Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and ZigBee Network

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ABSTRACT

Coconut sap, a watery substance obtained by manually tapping the inflorescence of a coconut tree is the main ingredient to coco-sugar, an all-natural alternative sweetener popular for its superb health benefits. Thus, coco-sap is very delicate and prone to spontaneous fermentation, which doesn't optimize full coco-sugar production. This study presents the development of a wireless sensor network and GSM alerting system for coco-sap harvesting to address the problems and difficulties encountered by the traditional harvesting method.

The system is composed of two major parts: the transmitter system, which monitors critical sap parameters namely, pH level, ambient temperature, and volume; the receiver system that processes data and sends text notification to the farmer. Data obtained from sensor readings were analyzed through the ARIMA model these were set as the training dataset to generate a prediction for every parameter. A linear regression model was created in order to make the data stationary, removing trend and seasonal structures that may affect the regression model to predict and establish efficient coco-sap harvesting schedule.

The relationship between the parameters where resulted to a positive correlation of 0.587487 for pH and temperature while a negative correlation of -0.99696 for the pH and volume parameters. The accuracy of the predictive model measured through RMSE giving an 86% and 90% for volume and pH respectively. Based on the data gathered time and temperature greatly affects the fermentation process of the sap, in addition, the alerting system was able to notify the farmer of the sap's current condition preventing wrong sap quality classification. Results showed that the model produced increased good quality sap harvest by 81.57% leading to a greater coco-sugar production.

TABLE OF CONTENTS

List of Figures

List of Tables

Chapter 1

THE PROBLEM AND ITS BACKGROUND

1.1 Introduction

Cocos Nucifera L., locally known as Coconut is one of the most important sources of food products, and by-products not only in the Philippines; but demands reaches the global market as well (Manivannan, Bhardwaj, Padmanabhan, Suneja, & Hebbar, 2016). Found in tropical countries coconut, dubbed as the “tree of life” for its diverse commodities production and the variety of livelihood it offers to the Filipino community. As stated by the Bureau of Agricultural Statistics, Philippines is the second largest producer of coconut and the major exporter of coconut goods worldwide with 9.2 billion US$ market in 2010.

Coconut products known for its immense health benefits gaining attention throughout the globe: coconut water and coconut sugar has been highly regarded by health experts for its healthy and natural contents. Coco-sugar is amongst the non-traditional processed products greatly demanded by consumers. It is a promising alternative sweetener derived from the sap of the coconut tree, which contains amino acids and vitamins beneficial to the human body; it is also safe for diabetic patients for its low glycemic index.

The coconut sap (neera) is the main ingredient of coconut sugar. Obtained by manually tapping the spadix of the coconut tree in an organized manner. Fresh neera is oyster white, sweet, and translucent with nearly neutral pH (Borse, Rao, Ramalakshmi, & Raghavan, 2005). Current harvesting technology for coconut sap encounters risks in gathering good quality neera essential for the production of premium quality coco-sugar. The collection period is usually four (4) to five (5) times a day that lasts for four (4) to six

(6) hours each gathering period depending on the ambient temperature. On the other hand, the manual acquisition of the coconut sap opposes stakes regarding microbial and physical contamination, defective and inaccurate pH meter and unpredictable fermentation of the collected coco-sap (Masa, 2012). Development of technology addressing the problem in coconut sap harvesting leads to premium quality coco-sugar for export resulting into an increase in the gross national product and global competitiveness of the Philippines.

1.2 Background of the Study

Based on World Health Organization (WHO) Global Report on Diabetes, people suffering from diabetes increases from 108 million in 1980 to 422 million in 2014, causing 1.5 million deaths in 2012. The global prevalence among adult population risen from 4.7% to 8.5% since 1980. Low and middle – income countries diabetes prevalence increase faster than the high – income countries over the past decade. It is one of the four priority non-communicable diseases (NCDs) targeted to work out by different countries. Diabetes is an important health problem leading to risk in serious health issues like heart related problems, blindness, amputation, and kidney failure. In the Philippines, diabetes is the fourth leading cause of death in 2012 and continuously rising through the years.

Diabetes is a chronic, cumulative disease distinguished by raised in level of blood glucose. To reduce the risk of acquiring it, consuming low-diet GI is suggested. The Glycemic Index (GI) measures how a carbohydrate- containing food affects the rise in blood glucose. Glycemic Index is categorized into three categories: low with GI of ≤ 55, moderate with GI of 56-69 and high, GI of ≥ 70. Low GI food plays an important role in

the dietary management of diabetes, weight reduction, peak sport performance and the reduction of risks associated with heart disease and hypertension. (Jenkins et al.1981).

Coconut sugar as a traditional sweetener is becoming popular because of its low glycemic index (GI of 35) as well as other essential nutrients. Based on the nutritional analysis conducted by Food and Nutrition Institute, shows that coconut sugar is rich in potassium, vitamin C, zinc and calcium.

Coconut is the third major agricultural crop in the Philippines (Braganza, 2018). According to Food and Agriculture Organization of the United Nations Statistics (FAOSTAT), Philippines is only second to Indonesia in terms of coconut production. However, in producing coconut sugar, Philippines top with 52% share of global exports. Coconut sugar production is purely manual. After harvesting, the farmers boil the gathered sap, which will turn into syrup and let it dry and undergoes the process of crystallization and granulation process.

There are requirements for processing of coconut sap to coconut sugar: color, pH level, odor, and taste. In pH, the required level should be equal or greater than 6; if it is lesser the coconut sap cannot longer be processed into coconut sugar but still can be used to produce other coconut products like wine or vinegar.

1.3 Statement of the Problem

1. Harvesters mainly depends on the smell, taste and color of the coconut sap in order to know if it is still fresh which results to wrong classification of the sap.

2. Coconut farmers unknowingly mix fermented sap to fresh sap affecting all the collected coconut sap causing rejection of the neera for sugar production.
3. The current coconut sap harvesting method does not optimize full production of coconut sugar due to the unpredictable rise of its pH level.
4. pH level measurement of the gathered coconut sap is made after the harvesting period making it susceptible to spontaneous fermentation.

1.4 Objectives

This study aims to develop a coconut sap harvesting system mainly for sugar production that automatically monitors and notifies the farmer of the pH level and volume of the sap ready for collection and the ambient temperature during the collection.

Specifically, this study aims to meet the following goals for the development of the coco-sap harvesting system:

1. Design a wireless sensor network that automatically monitors the pH level and volume of the coconut sap and the temperature of the environment using ZigBee Network.
2. Design a remote GSM notification system for farmers.
3. Design a device that can stand environment conditions and climate changes.
4. Design a predictive model of the yield of the coconut sap based on the initial pH level, volume, and environment temperature using Linear Regression.
5. Evaluate the efficiency, functionality, and reliability of the developed system.

1.5 Significance of the Study

This study aims to produce an effective monitoring and alerting system in harvesting coconut sap suitable for coconut sugar production. Coco-sap gathering encounters many critical parameters including contamination, and wrong classification of coconut sap due to its rapid fermentation.

This technology aids the coconut farmers who were in trouble of collecting good quality coco-sap every harvesting period. Also, to prevent rejection of the neera in coco-sugar production. Consequently, coconut sugar produced from coconut sap is proven to be a healthy and natural alternative sweetener; it contains electrolytes, minerals, vitamins, antioxidant properties and has a low glycemic index beneficial not only to diabetic and obese patients but to all the consumers as well.

The study benefits the coconut industry in the country, specifically the coco-sugar production. Since, it is one of the main export goods in the Philippines due to high international demand; this enables the agricultural industry to have a vast economic prospect and competitive market locally and globally resulting to a better gross national product and an increase in the gross national income.

This study also benefits small-scale coconut farmers and producers in rural communities to increase production and improve quality of the coconut sugar through viable and low investment farm technology providing immediate and sustainable source of income.

1.6 Scope and Delimitations of the Study

The study focuses on the development of a microcontroller based collection-monitoring system of the coconut sap using pH sensor, ultrasonic sensor and temperature sensor, pH level is the parameter prioritized in this study since the quality of the coco-sugar production mainly depends on the freshness of the sap. Moreover, volume of the sap and the surrounding temperature are also considered major factors in sugar production. Thus, the harvesting of the coconut sap is still done manually by the coconut farmer.

To optimize the production and quality of the coconut sap, a transmitter system composed of pH sensor, ultrasonic sensor, temperature sensor, Arduino Nano and XBee module are placed on the coconut tree. The pH level and volume of the sap was the input signal of the pre-programmed Arduino using C/C++ language, an output signal corresponding the equivalent pH level and volume of the sap as well as the ambient temperature would be relayed to the XBee module.

The information from the transmitter system is conveyed to the receiver system composed of the XBee module and Raspberry Pi to process the signal, GSM module is used to send alerts to the farmers through a text message, when the container is full, the sap is about to ferment, and when the sap has fermented. All the recorded data is used to train the predictive model through machine learning and python programming.

The system is designed to be low powered. Thus, 10000 mah power banks are used for the transmitter attached on the coconut trees. However, AC to DC adapter is used for the receiver system. The project is to be deployed in Alabat, Quezon, since the said area is being developed by the Philippine Coconut Authority to be the coconut capital of our

country. Lastly, the coconut specie to be used is a hybrid dwarf adaptation of Cocos Nucifera Linn, endemic in the Philippines.

1.7 Operational Definition of Terms

The following are the technical terms used in the discussion of this study. Definitions are provided for easy understanding of this content.

Arduino Nano – microcontroller used to process the data given by the pH and ultrasonic sensor for the transmitter part of the system

Coconut Sap (Neera) – watery substance derived from the spadix of the coconut tree, it is also the input of the transmitter system

GSM module - used to notify the farmer of the current standing of the sap via text message

Industrial pH Sensor – used to determine the pH level of the coconut sap

Inflorescence (Spadix) – part of the coconut tree where the sap drips

Machine Learning – used in order to train the predictive model

Multiple Linear Regression – type of time series analysis used to train the data

pH level - important parameter of the coconut sap to be produced into coconut sugar; monitored by the industrial pH sensor

Power Banks – the primary source of power of the transmitter system

Raspberry Pi – microcontroller used for the receiver part of the system, which is the server

Real Time Clock (RTC) – used for time monitoring of coconut sap condition

Receiver System – installed at the farmhouse, receives and analyzes sensor data

Transmitter System – installed in each coconut tree, sends sensor data

Ultrasonic Sensor – sensor used to determine the volume of the coconut sap

XBee Module – used to transmit and receive data given by the Arduino

Waterproof Temperature Sensor – used to determine the temperature of the farm surroundings

ZigBee Protocol – wireless communication protocol used for the transmitter and receiver system of the data

Chapter 2

REVIEW OF RELATED LITERATURE

2.1 Conceptual Literature

2.1.1 Philippine Coconut Industry

2.1.1.1 Global Production Outlook

The Philippines, India, and Indonesia were the leading countries in coconut production, producing three quarters or 75 percent of the world's coconut in plantations locally (PARDI, 2011). Coconut grows to over 97 countries in the tropical belt mostly in Asia, East Africa and America. Consequently, Philippines and Indonesia comprises 56 percent of the global production, followed by India and Brazil (Elias, 2015). The Philippines ranked one (1) and has the largest coconut cultivation area worldwide with an average of 3,474,463 million hectares; Indonesia ranking second has a total area of 2,798,777 million hectares; India being the third with 2,022,892 million hectares as stated by the Food and Agriculture Organization of the United Nations Statistics (FAOSTAT) in 2015.

On the other hand, in terms of coconut production Indonesia ranked first among the three major countries with an average of 18,234, 313 million nuts, which is almost 31.5 percent or the world production, followed by the Philippines with approximately of 15, 216,062 million nuts that's 26.29 percent. Lastly India on the third rank with 11,841,047 million production, which is 20.46 percent (Naik, 2017)

Table 2.1: Average Area under Coconut Cultivation of Selected Countries during 2005-06 to 2014-15

Sl. No	Country	Average	Percentage	Rank
1	Indonesia	2798777	26.31	2
2	Philippines	3474463	32.67	1
3	India	2022892	19.02	3
4	Brazil	270648	2.54	6
5	Sri Lanka	401571	3.78	5
6	Vietnam	98097	0.92	11
7	Papua New Guninea	221884	2.09	8
8	Mexico	168793	1.59	9
9	Thailand	227636	2.14	7
10	Malaysia	102348	0.96	10
11	United Republic of Tanzania	613953	5.77	4

Source: Food and Agriculture Organization of the United Nations Statistics (FAOSTAT), Annual Reports various issues from 2005 -2015

Philippines is the top exporter of coco-sugar with almost 52 percent share and Indonesia being the second with 24 percent share globally. The coconut industry contributes about 1.14% of the Gross National Product (GNP) since it is one of the top five (5) dollar earner export of the country with approximately 760 million US dollar per annum (PCA, 2015).

2.1.1.2 Local Production Outlook

According to the Philippine Statistics Authority (PSA), coconuts are grown in over 68 provinces of the country, covering 26 percent of share in agricultural lands approximately 3.5 million hectares of land. There are roughly 330 million nut-bearing trees planted over the archipelago. Coconut industry is the fourth largest sector of Philippine agriculture, with major agricultural crops such as copra, coconut, and coconut oil. There are 3.5 million coconut farmers and farm workers in the country,

with 12, 500 coconut farmers' cooperatives and organization (Flandez-Galvez, 2018).

The top five growing regions of coconut in the country is shown on the graph below. The largest farmland is in the Bicol region with 13% of the total land area in the country with an average of 453,501 hectares, followed by CALABARZON and the Eastern Visayas region each with 12% share while Davao and Zamboanga each has 11% of the total coconut farmland (Flandez-Galvez, 2018).

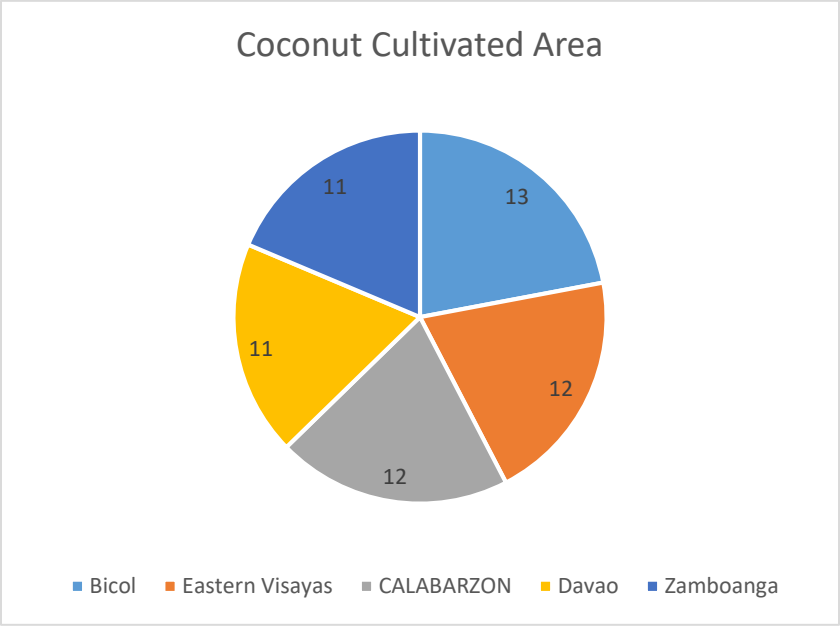


Figure 2.1: Top five Coconut Areas in the Philippines (PCA, 2015)

As stated by the Philippine Coconut Authority (PCA) in 2015, the CALABARZON and Eastern Visayas region showed a promising increase of 1.4% and 2.8% respectively in area harvesting which encompassed the national average period. With the Coco-sugars' increasing domestic and global demand; Northern Mindanao has been its major source with about 32% of the total national product, followed by the SOCCKSARGEN and Davao Region.

2.1.1.3 Export Market of Coco-sugar

Market trend for coconut sugar has been highly demanded now a days, it is observed that the exportation grows significantly from 36 metric tons in 2010 to 220 metric tons by the end of 2012. Increase in volume of export means an increase in sales and export price from 1.5 US dollar to 6.50 per pound. There is a 92.78% increase in the total export of coconut sugar approximately 70,000 kilograms in 2011, it showed a remarkable leap of 224.20 percent from the total exports in 2009.

Coconut sugar production has been a rising commodity for its three major producers namely the Philippines, Thailand and Indonesia. Philippine coco-sugar has been considered as premium quality amongst the three countries, it is exported in Australia, N ew Zealand, Korea, Japan and more it is also an emerging product in the Middle East and Europe market (PCA, 2015).

2.1.1.4 Philippine Coconut Sugar Producers

According to the Philippine Coconut Authority**,** Mindanao produced the largest amount of coco-sugar for export amounting to 86 percent of the total export of the country. Northern Mindanao contributed 108 metric tons of national production of coconut sugar, followed by the SOCCKSARGEN and Davao Region respectively with 68.4 and 61.9 metric tons. The Bicol Region produced 5% share, while only 3% was produced by the CALABARZON region.

Table 2.2: Coco-Sugar Major Producers

Region	2010	2011	2012	2013
SOCCKSARGEN	7.56	14.7	46.2	68.56
Davao Region	6.84	13.3	41.8	61.94
CARAGA	3.96	7.7	24.2	35.86
MIMAROPA	1.08	2.1	6.6	9.78
CALABARZON	1.08	2.1	6.6	9.78
Bicol	1.8	3.5	11	16.3
Western Visayas	1.08	2.1	6.6	9.78
Zamboanga	1.08	2.1	6.6	9.78
Northern Mindanao	11.52	22.4	70.4	104.32

Source: Philippine Coconut Authority Report in 2015

2.1.1.5 Domestic and Export Price

Figure 2.2 illustrates the price increase of coconut sugar in the past few years. It is seen that from Php 180 in 2010, the price tremendously increase to 300 pesos by the end of 2014 (PCA, 2015).

Figure 2.2: Price Trends of Coconut Sugar in the Philippines (PCA, 2015)

As stated by the PCA, the price ranges from Php 250 being the average to Php 440 being the highest buying price in markets, malls and pasalubong centers. Mostly the production of coco-sugar locally are homebased, coconut farmers and workers are unaware of the economic importance of coco-sugar due to the lack of technology and capital unlike Coco Republic which aims for a world class product. On the other hand price ranges from 4.5 to 6.5 US dollars globally.

2.1.2 Coconut Sugar

2.1.2.1 Description and Its Major Uses

According to the Food and Nutrition Research Institute, coconut sugar is a traditional sweetener that is all natural, healthy and cheap sugar alternative.

Figure 2.3: Coconut Sugar (FNRI)

Coconut sugar comes in form of crystal, granules, or syrup. It is produced from the collected coco-sap from the tapped spadix of the tree. The sap is sweet, and translucent with neutral pH; about 80% of the sap is water .

Figure 2.4: Coconut Inflorescence (FNRI)

Each tapped flower buds can produce two (2) to four (4) liters a day; with an approximate production of eight (8) gallons of sap daily, the sap is collected every morning and evening. For the production of coco-sugar two (2) gallons of coconut sap is needed to produce one (1) kilogram of sugar. Consequently, two (2) hectares

land composed of 300 dwarf hybrid coconut produced 3.5 metric tons of coconut sugar.

Figure 2.5: Tapped Coconut Flower Bud with Dripping Sap (FNRI)

According to the research conducted by the Davao Research Center, when the coconut sap is tapped on the first half of the coconut blossom, it allows the remaining half blossom to develop into mature. Coconut trees is much more productive that way producing both coconut sap and coconut fruit yielding up to seven (7) times higher productivity than the traditional method.

2.1.2.2 Coco-sugar Health Benefits

As seen from the table below, coconut sugar possess less sucrose composition, thus showed greater fructose, glucose, macronutrients and micronutrients than refined sugar which makes it healthier than any other forms of “synthetic” sugar.

Table 2.3: Coco-Sugar Composition

	Composition (%)				
Type of Sugar	Sucrose*	Fructose*	Glucose*	Macro-nutrients**	Micro-nutrients**
Coconut Sap Sugar	84.98	2.90	2.00	1.89	0.005
Refined cane sugar	99.7	-	-	0.02	0.0003

Source: Philippine Coconut Authority Report in 2015

Coconut sugar also contains amino acids; out of the 20 amino acids needed by our body for repair, maintenance, and growth 16 of them is found in coconut sap sugar. Amino acids is essential to the metabolism, proper function and health of the human body. Studies showed that glutamine is the highest amount of amino acid present in the coco-sugar. Glutamine prioritizes the metabolic process; it assists in maintaining proper acid and alkaline balance in the body. Thus, it is also termed and the nature's "brain food" for it improves mental capacities and is used to treat depression, fatigue, alcoholism, epilepsy and more (Natural Healthy Choices, 2014).

Table 2.4: Coco-Sap Vitamin Composition

VITAMIN	VALUE (MG/DL)
Thiamine	**77.00**
Riboflavin	12.20
Pyridoxine	
Paraaminobenzoic Acid	38.40-47.10
Pyridoxal	38.40
Pantothenic Acid	5.20
Nicotinic Acid	40.60
Biotin	0.17
Folic Acid	0.24
Inositol	**127.70**
Choline	9.00
Vitamin B12	trace

Source: Natural Healthy Choices Report in 2014

Coconut sap also contains twelve essential vitamin B complex; one of them is Inositol. Inositol is needed by the body in small amounts to stay healthy and functional; it plays an important role in nerve transmission, regulation of enzyme activity and aids in redistribution of fats within the body. It is also under research for its anti-cancer property, and reduced blood cholesterol, depression, panic attacks. Thus, it is also reported to be beneficial in treating eye abnormalities and prevents eczema and psoriasis (Natural Healthy Choices, 2014).

Table 2.5: Coconut Sugar Nutrients Composition

MACRONUTRIENT mg/L(ppm) in Dry Matter	Coconut Sap Sugar	Brown Cane Sugar	Refined Cane Sugar
Nitrogen (N)	2,020.0	100.0	0.0
Phosphorus (P)	790.0	30.0	0.7
Potassium (K)	10,300.0	650.0	25.0
Calcium (Ca)	60.0	240.0	80.0
Magnessium (Mg)	290.0	70.0	10.0
Sodium (Na)	450.0	20.0	10.0
Chlorine (Cl)	4700.0	180.0	100.0
Sulfur (S)	260.0	130.0	20.0
Boron (B)	6.3	0.0	0.0
Zinc(Zn)	21.2	2.0	1.2
Manganese (Mn)	1.3	2.0	0.6
Copper (Cu)	2.3	0.6	0.6
Iron (Fe)	21.9	12.6	1.2

Source: Philippine Coconut Authority - Plant Tissue Analysis Laboratory

As shown from the table of nutrients above, coco-sugar has significantly higher contents of nutrients compared to brown sugar and refined table sugar produced by sugar cane. Potassium, zinc, iron and mineral is also is greater in coconut sugar. Potassium played a vital role in the maintenance of blood pressure, contributing in the reduction of cardiovascular and coronary heart disease (Natural Healthy Choices, 2014).

As reported by the Food and Nutrition Research Institute states that coconut sap contains phytonutrients such as Polyphenols, flavonoids, ascorbic acid and anthocyanin as well. Thus, making coco-sugar a good antioxidant free from radical scavenging activity that exhibit good reducing power. It also possess anti-aging, anti-mutagen and antitumor properties (Devi, et.al, 2015)

Table 2.6: Glycemic Index Classification

HIGH	MEDIUM	LOW
75-100	56-74	55 or less

Source: Philippine Coconut Authority

Glycemic Index (GI) is a food classification for blood glucose response. It has three classifications HIGH, MEDIUM, and LOW; Low GI food shows reduced postprandial glucose and insulin response to improve lipid and glucose concentration for consumers' especially diabetic patient. Consequently, coconut sugar is known for its low glycemic index of 35, therefore it is considered healthier that refined sugar and brown sugar which has glycemic index of 60 and 64 respectively. Coco-sugar can be used as a 1:1 alternative sweetener for coffee, tea, baking and cooking (Trinidad, 2015).

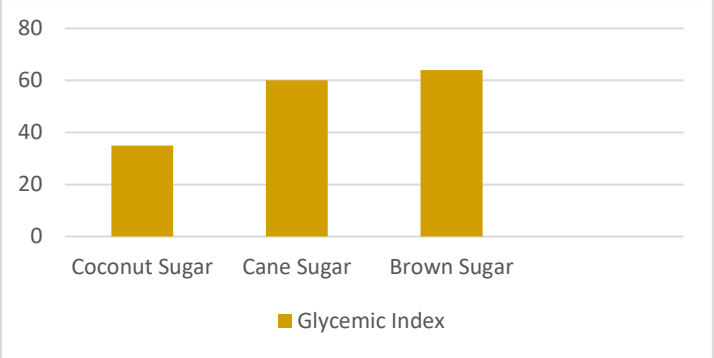


Figure 2.6: Comparison of Glycemic Index (Trinidad, 2011)

According to the World Health Organization, diabetes has contributed 1.5 million deaths worldwide in 2012; it was one of the leading causes of death for men and women. On the other hand, there is an estimated 3.7 million deaths related to high blood glucose 2.2 million deaths were caused by cardiovascular disease, kidney disease and tuberculosis. Philippines ranked in top 15 as one of the world's emerging diabetes hotspots. More than 4 million Filipinos has been diagnosed with diabetes. Diabetes Mellitus condition in the Philippines rises from 7.2% to 10.2% (Jimeno, Kho, Matawaran, Duante, & Jasul, 2015).

2.1.3 Coconut Sap Tapping Technique

Traditional method of coco-sap collection involves the tapping of the spadix when the sap starts oozing out, a coco leaf lamina is also tied to the inflorescence of the tree to allow the sap to trickle. The sap is collected in an open pot or plastic gallon placed on the top of the palm for at least 8-12 hours. The sap collected is translucent oyster white, and enemates a strong odor contaminants such as ants, pollen and dust particles are also present (Hebbar, et al., 2015).

Figure 2.7: Traditional Method of Coco-sap Collection (Hebbar, et al., 2015)

2.1.4 Coconut Sugar Production

Production of coco-sugar in the country is done purely manual by coconut farmers and workers. They follow the traditional way of collecting the sap and cooking of the sugar in wood fire then weighing and packing the sugar (Masa, 2012). Current processing technology of Coconut sugar in the Philippines is shown on the figure below.

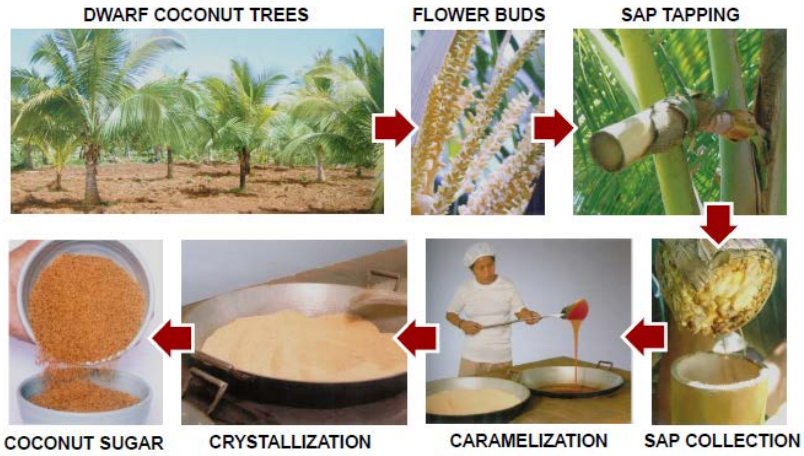


Figure 2.8: Steps in Coconut Sugar Production (Azukar Organics, 2008)

A study has been conducted to improve the quality of coconut sugar, which utilizes genetic algorithm using stochastic universal sampling for the selection process. The study focused on two factors namely the treatment time and color of the honey produced. Results showed that certain parameters like volume and cooking environment should also be considered since it also affects the physical changes of the sugar. Thus, the system developed is capable of categorizing the difference of the two processes by the color of the sap material, it is recommended to have a classification algorithm to differentiate the time factor (Baldovino, et al., 2017).

