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Implementation of SMS Starter for Irrigation Pump using GSM Modem and Arduino Uno Microcontroller

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ABSTRACT: The agricultural process significantly depends on water resources. Water must be supplied to the designated locations within the farmland for various needs. To provide water, farmers use irrigation pumps. Operating the pump is a manual task for the farmer, often requiring the farmer to travel to the farmland solely for this purpose. To address this inconvenience and automate the manual task, this paper introduces the design and development of the GSM (Global System for Mobile Communications) based starter. This innovative solution enables remote pump operation, eliminating the need for farmers to travel to the farmland solely for manual pump activation. The designed GSM-based starter undergoes evaluation in actual farmland, demonstrating the effectiveness of the proposed scheme in enhancing operational efficiency and reducing unnecessary travel for farmers.

KEYWORDS: Arduino Uno, GSM Modem, SMS (Short Message Service), Relay Module, DOL (Direct On-Line) Starter, Irrigation Pump, Solenoid Valve.

I. INTRODUCTION

In India, irrigation comprises an intricate network of major and minor canals sourced from Indian rivers, alongside systems based on groundwater wells, tanks, and various rainwater harvesting projects to support agricultural activities. Among these, the groundwater system stands out as the most extensive. All these systems involve electrical machinery, precisely irrigation pumps, to deliver water to the farms. Traditionally, controlling these pumps has been a manual task handled by the farmer.

In adverse weather conditions such as rain, darkness, cold, or storms, traditional manual operation of irrigation pumps becomes challenging. In areas with wildlife mobility, particularly at night, the need for farmers to travel to the farmland and manually operate the pump poses a potential threat to their safety.

Operating in remote locations becomes feasible with technology, allowing farmers to manage their irrigation systems from a distance. This independence minimizes the need for farmers to be physically present, ensuring both human safety and uninterrupted pump operation.

This paper delves into leveraging widely available cellular technology to remotely control the irrigation pump utilizing the existing mobile phone network infrastructure, eliminating the need for new investments. This accessibility ensures that

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farmers can quickly adopt and integrate the technology into their existing systems. Moreover, the study endeavors to provide a cost-effective solution that minimizes modifications to the existing irrigation systems. The overarching goal is to provide an efficient and accessible approach, empowering farmers to manage their irrigation systems with enhanced convenience and affordability. This paper also invites you to explore and embrace digital technology in farming practices.

II. SYSTEM INTERPRETATION

The system operates on cellular technology, utilizing a GSM modem for communication. As a crucial interface, the GSM modem facilitates communication between an Arduino microcontroller and the GSM network. It is a bridge enabling seamless two-way data transmission across the GSM cellular network, including Short Message Service (SMS) messages. When a GSM modem attempts to connect to the GSM network, the network checks the SIM (Subscriber Identity Module) card's IMSI (International Mobile Subscriber Identity) and validates the modem's identity. This process ensures that only authorized users can access the network. SIM cards play a vital role in securing communication over the GSM network. They store encryption keys and algorithms to secure voice and data transmissions between the mobile device and the network. Users can register and associate their SIM card with the SMS starter GSM modem.

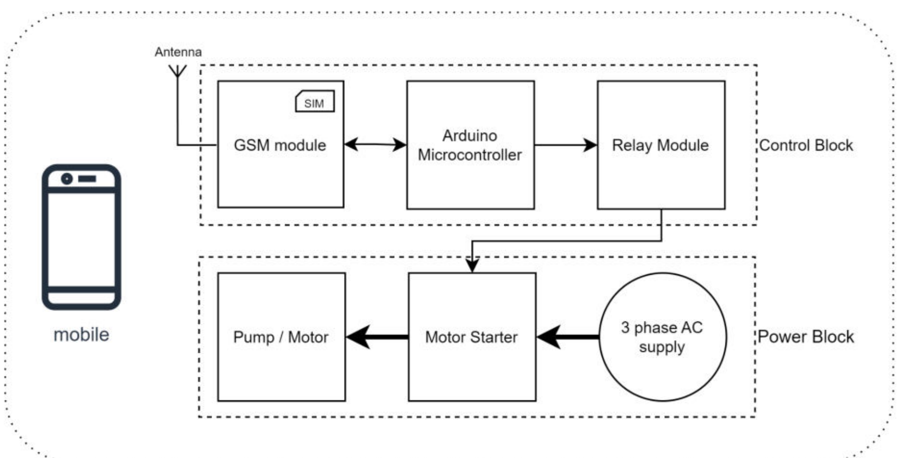

Figure 1 System block diagram of SMS starter

: System block diagram of SMS starter. This illustrates the system-level block diagram of an SMS starter, which contains all the necessary blocks to control the irrigation pump remotely through the farmer’s mobile phone. At the core of the system is the Arduino Uno microcontroller, serving as the system's brain. Arduino Uno is a popular open-source and versatile development board powered by an ATMega328p microcontroller. The Arduino Uno microcontroller is the flagship product of Arduino, an Italian company. Arduino tools are used for educational purposes and industry-related tasks[2].

