Design and Development of Smart Water Purification Level Tester For Visually Impaired Person

by

Khabbab Hossain Tusher

2014-3-60-018

Alinoor Hossain Olip

2014-3-60-008

A thesis submitted in partial fulfilment of the requirements for the degree of

Bachelor of Science `Computer Science & Engineering`

Department of *Computer Science & Engineering*

East West University, Dhaka, Bangladesh

August 2018

Abstract

In this project we introduce a smart device for visually impaired persons, which will helps them to determine the purification level of drinking water. Without water lives wont exists means that water is life. The lifestyles of visually impaired person or blind people are too much challenging compared to normal people. We cannot say that, nobody can find a trouble-ness day for them. Due to their blindness they are facing huge troubles throughout their life. Smart and mobile devices are always trying to reduce their trouble-ness. In this paper we present a smart device for them for determining the purity level of drinking water based on conductivity properties. With conductivity our device can measure the TDS (Total Dissolved Solids) value that can determine water purity level. For visually impaired people proper audio message incorporate to TDS value will be transmitted.

Acknowledgements

Khabbab Hossain Tusher   Alinoor Hossain Olip

Contents

List of Tables

List of Figures

Chapter 1

Introduction and Overview

In this project we have discussed about different gadgets/tools that are offered to visually impaired people and why our device is needed to help visually impaired persons. In this section we have discussed about the motivation behind our work, problem statement and the overview of our whole work.

1.0.1 Motivation

Our main motivation was to develop something which will be useful and effective not just fancy. The world is harsh for everyone but it is more difficult for persons with physical short comings. Vision Impairment is one of such a kind physical disability that many people has around the world. According to the World Health Organization (WHO), there are 253 million people living in the globe with some sort of vision impairment and around 1.1 billion people have near-vision impairment [1]. Among them 36 million are totally blind and rest of them are suffering moderate type of vision impairment. Around 81 percent visually impaired people are aged 50 to above

and 19 million people are suffering vision impairment whose age are less than 15 years [2]. They are facing huge amount of troubles in their daily lives, due to their blindness. They have full of emotional distress and pain [3]. Jobs sectors are not welcoming them. In Ireland only 16% of blind people are working. 41.36% and 33% blind people respectively go for work in United Kingdom, Australia and Canada [4]. The numbers are much lower in developing countries in South Asian region.
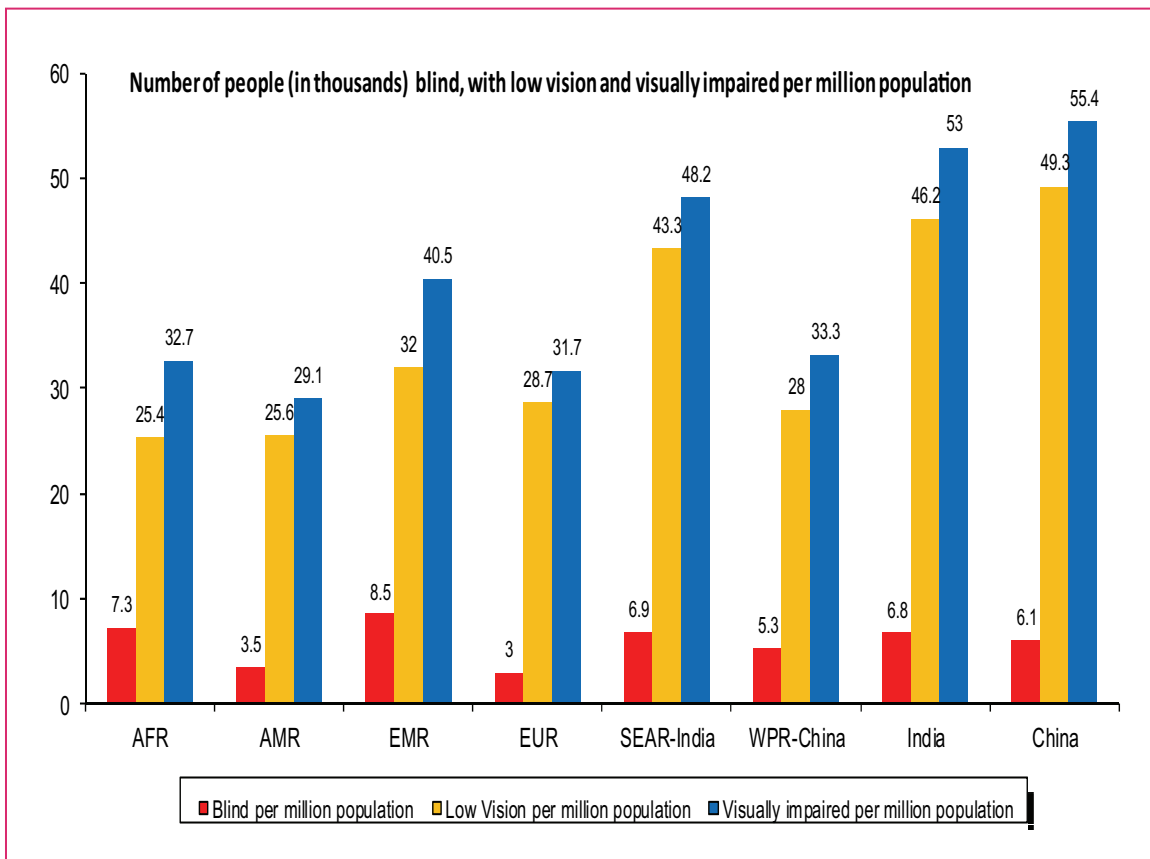
Figure 1.1: Blind people wordwide.

1.0.2 Problem Statement

We already discussed the sufferings of visually impaired people and some smart gadgets to help them but we felt the scarcity of a device that can tell a visually impaired person that is the water he/she drinking is pure or impure. In advanced countries many people lives alone and with visual imparity things get critical for them which are normal to common people. As water is very essential for life its important to test the purity. There are enormous devices for normal people to help measure the purity of water but there is none for visually impaired people. Our device could help them in this case.

