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Designing and Implementation of low-cost DTMF Based remotely controlled irrigation system with interactive voice response in Bangladesh

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Abstract

In this paper, a low-cost device for efficient controlling of irrigation pumps over the phone call without the internet was designed and implemented having the goal of converting a remote manual irrigation system into a smart automatic irrigation system to control the irrigation pump remotely whenever an abnormal condition arises by using the Dual Tone Multiple Frequency (DTMF) technologies. The purpose of this research is to build an internet-independent automated irrigation system at a low cost for the rural farmer. An Arduino nano and a GSM module are used for controlling the system and a DFplayer mini-MP3 module is also employed for voice response. Here, we practically implemented the designed architecture to justify the design and found that the proposed irrigation system works successfully with an overall system cost of 14.15$. The designed and implemented system does not need an internet connection to operate which makes the device more acceptable to the village farmer of Bangladesh where an internet connection isn't strong enough.

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1. Introduction

Bangladesh is currently a developing country that doesn't have sound internet connections in many rural areas. Moreover, due to the current worldwide energy and power crisis, it is difficult for farmers to irrigate their land properly in due time. Farmers' houses are so far from their farms, and Irrigation may lead to odd timing due to the Irregularity of the power supply in the current worldwide power crisis scenario. An irrigation system needs pumps to supply water to the entire field. The artificial application of water to the soil through various systems of tubes, pumps, and sprays is called Irrigation. where rainfall is irregular or dry times of drought are expected there needs to set an irrigation system. Many types of irrigation systems exist, in which water is supplied to the entire field uniformly. Smart technologies are used in irrigation systems for controlling the system. in order to convert a Manual irrigation system into a remote irrigation system, it is important to have a facility to control the pumps remotely. Because many abnormal conditions can arise. By using DTMF this need can be fulfilled. The overwhelming part of irrigation system frameworks in Bangladesh is physically worked. These antiquated methods are being replaced by semi-computerized and mechanized processes. His readily available conventional processes are similar to a dump water system, terraced drainage system, dribble water system, and sprinkler architecture. The global water system scenario is characterized by increased interest in improved agrarian revenue, poor execution, and limited water accessibility for farming. On farms, it is possible the presence of venomous creatures. Due to these problems, manual irrigation systems sometimes harm farmers. Countries like Bangladesh can't use IoT systems for irrigation because it's expensive, and also to function IoT systems properly need the Internet. And In Countries like Bangladesh, don't have strong internet connections in the village. So we have designed and implemented a system that can solve these problems. The system can be supervised remotely with a simple phone call. Our proposed method can be beneficial for village farmers. So, In this paper, we have designed and implemented a smart low-cost automatic irrigation system without the necessity of the internet. Our proposed irrigation system can be operated by a simple phone call using Dual Tone Multiple Frequency (DTMF) technologies. This type of investigation and use of DTMF-based irrigation systems without using the internet are rare in Bangladesh. The purpose of this research is to build an internet-independent automated irrigation system at a low cost for the rural farmer. So in this research, a low-cost irrigation system is designed and implemented to remotely control the irrigation pump with an interactive voice response, whose operation is so simple to handle this technology for rural farmers.

2. Literature Review

DTMF is a concept of wireless communication used in mobile phones. A DTMF tone is produced by two frequencies, one is high frequency and the other one is Low frequency. This smart technology has been chosen by many researchers working on different methodologies to achieve their objectives (Charki et al.,2017; Ladwa et al., 2009). Shrivastava et al. (2014) implemented a DTMF Based remote robot controlling system (Shrivastava et al., 2014). Dubey et al. (2011) and Islam et al. (2014) designed a wireless sensor network-based remote irrigation control system and automation using DTMF code (Dubey et al.,2011; Islam et al. 2014). There are several projects are conducted to make a DTMF-based remote controlling system (Chan Cho and Wook Jeon, 2008; Kannan Megalingam et al. 2015; Artal et al. 2014). Nandhini et al. (2017) implemented and demonstrated a microcontroller-based automated irrigation system for efficient water management and intruder detection system (Nandhini et al. 2017). Athani et el. (2017) designed a system that will monitor soil moisture through sensors based on a neural network algorithm. Consequently, a series of assessments will be experimented with to show the soil condition, and properties via simple obtainable steps