ATMega328p microcontroller is an 8-bit AVR processor which runs at 16MHz clock frequency and consists of inbuilt memory of 32KB flash to store the program along with 2KB of SRAM and 1KB of EEPROM. The board includes 14 digital and six analog input/output pins, which can also be configured as serial communication ports, namely USART (universal synchronous/asynchronous receiver/transmitter), SPI (serial peripheral interface), and I2C (Inter-Integrated Circuit). These pins allow users to interface sensors, actuators, and other electronic components[2].

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The Arduino Uno features a USB (Universal Serial Bus) interface, which programs the board and serial communication with computers for debugging and powering the board. In addition to the USB interface, the board can be powered through an external power source, accepting input voltages within the 7 to 12 volts2 range.

Communication between the GSM modem and Arduino Uno is established through the UART (universal asynchronous receiver/transmitter) serial port. A relay module activates the irrigation pump starter, which controls turning the pump on and off by supplying 3-phase AC (Alternating current) power to the irrigation pump motors.

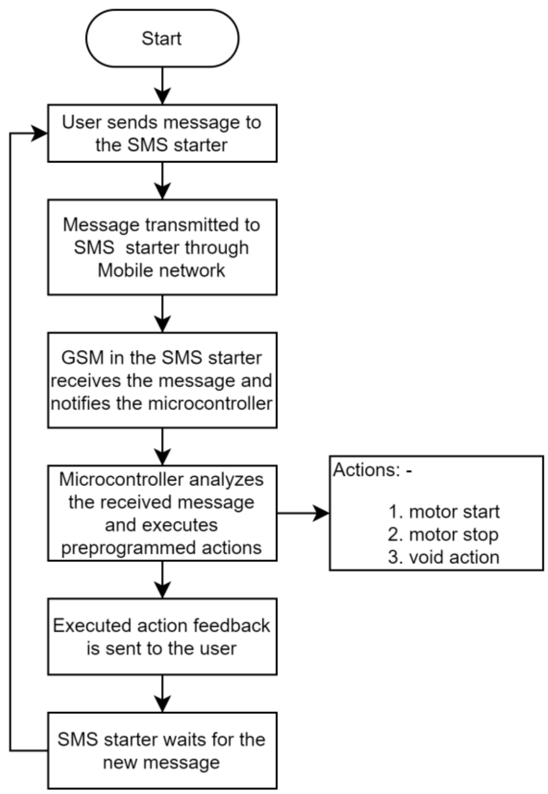

Figure 2 system operation flowchart

Figure 2 system operation flowchart illustrates the system functional flowchart. To facilitate the operation of the irrigation pump from a remote location, the farmer sends an actuation message to the SMS starter using their mobile phone. The SMS is then transmitted over the GSM network and received by the designated GSM modem. Upon receiving the SMS from the user's mobile device, the GSM modem initiates a signal to the Arduino microcontroller. The microcontroller is responsible for retrieving, processing, analyzing, and verifying the received data for authenticity.

Upon successful validation, the relay module is activated, enabling control over the pump and initiating the desired action, such as starting, stopping, or voiding the operation of the irrigation pump starter. In addition to this automated process, informative feedback concerning the action taken is promptly relayed to the user via SMS. This comprehensive system

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ensures efficient and secure remote management of the irrigation pump, providing users with real-time updates on the system's status and actions.

This integrated system showcases the effective synergy between the Arduino Uno microcontroller and the GSM modem, ensuring reliable communication, data analysis, and automated control of the specified device – in this case, the irrigation pump.

III. HARDWARE IMPLEMENTATION

SMS starter hardware is built to utilize the existing Direct online starter (DOL) of the irrigation pump system and minimum electrical connections to set up and run the system.