2.1.5 Monitoring and Alerting System

2.1.5.1 pH level

Parameters to be considered for the production of coconut sap to coconut sugar includes pH level, color, odor and brix (sugar content). In this study, the researchers focus on specific parameter which is pH level. The required value of pH for the coconut sap is pH ≤6 . Increase in pH level of the coconut sap means it cannot be longer processed into coconut sugar. (D.B.Masa,2012)

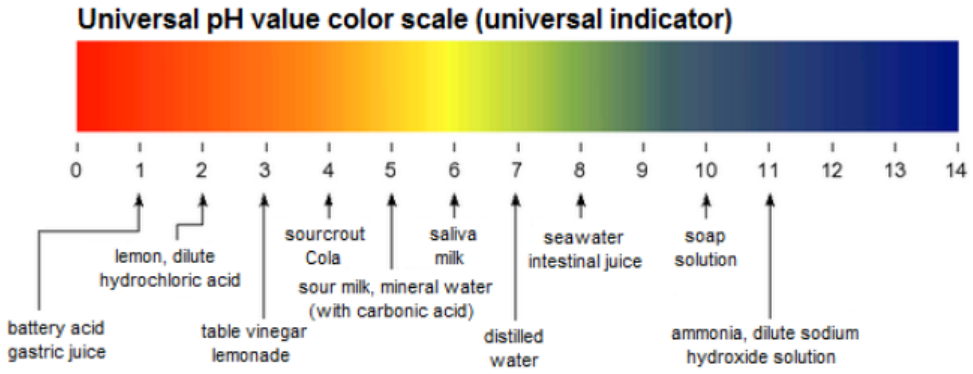


Figure 2.9: Universal pH indicator (Bishal and Sigdel , 2017)

2.1.5.2 pH sensor

A device that detects pH of liquid substances. The term pH came from Latin word “potential hydrogenii” which means power of hydrogen. Measurement of pH is widely used in industrial applications. pH is the hydrogen –ion concentration in water – based solutions, which will distinguish the acidity and alkalinity in the solution (Bishal and Sigdel, 2017).

2.1.5.3 Ultrasonic sensor

Ultrasonic sensor is an electronic device that converts electrical energy to mechanical energy in the form of ultrasonic sound waves (M. Husni , 2016). It applies

sound vibrations to estimate the distance between a source (sensor) and the given target. The echo of the emission is used to calculate the distance between the two. It is usually used in measuring liquids inside tanks.(Rogienfisz,et.al,2017). It uses electrical-mechanical energy to determine the distance of an object from it. It is an advisable sensor for measuring the volume inside the container without touching the liquid itself (Sidik and Ghani, 2017).

2.1.5.4 Arduino (Nano)

Arduino Nano, base on ATmega328P, which has the same specifications, function and connectivity as the Arduino UNO but in a smaller form factor. With a mini USB –cable connected, it is programmed in using Arduino Software (IDE) to perform diverse tasks in a given program. It is breadboard – friendly which makes it more efficient as given its size than other packages. (Arduino,2018)

2.1.5.5 ZigBee

ZIGBEE is a wireless sensor network (WSN) that commonly used with microcontroller in many applications such as home appliances, agriculture field, robotics etc. The sensor module monitors the sensors attached and transmit the data obtain via ZIGBEE to substation module and evaluate with the data stored and execute the action according to the program (Ali Ibrahim 2015).It is based on IEEE 8805.15.4 protocol , low powered (most cases 1mW) yet offer a range up to 150 meters in outdoor (Ramya, et. al,2016).

2.1.5.6 Raspberry Pi

Raspberry Pi is a cheap, small sized computer and low powered consumed device. It is a device used by many to explore computing programming which helps to understand program languages such as Python and Scratch. It is widely used in digital projects, detectors, can be connected to Internet of Things(IOT) and even perform tasks to be used for Machine Learning (raspberrypi.org)

2.1.5.7 Machine Learning

Deep learning is a subset of machine learning which is an application of Artificial Intelligence (AI). Learning primarily aims to develop computers to learn automatically without human supervision. Machine learning is often supervised and unsupervised. In this study, supervised machine learning will be used to apply the learned past data to predict future events. Through analyzing the data gathered, the system is able to provide a comparison between the outputs to identify its accuracy and identify errors to revise the model consequently (expertsystem, 2018).

2.1.5.8 Temperature Sensor

The waterproof sensor DS18B20 a small temperature sensor with 12 bit built in ADC. It communicates over a one wire bus that is easily connected to an Arduino digital input. The temperature sensor has an accuracy of +/-0.5 degree Celsius within the range of -10 to +85 degree Celsius. Multiple sensors are connected to the same data bus, each with unique serial number. It can operate in normal or parasite mode. For the normal mode, a three wire connection is made while in parasite mode the sensor derive its power from the data line (Reed, 2018).

2.2 Related Literatures

On the study by Hebbar, et.al (2015), a portable coconut sap collector is developed from a hollow PVC pipe with one end expanded into a box to hose the collection container with ice cubes, while the other end is wide enough move the container in and out of the box with two liters capacity; it is called the coco-sap chiller. Insulation jacket is used as the walls of the device; it is light-weight, water-proof, easy to connect to the spadix, requires less ice and retains low temperature for longer periods compared to commercially available ice boxes. This device preserves the freshness, flavor and aroma of the gathered sap.

Another study by Aquino, et al (2017), the problems in the traditional cooking method of coco-sugar has been addressed by the development of a neuro-fuzzy mixing control model. The model developed showed 95.4% accuracy during the testing period, it has been trained with various fuzzy inference system wherein data are automatically fuzzified by the neuro-fuzzy network and neural network. The Grid partition system showed small training errors but gives poor performance during the testing period, while the C-means clustering gives the best results for accurately controlling the mixing setting for coco-sugar production.

An automated cooking method for coconut sap was developed by the study entitled *Characterization of Critical Parameters for Automated Coconut Sugar Production using Thermal Vision System.* Processing the coconut sap to produce coconut sugar is done manually, which leads to inconsistency of the quality of the coconut sugar produced. Through this study, a device is created to fully automate the process of cooking using vision system and computational algorithms. Instead of doing the cooking manually, the

technology will improve the overall production and the quality of the coconut sugar produced.

The study of Dingli and Fornier (2017) titled *Financial Time Series Forecasting – A Deep Learning Approach* is a follow up of a previous study. With the same dataset but with a different approach, machine learning is used to established a stock market forecast of the next period price direction with respect to the current time. Convolutional Neural Networks (CNNs) is used which accomplished a 65% accuracy on the first forecast and 60% for the next forecast. The drawback of the study is the results obtained were not able to exceed the available leading techniques in the industry.

Chapter 3

METHODOLOGY

3.1 Research Design

The input of the system is placed on the coconut tree for monitoring. The pH sensor and ultrasonic sensor are used to determine the acidity/alkalinity and the volume of the coconut sap while waterproof temperature sensor is used for the monitoring of the surrounding temperature. These sensors are interfaced with Arduino board which serves as the microcontroller board for the input system. To be able to transmit the data to the server, ZigBee is used as the mode of communication and XBee as the transmitter module. In addition, another requirement is to be knowledgeable of C/C++ language to program the Arduino board.

On the process, the acquired data were sent to the server. Thus, another XBee module is used for the reception of data. Raspberry Pi programmed using Python analyzed the received data then it determines if the coconut sap is ready for collection.

The farmer is notified through SMS if the sap is ready for collection using a GSM module interfaced to the Raspberry Pi.

Research design comprises the following stages:

- Gathering of Data
- IPO Diagram
- Flowchart of the Program

3.1.1 Gathering Data

The project study is verified feasible through research from academic resources on the internet and in the university library. The group evaluated previous related studies in the Electronics Department of the university and other universities as well. Different aspects such as benefits to the end-users and technological innovation are considered in choosing the study. Topics covered in analyzing the study are the following:

- Arduino Nano Development
- Raspberry Pi Development
- Programmable pH sensors
- Programmable ultrasonic sensor
- Programmable temperature sensor
- GSM module applications
- ZigBee wireless communication
- Machine Learning - Time Series Analysis
- Local and international studies related to coco-sap sugar production
- The process of monitoring pH and volume level for coco-sap harvesting
- Coco-sap harvesting procedure

3.1.2 IPO Diagram

Figure 3.1: Input-Process-Output Diagram of the System

Figure 3.1 shows the IPO diagram of the device. The input of the system is the coconut sap oozing from the spadix of the coconut tree, two parameters were monitored from the sap namely, pH level and volume while the environment temperature is also considered as one of the inputs. The process part starts with the conversion of analog data

inputs from the sensors to digital data output by Arduino Nano microcontroller to send signal to the server composed of the receiving XBee and Raspberry Pi. The output of the system is made possible through a GSM module for the notification of the coconut farmers.

3.1.3 Flow Charts

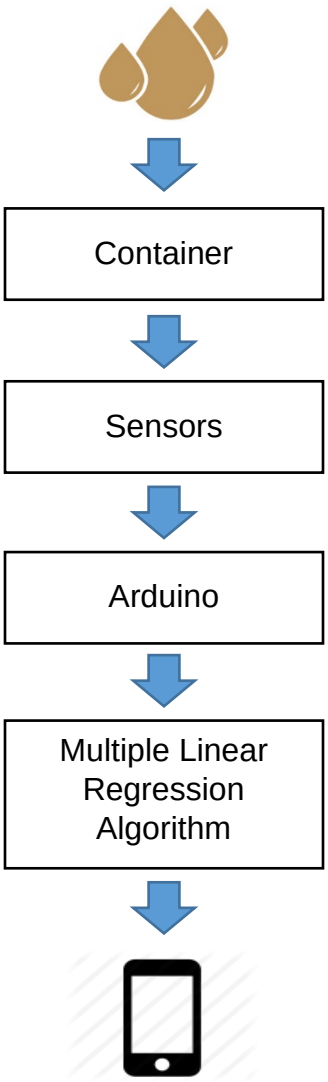


Figure 3.2: Process Flow Chart of the System

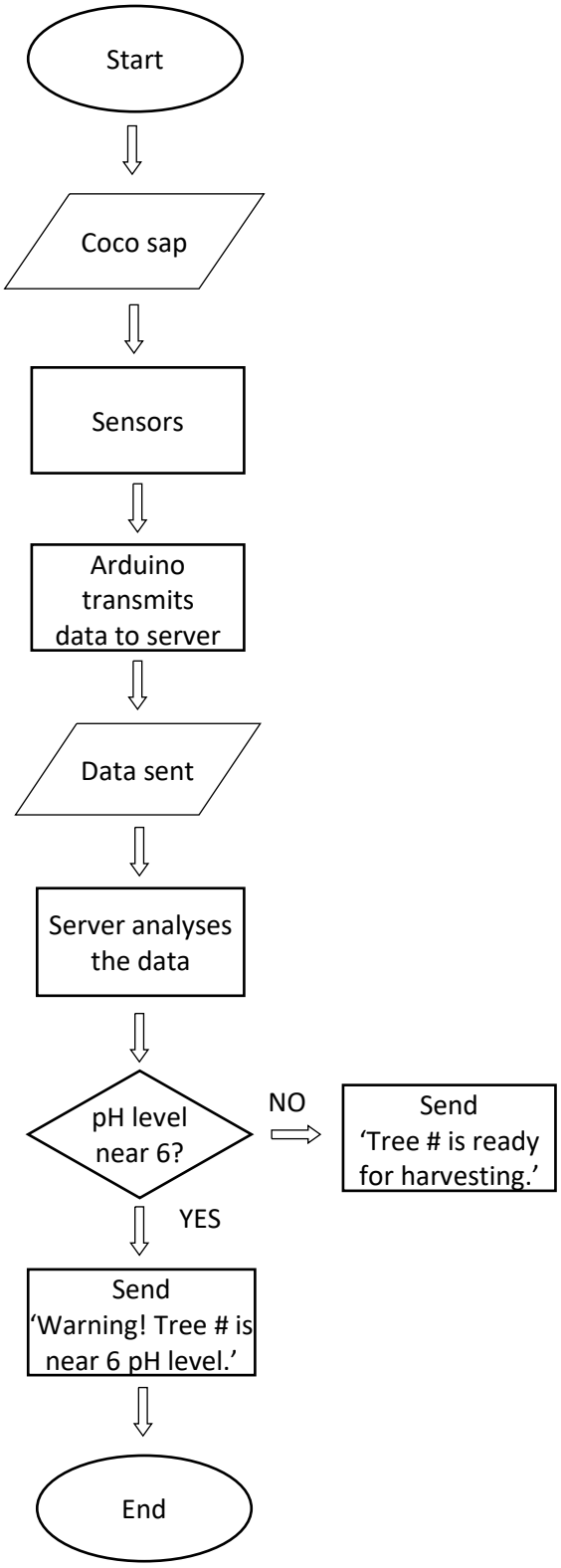


Figure 3.3: Program Flow Chart of the System

Figure 3.2 shows the process flowchart of the system where the coconut sap is gathered in the container with sensors to determine the pH level, volume and temperature of the sap. The Arduino converts the signal from the sensors to digital data processed by the Raspberry Pi for machine learning. The output is the SMS alert send to farmers for the collection of the sap.

On the other hand figure 3.3 shows the program flowchart of the study. The coconut sap is the input of the sensors and gives signal to the Arduino. The Arduino converts the signal from analog to digital and transmits it to the server via ZigBee. The Raspberry Pi is programmed to send alerts to the farmer regarding the status of the sap. If the pH level is near 6, a message is sent to the mobile phone to warn that the sap is near to ferment, and if not near 6, it sends/displays a message that the sap is ready for harvesting.

3.2 Project Design

The primary component of the project are the XBee modules that transmits and receives the data from the transmitter to the receiver of the system, the GSM module notifies the farmers to harvest the sap. The sensor unit monitors the pH level and volume of the coco-sap, the environment temperature is considered as well. These data are transmitted to the server via ZigBee network then to the receiver to the Raspberry Pi for the machine learning and GSM notification

3.2.1 Prototype Fabrication

3.2.1.1 Transmitter System

A. Data Acquisition

pH Sensor and Module

The pH sensor is calibrated by measuring buffer solutions with pH 4 and 7. This sensor is used as a measuring device for alkalinity/acidity of the coconut sap. It sends analogue signal to the Arduino board that is linearly proportional from measured pH level. This waterproof sensor is suitable for long-term monitoring. Recalibration must be conducted to return the accuracy of pH sensor after a few months.

Figure 3.4: Industrial pH Sensor

Ultrasonic Sensor

The ultrasonic sensor uses sound waves to measure distance the concept behind this is similar to the sound navigation and ranging (SONAR). The purpose of ultrasonic sensor in this project study is to determine the volume of the coconut sap inside the container.

Figure 3.5: Ultrasonic Sensor

A cylindrical container serves as the reservoir for the coconut sap, having dimensions of h as its height and r as the radius of the base of cylinder. Thus, the area of the base is computed by this formula: $A_{BASE} = \pi r^2$

The ultrasonic sensor faces downward to the base of container. When the sensor emit sound waves, it travels through the air. Once the waves hits the coconut sap surface, the sound waves bounces back to the sensor. The Arduino Nano determines the time from release of sound waves up to the time when it returns to the sensor. The obtained time is halved since it matters only the time interval between flight and when the waves strikes the liquid surface. That interval is time T.

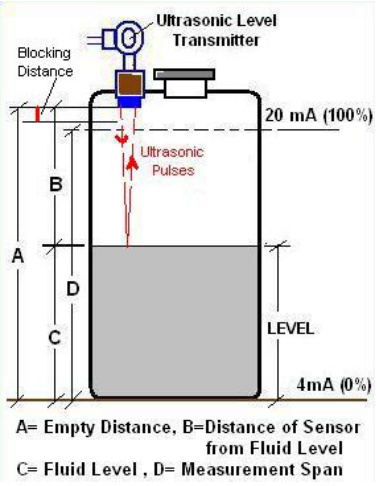


Figure 3.6: Ultrasonic Sensor Measurement (Coulton.com)

As shown in the figure above, by using the relationship between distance, time and speed it determines the distance B by using the time and the constant, 344 m/s as the speed of ultrasonic waves on air.

$$\text{Distance of B} = 344 \text{ m/s} * \text{time T}$$

The distance of B is found, to determine the level of liquid, C, by subtracting the distance of B from distance of A.

$$C = A - B$$

Then, the volume of liquid is determined by using the formula for cylinder. C as the height and the A as the area of the base since these dimensions are the occupied space of the coconut sap.

$$\text{Volume} = C * A$$

The volume of liquid are now found. This data is sent to the server for further process. The arithmetic computations are conducted by Arduino board.

Temperature Sensor

To determine the ambient temperature at the farm, the temperature sensor use in this project study is a waterproof temperature sensor based on DS18B20 digital temperature sensor. It has 3 pins, the ground, supply, and the data. The circuit diagram including the microcontroller board and the 4.7k ohm pull-up resistor were made. It returns 9-12 bits of digital signal corresponding to the measured temperature and interpreted by source code in Arduino board.

Figure 3.7: Temperature Sensor

B. Processing Unit

Arduino Nano

This microcontroller board serves as the central processing unit of the transmitter system. It does the calculations, decisions, and commanding within the local of transmitter. It receives the signals sent by the pH, ultrasonic and temperature sensor. It also commands the XBee module to transmit the data.

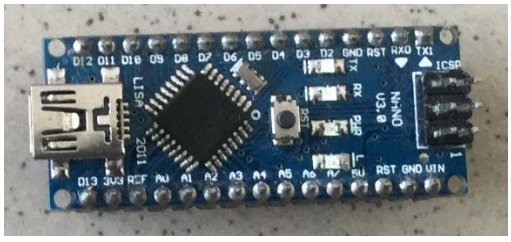


Figure 3.8: Arduino Nano

C. Medium of Communication

XBee S2C Module

The function of XBee module is to send and receive data from the transmitter to receiver, respectively. It uses ZigBee network protocol as means of communication. The module works with 3.3 V therefore it is not compatible with Arduino Nano since this microcontroller board has 5V output voltage. Thus, providing a XBee regulator board is necessary to regulate the voltage entering the XBee module. In addition, it was used for easy interfacing with the Arduino. The X-CTU software was used to set the configurations in the module.

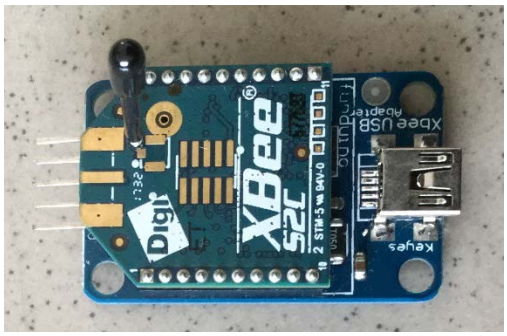


Figure 3.9: XBee module and XBee Explorer Shield

3.2.1.2 Receiver System

Raspberry Pi

The Raspberry Pi serves as the computer of the system; it contains the database of the study. It enables the training of the machine learning for the predictive model. Also, it sends a command to the GSM module for notification.

Figure 3.10: Raspberry Pi Module

3.2.1.3 GSM Alerting System

The SMS notification system is made possible by using GSM module. Text messages alerts the farmers that the coconut sap is reaching its minimum pH level of 6. The text message includes if the container is full, if the sap is about to ferment, and if the sap has fermented

The process is described as follows:

1. The GSM module receives data from the raspberry pi.
2. The GSM module sends SMS notification to the farmers to alert about the current standing of the sap at each tree.

Figure 3.11: GSM Module

3.2.1.4 Machine Learning

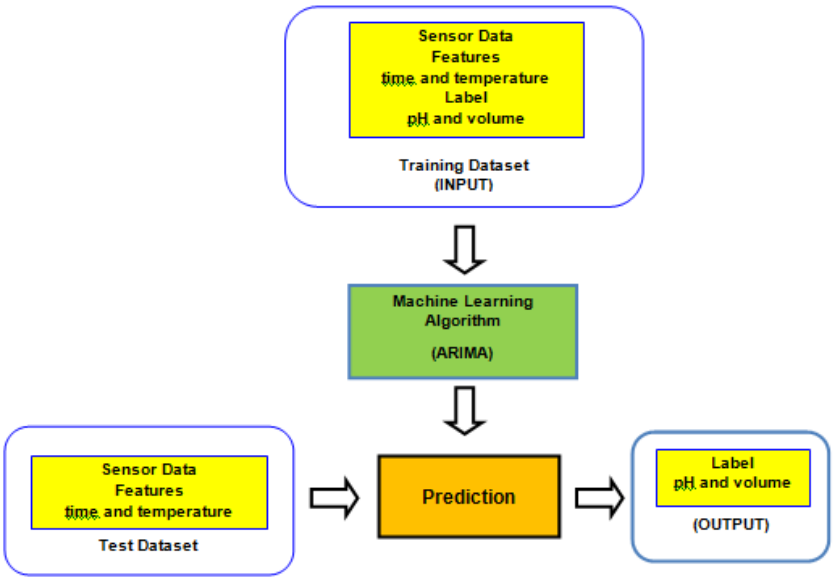


Figure 3.12 Supervised Machine Learning

Table 3.1 Machine Learning Training Data

Feature		Label	
Time	Temperature	pH	Volume
X	Y	A	B

Table 3.2 Machine Learning Test Dataset

Feature (Input)		Label (Output)	
Time	Temperature	pH	Volume
X	Y	?	?

Figure 3.12 represents the diagram for the supervised machine learning. The features of temperature and time, and labels of pH and volume, are used as the

training dataset for the machine learning. These values are the pre-determined and accurate values. After training the model, test dataset are now used. The system in deployment stage is used to test its learning process. This time, the model predicts the expected label (output). The obtained label from testing are now compared with the history of model to determine the error and adjust the accuracy of model. The training and test dataset are shown in Tables 3.1 and 3.2, Machine Learning Algorithm is used to develop the predictive model. Time Series Forecasting Modeling provides the forecast of future values from the given previous data. Autoregressive Integrated Moving Average (ARIMA) model is a class of statistical model for analyzing and forecasting time series data. Python is used for building the algorithm and the other parts of system.

3.2.1.4.1 Regression

Regression is a statistical method which identify and describes the relationship between given variables. The identification is labeled by dependent and independent variables. It is described by the formula below

$$Y = f(X, \beta)$$

Where Y is the dependent variable, X as the independent variable and β as the parameter to be identified.

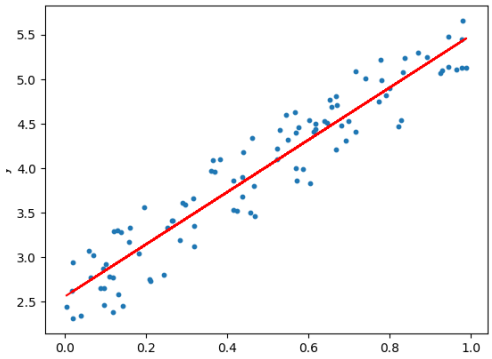


Figure 3.13: Regression

Regression models predict the result form the two given variables. Linear regression is widely used for predictive model to identify the relationship among the variables. It is described in equation below,

$$\boldsymbol{Y = x\beta + \varepsilon}$$

Where Y is the is the independent variable that can be continuous or categorical value , x which is always a continuous variable is the dependent variable. It is done using multivariate analysis which main focused on conditional probability distribution

3.2.1.5 Container Design

Figure 3.14: Actual Coco-sap Container

The figure shows the actual container of the coconut sap as well as the placement of the pH and volume sensors respectively. Tube no.1 is connected directly to the spadix of the tree and uses plastic ties to connect tube no.2 where the ultrasonic sensor is located. The container used for the gathering of the sap is hooked to tube no. 2 while another screw hook guides the connecting wires to the transmitter device.

3.2.2 Chassis Design

Ultrasonic Sensor

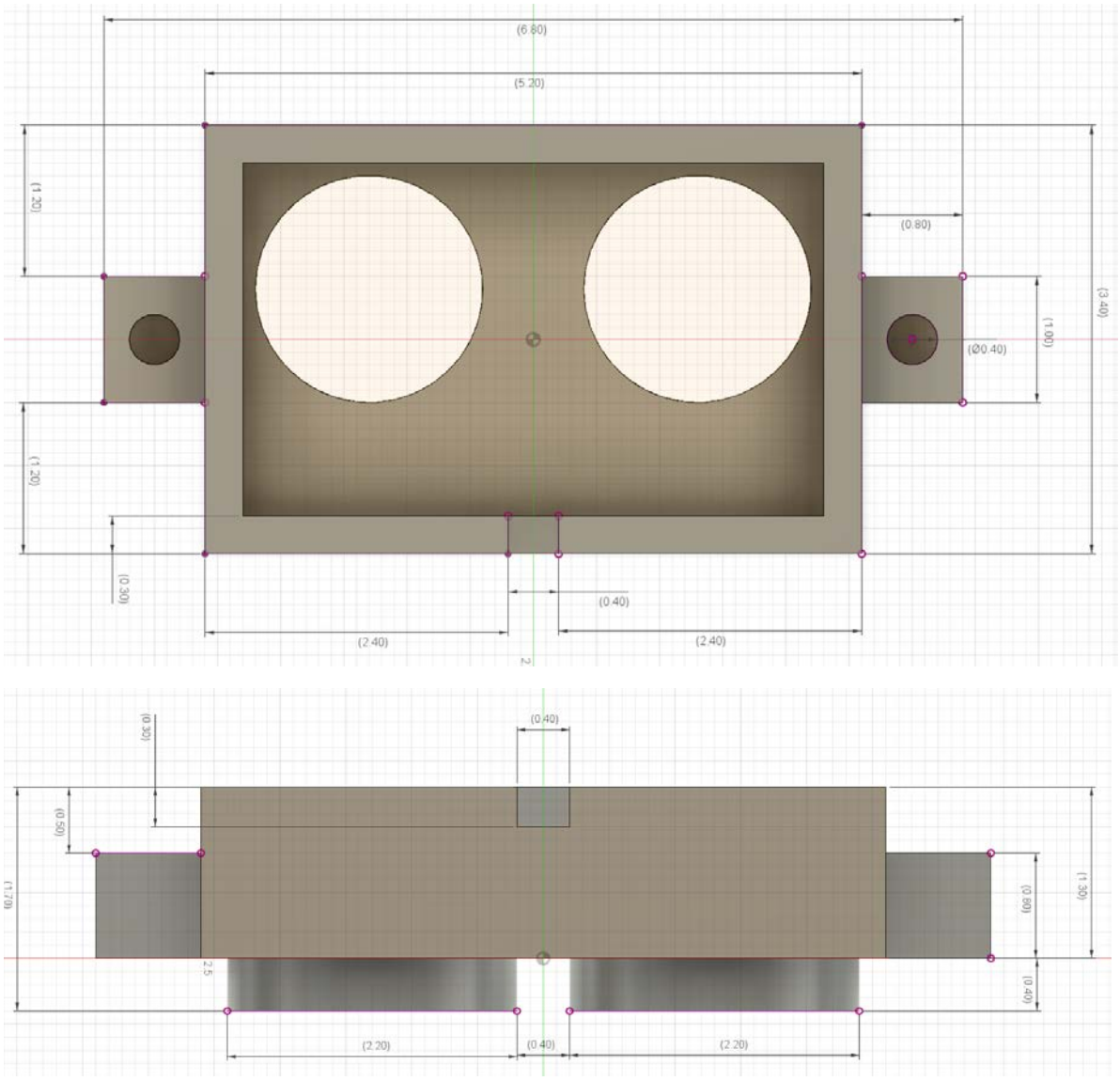


Figure 3.15: Ultrasonic Sensor Chassis 3D Design

The figure above shows the top view and side view of the designed ultrasonic sensor case using Autodesk Fusion 360.

