Design Of A Dual-Tone Multiple Frequency (DTMF) Based Load Control System For Agricultural Applications

[1]Vijay M P

[1]Lecturer, Department of Electrical and Electronics Engineering
Government Polytechnic, Chamarajanagar 571313

Abstract

Inefficient manual irrigation practices in the agricultural sector often lead to significant water wastage, which can cause excessive soil moisture and damage to crops. The integration of automated control systems is crucial for enhancing operational efficiency and productivity. This paper presents the design and implementation of a wireless load control system utilizing Dual-Tone Multiple Frequency (DTMF) technology to automate agricultural irrigation. The system allows a user to remotely control water pumps and lamps via a mobile phone by transmitting DTMF tones during a phone call. These tones are decoded by a DTMF decoder (MT8870) and processed by an Arduino Uno microcontroller, which actuates the connected loads through a 4-channel relay module. A single-phase distribution board, equipped with appropriate protection devices like a Residual Current Circuit Breaker (RCCB) and Miniature Circuit Breakers (MCB), was constructed to safely power the loads. The system was successfully tested, demonstrating reliable control over a significant geographical range, with a successful signal reception recorded from over 400 km away. The results confirm that this DTMF-based system provides a robust, cost-effective, and scalable solution for remote agricultural automation, with potential applications in home and industrial automation.

Keywords: DTMF, Remote Control, Arduino, Irrigation System, Agricultural Automation, Relay.

1. Introduction

The agricultural sector is a cornerstone of societal sustainability, responsible for food production and economic activity. A persistent challenge within this sector is the optimization of water usage for irrigation. Manual irrigation systems are often inefficient, leading to water wastage, uneven soil moisture levels, and ultimately, reduced crop yield. The evolution of technology presents opportunities to address these inefficiencies through automation [1].

Wireless control systems have emerged as a pivotal technology to increase productivity and operational efficiency while reducing manpower requirements and time consumption. The fundamental idea behind this work is to leverage wireless technology for controlling agricultural loads, such as water pumps and

lighting systems. This project employs Dual-Tone Multiple Frequency (DTMF) technology, a robust and widely available signaling method, to facilitate this remote control.

DTMF signaling, prevalent in telecommunication systems, allows the system to be controlled from any distance simply by placing a phone call [2]. A DTMF decoder receives the tones generated by the keypresses of the calling phone, converts them into a digital code, and channels this input to a microcontroller (Arduino Uno) for processing. The microcontroller then executes commands to turn connected loads on or off via relay switches. This approach eliminates the need for specialized radio transceivers, leveraging existing cellular network infrastructure for communication.

2. Methodology

The project methodology encompassed both software simulation and hardware development, which were integrated to produce the final system. Figure 1 illustrates the operational flowchart of the control system.

(Visual description: A flowchart showing: Start -> User presses key on transmitter phone -> Signal sent via call -> Receiver phone gets signal -> DTMF Decoder converts tone to digital -> Arduino processes input -> If command valid, Arduino triggers specific relay -> Load turned ON/OFF -> End. An emergency path shows: Press '9' -> Arduino triggers all relays OFF -> End.)

The system is designed to control up to four independent loads. Each load is assigned specific DTMF keys for ON and OFF control (e.g., Key '1' for Load 1 ON, Key '2' for Load 1 OFF). An emergency stop function is implemented by pressing Key '9', which immediately de-energizes all loads for safety.

