Design and Implementation of Monitoring System Automatic Water Level Reservoir Controller

Kadek Suar Wibawa[1], Putu Wirabuana[2]
[1](*Information Technology Department, Udayana University, Indonesia*)
[2](*Information Technology Department, Udayana University, Indonesia*)

Abstract: Bali's water crisis, according to a study by The Bali Institute for Economic Development and Planning (IDEP) revealed that the water crisis in Bali is expected to worsen aswater supply in Bali just only 20 percent. Bali's water crisis cause most of the population in South Bali use a deep wells and keep the clean water in the reservoir/water tank. The application of conventional techniques in measure water level automatically was inefficient and ineffective because difficulty in monitoring. This study offers one method in measurement of water level using ultrasonic sensor (contactless sensor). Sound waves generated from ultrasonic transducers are capable of measuring water levels in real-time and continuous, sophisticated, reliable, more accurate by using microprocessors as signal processors and at low cost. Real time measurement results show the measurement accuracy level with standard deviation of 0.71756 cm at the measurement distance from 5cm up to 150 cm

Keywords: Embedded System, Water Level, Ultrasonic Sensor, Microcontroller, Data Realtime

I. INTRODUCTION

Bali is one of the most enchanting and the most destination in the world. South Bali is the center of tourism accommodation and economic. Consumption of clean water in the southern bali region is greater than other regions. According to a study conducted by Bali's Institute for Development and Economic Planning (IDEP), the water crisis in Bali is increasingly critical is worriying, that Bali's water reserves are only 20 percent[1]. The water crisis that occurred caused most of the inhabitants of South Bali area to use a deepwell and keep the clean water in the reservoir/water tank.

Manual pump water control system (on / off switch) is not efficientbecause it often causes. Overflow of water from the tanks due to user is careless and wasteful consumption of electrical power. One of the cost-saving tips is use a water pump using automatic float or air presure control system[2]. Failure might occur due to a small leakage form the pipeline installation or float switch doesn't work preperly to open or close a circuit as level of water [3][4][5].

Currently one of the most popular water level measurement method is using speed of sound. Speed of sound from ultrasonic transducers can be utilized to measure the water level in real-time and continuous, advance, reliable, accurate using microcontroller to signal processing[6][7].

II. OVERVIEW

Ultrasonic sensors can be used to detect the surface of an object, because almost every object can reflect ultrasonic waves such as: wood, glass, stone, paper etc. so they are easierdetected. Objects such as linen, cotton, woll, etc. difficult to detected because it is easy to absorb ultrasonic waves. Objects that have wide surface undulations are also difficult to detect because it will produce irregular wave reflection

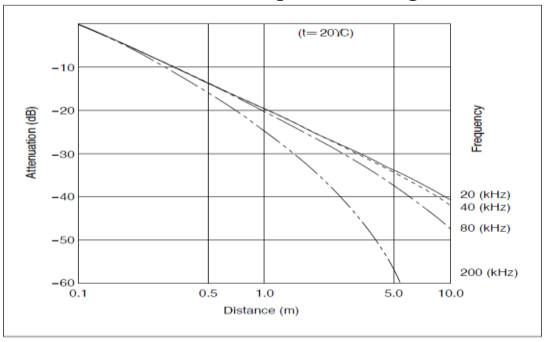


Fig1. Distance vs Gain

Intensity of spread ultrasonic wave signals in air can proportionally weaken the distance measurement [8]. This is caused by loss of diffusion from the round surface due to the phenomenon of diffraction and the loss of absorption. The energy absorbed by the medium is given in Fig 1. The distance of object detected from ultrasonic waves can be expressed by equations:

$S = c * \left(\frac{t}{2}\right)$ ....(1)

Propagation speed of sound (c) expressed by equation:

$c = 331.5 + (0.607 * T)$……………………… (2)

in meter/second (m/s), T = air temperature.

result of measurement distance of water level , we can calculate volume water in reservoir by equation

$V = \pi * \left(\frac{1}{2} * D\right)^2 * t$ ……………………… (3)