Transmitter

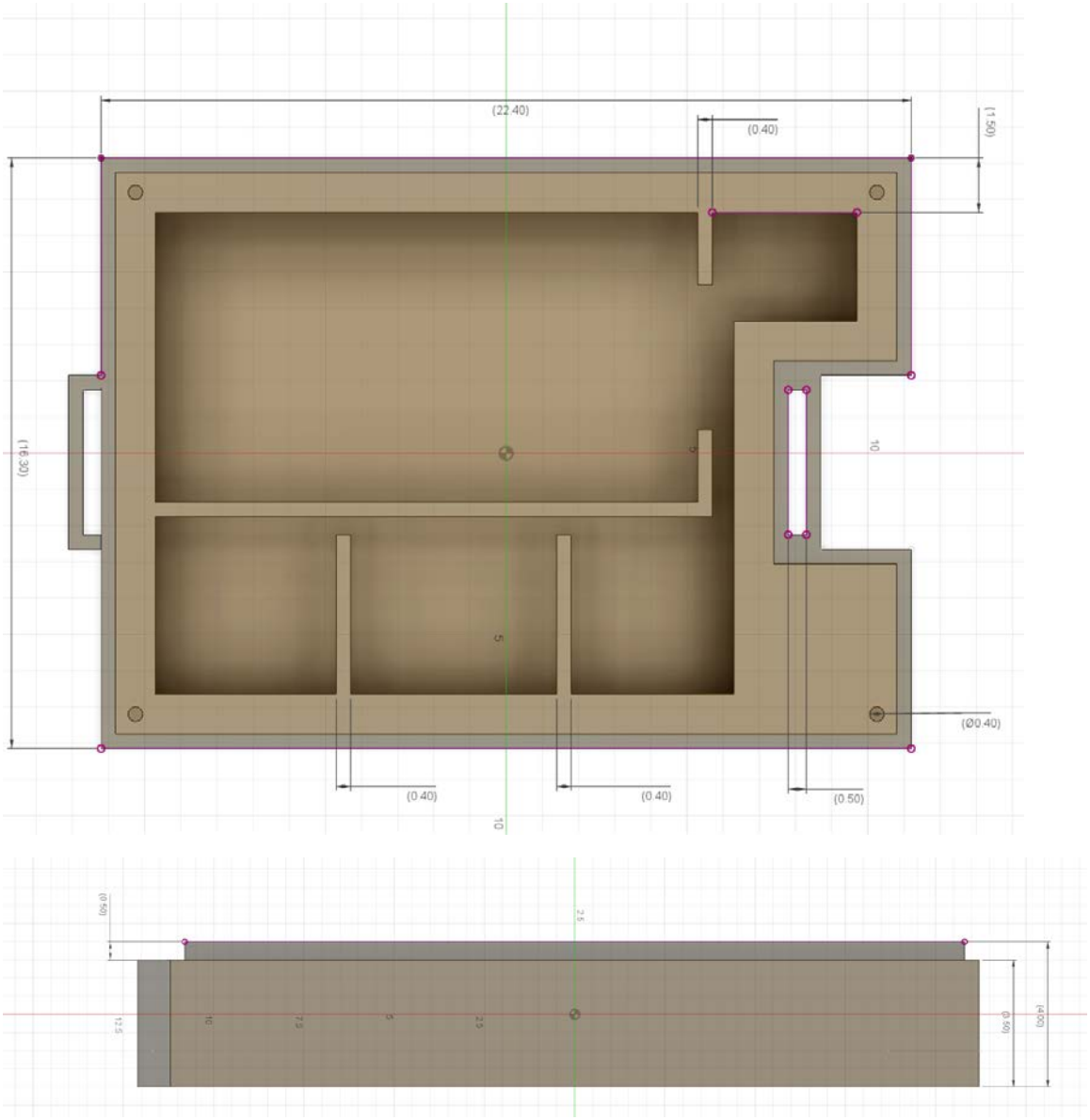


Figure 3.16: Transmitter Chassis 3D Design

Figure 3.16 shows the top view and side view of the designed transmitter chassis with dimensions using Autodesk Fusion 360.

Receiver

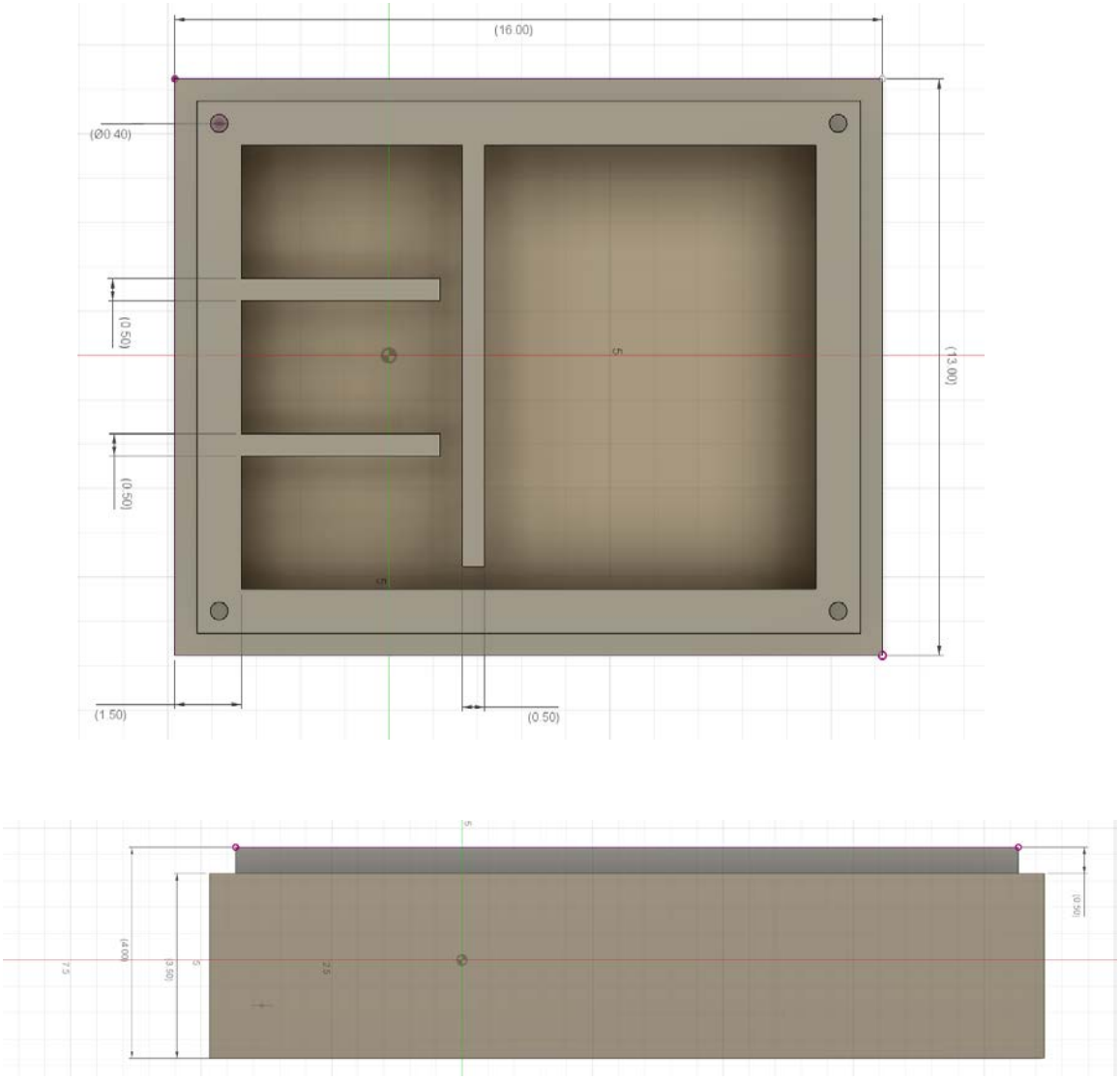


Figure 3.17: Receiver Chassis 3D Design

Illustrated above was the top view and side view of the designed receiver chassis with dimensions using Autodesk Fusion 360.

3.2.3 Block Diagram

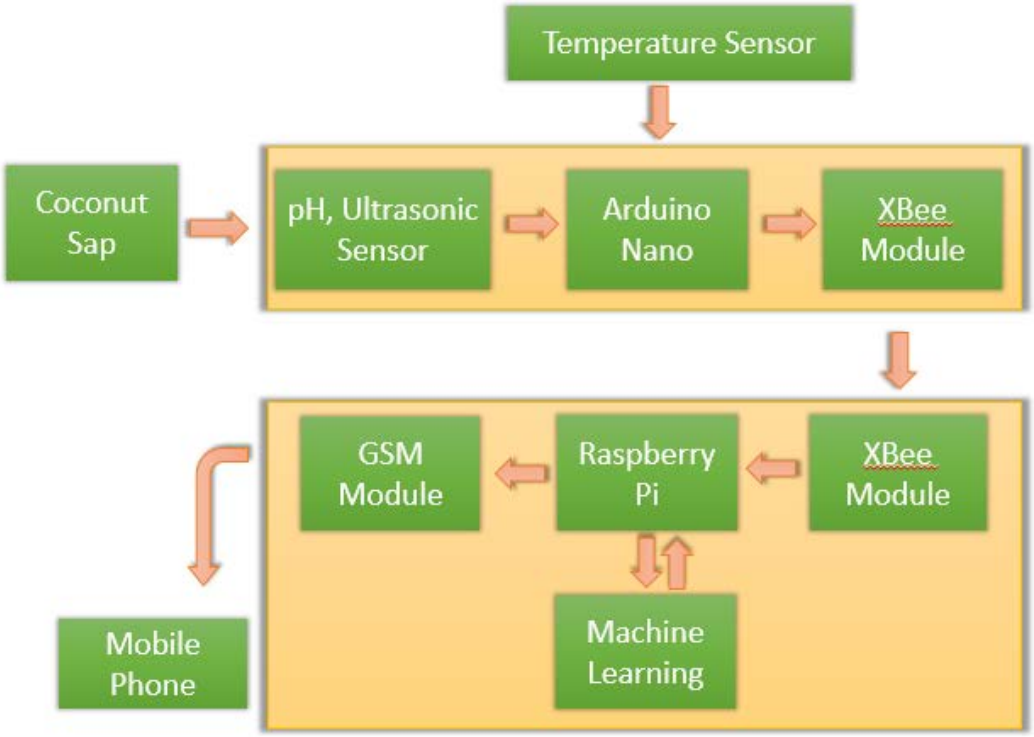


Figure 3.18 Block Diagram of the System

In the block diagram shown above, the coconut sap is the input of the system. The sensors determine the pH level, and volume of the sap as well as the temperature of the surroundings. It then sends an analog signal to the Arduino and converts the signal to a digital data sent to the server using XBee module. The server receives the data by an XBee Module while the Raspberry Pi interprets the data for machine learning, and send a command to the GSM Module for notification. The mobile phone receives a text message when the specific tree is ready for harvesting.

3.2.4 Wireless Sensor Network Architecture

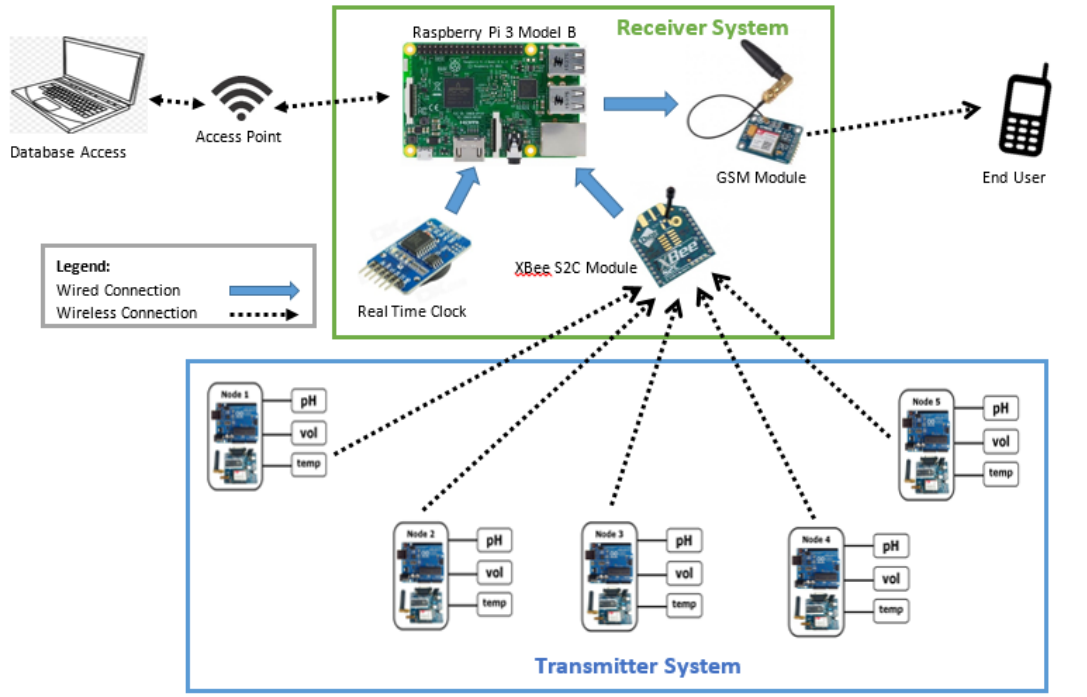


Figure 3.19 WSN Architecture of the System

In figure 3.16, shows the five (5) end devices each attached in the trees are connected to the receiver through a wireless network.

3.3 Programming

3.3.1 Arduino Nano

The Arduino NANO board is programmed using Arduino IDE. Arduino NANO is the microcontroller for the transmitter system; transmitter system converts the analog signal from the pH and level sensors to a digital signal and transmits the data to the server using the XBee module.

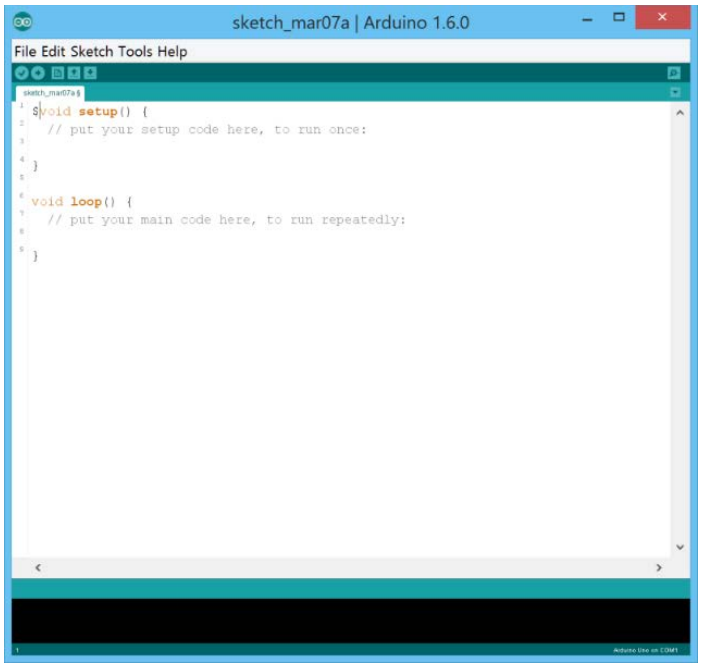


Figure 3.20: Arduino IDE

3.3.2 Raspberry Pi

The Raspberry Pi 3 programs are coded using Python IDE. It is the best suitable programming language for machine learning and it is the official programming language of Raspberry Pi 3.

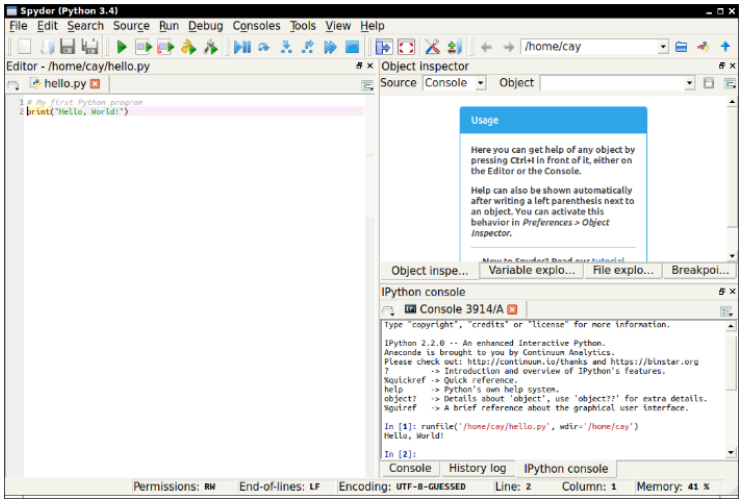


Figure 3.21: Python IDE

The Raspberry Pi receives the data through XBee signals and use the data for interpretation and machine learning.

3.4 Sensor Calibration

Figure 3.22: pH sensor calibration

As illustrated above, DFRobot SEN0169 Industrial pH sensor was used which was calibrated using buffer solutions with pH 4, and 7. Its functionality and accuracy was tested and compared with a pH meter.

Table 3.3: pH sensor calibration data

Buffer Solution pH level	pH sensor measurement	Voltage
4	4.1	1.13
7	7.11	1.99

Table 3.4 shows the data of the pH sensor when calibrated with pH 4 and 7. Two-point calibration is done since the pH level of the sap is starting from pH level of 8 downwards.

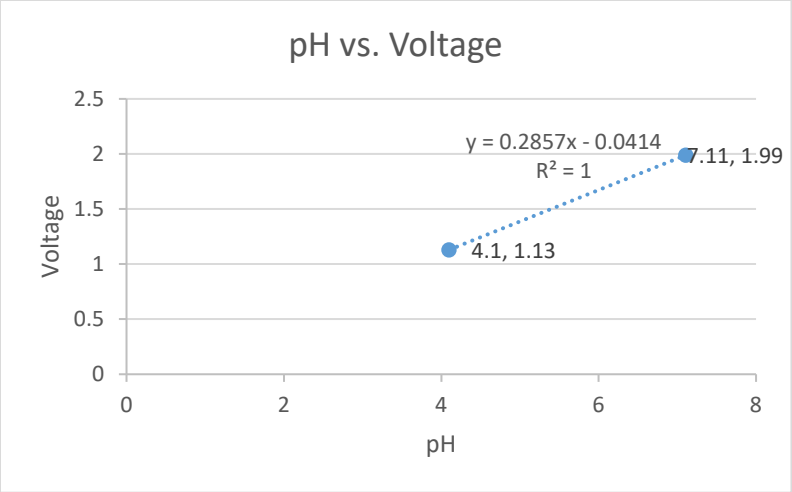


Figure 3.23: pH sensor sensitivity

The figure above shows the fitting linear curve of the pH sensor calibration.

3.5 Operation

The project was designed to remotely monitor the pH and volume of the coconut sap and the surrounding temperature. The device gets its power through powerbank. Without visiting the coconut tree, the farmer is notified if the sap is ready to harvest by SMS notification sent to his phone. The data in each tree (where the device has been deployed) are recorded in the database.

3.5.1 Testing Procedure

3.5.1.1 Sampling Technique

Five (5) devices were produced for the study, each device installed in the coconut tree would monitor the coconut sap harvesting of the farmers, which happens four (4) times a day. The said devices are deployed at the same day for the first five (5) trees after one cycle the devices are installed to another set of trees for the second part of the data gathering. This procedure is done six times in

order to cover thirty (30) trees for the testing of the accuracy, reliability and stability of the device developed.

3.5.1.2 Data Analysis

Table 3.4: Machine Learning Data Results

Time	Temperature	Actual		Predicted Output	
		pH	Volume	pH	Volume

Root-mean-square deviation is used to measure the difference between the values obtained from the predictive model developed and the actual values of the three parameters, by comparing the data given, the accuracy is measured. The data gathered is tabulated as shown in the table above.

3.5.2 Client Evaluation

The project was set up in the Alabat, Quezon and be assessed by the farmers residing in the area. Figure 3.18 shows the evaluation form containing satisfaction criteria. The evaluation form assess different criteria as follows:

- Efficiency - measures if the device is effective with respect to its output
- Functionality – criteria that measures if the device serve its purpose
- Stability – measures the device ability to stand any weather conditions
- User – friendly – criteria to test the device's ease of use

- Aesthetics – criteria to measure the device appearance for the user

Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and ZigBee Network

SURVEY FORM

Pangalan:_____ Petsa:_____

Itiman ang bilog ng bilang ayon sa antas ng kasiyahan.
5 bilang pinakamataas at 1 ang pinakamababa.

	1	2	3	4	5
Kahusayan (Efficiency)					
• Nakakakuha ng magandang kalidad ng cocosap ang debays	○	○	○	○	○
• Ang paalala sa pagkuha ng Cocosap ay nasa tamang oras	○	○	○	○	○
Kapakinabangan (Functionality)					
• Mas maraming nakokolektang cocosap sa tulong ng debays	○	○	○	○	○
• Tamang sukat ng dami nang nakokolektang cocosap	○	○	○	○	○
• Walang nasasayang na cocosap sa paggamit ng debays	○	○	○	○	○
Katatagan (Stability)					
• Ang debays ay kayang tagalan ang anumang uri ng panahon	○	○	○	○	○
• Ang debays ay tuloy-tuloy sa paggana	○	○	○	○	○
Kadalian sa Paggamit (User –Friendly)					
• Ang debays ay madaling gamitin	○	○	○	○	○
• Ang mga instraksyon sa paggamit ng debays ay medaling intindihin	○	○	○	○	○
Panlabas na Kaanyuan (Aesthetics)					
• Ang debays ay may kaaya-ayang pisikal na itsura	○	○	○	○	○
• Ang mga parte ng debays ay nasa tamang ayos at pagkasalansan	○	○	○	○	○

KABUUANG RAYTING

1	2	3	4	5
○	○	○	○	○

KOMENTS/SUHESTYON

_____

_____

Figure 3.24: Client Survey Form

3.6 Gantt Chart

The following table summarizes the activities of the group on a monthly basis. These serves as the schedule for the development of the project.

Table 3.5: Activities from April to March 2019

Activities	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Lecture and Research												
Project Topic Proposal												
Topic Defense												
Research on RRL												
Drafting of Chapters 1 and 2												
Title Defense												
Drafting of Chapter 3												
Project Proposal Submission												
Canvassing of Materials												
Purchasing of Materials												

Prototyping Sensor and Transmitter												
Progress Defense												
Prototyping the Receiver												
Programming												
Data Gathering												
Pre- Final Defense												
Trouble-shooting and Revising of Program and Prototype												
Deployment												
Data Gathering of Device												
Drafting Chapters 1 to 5												
Final Defense												
Finalization of Paper												
Book Submission												

Chapter 4

RESULTS AND DISCUSSION

This chapter presents the projects technical description, project structure, interpretation of data, and analysis of findings relative to the tests conducted.

4.1 Project Technical Description

The system is composed of two major parts: the hardware development and the software development. Consequently, the hardware developed is comprised of two parts namely the transmitter system, and the receiver system. It monitors the critical parameters in coco-sap harvesting which are the pH level, volume, and the ambient temperature. In addition, the system alerts the farmer when the container is full, the sap is about to ferment, the sap has fermented, and the saps predicted time of harvest. An Arduino microcontroller operated the transmitter system where analog sensor data were converted to digital data. Meanwhile, Raspberry Pi was used by the receiver system for predictive model and data storage, as well as to command text message alerts.

The software developed through machine learning and Python programming was a predictive model of the yield of the coconut sap depending on the initial pH level, volume, and ambient temperature. By means of Time Series Forecasting, specifically ARIMA model an optimized coco-sugar harvesting scheduled was produced to increase good quality sap harvest.

4.2 Project Structural Organization

4.2.1 Transmitter System

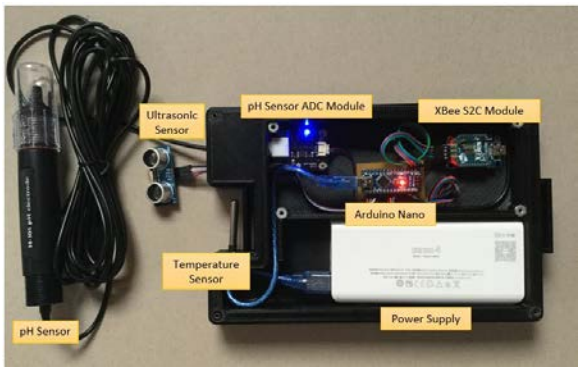


Figure 4.1: Transmitter System

The developed transmitter system composed of pH sensor, ultrasonic sensor, temperature sensor, power supply, Arduino Nano, and XBee module enclosed in the pre-made chassis is shown in the figure above. pH sensor and temperature sensor were waterproof while a water resistant enclosure was fabricated for the ultrasonic sensor.

4.2.2 Receiver System

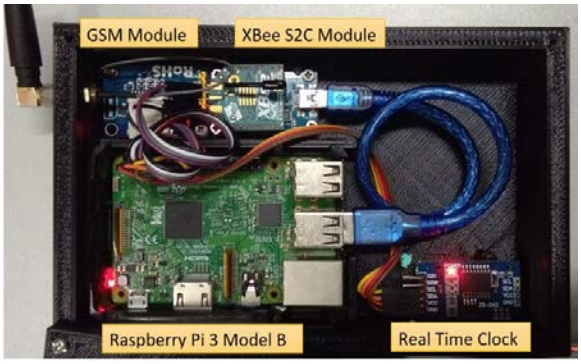


Figure 4.2: Receiver System

Figure 4.2 shows the developed receiver system comprised of a Raspberry Pi, Real Time Clock, GSM module, and XBee module. All the recorded data were

stored in the Raspberry Pi database for further use. An AC to DC adapter was used as the power source.

4.2.3 GSM Alerting System

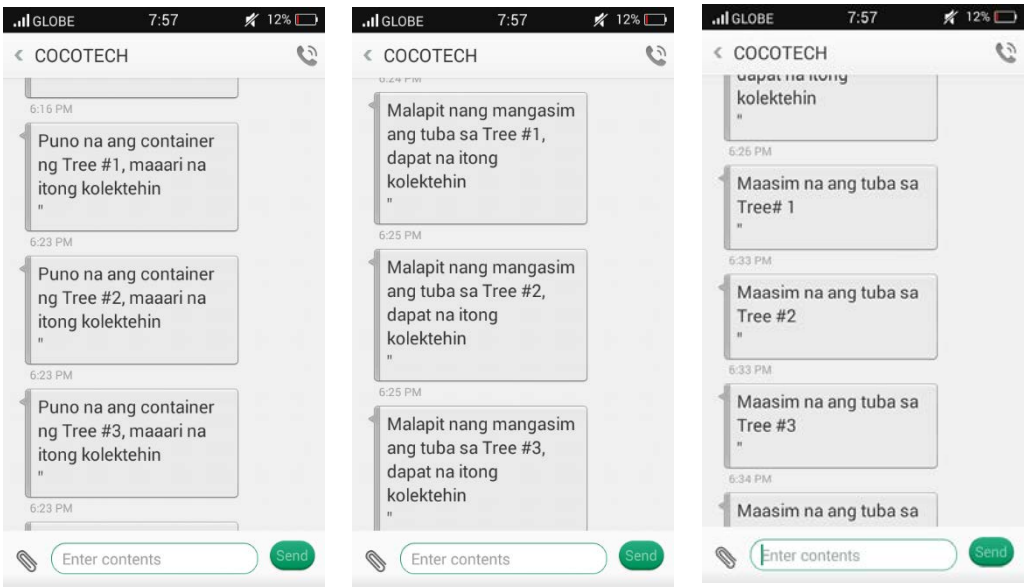


Figure 4.3: SMS Alerts

Figure 4.3 shows the text message alerts sent to farmers during the deployment of the device at Ms. Loza's Farm when the container is full, when the sap is about to ferment, and when the sap has fermented.

4.3 Project Limitations and Capabilities

The system monitors the pH level and volume of the sap, and the ambient temperature. It also alerts the farmer via text message regarding coco-sap harvest information. Thus, harvesting is done manually.

4.4 Project Evaluation

The efficiency, functionality, and reliability of the system was evaluated through the testing, deployment, and data gathering of the device at several coconut sugar producer farms.

4.4.1 Data Gathering

The data gathering was made possible in collaboration with the Philippine Coconut Authority and the Local Government of Alabat Island, Quezon Province. Ms. Mylene L. Culing, the local PCA-CCD Officer, guided the proponents to farm visits and device installation.

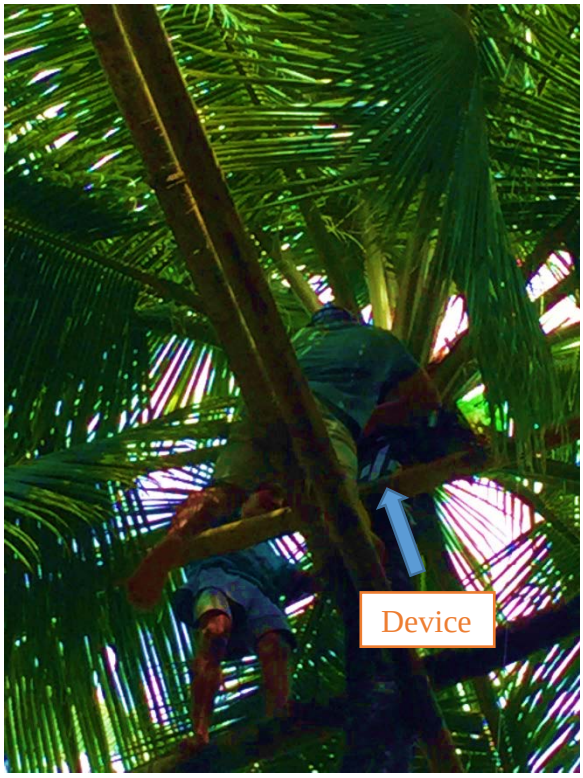


Figure 4.4: Coconut Farmers installing the transmitter to the coconut tree

The farmers were oriented on how to properly install the device to the coconut trees. The farmer climbs up the tree, while the device was elevated by a pulley system used to change the sap container locally known as “tukil” in harvesting. The device was secured to the tree by a belt and the sensor wirings were safely lined through the body of the tree to prevent the farmer from tripping. The sap gatherers were also taught on how the device is functioning, the proper cleansing of the pH meter every harvest, and the replacement of transmitter power supply every three (3) days.

