2020-10-01

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SCHOOL OF RESEARCH AND POSTGRADUATE STUDIES

FACULTY OF COMPUTING

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October 1, 2020

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A thesis submitted to the school of Research and Graduate Studies of Bahir Dar Institute of Technology, BDU in partial fulfillment of the requirements for the degree of

Master of Computer science in the Extension program in the Faculty of Computing.

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October 1, 2020

DECLARATION

I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have acknowledged and refereed all materials used in this work. I understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/ fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

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Date of submission: ____23/06/2020_____

Place: Addis Ababa

This thesis has been submitted for examination with my approval as a university advisor.

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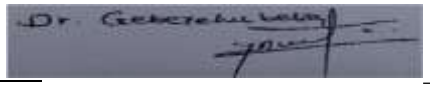
Advisor's Signature: _____  _____

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Approval of thesis for defense result

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

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As members of the board of examiners, we examined this thesis entitled "Model Development for Dam Safety Monitoring using Wireless Sensor Network" by Derese Wudu Mekonen We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Masters of Science in "Computer Science".

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To my Family Specially my wife and my little sister

Acknowledgements

First I would like to thank GOD to give me all what I have and I would like to thank Dr. Gebeyehu Belay (PhD) for his professional guidance and valuable advice. And also this is the only opportunity I got to thank the department of computer science for the chance I was given to join M.SC program. I would also like to thank my work mates.

ABSTRACT

Sensor based modeling pertinent to automate dam safety and end control system. Many dams' uses for irrigation, hydroelectric power, and other purposes for human beings these are needed to be efficient and effective for the best of their service and utilization. These dams are monitored by traditional ways of monitoring and monitoring task performed by a group of people based on visiting dam data, and site inspection. This is labor intensive and not available to the stakeholders easily.

In this thesis, we aim to develop model for dam safety monitoring using wireless sensor network and it overcomes these challenges and other defects. The model is developed using wireless sensor networks and sensor nods to access the real time status data about the reservoir dam. We have implemented water level physical sensor including ultrasonic sensor in small water tank, simulation design using Proteus professional design tools and programmable code in C using Arduino IDE. And also web application monitoring system for monitoring centrally and generating reports in order to access the status of reservoir dam easily. Finally, we present both physical sensor implementation experimental result and simulation results. The experiment presented inspiring results.

Keywords: Wireless Sensor Networks, Dam Safety Monitoring, Sensors, Model Development for Dam safety Monitoring, Simulation

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Abbreviations

AA	Addis Ababa
AAWSA	Addis Ababa Water and Sewerage Authority
ADC's	Analog-to-Digital convertors
DB	Database
DSM	Dam Safety Monitoring
DSMWSN	Dam Safety Monitoring using Wireless Sensor Network
EJB	Enterprise JavaBeans
FS	File System
IEEE	Institute of Electrical and Electronics Engineers
ISIS	Institute for Software Integrated Systems
LCD	Liquid Cristal Display
MEMS	Micro Electro Mechanical Systems
Modem	modulator demodulator
NS	Network Simulator
Ns 2	Network Simulator Version 2
PADS	Practical Algorithm for Data Security
PC	Personal Computer
PDP	Programmed Data Processor
PIC	Peripheral Interface Controller
SMS	Short Message Service
SOWSN	Self-Organizing Wireless Sensor Network
TCP	Transmission Control Protocol
TDSMS	Traditional Dam Safety Monitoring System
WI-FI	wireless fidelity
WLAN	wireless local area networking
WSN	Wireless Sensor Networks

LIST OF SYMBOLS

t	Tolerance factor
K	Kelvin
eV	electron volt
$\triangle H_F$	Enthalpy of Formation.

LIST OF FIGURES

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CHAPTER ONE

1. INTRODUCTION

The dam safety monitoring is the key factor to evaluate the operating status of the dam and ensure its normal operation. To improve dam safety monitoring, it is necessary to develop a set of practical security software for monitoring and management. Dam safety monitoring is to conduct measurement and observation for the dam body, foundation, abutment, bank slope in the near dam region and the surrounding environment. The monitoring objects include hydraulic structures and equipment related to the dam; monitoring is comprised of instrument observations for the dam fixed point with certain frequency, regular visual inspection and instrument detection for the appearance and the large-scale object in the internal part of the dam [1].

Dam is a critical civil infrastructure for many nations [2]. There are many factors to influence dam deformation, such as climate, flood, material, geology, structure, management etc., some of which is with characteristic of periodicity, some of which with tendency, and other of which with random city[3]. The reliability of dam safety monitoring system is very important for erecting dam safety monitoring and controlling models, feed backing and controlling the dam safe state and judging of its working character synthetically [4].

In a dam monitoring system, the parameters that are being measured are generally seepage and displacement. Environmental variables like temperature, water level, and rainfall are also measured in order to get an accurate picture of the dam properties [5]. The instrument monitoring mainly contain environmental monitoring, seepage monitoring, deformation monitoring, trees-strain and temperature monitoring [1]. Traditionally dam safety monitoring is performed by examining the health of the existing dam by a team of persons who are qualified either by experience or education to evaluate a particular structure. It is based on a review of existing data and information, first hand Input from field and operational personnel, and site inspection. This is a labor intensive activity and may reduce

the quality of the data gathered. As a result, the reliability and accuracy of the dam safety monitoring task will be doubtful [2].

Wireless sensor network (WSN) is the most standard services employed in commercial and industrial applications, because of its technical development in a processor, communication, and low-power usage of embedded computing devices. The WSN is built with nodes that are used to observe the surroundings like temperature, humidity, pressure, position, vibration, sound etc. These nodes can be used in various real-time applications to perform various tasks like smart detecting, a discovery of neighbor node, data processing and storage, data collection, target tracking, monitor and controlling, synchronization, node localization, and effective routing between the base station and nodes [6].

Now a days, the emerging of technology automated and real time dam safety monitoring is necessary to increase security, efficient and effective monitoring, predict status, deliver real time information to stakeholders, and evaluate status of dams. And the outcome are used to reduce human labor, cost of maintenance, and to change from traditional dam monitoring system to automated dam safety monitoring using WSNs. Dam safety monitoring using a wireless sensor network should consist of wireless sensor nodes which are highly energy and processing power constraint devices, data collection techniques, energy efficient data processing and data management, dam safety evaluation techniques, and physical sensor deployment on the surface of reservoir dam take appropriate action

The main purpose of the developed model is to enhance dam safety monitoring methods using wireless sensor network. And deploy sensor node on dam, integrate deployed sensor with dam safety monitoring model, integrate alarm and notification service with the model and mange dam using the developed model are the main activity performed in this research. The outcome is important to overcome traditional dam safety monitoring system and also used to reduce human labor, flood damage, and to enhance security of reservoir dam.

1.1 Background

Gefersa and Legedadi are powered by Addis Ababa water and sewerage authority (AAWSA) and used as the main source of water supply for Addis Ababa (AA) and Oromia regional state that are neighbored to AA. The monitoring mechanism for both Legedadi and Gefersa are performed in traditional dam safety monitoring system (TDSMS). In this monitoring status report and water balance calculation are generated from manually filled data by group of expertise and laboratory technicians of the dam.

In TDSMS monitoring task performed by a group of people based on visiting existing data and information by manual intervention and generate report from manually filled data. Even when the reservoir dam water level are above the threshold value the outflow gate are opened manually to remove watery by experts and vice versa. Which is labor intensive activity and prone to error, in order to overcome these challenges develop automated dam safety monitoring system is mandatory. And after the developed model implemented these challenges are resolve.

1.2 Statement of the Problem

Sensor based modeling is needed to enhance dams utilization and efficiency, which is digitally connected and integrated for a given common goal. However, the existing dam safety monitoring methods are mainly traditional way of monitoring, and these monitoring methods have many defect, such as inefficient, inaccurate, not real time, difficult to estimate the status of the dam, labor intensive, cannot easily access status and dam safety related data and other defects. In order to overwhelm traditional dam safety monitoring, and to overcome their challenges, we develop a model for dam safety monitoring using WSN and the outcome overcomes these challenges. This model mainly uses sensors to collect the water level. And Arduino board for uploading and executing programmable code and LED or LCD for displaying status, ultrasonic sensor to measure the level of water, buzzers for alarm sound, jumper and resistor as well. And also modem for SMS notification to send dam safety related information to authorized person. The following research questions are answered by this study:

- How to develop a model for dam safety monitoring using WSN?

- How to integrate sensor nodes to dam safety monitoring system model using WSN?
- How to deploy and integrate physical sensor on reservoir dam and store real time status of dam in MySQL database server?
- How to measure water level, pH level, temperature and humidity level of water on reservoir dam using monitoring model?
- How to implement real time data management, report generation and SMS alert for real time data delivery on dam safety monitoring using WSN?

1.3 Objectives of the Study

General objective

The general objective of this study is to develop a sensor based model for dam safety monitoring using wireless sensor network.

Specific objectives

The specific objective of this thesis covered the following:

- Analyzing the current dam safety monitoring model using wireless sensor network.
- deploy and integrate physical sensor on reservoir dam and store real time status of dam in MySQL database server
- Integrate sensor nodes to the developed dam safety monitoring model.
- Deploy sensor nodes to developed model and simulate in Proteus professional and Arduino.
- Implement alert and notification to dam safety monitoring model for real time data delivery and management.

1.4 Scope and limitations

This study mainly focused on developing model for dam safety monitoring using WSN ,implement physical sensor deployment on the surface of the reservoir dam and also simulate the dam status using Proteus professional designing tools and Arduino boards, and Configure simulation tools for integrating of sensor nodes with developed model.

Finally implement alert service to send dam safety related information to the responsible person.

- Deployment is done on small water tank and only for water level
- Silt level monitoring is not considered.

1.5 Significance of the Study

There are several dams are there in Ethiopia which is controlled by team or group of experts and experienced people these teams and their management staff would be benefited from the developed model. And the list I mentioned below is benefited from the new dam safety monitoring model.

- Dam monitoring management staff.
- Ethiopia Water and sewerage authority.
- The ongoing researches in this domain area.

1.6 Organizations of the Thesis

In this work, the structure of the thesis is organized as the following, chapter two present's literature reviews and related work on model development and safety monitoring of dam in wireless sensor network. In chapter three, the methodology of the study and simulation tools and setups, techniques, software, hardware and technology used are presented. In chapter four we presented the experimental result of sensor deployment and integration of sensor node with the proposed enhanced monitoring model and dam safety monitoring web application system. Chapter five simulation design and results and finally in chapter six present conclusion and recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

This section summarizes some of recent works that are related to dam safety monitoring, Dam safety monitoring using WSN, WSN approach for dam monitoring, simulation tools for WSN, and distributed network in sensor nodes.

Simulation model developed a WSN application for dam monitoring on top of TinyOS operating system using nesC programming and implemented data management and visualization method to present data to the user and SMS alarm notification. However, security aspect of WSN, data comparison techniques, data fusion techniques dam safety evaluation techniques are does not covered in this work and this study is mainly focus on how to communicate clustering of nodes to base station [2].

A WSN in a greenhouse area environment monitoring system based on TinyOS is designed. And environmental parameters such as temperature, humidity and light are monitored to achieve the monitoring of the greenhouse environments. And automatic collection, transmission and intelligent controlling of the parameters information should be achieved. The user can get the high precision data of environment uninterruptedly. According to the characteristics of greenhouse production, the design of WSN system need to meet the requirements of data collection, and the environment parameters of the greenhouse should be easy to query and get by users in real time. It is mainly formed by three parts this are PC, sink node, and sensor nodes. [7].

A great number of data monitoring nodes, distributed in water area to be detected, dynamically constitute a monitoring network, in which each node can only collect
Parameters such as pH, amount of dissolved oxygen, electrical conductivity rate and temperature, but also is capable of operating linearization and temperature compensation, data packaging, collected parameter memorizing and routing to a data base station; the data from the monitoring nodes is transferred to a remote monitoring center by the base station via a GPRS network; the monitoring center analyzes and processes the water quality parameters, gives an alarm for emergencies like water contamination, in addition any sudden changes in water quality, and provides support for decision making in prevention

and remediation of water contamination; the end-user can also realize an all-weather detection on the target water area via the Internet[8].

Sensor nodes are often deployed in an ad hoc manner. The nodes sense the environment and communicate the information gathered from the monitoring field (e.g., an area) through wireless links. The information is forwarded via multiple hops, to a sink which can be a controller or a monitor that uses it locally or the Internet through a gateway. The nodes can be either stationary or moving, may or may not be aware of their location and can be either homogeneous or heterogeneous. Sensors can be deployed in continuous changing environments or in environments that are inaccessible for humans. Sensor networks offer good solutions to many applications like health monitoring, fault diagnosis and innovative human-machine interaction paradigms and spans from military applications to almost every field in day to day life [9].

In dam safety monitoring applications, groups of sensors are deployed in specific areas to observe quantities as stress, stain or pressure and report to a remote central station in monitoring area. Sensors are typically grouped around specific points of interest in a component of the structure. At the physical level, the sensor network consists of the Sensor Nodes (SN), Cluster Heads (CH), and Station Management Node (SMN) and the multi-agent system based DSM provides an information collaborating architecture for dam safety monitoring application. The software architecture involves the following four types of software agents these are Structure monitoring agents (SMA), Data manager agents (DMA), SHM application agents (SAA), User interface agent (UIA) [10].

In [11] module, automatic measurement equipment is used to collect data automatically or semi automatically. These data include mixing temperature, forming temperature, placing temperature of concrete, concrete temperature after placement, flow rate in the pipe, water temperature in the pipe, temperature gradient on the dam surface, air temperature, and solar radiation Heat, horizontal displacement of dam, and vertical displacement of dam. The monitoring equipment automatically collects concrete temperature after placement, flow rate, water Temperature, temperature gradient on the dam surface, air temperature, solar

radiation heat, and so forth, and also other basic information for the simulation analysis can be obtained Semi automatically or by manual work.