D = diameter, t = high fluid level

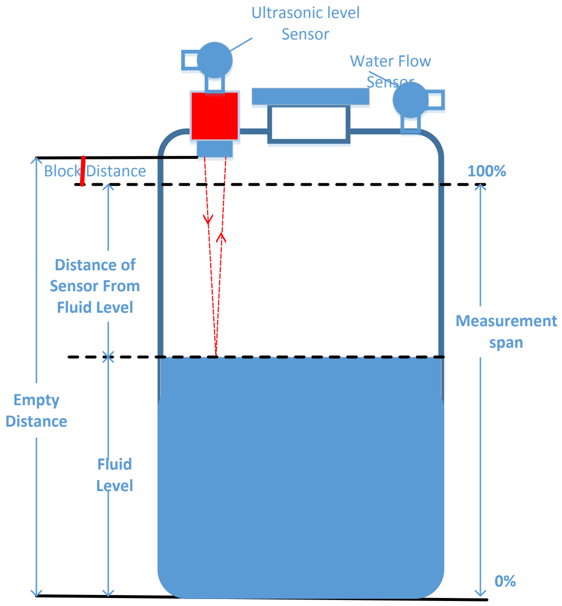


Fig 2. Ultasonic Water Level Mesuarement

The speed of sound in air is determined by the air itself and is not dependent upon the amplitude, frequency, or wavelength of the sound. Only because of the decreasing air temperature, which decreases with altitude, the speed of sound decreases

III. SYSTEM DESIGN

3.1 Overview System Design

System can be classified in two categories : 1) Field System consisting of a water level sensor and a Control System Unit, dan 2) Eksternal system(android mobile application dan firebse databse realtime). Sensors take measurements periodically in an interval of 200ms(measuring water level and water flow). Measuring water level is used as a reference for controlling pump switches (On/Off). The water flow sensor can be used as an indicator of the pump state(On or Off condition).

Measurement data is sent to the System Control Unit via RS485 BUS communication every one second. The Control System unit receives sensor measuring data and stores it in internal memory (data is deleted periodically).Control System Unit for processing data and calculating the capacity of water in a tank. If the water level is at the minimum threshold value, Control System unit send a signal to turn on the pump. And when the water level is at the maximum threshold value, Control System unit send a signal to turn ooff the pump.

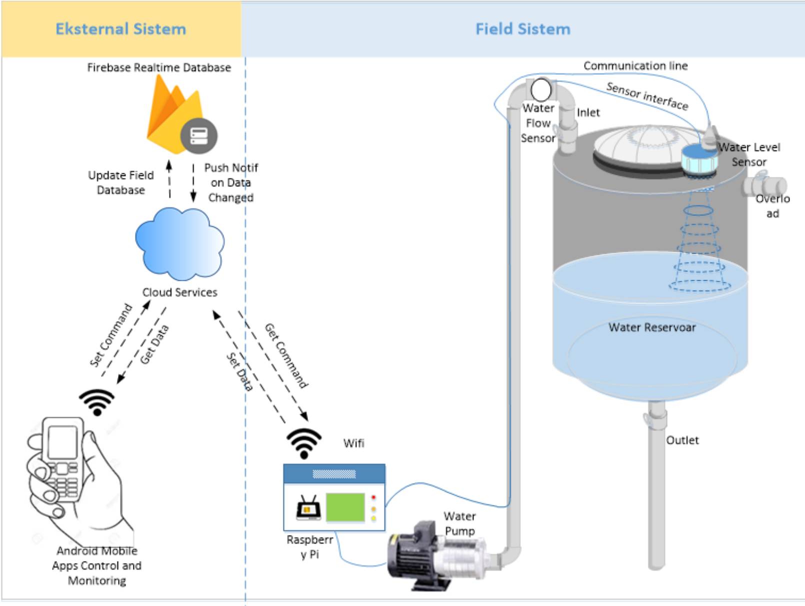


Fig 3: Overview of design system

User can monitor the volume of water in the reservoir through an android-based mobile application.Users can also control the pump remotely (over internet connetion).The application provides realtime data through a real time firebase databasewhich functioned as a gateway(not as a data storage media).

3.2 Block Diagram System

Ultrasonic sensor using HC-SR04 module. The proposed data acquisition unit uses microcontroller ATMega-8 embedded system developed prototyping board with 7.372800 MHz external crystal.