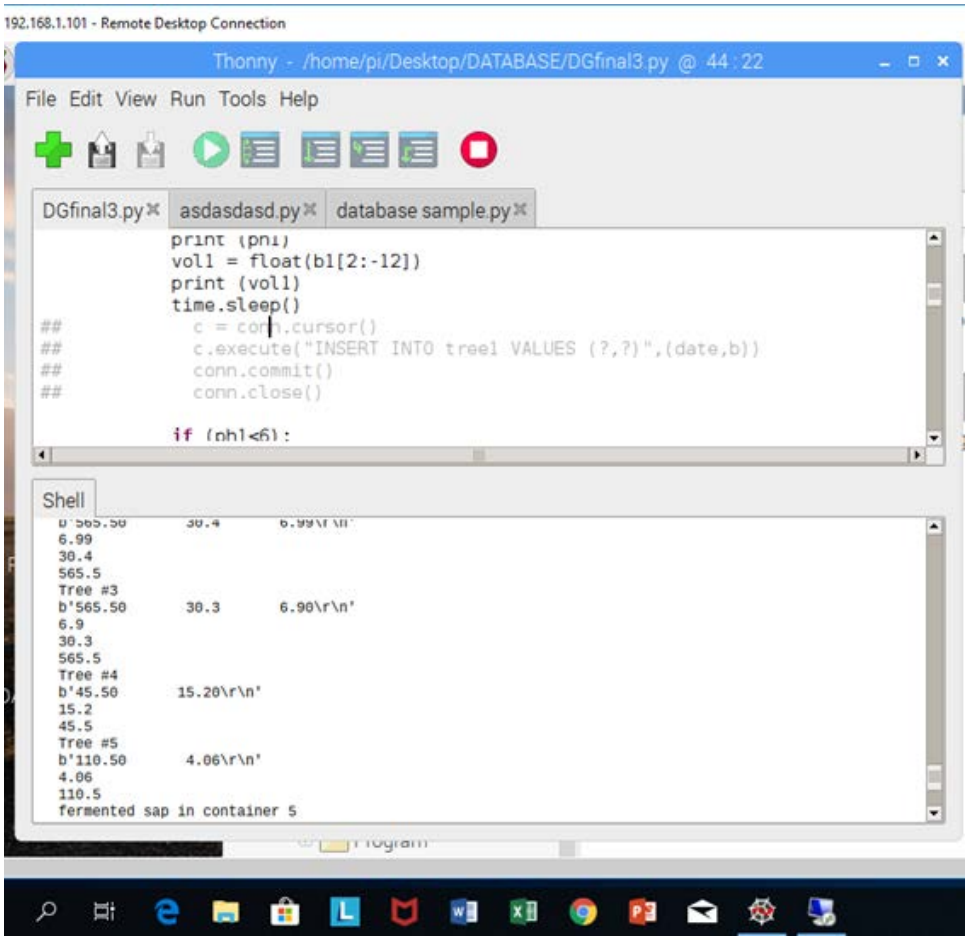


Figure 4.5: Received sensor readings stored at raspberry pi

Once the entire five transmitter were installed, the receiver system was powered on receiving all the sensor readings of each tree with an interval of three minutes. The illustration above is the actual transmitted data during one of our deployment these data were stored to the created raspberry pi database.

Figure 4.6: Verification of sensor data every harvesting period

Table 4.1: Comparison of Sensor Data and Manual Reading

	pH Sensor	Ultrasonic Sensor	pH Meter	Plastic Beaker
Tree 1	6.6	248 mL	6.5	245 mL
Tree 2	4.6	309 mL	4.6	300 mL
Tree 3	5.3	277 mL	5.2	275 mL
Tree 4	5.8	277 mL	5.9	270 mL
Tree 5	6.8	329 mL	6.8	325 mL

Figure 4.6 shows the manual measurement of the volume and pH level of the sap using plastic beaker and pH meter respectively. The measurements were done right after the farmer brought down the container using a pulley, data obtained were recorded and compared to sensor readings. Table 4.1 shows the data obtained from the sensor readings

and manual measurement. The compared readings of the sensors and the manual measurement were almost the same.

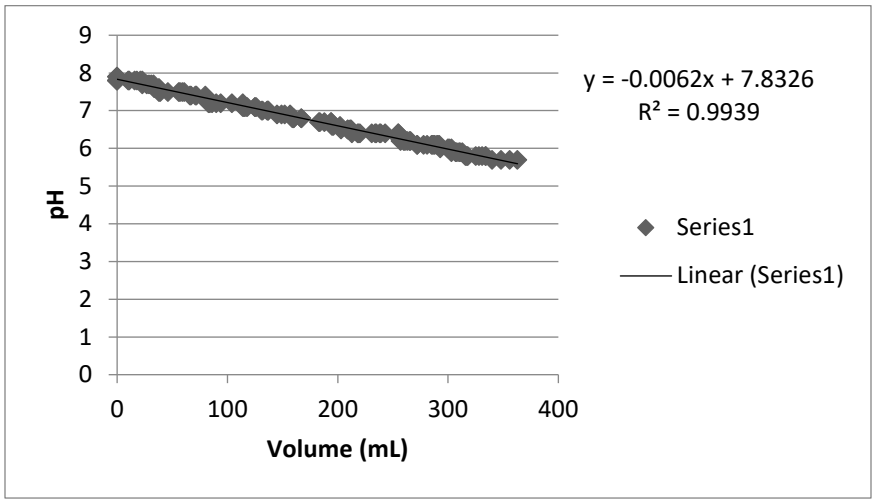
4.4.2 Predictive Model Training

To established a predictive model, a set of data is needed which will be used as the training data for the model. The training data was obtained through deployment of the device which comprises of the following critical parameters of coconut sap namely: pH, volume and ambient temperature. The data was obtained from 30 coconut trees from the deployment of the device.

Table 4.2: Sample of database

Date	Time	Volume (mL)	Temperature (˚C)	pH
9/22/2018	52:31.0	75.5	26.7	6.79
	01:34.4	68.7	26.7	6.78
	04:34.6	75.5	26.7	6.78
	07:34.7	78.9	26.7	6.78
	10:34.8	78.9	26.7	6.78
	13:34.9	72.1	26.7	6.79
	16:35.1	78.9	26.6	6.78
	19:35.2	82.2	26.7	6.78
	22:35.3	109.3	26.7	6.79
	25:35.4	102.5	26.7	6.79
	28:35.6	83.4	26.7	6.79
	31:35.7	84.5	26.6	6.79
	34:35.8	85.6	26.6	6.79
	37:35.9	78.9	26.6	6.79
	40:36.1	86.8	26.6	6.78
	43:36.2	85.6	26.6	6.78
	46:36.3	85.6	26.6	6.79
	49:38.0	80	26.6	6.79

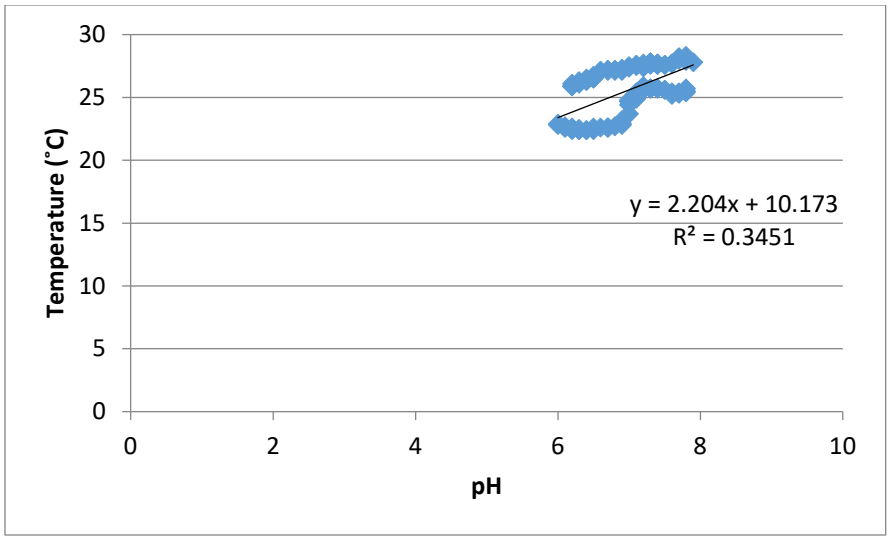
Table 4.3 shows the acquired database during the data gathering. The sample were obtained from 30 coconut trees following the minimum number of samples for training of data. Each table represents one transmitter which after completing a whole cycle (24 hours) will be transferred to another tree.



	VOLUME	*PH*
VOLUME	1	
PH	-0.99696	1

Figure 4.7 Relationship between pH and volume

Figure 4.7 shows the relationship of two parameters; pH and volume. Correlation is done to identify the relationship between the two parameters. The correlation shows -0.99696 which implies a negative correlation wherein as the volume increases, the pH decreases.



	PH	*TEMPERATURE*
PH	1	
TEMPERATURE	0.587487	1

Figure 4.8 Relationship between temperature and pH

Figure 4.8 shows the correlation of temperature with the sap fermentation. A positive correlation represents a relationship between two variables. It means that as the temperature increases so as the pH.

Table 4.3: Summary of gathered data for a week

	11 A.M. - 4:30 P.M.		4:30 P.M. - 11:00 P.M.		11:00 P.M. - 6:00 A.M.		6:00 A.M. - 11:00 A.M.	
	Volume	pH	Volume	pH	Volume	pH	Volume	pH
1	160	7.8	347	6.5	248	6.6	167	5.9
2	188	6.4	257	6.4	260	4.5	180	6
3	269	7.4	307	4.7	285	5.5	320	5.9
4	149	7.8	349	5.8	309	4.6	208	6.3
5	149	5.8	202	5.8	198	6.1	169	5.6
6	218	5.3	190	4.7	170	4.1	149	5.9
7	163	6	318	5.3	277	5.3	178	6.5

Table 4.3 shows the summary of the data gathered specifically the saps' volume and pH level per harvest time for the seven days testing of the device in Alabat, Quezon.

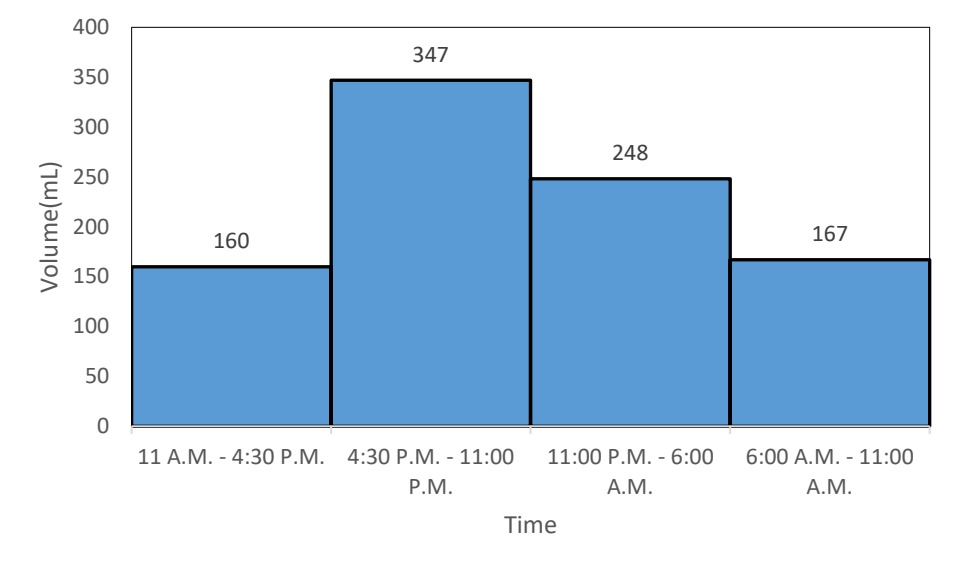


Figure 4.9 Volume in one cycle (24 hours)

Figure 4.9 show a bar graph of data for every harvest in one cycle(24hours). It shows that during the time of 4:30 PM -11:00PM, the highest yield is achieved which is 347 mL. While during daytime, from 11AM – 4:30PM, the lowest yield is gathered by 160 mL.

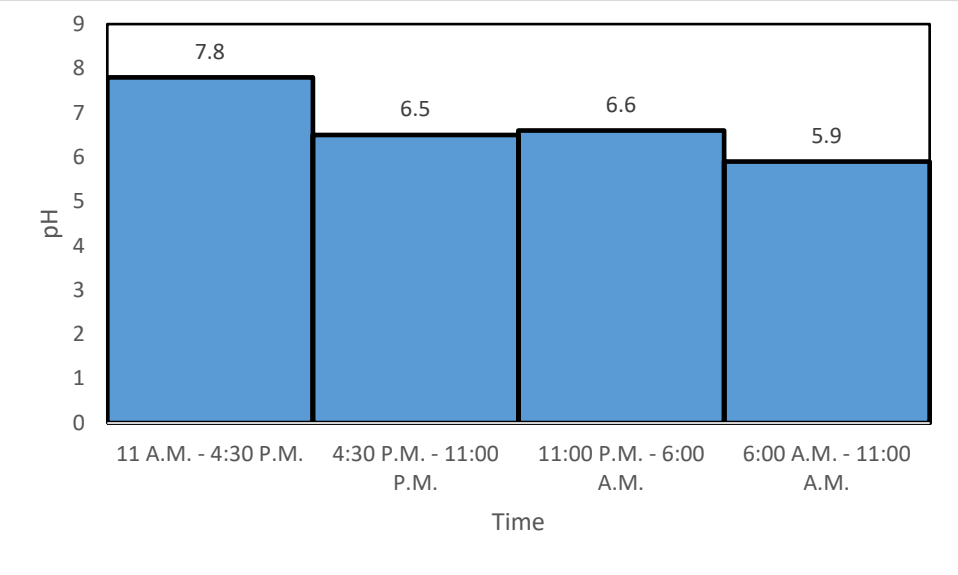


Figure 4.10 pH in one cycle (24 hours)

Figure 4.10 shows bar graph of the data acquired of pH sensor for one cycle or 24 hours. It can be observed that the coconut sap harvested during the period falls on the ideal pH for coconut sap which is pH≥6.

Table 4.4 Predicted values of volume,pH and temperature

		TIME	VOLUME	PH	TEMPERATURE	PREDICTED VOLUME	PREDICTED PH
0	11/9/2018	16:32:00	0	8	26.2	0	7.9
1	11/9/2018	16:35:00	0	8	28.7	0	7.9
2	11/9/2018	16:38:00	0	8	28.6	0	7.9
3	11/9/2018	16:41:00	0	8	28.9	0	7.9
4	11/9/2018	16:44:00	0	8	25.9	0	7.9
5	11/9/2018	16:47:00	10	8	29.2	11	7.9
6	11/9/2018	16:50:00	11	8	28.8	12	7.9
….		…	…	…	…	…	
1430	11/12/2018	16:02:00	300	6	24.7	174	6
1431	11/12/2018	16:05:00	308	5.9	24.7	175	6
1432	11/12/2018	16:08:00	311	5.9	24.7	178	6
1433	11/12/2018	16:11:00	314	5.9	24.7	180	6
1434	11/12/2018	16:14:00	314	5.9	24.7	181	6
1435	11/12/2018	16:17:00	319	5.9	24.8	181	6
1436	11/12/2018	16:20:00	320	5.9	24.7	182	6

Table 4.4 shows the result of the designed predictive model were it shows under the column of PREDICTED VOLUME and PREDICTED PH values which then used for GSM notification system. The training data are the TIME, VOLUME, PH and TEMPERATURE which were obtained through data gathering.

4.4.3 Accuracy Test

To test the accuracy of predictive model, Linear Regression was used by means of R squared. The R- Squared test was done differently for the pH and volume parameter.

Table 4.5 Linear Regression Results

Dep. Variable	**PH**	**R-squared**	**0.897**
Model	LS	Adj. R-squared	0.897
Method	Least Squares	F-statistic	1920
No. of Observations	1437	Prob(F-statistic)	6.11E-267
Df Residuals	1437	AIC	2050
Covariance Type	nonrobust	BIC	2061

Dep. Variable	**VOL**	**R-squared**	**0.857**
Model	LS	Adj. R-squared	0.857
Method	Least Squares	F-statistic	2823
No. of Observations	1437	Prob(F-statistic)	6.11E-267
Df Residuals	1437	AIC	1.52E+04
Covariance Type	nonrobust	BIC	1.52E+04

By dividing the data gathered from training data to test data, thorugh Linear Regression where the data were fitted to create a predictive model, the above figure shows the result of Linear Regression by showing different characteristic and values from the model. For the volume, the obtained R-squared is 0.857 or equivalent to 86% while for the prediction of pH , the obtained R-squared is 0.897 or 90%.

4.4.4 New Harvest Schedule

From the predictive model, a new harvest schedule was acquired which are 7AM, 12PM, 4PM and 12AM. It can be observes that a shorter interval during daytime while during nightime, a longer interval.

Table 4.6 Previous and New Harvesting Schedule

Previous Collection Schedule	New Collection Schedule
6 AM – 11AM	7AM – 12 NN
11AM – 4:30 PM	12NN – 4 PM
4:30 PM – 11PM	4PM – 12 AM
11PM – 6AM	12AM – 7 AM

The new harvest schedule was able to increase the yield and quality of coconut sap produced. The table below shows the comparison between the previous and new harvest schedule.

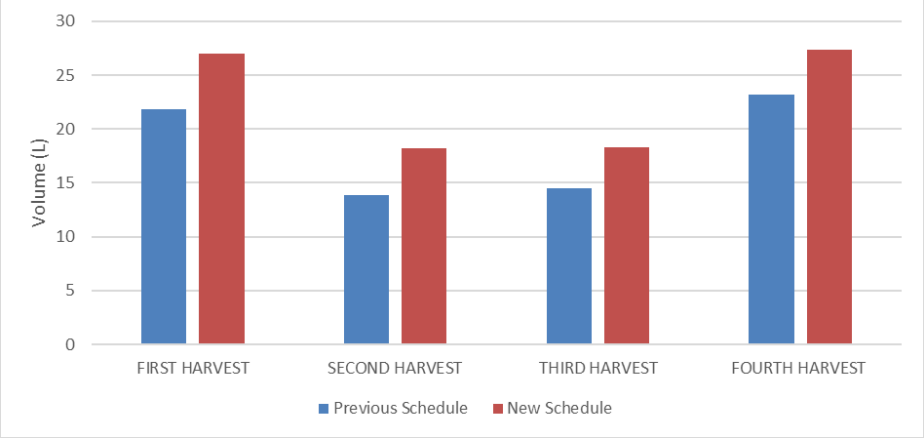


Figure 4.11 Comparison of yield between two schedule

Figure 4.11 shows the comparison of the average yield of harvested coco-sap using the previous and new schedule. The data was computed by getting the average of the harvested sap for one week for each schedule. An increase was visible by the time the new schedule was implemented.

Table 4.7 Income Generation Between Two Schedules for a week

	Syrup (L)	Coco-sugar (kg) 1 L = 0.8kg	Income 1kg = P300.00
Traditional Method	38	30.4	P9,120.00
CocoTech Device	69	55.2	P16,560.00
Difference	69 – 38 = 31	24.8	P7,440.00
81.57% increase			

The efficiency of the new harvest schedule can be seen from Table 4.7. The latter table shows the income generation difference obtained from the previous schedule and the new harvest schedule. A 81.57% increase was achieved using the new harvest schedule.

Table 4.8 Cost Analysis of the device

Total Amount of Prototype per tree:		
For Transmitter:	**P 8416,00**	
For Receiver	P3,500.00	
	/ 5(units)	
	P700.00	
	P8416.00	
	+ P700.00	
	P9,116.00	**per tree**
8L of coconut sap : 1kg of coconut sugar		
84.555L /n = 8/1	n = 8.45555	
Price of coconut sugar	**P300.00**	
	8.45555	
	x P300.00	
	2,536.67	

		9,116.00
	x	30(units)
		273480
	÷	2536.67
		107.8106336
ROI(Return of Investment)		**107.81**
		365 days/107.81
		3.38 (3 and half months)

From Table 4.8, a cost analysis was computed to further show the impact of the created schedule on the coconut sugar production. The cost analysis is to identify the time for the investment using the device to return and earn revenue.

4.4.5 Test Run of the Coco-sap Harvesting System

Figure 4.12: System set-up for test run

Illustrated above was the set-up of the transmitter system during the test run conducted in order to evaluate the functionality of the monitoring and alerting system. It was tested for a day within four (4) harvest, this was done to familiarize the farmer to the device as well.

4.4.6 Technical Evaluation

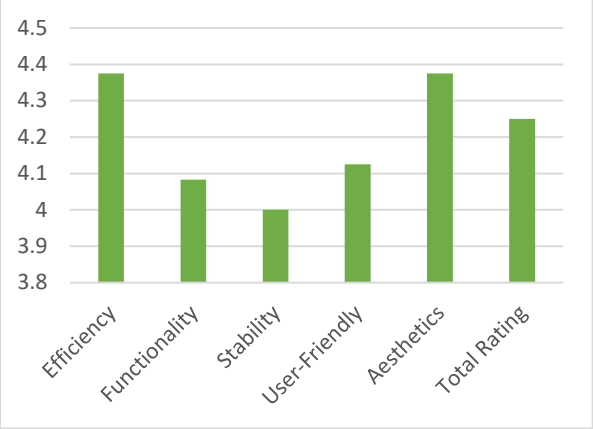


Figure 4.13: Technical Evaluation of Device

Figure 4.13 shows the overall technical evaluation of the four respondents who have used the device in Alabat, Quezon. From the graph efficiency and aesthetics has the highest rating of 4.375, followed by the devices' user-friendliness with a rating of 4.125, functionality and stability has a rating of 4.083 and 4 respectively.

Table 4.9: Tabulated data of survey results

	Farmer 1	Farmer 2	PCA Officer	Coco-syrup Cook	Mean	Overall
Efficiency	4	4	5	4	4.25	**4.375**
	3	5	5	5	4.5	
Functionality	4	4	5	3	4	**4.083**
	4	4	5	4	4.25	
	2	4	5	5	4	
Stability	1	5	5	2	3.25	**4**

	Farmer 1	Farmer 2	PCA Officer	Coco-syrup Cook	Mean	Overall
	5	5	5	4	4.75	
User-Friendly	3	4	4	5	4	**4.125**
	3	5	4	5	4.25	
Aesthetics	2	4	5	5	4	**4.375**
	5	5	5	4	4.75	
Total Rating	3	4	5	5	4.25	**4.25**

The table above shows the evaluation results of the local PCA officer of Alabat, the coconut farmers who have used the device of a week, and the coco-syrup maker of Mr. Janero's farm at Barangay VillaJesus Weste. The device has an overall rating of 4.25, 5 being the highest rating.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings, conclusions, and recommendations relative to the results of the study conducted.

5.1 Summary of Findings

The hardware is composed of two major parts: the transmitter, and receiver system. From the operation of the device during the data gathering, it is known that:

A negative correlation of -0.99696 or an inverse relationship for volume and pH parameter while a positive correlation of 0.587487 or a linear relationship between the temperature and sap fermentation was achieved. The essential parameters that affects the sap fermentation is time and temperature. In which, during daytime, the sap was easily fermented which also results to low quantity of harvested sap. Unlike during nighttime, fermentation of sap takes time, which will result, to greater quantity of harvested sap.

From the predictive model designed, for the parameters volume and pH, a RMSE of 86% and 90% respectively was obtained, it shows the accuracy of the prediction for the said parameters. The new harvest schedule was able to increase the yield of coconut sap by 81.57%.

5.2 Conclusion

In accordance with the data gathered and results of the device deployment, the researchers concluded that:

1. The transmitter system is effective in monitoring the critical sap parameters and in relaying the data to the receiver via wireless transmission. Accurate data were gathered without any loss in transmission.
2. The receiver system was able to give the farmer text message notifications of the sap standing and the predicted harvest time.
3. The device was able to stand different weather conditions without breaking or malfunctioning, the material used for the chassis is suitable for extreme environment changes.
4. The predictive model has been accurate due to the training data obtained by the transmitter, since the produced schedule efficiently increase the sap harvested.
5. A positive correlation of 0.587487 for pH and temperature and negative correlation for pH and volume of -0.99696, the relationship between pH and temperature is proportional due to the nearly constant value of ambient temperature while inversely proportional for volume and pH which is expected.
6. An accuracy of 86% and 90% for volume and pH parameters respectively, the created model was able to achieved an efficient prediction concerning the volume and pH which is an essential parameter for coconut sap production.
7. An increase of 81.57% in the yield of coconut sap implies the efficiency of the created schedule for coconut sap harvesting.

5.3 Recommendation

For further improvement of the study, the researchers recommends the following:

1. To develop a container design maintaining low temperature that will prolong the fermentation process of the sap, especially when the bud is directly facing the sun.
2. To make the tree set up complete wireless from the container to the transmitter to make installment easier and to avoid hindrance to farmers while harvesting.
3. To consider other factors such as humidity and wind intensity as is also affects the quality of the sap according to the farmers and the local PCA officer.
4. To use different types of sensors and different time series analysis that will give a more accurate prediction for an efficient coconut sap harvesting schedule
5. To develop an Android Application or a Web Application that can give easy access to the farm owner, Local Government Unit, Philippine Coconut Authority, and the coconut farmers of the harvesting information.