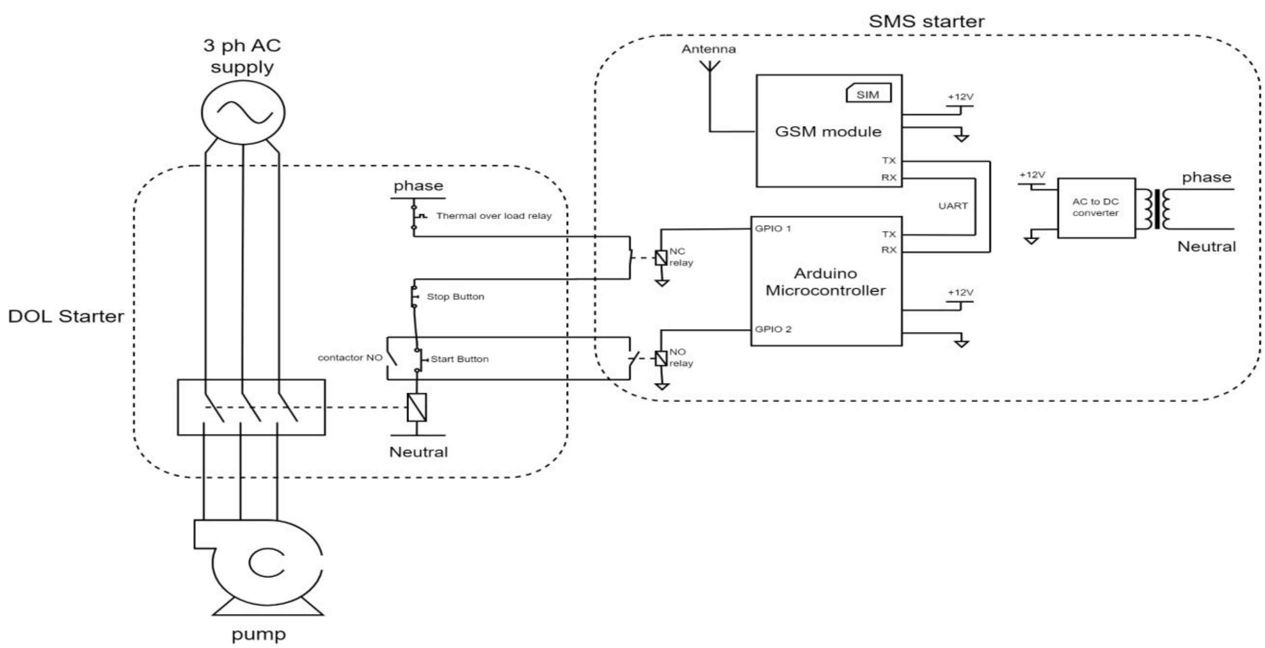

Figure 3 Circuit diagram of the SMS starter interfaced with the DOL starter.

DOL starter consists of two push buttons to operate the starter: start, stop, and manage, as the name implies. The SMS starter is connected adjacent to these buttons to accommodate both online control and manual override.

SMS starter comprises two relays: Normally Closed (NC) and Normally Opened (NO) for the primary contacts. This configuration is deliberately chosen to mirror the DOL starter push buttons, where the stop button corresponds to the NC contact and the start button corresponds to the NO contact. The NC relay is connected in series to interrupt the power to the DOL contactor coil, and the NO relay is connected in parallel to bypass the power through the start button to the DOL contactor coil. Figure 3 illustrates the circuit diagram of the SMS starter interfaced with the DOL starter.
The relay coils are connected to the Arduino microcontroller's two GPIO (General Purpose Input/Output) pins. The GSM modem and Arduino communicate through a dedicated UART serial port. All the electronics inside the SMS starter are

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powered through a regulated 12-volt DC (Direct current) power supply. Facilitated by a stepdown transformer from 240 volts AC and rectified by an AC to DC converter.

With two relay connections to the DOL starter and one power connection to the SMS starter, the hardware interface to the irrigation system is comprehensively established.

Software Implementation

The software is coded in the C programming language using the Arduino IDE (Integrated Development Environment) framework. Arduino IDE is a user-friendly platform that simplifies the process of writing, compiling, and uploading code to the Arduino Uno. Arduino programming is based on the C/C++ programming languages[3]. Users write code in a simplified version of C/C++ known as the Arduino programming language or Sketches, which the Arduino IDE supports. The Arduino IDE provides syntax highlighting to visually distinguish different code elements, making it easier to read and understand.

The IDE verifies the code for syntax errors and highlights issues, making it easier for users to identify and fix mistakes. When the code is error-free, the IDE compiles it into machine code that the Arduino microcontroller can execute. The Arduino IDE allows users to upload their compiled code to the connected Arduino board through a USB interface. The IDE includes a Serial Monitor tool that allows users to communicate with the Arduino board and monitor data output in real time. This feature helps debug and test, providing a way to view messages, sensor readings, and other information the Arduino sends during program execution [3]. The Arduino IDE is compatible with Windows, macOS, and Linux, ensuring users can write and upload code regardless of their preferred operating system[2].