The whole system consists of four main subsystems, namely, data acquisition and analysis subsystem, HPC simulation subsystem, intelligent inverse analysis subsystem, and out-processing analysis and pre-warning subsystem. Each subsystem is a module, and the subsystems constitute the whole real-time thermal stress simulation analysis and inverse analysis system. The system is featured by real time, automation, intelligence, and visualization. It can realize the real-time, smart, and quick analysis and inverse analysis of construction quality of concrete placement site, and visual presentation of analysis results and safety pre-warning.

In [12] deals with the PIC16F72 microcontroller to switch on/off the water pump automatically when the soil moisture sensor detects the water level to the plant. The system also includes temperature sensor based fan speed control system. The proposed controlling technique can be used to reduce deaths of people due to current shocks at fields and also to on/off the motor automatically by using soil moisture sensors at fields which avoids need of a human being.

In [13] designed the tailings safety monitoring system based on Internet of things, the system can intelligently sensing the tailing dam deformation, seepage line, water level, rainfall and other key safety parameters of tailings dam operation, make format conversion and pre recognition processing on the collected information and data, and transmits the outcome to the tailings dam safety monitoring center. The network architecture of the system is divided into three layers, the bottom is the perception layer based on ZigBee wireless sensor network, the middle layer is the network layer with 3G/4G network as the backbone transmission network, and the upper layer is the tailings dam safety monitoring center as the application layer.

The hardware structure design of the network coordinator node is mainly Includes 3G/4G module, CC2630 chip module, RS232 interface conversion circuit and power management

circuit. The coordinator realizes the function of network and routing organization, and the sensor terminal node communicates with the external network through coordinator. The design of the lower computer software includes the wireless sensor network data acquisition, network organization, data upload, instruction management, etc... And the host computer software was designed based on Windows Server operating system and SQL Server database system, online real-time monitoring and multi thread programming are adopted, integrated the safety monitoring system of with the geographic information system and decision support expert system, developed the tailings online monitoring software platform, main functions included port monitoring, data receiving, data processing, data storage and processing the client Connection requests.

In [14], the author studies on the design and implementation of dam safety monitoring routing algorithm based on wireless data transmission technology. A mixed repository which based on rule and ANN was studied. The method of reasoning, controlling and repository mange was discussed. In sensor network, each node determines its own position in the space of a space coordinate system called node localization process. Due to limited energy wireless sensor networks, large number, low cost, Each sensor node is equipped with a GPS receiver, or prior to the specified location information for each node, where that are unrealistic.

On [15] the model electrical sensors were connected to a water container that will measure water level. This information was transmitted to a server via Wi-Fi. Information can be accessed via PC or Laptop and announcement will be made on speaker near flood area. Data will be sent to Cloud and trigger email notifications to users about alert messages. Historical Data will be stored on file / webpage for future references. And used water level sensor to detect and identify water level. Microcontroller and Wi-Fi used to implement the module.

In [16] work, proposes to have sensing nodes across the country and the servers collect data from sensors, communication abstraction is created to propagate sensitive information and periodic updates of current status of water level. In paper [17] involves different

sensors deployed at various strategically chosen locations to measure the quality of water by generating real time data. The system also provides an alert mechanism which notifies the different level of authorities through email and SMS in case of any issues.
Designed integrated monitoring platform for water body based on B/S structure, and builds the overall architecture of water monitoring platform. Reservoir dam monitoring platform has been designed to enhance emergency response capability. This system effectively improves the level of information and intelligence [18].

To overcome the many disadvantages of the wired systems, uses of wireless technologies have been proposed for structural monitoring. With the advent of low cost wireless technologies, such as Bluetooth, ZigBee/IEEE 802.15.4, etc., there has been considerable interest in Wireless Sensor Network (WSN) as a viable alternative to the wired systems.
In a dam monitoring system, the parameters that are being measured are generally seepage and displacement. Environmental variables like temperature, water level, and rainfall are also measured in order to get an accurate picture of the dam properties.
In a wired monitoring system, wiring has to be done at a great expense and power is the least of the problems. Whereas in a wireless monitoring system, the sensor units will have to depend on batteries to provide their power, therefore the sensor units have to be very energy efficient so that they can survive for one complete maintenance cycle using one battery power [19].

The system will automatically monitor the dam safety; analyze the real time measure data. Use some sensors to determine the parameters of the dam**.** With the help of IOT network, the parameters of the dam will be transferred to the computer server. With that we can also get messages through GSM modem attached to IOT. In this system we use different sensors to determine the various parameters of a dam. Each sensor is connected to their respective pins of PIC controller [20].

In [21] implemented the system for sensing the water level and sending data to server through Wi-Fi module and wireless controller using Internet of Things (IoT). And used as hard ware like water level sensor is detect and identify amount of water. Micro-Controller

is an integrated computer chip which is easy for receive and transmit data. Wi-Fi Trans-receiver: It is microcontroller with an integrated TCP/IP socket which gives access to Wi-Fi network. It is the popular platform for Internet of Things (IoT). And software likes Linux system (Ubuntu) PHP Python and Algorithms

A wireless solution, based on Global System for Mobile Communication (GSM) network for the monitoring and controlling of the river water level parameter. One of the advantages of the system is that it can be used for monitoring decrement of water level in the rivers and water level rising in case of flooding. The system at a certain interval continuously sends river water level measurements to the concerned authority with water environmental flow management. The designed system is simulated by using Proteus 8 design suit software. [22]

In [23], Design prototype water level control system by open and close automatically the water gate use ultrasonic sensor. Open and close automatically the water gate becomes one of the means of service in an effort to control the distribution of more efficient drainage system to every aspect so as to minimalize the risk of the flood . The water gate will be driven using a Servo Motor. The output of the water level status is displayed in the form of LCD display and is also followed by sound output for people with visual impairments.

In [24], are developed to monitor the water level of the river and control the opening and closing of sluice gate which will protect the people from flood and also protect natural vegetation and beauty of the country. Sensors can be placed at the reservoirs built across the river downstream basins. The sensors will detect the water-level and the resulting data will be sent to the control room for comparison with the pre-recorded data and finding out whether the condition is normal or some alerts are to be sent for emergency. The designed is done by Proteus professional suit simulation software.

The GSM-Based water level monitoring system with GUI capabilities focuses on the use of an automated method of water level detection, monitoring and control. Ultrasonic sensor senses the level of water in the water tank, send the information to a microcontroller, the microcontroller converts the information into digital data; the data is transmitted using IOT

technology to a GUI for control and monitoring. This designed circuit was simulated using the Proteus professional environment. [25]

In [26], are Automatic water level controllers for both overhead and underground tank is designed to monitor the level of water in tank. It displays the level of water and when it is at the lowest level; a pump is activated automatically to refill the tank. When the tank is filled to its maximum capacity, the pump is automatically de-energized. Several circuits are put together to ensure proper working of this design, and the block diagram includes the supply unit, the micro-processor unit, the sensor unit, the display unit and the pump drives unit.

Design water level indicator with automatic water pump controlling system. Water level sensor has been made for apprehended water level properly. Microcontroller is plighted to restrain the overall system accurately that reduces the control complexity. It takes input through the sensor unit that senses the water level. After taking input, output intends the pump's action (on/off) with respect to current water status of the tank. A display unit indicates the status of pump and water level. The device also monitors the state of level of water whether it is stable, increasing or decreasing with what velocity. It also stores the total time of pump being kept ON. It also keep monitoring whether the pumping is working well or not. While keeping the motor ON it detects whether the motor pump is working well or not every minute. [27]

In [28], water level monitoring systems with an integration of GSM module to alert the person-in-charge through Short Message Service (SMS) are developed. And the water level is monitored and its data sent through SMS to the intended technician mobile's phone upon reaching the critical level. Water detector detects the water level and then sends signal to microcontroller unit. The microcontroller circuit sends signal to GSM modem and then GSM modem sends SMS to the person in-charge mobile phone. The mobile number of the user has been set in AT command of PIC16F877A and sends alert messages of the status of the current water level. The serial port connects GSM modem for communication and PIC16F877A was used in a microcontroller circuit for processing unit.

In [29], water level controlling system was developed in Arduino program developing environment and uploaded to the Microcontroller. Water level in the system is controlled automatically. The controller operates on a battery power. Whenever the system encounters empty level and the status of load shedding, the SMS notification is sent to the user. System runs on battery power and comprises of four sub circuits working synchronously; sensor circuit, controller circuit, SMS circuit and relay driver circuit. Sensor senses the level of the water in tank which is continuously fed to controller system. As the system encounters the empty level (A0) condition, status of load shedding is checked. Relay coil is energized and the pump operates when there is no load shedding. SMS is only delivered if status of load shedding is encountered by the controller.

With the help of sensor nodes located in different sections of the tunnels in the dam, temperature and humidity values were monitored via the interface program by establishing a wireless sensor network in tree topology, whereupon the control of temperature and humidity was also performed. [30] And Design scheme of the dam safety monitoring system based on wireless sensor networks. The system mainly use various sensors to collect the water level, seepage, seepage pressure and the dam deformation data, and then send to the host by route and gateway nodes, after data analysis and processing, to judge the safety of the dam, and to help the staff make correct dam safety precautions. The system has the advantages of the low power and the wireless transmission of the monitoring data. [31]

Automatic water level controller through the use of different technologies in its design, development, and implementation are developed. They uses Arduino Uno to automate the process of water pumping in over-head tank storage system and has the ability to detect the level of water in a tank, switch on/off the pump accordingly .The water level and other important data are displayed on a 16×2 LCD display. The circuit also monitoring the level of water in the sump tank [32]

2.1 Related works analysis

NAME	TITLE	FOCUSING AREA AND RESULTS
Salah Adin Seid	Dam safety monitoring using wireless sensor network(2013)	• Focused specifically on reliable data collection, routing, data management, safety analysis, and visualization techniques. • Security of routing with in different nodes • Perform simulation in TOSSIM Simulator • Considered network protocol of multi-hop clustering node.
Ramadhan Sinde, Shubi Kaijage	Design of an Automated River Water Level Monitoring System by using Global System for Mobile Communications(2016)	• Use only water level measurement • Simulation is done for only river water level Monitoring. • Storing the status of water for analysis and prediction is not done.
Eiyike,Kpochi, Abubakar	An Ultrasonic & Gsm Module Based Water Level Monitoring System via Iot (2018)	• Level monitoring is done for water tank, which Limited size and small amount of water • Uses Ultrasonic sensor to monitoring river water. • Storing the status of water for analysis and prediction is not done.
ogbidi joseph	Construction of automatic water level controller for both overhead and underground tanks (2013).	• Monitoring is done for water level of tanks • Integration of sensor is not done • Storing the status of water for analysis and prediction is not done.
Md.Sourove kther Momin,Pratik Roy, Mr.Md.Golam Kader3 ,et al	Construction of Digital Water Levels Indicator and Automatic Pump Controlling System(2016)	• Design is done for water pump controlling system. • Storing the total time of pump being kept ON. It also keep monitoring whether the pumping is working well or not but not store the status water level in storage devices

Resul DOĞAN , Abubakar ERDEM	Temperature and Humidity Control of the Tunnels in the Dam Using Wireless Sensor Networks(2015)	• Temperature, water, humidity level monitoring is done but storing to database for reporting, analysis and prediction is not done.
Asaad Ahmed Mohammedahmed Eltaieb, Zhang Jian Min	Automatic Water Level Control System(2014)	• The process of water pumping in over-head tank storage system and detect the level of water in a tank, switch on/off the pump accordingly is done but controlling is only water level.

Table 1.1 Review summary analyses

The main purpose of the monitoring model is to enhance safety monitoring of a reservoir dam. Monitoring must enable the timely detection of any behavior that could worsen the dam, like water level, pH level, Temperature and humidity level and other status of dam, through corrective measure implementation on reservoir dam.

However some on the previous works does not cover sensor node deployment on dam and storing real time value data to storage server for reporting and analysis purpose. but in this research we have used sensor node based dam monitoring model using WSN on reservoir dam with SMS gateway to send dam related notification to authorized person and buzzers to announce the severity status of dam for delegated person. In addition, we have used LCD display for displaying the status of the dam.

2.2 Literature Review Summary

In the literature review chapter, we have provided review of recent works in dam monitoring using wireless sensor network. Summary of recent works, the methodology and tools of the resent works are described and how they integrate tools and techniques for monitoring dam using wireless sensor networks and approaches they used are explained.

CHAPTER THREE

3. METHODOLOGY

3.1 The Proposed Model

The designed dam safety monitoring model is developed using WSN and can able to do measure and understand Wireless sensor nodes data of Temperature, humidity, water, PH level, and transferring real time sensed data to Database. It consists of various sensors like ultrasonic, Temperature, humidity, water level, and pH sensor. These sensors sense real time value of the dam status, and send to microcontroller in order to identify severity and commandment the inflow and outflow gates accordingly and to database storage server for storing the status.

The monitoring web application model can able to access the real value status of dam using mobile and desktop computer and clearly specified in circle diagram and data grid for easily knowing the status and displayed status in LCD display screen to shows the detailed status of dam based on the given parameter accordingly. When the reservoir dam below or above threshold value is reached the buzzer is functioning and GSM gate way is responsible for sending notification to responsible organ.

In case of water level ,the sensed data are analyzed in real time using Arduino board and Arduino understand the status which is below or above the limit send command automatically to gate motor either switched off or switched on based on the parameter accordingly.

The model uses commercial hardware to allow the acquisition of [22] dam status data from sensor which placed near to the dam surface. Data acquisition done by using sensors (water

level, Temperature level, Humidity level, pH level).When the sensors gathers information about change in status of reservoir dam, then Arduino and GSM start to processed this data. After the data acquisition made, with a defined level, data is processed by Arduino and sent by GSM network to the database server of the safety monitoring model for storing and further processing. By the help of Arduino boards and real time data logger, dam safety monitoring model is responsible to inform every time when the minimum critical parameter is reached.

The responsible person can access information about the status of dam based on the given parameter in different ways. First, message is sent to authorized person, second using GUI URL of safety monitoring web application of dam, and finally through buzzer sound.