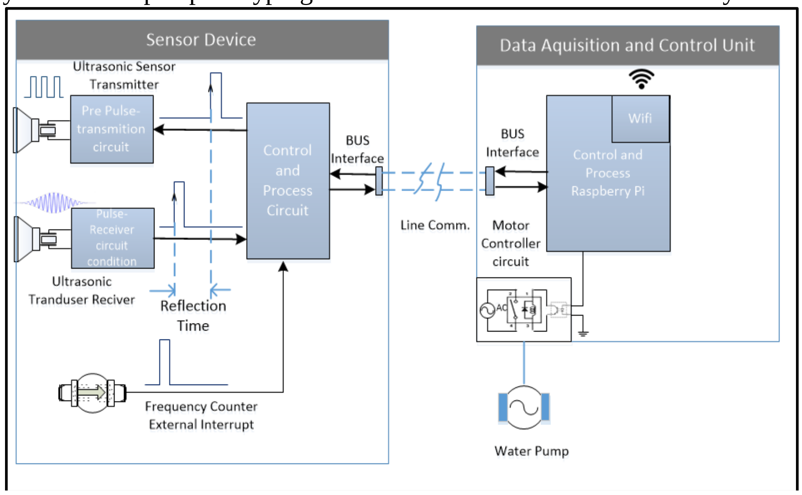


Fig 4. System Block Diagram

The sensor to measure temperature used SHT 10 from Sensirion's family. There are only four wires required to connect the sensor with microcontroller board with standard two wire serial interface communication. Water flow sensor based on interrupt external signal for speed pulse counter. for data aquisition and controll system (Unit Control System) used Raspbery pi ver 3.

IV. SOFTWARE DESIGN

4.1 Sensor Software Design

Sensor software applications was developed using ANSI C programming language. Structure of applications made a list of process to be executed within a certain slot-time. The Process list include: Measurement, Acquisition and data Transmission.