1.0.3 Objectives

The main objectives of our project are listed below:

- To develop an effective device for visually impaired person for testing the purity level of drinking water.

- Building a user friendly device for them.

1.0.4 Report Organization

The rest of the report is organized as:

- Chapter 2 Presents some literature review about water purification testing devices.

- Chapter 3 Introduction to hardware tools used in this project.

- Chapter 4 System implementation of the project.

- Chapter 5 Result Analysis.

- Chapter 6 Conclusion and future scope of the work.

Chapter 2

Literature Review

There are tons of devices, application that made visually impaired peoples life easier. With help of science and growing technology many unique and effective solutions are being offered to them. In this section we will demonstrate some of the device.

2.1 VizWiz Social

VizWiz Social is an open source application (Facebook or tweeter like social apps) developed by Apple corporation with more than 5000 active users [5], specially designed for blind people. The Blind or visually impaired person can post photographs and questionnaires through audio message for requesting help (asked query) based on the posted photographs. Since, its a social like application other users (non-blind person) help them by providing the appropriate answer through audio message. Various users (blind persons) asked for various types of questions among them 28 percent quires are related to daily foods and beverages [6]. Figure 2.1 shows the screenshort of Vizwiz and details are available in [7]

Figure 2.1: VizWiz social collaboration based apps for blind person.

2.2 Finger Reader

This device is in a prototype state (under research) created by the MIT Media Labs. It is a wearable device (like a finger ring). Its a real time visual interpreting device. The device instantly read (audio output) the printed lines during the movement of the device over the printed text. The device has also Built in vibrating system which tells the users if there is any deviation off the line. The more details specifications are available on MITs website.

2.3 BitTab

BItlab is an excellent braille device made by Bitlab which is the worlds first tablet for the blind people. This device turns any texts into braille writing, which is easily recognizable by blind person. It has micro size physical bubble on screen which will automatically rise up/down depending on the contents. This device easily performs the communication with personal computer via serial port.

Figure 2.2: MIT's FInger Reader for Blind Person.

Figure 2.3: BitTab a smart tablet for blind person.

2.4   Bell Mug

Bell Mug is a smart mug that indicates the water level specially designed for blind persons. Blind people can set the preference level of the liquid, by using built-in indicators (only three level of indicators are available), they want to pour and when the level is achieved the mug makes an indication or beep Sound.
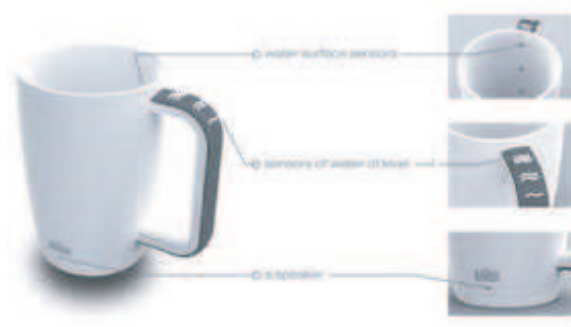
Figure 2.4: Bell Mug, a smart mug.

2.5   Water Purification Meter

2.5.1   TDS 3 Pen

TDS3 can test purity of the water quality at any time and lower power processor this meter saves measurements for convenient reading and recording. Accurate testing the purity of the water quality at home. This TDS3 meter can be used in: water purifiers and filters, food (vegetable, fruits); drink quality monitoring, pools and spas, aquariums, hydroponics. Using this TDS3 you can saves measurements for convenient

Figure 2.5: TDS -3 pen.

reading and recording and another function of this turns off meter after 10 minutes of non-use to conserve batteries. It measures form 0-999ppm, with a resolution of 1ppm. From 1,000 to 9,999ppm [8] the resolution is 10ppm, indicated by drinking x10image, Factory calibrated and the Range: 0-9999ppm, Accuracy: +/-2%, Battery: 2 x 1.5V Button Cell battery and the size: 156mm x 30mm x 20mm (6.1 x1.2 x0.9in).

2.5.2 OBS-3+ Turbidity Sensor

Turbidity sensor checks the cloudiness of water (the transparent level of the water). It uses light transmittance and sees the scattering rate and then checks the turbidity. Measuring turbidity level is an intelligent way for determining the water purity level. Sideways facing optics avoids obstructions above and below the probe. Measures suspended solids and turbidity for up to 4000 NTUs [9].Provides a compact, low-

Figure 2.6: OBS-3+ Turbidity Sensor

power probe that is field proven. Compatible with most Campbell Scientific data loggers. Accurate and rugged Stainless-steel body allows use down to 500 m in fresh water. Titanium body allows use down to 1500 m in fresh or salt water. Fitted with MCBH-5-FS, wet-pluggable connectormultiple mating cable length options available. Offers an optional five-point sedimentation calibration for better measurements.

2.5.3 Xiomi TDS Pen

Figure 2.7: TDS pen by xiomi.

Anyone can able to check the water purity level by using this pen like hand-held device shown in igure 2.7.It measures total dissolved solid in water through the conductivity properties of water. It gives a numerical value in ppm unit. This numerical value is then mapped with a chart for determining actual purity level. The mapping chart is also presented in Figure 2.7 there are several companies who sell similar types of devices. Economy model that is ideal for end-users. Highly efficient and accurate due to its advanced microprocessor technology. Meters can be re-calibrated with a mini-screwdriver. Fun, translucent blue housing that's very strong and durable.

2.5.4   Manual TDS Calculation

- Low Level — 0-50

- Relatively low level — 50-100

- Lower Level — 101-300

- Higher level — 301-600

- Relative high level — 600-1000

- Dirty water — 1000+

This device could not find out the purity of drinking water with naked eyes, seemingly crystal water may contain many impurities. TDS value represents the total soluble solids content of the water, it can reflect the water quality to a certain extent. MI water TDS quality detection pen can accurately detect the water TDS value. World

Health Organization (WHO) recommends TDS values below 600 [10] are generally considered good quality water or appropriate of drinking, when TDS value greater than 1000, there will be a significant change in the taste of drinking water.