APPENDIX

APPENDIX A

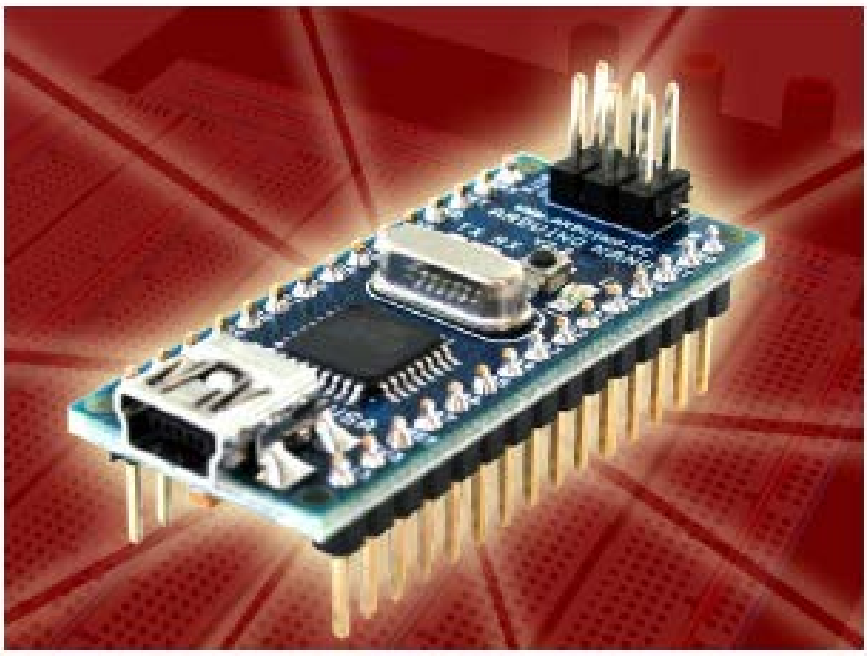
Data Sheets

Appendix A

Data Sheets

Arduino Nano (V2.3)

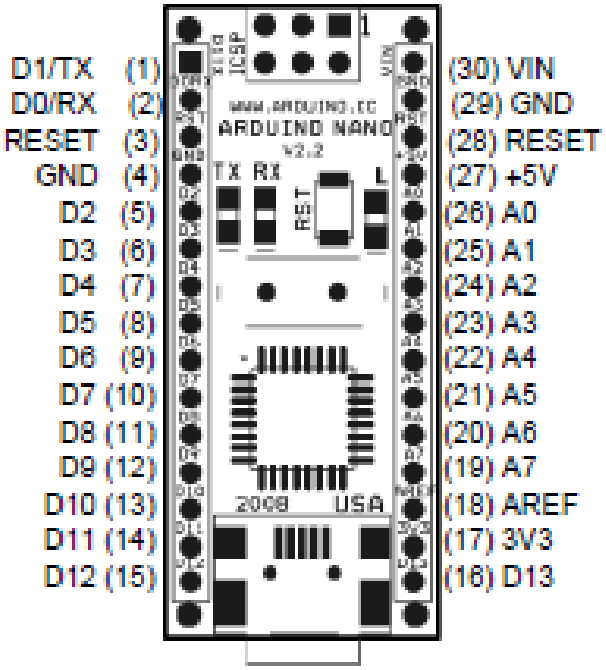
User Manual



More information:

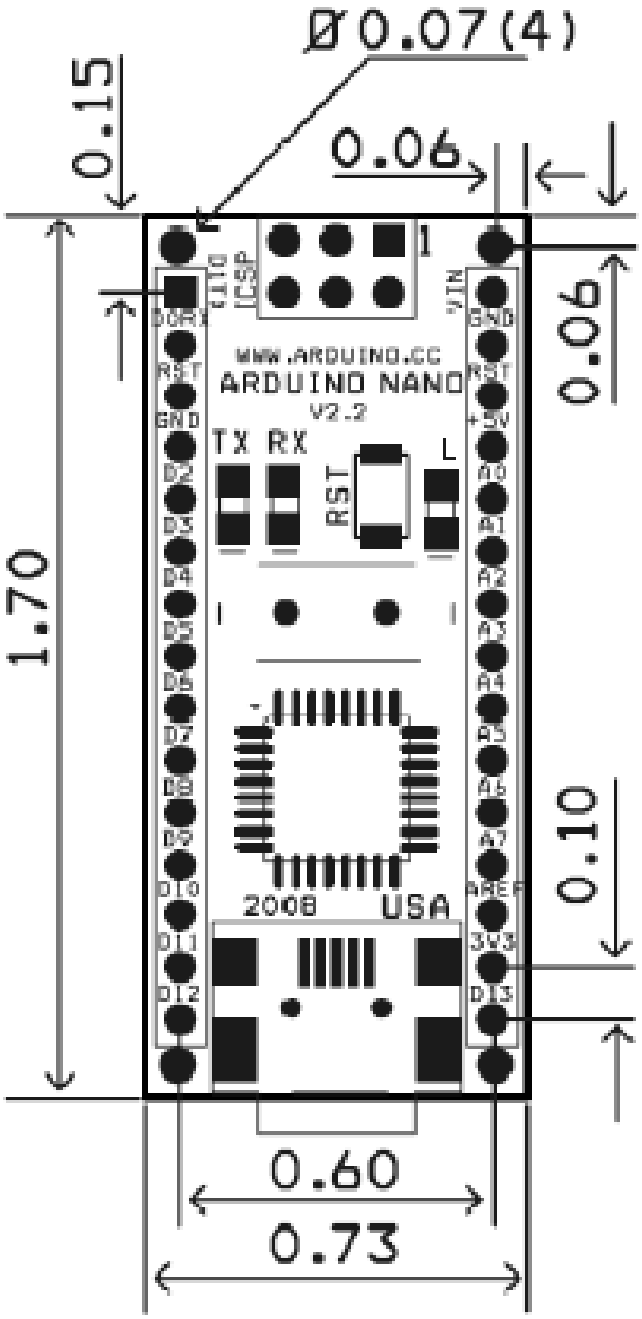
www.arduino.cc Rev. 2.3

Arduino Nano Pin Layout



Pin No.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3, 28	RESET	Input	Reset (active low)
4, 29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A7-A0	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)
30	VIN	PWR	Supply voltage

Arduino Nano Mechanical Drawing



ALL DIMENTIONS ARE IN INCHES

Arduino Nano Specifications:

Microcontroller	Atmel ATmega168 or ATmega328
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limits)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader
SRAM	1 KB (ATmega168) or 2 KB (ATmega328)
EEPROM	512 bytes (ATmega168) or 1 KB (ATmega328)
Clock Speed	16 MHz
Dimensions	0.73" x 1.70"
Length	45 mm
Width	18 mm
Weigth	5 g

Version：1005

GSM/GPRS Module

SIM800L

SIM800L is a complete Quad-band GSM/GPRS solution in a LGA type which can be embedded in the customer applications.

SIM800L support Quad-band 850/900/1800/1900MHz, it can transmit Voice, SMS and data information with low power consumption. With tiny size of 15.8*17.8*2.4 mm, it can fit into slim and compact demands of customer design.

Smart Machine Smart Decision

General features

•Quad-band 850/900/1800/1900MHz
•GPRS multi-slot class 12/10
•GPRS mobile station class B
•Compliant to GSM phase 2/2+
  – Class 4 (2 W @ 850/900 MHz)
  – Class 1 (1 W @ 1800/1900MHz)
•FM: 76~109MHz worldwide bands with 50KHz tuning step
•Dimensions: 15.8*17.8*2.4 mm
•Weight: 1.35g
•Control via AT commands (3GPP TS 27.007, 27.005 and SIMCOM enhanced AT Commands)
•Supply voltage range 3.4 ~ 4.4V
•Low power consumption
•Operation temperature:-40℃ ~85℃

Specifications for GPRS Data

•GPRS class 12: max. 85.6 kbps (downlink/uplink)
•PBCCH support
•Coding schemes CS 1, 2, 3, 4
•PPP-stack
•CSD up to 14.4 kbps
•USSD
•Non transparent mode

Specifications for SMS via GSM/GPRS

•Point to point MO and MT
•SMS cell broadcast
•Text and PDU mode

Software features

•0710 MUX protocol
•Embedded TCP/UDP protocol
•FTP/HTTP
•MMS
•E-MAIL
•DTMF
•Jamming Detection

Specifications for voice

•Tricodec
  – Half rate (HR)
  – Full rate (FR)
  – Enhanced Full rate (EFR)
•AMR
  – Half rate (HR)
  – Full rate (FR)
•Hands-free operation
  （Echo suppression）

Interfaces

88 LGA pads including:
•Analog audio interface
•PCM interface
•RTC backup
•Serial interface
•USB interface
•Interface to external SIM 3V/1.8V
•Keypad interface
•GPIO
•ADC
•GSM Antenna pad
•FM Antenna pad

Compatibility

•AT cellular command interface

Certifications(Plan):

•CE
•GCF
•FCC
•ROHS
•REACH

More about SIMCom SIM800L
Please contact:
Tel: 86-21-32523300
Fax: 86-21-32523301
Email: simcom@sim.com
Website: www.sim.com/wm

DIGI

EMBEDDED RF
MODULES FOR OEMS

DIGI XBEE® S2C 802.15.4 RF MODULES

Low-cost, easy-to-deploy modules provide critical end-point connectivity to devices and sensors

Digi XBee RF modules provide OEMs with a common footprint shared by multiple platforms, including multipoint and ZigBee/Mesh topologies, and both 2.4 GHz and 900 MHz solutions. OEMs deploying the Digi XBee can substitute one Digi XBee for another, depending upon dynamic application needs, with minimal development, reduced risk and shorter time-to-market.

Digi XBee 802.15.4 RF modules are ideal for applications requiring low latency and predictable communication timing. Providing quick, robust communication in point-to-point, peer-to-peer, and multipoint/star configurations, Digi XBee 802.15.4 products enable robust end-point connectivity with ease. Whether deployed as a pure cable replacement for simple serial communication, or as part of a more complex hub-and-spoke network of sensors, Digi XBee 802.15.4 RF modules maximize performance and ease of development.

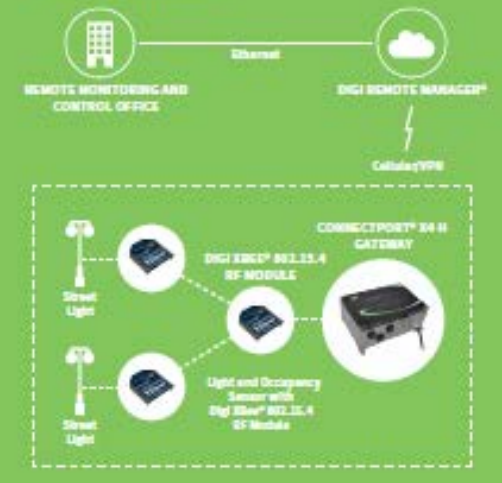
Digi XBee 802.15.4 modules seamlessly interface with compatible gateways, device adapters and range extenders, providing developers with true beyond-the-horizon connectivity.

The updated Digi XBee S2C 802.15.4 module is built with the SiliconLabs EM357 SoC and offers improved power consumption, support for over-the-air firmware updates, and provides an upgrade path to DigiMesh® or ZigBee® mesh protocols if desired.

BENEFITS

- Simple, out-of-the-box RF communications, no configuration needed
- Point-to-multipoint network topology
- 2.4 GHz for worldwide deployment
- Common Digi XBee footprint for a variety of RF modules
- Industry leading sleep current of sub 1uA
- Firmware upgrades via UART, SPI or over the air
- Migratable to DigiMesh and ZigBee PRO protocols and vice-versa

APPLICATION EXAMPLE

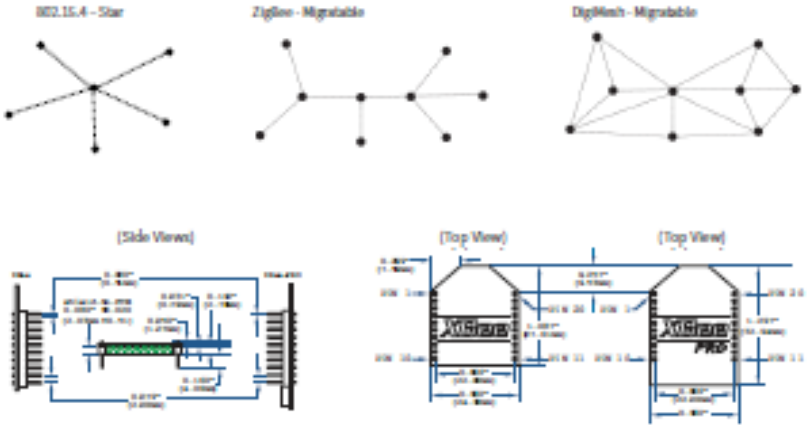


RELATED PRODUCTS

SPECIFICATIONS	Digi XBee® S2C 802.15.4	Digi XBee-PRO® S2C 802.15.4
PERFORMANCE		
TRANSCEIVER CHIPSET	Silicon Labs EM357 SoC	
DATA RATE	RF 250 Kbps, Serial up to 1 Mbps	
INDOOR/URBAN RANGE*	Up to 200 ft (60 m)	Up to 300 ft (90 m)
OUTDOOR/RF LINE-OF-SIGHT RANGE*	Up to 4000 ft (1200 m)	Up to 2 miles (3200 m)
TRANSMIT POWER	3.1 mW (+5 dBm) / 6.3 mW (+8 dBm) boost mode	63 mW (+18 dBm)
RECEIVER SENSITIVITY (1% PER)	-100 dBm / -102 dBm boost mode	-101 dBm
FEATURES		
SERIAL DATA INTERFACE	UART, SPI	
CONFIGURATION METHOD	API or AT commands, local or over-the-air (OTA)	
FREQUENCY BAND	ISM 2.4 GHz	
FORM FACTOR	Through-Hole, Surface Mount	
HARDWARE	S2C	
ADC INPUTS	(4) 10-bit ADC inputs	
DIGITAL I/O	11	
ANTENNA OPTIONS	Through-Hole: PCB Antenna, U.FL Connector, RPSMA Connector, or Integrated Wire SMT: RF Pad, PCB Antenna, or U.FL Connector	
OPERATING TEMPERATURE	-40° C to +85° C	
DIMENSIONS (L X W X H) AND WEIGHT	Through-Hole: 0.960 x 1.087 in (2.438 x 2.761 cm) SMT: 0.866 x 1.33 x 0.120 in (2.199 x 3.4 x 0.305 cm)	Through-Hole: 0.960 x 1.297 in (2.438 x 3.294 cm) SMT: 0.866 x 1.33 x 0.120 in (2.199 x 3.4 x 0.305 cm)
NETWORKING AND SECURITY		
PROTOCOL	Digi XBee 802.15.4 (Proprietary 802.15.4)	
UPDATABLE TO DIGIMESH PROTOCOL	Yes	
UPDATABLE TO ZIGBEE PROTOCOL	Yes	
INTERFERENCE IMMUNITY	DSSS (Direct Sequence Spread Spectrum)	
ENCRYPTION	128-bit AES	
RELIABLE PACKET DELIVERY	Retries/Acknowledgements	
IDS	PAN ID and addresses, cluster IDs and endpoints (optional)	
CHANNELS	16 channels	15 channels
POWER REQUIREMENTS		
SUPPLY VOLTAGE	2.1 to 3.6V	2.7 to 3.6V
TRANSMIT CURRENT	33 mA @ 3.3 VDC / 45 mA boost mode	120 mA @ 3.3 VDC
RECEIVE CURRENT	26 mA @ 3.3 VDC / 31 mA boost mode	31 mA @ 3.3 VDC
POWER-DOWN CURRENT	<1 µA @ 25° C	<1 µA @ 25° C
REGULATORY APPROVALS		
FCC, IC (NORTH AMERICA)	Yes	Yes
ETSI (EUROPE)	Yes	No
RCM (AUSTRALIA AND NEW ZEALAND)	No (Coming soon)	No (Coming soon)
TELEC (JAPAN)	No (Coming soon)	No (Coming soon)

*Range figure estimates are based on free-air terrain with limited sources of interference. Actual range will vary based on transmitting power, orientation of transmitter and receiver, height of transmitting antenna, height of receiving antenna, weather conditions, interference sources in the area, and terrain between receiver and transmitter, including indoor and outdoor structures such as walls, trees, buildings, hills, and mountains.

PART NUMBERS	DESCRIPTION
KIT	
XK2Z-A2T-WWC	Wireless Connectivity Kit with Digi XBee 802.15.4 (S2C)
MODULES	
XB24CAWIT-001	Digi XBee 802.15.4 through-hole module w/ wire antenna
XB24CAPIT-001	Digi XBee 802.15.4 through-hole module w/ PCB antenna
XB24CAUIT-001	Digi XBee 802.15.4 through-hole module w/ U.fl connector
XB24CASIT-001	Digi XBee 802.15.4 through-hole module w/ RPSMA connector
XB24CAPIS-001	Digi XBee 802.15.4 SMT module w/ PCB antenna
XB24CAUIS-001	Digi XBee 802.15.4 SMT module w/ U.fl connector
XB24CARIS-001	Digi XBee 802.15.4 SMT module w/ RF Pad connector
XBP24CAWIT-001	Digi XBee-PRO 802.15.4 through-hole module w/ wire antenna
XBP24CAPIT-001	Digi XBee-PRO 802.15.4 through-hole module w/ PCB antenna
XBP24CAUIT-001	Digi XBee-PRO 802.15.4 through-hole module w/ U.fl connector
XBP24CASIT-001	Digi XBee-PRO 802.15.4 through-hole module w/ RPSMA connector
XBP24CAPIS-001	Digi XBee-PRO 802.15.4 SMT module w/ PCB antenna
XBP24CAUIS-001	Digi XBee-PRO 802.15.4 SMT module w/ U.fl connector
XBP24CARIS-001	Digi XBee-PRO 802.15.4 SMT module w/ RF Pad connector



DIGI SERVICE AND SUPPORT / You can purchase with confidence knowing that Digi is always available to serve you with expert technical support and our industry leading warranty. For detailed information visit www.digi.com/support.

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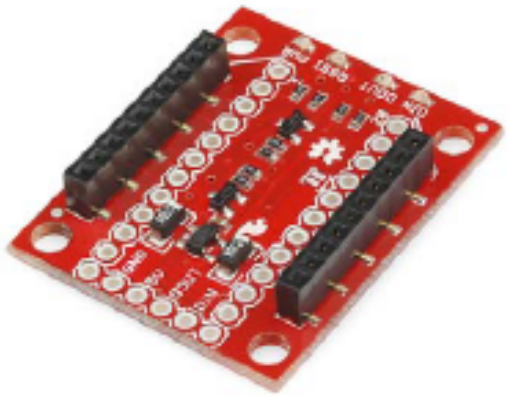
Sticky Notes

SparkFun XBee Explorer Regulated

WRL-11373 ROHS✔



Description: The SparkFun XBee Explorer Regulated takes care of the 3.3V regulation, signal conditioning, and basic activity indicators (Power, RSSI and DIN/DOUT activity LEDs). It translates the 5V serial signals to 3.3V so that you can connect a 5V (down to 3.3V) system to any XBee module. The board was conveniently designed to mate directly with Arduino Pro boards for wireless bootloading and USB based configuration.

This unit works with all XBee modules including the Series 1 and 2, standard and Pro versions. Plug an XBee into this breakout and you will have direct access to the serial and programming pins on the XBee unit and will be able to power the XBee with 5V.

This board comes fully populated with 3.3V regulator (5V max input), XBee socket, four status LEDs, and level shifting. In the latest revision the diode level shifter is replaced with a more robust MOSFET level shifter. This board does not include and XBee module.

General Description

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply.

Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.

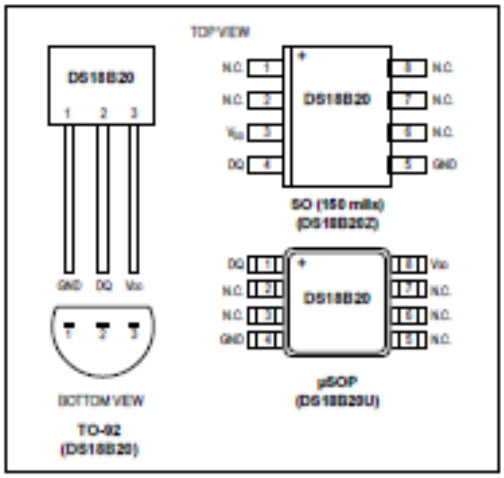
Applications

- Thermostatic Controls
- Industrial Systems
- Consumer Products
- Thermometers
- Thermally Sensitive Systems

Benefits and Features

- Unique 1-Wire® Interface Requires Only One Port Pin for Communication
- Reduce Component Count with Integrated Temperature Sensor and EEPROM
  - Measures Temperatures from -55°C to +125°C (-67°F to +257°F)
  - ±0.5°C Accuracy from -10°C to +85°C
  - Programmable Resolution from 9 Bits to 12 Bits
  - No External Components Required
- Parasitic Power Mode Requires Only 2 Pins for Operation (DQ and GND)
- Simplifies Distributed Temperature-Sensing Applications with Multidrop Capability
  - Each Device Has a Unique 64-Bit Serial Code Stored in On-Board ROM
- Flexible User-Definable Nonvolatile (NV) Alarm Settings with Alarm Search Command Identifies Devices with Temperatures Outside Programmed Limits
- Available in 8-Pin SO (150 mils), 8-Pin µSOP, and 3-Pin TO-92 Packages

Pin Configurations



Ordering Information ***appears at end of data sheet.***

1-Wire is a registered trademark of Maxim Integrated Products, Inc.

19-7487; Rev 4; 1/15

maxim integrated.

Absolute Maximum Ratings

Voltage Range on Any Pin Relative to Ground....-0.5V to +6.0V
Operating Temperature Range.....-55°C to +125°C
Storage Temperature Range.....-55°C to +125°C
Solder Temperature.....Refer to the IPC/JEDEC J-STD-020 Specification.

These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

DC Electrical Characteristics

(-55°C to +125°C; V_{DD} = 3.0V to 5.5V)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage	V_{DD}	Local power (Note 1)		+3.0		+5.5	V
Pullup Supply Voltage	V_{PU}	Parasite power	(Notes 1, 2)	+3.0		+5.5	V
		Local power		+3.0		V_{DD}	
Thermometer Error	t_{ERR}	-10°C to +85°C	(Note 3)			±0.5	°C
		-55°C to +125°C				±2	
Input Logic-Low	V_{IL}	(Notes 1, 4, 5)		-0.3		+0.8	V
Input Logic-High	V_{IH}	Local power	(Notes 1,6)	+2.2		The lower of 5.5 or V_{DD} + 0.3	V
		Parasite power		+3.0			
Sink Current	I_L	$V_{I/O}$ = 0.4V		4.0			mA
Standby Current	I_{DDS}	(Notes 7, 8)			750	1000	nA
Active Current	I_{DD}	V_{DD} = 5V (Note 9)			1	1.5	mA
DQ Input Current	I_{DQ}	(Note 10)			5		µA
Drift		(Note 11)			±0.2		°C

Note 1: All voltages are referenced to ground.
Note 2: The Pullup Supply Voltage specification assumes that the pullup device is ideal, and therefore the high level of the pullup is equal to V_{PU}. In order to meet the V_{IH} spec of the DS18B20, the actual supply rail for the strong pullup transistor must include margin for the voltage drop across the transistor when it is turned on; thus: $V_{PU\_ACTUAL} = V_{PU\_IDEAL} + V_{TRANSISTOR}$.
Note 3: See typical performance curve in Figure 1.
Note 4: Logic-low voltages are specified at a sink current of 4mA.
Note 5: To guarantee a presence pulse under low voltage parasite power conditions, V_{ILMAX} may have to be reduced to as low as 0.5V.
Note 6: Logic-high voltages are specified at a source current of 1mA.
Note 7: Standby current specified up to +70°C. Standby current typically is 3µA at +125°C.
Note 8: To minimize I_{DDS}, DQ should be within the following ranges: GND ≤ DQ ≤ GND + 0.3V or V_{DD} – 0.3V ≤ DQ ≤ V_{DD}.
Note 9: Active current refers to supply current during active temperature conversions or EEPROM writes.
Note 10: DQ line is high ("high-Z" state).
Note 11: Drift data is based on a 1000-hour stress test at +125°C with V_{DD} = 5.5V.

Raspberry Pi

Raspberry Pi 3 Model B

Product Name	**Raspberry PI 3**
Product Description	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 you a more powerful processor, 10x faster than the first generation Raspberry PI. Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.
RS Part Number	**896-8660**

RS

www.rs-components.com/raspberrypi

Raspberry Pi

Raspberry Pi 3 Model B

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. Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA Infrastructure
Memory	1GB LPDDR2
Operating System	Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT
Dimensions	85 x 56 x 17mm
Power	Micro USB socket 5V1, 2.5A

Connectors:

Ethernet	10/100 BaseT Ethernet socket
Video Output	HDMI (rev 1.3 & 1.4 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

Key Benefits

- Low cost
- Consistent board format
- 10x faster processing
- Added connectivity

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)

RS

Ultrasonic Ranging Module HC - SR04

Product features:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:
(1) Using IO trigger for at least 10us high level signal,
(2) The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
(3) IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.
Test distance = (high level time×velocity of sound (340M/S) / 2,

Wire connecting direct as following:

- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

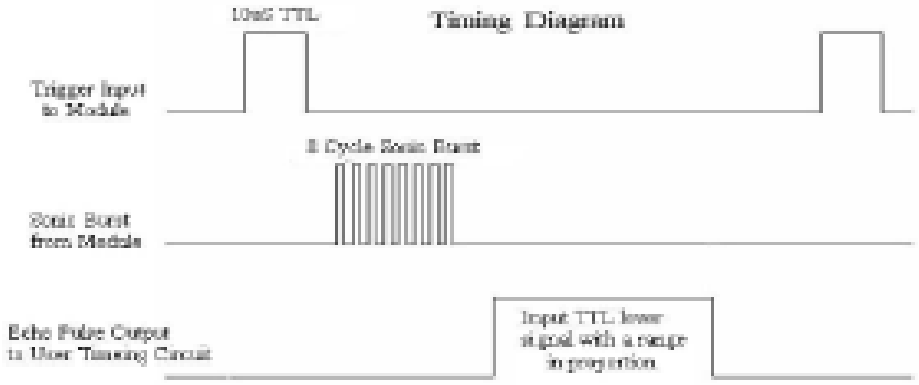
Electric Parameter

Working Voltage	DC 5 V
Working Current	15mA
Working Frequency	40Hz
Max Range	4m
Min Range	2cm
MeasuringAngle	15 degree
Trigger Input Signal	10uS TTL pulse
Echo Output Signal	Input TTL lever signal and the range in proportion
Dimension	45*20*15mm

Vcc Trig Echo GND

Timing diagram

The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: uS / 58 = centimeters or uS / 148 =inch; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.



PH meter(SKU: SEN0161)

Analog pH Meter Kit SKU: SEN0161

Analog pH Meter Kit SKU: SEN0169

Specification

- Module Power : 5.00V
- Module Size : 43mmx32mm
- Measuring Range :0-14PH
- Measuring Temperature :0-60 ℃
- Accuracy : ± 0.1pH (25 ℃)
- Response Time : ≤ 1min
- Industry pH Electrode with BNC Connector
- PH2.0 Interface (3 foot patch)
- Gain Adjustment Potentiometer
- Power Indicator LED

pH Electrode Characteristics

The output of pH electrode is Millivolts,and the pH value of the relationship is shown as follows (25 ℃):

VOLTAGE （mV）	pH value	VOLTAGE （mV）	pH value
414.12	0.00	-414.12	14.00
354.96	1.00	-354.96	13.00
295.80	2.00	-295.80	12.00
236.64	3.00	-236.64	11.00
177.48	4.00	-177.48	10.00
118.32	5.00	-118.32	9.00
59.16	6.00	-59.16	8.00
0.00	7.00	0.00	7.00

APPENDIX B

Training Data

Appendix B

Training Data

Transmitter 1

DATE_TIME	VOLUME	PH
11/7/2018 16:30	0	7.01
11/7/2018 17:00	22	4.63
11/7/2018 17:30	48	4.76
11/7/2018 18:00	68	4.91
11/7/2018 18:30	86	4.95
11/7/2018 19:00	110	5.07
11/7/2018 19:30	126	5.22
11/7/2018 20:00	162	5.34
11/7/2018 20:30	176	5.55
11/7/2018 21:00	194	5.7
11/7/2018 21:32	213	5.87
11/7/2018 22:02	243	6.02
11/7/2018 22:29	270	6.04
11/7/2018 23:02	0	4.34
11/7/2018 23:32	29	5.18
11/8/2018 0:02	85	5.73
11/8/2018 0:32	125	5.7
11/8/2018 1:02	164	5.53
11/8/2018 1:32	183	5.39
11/8/2018 2:02	225	5.5
11/8/2018 2:32	252	5.7
11/8/2018 3:02	284	5.76
11/8/2018 3:32	313	5.85
11/8/2018 4:02	347	5.85
11/8/2018 4:32	374	5.99
11/8/2018 5:02	404	5.35
11/8/2018 5:32	438	4.77
11/8/2018 6:02	0	4.81
11/8/2018 6:32	23	4.98
11/8/2018 7:02	35	4.89
11/8/2018 7:32	45	4.48
11/8/2018 8:02	60	4.22
11/8/2018 8:32	75	4.14
11/8/2018 9:02	94	4
11/8/2018 9:32	108	3.9
11/8/2018 10:02	121	3.71
11/8/2018 10:32	148	3.87
11/8/2018 11:02	0	4.31
11/8/2018 11:32	29	4.55
11/8/2018 12:02	45	4.57
11/8/2018 12:32	63	4.58
11/8/2018 13:02	81	4.52
11/8/2018 13:32	94	4.53
11/8/2018 14:02	109	4.5
11/8/2018 14:32	133	4.5
11/8/2018 15:02	150	4.52

11/8/2018 15:32	**174**	**4.28**
11/8/2018 16:02	**189**	**4.15**
11/8/2018 16:32	**0**	**7.1**
11/8/2018 17:02	**20**	**6.56**
11/8/2018 17:32	**36**	**5.6**
11/8/2018 18:02	**43**	**5.56**
11/8/2018 18:32	**52**	**5.54**
11/8/2018 19:02	**79**	**5.51**
11/8/2018 19:32	**95**	**5.48**
11/8/2018 20:02	**114**	**5.44**
11/8/2018 20:32	**128**	**5.32**
11/8/2018 21:02	**132**	**5.17**
11/8/2018 21:32	**156**	**5.04**
11/8/2018 22:02	**167**	**4.98**
11/8/2018 22:32	**178**	**4.89**
11/8/2018 23:02	**199**	**4.75**
11/8/2018 23:32	**22**	**4.67**
11/9/2018 0:02	**56**	**4.52**
11/9/2018 0:32	**81**	**4.5**
11/9/2018 1:05	**107**	**4.34**
11/9/2018 1:32	**134**	**4.2**
11/9/2018 2:02	**162**	**4.45**
11/9/2018 2:32	**182**	**4.51**
11/9/2018 3:02	**204**	**4.55**
11/9/2018 3:32	**222**	**4.7**
11/9/2018 4:02	**241**	**4.79**
11/9/2018 4:32	**259**	**4.93**