Arduino Uno peripherals are configured in the initialization step, including UART for GSM modem communication, two GPIOs for relay control, EEPROM for storing registered phone numbers, and timers for creating delay functions.

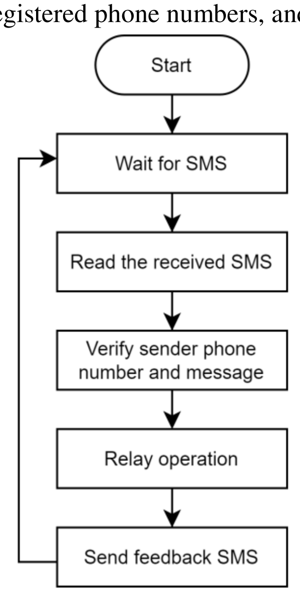

Figure 4 software implementation flow

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Polling Architecture is implemented in the state machine with five distinct states: wait, read, validate, decide, and respond. Upon bootup, the Arduino microcontroller undergoes diagnostic testing to ensure the proper functioning of the GSM modem. Upon successful diagnostics, the microcontroller enters the state machine loop, and the state flow is illustrated in Figure 4 software implementation flow.

In the initial "wait" state, the microcontroller patiently awaits an SMS notification from the GSM modem, transitioning to the "read" state upon reception. In the "read" state, the microcontroller retrieves SMS data from the GSM modem using manufacturer-defined AT commands (AT commands are mainly used to configure and debug modems) through the UART port. Subsequently, the state machine advances to the "validate" state, where the microcontroller verifies the sender's mobile number with the registered user number. If a match is confirmed, the state machine progresses; otherwise, it terminates the state, notifying the sender of access denial.

Table 1 list of SMS codes with their corresponding actions

SMS Code	Preconfigured Action
1	Start the Pump
2	Stop the Pump
other	invalid/void

Upon confirming the sender's number, the state advances to the "decide" state, where the controller takes a preconfigured action based on the received SMS (refer to Table 1, list of SMS codes with their corresponding actions). For instance, the start relay is actuated for an SMS code ‘1’, and the Stop relay is actuated for an SMS code ‘2’; any other SMS code is deemed invalid, resulting in no action. Post-action, the state transitions to the "respond" state, where the microcontroller dispatches a feedback SMS message to the sender detailing the performed action. The state then resets to the initial "wait" state, and the process iterates for each successfully received SMS.

To extend functionality, registered owners can add multiple user phone numbers, enhancing product operability. Successive user numbers are stored in the built-in EEPROM memory of the Arduino microcontroller.

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IV. TEST AND RESULTS

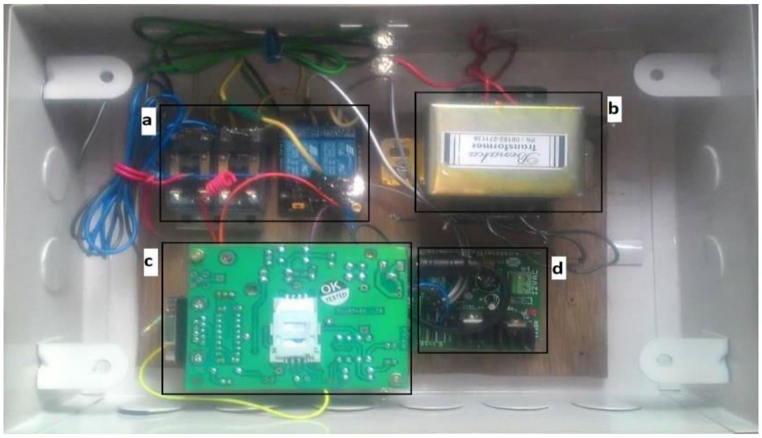

Figure 5 SMS starter hardware kit ((a). Relay module, (b). stepdown transformer, (c). GSM modem placed over Arduino Uno, (d). AC to DC converter)

Figure 5 illustrates the designed and fabricated SMS starter assembly inside the secure metal enclosure. This assembly incorporates a 230 volts AC to 12 volts AC step-down transformer (Fig. 5b), and the output of 12 Volts AC is fed into the AC to DC converter (Fig. 5d). The converter ensures a stable and regulated 12 volts DC supply to power various subcomponents. The Arduino Uno microcontroller is positioned beneath the GSM modem (Fig. 5c), and the relay module (Fig. 5a) is interfaced with the microcontroller. To illustrate the practical application of this setup, the SMS starter kit has been deployed in an operational farmland with an existing irrigation unit.