(Athani et al. 2017). Alraisi et al. (2019) have proposed a real-time, portable monitoring of soil goodness by using Arduino (Alraisi et al. 2019). Arduino along with the smart sensors measures the quality (moisture, pH, and temperature) and effectiveness of soil. Naik and Prasanthi (2017) made an attempt to cut down the wastage of irrigation water was tried (Naik and Prasanthi, 2017). The project also aimed to design an IoT sensor system, which will be capable of detecting the moisture level humidity, and pH value of the soil. Kumar et al. (2019) found that plant growth and health depend on the three major nutrients named nitrogen, potassium, and phosphorous. the pH level of the soil, fertility, and soil moisture are the major issues to increase crop productivity (Kumar et al. 2019). Rajkumar et al. (2017) mentioned that real-time information about land irrigation could be extracted from their proposed system (Rajkumar et al. 2017). Sultana et al (2021) analyze the techno-economic effect of the micro of-grid system, but they don't consider any irrigational load Sultana et al. 2021). Based on the collected information; the water irrigation process is conducted to fulfill the actual need of the plants. But none of these papers applies DTMF in motor control with an interactive voice response. When a phone user presses a key on the phone's keypad, a DTMF signal is produced. By processing the signal, it can be identified which digit was pressed. the identified digit can be used as a triggering switch of a system. An irrigation system needs pumps to supply water to the entire field. To convert a manual irrigation system into a remote irrigation system, it is important to have a facility to control the pumps remotely which can be fulfilled by using DTMF. This type of investigation and use of DTMF-based irrigation systems without using the internet are rare in Bangladesh. So in this research, a low-cost irrigation system is designed and implemented to remotely control the irrigation pump with an interactive voice response, whose operation is so simple to handle this technology for rural farmers.

3. The Proposed Irrigation System

An Arduino nano which is a microcontroller is used for controlling the total system and also processing some data. The GSM SIM800L module is used for receiving the call and DTMF data. DTMF(Dual Tone Multiple Frequency) is a general communication system for touch-tone. The tones are generated when a person presses a specific digit on the keypad on the phone. And that tones could be used to identify those digits, cause each digit generates two frequencies on pressing. And This is the basis of using dual-tone in DTMF communication. Two frequencies are used to minimize the false alarm rate. If one digit generates one frequency there is always a chance an unexpected sound will be generated for the same frequency. But if we use two frequencies one is high and another one is low it is possible to reduce the false signaling to zero level. The "DFplayer mini-MP3" module is used for sending interactive voice to the client's phone so that they can control the system properly. The relay module is for switching the high voltage by receiving the Arduino commands. A Magnetic contactor should be used for switching the high-power water pump. Cause the relays cannot handle the huge current flow while starting the induction pump. When the farmer calls the SIM800l module, with the help of Arduino nano the module receives the call and when the farmer presses a specific digit on his mobile phone DTMF signal is sent from his mobile to SIM800l and SIM800l process and Identifies that digit and then SIM800l send the digit number to the Arduino nano according to digit number Arduino nano turned on the relay and send a command to "DFplayer mini_MP3" module to send the farmer a voice confirmation the "DFplayer mini_MP3" module send a voice to the Sim800L Module and then the SIM800l Module send that voice to the farmer. The relay turns on the Magnetic contactor and the Magnetic contactor turns on the pump. Figure 1 shows the total block diagram for the system.

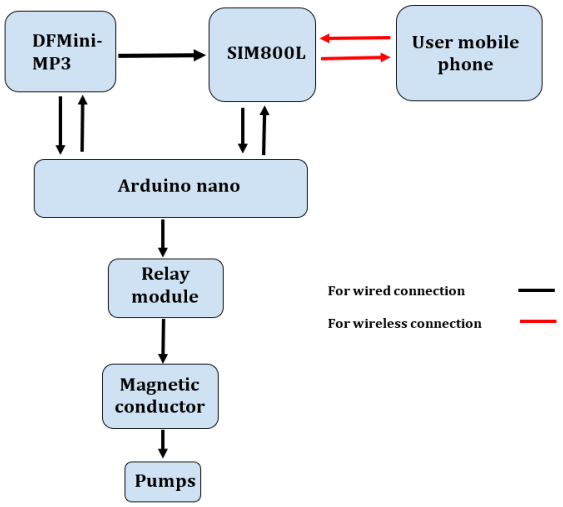

Fig. 1: Block Diagram of the proposed system

4. Proposed Methodology:

In this research, we proposed a DTMF [dual tone multiple frequencies] based communication method by which one can control remote irrigation pumps over the phone call without using the internet. The idea was generated from problems faced by farmers in day-to-day life and can be solved by concepts of DTMF communication technology. figure 2 shows a complete Flow chart and figure 3 shows a complete schematic diagram.