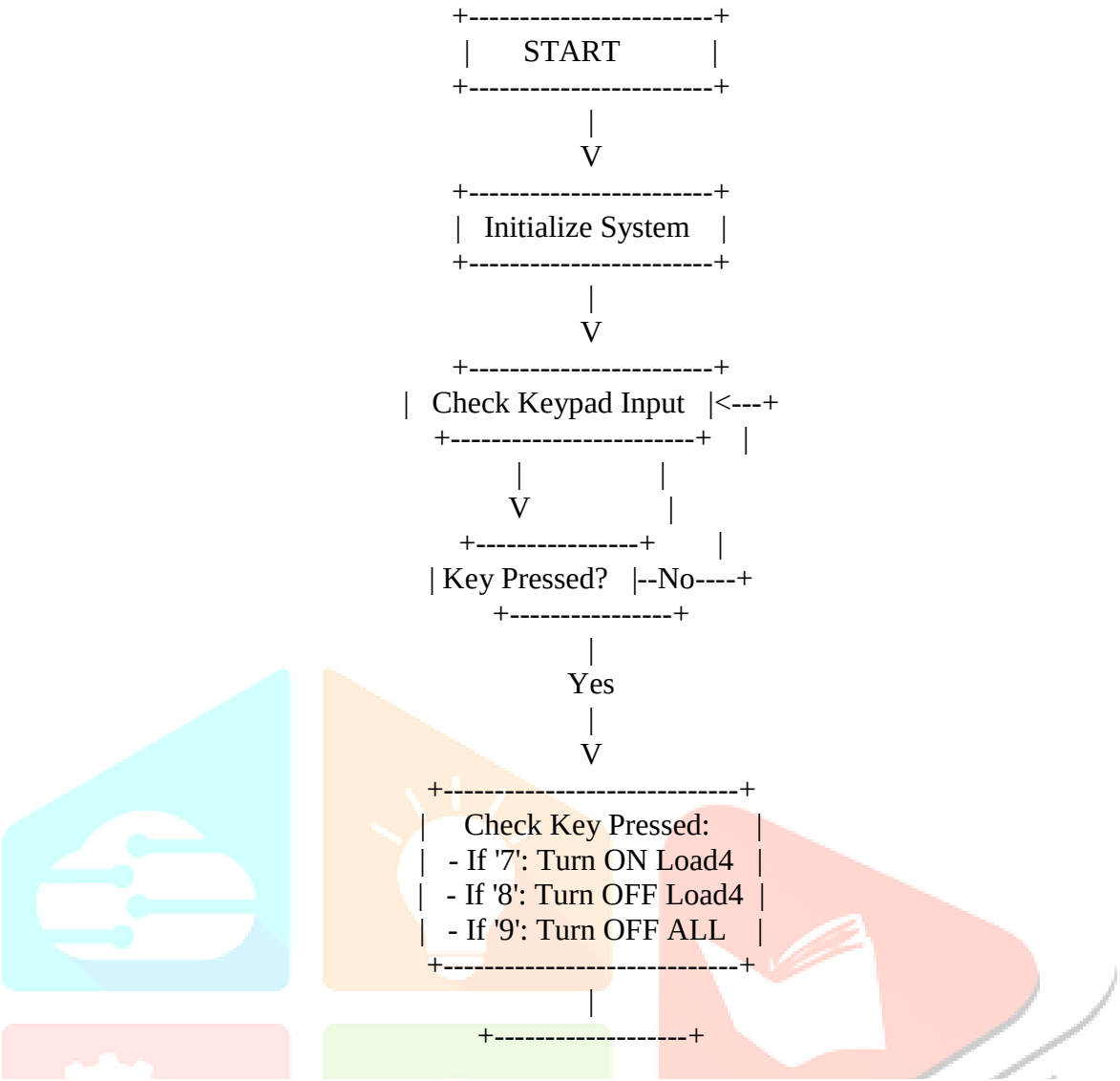
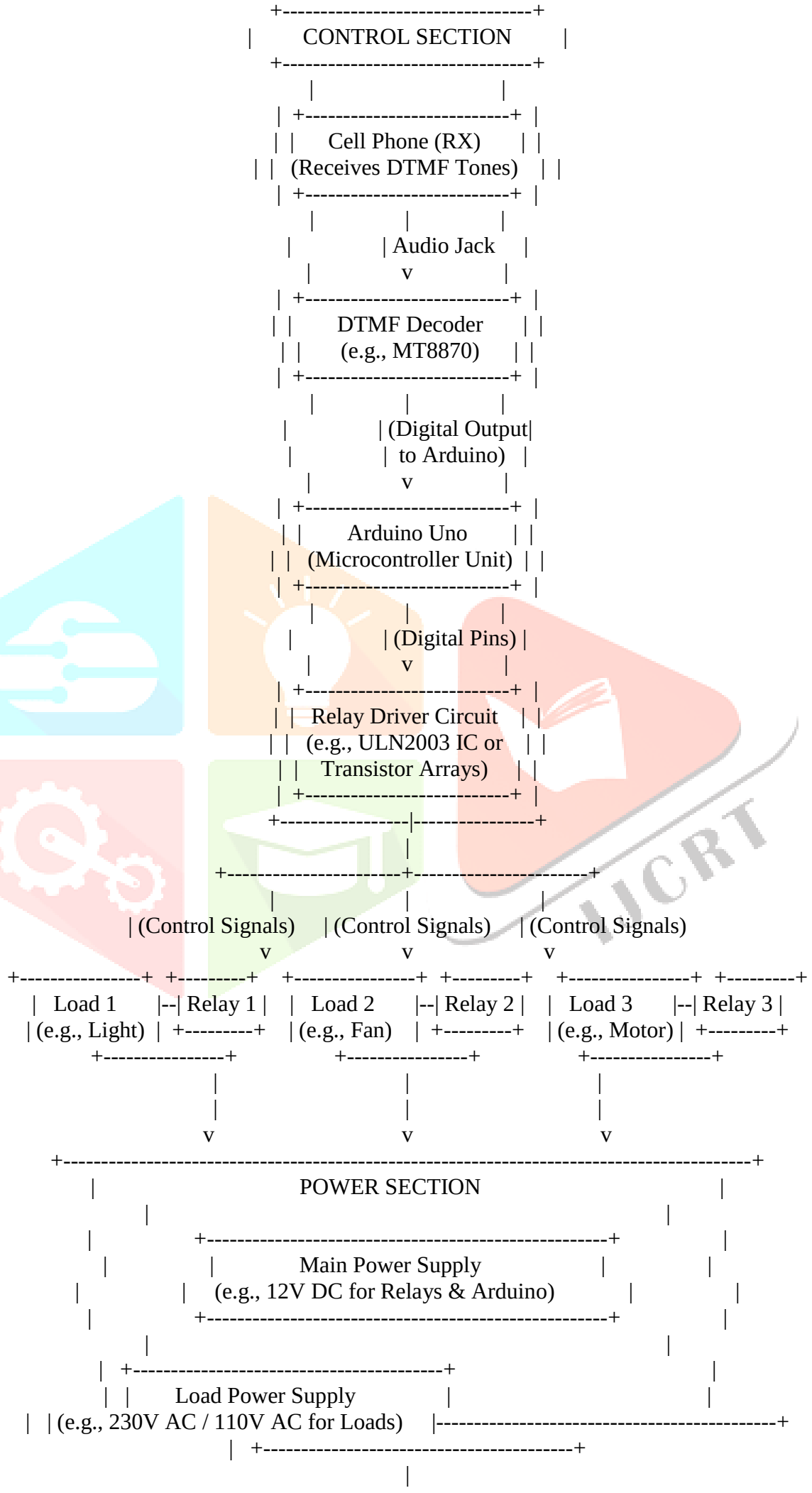