Chapter 3

Hardware Components

This section is for the demonstration of hardware components that is used in this project. For better understanding the project we have discussed broadly about the different hardware.

3.1 Raspberry Pi 3

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings a more powerful processer, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs., boasting a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT The dual-band wireless LAN comes with modular

compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market. The Raspberry Pi 3 Model B+ maintains the same mechanical footprint as both the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.
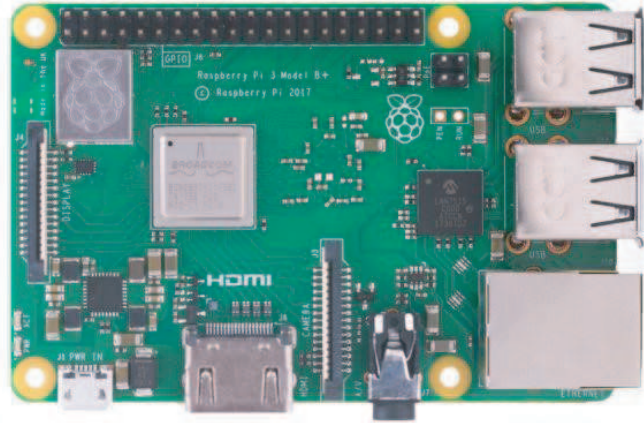
Figure 3.1: Raspberry Pi, a single board computer.

3.1.1 Technical Specifications

- Processor - Broadcom BCM2387 chipset. 1.2GHz Quad-Core ARM Cortex-A53

- 802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)

- GPU - Dual Core VideoCore IV Multimedia Co-Processor.

- Memory - 1GB LPDDR2

- Operating System - Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT

14

- Dimensions - 85 x 56 x 17mm

- Power - Micro USB socket 5V1, 2.5A

3.1.1.1 Connectors

- Ethernet - 10/100 BaseT Ethernet socket

- Video Output - HDMI (rev 1.3 & 1.4 and Composite RCA (PAL and NTSC)

- Audio Output - Audio Output 3.5mm jack, HDMI

- USB 4 x USB 2.0 Connector

- GPIO Connector - 40-pin 2.54 mm (100 mil) expansion header: 2x20 strip Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines

- Camera Connector - 15-pin MIPI Camera Serial Interface (CSI-2)

- Display Connector - Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane

- Memory Card Slot - Push/pull Micro SDIO

3.1.1.2 Key Benefits

- Low cost

- Consistent board format

- 10x faster processing

- Added connectivity

3.1.1.3 Key Applications

- Low cost PC/tablet/laptop

- IoT applications

- Media centre

- Robotics

- Industrial/Home automation

- Server/cloud server

- Print server

- Security monitoring

- Web camera

- Gaming

- Wireless access point

- Environmental sensing/monitoring (e.g. weather station)

3.1.1.4 Input/Output Pin

First thing to notice, the top 26 pins of the 40-pin connector are the same as the original That means that most/many Pi Plates that plug into the Model B will plug into the B+ just fine. They wont sit in the same location - they'll be slid down just a bit but electrically-wise its the same.
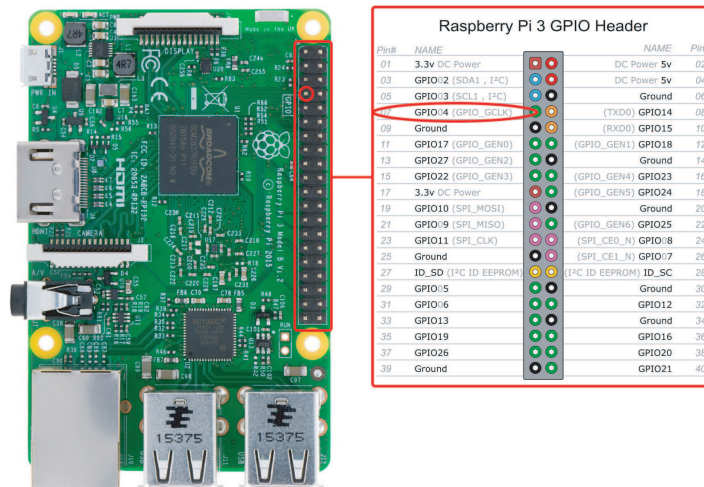
Figure 3.2: Raspberry Pi; I/O pin.

3.2 Arduino Nano

Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila/Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power, there is no need for the power select jumper. Nanos got the breadboard-ability of the Boarduino and the Mini+USB with smaller footprint than either, so users have more breadboard space. Its got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, and GND on one top, power and ground on the other). This new version 3.0 comes with AT-MEGA328 which offer more programming and data memory space. It is two layers. That make it easier to hack and more affordable.
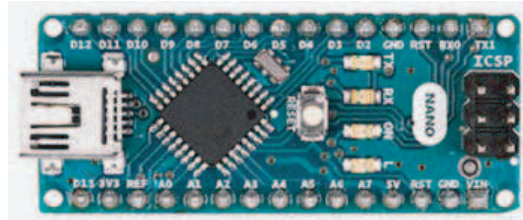
Figure 3.3: Arduino Nano microcontroller.
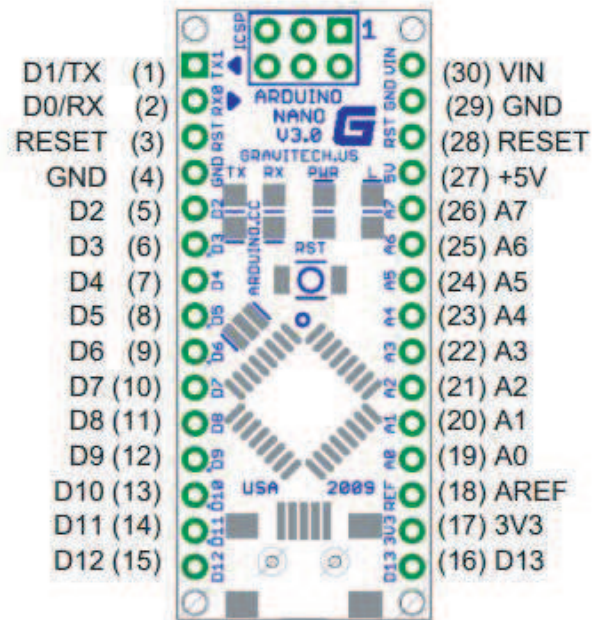
Figure 3.4: Arduino Uno pin diagram.

