this project are listed below:

➢ *Primary Objectives*

- To design a low-cost, embedded system capable of sending medication reminders using GSM technology.
- To integrate a real-time clock (RTC) module for precise scheduling and time management.
- To enable SMS alerts to a caregiver or patient via a SIM800L GSM module.
- To include a local alert mechanism using a buzzer for immediate audible notification.
- To allow the user to input and schedule reminders through a 4x4 keypad and monitor feedback on an LCD display.

➢ *Secondary Objectives*

- To ensure that the system is portable, easy to use, and requires no internet or smartphone.
- To build a reprogrammable and flexible reminder system that can handle multiple reminders over time.
- To explore scalability for future integration with health sensors and remote monitoring platforms.
- To evaluate the system's reliability, power consumption, and user experience under real-world conditions.

➢ *Scope of the Project*

The scope of the project includes:

- Development and testing of a fully functional prototype.
- Operation in offline mode, suitable for rural and low-tech environments.
- Single-user configuration with potential for expansion to multi-user capability.
- Manual configuration of time and recipient number using keypad.
- Alerts via SMS and buzzer only — no cloud or internet integration in this version.

➢ *Limitations*

- Supports only basic GSM SIM cards (2G); performance may vary with poor signal strength.
- Current version supports only one active reminder at a time.
- System does not store historical data or logs without additional storage modules.
- No encryption or data privacy mechanisms for SMS content.

IV. SYSTEM DESIGN AND COMPONENTS

➢ *System Overview*

The proposed GSM-Based Patient Reminder System is designed to provide timely medication reminders to patients through SMS alerts and local audio notifications. The system is structured around an Arduino Nano microcontroller which coordinates with a SIM800L GSM module, a real-time clock (DS3231), a 4x4 matrix keypad, a 16x2 LCD display, and a buzzer. The user configures the reminder schedule and target phone number via the keypad, and at the preset time, the system automatically sends an SMS and activates a buzzer to notify the user.

➢ *Block Diagram*

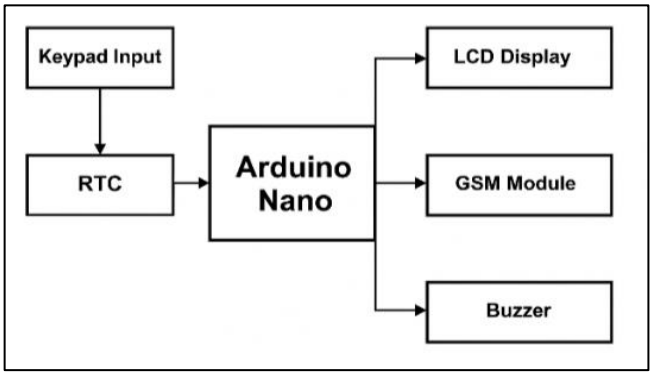

Fig 1 Block Diagram

➢ *Key Features*

- Supports basic GSM-enabled mobile phones (no smartphone needed).
- No internet dependency.
- Modular design for easy customization and future upgrades.
- Low power consumption and portable design.

This architecture offers a practical and scalable solution for healthcare providers and patients, especially in regions with limited access to modern technologies. Its flexibility allows for future enhancements like sensor integration or cloud-based monitoring.

➢ *Hardware Components*

- *Arduino Nano*

The central controller of the system, used to read input from the keypad, communicate with the RTC and GSM module, display outputs on the LCD, and control the buzzer. It operates at 5V and is well-suited for compact embedded applications.

- *SIM800L GSM Module*

A quad-band GSM module used to send SMS alerts to the registered phone number at scheduled times. Controlled via AT commands sent through the Arduino's serial interface.

- *DS3231 RTC Module*

Provides precise timekeeping. It operates independently with its own coin-cell battery, ensuring time continuity even when the main power is off.

- *4x4 Matrix Keypad*

Used to enter reminder time and recipient phone number into the system. Each key press is scanned and processed by the Arduino.