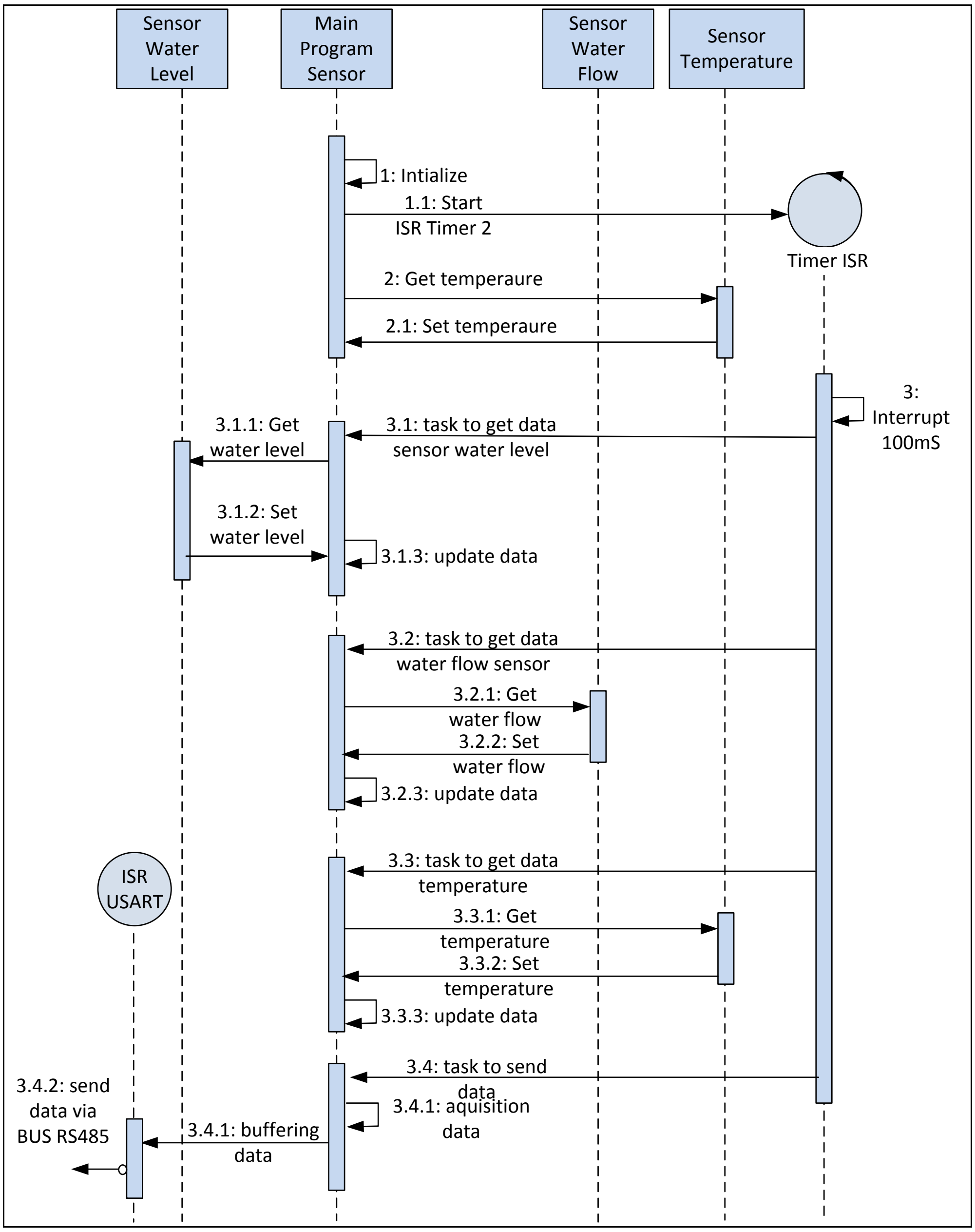


Fig 5: Sensor Software Design

Interrupt Service Routine (ISR) generates triggers every 100 mS, this trigger for generate counters every second (10 times). Counter time is a ticker, each every sensor has a certain time slot to complete the task.The complete measurement results of the sensors are transmitted to the Control System Unit via RS485 serial communication.Software design with a scheduler system, makes the system predictable.

4.2 Database Firebase Design

Firebase Realtime Database is data storage and synchronized in realtime to every connected clientapplication. The application will automatically receive if any updates newest data.Database design is not used as an addition to new data in each field. Every time there is a change of data, old data is update with the new data.

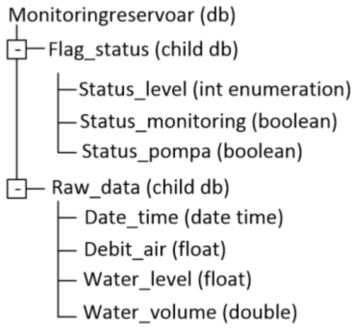


Fig 6: Firebase Database Design

Child databases are divided into twopart: 1) status flags that function as system interactions for user generated events, and 2) Raw data that functions to receive measuring and calculating data from the sensor to the monitoring application user.

4.3 Unit Control System Software Design

Unit Control System software applications was developed using python interpreteur programming language overRaspbian PiVer. 3.Supported of the firebase application library on the Raspberry pi, this design makes it possible to conduct real-time two-way communication.

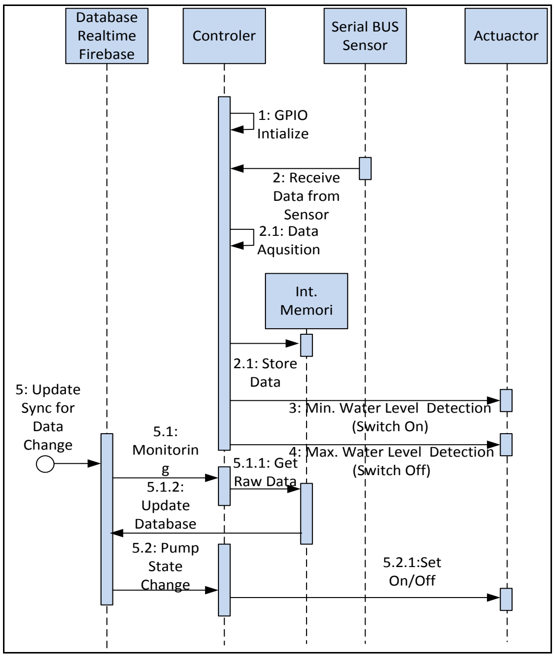


Fig 7: Unit Control System Software Design

V. RESULT AND TESTING

The circuit was assembled on soldering board to enable testing of the circuit design and easy modification when necessary. Circuit board that has been in the preliminary test assembled into cassing made from PVC. PVC is very durable, easy to use for implement model of applications and weather resistant. The size of the circuit board is determined by the size of the selected casing, to make the sensor device portable and easy to installation. The circular holes are made for ultrasonic wave propagation sensors. LED lights in sensor device can indicate useful information about system status. The finally of the sensor device is shown as the Figure 8.