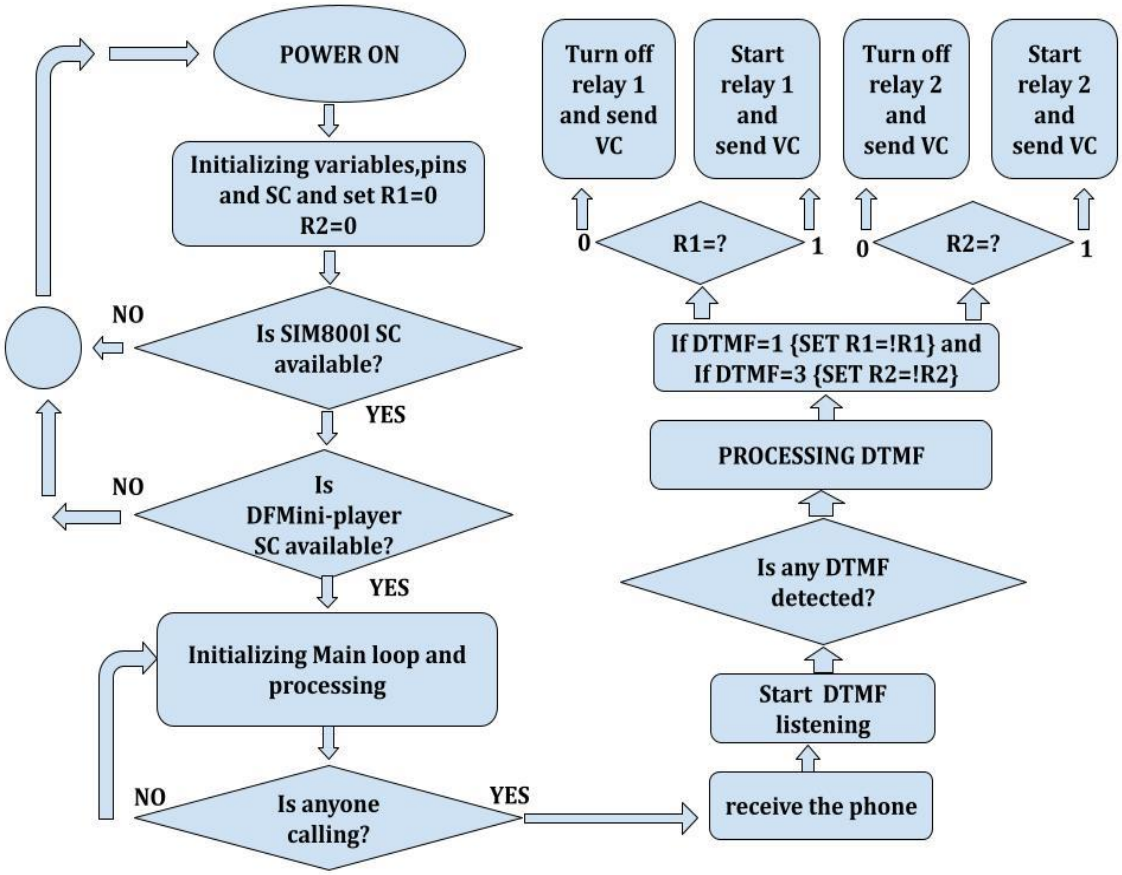

Fig. 2: Operation flow of the system

(Note: SC= Serial Communication, VC= Voice Confirmation)

After turning on the power, the microcontroller initializes and sets the variable R1 and R2 values to zero. After that, the microcontroller checks if there is any sim800l connected, and if the result is true, the microcontroller checks whether the DFmini player is connected. if both sim800l and DFmini player is connected, then the microcontroller starts the main loop and processing. Then the microcontroller checks if there are any incoming calls or not. If this condition is true the microcontroller sends the command to sim800l to receive the call and then set the mode to DTMF listening. When there is any key pressed on the user's cellphone, that phone sends a DTMF signal to our system and our system detects that signal and identifies the pressed key number. After identifying the number the microcontroller starts a condition. If the number is 1 the first variable value gets inverted. if the number is 3 the second variable value gets inverted. Now the microcontroller starts relays 1 and 2 according to the variables R1 and R2. for example If R1 = 0 relay 1 is OFF and if R1=1 relay 1 is ON. If R2 = 0 relay 2 is OFF and if R2=1 relay 2 is ON.