11/9/2018 5:02	**300**	**5**
11/9/2018 5:32	**322**	**5.07**
11/9/2018 6:02	**0**	**5.2**
11/9/2018 6:32	**20**	**5.39**
11/9/2018 7:02	**42**	**5.44**
11/9/2018 7:32	**67**	**5.49**
11/9/2018 8:02	**83**	**5.52**
11/9/2018 8:32	**99**	**5.54**
11/9/2018 9:02	**113**	**5.56**
11/9/2018 9:32	**133**	**5.6**
11/9/2018 10:02	**154**	**5.9**
11/9/2018 10:32	**184**	**6.1**
11/9/2018 11:02	**0**	**6.24**
11/9/2018 11:32	**28**	**6.31**
11/9/2018 12:02	**52**	**6.4**
11/9/2018 12:32	**75**	**6.45**
11/9/2018 13:02	**108**	**6.5**
11/9/2018 13:32	**128**	**6.57**
11/9/2018 14:02	**151**	**7**
11/9/2018 14:32	**181**	**7.3**
11/9/2018 15:02	**222**	**7.51**
11/9/2018 15:32	**248**	**7.65**
11/9/2018 16:02	**282**	**7.74**
11/9/2018 16:32	**0**	**6.38**
11/9/2018 17:32	**48**	**5.87**
11/9/2018 18:02	**99**	**7.95**
11/9/2018 18:32	**118**	**9.01**

11/9/2018 19:02	**129**	**8.31**
11/9/2018 19:32	**159**	**7.87**
11/9/2018 20:02	**187**	**7.62**
11/9/2018 20:32	**209**	**7.36**
11/9/2018 21:02	**260**	**7.06**
11/9/2018 21:32	**279**	**6.71**
11/9/2018 22:02	**306**	**6.42**
11/9/2018 22:32	**331**	**6.68**
11/9/2018 23:02	**0**	**6.82**
11/9/2018 23:32	**18**	**6.72**
11/10/2018 0:02	**44**	**7.13**
11/10/2018 0:32	**106**	**8.36**
11/10/2018 1:02	**126**	**8.64**
11/10/2018 1:32	**156**	**8.44**
11/10/2018 2:02	**191**	**8.16**
11/10/2018 2:32	**216**	**7.61**
11/10/2018 3:02	**263**	**7.37**
11/10/2018 3:32	**289**	**6.81**
11/10/2018 4:02	**321**	**6.62**
11/10/2018 4:32	**338**	**6.54**
11/10/2018 5:02	**380**	**6.24**
11/10/2018 5:32	**418**	**6.07**
11/10/2018 6:02	**0**	**5.58**
11/10/2018 6:32	**19**	**5.3**
11/10/2018 7:02	**34**	**5.03**
11/10/2018 7:32	**38**	**6.21**
11/10/2018 8:02	**51**	**6.65**

11/10/2018 8:32	**61**	**6.53**
11/10/2018 9:02	**69**	**6.21**
11/10/2018 9:32	**82**	**6.02**
11/10/2018 10:02	**89**	**6.13**
11/10/2018 10:32	**105**	**6.14**
11/10/2018 11:02	**0**	**5.65**
11/10/2018 11:32	**30**	**5.03**
11/10/2018 12:02	**47**	**4.82**
11/10/2018 12:32	**67**	**4.67**
11/10/2018 13:02	**86**	**4.33**
11/10/2018 14:02	**138**	**4.25**
11/10/2018 14:32	**158**	**4.25**
11/10/2018 15:02	**184**	**4.23**
11/10/2018 15:32	**208**	**5.89**
11/10/2018 16:02	**224**	**6.59**
11/10/2018 16:32	**248**	**6.96**

Transmitter 2

DATE_TIME	VOL	PH	TEMP
11/7/2018 16:30	0	7.03	28.3
11/7/2018 17:00	26	4.12	28.9
11/7/2018 17:30	73	4.31	28.9
11/7/2018 18:00	102	4.19	28.1
11/7/2018 18:30	136	4.05	27.9
11/7/2018 19:00	168	3.85	27.9
11/7/2018 19:30	189	3.7	27.9
11/7/2018 20:00	228	3.49	27.8
11/7/2018 20:30	268	3.23	27.9
11/7/2018 21:00	302	3.17	27.7
11/7/2018 21:32	343	3.18	27.7
11/7/2018 22:02	381	4.8	27.6
11/7/2018 22:32	408	5.17	26.1
11/7/2018 23:02	0	5.99	26.1
11/7/2018 23:32	45	5.87	26.1
11/8/2018 0:02	101	6.96	26.4
11/8/2018 0:32	138	7.06	26.4
11/8/2018 1:02	184	7.06	26.5
11/8/2018 1:32	209	6.42	27.1
11/8/2018 2:02	259	5.9	27.1
11/8/2018 2:32	281	7.03	26.7
11/8/2018 3:02	314	7.03	25.9
11/8/2018 3:32	336	7.01	23.9
11/8/2018 4:02	377	7.02	24.5
11/8/2018 4:32	413	7.02	25
11/8/2018 5:02	459	7.03	25.1
11/8/2018 5:32	500	7.03	25.1
11/8/2018 6:02	0	7.03	25.4
11/8/2018 6:32	15	7.03	25.2
11/8/2018 7:02	25	7.03	25.2
11/8/2018 7:32	35	7.01	25.4
11/8/2018 8:02	55	7.03	25.6
11/8/2018 8:32	65	7.05	25.6
11/8/2018 9:02	80	7.07	26.1
11/8/2018 9:32	99	1.05	26.6
11/8/2018 10:02	116	0.24	31.6
11/8/2018 10:32	122	2.87	30.7
11/8/2018 11:02	0	4.84	30.7
11/8/2018 11:32	18	2.16	31.6
11/8/2018 12:02	23	2.76	31.6
11/8/2018 12:32	32	1.82	30.7
11/8/2018 13:02	42	0.82	39.9
11/8/2018 13:32	53	0.76	33.6
11/8/2018 14:02	63	0.35	32.1
11/8/2018 14:32	71	0.09	31.2
11/8/2018 15:02	84	-0.73	30.7
11/8/2018 15:32	95	-2.56	30.4
11/8/2018 16:32	0	7.03	33.7
11/8/2018 17:02	25	7.03	29.4
11/8/2018 17:32	52	3.78	28.1
11/8/2018 18:02	81	6.99	27.6

11/8/2018 18:32	**103**	**6.98**	**27.7**
11/8/2018 19:02	**128**	**6.99**	**27.6**
11/8/2018 19:32	**152**	**6.99**	**27.5**
11/8/2018 20:02	**189**	**6.99**	**27.5**
11/8/2018 20:32	**206**	**6.99**	**27.4**
11/8/2018 21:02	**231**	**6.98**	**27.6**
11/8/2018 21:32	**250**	**6.99**	**26.6**
11/8/2018 22:02	**264**	**6.99**	**27.4**
11/8/2018 22:32	**287**	**6.98**	**26.1**
11/8/2018 23:02	**0**	**6.99**	**24.1**
11/8/2018 23:32	**52**	**6.98**	**25.4**
11/9/2018 0:02	**89**	**6.98**	**24.6**
11/9/2018 0:32	**132**	**6.99**	**25.2**
11/9/2018 1:02	**175**	**6.98**	**25.3**
11/9/2018 1:32	**212**	**6.99**	**24.9**
11/9/2018 2:02	**266**	**6.99**	**25.1**
11/9/2018 2:32	**286**	**6.98**	**24.8**
11/9/2018 3:02	**338**	**6.98**	**24.6**
11/9/2018 3:32	**410**	**6.98**	**25.2**
11/9/2018 4:02	**460**	**6.98**	**24.7**
11/9/2018 4:32	**509**	**6.98**	**24.7**
11/9/2018 5:02	**553**	**6.99**	**24.3**
11/9/2018 5:32	**614**	**6.99**	**25.2**
11/9/2018 6:02	**0**	**5.37**	**24.4**
11/9/2018 6:32	**25**	**4.04**	**24.7**
11/9/2018 7:02	**41**	**5.03**	**24.4**
11/9/2018 7:32	**55**	**4.7**	**24.4**

11/9/2018 8:02	**70**	**3.97**	**24.4**
11/9/2018 8:32	**86**	**2.7**	**23.9**
11/9/2018 9:02	**97**	**2.62**	**24**
11/9/2018 9:32	**105**	**1.79**	**24.6**
11/9/2018 10:02	**119**	**2.43**	**24.9**
11/9/2018 10:32	**136**	**3**	**25.5**
11/9/2018 11:02	**0**	**2.53**	**26.3**
11/9/2018 11:32	**23**	**1.93**	**26.6**
11/9/2018 12:02	**30**	**2.35**	**26.8**
11/9/2018 12:32	**45**	**2.58**	**26.7**
11/9/2018 13:02	**58**	**2.76**	**27**
11/9/2018 13:32	**77**	**3**	**26.9**
11/9/2018 14:02	**96**	**3.93**	**27**
11/9/2018 14:32	**112**	**4.33**	**27.6**
11/9/2018 15:02	**127**	**4.64**	**27.6**
11/9/2018 15:32	**156**	**4.98**	**27.4**
11/9/2018 16:02	**185**	**5.52**	**27.4**
11/9/2018 16:32	**0**	**7.03**	**27.6**
11/9/2018 17:02	**29**	**7.03**	**27.4**
11/9/2018 17:32	**47**	**3.78**	**26.9**
11/9/2018 18:02	**77**	**6.99**	**26.9**
11/9/2018 18:35	**103**	**6.99**	**27.1**
11/9/2018 19:02	**125**	**6.99**	**27.3**
11/9/2018 19:32	**158**	**6.99**	**26.9**
11/9/2018 20:02	**206**	**6.99**	**27.2**
11/9/2018 20:32	**272**	**6.99**	**27.2**
11/9/2018 21:02	**310**	**6.98**	**27.6**

11/9/2018 21:32	**341**	**6.99**	**26.9**
11/9/2018 22:02	**361**	**6.99**	**25.4**
11/9/2018 22:32	**386**	**6.98**	**26.1**
11/9/2018 23:32	**34**	**6.98**	**26.2**
11/10/2018 0:02	**75**	**6.98**	**26.2**
11/10/2018 0:32	**115**	**6.99**	**25**
11/10/2018 1:02	**166**	**6.98**	**25.4**
11/10/2018 1:32	**188**	**6.99**	**25.7**
11/10/2018 2:02	**233**	**6.99**	**25.5**
11/10/2018 2:32	**269**	**6.98**	**25.1**
11/10/2018 3:02	**283**	**6.98**	**24.2**
11/10/2018 3:32	**305**	**6.98**	**23.9**
11/10/2018 4:02	**335**	**6.98**	**24.8**
11/10/2018 4:32	**375**	**6.98**	**25.2**
11/10/2018 5:02	**393**	**6.99**	**26.2**
11/10/2018 5:32	**420**	**6.99**	**25.9**
11/10/2018 6:02	**0**	**5.37**	**25.5**
11/10/2018 6:32	**13**	**4.04**	**26.4**
11/10/2018 7:02	**22**	**5.03**	**26.2**
11/10/2018 7:32	**30**	**4.7**	**25.7**
11/10/2018 8:02	**40**	**3.97**	**26.4**
11/10/2018 8:32	**46**	**2.7**	**26.5**
11/10/2018 9:02	**53**	**2.62**	**26.5**
11/10/2018 9:32	**71**	**1.79**	**24.9**
11/10/2018 10:02	**81**	**2.43**	**25.6**
11/10/2018 10:32	**91**	**3**	**25.8**
11/10/2018 11:02	**0**	**2.53**	**26.2**
11/10/2018 11:32	**14**	**2.11**	**26.7**
11/10/2018 12:02	**18**	**1.09**	**26.5**
11/10/2018 12:32	**25**	**0.78**	**27.4**
11/10/2018 13:02	**35**	**0.57**	**26.7**
11/10/2018 13:32	**41**	**0.37**	**26.7**
11/10/2018 14:02	**49**	**0.98**	**26.8**
11/10/2018 14:32	**53**	**2.04**	**27.3**
11/10/2018 15:02	**56**	**3.05**	**27.2**
11/10/2018 15:35	**64**	**3.42**	**27.2**
11/10/2018 16:02	**72**	**4.58**	**27.2**
11/10/2018 16:32	**80**	**7.03**	**27.2**

Transmitter 3

DATE_TIME	VOL	PH	TEMP
11/7/2018 16:30	0	6.73	28.4
11/7/2018 17:00	35	6.2	27.9
11/7/2018 17:30	72	7.99	27.9
11/7/2018 18:00	125	7.99	27.9
11/7/2018 18:30	168	7.96	27.7
11/7/2018 19:00	216	7.94	27.6
11/7/2018 19:30	282	7.79	27.7
11/7/2018 20:00	323	7.54	27.8
11/7/2018 20:03	328	7.52	27.7
11/7/2018 20:06	331	7.55	27.7
11/7/2018 20:30	373	7.42	27.8
11/7/2018 21:00	408	7.21	27.6
11/7/2018 21:32	449	7.12	25.4
11/7/2018 22:02	500	6.9	26.3
11/7/2018 22:32	546	6.57	26.6
11/7/2018 23:02	0	6.39	26.1
11/7/2018 23:32	62	5.85	26.4
11/8/2018 0:02	108	7.7	26.1
11/8/2018 0:32	152	7.55	26.4
11/8/2018 1:02	207	7.1	26.2
11/8/2018 1:32	250	6.78	26.4
11/8/2018 2:02	300	6.47	25.4
11/8/2018 2:32	362	7.29	23.6
11/8/2018 3:02	409	7.15	24.1
11/8/2018 3:32	437	7.27	24.9
11/8/2018 4:02	484	6.37	25.5
11/8/2018 4:32	546	5.22	25.7
11/8/2018 5:02	587	4.96	26
11/8/2018 5:32	624	4.61	25.9
11/8/2018 6:02	0	4.4	25.9
11/8/2018 6:32	22	4.21	26.1
11/8/2018 7:32	81	6.03	26.1
11/8/2018 8:02	104	7.36	26.2
11/8/2018 8:32	125	6.98	27.9
11/8/2018 9:02	148	6.63	28.6
11/8/2018 9:32	170	6.13	28.8
11/8/2018 10:02	197	5.49	28.8
11/8/2018 10:32	216	5.1	28.9
11/8/2018 11:02	0	4.9	29.4
11/8/2018 11:32	31	4.71	28.9
11/8/2018 12:02	63	6.62	28.9
11/8/2018 12:32	104	6.4	29.2
11/8/2018 13:02	128	6.13	28.9
11/8/2018 13:32	156	5.87	28.6
11/8/2018 14:02	183	5.31	28.9
11/8/2018 14:32	204	4.61	28.7
11/8/2018 15:02	223	4.42	28.3
11/8/2018 15:32	270	4.33	28.4
11/8/2018 15:47	275	4.16	28.4
11/8/2018 16:32	0	7.03	28.4
11/8/2018 17:02	11	7.03	27.9
11/8/2018 17:32	14	3.78	27.9

11/8/2018 18:02	**16**	**6.99**	**27.6**
11/8/2018 18:32	**18**	**6.98**	**27.6**
11/8/2018 19:02	**19**	**6.99**	**27.4**
11/8/2018 19:32	**23**	**6.99**	**27.5**
11/8/2018 20:02	**26**	**6.99**	**27.5**
11/8/2018 20:32	**28**	**6.99**	**27.3**
11/8/2018 21:02	**30**	**6.98**	**27.5**
11/8/2018 21:32	**32**	**6.99**	**25.7**
11/8/2018 22:02	**35**	**6.99**	**25.9**
11/8/2018 22:32	**37**	**6.98**	**25.8**
11/8/2018 23:02	**0**	**6.99**	**23.9**
11/8/2018 23:32	**18**	**6.98**	**24.4**
11/9/2018 0:02	**23**	**6.98**	**23.7**
11/9/2018 0:32	**30**	**6.99**	**23.9**
11/9/2018 1:02	**39**	**6.98**	**24.1**
11/9/2018 1:32	**45**	**6.99**	**24.1**
11/9/2018 2:02	**51**	**6.99**	**24**
11/9/2018 2:32	**60**	**6.98**	**24.1**
11/9/2018 3:02	**68**	**6.98**	**24.1**
11/9/2018 3:32	**76**	**6.98**	**24.2**
11/9/2018 4:02	**83**	**6.98**	**24.4**
11/9/2018 4:32	**89**	**6.98**	**23.6**
11/9/2018 5:02	**94**	**6.99**	**23.9**
11/9/2018 5:32	**101**	**6.99**	**24.3**
11/9/2018 6:02	**0**	**5.37**	**24.2**
11/9/2018 6:32	**18**	**4.04**	**24**
11/9/2018 7:02	**40**	**5.03**	**23.9**

11/9/2018 7:32	**57**	**4.7**	**23.8**
11/9/2018 8:02	**74**	**3.97**	**24**
11/9/2018 8:32	**94**	**2.7**	**23.7**
11/9/2018 9:02	**105**	**2.62**	**23.8**
11/9/2018 9:32	**125**	**1.79**	**23.8**
11/9/2018 10:02	**132**	**2.43**	**23.9**
11/9/2018 10:32	**150**	**3**	**24.6**
11/9/2018 11:02	**0**	**2.53**	**25.1**
11/9/2018 11:32	**20**	**1.93**	**25.6**
11/9/2018 12:02	**33**	**2.35**	**25.9**
11/9/2018 12:32	**45**	**2.58**	**26.1**
11/9/2018 13:02	**51**	**2.76**	**26.8**
11/9/2018 13:32	**60**	**3**	**26.4**
11/9/2018 14:02	**76**	**3.93**	**26.7**
11/9/2018 14:32	**84**	**4.33**	**27.3**
11/9/2018 15:02	**93**	**4.64**	**26.7**
11/9/2018 15:32	**99**	**4.98**	**26.3**
11/9/2018 16:02	**113**	**5.52**	**26.2**
11/9/2018 16:32	**0**	**7.03**	**26.2**
11/9/2018 17:02	**18**	**7.03**	**26.6**
11/9/2018 17:32	**34**	**3.78**	**26.4**
11/9/2018 18:02	**53**	**6.99**	**25.8**
11/9/2018 18:32	**70**	**6.98**	**25.9**
11/9/2018 19:02	**101**	**6.99**	**26**
11/9/2018 19:32	**126**	**6.99**	**26.7**
11/9/2018 20:02	**134**	**6.99**	**26.4**
11/9/2018 20:32	**152**	**6.99**	**26.7**

11/9/2018 21:02	**165**	**6.98**	**26.9**
11/9/2018 21:32	**185**	**6.99**	**27.3**
11/9/2018 22:02	**203**	**6.99**	**26.9**
11/9/2018 22:32	**218**	**6.98**	**24.9**
11/9/2018 23:02	**0**	**6.99**	**25.8**
11/9/2018 23:32	**21**	**6.98**	**26.1**
11/10/2018 0:02	**41**	**6.98**	**26.1**
11/10/2018 0:32	**53**	**6.99**	**26.2**
11/10/2018 1:02	**80**	**6.98**	**24.8**
11/10/2018 1:32	**102**	**6.99**	**25.1**
11/10/2018 2:02	**118**	**6.99**	**25.6**
11/10/2018 2:32	**134**	**6.98**	**25.4**
11/10/2018 3:02	**153**	**6.98**	**24.9**
11/10/2018 3:32	**168**	**6.98**	**24**
11/10/2018 4:02	**191**	**6.98**	**23.6**
11/10/2018 4:32	**212**	**6.98**	**24.7**
11/10/2018 5:02	**238**	**6.99**	**25.2**
11/10/2018 5:32	**255**	**6.99**	**25.6**
11/10/2018 6:02	**0**	**5.37**	**25.6**
11/10/2018 6:32	**23**	**4.04**	**25.5**
11/10/2018 7:02	**41**	**5.03**	**26**
11/10/2018 7:32	**55**	**4.7**	**26**
11/10/2018 8:02	**80**	**3.97**	**25.5**
11/10/2018 8:32	**95**	**2.7**	**25.9**
11/10/2018 9:02	**116**	**2.62**	**26.2**
11/10/2018 9:32	**143**	**1.79**	**26**
11/10/2018 10:02	**152**	**2.43**	**25.1**
11/10/2018 10:32	**160**	**3**	**25.9**
11/10/2018 11:02	**0**	**2.53**	**26.7**
11/10/2018 11:32	**19**	**2.11**	**27.4**
11/10/2018 12:02	**26**	**1.09**	**25.9**
11/10/2018 12:32	**39**	**0.78**	**25.6**
11/10/2018 13:02	**46**	**0.57**	**26**
11/10/2018 13:32	**55**	**0.37**	**26.4**
11/10/2018 14:02	**69**	**0.98**	**25.9**
11/10/2018 14:32	**81**	**2.04**	**25.7**
11/10/2018 15:02	**95**	**3.05**	**26**
11/10/2018 15:32	**104**	**3.39**	**26.3**
11/10/2018 16:02	**121**	**4.58**	**26.9**
11/10/2018 16:32	**132**	**7.03**	**26.5**

Transmitter 4

DATE_TIME	VOL	PH
11/7/2018 16:39	0	5.68
11/7/2018 17:09	14	5.53
11/7/2018 17:39	21	5.79
11/7/2018 18:09	25	6.72
11/7/2018 18:39	33	7.07
11/7/2018 19:09	41	7.84
11/7/2018 19:39	50	7.84
11/7/2018 20:09	57	7.82
11/7/2018 20:39	66	7.8
11/7/2018 21:09	79	7.75
11/7/2018 21:38	88	7.68
11/7/2018 22:08	94	7.51
11/7/2018 22:38	99	7.42
11/7/2018 23:08	0	7.48
11/7/2018 23:38	38	6.38
11/8/2018 0:08	58	6.37
11/8/2018 0:38	100	7.33
11/8/2018 1:08	131	7.68
11/8/2018 1:38	159	7.61
11/8/2018 2:08	198	7.44
11/8/2018 2:38	222	7.34
11/8/2018 3:08	242	7.1
11/8/2018 3:38	265	6.73
11/8/2018 4:08	296	6.81
11/8/2018 4:38	350	6.8
11/8/2018 5:08	388	6.66
11/8/2018 5:38	430	6.42
11/8/2018 6:08	0	6.13
11/8/2018 6:38	44	5.38
11/8/2018 7:08	58	4.8
11/8/2018 7:38	71	5.04
11/8/2018 8:08	87	6.66
11/8/2018 8:38	104	6.74
11/8/2018 9:08	122	6.46
11/8/2018 9:38	136	6.11
11/8/2018 10:08	155	5.6
11/8/2018 10:38	194	5.07
11/8/2018 11:08	0	6.81
11/8/2018 11:38	27	6.41
11/8/2018 12:08	63	6.88
11/8/2018 12:38	79	7.23
11/8/2018 13:08	109	7.51
11/8/2018 13:38	128	7.09
11/8/2018 14:08	140	6.89
11/8/2018 14:38	154	6.62
11/8/2018 15:08	183	6.32
11/8/2018 15:38	204	5.87
11/8/2018 16:08	247	5.6
11/8/2018 16:38	0	6.78
11/8/2018 17:08	54	6.48
11/8/2018 17:38	84	6.16

11/8/2018 18:08	**110**	**5.72**
11/8/2018 18:38	**173**	**5.61**
11/8/2018 19:08	**203**	**4.13**
11/8/2018 19:38	**234**	**4.27**
11/8/2018 20:08	**266**	**3.98**
11/8/2018 20:38	**282**	**5.09**
11/8/2018 21:08	**317**	**5.7**
11/8/2018 21:38	**348**	**5.77**
11/8/2018 22:08	**389**	**5.87**
11/8/2018 22:38	**403**	**5.37**
11/8/2018 23:08	**0**	**5.21**
11/8/2018 23:38	**44**	**5.07**
11/9/2018 0:08	**89**	**5**
11/9/2018 0:38	**127**	**4.81**
11/9/2018 1:08	**155**	**4.64**
11/9/2018 1:38	**182**	**4.16**
11/9/2018 2:08	**216**	**6.15**
11/9/2018 2:38	**235**	**6.38**
11/9/2018 3:08	**259**	**6.42**
11/9/2018 3:38	**282**	**6.25**
11/9/2018 4:08	**315**	**6.09**
11/9/2018 4:38	**352**	**5.58**
11/9/2018 5:08	**377**	**5.48**
11/9/2018 5:38	**394**	**5.3**
11/9/2018 6:08	**0**	**5.58**
11/9/2018 6:38	**12**	**5.31**
11/9/2018 7:08	**17**	**5.74**

11/9/2018 7:38	**19**	**5.53**
11/9/2018 8:08	**22**	**5.93**
11/9/2018 8:38	**27**	**5.55**
11/9/2018 9:08	**31**	**5.68**
11/9/2018 9:38	**38**	**5.43**
11/9/2018 10:08	**42**	**6.97**
11/9/2018 10:38	**47**	**6.95**
11/9/2018 11:08	**0**	**7.07**
11/9/2018 11:38	**18**	**6.86**
11/9/2018 12:08	**27**	**6.21**
11/9/2018 12:38	**38**	**6.73**
11/9/2018 13:08	**50**	**5.8**
11/9/2018 13:38	**65**	**4.53**
11/9/2018 14:08	**81**	**6.25**
11/9/2018 14:38	**89**	**6.11**
11/9/2018 15:08	**105**	**6.42**
11/9/2018 15:38	**126**	**6.17**
11/9/2018 16:38	**0**	**5.21**
11/9/2018 17:08	**22**	**4.79**
11/9/2018 17:38	**36**	**4.32**
11/9/2018 18:08	**55**	**4.18**
11/9/2018 18:38	**64**	**5.48**
11/9/2018 19:08	**76**	**6.07**
11/9/2018 19:38	**87**	**5.99**
11/9/2018 20:08	**101**	**5.82**
11/9/2018 20:38	**111**	**5.48**
11/9/2018 21:08	**120**	**5.08**

11/9/2018 21:38	**136**	**4.82**
11/9/2018 22:08	**154**	**4.59**
11/9/2018 22:38	**163**	**4.51**
11/9/2018 23:08	**0**	**4.4**
11/9/2018 23:38	**23**	**4.03**
11/10/2018 0:08	**44**	**3.65**
11/10/2018 0:38	**56**	**3.57**
11/10/2018 1:08	**71**	**3.6**
11/10/2018 1:38	**79**	**3.57**
11/10/2018 2:08	**88**	**3.75**
11/10/2018 2:38	**100**	**3.62**
11/10/2018 3:08	**107**	**3.82**
11/10/2018 3:38	**117**	**4.92**
11/10/2018 4:08	**129**	**4.73**
11/10/2018 4:38	**142**	**5.09**
11/10/2018 5:08	**147**	**4.8**
11/10/2018 5:38	**158**	**4.81**
11/10/2018 6:08	**0**	**4.62**
11/10/2018 6:38	**12**	**4.47**

11/10/2018 7:08	**16**	**4.1**
11/10/2018 7:38	**21**	**4.01**
11/10/2018 8:08	**27**	**3.92**
11/10/2018 8:38	**31**	**3.89**
11/10/2018 9:08	**33**	**3.86**
11/10/2018 9:38	**39**	**3.84**
11/10/2018 10:08	**43**	**3.83**
11/10/2018 10:38	**47**	**3.92**
11/10/2018 11:08	**0**	**3.79**
11/10/2018 11:38	**17**	**4.17**
11/10/2018 12:08	**31**	**4.08**
11/10/2018 12:38	**49**	**4.9**
11/10/2018 13:08	**54**	**5.02**
11/10/2018 13:38	**71**	**4.74**
11/10/2018 14:08	**83**	**4.59**
11/10/2018 14:38	**94**	**4.23**
11/10/2018 15:08	**108**	**4**
11/10/2018 15:38	**119**	**3.98**
11/10/2018 16:08	**131**	**3.91**