Basically dam safety monitoring model is an integrated model for all sensors (Water level, temperature, PH and other) that has been mentioned above and transfers all sensor data to database server accordingly. So before design the integrated model first design each sensor model separately.

1 Water Level Sensor

The water level sensor model is defined as a model which indicates the information about the water level in reservoirs dam using sensor nodes that deployed to the reservoir dam and this sensor sense the level of water and send to database server to store information on storage server and Arduino board using GSM network. Then Arduino analyzed the data and send command to buzzer and motor of dam gates based on the given parameter, if it sense as critical level which is above the threshold buzzer give sound and gate motor opened immediately to remove watery and when level of water is back the gate is automatically off. The model works vice versa based on the given parameter accordingly. The authorized person can able to access this status from database server through web application monitoring system.

2 PH Level Sensor

The pH value is a good indicator of whether water is hard or soft. Pure water has a pH of 7 and is considered neutral because it has neither acidic nor basic qualities. A pH meter consists of special probes which are connected to an electronic meter that would display the reading. If the pH level is less than 7 then it is acidic in nature, if the pH level is greater than 8 then it is alkaline in nature, and generally the range of pH is 0-14.

Water pH level sensor model is a model used to indicate pH level in reservoir dam water and send the sensed data to database server for storing the status and to Arduino board through GSM network. Then Arduino analyze the sensed data and send command to display to show on screen. In addition to this, authorized person can able to access this status using web application.

3 Temperature and Humidity Sensor

Humidity and temperature are common parameters to measure environmental conditions. A combined temperature and humidity sensor is used with Arduino Uno to develop the Celsius scale thermometer and percentage scale humidity measurement model. In this model once senses the humidity and temperature by using humidity and temperature sensor, and then read the sensor nodes output and extracts temperature and humidity values into a suitable number in percentage and Celsius scale and send to database to store humidity and temperature records of the dam.

If the humidity and temperature level is equal to or above the given parameter the buzzer give sound, and system displays humidity and temperature level on display screen apart from displaying send SMS notification, to responsible organ and also it is accessible in web through GUI of the model.

4 Dam Safety Monitoring Model Architecture

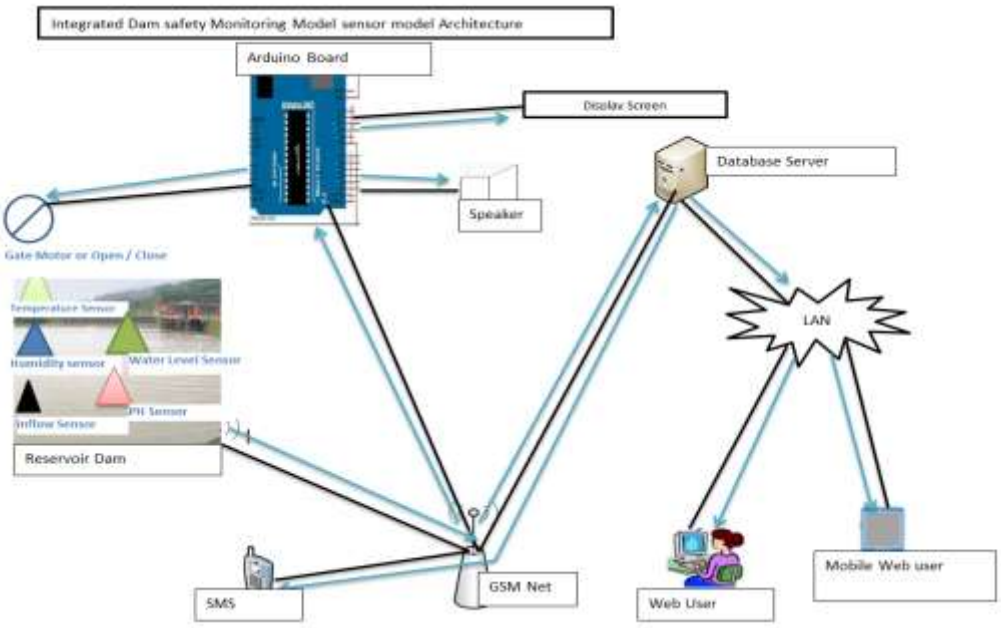


Figure 3-1 Dam Safety Monitoring Model Arc

3.2 Simulation Equipment's

To achieve the proposed model and architecture, we have used the following simulation equipment's and their integration.

- Windows Operating system
- Proteus professional simulation design tool version 8.4
- Integration

Proteus professional is a simulation tool and have a lot library that able to simulate defined events by default but the default library that included in setup is not enough to simulate all events but setup is not limited to this library only. Proteus professional setup has a lot of features that experts can download appropriate library for his action and integrate to the

installed setup. In order to integrate Proteus professional and Arduino, first add downloaded Arduino library and add to Proteus professional default library or copy the download Arduino library and browse the Proteus library and past it.

- Arduino Software (IDE)

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuine hardware to upload programs and communicate with them.

- Keil µVision5

The µVision IDE combines project management, run-time environment, build facilities, source code editing, and program debugging in a single powerful environment. µVision is easy-to-use and accelerates your embedded software development. µVision supports multiple screens and allows you to create individual window layouts anywhere on the visual surface. The µVision Debugger provides a single environment in which you may test, verify, and optimize your application code. The debugger includes traditional features like simple and complex breakpoints, watches windows, and execution control and provides full visibility to device peripherals.

- Database driver or Arduino Connector

The Arduino Connector is a new technology made for the Arduino permitting you to connect your Arduino project to a database server via an Ethernet shield without using an intermediate computer or a web-based service.

- Microcontroller

One of the major reasons of advanced technology and high ending specs in new systems are micro-controllers. There are many micro-controllers which are used for different purposes but there are also few micro-controllers which are widely used all over the world

and in every industry whether it is small or big scale. Some of the major phenomenon in the field of micro-controllers is 8051 and Arduino boards.

- 8051

8051 is an 8-bit family of microcontroller developed by Intel in the year 1981. This is one of the most popular families of microcontroller being used all across the world. This microcontroller was also referred as "system on a chip" because it has 128 bytes of RAM, 4Kbytes of ROM, 2 Timers, 1 Serial port, and four ports on a single chip. The CPU can work for only 8bits of data at a time because 8051 is an 8-bit processor. In case the data is larger than 8 bits then it has to be broken into parts so that the CPU can process conveniently. Most manufacturers have put 4Kbytes of ROM even though the quantity of ROM can be exceeded up to 64 K bytes.

- Arduino board

Arduino board is an open-source platform used to make electronics projects. It consists of both a micro-controller and a part of the software or Integrated Development Environment (IDE) that runs on your PC, used to write & upload computer code to the physical board. It is hardware component to sense real value of data and send to storage or take appropriate action based on sensed data and given setups. But in this study we have use simulation library for Arduino. And download appropriate library for Proteus professional version 8.6 from the Arduino site.

3.3 Data collection and analysis

Data collection is a process of collecting information from all the relevant sources to find answers to the research problem, test the hypothesis and evaluate the outcomes. Data collection methods can be divided into two categories: secondary and primary source of data collection. Secondary data is a type of data that has already been published in books, newspapers, magazines, journals, online portals etc.

Primary data collection methods can be divided into two groups: quantitative and qualitative.

Quantitative data collection methods are based in mathematical calculations in various formats. Methods of quantitative data collection and analysis include questionnaires with closed-ended questions, methods of correlation and regression, mean, mode and median and others. Quantitative methods are cheaper to apply and they can be applied within shorter duration of time compared to qualitative methods. Moreover, due to a high level of standardizations of quantitative methods, it is easy to make comparisons of findings.
Qualitative research methods, on the contrary, do not involve numbers or mathematical calculations. Qualitative research is closely associated with words, sounds, feeling, emotions, colors and other elements that are non-quantifiable. Qualitative studies aim to ensure greater level of depth of understanding and qualitative data collection methods include interviews, questionnaires with open-ended questions, focus groups, observation, game or role-playing, case studies etc.

In order to developing monitoring model for dam safety data collection is critical tasks. And we have used qualitative data collection methods to collect the necessary information how they currently monitored the dam from Addis Ababa water and sewerage authority and also consult other responsible stakeholders.

3.4 Sensors, Software, Techniques and Hardware Tools

To achieve the general and specific objectives that mentioned above, we have used the following software, simulations and hardware tools.

Sensors: are used by wireless sensor nodes to capture data from their environment. They are hardware devices that produce a measurable response to a change in a physical condition. Sensors measure physical data of the parameter to be monitored and have specific characteristics.

The sensor is a device that detects and responds to some type of input from the physical environment. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing [33].

WSN used for typical purposes like event monitoring, fault detection, measuring humidity etc. employ large number of sensor nodes. The sensor nodes are responsible for sensing and processing to some extent as well. A sensor node is made up of sensing, processing, power unit and transceiver basic components [34].

There are a few types of sensors such as temperature sensors, IR sensors, ultrasonic sensors, pressure sensors, proximity sensors, and touch sensors are frequently used in most of the electronics applications [35], from these measuring temperature sensors, measuring pressure sensors and measuring water level sensor will be applied in this research. Sensors can be classified based on power or energy supply requirement of the sensors these are active and passive sensor [36].

PH sensor: pH, commonly used for water measurements, pH sensor is a used to sense of acidity and alkalinity of water.

Water level sensor: Level sensors are used to detect the level of substances that can flow. Such substances include liquids, slurries, granular material and powders. Level measurements can be done inside containers or it can be the level of a river or lake. Such measurements can be used to determine the amount of materials within a closed container or the flow of water in open channels [37].

Humidity sensor: measures and reports both moisture and air temperature. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity. Relative humidity becomes an important factor when looking for

comfort. Humidity sensors work by detecting changes that alter electrical currents or temperature in the air

Vibration sensor: Swift Sensors Wireless Waterproof Vibration Amplitude Sensor activates at a user-defined interval and measures g-force along X, Y and Z axes. This sensor is ideal for monitoring rotating equipment and machines and can be exposed to or briefly submerged in water [38].

Temperature level sensor: Water temperature is a physical property expressing how hot or cold water is. As hot and cold are both arbitrary terms, temperature can further be defined as a measurement of the average thermal energy of a substance [39].

Linux operating system (Ubuntu/Centos): is a Linux distribution that provides a free, enterprise-class, community-supported computing platform functionally compatible with its upstream source and also it is an operating system or a kernel. It is distributed under an open source license [40].Ubuntu is a free and open-source Linux distribution based on Debian. Ubuntu is officially released in three editions: Desktop, Server, and Core (for internet of things devices and robots)[41],we have used Windows operating system for this study due to simulation, but Linux operating system is recommended for real environment due to speed and security.

Kannel services: In computing, Kannel is an open-source WAP gateway. It provides the essential part of the WAP infrastructure as open source software to everyone so that the market potential for WAP services, both from wireless operators and specialized service providers, will be realized as efficiently as possible. Kannel also works as an SMS gateway for GSM networks. Almost all GSM phones can send and receive SMS messages, so this is a way to serve many more clients than just those using WAP [42].

SSHD services: is the OpenSSH server process. It listens to incoming connections using the protocol and acts as the server for the protocol. It handles user authentication, encryption, terminal connections, file transfers, and tunneling [43]. It also needed to provide a remote access to Ubuntu Linux based server [44].

Server: server Machine is installed in monitoring area and has database to store all transactions that related to dam detail, and for this research we will use laptop Machine as a server and client user Machine.

Thin Client: dam will have a thin client and each thin client will have number of sensors. This sensor will have been fixed to the dam; they both will maintain wireless and Bluetooth communication with the thin client.

MICAz: is a 2.4 GHz Mote module used for enabling low-power, wireless sensor networks. And it is a 3rd generation, tiny, wireless platform for smart sensors and it provides a wireless communication with every node as router.

ZigBee: ZigBee network structure can connect over 65,000 nodes. In addition, ZigBee network has a character of low power consumption via multi-hop technology and has the option to self-organize the whole sensor network [19].

PIC controller: PIC microcontroller was developed in the year 1993 by microchip technology. The term PIC stands for Peripheral Interface Controller. Initially this was developed for supporting PDP computers to control its peripheral devices, and therefore, named as a peripheral interface device. These microcontrollers are very fast and easy to execute a program compared with other microcontrollers. PIC Microcontroller architecture is based on Harvard architecture. PIC microcontrollers are very popular due to their ease of programming, wide availability, easy to interfacing with other peripherals, low cost, large user base and serial programming capability (reprogramming with flash memory) [45].

Arduino Uno is a microcontroller board based on the datasheet. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer

with a USB cable or power it with a AC-to-DC adapter or battery to get started. **Uno** means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform.

Motor: Motor of dam gate will be constantly running. This controller unit has a fully automatic function (Auto ON and Auto OFF Function) based on the level of water and given parameter.

Modem: Short for modulator/demodulator, a modem is a hardware device that allows a computer to send and receive information over telephone lines. When sending a signal, the device converts ("modulates") digital data to an analog audio signal, and transmits it over a telephone line. Similarly, when an analog signal is received, the modem converts it back ("demodulates" it) to a digital signal [46].

GSM (Global System for Mobile communication) is a digital mobile network that is widely used by mobile phone. GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. GSM, together with other technologies, is part of the evolution of wireless mobile telecommunications that includes High-Speed Circuit-Switched Data (HSCSD), General Packet Radio Service (GPRS), Enhanced Data GSM Environment (EDGE) and Universal Mobile Telecommunications Service (UMTS).

Local area network (LAN) is a computer network that interconnects computers within a limited area. In this study we have used LAN for interconnection of centralized dam monitoring system, in order to access everywhere by every time

LCD display: A liquid crystal display is a combination solid and liquid. LCD uses a liquid crystal to produce a visible image. It has super-thin technology display screen that are generally used in laptop computer screen, TVs and cell phones.

Power supply: To convert unregulated AC to DC the best method used is regulated power supply a combination of a transformer, rectifier and a filter.

Buzzer: Buzzer is a less weight and cheap product. It is usable in various applications like car/truck reversing indicator, computers, call bells etc. to produce sound [20].