3.2.1 Technical Specifications

The Arduino Software (IDE), is used to program Arduino Nano. The Arduino Software is an Integrated Development Environment that is common to all Arduino boards and runs both online and offline. The detailed specification of the Arduino Nano board is as follows:

1. Microcontroller: AT mega328

2. Operating voltage: 5V

3. Input voltage (recommended): 7-12V

4. Input voltage (limits): 6-20V

5. Digital I/O pins: 14(of which 6 provide PWM output)

6. Analog input pins: 6

7. DC current per I/O pin: 40mA

8. DC current for 3.3V pin: 50mA

9. Flash memory: 32KB of which 0.5KB used by bootloader

10. SRAM: 2KB (ATmega328)

11. EEPROM: 1KB(ATmega328)

12. Clock speed: 16MHz

3.2.2 Power

The FTDI FT232RL chip on the Nano is only powered if the board is being powered over USB. As a result, when running on external (non-USB) power, the 3.3V output (which is supplied by the FTDI chip) is not available and the RX and TX LEDs will flicker if digital pins 0 or 1 are high.

3.2.3 Memory

The ATmega168 has 16 KB of flash memory for storing code (of which 2 KB is used for the bootloader); the ATmega328 has 32 KB, (also with 2 KB used for the bootloader). The ATmega168 has 1 KB of SRAM and 512 bytes of EEPROM (which can be read and written with the EEPROM library); the ATmega328 has 2 KB of SRAM and 1 KB of EEPROM.

3.2.4 Input and Output

Each of the 14 digital pins on the Nano can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX)**. Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip.

- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.

- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off. The Nano has 8 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the analogReference() function. Additionally, some pins have specialized functionality:

- **I2C: 4 (SDA) and 5 (SCL).** Support I2C (TWI) communication using the Wire library (documentation on the Wiring website).

- **AREF.** Reference voltage for the analog inputs.

- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

3.2.5 Communication

The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega168 and ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over

USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Nano's digital pins.

The ATmega168 and ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega168 or ATmega328 datasheet.

3.2.6   Programming

The Arduino Nano can be programmed with the Arduino software .Select "Arduino Diecimila, Duemilanove, or Nano w/ ATmega168" or "Arduino Duemilanove or Nano w/ ATmega328" from the Tools Board menu (according to the microcontroller on your board). The ATmega168 or ATmega328 on the Arduino Nano comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

3.2.7 Digital Button Switch

This is a digital push button sensor, which detects your press action. It is ideal for beginner class to test the Raspberry pi.
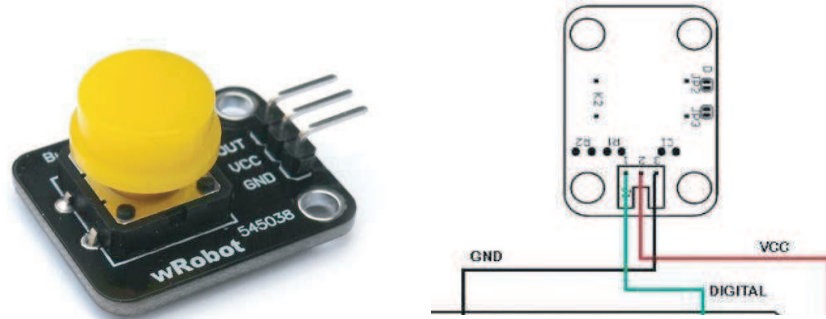
Figure 3.5: Digital push button.

3.2.8 Features

1. Support plug and play

2. Large button keypad and high-quality first-class hat

3. Able to achieve very interesting and an interactive work

4. Pin Definitions: (1) Output (2) Vcc (3) GND

5. Power Supply: 5V

6. Interface: Digital

3.2.9 EC (Electrical Conductivity) Probe

This probe is designed by us using resistor, copper wires, stainless steel and silicon glue. It has three pins that are connected to Arduinos ground (denoted as gnd), input (denoted as A0) and output pin (denoted as A5). Two stainless steel plates is set 1 cm apart for getting the value in cm scale. When submerged into water with 5V input EC probe measure the resistance of water using voltage divider rule.
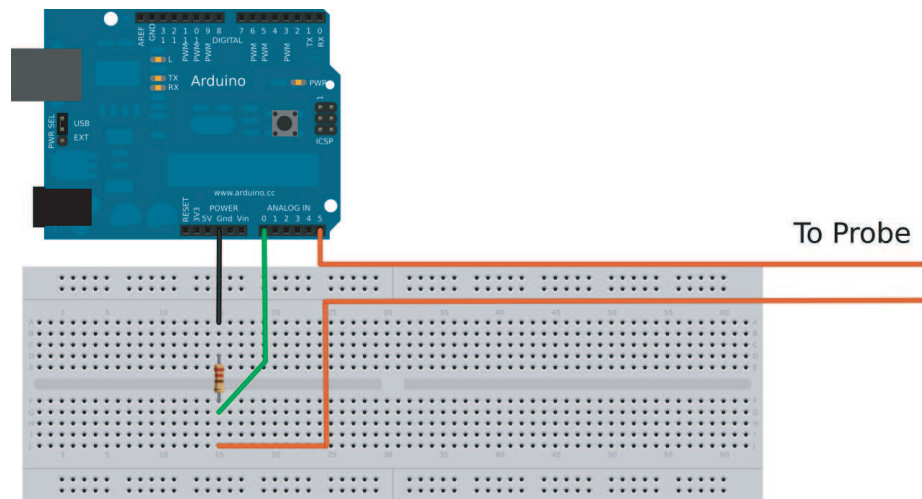
Figure 3.6: The circuit diagram of EC probe.