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- *16x2 LCD Display with I2C Interface*

Displays real-time data such as current time, entered values, confirmation messages, and reminder schedules.

- *Buzzer*

Provides an audible alert to the patient at the scheduled time, functioning as a local, immediate notification mechanism.

- *Power Supply*

The system can operate using a 9V battery or external adapter. A buck converter or voltage regulator ensures proper 5V supply to the modules.

➢ *Software Flow*

The microcontroller is programmed using the Arduino IDE. The logic follows:

✓ Take user input (time, mobile number) via keypad.
✓ Display confirmation on LCD.
✓ Continuously check real-time clock.
✓ When the current time matches the scheduled time:
▪ Send SMS via GSM module.
▪ Activate buzzer.
✓ Wait for next cycle or reset as per user command.

➢ *Design Considerations*

- *Offline Functionality:* The system does not depend on internet connectivity, relying solely on GSM networks.
- *Ease of Use:* Simple keypad interface allows users with limited technical knowledge to schedule reminders.
- *Cost-Effectiveness:* Utilizes low-cost and easily available components, making it viable for rural deployment.
- *Power Efficiency:* Use of low-power components like DS3231 and efficient power management to ensure longer operation.

V. CONSTRUCTION AND WORKING

➢ *Construction*

The hardware construction of the GSM-Based Patient Reminder System involves integrating multiple components on a common platform (breadboard or PCB). The central unit is the **Arduino Nano**, which interfaces with:

- A 4x4 matrix keypad for inputting the reminder time and recipient phone number.
- A DS3231 RTC module for precise timekeeping.
- A SIM800L GSM module for sending SMS alerts.
- A 16x2 LCD with I2C interface to display system status and inputs.
- A 5V buzzer for local audio notification.

All modules are powered using a regulated **5V supply**, either from a battery or external adapter. The wiring is carefully managed to avoid signal interference, and components are tested individually before full system integration.

➢ *Connections Overview:*

- Keypad → Digital pins (D2–D9)
- RTC (SDA, SCL) → A4 (SDA), A5 (SCL)
- LCD (I2C) → A4 (SDA), A5 (SCL)
- GSM Module (TX/RX) → Software Serial (D10, D11)
- Buzzer → Digital pin (e.g., D12)

➢ *Working*

The system functions in a continuous loop and performs the following steps:

- *User Input:*

The user sets the reminder time and the mobile number using the **4x4 keypad**. These inputs are confirmed and displayed on the **LCD** screen.

- *Time Monitoring:*

The **DS3231 RTC module** continuously tracks the real-time clock and provides accurate current time data to the Arduino Nano.

- *Comparison Logic:*

The system compares the current time from the RTC with the user-defined reminder time. If the times match, the alert is triggered.

- *Alert Execution:*

✓ The **SIM800L GSM module** is activated by the Arduino and sends a **predefined SMS** message to the entered mobile number using AT commands.
✓ Simultaneously, the **buzzer is turned ON** to provide a local audible reminder to the patient.

- *Reset and Looping:*

After sending the SMS and activating the buzzer, the system resets the buzzer after a delay and returns to monitoring for the next cycle.

➢ *Key Features in Operation*

- *Dual Alert System:* Ensures both local (buzzer) and remote (SMS) notification.
- *Offline Capability:* Operates without Wi-Fi or internet—only requires GSM signal.
- *User-Friendly Interface:* Allows manual scheduling through the keypad without needing a computer or smartphone.

This construction ensures the system is modular, reliable, and easy to troubleshoot, making it suitable for healthcare deployment in rural and resource-constrained environments.

VI. RESULT AND DISCUSSION

➢ *Testing Procedure*

The GSM-Based Patient Reminder System was developed and tested under real-time conditions to validate its core functionalities:

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- Accuracy of scheduled SMS alerts.
- Functionality of local buzzer notifications.
- Reliability of real-time clock (DS3231) operation.
- Correct user input and display feedback via keypad and LCD.