5. Design of low-cost DTMF-based remotely controlled irrigation system with interactive voice response

In this research we used the Arduino nano is used as a microcontroller to control the circuit. SIM800l module is used to receive the call with the help of the Arduino nano and when the farmer presses a specific digit on his mobile phone, a DTMF signal is sent from his mobile to SIM800l, and SIM800l process and Identifies that digit, and then SIM800l send the digit number to the Arduino nano according to digit number Arduino nano turned on the relay and send a command to “DFplayer mini_MP3” module to send the farmer a voice confirmation the “DFplayer mini_MP3” module send a voice to the Sim800L Module and then the SIM800l Module send that voice to the farmer. The relay turns on the Magnetic contactor and the Magnetic contactor turns on the pump. The circuit diagram of the Implemented Prototype of the Research is shown in figure 03.

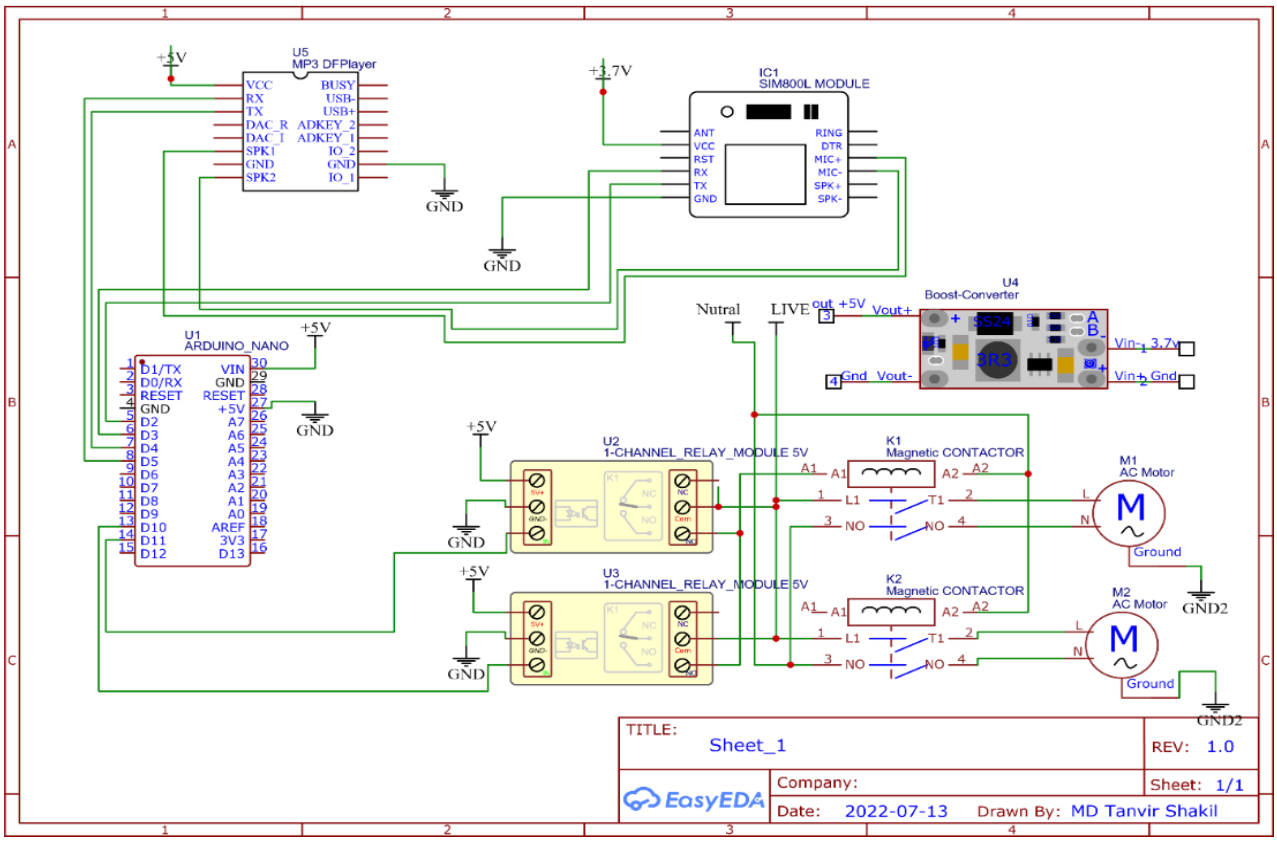

Fig. 03: Circuit diagram of the Implemented Prototype of the Research

6. Component Specifications and Purpose of Utilization

6.1. The Microcontroller:

In this research, an Arduino nano is used as a microcontroller. it can be programmed through the Arduino IDE. For serial communication "software-serial" library is used because the Arduino RX and TX pin is used to program the microcontroller and also to build a serial communication with the computer for bug detection. the proposed method 2 serial communication ports one for the SIM800l and another one for "DFplayer mini player-MP3".In this case pin, D2 and D3 are used as RX, TX respectively for SIM800l on the other hand for the "DFplayer mini player-MP3" pin.D4 and D5 are used as RX, TX respectively. Pin D8 and D9 are used for turning ON/OFF Relay 1 and Relay 2 respectively. Pin Vin and GND are used for powering up the Microcontroller.

6.2. The SIM800l Module:

The sim800l module is can be used as a phone by using an external microcontroller. In this case, Arduino Nano is used. There are some AT commands for controlling the SIM800l module. In this method first The microcontroller tries to build a serial communication through the RX and TX pin. Then if there is an incoming call the SIM800L alert the Microcontroller. After that, the Microcontroller Sends 2 AT commands one for receiving the call and another one to enable the DTMF communication between the caller and the SIM800l. After receiving the call the SIM800l tries to listen to the DTMF signal. once the SIM800l receives a DTMF signal it will process that and identify the digit corresponding to it. And then the digit will be sent to the microcontroller by serial communication for further processing. SIM 800l's power pin is connected to 3.7v and GND to GND of the microcontroller. The RX pin of the microcontroller is connected to the TX pin of SIM800l and the TX pin of the microcontroller is connected to the RX pin of SIM800l.

6.3.The DFplayer mini player:

In this research work, it is necessary to send a voice confirmation to the farmer about the state of this pump or to control properly the system. first The microcontroller tries to build a serial communication through the RX and TX pin. The RX pin of the microcontroller is connected to the TX pin of the DFplayer mini player and the TX pin of the microcontroller is connected to the RX pin of the DFplayer mini player. when SIM800l sends a digit to the microcontroller process according to programming the microcontroller turns ON/OFF Relays and through the serial communication port sends a command to the DFplayer mini player for sending the voice confirmation signal to the SIM800l's MIC port for sending that to the farmer.

6.4. The Magnetic contactor:

A magnetic contactor is an electrical device that can use as a relay but its current controlling capacity is much higher than a general relay. The relay can handle up to 10 Amps of current whereas the Magnetic contactor can handle up to 1000 Amps of current. hence an irrigation induction pump needs a huge amount of initial current a magnetic contactor needs to be implemented because the normal relay cannot handle the initial current of an induction motor.

7.The Experimental Setup:

Figure 04 shows the basic experimental setup hence we don't have much space in our dot zero board we implement the DFplayer mini player separately on a breadboard.