Transmitter 5

DATE_TIME	VOL	PH
11/7/2018 16:39	0	7.32
11/7/2018 17:09	51	7.51
11/7/2018 17:39	75	7.29
11/7/2018 18:09	102	7.07
11/7/2018 18:39	121	7.22
11/7/2018 19:09	144	7.07
11/7/2018 19:39	173	6.95
11/7/2018 20:09	192	6.38
11/7/2018 20:39	211	6
11/7/2018 21:09	226	5.97
11/7/2018 21:38	257	5.65
11/7/2018 22:08	279	5.17
11/7/2018 22:38	317	4.44
11/7/2018 23:08	0	5.71
11/7/2018 23:38	31	6.46
11/8/2018 0:08	45	6.18
11/8/2018 0:38	69	6.23
11/8/2018 1:08	82	5.67
11/8/2018 1:38	109	5.65
11/8/2018 2:08	130	5.36
11/8/2018 2:38	147	5.28
11/8/2018 3:08	167	5.17
11/8/2018 3:38	184	4.95
11/8/2018 4:08	214	4.81
11/8/2018 4:38	235	4.62
11/8/2018 5:08	259	4.35
11/8/2018 5:38	272	4.13
11/8/2018 6:08	0	3.91
11/8/2018 6:38	22	5.59
11/8/2018 7:08	30	6.65
11/8/2018 7:38	45	6.71
11/8/2018 8:08	59	6.41
11/8/2018 8:38	68	6.23
11/8/2018 9:08	72	5.94
11/8/2018 9:38	87	5.77
11/8/2018 10:08	91	5.59
11/8/2018 10:38	104	6.2
11/8/2018 11:08	0	6.16
11/8/2018 11:38	41	6.38
11/8/2018 12:08	51	6.64
11/8/2018 12:38	63	6.33
11/8/2018 13:08	80	6.11
11/8/2018 13:38	103	5.84
11/8/2018 14:08	126	5.56
11/8/2018 14:38	144	5.17
11/8/2018 15:08	153	5.24
11/8/2018 15:38	166	5.31
11/8/2018 16:08	189	6.38
11/8/2018 16:38	0	5.32
11/8/2018 17:38	23	5.72
11/8/2018 18:08	43	5.47
11/8/2018 18:38	54	5.97

11/8/2018 19:08	**65**	**5.96**
11/8/2018 19:38	**82**	**6**
11/8/2018 20:08	**94**	**6**
11/8/2018 20:38	**109**	**5.73**
11/8/2018 21:08	**117**	**5.59**
11/8/2018 21:38	**128**	**5.45**
11/8/2018 22:08	**138**	**5.33**
11/8/2018 22:38	**149**	**5.22**
11/8/2018 23:08	**0**	**4.9**
11/8/2018 23:38	**48**	**4.73**
11/9/2018 0:08	**82**	**4.55**
11/9/2018 0:38	**130**	**4.21**
11/9/2018 1:08	**179**	**4.43**
11/9/2018 1:38	**211**	**5.64**
11/9/2018 2:08	**232**	**5.53**
11/9/2018 2:38	**259**	**5.56**
11/9/2018 3:08	**295**	**5.31**
11/9/2018 3:38	**321**	**5.24**
11/9/2018 4:08	**377**	**5.02**
11/9/2018 4:38	**451**	**4.67**
11/9/2018 5:08	**484**	**4.49**
11/9/2018 5:38	**515**	**4.4**
11/9/2018 6:08	**0**	**4.3**
11/9/2018 6:38	**13**	**4.26**
11/9/2018 7:08	**16**	**4.22**
11/9/2018 7:38	**23**	**4.15**
11/9/2018 8:08	**28**	**4.38**

11/9/2018 8:38	**33**	**5.02**
11/9/2018 9:08	**36**	**5.53**
11/9/2018 9:38	**41**	**5.49**
11/9/2018 10:08	**45**	**5.37**
11/9/2018 10:38	**52**	**5.1**
11/9/2018 11:08	**0**	**4.97**
11/9/2018 11:38	**18**	**4.81**
11/9/2018 12:08	**39**	**4.54**
11/9/2018 12:38	**58**	**4.61**
11/9/2018 13:08	**81**	**5.32**
11/9/2018 13:38	**92**	**5.6**
11/9/2018 14:08	**110**	**5.53**
11/9/2018 14:38	**117**	**5.26**
11/9/2018 15:08	**126**	**4.98**
11/9/2018 15:38	**134**	**4.9**
11/9/2018 16:08	**140**	**4.69**
11/9/2018 16:38	**0**	**4.64**
11/9/2018 17:08	**54**	**4.48**
11/9/2018 17:38	**84**	**4.16**
11/9/2018 18:08	**119**	**5.27**
11/9/2018 18:38	**152**	**5.29**
11/9/2018 19:08	**202**	**5.32**
11/9/2018 19:38	**245**	**5.19**
11/9/2018 20:08	**292**	**5.32**
11/9/2018 20:38	**337**	**4.98**
11/9/2018 21:08	**391**	**4.81**
11/9/2018 21:38	**424**	**4.52**

11/9/2018 22:08	**466**	**4.44**
11/9/2018 22:38	**495**	**4.44**
11/9/2018 23:08	**0**	**4.37**
11/9/2018 23:38	**41**	**4.28**
11/10/2018 0:08	**84**	**4.09**
11/10/2018 0:38	**133**	**5.55**
11/10/2018 1:08	**171**	**5.69**
11/10/2018 1:38	**200**	**5.76**
11/10/2018 2:08	**227**	**5.53**

11/10/2018 2:38	**269**	**5.34**
11/10/2018 3:08	**313**	**4.91**
11/10/2018 3:38	**358**	**4.66**
11/10/2018 4:08	**419**	**4.49**
11/10/2018 4:38	**486**	**4.45**
11/10/2018 5:08	**513**	**4.52**
11/10/2018 5:38	**553**	**4.3**

APPENDIX C

Program Codes

Appendix C

Program Codes

Transmitter with Temperature Sensor

```
/*Change Offset value when uploading to its corresponding transmitter no.
 Tx2=0.27 Tx3=0.00
*/

#include <OneWire.h>

int DS18S20_Pin = 2; //DS18S20 Signal pin on digital 2

//Temperature chip i/o
OneWire ds(DS18S20_Pin);  // on digital pin 2



#define SensorPin 1          //pH meter Analog output to Arduino Analog Input 1
double Offset=0.27; //deviation compensate
unsigned long int avgValue;  //Store the average value of the sensor feedback
float b;
int buf[10],temp;

#define trigPin 9  //configurations for ultrasonic sensor
#define echoPin 10
float duration, distance;

void setup() {
  pinMode(13,OUTPUT); //for ph
```

```
  pinMode(trigPin, OUTPUT); //pins for ultrasonic sensor
  pinMode(echoPin, INPUT);
  Serial.begin(9600);
}

void loop() {
  //Ultrasonic sensor
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);
  distance = (duration*0.0340)/2;

  float height=16.2;  //height of container in cm
  float base_area=70.9; //base area of the container in cm^2
  float level=height-distance;  //level of liquid in cm
  double pHarea = 5.9;  //area of pH sensor in cm^2
  float volume=(base_area*level)-(level*pHarea); //volume of the liquid in cm^3



  //pH sensor
  for(int i=0;i<10;i++)       //Get 10 sample value from the sensor for smooth the value
  {
```

```
  buf[i]=analogRead(SensorPin);
  delay(10);
}
for(int i=0;i<9;i++)        //sort the analog from small to large
{
  for(int j=i+1;j<10;j++)
  {
    if(buf[i]>buf[j])
    {
      temp=buf[i];
      buf[i]=buf[j];
      buf[j]=temp;
    }
  }
}
avgValue=0;
for(int i=2;i<8;i++)                    //take the average value of 6 center sample
  avgValue+=buf[i];
float phValue=(float)avgValue*5.0/1024/6; //convert the analog into millivolt
phValue=3.5*phValue + Offset;                    //convert the millivolt into pH value



//DS18S20 temperature sensor
float temperature = getTemp();



//All printouts
```

```
  //Serial.print("Volume: "); //Display the volume on Serial monitor
  Serial.print(volume,2);
  //Serial.print(" mL");
  Serial.print("       ");
  //Serial.print("Temperature: "); //Display the temperature on Serial monitor
  Serial.print(temperature,1);
  //Serial.print(" C");
  Serial.print("       ");
  //Serial.print("pH: "); //Display the pH on Serial monitor
  Serial.println(phValue,2);

  delay(500); //180,000 sampling rate
}

//extension code for temperature sensor
float getTemp(){
  //returns the temperature from one DS18S20 in DEG Celsius

  byte data[12];
  byte addr[8];

  if ( !ds.search(addr)) {
      //no more sensors on chain, reset search
      ds.reset_search();
      return -1000;
  }

  if ( OneWire::crc8( addr, 7) != addr[7]) {
```

```
   Serial.println("CRC is not valid!");
   return -1000;
}

if ( addr[0] != 0x10 && addr[0] != 0x28) {
   Serial.print("Device is not recognized");
   return -1000;
}

ds.reset();
ds.select(addr);
ds.write(0x44,1); // start conversion, with parasite power on at the end

byte present = ds.reset();
ds.select(addr);
ds.write(0xBE); // Read Scratchpad


for (int i = 0; i < 9; i++) { // we need 9 bytes
  data[i] = ds.read();
}

ds.reset_search();

byte MSB = data[1];
byte LSB = data[0];

float tempRead = ((MSB << 8) | LSB); //using two's compliment
```

```
  float TemperatureSum = tempRead / 16;

  return TemperatureSum;

}
```

Transmitter without Temperature Sensor

```
/*Change Offset value when uploading to its corresponding transmitter no.
 Tx1=0.0 Tx4=0.2 Tx5=0.06
*/

#define SensorPin 1          //pH meter Analog output to Arduino Analog Input 1
double Offset=0.2;
unsigned long int avgValue;  //Store the average value of the sensor feedback
float b;
int buf[10],temp;

#define trigPin 9  //configurations for ultrasonic sensor
#define echoPin 10
float duration, distance;

void setup() {
  pinMode(13,OUTPUT); //for ph

  pinMode(trigPin, OUTPUT); //pins for ultrasonic sensor
  pinMode(echoPin, INPUT);

  Serial.begin(9600);
```

```
}

void loop() {
  //Ultrasonic sensor
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);
  distance = (duration*0.0340)/2;

  float height=16.7;  //height of container in cm, 18 prev
  float base_area=70.9; //base area of the container in cm^2
  float level=height-distance;  //level of liquid in cm
  double pHarea = 6.5;  //area of pH sensor in cm^2 5.9
  float volume=(base_area*level)-(level*pHarea); //volume of the liquid in cm^3


  //pH sensor
  for(int i=0;i<10;i++)       //Get 10 sample value from the sensor for smooth the value
  {
    buf[i]=analogRead(SensorPin);
    delay(10);
  }
  for(int i=0;i<9;i++)        //sort the analog from small to large
  {
```

```
  for(int j=i+1;j<10;j++)
  {
    if(buf[i]>buf[j])
    {
      temp=buf[i];
      buf[i]=buf[j];
      buf[j]=temp;
    }
  }
}
avgValue=0;
for(int i=2;i<8;i++)                    //take the average value of 6 center sample
  avgValue+=buf[i];
float phValue=(float)avgValue*5.0/1024/6; //convert the analog into millivolt
phValue=3.5*phValue + Offset;                    //convert the millivolt into pH value



//All printouts
//Serial.print("Volume: "); //Display the volume on Serial monitor
Serial.print(volume,2);
//Serial.print(" mL");
Serial.print("       ");
//Serial.print("pH: "); //Display the pH on Serial monitor
Serial.println(phValue,2);

delay(500); //180,000 sampling rate
}
```

Receiver

```
from xbee import ZigBee
import serial
import struct
import datetime
import sqlite3
import os, time
import RPi.GPIO as GPIO
import send
import pred
import predicted

GPIO.setmode(GPIO.BOARD)

serial_port = serial.Serial('/dev/ttyUSB0', 9600)
zb = ZigBee(serial_port)
mobile_number = (b'+639285212995')

# EDIT THE MOBILE NUMBER TO MAKE SURE WHO WILL BE RECEIVING THE TEXT MESSAGE

# SENDS MESSAGE IF THE DEVICE IS ONLINE
##online = send.DeviceOnline()


while True:
    try:
        data = zb.wait_read_frame() #Get data for later use
```

```
        #print data # for debugging only
        a = data['source_addr_long']
        b = data['rf_data']
        tree3 = b'\x00\x13\xa2\x00Av\xe0\x99'
        tree5 = b'\x00\x13\xa2\x00Av\xe0O'
        tree2 = b'\x00\x13\xa2\x00Av\xe0\x9a'
        tree4 = b'\x00\x13\xa2\x00Avs\xd9'
        tree1 = b'\x00\x13\xa2\x00A^4\xff'
        date = datetime.datetime.now()
        time = datetime.datetime.now().strftime("%H:%M")

        if  a == tree1:
            tree_num = '1'
            print ('Tree #1')
            print (b)
            b1 = str(b)
            ph1 = float(b1[2:-5])
            ph11 = str(ph1)
            print (ph1)
            c = pred.Prediction(ph11,tree_num,mobile_number)

# INSERTING DATA TO DATABASE
# COMMENT OUT IF READY FOR DEPLOYMENT (default with comment)
            conn = sqlite3.connect('cocotech.db')
            c = conn.cursor()
            c.execute("INSERT INTO tree1 VALUES (?,?)",(date,b))
            conn.commit()
            conn.close()
```

```
        # SENDING MESSAGE IF SAP IS GOOD OR FERMENTED (default no comment)
        if (ph1<6):
            print('fermented sap in container 1')
            messaget1 = smg.harvest1()



        if (6.0<=ph1<=6.5):
            print('sap in container 1 is near fermentation')
            messagettt1 = gsm.harvest1()



    if a == tree2:
        tree_num = '2'
        print ('Tree #2')
        print(b)
        b2 = str(b)
        ph2 = float(b2[2:-12])
        ph22 = str(ph2)
        print (ph2)
        c = pred.Prediction(ph22,tree_num,mobile_number)
# INSERTING DATA TO DATABASE
# COMMENT OUT IF READY FOR DEPLOYMENT (default with comment)
        conn = sqlite3.connect('cocotech.db')
        c = conn.cursor()
        c.execute("INSERT INTO tree2 VALUES (?,?)",(date,b))
        conn.commit()
        conn.close()
```

```
        # SENDING MESSAGE IF SAP IS GOOD OR FERMENTED (default no comment)
        if (ph2<6):
            print('fermented sap in container 2')
            messaget2 = smg.harvest2()
            time.sleep(1)
        if (6.0<=ph2<=6.5):
            print('sap in container 2 is near fermentation')
            messagettt2 = gsm.harvest2()
            time.sleep(1)


    if a == tree3:
        tree_num = '3'
        print ('Tree #3')
        print (b)
        b3 = str(b)
        ph3 = float(b3[2:-12])
        ph33 = str(ph3)
        print (ph3)
        c = pred.Prediction(ph33,tree_num.mobile_number)
# INSERTING DATA TO DATABASE
# COMMENT OUT IF READY FOR DEPLOYMENT (default with comment)
        conn = sqlite3.connect('cocotech.db')
        c = conn.cursor()
        c.execute("INSERT INTO tree3 VALUES (?,?)",(date,b))
        conn.commit()
        conn.close()
```

```
        # SENDING MESSAGE IF SAP IS GOOD OR FERMENTED (default no comment)
        if (ph3<6):
            print('fermented sap in container 3')
            messaget3 = smg.harvest3()
            time.sleep(1)
        if (6.0<=ph3<=6.5):
            print('sap in container 3 is near fermentation')
            messagettt3 = gsm.harvest3()
            time.sleep(1)


    if a == tree4:
        tree_num = '4'
        print ('Tree #4')
        print (b)
        b4 = str(b)
        ph4 = float(b4[2:-5])
        ph44 = str(ph4)
        print (ph4)
        c = pred.Prediction(ph44,tree_num,mobile_number)
# INSERTING DATA TO DATABASE
# COMMENT OUT IF READY FOR DEPLOYMENT (default with comment)
        conn = sqlite3.connect('cocotech.db')
        c = conn.cursor()
        c.execute("INSERT INTO tree4 VALUES (?,?)",(date,b))
        conn.commit()
        conn.close()

        # SENDING MESSAGE IF SAP IS GOOD OR FERMENTED (default no comment)
```

```
        if (ph4<6):
            print('fermented sap in container 4')
            messaget4 = smg.harvest4()
            time.sleep(1)
        if (6.0<=ph4<=6.5):
            print('sap in container 4 is near fermentation')
            messagettt4 = gsm.harvest4()
            time.sleep(1)

    if a == tree5:
        tree_num = '5'
        print ('Tree #5')
        print (b)
        b5 = str(b)
        ph5 = float(b5[2:-5])
        ph55 = str(ph5)
        print (ph5)
        c = pred.Prediction(ph55,tree_num,mobile_number)
# INSERTING DATA TO THE DATABASE
# COMMENT OUT IF READY FOR DEPLOYMENT (default with comment)
        conn = sqlite3.connect('cocotech.db')
        c = conn.cursor()
        c.execute("INSERT INTO tree5 VALUES (?,?)",(date,b))
        conn.commit()
        conn.close()

        # SENDING MESSAGE IF SAP IS GOOD OR FERMENTED (default no comment)
        if (ph5<6):
```

```
            print('fermented sap in container 5')
            messaget5 = smg.harvest5()
            time.sleep(1)
        if (6.0<=ph5<=6.5):
            print('sap in container 5 is near fermentation')
            messagettt5 = gsm.harvest5()
            time.sleep(1)

    except KeyboardInterrupt:
        break

serial_port.close()
```

GSM Notification

```
import serial
import RPi.GPIO as GPIO
import os, time

GPIO.setmode(GPIO.BOARD)

# Enable Serial Communication
port = serial.Serial("/dev/ttyS0", baudrate=9600, timeout=1)

# Transmitting AT Commands to the Modem
# '\r\n' indicates the Enter key

# SENDING A MESSAGE FOR HARVESTING
def sms():
```

```
    port.write(b'AT\r')
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'ATE0\r\n')      ## Disable the Echo
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CMGF=1\r\n')  # Select Message format as Text mode
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CNMI=2,1,0,0,0\r\n')   # New SMS Message Indications
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

# Sending a message to a particular Number

    port.write(b'AT+CMGS="+639285212995"\r\n') # INSERT NUMBER
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)
```

```
    port.write(b'Pwede nang kuhanin ang tuba sa mga puno.\r\n')  # Message
    rcv = port.read(10)
    print (rcv)

    port.write(b'"\x1A"') # Enable to send SMS
    for i in range(10):
        rcv = port.read(10)
        print (rcv)
    print ('Message Sent')

# ONLINE RX INDICATOR
def DeviceOnline():

    port.write(b'AT\r')
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'ATE0\r\n')      ## Disable the Echo
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CMGF=1\r\n')  # Select Message format as Text mode
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)
```

```
    port.write(b'AT+CNMI=2,1,0,0,0\r\n')   # New SMS Message Indications
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

# Sending a message to a particular Number

    port.write(b'AT+CMGS="+639162542809"\r\n')
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'The RX is online.\r\n')  # Message
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'"\x1A"') # Enable to send SMS
    for i in range(10):
        rcv = port.read(10)
        print (rcv)
    print ('Message Sent')

def harvest1():

    port.write(b'AT\r')
    rcv = port.read(10)
    print (rcv)
```

```
    time.sleep(1)

    port.write(b'ATE0\r\n')      ## Disable the Echo
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CMGF=1\r\n')  # Select Message format as Text mode
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CNMI=2,1,0,0,0\r\n')   # New SMS Message Indications
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

# Sending a message to a particular Number

    port.write(b'AT+CMGS="+639162542809"\r\n')
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'Pwede nang kuhanin ang tuba sa Tree #1 pagkatapos ng 15 minuto.\r\n')  #
Message
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)
```

```
    port.write(b'"\x1A"') # Enable to send SMS
    for i in range(10):
        rcv = port.read(10)
        print (rcv)
    print ('Message Sent')
```

Predictive Model

```
# scipy
import scipy
#print('scipy: %s' % scipy.__version__)
# numpy
import numpy
#print('numpy: %s' % numpy.__version__)
# matplotlib
import matplotlib
#print('matplotlib: %s' % matplotlib.__version__)
# pandas
import pandas
#print('pandas: %s' % pandas.__version__)
# scikit-learn
import sklearn
#print('sklearn: %s' % sklearn.__version__)
# statsmodels
import statsmodels
#print('statsmodels: %s' % statsmodels.__version__)
####
from pandas import Series
```

```
#series = Series.from_csv('data.csv', header=0)
#split_point = len(series) - 12
#dataset, validation = series[0:split_point], series[split_point:]
#print('Dataset %d, Validation %d' % (len(dataset), len(validation)))
#dataset.to_csv('dataset.csv')
#validation.to_csv('validation.csv')
#####
#from sklearn.metrics import mean_squared_error
#from math import sqrt
...
#test = ...
#predictions = ...
#mse = mean_squared_error(test, predictions)
#rmse = sqrt(mse)
#print('RMSE: %.3f' % rmse)
####
# prepare data
#X = series.values
#X = X.astype('float32')
#train_size = int(len(X) * 0.50)
#train, test = X[0:train_size], X[train_size:]
##
# walk-forward validation
#history = [x for x in train]
#predictions = list()
#for i in range(len(test)):
        # predict
#       yhat = ...
```

```
#         predictions.append(yhat)
          # observation
#         obs = test[i]
#         history.append(obs)
#         print('>Predicted=%.3f, Expected=%3.f' % (yhat, obs))

##
from sklearn.cross_validation import train_test_split

##train, test = train_test_split(df1, test_size = 0.4)
##train = train.reset_index(drop=True)
##test = test.reset_index(drop=True)

#features_train = train[list(vif['Features'])]
#label_train = train['target']
#features_test = test[list(vif['Features'])]
#label_test = test['target']
##yog

import numpy as np
num = float(input("Enter a pH: "))

if  num in np.linspace(8.5, 9.0 , 6):
    print("Time of harvest is 5 hours and 30 minutes")
if  num  in np.linspace(8.0, 8.4, 5):
    print("Time of harvest is 5 hours and 15minutes")
if  num in np.linspace(7.5, 7.9 , 5):
    print("Time of harvest is 4 hours and 45 minutes")
```

```
if  num  in np.linspace(7.0, 7.4, 5):
     print("Time of harvest is 4 hours and 30minutes")
if  num in np.linspace(6.5, 6.9 , 5):
     print("Time of harvest is  4 hours")
if  num  in np.linspace(6.1, 6.4, 4):
     print("Time of harvest is 3 hours and 45 minutes")
if num == 6:
    print ("the sap reached its ideal pH. The sap should be harvested")
if int(num) < 6:
    print("The sap is fermented")
##
import numpy as np

def Prediction(num,tree_num,mob):

    if  num in np.linspace(8.5, 9.0 , 6):
        print("Time of harvest is 5 hours and 30 minutes")
        t1 = float(5.5)
        s1 = predicted.tree(t1,tree_num,mob)

    if  num  in np.linspace(8.0, 8.4, 5):
        print("Time of harvest is 5 hours and 15minutes")
        t2 = float(5.25)
        s2 = predicted.tree(t2,tree_num,mob)

    if  num in np.linspace(7.5, 7.9 , 5):
        print("Time of harvest is 4 hours and 45 minutes")
        t3 = float(4.75)
```

```
        s3 = predicted.tree(t3,tree_num,mob)

    if  num  in np.linspace(7.0, 7.4, 5):
        print("Time of harvest is 4 hours and 30minutes")
        t4 = float(4.5)
        s4 = predicted.tree(t4,tree_num,mob)

    if  num in np.linspace(6.5, 6.9 , 5):
        print("Time of harvest is  4 hours")
        t5 = float(4)
        s5 = predicted.tree(t5,tree_num,mob)

    if  num  in np.linspace(6.1, 6.4, 4):
        print("Time of harvest is 3 hours and 45 minutes")
        t6 = float(3.75)
        s6 = predicted.tree(t6,tree_num,mob)

    if num == 6:
        print ("the sap reached its ideal pH. The sap should be harvested")
        s7 = predicted.harvest(tree_num,mob)

    if int(num) < 6:
        print("The sap is fermented")
        s8 = predicted.fermented(tree_num,mob)
##
```

```
import serial
import RPi.GPIO as GPIO
import os, time

GPIO.setmode(GPIO.BOARD)

# Enable Serial Communication
port = serial.Serial("/dev/ttyS0", baudrate=9600, timeout=1)

# Transmitting AT Commands to the Modem
# '\r\n' indicates the Enter key

# SENDING A MESSAGE FOR HARVESTING
def tree(t,number,mob):

    number = str.encode(number)
    t = str(t)
    t = str.encode(t)
    port.write(b'AT\r')
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'ATE0\r\n')      ## Disable the Echo
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)
```

```
    port.write(b'AT+CMGF=1\r\n')  # Select Message format as Text mode
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CNMI=2,1,0,0,0\r\n')   # New SMS Message Indications
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

# Sending a message to a particular Number

    port.write(b'AT+CMGS="%b"\r\n' %mob) # INSERT NUMBER
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'Pwede nang kuhanin ang tuba sa Tree #%b pagkatapos ng %b oras.\r\n'%(number
,t))  # Message
    rcv = port.read(10)
    print (rcv)

    port.write(b'"\x1A"') # Enable to send SMS
    for i in range(10):
        rcv = port.read(10)
        print (rcv)
    print ('Message Sent')

# SENDING A MESSAGE FOR HARVESTING
```

```
def harvest(number,mob):

    number = str.encode(number)

    port.write(b'AT\r')
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'ATE0\r\n')      ## Disable the Echo
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CMGF=1\r\n')  # Select Message format as Text mode
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CNMI=2,1,0,0,0\r\n')   # New SMS Message Indications
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

# Sending a message to a particular Number

    port.write(b'AT+CMGS="%b"\r\n' %mob) # INSERT NUMBER
    rcv = port.read(10)
```

```
    print (rcv)
    time.sleep(1)

    port.write(b'Pwede nang kuhanin ang tuba sa Tree #%b.\r\n'%(number))  # Message
    rcv = port.read(10)
    print (rcv)

    port.write(b'"\x1A"') # Enable to send SMS
    for i in range(10):
        rcv = port.read(10)
        print (rcv)
    print ('Message Sent')

def fermented(number,mob):

    number = str.encode(number)

    port.write(b'AT\r')
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'ATE0\r\n')      ## Disable the Echo
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CMGF=1\r\n')  # Select Message format as Text mode
```

```
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'AT+CNMI=2,1,0,0,0\r\n')   # New SMS Message Indications
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

# Sending a message to a particular Number

    port.write(b'AT+CMGS="%b"\r\n' %mob) # INSERT NUMBER
    rcv = port.read(10)
    print (rcv)
    time.sleep(1)

    port.write(b'Hindi maari ang tuba sa Tree #%b.\r\n'%(number))  # Message
    rcv = port.read(10)
    print (rcv)

    port.write(b'"\x1A"') # Enable to send SMS
    for i in range(10):
        rcv = port.read(10)
        print (rcv)
    print ('Message Sent')


def treee(num,time):
```

```
print("Pwede nang kunin sa Tree #%b makaraan ang %b na oras")
```

APPENDIX D

Billing of Materials and Cost Analysis

Appendix D

Billing of Materials and Cost Analysis

Billing of Materials

Material	Quantity	Unit	Unit Cost (₱)	Amount (₱)
Tx Chassis	5	pc	1550	7750
Ultrasonic Chassis	5	pc	150	750
Temperature Sensor	5	pc	150	750
4.7 k ohm resistor	5	pc	1	5
Waterproof pH sensor	5	pc	3200	16000
XBee 3mW Wire Antenna S2C	5	pc	1500	7500
XBee Explorer USB	5	pc	500	2500
Ultrasonic Sensor	5	pc	100	500
Arduino Nano	5	pc	450	2250
Powerbank	10	pc	500	5000
M-F Jumper Wires	80	pc	3	240
M-M Jumper Wires	80	pc	3	240
Belt	10	pc	125	1250
16 pins Header	10	pc	15	150
Rx Chassis	1	pc	1100	1100
XBee 3mW Wire Antenna S2C	1	pc	1500	1500
XBee Explorer USB	1	pc	500	500
Raspberry Pi 3 Model B	1	pc	2400	2400
SIM800L GSM Module	1	pc	875	875
DS3231 RTC	1	pc	150	150
16 GB Sandisk SD Card	1	pc	500	500
Raspberry Pi Black Case	1	pc	300	300
			Total:	**52, 210**

Cost Analysis

Total Amount of Prototype per tree:
For Transmitter: P 8,416.00 per tree which has 5 units
For Receiver: P3,500.00 * 1 unit = P 3,500.00/5 trees = P700.00 per tree
P 8416.00 + P700.00 = **P9,116.00 total amount of prototype per tree**