Proteus professional Simulation tool: is the best simulation software in the world for various designs with electronics Proteus ISIS (Intelligent Schematic input system) & microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs for electronics hobbyist & expert [47].

Wi-Fi: is a family of radio technologies that is commonly used for the wireless local area networking (WLAN) of devices which is based around the IEEE 802.11 family of standards. Wi-Fi is a trademark of the Wi-Fi Alliance, which restricts the use of the term Wi-Fi Certified to products that successfully complete interoperability certification testing. Wi-Fi uses multiple parts of the IEEE 802 protocol family and is designed to seamlessly interwork with its wired sister protocol Ethernet. Devices that can use Wi-Fi technologies include desktops and laptops, smartphones and tablets, smart TVs, printers, digital audio players, digital cameras, cars and drones. Compatible devices can connect to each other over Wi-Fi through a wireless access point as well as to connected Ethernet devices and may use it to access the Internet [48].

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1 Experimental results

Now days, the emerging of technology automated and real time dam safety monitoring is necessary to increase safety monitoring of the reservoir dam. And the outcome reduced the challenges, and changed traditional dam monitoring system to automated dam safety monitoring. Dam safety monitoring using a wireless sensor network should consist of wireless sensor nodes and deploy physical sensor node on the surface of dam is required to take appropriate action. Real sensor implementation conduct by using different sensor nodes including ultrasonic sensor, Arduino Uno board, LED, resistor, jumper, Arduino Ethernet Shield, LCD, Patch Card Cable and small water tank.

The Physical sensor are deployed to measure the level of water, in this study the level of water measured using ultrasonic sensor. The Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. And wait for the sound to be reflected back, calculating distance based on the time required. With ultrasonic sensors, we have found the water depth calculation by finding the distance between the transceiver and the surface of the water. The sensor will transmit a short ultrasonic pulse, and we can measure the travel time of that pulse to the liquid and back. We can then subtract that distance from the total depth of the reservoir dam to determine the water level.

This method of measuring with ultrasonic sensors is more accurately described as water level measuring. It is important to note, to position the sensor at a fixed point above the reservoir dam. This can have benefits over underwater submersion, including greatly increasing the overall lifespan of the sensor. Because if the position of ultrasonic sensor is not stabile will gate the false echo and leads to get wrong level. In this study the ultrasonic sensor pin configuration have four pins which is The Vcc pin powers the sensor, typically with +5V, Trigger pin is an Input pin. This pin has to be kept high for 10us to initialize measurement by sending wave, Echo pin is an Output pin. This pin goes high for a period

of time which will be equal to the time taken for the wave to return back to the sensor, and ground pin .This pin is connected to the Ground of the system.

The ultrasonic sensor directly connected to breadboard, a breadboard is a solder less device for temporary prototype with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connects the holes on the top of the board. A breadboard is a rectangular plastic board with a bunch of tiny holes in it. These holes let you easily insert electronic components to prototype (meaning to build and test an early version of) an electronic circuit, like this one with a battery, switch, resistor, and an LED (light-emitting diode).

The light-emitting diode (LED) which is connected to breadboard is semiconductor light source that emits light when current flows through it, which means when the ultrasonic sensor wave turned back. If the level of water is below or above the threshold vale all LED emits light, whereas the color of the light (corresponding to the level of the water in there reservoir dam). The thermistor also connected in to breadboard a thermistor is a type of resistor whose resistance is dependent on temperature, more so than in standard resistors. And Jumper wires are used for making connections between items on breadboard and Arduino's header pins.

The Arduino Ethernet Shield allows an Arduino board to connect to the internet using the Ethernet library and to read and write data to database using respective library. This shield is fully compatible with the former version so that we have used in this study to write sensor data to monitoring application database. In order to use the shield, mount it on top of an Arduino Uno board. To upload sketches to the board, connect it to your computer with a USB cable as you normally would. Once the sketch has been uploaded, you can disconnect the board from your computer and power it with an external power supply. Connect the shield to your computer or a network hub or router using a standard Ethernet

cable (CAT5 or CAT6 with RJ45 connectors). Connecting to a computer may require the use of a cross-over cable (although many computers, including all recent Macs can do the cross-over internally).

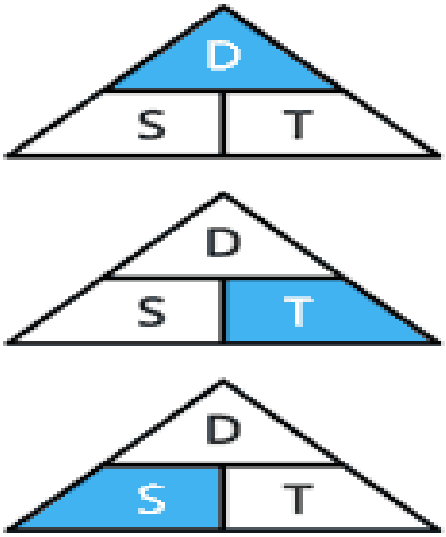
Patch Card Cable is a copper cable that has an RJ45, TERA or GG45 connector on both ends. It may also be used to connect a switch port or a server to the structured cabling system. Sometimes a patch card is used to connect a server directly to a switch port. We have used to as make connection between Arduino Uno board and laptop computer. And The Arduino Uno is an open source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 3.5 and 5 volts.

After make interconnection all materials that stated and described above the sketch diagram of designed model and designed model code are uploaded in Arduino Uno board to show the level of water by the help of ultrasonic sensor. When the level of water is reached below or above threshold value all LED emits light to indicate either below and or above the limit and the respective gate motors are opened. In addition the buzzers give the sound to announce the level of water is something in critical state. When the range of water in the reservoir dam is between below and above the threshold limit the respective LED emits light to show the level of water. In our experiment we have configured four LED light are labeled to show the level of water in reservoir dam are low, medium, full and over the limit. Apart from displaying the dam status in LED, the real time data stored in to database for further analysis purpose. And SMS notification also sent to authorized person.

1. Experimental Result

In our work, we assume small water tank as reservoir dam and the ultrasonic sensor node are deployed randomly on the surface of reservoir dam. Physical sensor implementation conduct by using different sensor nodes including ultrasonic sensor, Arduino Uno board, LED, resistor, jumper, Arduino Ethernet Shield, LCD, Patch Card Cable and laptop, small water tank. Sensor deployment is done for water level and measurements are done using ultrasonic sensors.

Ultrasonic sensors work by emitting sound waves at a frequency too high for humans to hear. Then wait for the sound to be reflected back and calculating distance based on the elapsed time. The distance calculation is done using the following formula



$$\text{Distance} = \text{Speed} \times \text{Time}$$

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

The main advantages of using ultrasonic sensor is simple installation and operation, no moving parts, on-contacting measurement, continuous water level detection, suitable for liquid and some solids, high accuracy and sensitivity. When we use ultrasonic sensor for water level keeping constant palace is cam in to consideration because this leads to get wrong echo.

1. Water Level Experimental Result

In the designed Water level monitoring model, the ultrasonic sensor measure the level of water in reservoir dam and the appropriate LED emits light to show the level of water and store the real time value of water level to database as well as switched on speakers sounds based on the given parameters. And based on the threshold value of water level inflow and outflow motor is open by Arduino boards automatically but motor and buzzers are not implemented yet in our experiment.

Scenario One: **Water is below 25 %**

When the developed model, water level indicator sensor sense water is below 25 % in the reservoir dam all LED emits light until water level becomes above 25%, this indicates to as waters are low or seems to empty in this case inflow motor is opened for recovering reservoir dam from other source until the water level becomes 50% and store the level of data to database for further processing. This data can access in web application system. Apart from displaying in LED the SMS notification is sent to management staff. The experimental result of dam safety monitoring model when water is below 25% is shown in figure 4.1.

Scenario Two: **Water is above 95%**

When the developed model, water level indicator sensor sense water is above 95 % in the reservoir dam all LED emits light, this indicates as waters are above the limit and out flow motor will be on for water is reduced and store the level of data to database for further processing. The status will be accessed in web application system. Apart from displaying in LED the SMS notification is sent to management staff. Experimental result of dam safety monitoring model when water level is above 95% is shown in figure 4.2.

Scenario Three: **Water in reservoir dam is between 90% and 95%**

When the developed model, water level indicator sensor sense water level is between 90% and 95% in the reservoir dam only LED four emits light, this indicates to as waters are full and normal state and level status are stored in to database for further processing. The status

will be accessed in web application system. Apart from displaying in LED the SMS notification sent to management staff. Experimental results of dam safety monitoring model when water level is between 90% and 95% is shown in figure 4.3.

Scenario Four: **Water level in reservoir dam is between 25% and 50%**

When the developed model, water level indicator sensor sense water is medium (greater than 25 %) in the reservoir dam only LED Three emits light, this indicates to as waters are medium but inflow motor is still on to recover the reservoir from other source. Once the level becomes 50% the inflow motor is off and the respective LED is emits light. If the level is between 50% and 95% reservoir dam is in normal state and all motor are off. All level status is stored in to database for further processing and will be accessed in web application system. Apart from displaying in LED the SMS notification is sent to management staff. Experimental results of dam safety monitoring model when water level is between 25% and 50% is shown in figure 4.4.

4.2Dam Safety Monitoring Web Application

1. Web Application

A web application is a computer program that utilizes web browsers and web technology to perform tasks over the network. It used PHP to handle the storage and retrieval of the information, and client-side scripts (CSS, JavaScript and HTML) to present information to users. It also requires a web server to manage requests from the client, an application server to perform the tasks requested, and, sometimes, a database to store the information. Dams are an important part of our infrastructure and provide us with many benefits, including water, power, and recreation. In order to get such benefits must keep safely and securely by the help of today's emerging technology. And the developed web application is very important to do such activates and mainly for monitoring and viewing the status of the dam centrally.

The developed Web application system used server side scripting language to handle the storage and retrial of sensor transaction which is deployed on dam surface, Apache as application server and database server to store the transactions of sensor, which give as to access real time status of reservoir dam in centrally or remotely by either in mobile or computer in addition to SMS notification. In this application all sensors data of the reservoir dam are clearly specified to identify easily. And the system has a capability to generate both current status and frequency (daily, weekly, monthly etc.) based reports for analysis purpose.

This web application is mainly view the status of data that logged by deployed sensor .In case the SMS notification is not sent to the stakeholder and the level of water is below or above the threshold value the viewer be able to get the status using this application and take appropriate action. Any researchers in this domain area and organization staffs can be able to get the status history of the dam to perform any analysis and conclusions' based on the generated report. The screenshot of web application system home is shown in figure 4.5

2. Database Application

Database is an organized collection of data. The data is typically organized to model aspects of reality in a way that supports processes requiring information. While dissemination data over a dedicated network in different platform are the basic and very important for dissection making especially in safety related system model. Database application for dam safety monitoring model are to be able to store data read from connected sensors devices.

Data read from connected sensor can give capability for get and monitor live data, and also able to get historic information for analysis and comparison. It also allows capturing real time data from multiple data input devices and display when it required. In this study water level related information are stored and kept in to database server. The monitoring web application database structure is shown in the following figure 4.10 and 4.11.

CHAPTER FIVE

5. SIMULATION DESIGN AND RESULTS

5.1 Introduction

Sensor based model is developed for all round monitoring of reservoir dam, to remove the limitation of traditional dam monitoring system. The designed model is simulated by using Proteus professional design suit software for schematic diagram and Arduino and Kiel IDE for programmable coding. When the water level is between 0 and 50 percent, inflow gate is open for recovering reservoir dam. The water level is between 51 and 95 percent the inflow and outflow gate are closed state which means reservoir dam seems good. The water level is above 95 percent the outflow is open to runoff the water which is above the limit. Whereas temperature and humidity level are displayed from, by increasing and decreasing the value in simulation sensor device

The Enhanced dam safety monitoring model for water level is designed using Arduino and 8051 microcontrollers, 80C51 devices MCS8051 library with 8051 core microcontrollers, LM044L display 20X4 LCD as displaying screen, Buzzer devices library which is generic buzzer symbol as speakers, SPST push button sensing the level of water in reservoir dam, active animated relay model, animated capacitor model and two active simple DC motor for automatic gate controlling of inflow water from different source to reservoir and outflow water from reservoir. And simulation is done using Proteus professional design tools and Arduino IDE and Keil IDE for coding and generating hex file.

5.2 Simulation Results

The program code is written in C language and compiled into a .hex file. After the model program code is compiled and generating .hex extension file, and then uploaded to the Proteus professional designed sketch model to run and simulate the designed model for all sensor nodes that deployed on the surface of dam. The button value was varied and the corresponding output was displayed and stored in database. Simulation is done separately for individual model (water, pH, and temperature and Humidity level).

1. Water Level Simulation

In the designed Water level monitoring model, the sensor sense the level of water in reservoir dam and displayed the appropriate value in liquid crystal display (LCD) displayed screen and store the real time value of water to database as well as switched on speakers sounds based on the given parameters. And based on the threshold value of water level inflow and outflow motor is open by Arduino boards automatically

Scenario One: **Water is below 25%**

When the developed model, water level indicator sensor sense water level is between 0 and 50 % the source or inflow gate is open until the level of water in reservoir dam is reached 50%, when the level is back to 50 percent inflow gate automatically closed. Apart from automatic controlling the alert is send to management staff and status of reservoir is displayed in LCD screen. If the reservoir water level is below 50% the buzzer is functioning to announce the severity. The simulation result of dam safety monitoring model using WSN water level indicator, when water is below 25% shown in figure 5.1.

Scenario Two: **Water level between 50 and 100%**

When water level indicator sensor sense water is between 50% and 95% of the reservoir dam the inflow motor (source gate) and outflow motor (outflow gate) are stopped or closed this indicates as the reservoir dam is normal state. Apart from automatic controlling the alert is send to management staff. And this status will be accessed in LCD screen. The simulation result of dam safety monitoring model using WSN level indicator, when water level between 50% and 95% are shown in figure 5.2.