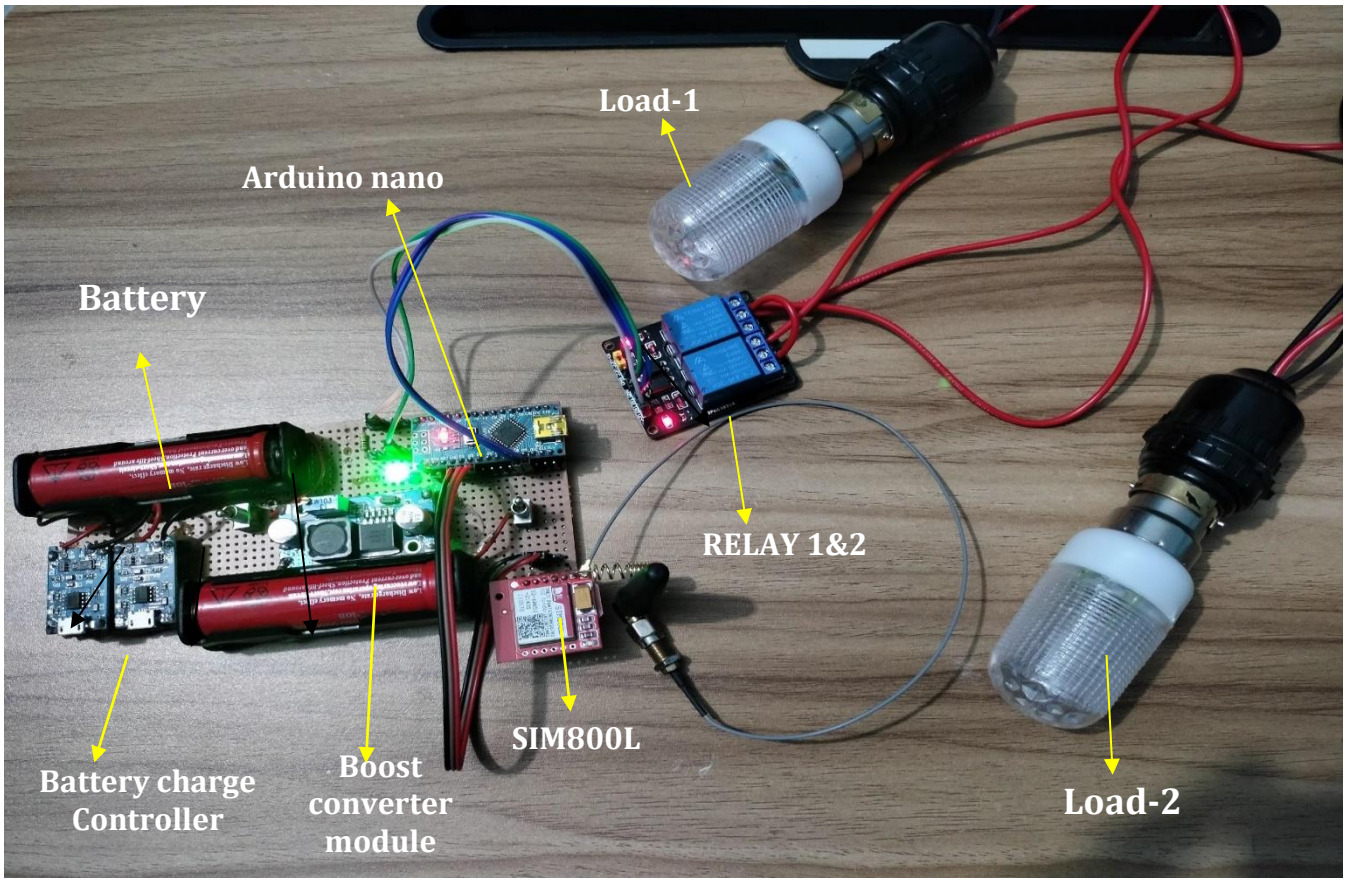

Fig. 04: Implemented Prototype of the Research

8. Cost analysis

Serial	Component Name	Quantity	Per unit price BDT	Per unit price USD	Cost in BDT (TK)	Cost in USD ($)
1	Arduino Nano	1	300	2.89	300	2.89
2	Relay 5v	2	30	.29	60	.58
3	Magnetic Contactor	2	200	1.93	400	3.86
4	Boost converter	1	80	.77	80	.77
5	Battery with charger	2 set	60	.58	120	1.16
6	Sim800L	1	300	2.89	300	2.89
7	DFmini-Player	1	200	1.93	200	1.93
8	Mini LED	2	5	.048	10	.168
				Total =	**1470 TK**	**14.15 $**

9. Experiment Results

After calling a specific number, the call will automatically be received. After then we open the keypad and then if we press 1 Load 1 will be on, if we press 3 Load 2 will be on, if we press 1 again the Load will be turned off and if we press 3 again the Load will be turned off. For

experimental purposes, only 2 relays are used, and later on, for turning ON/OFF a bigger load we added 2 magnetic contactors. Only two bulbs are used for experimental purposes, we replaced those bulbs with a bigger load later on. After adding all the components and putting them inside a box we added a magnetic contactor for the induction motor. Figures 5.a, 5.b, 5.c, 5.d, 5.e, 5.f is shown in these conditions respectively.