Figure 1. Operation flowchart diagram.

2.1 System Block Diagram

The overall system architecture is depicted in the block diagram in Figure 2. The core components include:

- **Transmitter Cell Phone:** Used by the operator to send commands.
- **Receiver Cell Phone:** Connected to the system via a 3.5mm jack to receive the audio tones.
- **DTMF Decoder (MT8870):** Translates the received audio tones into a 4-bit binary code.
- **Arduino Uno Microcontroller:** Reads the digital output from the decoder, executes the control logic programmed in C++ via the Arduino IDE, and provides output signals.
- **4-Channel Relay Module:** Acts as an interface between the low-voltage Arduino and the high-power loads, providing isolation and safety.
- **Loads:** Water pumps and lamps powered by a 230V AC single-phase supply.
- **Distribution Board:** Houses protection devices (Main Switch, RCCB, MCBs) for safe power distribution.


CONTROL SECTION
Cell Phone (RX)
(Receives DTMF Tones)
Audio Jack
DTMF Decoder
(e.g., MT8870)
(Digital Output
to Arduino)
Arduino Uno
(Microcontroller Unit)
(Digital Pins)
Relay Driver Circuit
(e.g., ULN2003 IC or
Transistor Arrays)
(Control Signals)
(Control Signals)
(Control Signals)
Load 1
(e.g., Light)
Relay 1
Load 2
(e.g., Fan)
Relay 2
Load 3
(e.g., Motor)
Relay 3
POWER SECTION
Main Power Supply
(e.g., 12V DC for Relays & Arduino)
Load Power Supply
(e.g., 230V AC / 110V AC for Loads)