Scenario Four: **Water level above 95%, water over flow in reservoir**

When the water in reservoir dam is above 95%, water level indicator sensor sense water is above the expected limit and reservoir dam is at critical point. In order to flow the overflow water from the reservoir to respective site, the outflow gate automatically switched on and water is flow from reservoir to outside until the water back to full level, and vice versa. Since the source gate is closed when the level of water is greater than or equal to 50% of

the reservoir. Apart from automatic controlling the alert is send to management staff. Status of reservoir is displayed in LCD screen and switched on the buzzer or speaker sound regularly. The simulation result of dam safety monitoring model using WSN water level indicator, when water is above 95% is shown in figure 5.5.

2. Temperature and Humidity Level Simulation

In this model the sensor sense the level of Temperature and humidity in reservoir dam and displayed the appropriate value in LCD displayed screen and store the real time value to database for reporting and further analysis. The simulation result of dam safety monitoring model using WSN temperature level indicator is shown in figure 5.6.

3. Logging Data to Database

Recording data and analyzing them is a common practice in most of the industries specially in monitoring area, because recording event is very crucial to monitoring and follow up tasks with in a specific interval of time for decision making.in modern technology there are a lot of data logger tools and library to store events and activists to database automatically by doing some design and parameters.

Data loggers are the core of every measurement station and perform key tasks to data collection, processing and storage of data, control of limit values, and transmission of alarm and status messages [49]. In order to store real time sensor data to database, we have implemented Arduino Ethernet shield. Arduino Ethernet Shield is a device used to connect microcontrollers to the wire from the internet router to the Ethernet shield. And each sensor library and Arduino connector tools is added to Arduino IDE for interconnecting the sensor device and database server. After configuring Ethernet shield, sensor library and Arduino connecter components real time dam status values are logged to database.

4. SMS Implementation on Simulations

There are different kinds of GSM modules available in market. The most popular module based Simcom SIM900, SIM900A and Arduino Uno is used to Interfacing a GSM module to Arduino board. A GSM Module is basically a GSM Modem connected to a PCB with different types of output taken from the board for 8051 and other microcontrollers and to interface directly with PC.

SIM900A is an ultra-compact and reliable wireless module. The SIM900A is a complete Dual-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industry-standard interface, the SIM900A delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mmx24mmx3mm, SIM900A can fit in almost all the space requirements in user applications, especially for slim and compact demand of design [50].

The Proteus simulation software can be used to interface real-time modules like the GSM Module [51]. And we have used GSM Module Library to implement SMS. And based on the status level SMS is fire to responsible person to aware the real time status of dam.

CHAPTER SIX

6. Conclusions and Recommendations

1. Conclusions

Dam is a critical civil infrastructure for many countries including Ethiopia, which has constructed for the purpose of generating hydroelectric power and for irrigation. As it is a critical civil infrastructure, keeping track of dam safety by obtaining useful information about the behaviors of the dams, and detect irregularities as early as possible to enable a timely response is the most important task. Currently dams are monitored by traditional dam safety monitoring system and monitoring task performed by a group of people based on visiting existing data, information, and site inspection. This is labor intensive, and not available to the stakeholders easily, As a result, the reliability and accuracy of the dam safety monitoring task will be doubtful.

To monitor the safety of a dam in real time, it is necessary to implement an automated monitoring system which increases dam monitoring frequency. In this thesis, we proposed model for dam safety monitoring using a wireless sensor network that consists of wireless sensor nodes which are highly energy and processing power constraint devices. The proposed model to perform automated safety monitoring of a dam overcomes the challenges and it is developed using wireless sensor networks and sensor nods to access the real time status data about the reservoir dam.

2. Recommendations

In this study, physical sensor deployment is done for water level in small water, which is difficult to conclude the level of reservoir dam. In the future I recommend deploy multiple sensor in real dam surface including the remaining temperature, humidity and water pH level. In this study mainly focus how to monitor dam centrally using the emerging technology. In future I also recommend considered the silt level, security, reliability and inter connection between the sensor nodes.