Chapter 4

System Implementation

This is the major part of our project. We have implemented this project following some steps. At first we gathered the hardwares which has been described in previous chapter.Then for reading the value and transmission we have imported lots of library and packages for Raspberry Pi. Lastly, connection of circuit and coding was set up to test the device. Figure 4.1 shows the prototype implementation of our system and the circuit diagram of our system shown in Figure 4.2.

1.Front Metal cover
2. Front Housing
3. Raspberry Pi Zero
4. Housing (middle)
5. Battery
6. Back Cover
7. E.C. Probe
8. Audio out
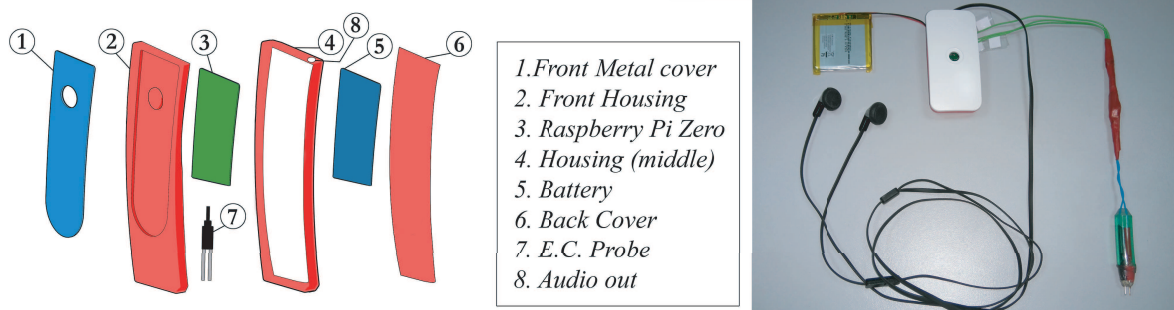
Figure 4.1: The prototype device.
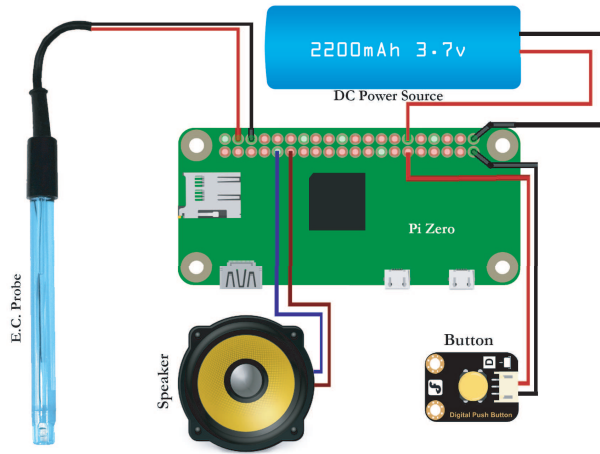
Figure 4.2: Circuit diagram of our system.

4.1 Setting up Raspberry Pi

Raspberry pi comes along with no operating system. We chose to flash the Raspbian OS which is a linux based OS that is widely used in RPi. RPi can support other OS but we chose raspbian as it is linux based and RPi natively support linux based system. A micro sd card is needed for flashing the OS. The flashing process was done from windows computer with the help of win32 disk manager. After the flash inserting the sd card into RPi with power on it boots up with operating system. After giving OS then proper library packages were installed related to our project. The first thing is to check if there is any update for the OS.

Raspberry pi doesnt have the built in clock synchronizing interface so after every boot up a command is exeuted to set up the date and time.

4.1.1 I2C communication channel setup

Raspberry pi cant access analogue data. An ADC (Analogue to Digital Converter, in our case Arduino works as an ADC) was used to communicate with Rpi which can convert analogue data to digital. Following line of code installs and enables the component for i2c detector.Then from command promt "sudo raspi-config" i2c can be enabled.

4.1.2 Serial Communication

We have used two microcontrollers in this project. One is Arduino another one is Raspberry Pi. There are several reasons to choose two different microcontrollers. First one is Arduino is very good at real time analogue data reading. Most Arduino has built in I/O pins that can read or output analogue data. Arduino doesnt contain any conventional operating system it is made for generating data and reading data but for our device we need to perform TTS synthesis which is not possible in Arduino so we need Raspberry Pi for that. In order to pass data between two microcontrollers we need some kind of protocol. It can be done with serial communication. Serial communication can be established by GPIO pins (Tx, Rx) or via USB. We chose USB communication because it needs less wire and communication is easy without any major issue. For enabling serial communication we have installed python-serial package in Pi. After that defining the serial port and serial rate in Pi connection between two microcontrollers is established.

4.1.3 Installing TTS (Text to Speech) Engine

For transmitting the voice message we need a TTS engine which will convert our text to speech. There are many engines that can be used for conversion of text to speech such as Google TTS, Espeak, Cepstral, Festival, Watson, Pico etc. Watson TTS and Google TTS are two best TTS engine but Watson is not open source where google need internet connection for speech synthesis. Other TTS engine has a robotic voice and loads of issue while synthesizing. We used Pico TTS for our project. Pico TTS is Googles android TTS, it is open source and it also gives Googles performance without internet connection. There need some initial setup for making Pi work with TTS.The first thing we have installed is ALSA Utils. The Advanced Linux Sound Architecture

```
sudo apt-get install alsa-utils
```

Figure 4.3: ALSA installing command.