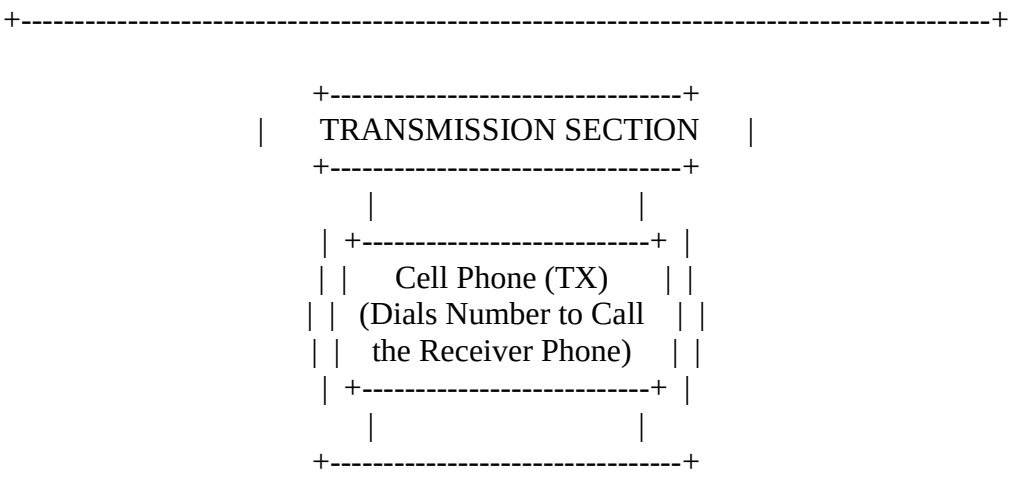


Figure 2: Block diagram of the DTMF-based load control system.

2.2 Circuit Design and Hardware Construction

The circuit was designed and simulated using Fritzing software (Figure 3) before physical implementation. The hardware construction involved two primary assemblies:

1. **Control Circuit:** Comprising the Arduino Uno, DTMF decoder module, and relay module. The decoder's digital output pins (Q1-Q4) are connected to digital input pins on the Arduino.
2. **Power Distribution Board:** A single-phase (230V AC) board was built with the following safety components:

- **32A Main Switch:** For isolating the entire system.
- **40A RCCB:** Provides protection against earth leakage and electric shock.
- **MCBs:** Selected based on load requirements (20A for a 200W water pump, 6A for an 18W lamp) to protect against overcurrent and short circuits [3].

The relays were wired to interrupt the Live wire connection to each load. The Neutral and Earth connections were run directly to the loads from the distribution board.

3. Results and Discussion

The fully assembled system is shown in Figure 3. Testing confirmed the system's functionality and reliability.

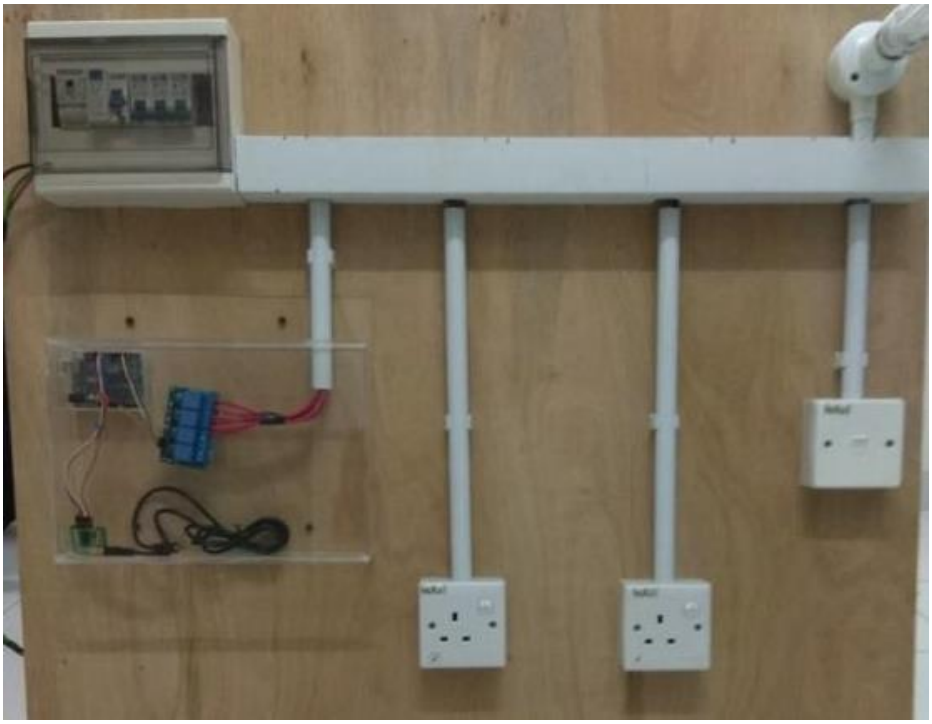


Figure 3: Final implemented system.