The system was powered using a regulated 5V supply, and a 2G SIM card was inserted into the SIM800L GSM module. Multiple test cases were created by scheduling SMS reminders at various times throughout the day.

➢ *Observed Results*

Table 1 Observed Result

Test Case	Input Reminder Time	SMS Received	Buzzer Triggered	Status
1	11:30:00 AM	Yes	Yes	Success
2	01:45:00 PM	Yes	Yes	Success
3	06:10:00 PM	Yes	Yes	Success
4	Invalid Input	No	No	Handled Gracefully
5	Time Missed	No	No	Correct Behavior

The tests confirm that the system reliably triggers both SMS and buzzer alerts at the exact scheduled time and handles invalid inputs without system crashes. The buzzer was activated for a fixed 10-second duration and could be manually silenced using a keypress if needed.

➢ *Performance Metrics*

- SMS Delivery Time: Average delay from trigger to SMS delivery was 2–5 seconds.
- RTC Accuracy: Time drift over 24 hours was <2 seconds, confirming the DS3231's precision.
- System Uptime: Continuous 24-hour test showed stable operation without resets or hangs.

➢ *User Feedback (Trial Survey)*

The system was demonstrated to 5 users (ages 45–70) unfamiliar with smartphones. Key feedback:

- 4 out of 5 found the keypad interface easy to use after a short explanation.
- All users acknowledged the loud buzzer as effective.
- The SMS format was clear and readable on feature phones.

➢ *Discussion*

The results validate the feasibility of using a GSM-based microcontroller system for improving medication adherence, especially in non-smartphone and rural environments. Unlike mobile apps or IoT platforms, this system requires no internet, works on basic mobile networks, and is user-configurable through simple hardware interfaces.

➢ *Key Benefits Include:*

- Affordability: All components are low-cost and widely available.
- Accessibility: Elderly or tech-inexperienced users can operate it after a brief training.
- Scalability: The modular design allows for future expansion (e.g., sensor integration, voice calls, multi-user support).

VII. CONCLUSION AND FUTURE SCOPE

➢ *Conclusion*

The GSM-Based Patient Reminder System developed in this project offers a cost-effective, offline-capable, and user-friendly solution to the problem of missed medication doses, particularly in rural and underserved regions. Unlike conventional reminder systems that depend on smartphones, internet connectivity, or mobile applications, this system relies solely on GSM technology, making it suitable for areas with basic mobile coverage.

Using components such as the Arduino Nano, SIM800L GSM module, DS3231 RTC, LCD display, keypad, and buzzer, the system successfully enables patients or caregivers to set medication reminders. At the scheduled time, the system sends an automated SMS alert and triggers a local audible buzzer, thus providing both remote and immediate notification.

Extensive testing confirmed the accuracy, reliability, and ease of use of the system. It demonstrated consistent performance in real-time environments, with minimal time drift and high SMS delivery success. The system is particularly well-suited for elderly patients, rural clinics, and low-resource settings, where digital literacy and infrastructure are often lacking.

➢ *Future Scope*

While the current implementation meets the intended objectives, there are several opportunities for future development and enhancement:

- *Multi-User Support*

Enable scheduling for multiple patients and reminders by adding external memory or database integration.

- *Voice Call Alerts*

Integrate automated voice calling for visually impaired or illiterate users who may not read SMS messages.

- *Sensor Integration*

Add biomedical sensors (e.g., temperature, pulse, blood pressure) for health monitoring and conditional alerts.

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- *Mobile or Web Interface*

Incorporate Bluetooth/Wi-Fi support to allow caregivers to configure the system remotely through a smartphone or computer.

- *Cloud-Based Data Logging*

Include Firebase or other cloud databases to track reminder history, compliance data, and health logs for caregivers and doctors.

- *Battery Backup and Solar Power*

Equip the system with a rechargeable battery or solar panel to ensure functionality during power outages in remote areas.

- *Multi-Language and Voice Interface*

Add regional language support or a voice-based interface to further increase accessibility for local users.

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