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Appendix

Experimental Results

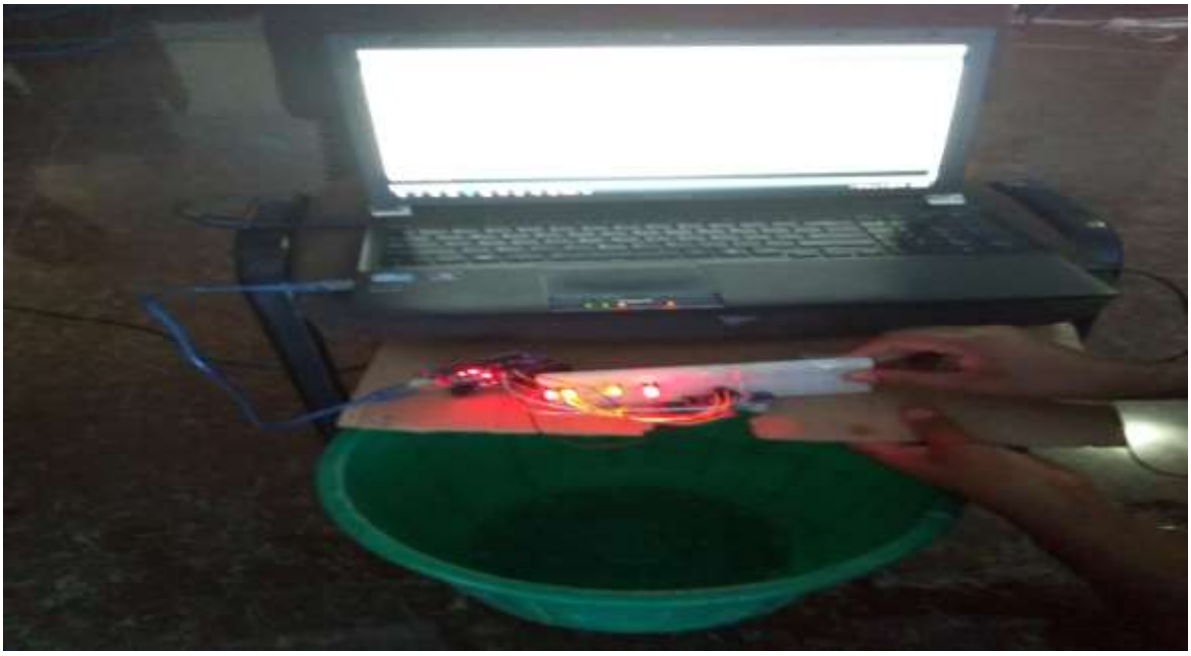

Figure 0-1 Water is below 25%

Figure 0-2 Water level in reservoir dam is above 95% and incoming in progress

Figure 0-3 Water in reservoir dam is full

Figure 0-4 Water level in reservoir dam is between 25% and 50%

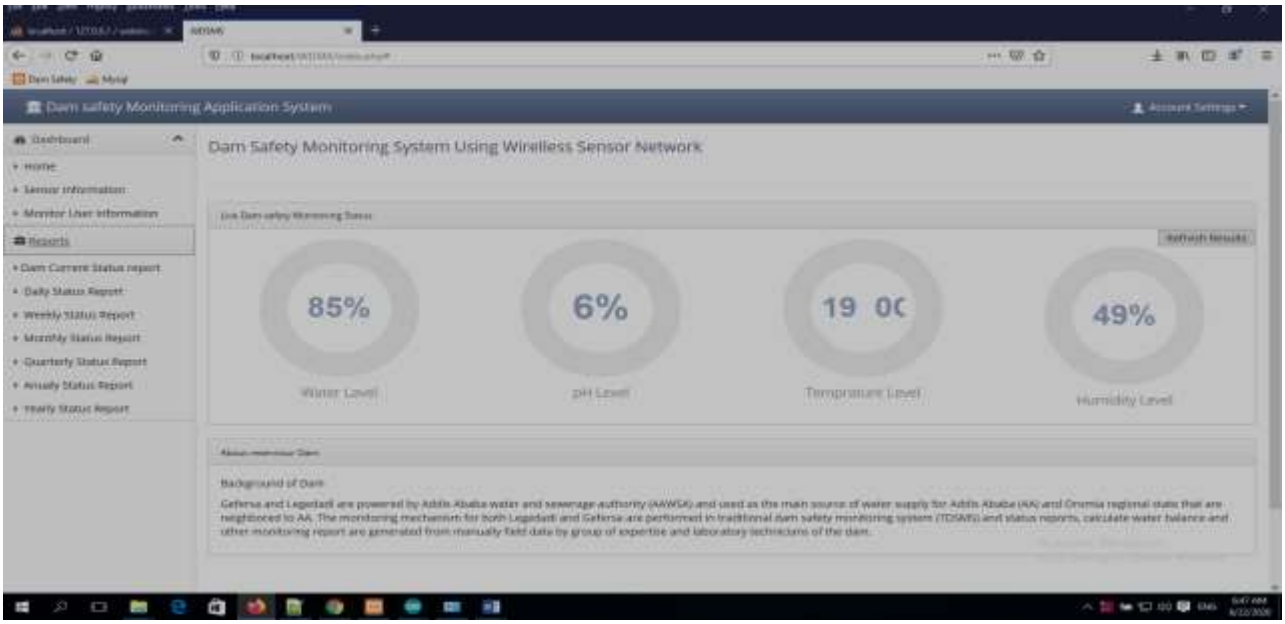

Figure 0-5 Dam monitoring web application home page

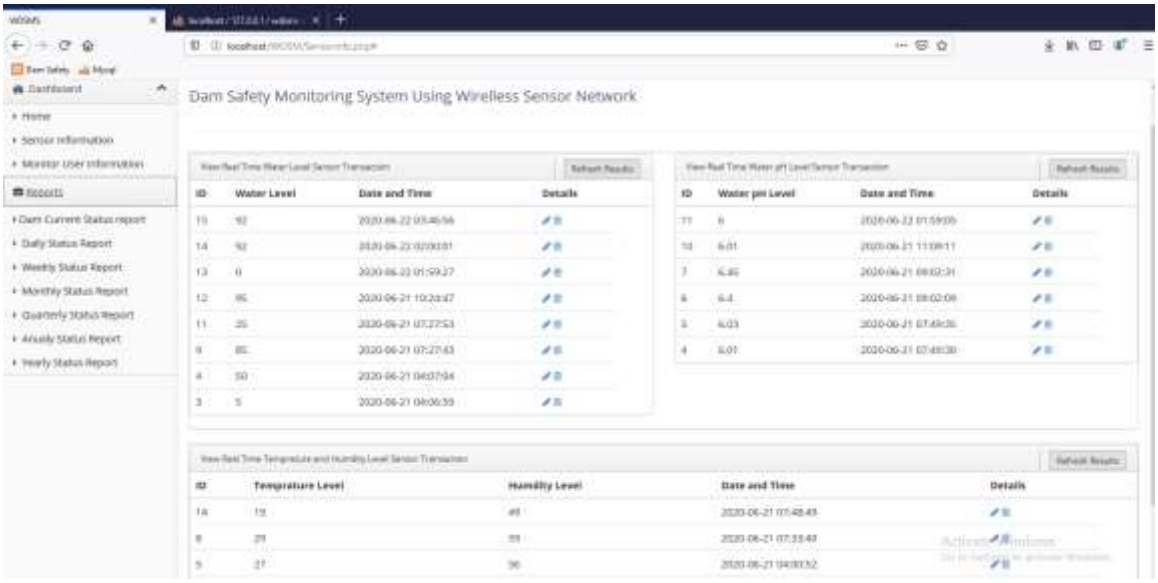

Figure 0-6 all sensor live transaction monitoring page

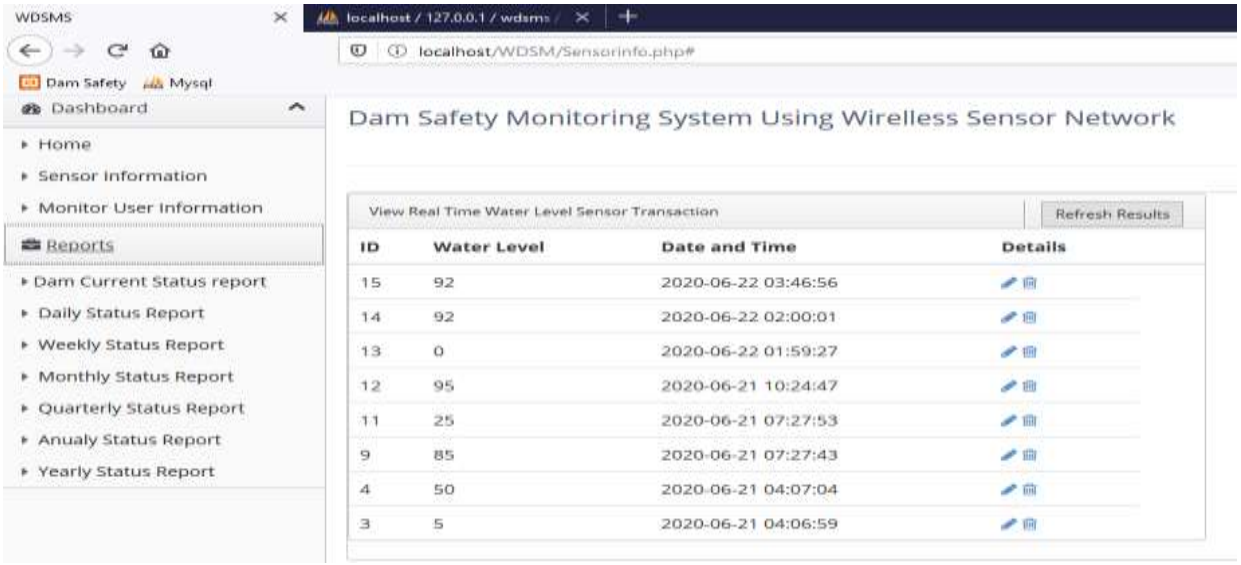

Figure 0-7 Water level sensor Transaction detail

Figure 0-8 Water pH level sensor transaction detail

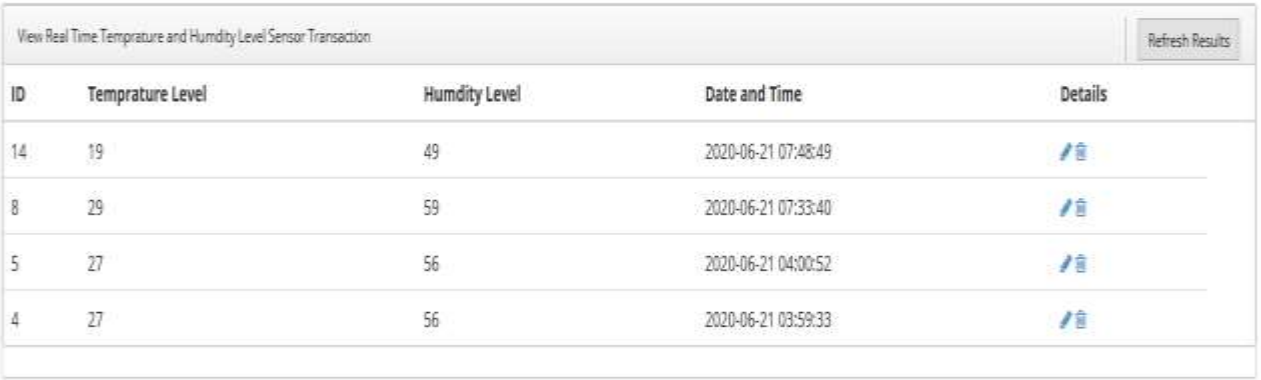

Figure 0-9 Temperature and humidity level sensor details

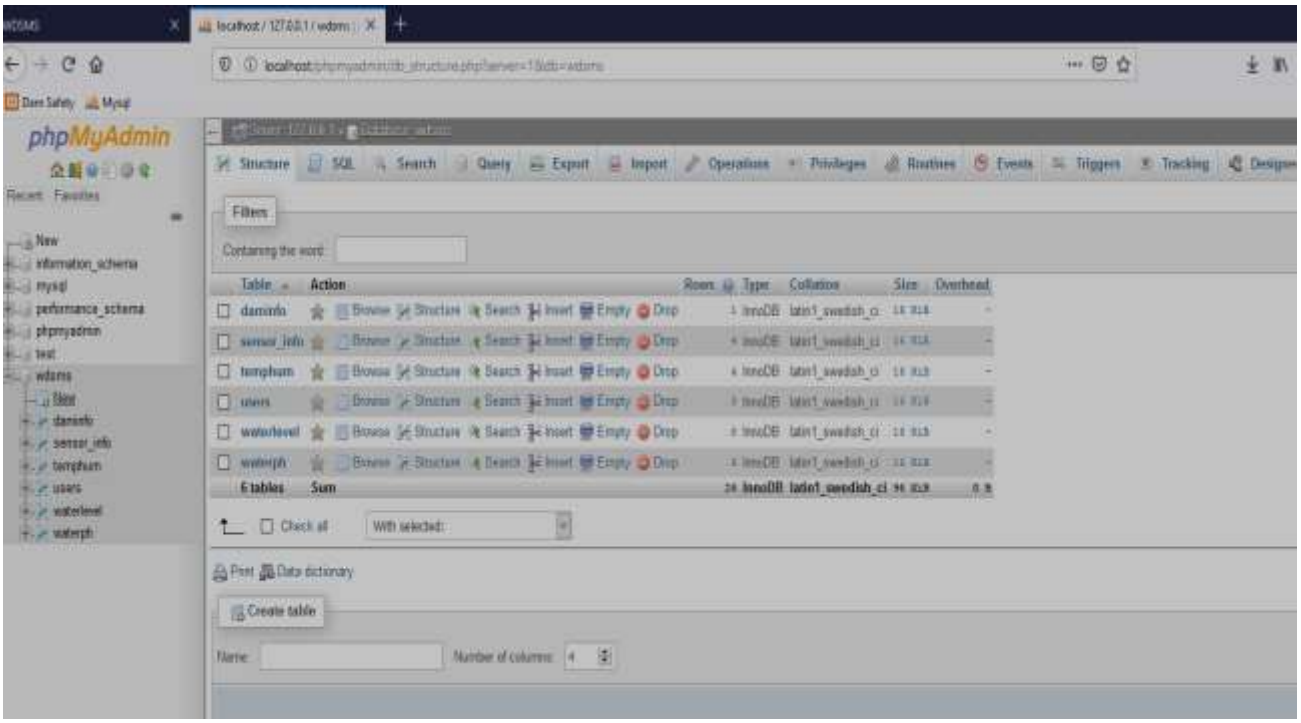

Figure 0-10 Database tables

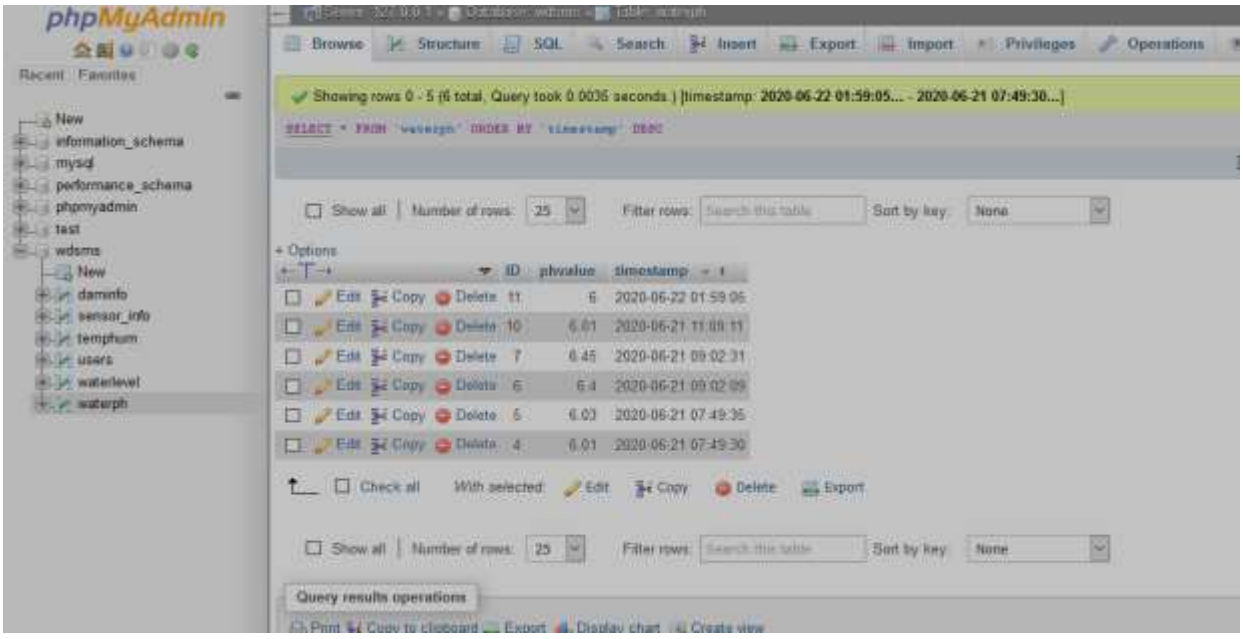

Figure 0-11 : table with value

Simulation Experimental Results

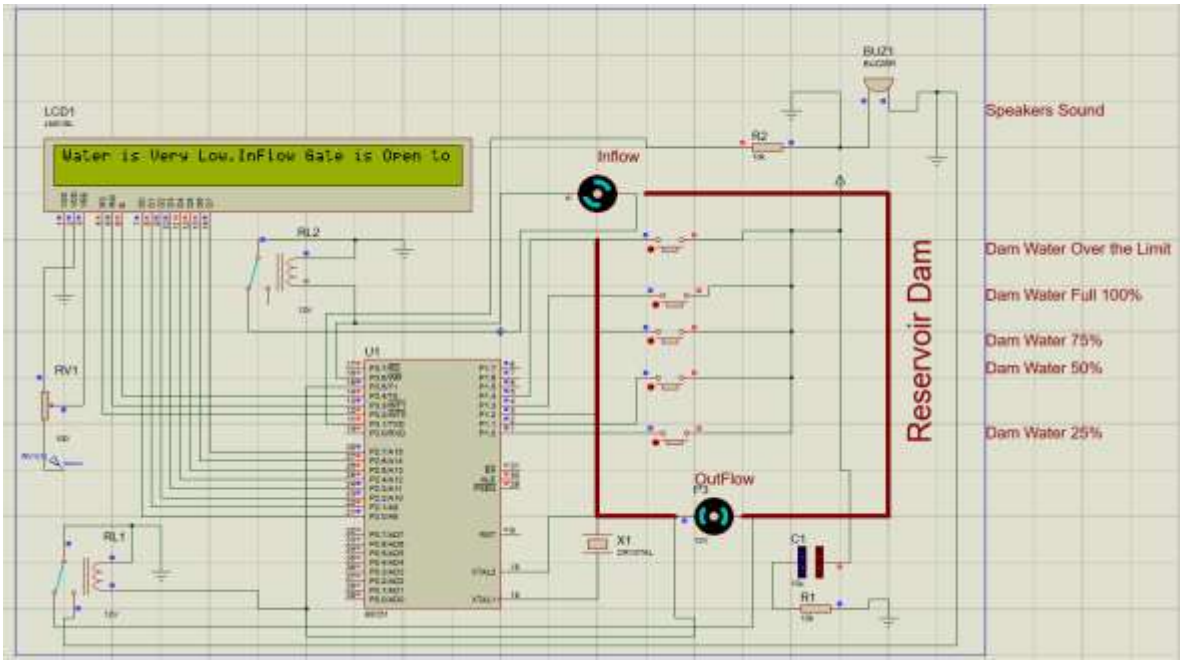

Figure 0-12 Water level below 25%

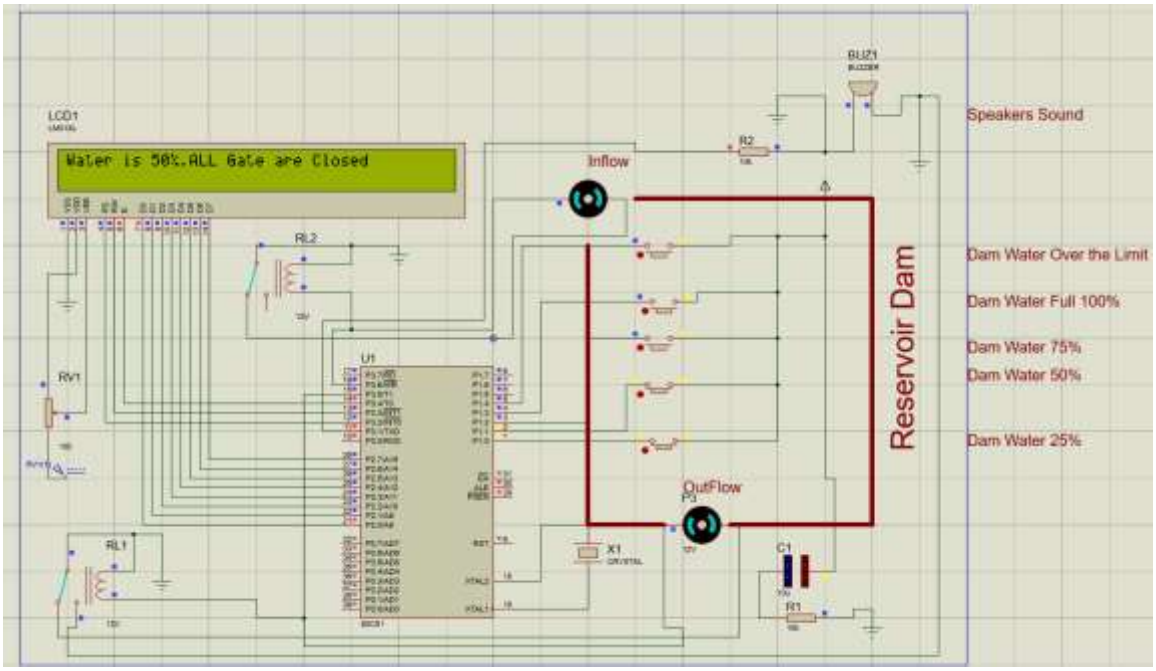

Figure 0-13 Water level above 50%

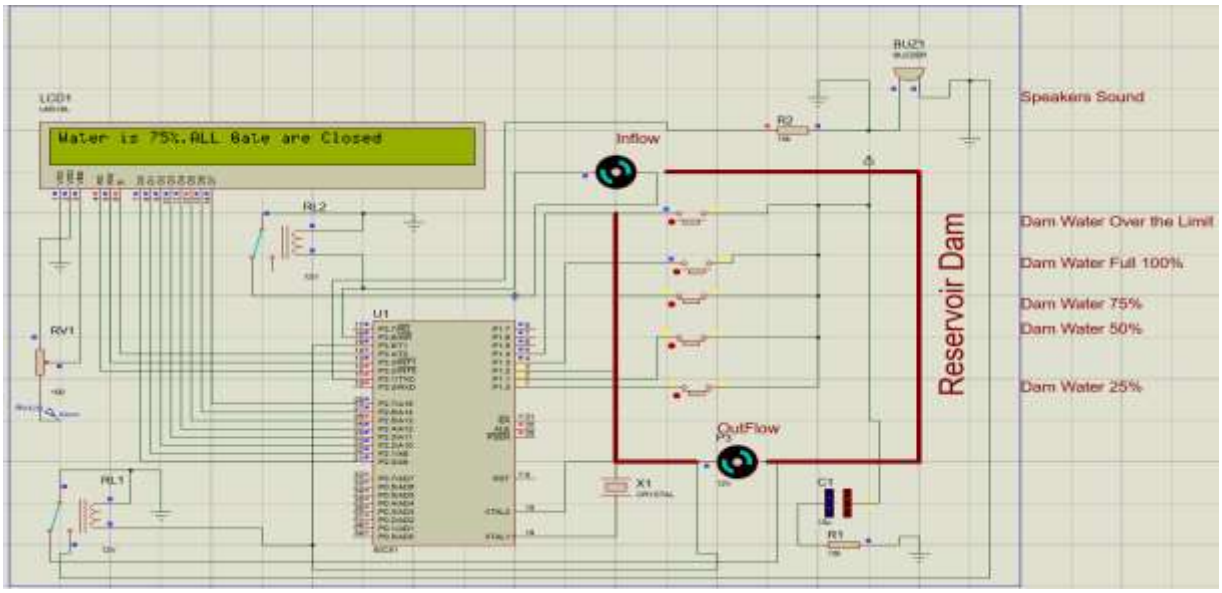

Figure 0-14 Water level above 75%

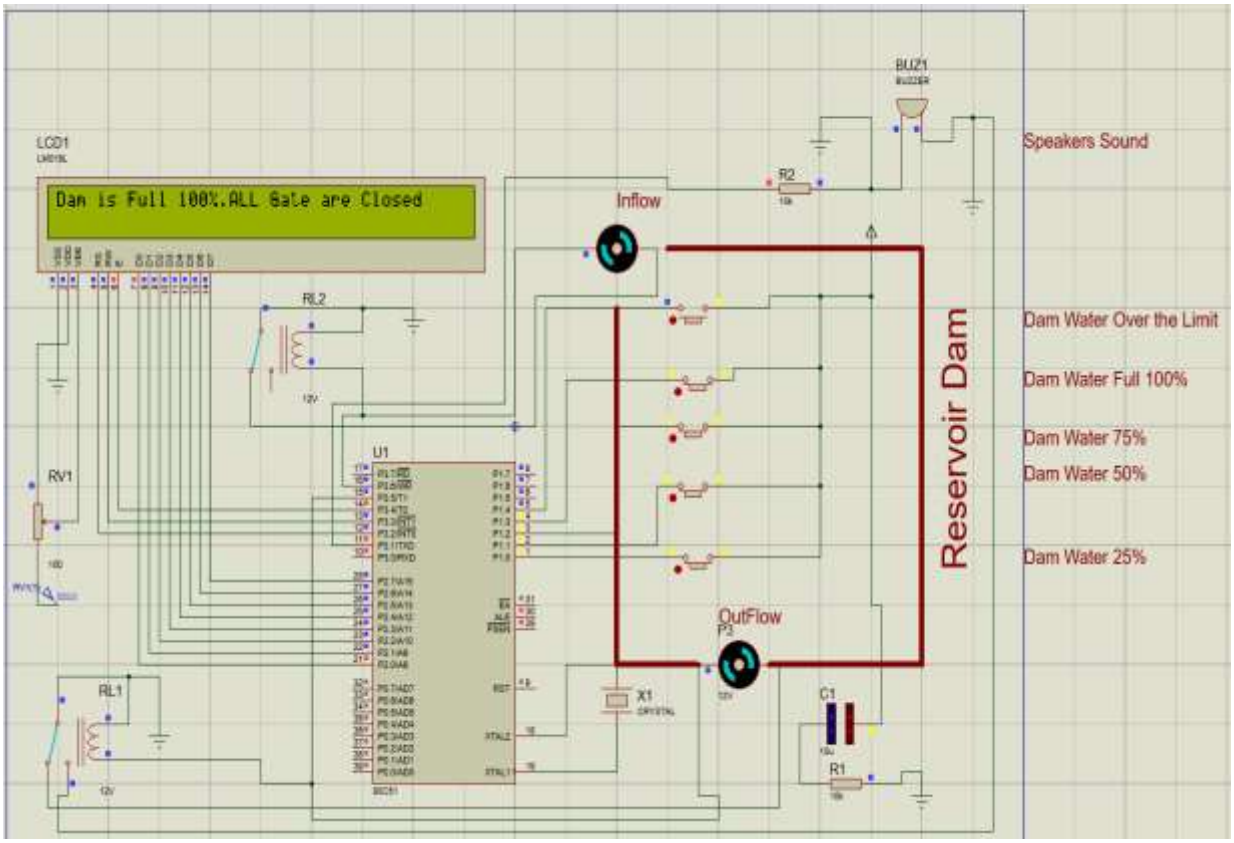

Figure 0-15 Water Level 95%, Reservoir dam is full

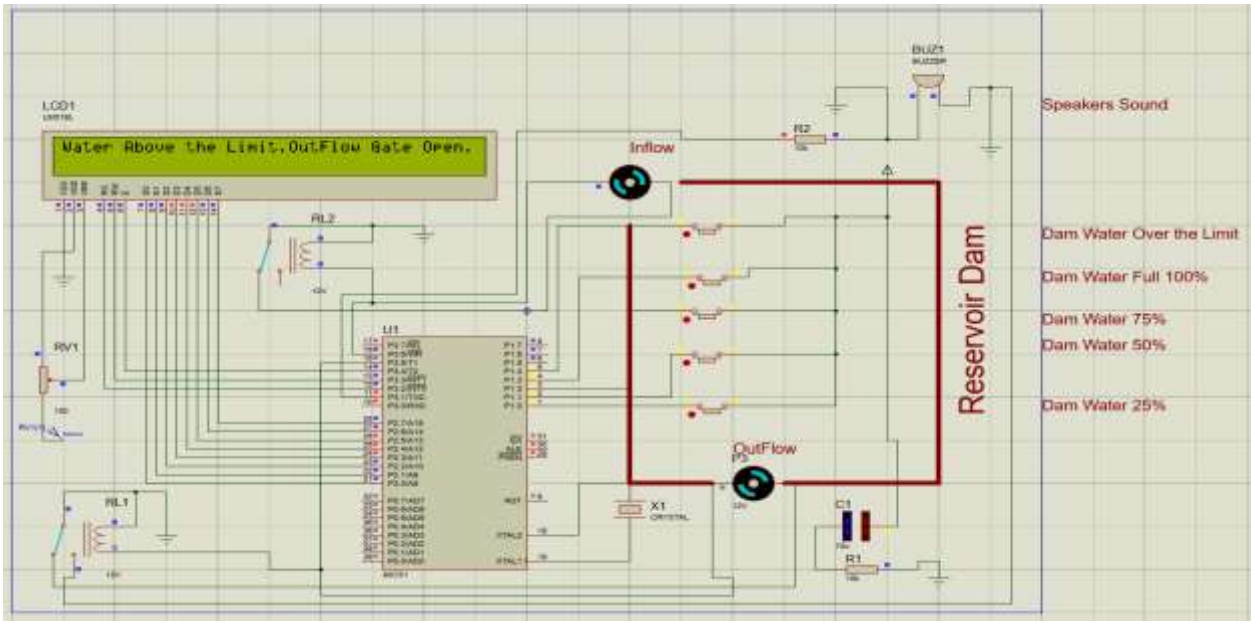

Figure 0-16 Water level above 100%

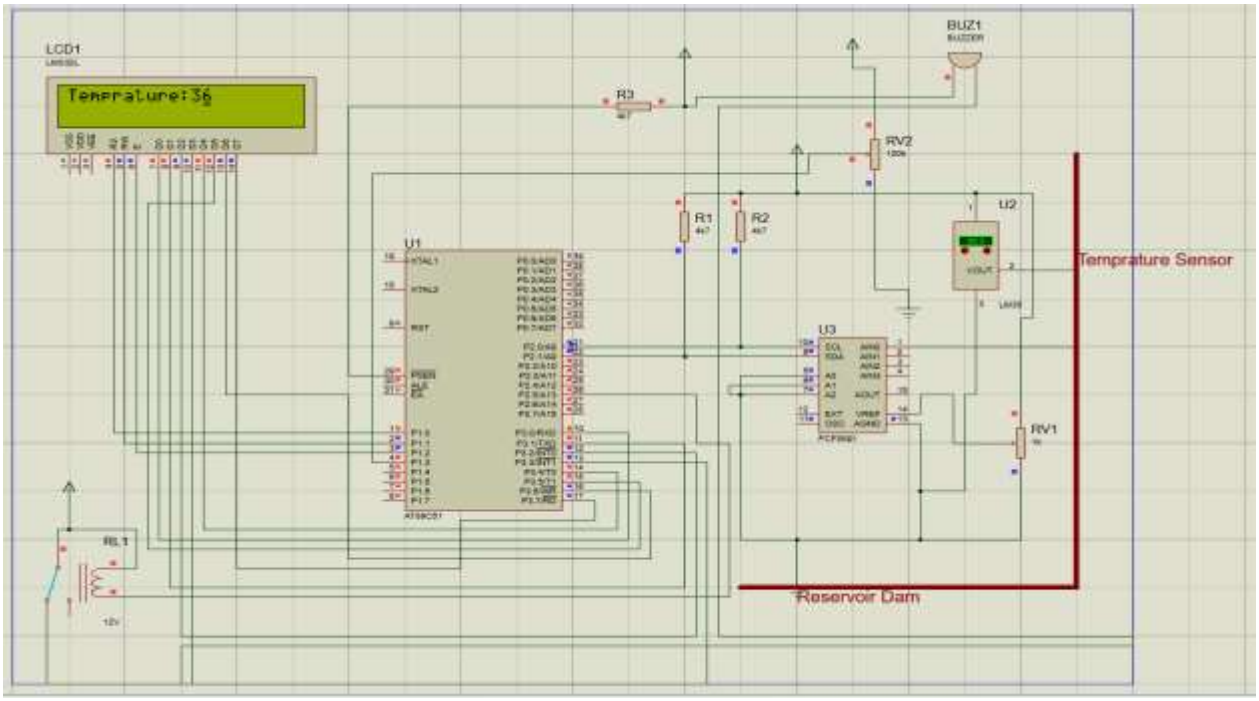

Figure 0-17 Temperature Level Indicator @ 36 ° C

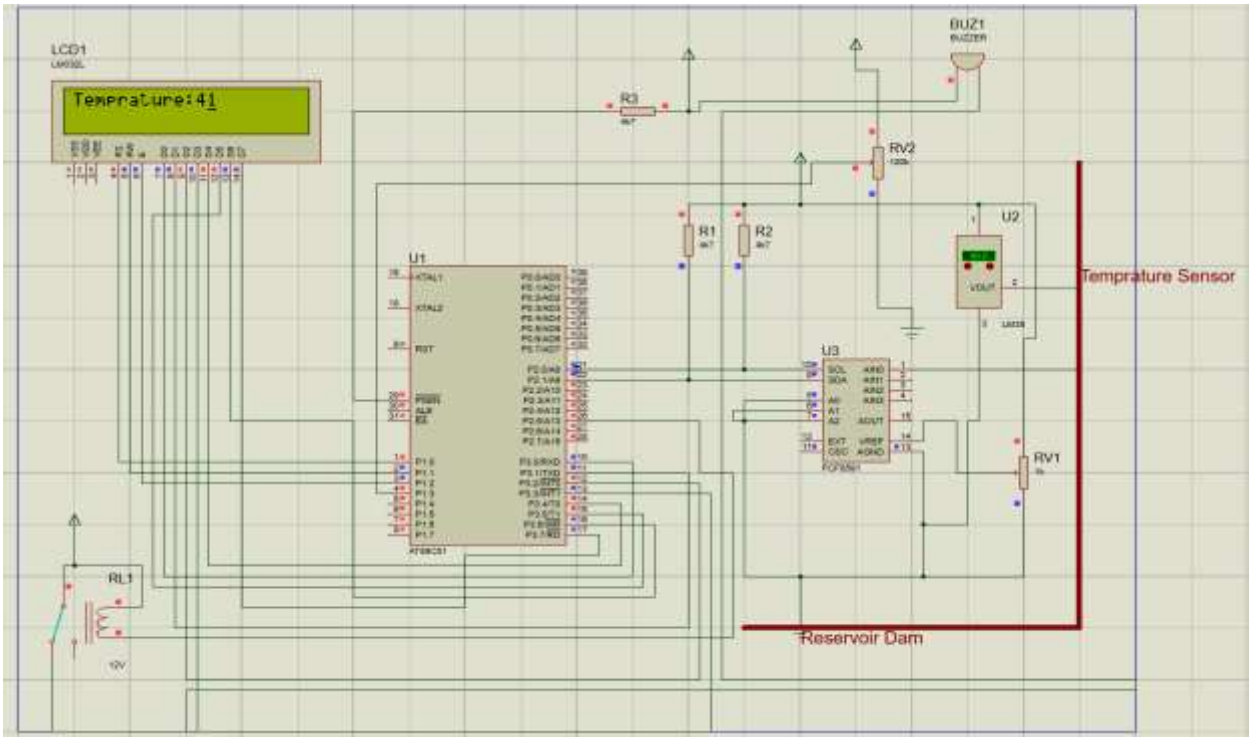

Figure 0-18 Temperature Level Indicator @ 41 ° C

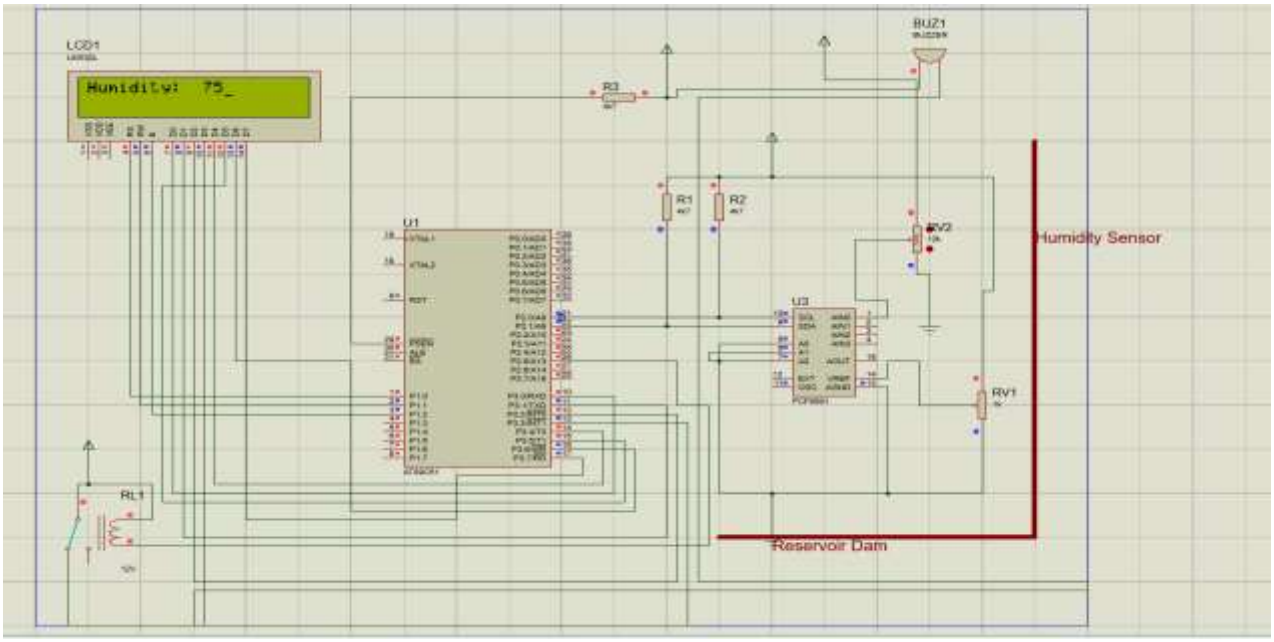

Figure 0-19 Humidity Level Indicator @75%

Arduino code for water level

```
#include "DHT.h"
#include <SPI.h>
#include <Ethernet.h>
byte mac[] = { 0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED }; //Setting MAC Address
//char server[]="192.168.10.81";
#define DHTPIN 2
#define DHTTYPE DHT11
DHT dht(DHTPIN,DHTTYPE);
float WaterLevel;
char server[] = "192.168.10.81";
IPAddress ip(192,168,0,177);
EthernetClient client;
int trigPin = 3;
int echoPin = 2;
int led = 7;
int led1 = 6;
int led2 = 5;
int led3 = 4;
void setup() {
  Serial.begin(9600);
  pinMode(led, OUTPUT);
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(led3, OUTPUT);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  // put your setup code here, to run once:
  dht.begin();
  if (Ethernet.begin(server) == 0) {
  Serial.println("Failed to configure Ethernet using DHCP");
  Ethernet.begin(mac, ip);
  }
  delay(1000);
}
void loop() {
  long duration, WaterLevel;
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(1000);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  WaterLevel = (duration / 2) / 29.1;
  Serial.print(WaterLevel);
  Serial.println("CM");
  delay(10);
WaterLevel = WaterLevel;
  Sending_To_phpmyadmindatabase();
```

```
 delay(10); // interval
 if ((WaterLevel <=5))
 {
  digitalWrite(led, LOW);
  digitalWrite(led1, LOW);
  digitalWrite(led2, LOW);
  digitalWrite(led3, LOW);
 }
  if (WaterLevel >25 && WaterLevel <=50)
  {
  digitalWrite(led, HIGH);
  digitalWrite(led1, HIGH);
  digitalWrite(led2, HIGH);
  digitalWrite(led3, LOW);
 }
  if (WaterLevel > 50 && WaterLevel <= 75)
 {
  digitalWrite(led, HIGH);
  digitalWrite(led1, HIGH);
  digitalWrite(led2, LOW);
  digitalWrite(led3, HIGH);
 }
 if (WaterLevel > 75 && WaterLevel <= 95)
 {
  digitalWrite(led, HIGH);
  digitalWrite(led1, LOW);
  digitalWrite(led2, HIGH);
  digitalWrite(led3, HIGH);
 }
    if (WaterLevel >= 95) {
  digitalWrite(led, LOW);
  digitalWrite(led1, LOW);
  digitalWrite(led2, LOW);
  digitalWrite(led3, LOW);
 }}
 void Sending_To_phpmyadmindatabase()   //CONNECTING WITH MYSQL
{
  if (client.connect(server, 80)) {
  Serial.println("connected");
  // Make a HTTP request:
  Serial.print("GET /WDSM/WaterLevel.php?WaterLevel=");
  client.print("GET /WDSM/WaterLevel.php?WaterLevel=");
  Serial.println(WaterLevel);
  client.print(WaterLevel);
  client.print("&WaterLevel=");
  Serial.println("&WaterLevel=");
  client.print(WaterLevel);
  Serial.println(WaterLevel);
```

```
   client.print(" ");     //SPACE BEFORE HTTP/1.1
   client.print("HTTP/1.1");