Figure 6 snapshot of user mobile phone protruding SMS interaction between user and SMS starter

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Figure 6 illustrates the short message service (SMS) interaction between the user and the SMS starter. Notably, the rapid and real-time feedback for the corresponding action codes (refer to Table 1 list of SMS codes with their corresponding actions) is evident, providing a clear and easily understandable response to each requested action. This deployment effectively demonstrates the system's functionality within the real-world context of agricultural practices, highlighting its seamless integration with the pre-existing irrigation infrastructure.

Expansion of Study

Modern irrigation systems encompass more than just pumping water. They incorporate advanced technologies and practices to optimize water usage, enhance efficiency, and improve agricultural productivity[4]. Some key technologies are drip irrigation, sprinkler systems, and variable rate Irrigation. These systems employ solenoid valves to regulate the water flow, ensuring optimal water usage and contributing to sustainable agricultural resource management.

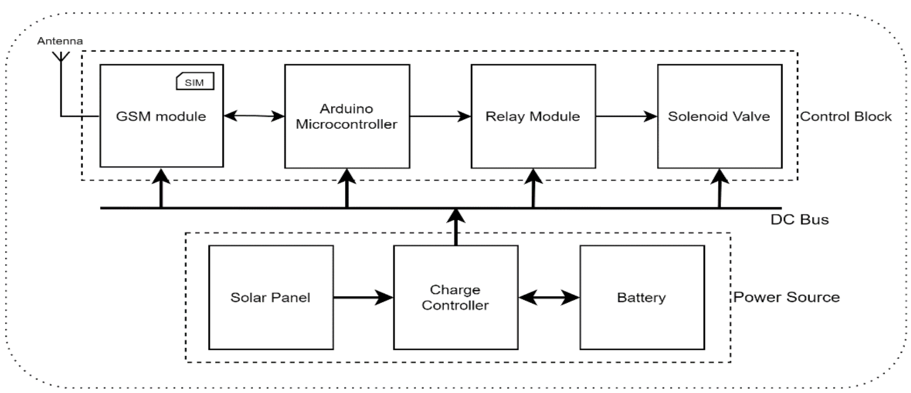

Figure 7 System block diagram for Solenoid Valve control unit

As outlined in this paper, the SMS starter system architecture is the framework for achieving precise control of solenoid valves within modern irrigation systems. Illustrated in Figure 7 is the system block diagram detailing the configuration of an SMS starter-based standalone solenoid valve controller. The control block mirrors that of the SMS starter kit (refer to Figure 1). However, instead of connecting the relay module with the DOL starter, it is interfaced with a solenoid valve to regulate the water flow from the irrigation pump to the designated area.

Since solenoid valves are often far from irrigation pumps, relying on wiring from the pump to these remote locations becomes impractical. To address this challenge and ensure independence from the primary irrigation pump system, the standalone solenoid valve controller is powered by dedicated solar panels and backup batteries to ensure continuous and uninterrupted power supply. The software implementation follows the same state flow as the SMS starter, as presented in this paper, requiring no modifications for implementation.

Notably, utilizing the same SMS code (refer to Table 1, which lists SMS codes with their corresponding actions), users can effectively control numerous solenoid valves through the SMS-based solenoid valve control units. This approach alleviates concerns about operating solenoid valves alongside the irrigation pump in farmland, offering a versatile and efficient solution for managing irrigation processes.

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V. CONCLUSIONS

The SMS starter is seamlessly integrated into an easy-to-install kit, requiring only three connections with the irrigation pump system's existing Direct On-Line starter (DOL). A mobile SIM card is also essential for the GSM modem to send messages, completing the straightforward setup. This user-friendly configuration ensures a hassle-free installation process, making the SMS starter a convenient and efficient solution for incorporating mobile-based control into the irrigation pump system. Users can use any mobile phone with SMS-sending capabilities, eliminating the necessity for an advanced smartphone.

An SMS starter offers a reliable alternative, ensuring continued operation irrespective of environmental conditions. The SMS starter emerges as a practical and effective solution, offering resilience against environmental challenges, enabling remote operation, mitigating wildlife-related concerns, leveraging existing technology, and enhancing overall reliability in irrigation pump management.

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BIOGRAPHY

Dr. Sham M V holds a Bachelor of Engineering in Electrical and Electronics from Kuvempu University, Shimoga, and a Master of Technology from Mangalore University. He earned his PhD in power system protection from the esteemed National Institute of Technology Karnataka, India. Specializing in flexible AC transmission systems (FACTS) and power systems, he currently serves as a selection grade lecturer at V.I.S.S.J. Government Polytechnic College in Bhadravathi, India.

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