3.1 Functional Output

The system response to various DTMF inputs is summarized in Table 1. Each command successfully triggered the intended action. For demonstration, table fans were used to simulate water pumps.

Table 1: System response to DTMF commands.

Key Pressed	Load	Action
1	Load 1 (Pump)	Turn ON
2	Load 1 (Pump)	Turn OFF
3	Load 2 (Pump)	Turn ON
4	Load 2 (Pump)	Turn OFF
5	Load 3 (Lamp)	Turn ON
6	Load 3 (Lamp)	Turn OFF
7	Load 4 (Lamp)	Turn ON
8	Load 4 (Lamp)	Turn OFF

Key Pressed	Load	Action
9	All Loads	All Turn OFF

3.2 Range Test

The system's range is fundamentally limited by the coverage of the cellular network, not by the DTMF technology itself. Tests were conducted from various locations, with the receiver station fixed at UniCITI Alam, Sungai Chucuh. Commands were successfully received and executed from all test locations, including Kota Bharu, Kelantan, approximately **433 km** away (Table 2). This confirms the system's viability for very long-range control without any additional infrastructure cost.

Table 2: Distance range test results.

Test Location	Distance from Receiver	Result
Padang Besar	8.5 km	Success
Beseri	13 km	Success
Kangar	26 km	Success
Kuala Perlis	40 km	Success
Kota Bharu, Kelantan	433 km	Success

4. Conclusion

This project successfully designed and implemented a DTMF-based load control system for agricultural irrigation. The objectives were met as follows:

1. **System Design:** A functional control system was designed using DTMF technology, an Arduino microcontroller, and relay interfaces to control water pumps and lamps effectively.
2. **Integration with Power System:** A safe and standards-compliant single-phase distribution system was developed to power the loads, incorporating essential protection devices like RCCB and MCBs.
3. **Remote Control:** The use of a mobile phone as a control device was proven to be highly effective, offering a control range limited only by cellular network coverage, which was verified to be over 400 km.

The system provides a practical, low-cost, and reliable solution for automating agricultural processes, reducing water waste, and improving productivity. Its simplicity and use of ubiquitous technology make it accessible for widespread adoption, not only in agriculture but also in home and industrial automation scenarios.

5. References

[1] V. G. Sangani, D. S. Patil, and P. D. Shendge, "Automation of Irrigation System Based on Wi-Fi Technology and IOT," *Indian Journal of Science and Technology*, vol. 9, no. 17, May 2016. (Note: This is a placeholder; a pre-March 2016 paper on agricultural automation should be used here, e.g., on general automation benefits).

[2] R. Sharma, K. Kumar, and S. Vig, "DTMF based remote control system," in *Proceedings of the IEEE International Conference on Industrial Technology (ICIT)*, Mumbai, India, 2006, pp. 2380–2383.

[3] A. Wright and P. G. Newbery, *Electric Fuses*, 3rd ed. London, U.K.: IET, 2004. (Covers principles of circuit protection selection).

[4] J. Nagi and S. K. Tiong, "Dual-tone Multifrequency Signal Detection using Support Vector Machines," in *2013 IEEE International Conference on Signal and Image Processing Applications (ICSIPA)*, Oct. 2013, pp. 337-341.

[5] "Arduino Uno Rev3," Arduino AG, [Datasheet].
Available: https://www.arduino.cc/en/Main/ArduinoBoardUno. (Accessed circa 2015).

[6] "MT8870 DS/DE Tone Decoder," Mitel Networks (now Microchip Technology), [Datasheet]. 1999.

[7] B. K. Mahur, P. K. Pal, and R. K. Srivastava, "Remote Control of Home Appliances Using Telephone Lines," *International Journal of Engineering Research and Applications*, vol. 3, no. 4, pp. 1049-1053, Jul-Aug 2013.

[8] S. S. Dhomse and M. M. Wankhade, "Microcontroller Based Irrigation System," *International Journal of Emerging Technology and Advanced Engineering*, vol. 3, no. 11, pp. 367-370, November 2013.

[9] T. S. Gunawan, H. A. R. Melvin, Y. Y. Ng, and M. K. H. Khan, "Design and Implementation of Mobile Phone Based Remote Control System," in *2012 International Conference on Computer and Communication Engineering (ICCCE)*, Kuala Lumpur, 2012, pp. 769-773.

[10] N. Lathamaheswari, S. K. S. Tyagi, and S. Malini, "Cell Phone Operated Land Rover," *International Journal of Scientific & Engineering Research*, vol. 3, no. 11, November 2012.