(ALSA) provides kernel driven sound card drivers. It replaces the original Open Sound System (OSS). Besides the sound device drivers, ALSA also bundles a user space driven library for application developers. We can then use those ALSA drivers for high level API development. This enables direct (kernel) interaction with sound devices through ALSA libraries. But we have to interface our hardware sound driver of Pi known as snd-bcm2835 for sending the receiving the sound by ALSA. We have done it to add a line of code to ALSA modules which allowed interfacing ALSA with snd-bcm2835. For our linux based Debian OS we installed the Pico to our raspberry pi using shell command. This command installs Pico to Pi. Now with a shell

28

```
sudo nano /etc/modules
snd_bcm2835
sudo apt-get install libttspico-utils
sudo reboot
```

Figure 4.4: Audio configaration command.

command the text command is given and Pico process it saves it as a .wav file and plays the sound.

4.2   TDS Calculation

4.2.1   Mathematical Calculation

From Volatge divider rule we know:

$$Vout = \frac{R2 \times Vin}{R1 + R2} \tag{4.1}$$

Here Vout is voltage drop across our known valued resistor R1 and Vin is input voltage which is 5V in our case. 5V is produced by Arduino output pin A5. If we substitute Vin from Vout we can get the voltage drop across the water. Now we can determine the resistances of water from voltage divider rule, which give us the resistance of water in Ohm.

$$R2 = \frac{R1 \times Vout}{Vin - Vout} \tag{4.2}$$

We know conductivity is reciprocal to Ohm now we can get the conductivity in unit of microSiemens/cm.

$$microSiemens = \frac{1.0}{\frac{resistance}{1000000}} \tag{4.3}$$

From microSiemens we can now get TDS which formula is

$$TDS = \frac{500 \times microSiemens}{1000} \qquad (4.4)$$

Here TDS factor or ppm (Parts Per Million) is 0.5 or known as TDS/PPM 500. TDS 640, 700 is used for other types of solution. For example ppm 640 is used for KCl based solution. 500 is for mainly for NaCl solution which is applicable for drinking water.

4.3   Our TDS Calculation Algorithm

- **Step 1:** Start

- Step 2: Set Input and Output Pin

- Step 3: Output 5V from Arduino to EC probe

- Step 4: Get the voltage drop from resistor via Input pin

- Step 6: Calculate voltage drop in water using voltage divider rule

- Step 7: Calculate the resistance

- Step 8: Calculate conductivity in microSiemens/cm from resistance

- Step 9: Calculate TDS from conductivity

- Step 10: Send the value of TDS from Arduino to Pi

- Step 11: Take proper decision based on TDS value

- Step 12: Transmit audio message respect to TDS value

- Step 13: End

The data flow diagram of our system is shown in Figure 4.5.
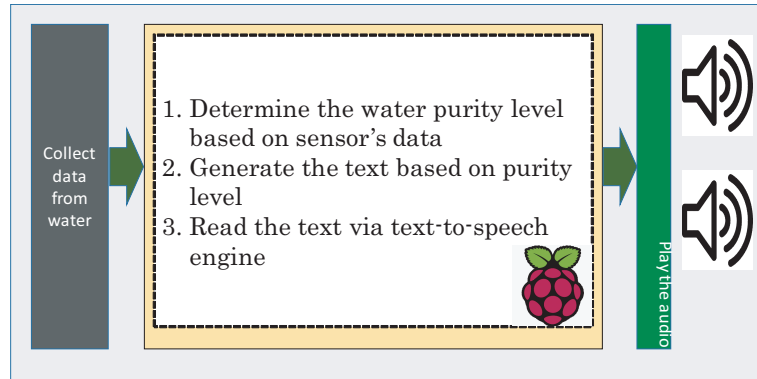
Figure 4.5: The data-flow diagram our system.

4.3.1 Meter Calibration and Testing

The accuracy of any sensor/meter (in our case, EC probe), depends on calibration. We choose distilled water as standard pure water, since distilled water does not contain any minerals. A thermometer is needed for recording the water temperature during the calibration process. We assume that, the conductivity reading of distilled water is equal to zero. This point is chosen as zeroth point of our meter. We add some salt with water, since salted water is very conductive. The measurement value of salted water is chosen as highest point of the meter. Two more middle points is determined by known conductivity readings of water, which is measured by standard TDS meter. After calibration we test our conductivity meter with different type of sample water and the result is compared with standard TDS meters reading (available in the market).

Chapter 5

Results

5.1 Result Analysis

After calibration we have test our conductivity meter with different type of sample water and the result is compared with standard TDS meters reading (available in the market). Result from this device is mostly accurate which we found comparing with other TDS meter. Distilled or Deionized water has a very less conductivity which we also found in our device. Adding salt concentration to water solution makes water very conductive in which case our device was also able to detect the high conductivity and declare it as not drinkable. As this device is for visually impaired people we have set range of TDS values which can able to provide sufficient information about water by providing audio message. We have analyzed the sample both from EAST WEST UNIVERSITYs water purifier filter and non-filtered Tap water. We found filter water is very which TDS value close to hundred. Surprisingly the water from tap was also drinkable which TDS value is in range from 110 to 170. Addition of approximately

one pinch of NaCl salt into water increases the conductivity and gives the value higher than 600 which is not recommended for drinking. Our values from different water sample were much close to commercially available TDS-3 device.