   client.println();
   client.println("Host: 192.168.10.81");
   client.println("Connection: close");
   client.println();
  } else {
   // if you didn't get a connection to the server:
   Serial.println("connection failed");
  } }
```

PHP code for water level

```
<?php

/* Attempt MySQL server connection. Assuming you are running MySQL

server with default setting (user 'root' with no password) */

$link = mysqli_connect("localhost", "root", "", "wdsms");

 // Check connection

if($link === false){

   die("ERROR: Could not connect. " . mysqli_connect_error());

} // Escape user inputs for security

$WaterLevel = mysqli_real_escape_string($link, $_REQUEST['WaterLevel']);

 // Attempt insert query execution

$sql = "INSERT INTO waterlevel (WaterLevel) VALUES ('$WaterLevel')";

if(mysqli_query($link, $sql)){

   echo "Water Level Sensor Data added successfully .";

} else{

   echo "ERROR: Could not able to execute $sql. " . mysqli_error($link);

} // Close connection

mysqli_close($link);

?>
```

Arduino code for water pH level

```
#include "DHT.h"
```

```
#include <SPI.h>
#include <Ethernet.h>
byte mac[] = { 0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED }; //Setting MAC Address
#define DHTPIN 2
#define DHTTYPE DHT11
DHT dht(DHTPIN,DHTTYPE);
float phvalue;
char server[] = "192.168.10.81";
IPAddress ip(192,168,0,177);
EthernetClient client;
int trigPin = 3;
int echoPin = 2;
int led = 7;
int led1 = 6;
int led2 = 5;
int led3 = 4;
void setup() {
 Serial.begin(9600);
   dht.begin();
 if (Ethernet.begin(mac) == 0) {
 Serial.println("Failed to configure Ethernet using DHCP");
 Ethernet.begin(mac, ip);
 }
 pinMode(led, OUTPUT);
 pinMode(led1, OUTPUT);
 pinMode(led2, OUTPUT);
 pinMode(led3, OUTPUT);
 pinMode(trigPin, OUTPUT);
```

```
 pinMode(echoPin, INPUT);
 // put your setup code here, to run once:
 delay(1000);
}
void loop() {
 long duration, WaterLevel;
 digitalWrite(trigPin, HIGH);
 delayMicroseconds(1000);
 digitalWrite(trigPin, LOW);
 duration = pulseIn(echoPin, HIGH);
 //WaterLevel = (duration / 2) / 29.1;
  phvalue = 6.5;   /// I never implement the Ph Sensor
 Serial.print(phvalue);
 Serial.println("CM");
 delay(10);
 Sending_To_phpmyadmindatabase();
 delay(30000); // interval
 if ((phvalue <=6))
 {
  digitalWrite(led, LOW);
  digitalWrite(led1, LOW);
  digitalWrite(led2, LOW);
  digitalWrite(led3, LOW);
 }
  if (phvalue >6 && phvalue <=6.5)
  {
  digitalWrite(led, HIGH);
  digitalWrite(led1, HIGH);
```

```
  digitalWrite(led2, HIGH);
  digitalWrite(led3, LOW);
 }
  if (phvalue > 6.5 && phvalue <= 7)
 {
  digitalWrite(led, HIGH);
  digitalWrite(led1, HIGH);
  digitalWrite(led2, LOW);
  digitalWrite(led3, HIGH);
 }
 if (phvalue > 7 && phvalue <= 7.5)
 {
  digitalWrite(led, HIGH);
  digitalWrite(led1, LOW);
  digitalWrite(led2, HIGH);
  digitalWrite(led3, HIGH);
 }
    if (phvalue >= 7.5) {
  digitalWrite(led, LOW);
  digitalWrite(led1, LOW);
  digitalWrite(led2, LOW);
  digitalWrite(led3, LOW);
 }}
 void Sending_To_phpmyadmindatabase()   //CONNECTING WITH MYSQL
{
  if (client.connect(server, 80)) {
  Serial.println("connected");
  // Make a HTTP request:
```

```
  Serial.print("GET /WDSM/WaterpH.php?phvalue=");
  //client.print("GET /WDSM/TempHum.php?humidity=");
  Serial.println(phvalue);
   client.print("&phvalue=");
  client.print(phvalue);
   client.print(" ");     //SPACE BEFORE HTTP/1.1
  client.print("HTTP/1.1");
  client.println();
  client.println("Host: 192.168.10.81");
  client.println("Connection: close");
  client.println();
 } else {
  // if you didn't get a connection to the server:
  Serial.println("connection failed");
 } }
```

PHP code for water pH level

```
<?php
/* Attempt MySQL server connection. Assuming you are running MySQL
server with default setting (user 'root' with no password) */
$link = mysqli_connect("localhost", "root", "", "wdsms");
 // Check connection
if($link === false){
  die("ERROR: Could not connect. " . mysqli_connect_error());
} // Escape user inputs for security
$phvalue = mysqli_real_escape_string($link, $_REQUEST['phvalue']);
 // Attempt insert query execution