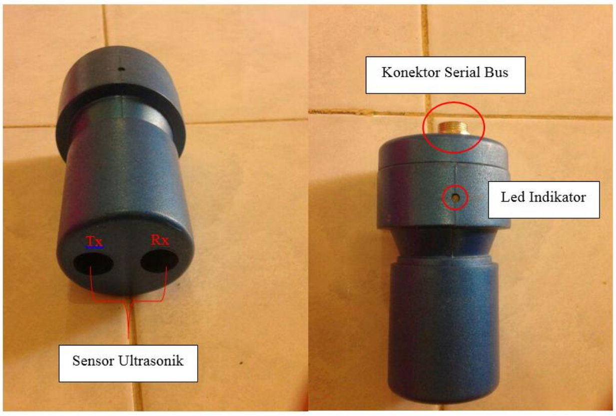


Fig 8: Ultrasonic Sensor Device

The technical data spesification of sensor device shown as Table.1

Table 1. Technical Sesor Specification

No	Unit	Specification
1	Main board	➢ Microcontroller ATMega 8A - Memory flash: 8KB, SRAM 2KB, EE-Promp 1024Byte ➢ Peripheral Board - Serial RS-485 - Port data ➢ Oscillator Clock 7.7328MHz ➢ Voltage in DC 5 Volt
2	Sensor HC-SR04	➢ frequency 40 KHZ ➢ Triger and Data Connection
3	Sensor	➢ SHT 10

Testing is done by installing a system in the reservoir simulator and water source. The water flow sensor is connected to the inlet pipefrom the water source to the reservoir. Water level sensor attached close to the water pipes. The reservoir simulator uses a diameter of 69 cm and a height of 146.5 cm. By using equation 3, the maximum capacity of water that can be load in the reservoir is 547.52 liters.

Installation of electronic hardware Control System Unit and water level sensor use serial RS485 cable (over RS485 to USB converter) and for conecting internet on Control System Unit can accessed by wifi module.system testing installation as shown in FIGURE 9.

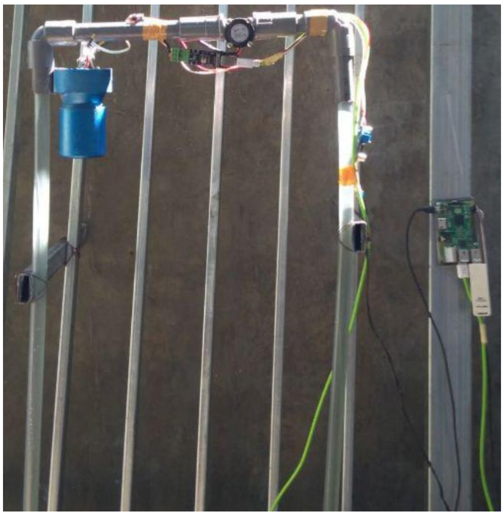


Fig 9: Implementation and Testing Instalation

After the installation is complete, testing is done by running the system and monitoring the condition of the system through a mobile application. In the initial stage the reservoir is empty, the pump is turned on to fill the reservoir. After filling, increased capacity of water in the tank is monitored (Figure 10.b). The water level is measured at 27,84 cm with a filling capacity of 19% which indicates the capacity of water in a low position (low treshold less then 20%)