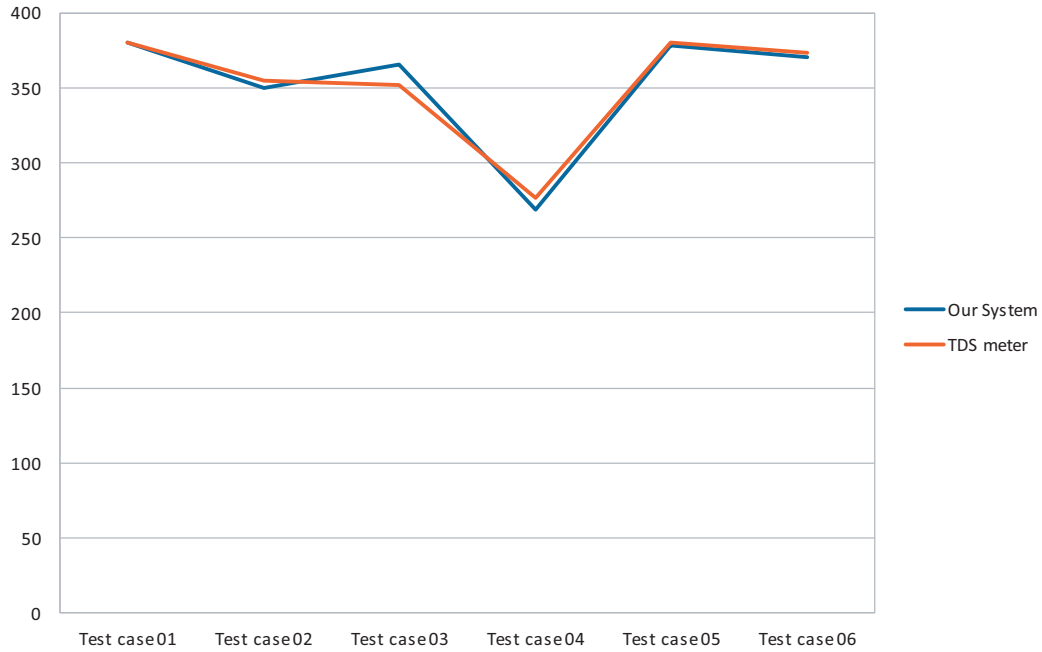Figure 5.1: The sample testing comparison between TDS meter and our system.

5.2   Limitations

There are some limitations that our device has or might face in future. The first thing is that our device value can be saturated due to temperature but the saturation is very less. Moreover in our EC probe we used stainless steel which can be affected by erosion if very ionized water is measured.

Chapter 6

Conclusions and Future Work

In this process, we developed a hardware system for identifying water purity level for visually impaired people. All the information about water goes to Raspberry Pi from Arduino via USB, then Raspberry Pi takes the value and a python script analyze it and transmit audio message via TTS engine. Our system is time efficient as it measure TDS via waters conductivity properties. Technologies are to help people and make their life easier. We believe our device can help lots of people who are suffering from visual imparity There is lot of work that can be done with this device.

We are planning to make this device work for every kind of liquid for example: Milk, Juice or any kind of Beverage. It will differentiate the liquid based on their property for which we need machine learning approach. We have also planned to do our own PCB design for better result and reduced size.

Bibliography

[1] Rupert RA Bourne, Seth R Flaxman, Tasanee Braithwaite, Maria V Cicinelli, Aditi Das, Jost B Jonas, Jill Keeffe, John H Kempen, Janet Leasher, Hans Limburg, et al. Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *The Lancet Global Health*, 5(9):e888–e897, 2017.

[2] Silvio P Mariotti. Global data on visual impairments 2010. *World Health Organization*, 20, 2012.

[3] Rohit Varma, Joanne Wu, Kelly Chong, Stanley P Azen, Ron D Hays, Los Angeles Latino Eye Study Group, et al. Impact of severity and bilaterality of visual impairment on health-related quality of life. *Ophthalmology*, 113(10):1846–1853, 2006.

[4] Chris White. Discrimination? only 16% of people who are blind or vision impaired in ireland are working. Technical report, National Council for the Blind, 2017.

[5] Erin L Brady, Yu Zhong, Meredith Ringel Morris, and Jeffrey P Bigham. Investigating the appropriateness of social network question asking as a resource

for blind users. In *Proceedings of the 2013 conference on Computer supported cooperative work*, pages 1225–1236. ACM, 2013.

[6] Erin Brady, Meredith Ringel Morris, Yu Zhong, Samuel White, and Jeffrey P Bigham. Visual challenges in the everyday lives of blind people. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2117–2126. ACM, 2013.

[7] Jeffrey P Bigham, Chandrika Jayant, Hanjie Ji, Greg Little, Andrew Miller, Robert C Miller, Robin Miller, Aubrey Tatarowicz, Brandyn White, Samual White, et al. Vizwiz: nearly real-time answers to visual questions. In *Proceedings of the 23nd annual ACM symposium on User interface software and technology*, pages 333–342. ACM, 2010.

[8] Filter water.com, 2017. [Online; Accessed 06-June-2018].

[9] Obs-3+ turbidity sensor, 2017. [Online; Accessed 06-June-2018].

[10] Tds of water, 2013. [Online; Accessed 06-June-2018].

[11] EPA. Monitoring and assessing water quality. *Annual Report*, 20, 2012.

[12] Ronald L Miller, Wesley L Bradford, and Norman E Peters. *Specific conductance: theoretical considerations and application to analytical quality control*. US Government Printing Office, 1988.

[13] Richard J Wagner, Harold C Mattraw, George F Ritz, and Brett A Smith. Guidelines and standard procedures for continuous water-quality monitors: Site

selection, field operation, calibration, record computation, and reporting. *US Geological Survey Water-Resources Investigations Report 00-4252*, 60, 2000.

[14] Rich Pawlowicz. What every oceanographer needs to know about teos-10 (the teos-10 primer). *Unpublished manuscript. Available at www. TEOS-10. org*, 2010.

[15] Ken Thompson. *Characterizing and managing salinity loadings in reclaimed water systems.* American Water Works Association, 2006.

[16] Phyllis Weber Scannell and Laura L Jacobs. Effects of total dissolved solids on aquatic organisms. Technical report, Technical Report, 2001.

Appendix A

Water conductivity and TDS

As water conductivity is the main thing to measure the TDS value in this section we discussed dome basic topics related to water conductivity and TDS.

A.1   Conductivity?