$sql = "INSERT INTO waterph (phvalue) VALUES ('$phvalue')";
if(mysqli_query($link, $sql)){
```

```
   echo "Water pH Level Sensor Data added successfully .";
} else{
   echo "ERROR: Could not able to execute $sql. " . mysqli_error($link);
} // Close connection
mysqli_close($link);
?>
```

Arduino code for Temperature and Humidity level

```
#include "DHT.h"
#include <SPI.h>
#include <Ethernet.h>
byte mac[] = { 0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED }; //Setting MAC Address
#define DHTPIN 2
#define DHTTYPE DHT11
DHT dht(DHTPIN,DHTTYPE);
float temperature;
float humidity;
char server[] = "192.168.10.81";
IPAddress ip(192,168,0,177);
EthernetClient client;
int trigPin = 3;
int echoPin = 2;
int led = 7;
int led1 = 6;
int led2 = 5;
int led3 = 4;
void setup() {
  Serial.begin(9600);
  pinMode(led, OUTPUT);
```

```
  pinMode(led1, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(led3, OUTPUT);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  // put your setup code here, to run once:
  dht.begin();
  if (Ethernet.begin(mac) == 0) {
  Serial.println("Failed to configure Ethernet using DHCP");
  Ethernet.begin(mac, ip);
  }
  delay(1000);
}
void loop() {
  long duration, WaterLevel;
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(1000);
  digitalWrite(trigPin, LOW);
  //duration = pulseIn(echoPin, HIGH);
  //WaterLevel = (duration / 2) / 29.1;
  //humidity=(25.0*duration*1000.0)/(1024*10);
  //temperature=(5.0*duration*1000.0)/(1024*10);
  Serial.print(temperature);
    Serial.print(humidity);
  Serial.println("CM");
  delay(10);
  temperature = dht.readTemperature();
    humidity = dht.readHumidity();
```

```
Sending_To_phpmyadmindatabase();
delay(30000); // interval
if ((temperature <=15))
{
  digitalWrite(led, LOW);
  digitalWrite(led1, LOW);
  digitalWrite(led2, LOW);
  digitalWrite(led3, LOW);
}
 if (temperature >15 && temperature <=20)
  {
  digitalWrite(led, HIGH);
  digitalWrite(led1, HIGH);
  digitalWrite(led2, HIGH);
  digitalWrite(led3, LOW);
}
 if (temperature > 20 && temperature <= 25)
{
  digitalWrite(led, HIGH);
  digitalWrite(led1, HIGH);
  digitalWrite(led2, LOW);
  digitalWrite(led3, HIGH);
}  if (temperature > 25 && temperature <= 30)
{    digitalWrite(led, HIGH);
  digitalWrite(led1, LOW);
  digitalWrite(led2, HIGH);
  digitalWrite(led3, HIGH);
}
```

```
   if (temperature >= 30) {
  digitalWrite(led, LOW);
  digitalWrite(led1, LOW);
  digitalWrite(led2, LOW);
  digitalWrite(led3, LOW);
 }}
 void Sending_To_phpmyadmindatabase()   //CONNECTING WITH MYSQL
{
  if (client.connect(server, 80)) {
  Serial.println("connected");
  // Make a HTTP request:
  Serial.print("GET /WDSM/TempHum.php?temperature=");
  client.print("GET /WDSM/TempHum.php?humidity=");     //YOUR URL
  Serial.println(temperature);
  client.print(humidity);
  client.print("&temperature=");
  Serial.println("&humidity=");
  client.print(temperature);
  Serial.println(humidity);
  client.print(" ");      //SPACE BEFORE HTTP/1.1
  client.print("HTTP/1.1");
  client.println();
  client.println("Host: 192.168.10.81");
  client.println("Connection: close");
  client.println();
 } else {
  // if you didn't get a connection to the server:
  Serial.println("connection failed");
```

```
 }

}
```

PHP code for Temperature and Humidity level

```
<?php

/* Attempt MySQL server connection. Assuming you are running MySQL

server with default setting (user 'root' with no password) */

$link = mysqli_connect("localhost", "root", "", "wdsms");

 // Check connection

if($link === false){

   die("ERROR: Could not connect. " . mysqli_connect_error());

} // Escape user inputs for security

$temperature = mysqli_real_escape_string($link, $_REQUEST['temperature']);

$humidity = mysqli_real_escape_string($link, $_REQUEST['humidity']);

 // Attempt insert query execution

$sql = "INSERT INTO temphum (temperature, humidity) VALUES ('$temperature', '$humidity')";

if(mysqli_query($link, $sql)){

   echo "Temprature and Humdity Sensor Data added successfully .";

} else{

   echo "ERROR: Could not able to execute $sql. " . mysqli_error($link);

} // Close connection

mysqli_close($link);

?>
```