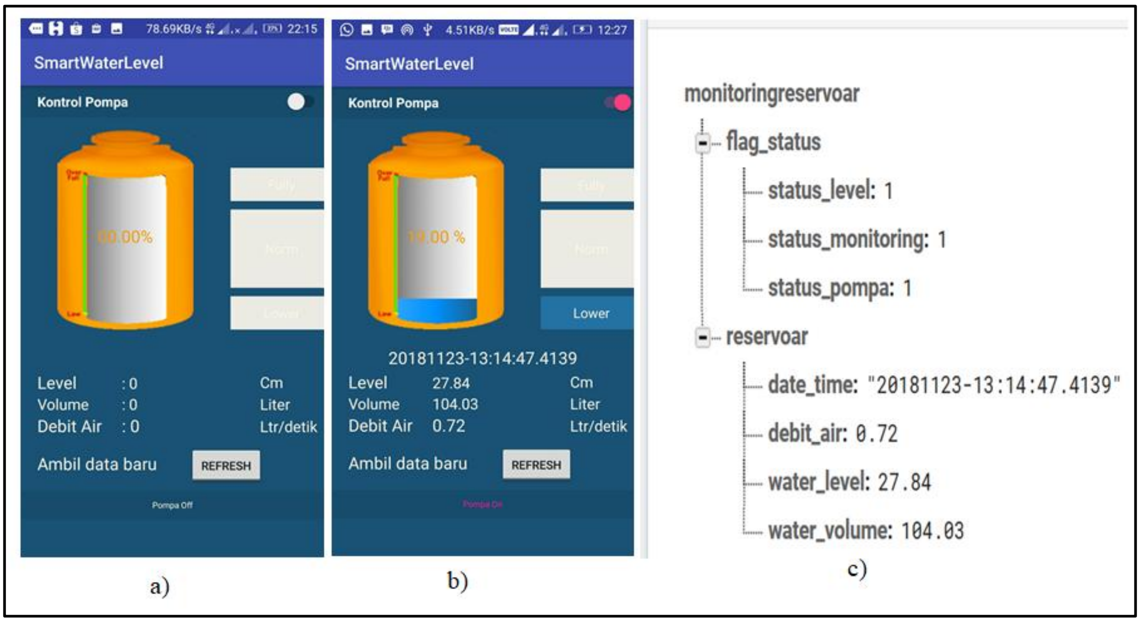
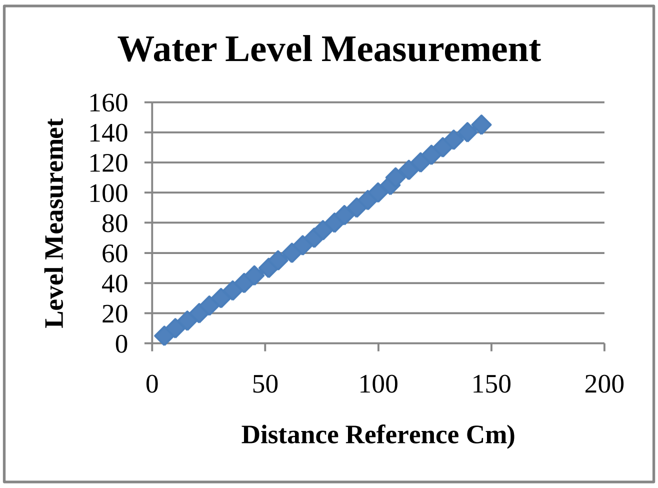


Fig 910: a) initial condition, b) monitoring system on process, c) database realtime firebase state

In Figure 10.c, shows the status of the data changes in the Firebase realtime database is in accordance with the sensor measurement results in the field sent via the Control System Unit. Measurement data and measurement error are shown as in table 2

Table 2. Measurement Result

No	Water Level (Cm)	Reference Distance (Cm)	Capacity (L)	Mean	Mean Power
1	5,32	5	19,88	-0.32	0.1024
2	10,17	10	38,01	-0.17	0.0289
3	15,48	15	57,85	-0.48	0.2304
4	20,73	20	77,48	-0.73	0.5329
5	25,2	25	94,18	-0.2	0.04
6	30,38	30	113,54	-0.38	0.1444
7	35,57	35	132,94	-0.57	0.3249
8	40,62	40	151,81	-0.62	0.3844
9	45,13	45	168,67	-0.13	0.0169
10	51,47	50	192,36	-1.47	2.1609
11	55,61	55	207,83	-0.61	0.3721
12	61,75	60	230,78	-1.75	3.0625
13	66,52	65	248,61	-1.52	2.3104
14	71,63	70	267,71	-1.63	2.6569
15	75,47	75	282,06	-0.47	0.2209
16	80,61	80	301,27	-0.61	0.3721



17	84,96	85	317,5	0.04	0.0016
18	90,42	90	337,93	-0.42	0.1764
19	95,32	95	356,25	-0.32	0.1024
20	99,84	100	373,14	0.16	0.0256
21	105,3	105	393,55	-0.3	0.09
22	107,62	110	402,22	0.38	0.1444
23	113,48	115	424,12	-0.48	0.2304
24	118,68	120	443,55	0.32	0.1024
25	123,47	125	461,45	-0.47	0.2209
26	128,5	130	480,25	0.25	0.0625
27	133,32	135	498,27	-0.32	0.1024
28	139,41	140	521,03	0.59	0.3481
29	145,6	145	544,16	-0.6	0.36
Standard deviation					0.71756

VI. CONCLUSION AND FUTURE SCOPE

The system has been able performing the measurement in realtime, which shows the measurement accuracy level with standard deviation of 0.71756 cm at the measuring distance from 5cm up to 150 cm. Reservoir monitoring and system control can be done through realtime mobile applications.Further research needed predict water use and pattern of water use smartly.

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