Conductivity is a measure of waters capability to pass electrical flow. This ability is directly related to the concentration of ions in the water [11]. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds [12]. Compounds that dissolve into ions are also known as electrolytes. The more ions that are present, the higher the conductivity of water. Likewise, the fewer ions that are in the water, the less conductive it is. Distilled or deionized water can act as an insulator due to its very low (if not negligible) conductivity value. Sea water, on the other hand, has a very high conductivity.

Figure A.1: Conductivity of Atom.

A.2   Conductivity Units

Conductivity is usually measured in micro- or millisiemens per centimeter (uS/cm or mS/cm). It can also be reported in micromhos or millimhos/centimeter (umhos/cm or mmhos/cm), though these units are less common. One siemen is equal to one mho [11]. Microsiemens per centimeter is the standard unit for freshwater measurements. Reports on seawater conductivity use micro-, milli- and and sometimes even just siemen/mho per centimeter, depending on the publication.

A.3   Conductance

Conductance is part of conductivity, but it is not a specific measurement on its own. Electrical conductance is dependent on the length of the conductor, just as resistance

is 18. Conductance is measured in mhos or Siemens. Conductivity is the conductance (S) measured across a specified distance (1 cm), which is incorporated into the units (S/cm). As such, the conductance of water will change with the distance specified.

A.4 Salinity

Salinity is the total concentration of all dissolved salts in water. These electrolytes form ionic particles as they dissolve, each with a positive and negative charge. As such, salinity is a strong contributor to conductivity. While salinity can be measured by a complete chemical analysis, this method is difficult and time consuming. Seawater cannot simply be evaporated to a dry salt mass measurement as chlorides are lost during the process. More often, salinity is not measured directly, but is instead derived

Figure A.2: The most common ions in sea water.

from the conductivity measurement [13]. This is known as practical salinity. These derivations compare the specific conductance of the sample to a salinity standard such as seawater [13]. Salinity measurements based on conductivity values are unit less, but are often followed by the notation of practical salinity units (psu) [14] . Salinity is not directly related to our topic but it has very close method of determining water composition which is related to TDS. The ions that provide salinity also falls under

TDS but there are many other ions that water contains besides these salts.

A.5   Total Dissolved Solids (TDS)

Total dissolved solids (TDS) combine the sum of all ion particles that are smaller than 2 microns (0.0002 cm). This includes all of the disassociated electrolytes that make up salinity concentrations, as well as other compounds such as dissolved organic matter. In clean water, TDS is approximately equal to salinity [15]. In wastewater or polluted areas, TDS can include organic solutes (such as hydrocarbons and urea) in addition to the salt ions [15]. While TDS measurements are derived from conductivity, some states, regions and agencies often set a TDS maximum instead of a conductivity limit for water quality [16]. At most, freshwater can have 2000 mg/L of total dissolved solids and most sources should have much less than that. Depending on the ionic properties, excessive total dissolved solids can produce toxic effects on fish and fish eggs. Salmonids exposed to higher than average levels of CaSO4 at various life stages experienced reduced survival and reproduction rates [16]. When total dissolved solids ranged above 2200-3600 mg/L, salmonids, perch and pike all showed reduced hatching and egg survival rates [16].

TDS can also affect water taste, and often indicates a high alkalinity or hardness [15].
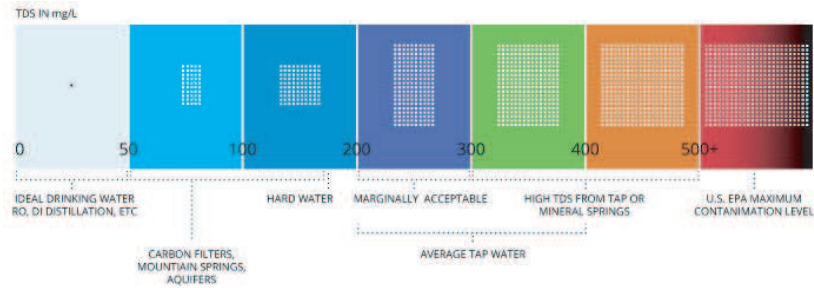
Figure A.3: The EPA, USPHS and AWWA recommend an upper limit of 500 mg/L TDS, though this is exceeded in some regions with little ill effect.

A.6 TDS Unit

Total dissolved solids are reported in mg/L. TDS can be measured by gravimetric (with an evaporation dish) or calculated by multiplying a conductivity value by a correlation factor. As TDS determination by evaporation is more time-consuming we have derived TDS from conductivity which is quicker. When calculating total dissolved solids from a conductivity measurement, a TDS factor is used. This TDS constant is dependent on the type of solids dissolved in water, and can be changed depending on the water source. Most conductivity meters and other measurement options will use a common, approximated constant around 0.65 [16]. However, when measuring mixed water or saline water (with a conductivity value greater than 5000 uS/cm), the TDS constant should be higher: around 0.735 and 0.8 respectively . Likewise, fresh or nearly pure water should have a lower TDS constant closer to 0.47-0.50. The amount of dissolved solids can be same for different types of substance in water in that case the correlation factor is changed for different types of substance. So the same conductivity can give different TDS value. Following table describes

the rest. For our project we have taken the factor 0.5. Which formula is TDS = 500*(micro Siemens/1000).

CONDUCTIVITY (µS/cm)	TDS ppm KCl	TDS FACTOR FOR KCl SOLUTION	TDS ppm NaCl	TDS FACTOR FOR NaCl SOLUTION
23	11.6	0.50	10.7	0.46
84	40.38	0.48	38.04	0.45
447	225.6	0.50	215.5	0.48
1413	744.7	0.53	702.1	0.50
1500	757.1	0.50	737.1	0.49
2070	1045	0.50	1041	0.50
2764	1382	0.50	1414.8	0.51
8974	5101	0.57	4487	0.50
12,880	7447	0.58	7230	0.56
15,000	8759	0.58	8532	0.57
80,000	52,168	0.65	48,384	0.60

Figure A.4: TDS and its factor.