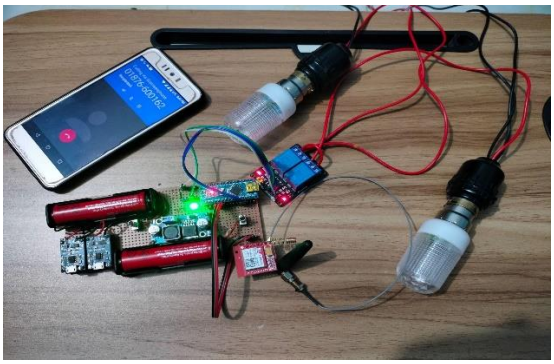

Fig. 5.(a): Calling

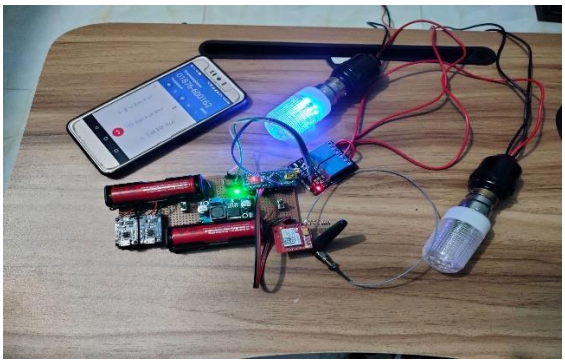

Fig. 5.(b): Load 01 is on

Fig. 5.(c): Both load 1 and Load 2 is on

Fig. 5.(d): Load 2 is on

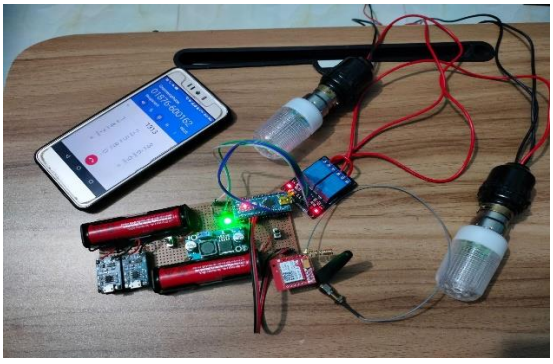

Fig. 5.(e): Both loads are off

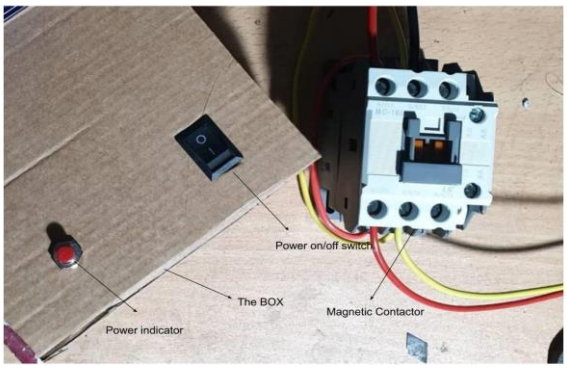

Fig. 5.(f): Implementation with Magnetic Contactor

Fig. 5: Different stages of implementing the prototype

10. Advantages of the Proposed Method over iot Control Method

1. IoT control method needs a strong network to operate but this system is internet free so the village farmer can easily operate this. cause in Bangladesh a strong internet connection is not available in the village.
2. The IoT devices are expensive but this method is cheaper as compared to the IoT system.

11. Results & Discussions

Experimentation of the prototype has been fully performed. The performance of the irrigation system using the proposed DTMF method is developed and tested. The experimental results are selected for different DTMF signals which are sent from a phone over the phone call and found that the prototype worked successfully for all attempts. And the outputs are taken from relays. for demo purposes, only 2 relays are used later on we will add 2 magnetic contactors. for turning ON/OFF bigger load. Only two bulbs are used for demo purposes but we replaced those with a bigger load later on. The overall cost of the prototype is 14.15$ which is shown in section 8. But when it is manufactured industrially, we hope the actual cost will be much less then.

12. Conclusion

The proposed method has been successfully implemented and satisfactory results are obtained. Here, we practically implemented the designed architecture to justify the design and found that the proposed irrigation system works successfully with an overall system cost of 14.15$. It has been taken care of to make the circuit more simple, more practical, and more economical with high efficiency. The method has achieved the main goal i.e. to control the irrigation system remotely with DTMF communication with a voice response at a low cost (14.15$). The designed and implemented system does not need an internet connection to operate which makes the device more acceptable to the village farmer of Bangladesh where an internet connection isn't strong enough.

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