A ratio of **8L of coconut sap : 1kg of coconut sugar** is needed for the coconut sugar production.
84.555L /n = 8/1
n = 8.45555 x P200.00/ kg of coconut sugar
= 1691.1
(P9,116.00 *30)/ 1691.1 = **149**
.368 days or approximately equal to 5 months before the expenses will return

APPENDIX E

Documentation

Appendix E

Documentation

Fresh Coconut Sap

Mr. Felimon Janero's Coconut Farm

Mr. Felimon Janero’s Farm House

Assembling of Devices at Villa Mayor Farm

Installed Transmitter System at Ms. Loza's Farm

Changing of Power Banks at Ms. Loza's Farm

Group Picture at Alabat Port

Group Picture with Ms. Mylene of PCA-Alabat

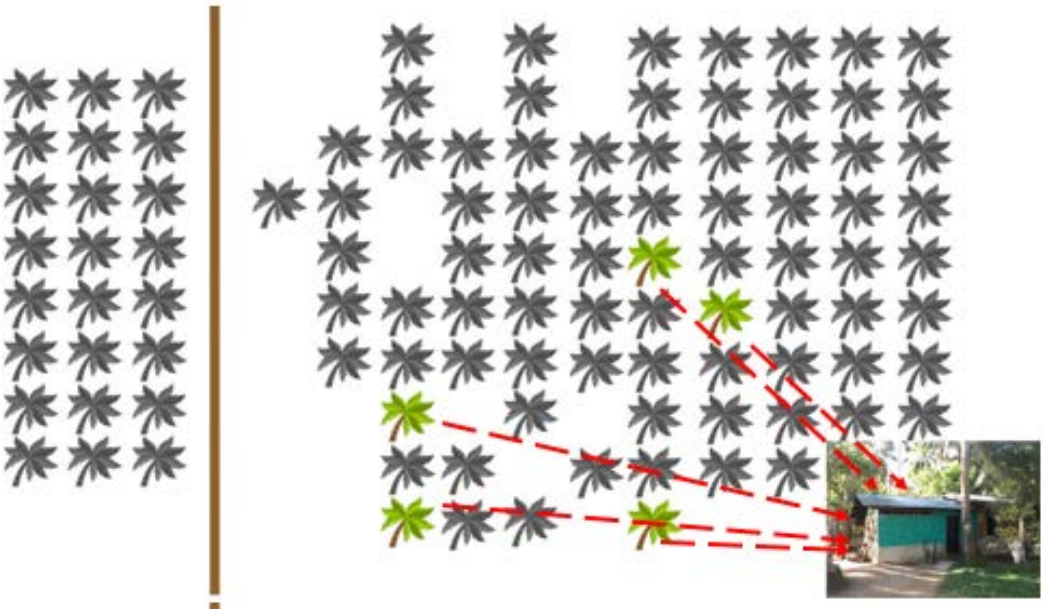
Group Picture with Kuya Lester, coconut farmer at Villa Mayor Farm

Group Picture with Kuya Johndel and Kuya Jonathan, coconut farmers at Ms. Loza's Farm

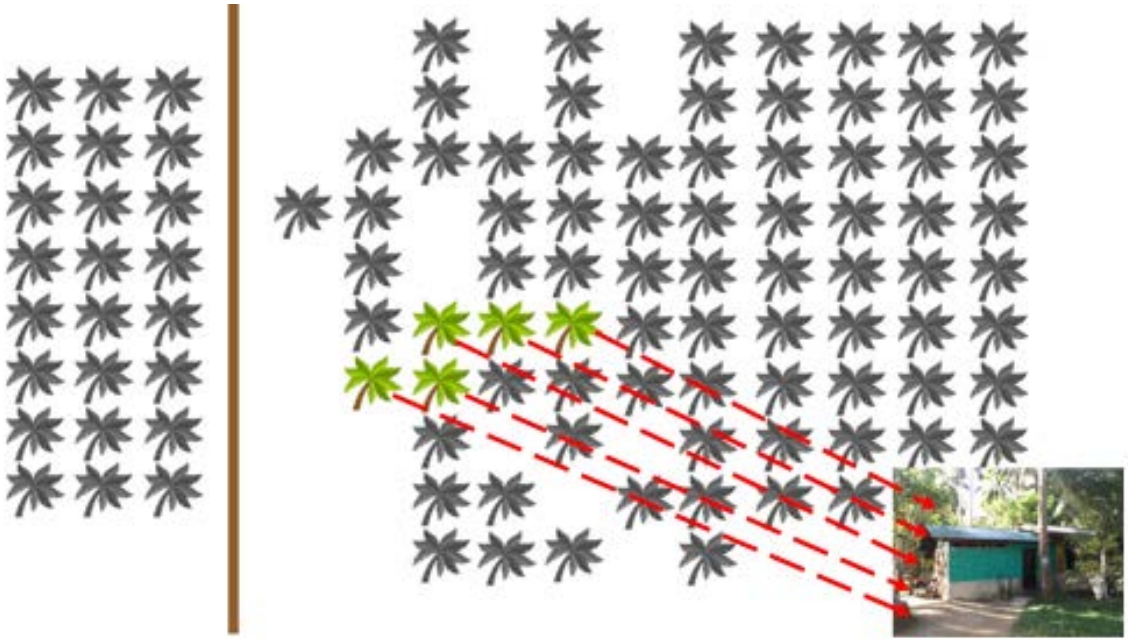
Group Picture with the Soliano Family, coconut farmers and coco-syrup maker of Mr. Janero's Farm

Cocopals Pre-Final Defense Group Photo

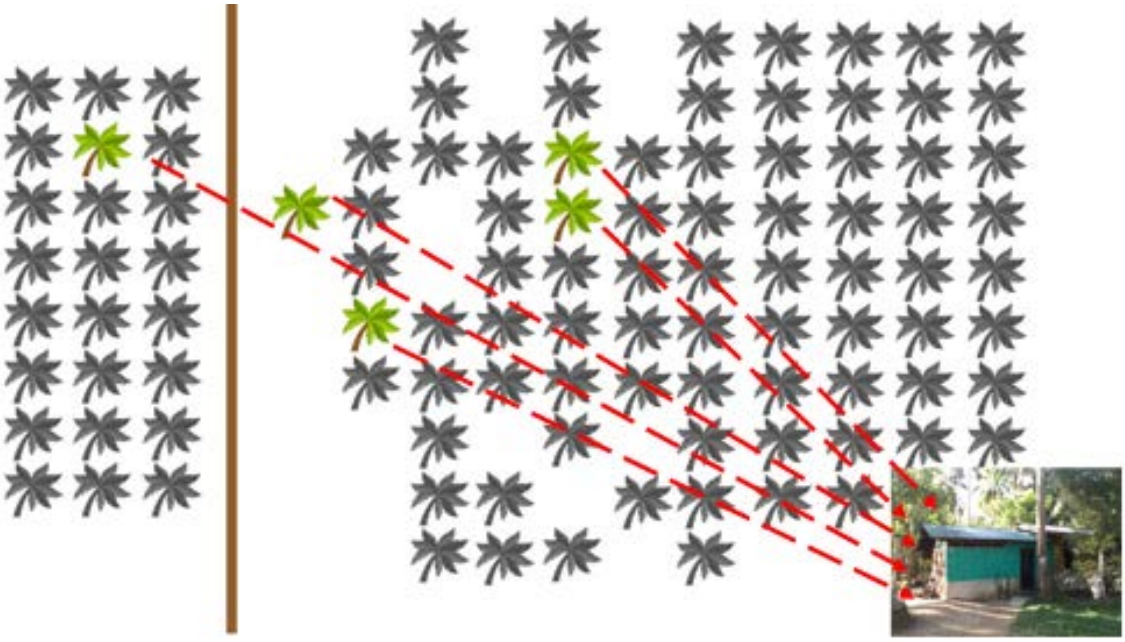
Final Defense Group Photo



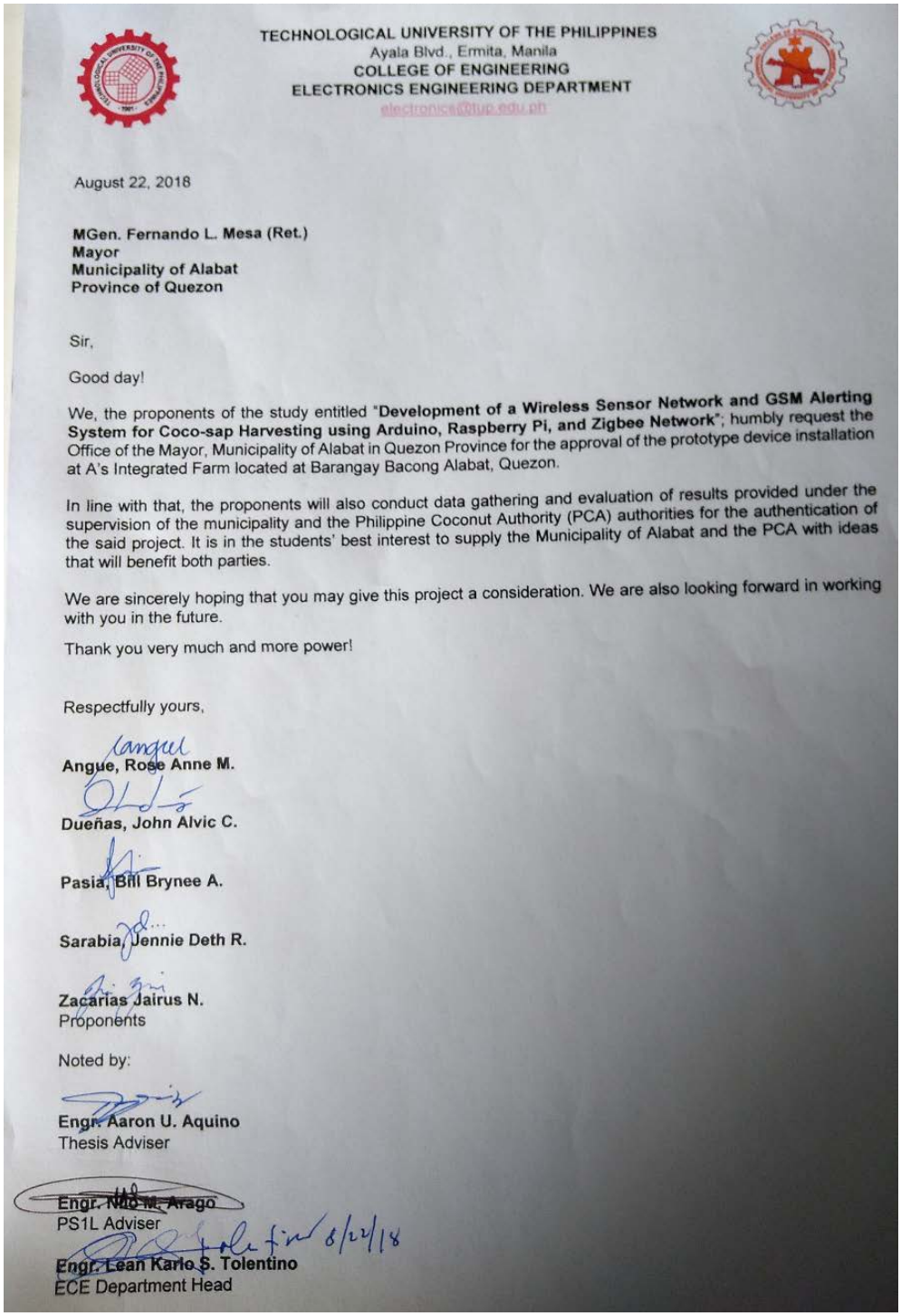
Layout Diagram Day 1



Layout Diagram Day 2



Layout Diagram Day 3



TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES
Ayala Blvd., Ermita, Manila
COLLEGE OF ENGINEERING
ELECTRONICS ENGINEERING DEPARTMENT
electronics@tup.edu.ph

August 22, 2018

MGen. Fernando L. Mesa (Ret.)
Mayor
Municipality of Alabat
Province of Quezon

Sir,

Good day!

We, the proponents of the study entitled "**Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and Zigbee Network**"; humbly request the Office of the Mayor, Municipality of Alabat in Quezon Province for the approval of the prototype device installation at A's Integrated Farm located at Barangay Bacong Alabat, Quezon.

In line with that, the proponents will also conduct data gathering and evaluation of results provided under the supervision of the municipality and the Philippine Coconut Authority (PCA) authorities for the authentication of the said project. It is in the students' best interest to supply the Municipality of Alabat and the PCA with ideas that will benefit both parties.

We are sincerely hoping that you may give this project a consideration. We are also looking forward in working with you in the future.

Thank you very much and more power!

Respectfully yours,

Angue, Rose Anne M.

Dueñas, John Alvic C.

Pasia, Bill Brynee A.

Sarabia, Jennie Deth R.

Zacarias Jairus N.
Proponents

Noted by:

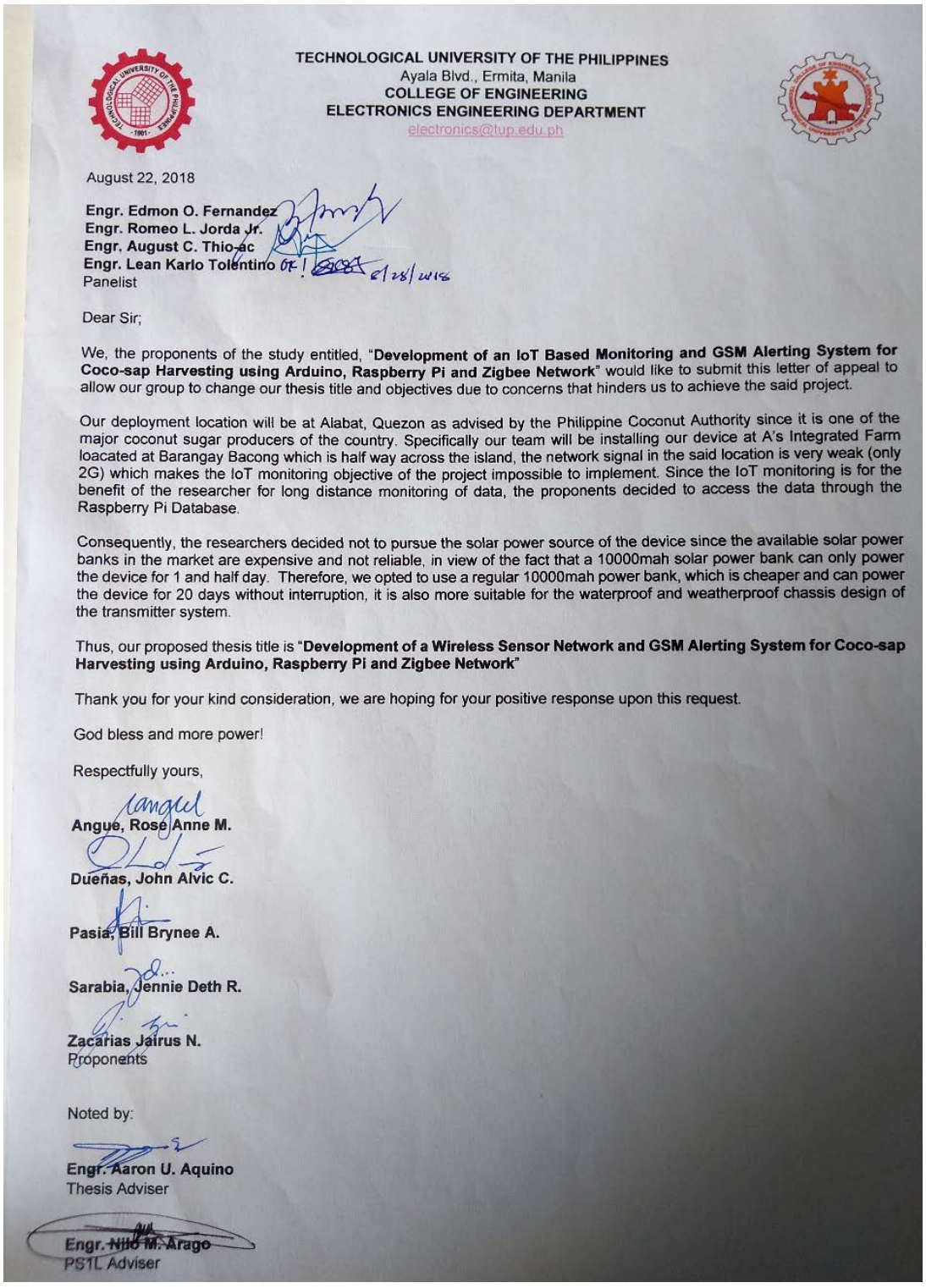
Engr. Aaron U. Aquino
Thesis Adviser

Engr. Nilo M. Arago
PS1L Adviser

8/22/18

Engr. Lean Karlo S. Tolentino
ECE Department Head

Deployment Letter



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August 22, 2018

Engr. Edmon O. Fernandez
Engr. Romeo L. Jorda Jr.
Engr. August C. Thio-ac
Engr. Lean Karlo Tolentino
Panelist

Dear Sir;

We, the proponents of the study entitled, "**Development of an IoT Based Monitoring and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi and Zigbee Network**" would like to submit this letter of appeal to allow our group to change our thesis title and objectives due to concerns that hinders us to achieve the said project.

Our deployment location will be at Alabat, Quezon as advised by the Philippine Coconut Authority since it is one of the major coconut sugar producers of the country. Specifically our team will be installing our device at A's Integrated Farm loacated at Barangay Bacong which is half way across the island, the network signal in the said location is very weak (only 2G) which makes the IoT monitoring objective of the project impossible to implement. Since the IoT monitoring is for the benefit of the researcher for long distance monitoring of data, the proponents decided to access the data through the Raspberry Pi Database.

Consequently, the researchers decided not to pursue the solar power source of the device since the available solar power banks in the market are expensive and not reliable, in view of the fact that a 10000mah solar power bank can only power the device for 1 and half day. Therefore, we opted to use a regular 10000mah power bank, which is cheaper and can power the device for 20 days without interruption, it is also more suitable for the waterproof and weatherproof chassis design of the transmitter system.

Thus, our proposed thesis title is "**Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi and Zigbee Network**"

Thank you for your kind consideration, we are hoping for your positive response upon this request.

God bless and more power!

Respectfully yours,

Angue, Rose Anne M.

Dueñas, John Alvic C.

Pasia, Bill Brynee A.

Sarabia, Jennie Deth R.

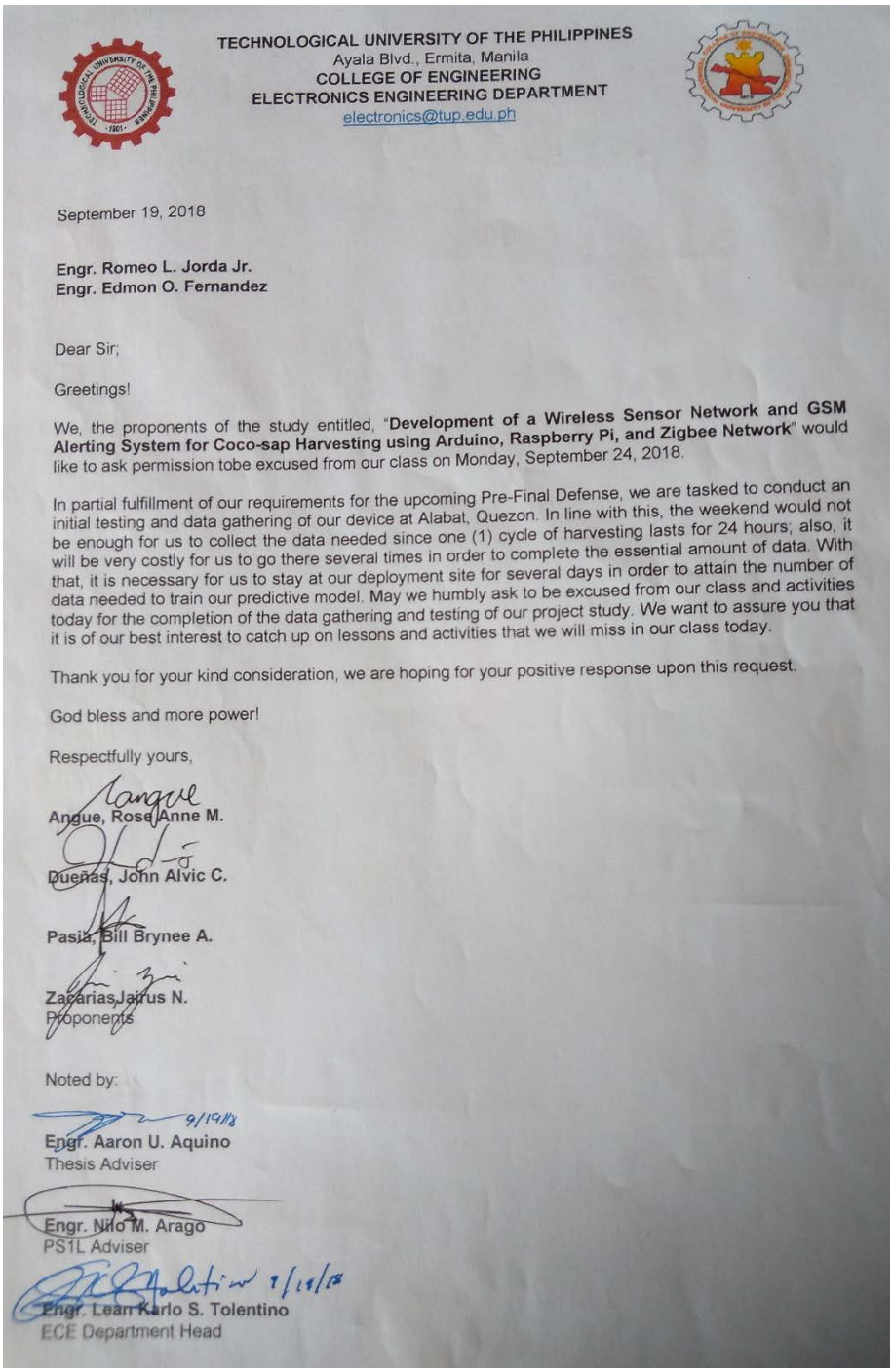
Zacarias Jairus N.
Proponents

Noted by:

Engr. Aaron U. Aquino
Thesis Adviser

Engr. Nilo M. Arago
PS1L Adviser

Letter of Appeal



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September 19, 2018

Engr. Romeo L. Jorda Jr.
Engr. Edmon O. Fernandez

Dear Sir;

Greetings!

We, the proponents of the study entitled, "**Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and Zigbee Network**" would like to ask permission tobe excused from our class on Monday, September 24, 2018.

In partial fulfillment of our requirements for the upcoming Pre-Final Defense, we are tasked to conduct an initial testing and data gathering of our device at Alabat, Quezon. In line with this, the weekend would not be enough for us to collect the data needed since one (1) cycle of harvesting lasts for 24 hours; also, it will be very costly for us to go there several times in order to complete the essential amount of data. With that, it is necessary for us to stay at our deployment site for several days in order to attain the number of data needed to train our predictive model. May we humbly ask to be excused from our class and activities today for the completion of the data gathering and testing of our project study. We want to assure you that it is of our best interest to catch up on lessons and activities that we will miss in our class today.

Thank you for your kind consideration, we are hoping for your positive response upon this request.

God bless and more power!

Respectfully yours,

Angue, Rose Anne M.

Dueñas, John Alvic C.

Pasia, Bill Brynee A.

Zacarias, Jairus N.
Proponents

Noted by:

9/19/18
Engr. Aaron U. Aquino
Thesis Adviser

Engr. Nilo M. Arago
PS1L Adviser

9/19/18
Engr. Lean Karlo S. Tolentino
ECE Department Head

Excuse Letter for Deployment

Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and ZigBee Network

SURVEY FORM

Pangalan: Rommel Soliano Petsa: 02/03/19

Itiman ang bilog ng bilang ayon sa antas ng kasiyahan.
5 bilang pinakamataas at 1 ang pinakamababa.

	1	2	3	4	5
Kahusayan (Efficiency)					
• Nakakakuha ng magandang kalidad ng cocosap ang debays				●	
• Ang paalala sa pagkuha ng Cocosap ay nasa tamang oras					●
Kapakinabangan (Functionality)					
• Mas maraming nakokolektang cocosap sa tulong ng debays				●	
• Tamang sukat ng dami nang nakokolektang cocosap				●	
• Walang nasasayang na cocosap sa paggamit ng debays				●	
Katatagan (Stability)					
• Ang debays ay kayang tagalan ang anumang uri ng panahon					●
• Ang debays ay tuloy-tuloy sa paggana					●
Kadalian sa Paggamit (User –Friendly)					
• Ang debays ay madaling gamitin				●	
• Ang mga instraksyon sa paggamit ng debays ay medaling intindihin					●
Panlabas na Kaanyuan (Aesthetics)					
• Ang debays ay may kaaya-ayang pisikal na itsura				●	
• Ang mga parte ng debays ay nasa tamang ayos at pagkasalansan					●

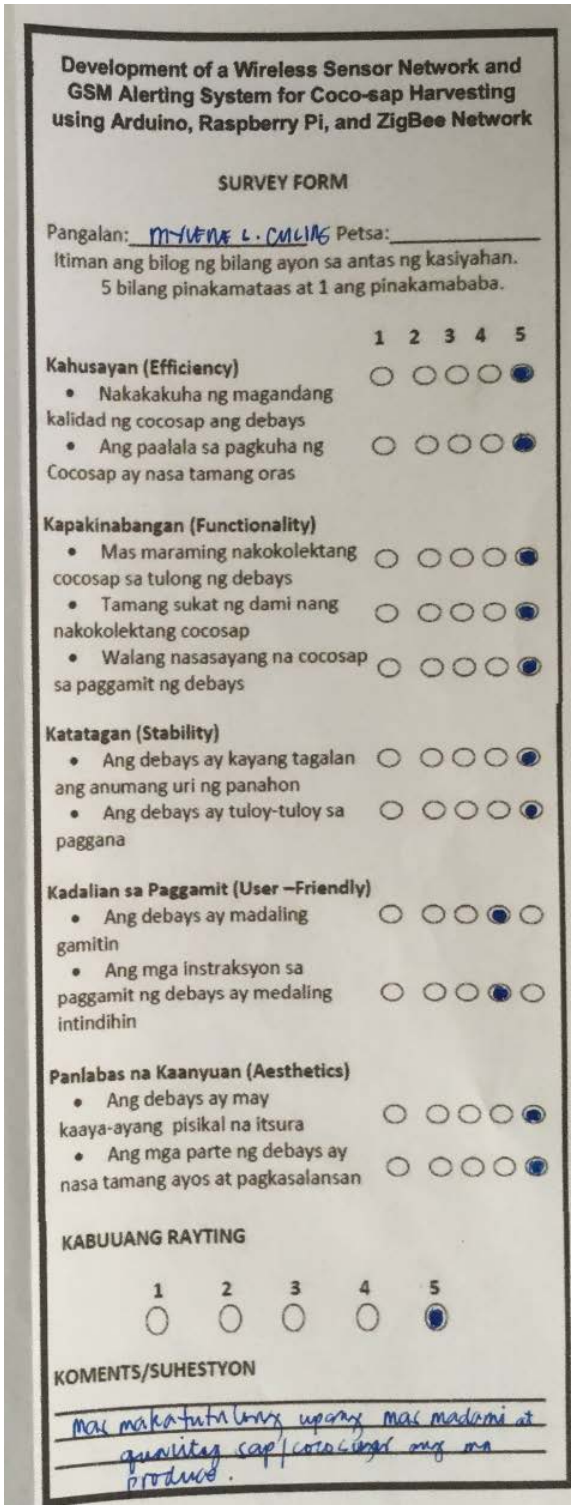
KABUUANG RAYTING

1	2	3	4	5
○	○	○	●	○

KOMENTS/SUHESTYON

Mas Maganda ang Pagkolekta ng Cocosap sa Tulong ng Debays Dahil nasa Tamang Oras

Client Evaluation Form Respondent 1



Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and ZigBee Network

SURVEY FORM

Pangalan: MYLENE L. CULING Petsa: _____

Itiman ang bilog ng bilang ayon sa antas ng kasiyahan.
5 bilang pinakamataas at 1 ang pinakamababa.

	1	2	3	4	5
Kahusayan (Efficiency)					
• Nakakakuha ng magandang kalidad ng cocosap ang debays	○	○	○	○	●
• Ang paalala sa pagkuha ng Cocosap ay nasa tamang oras	○	○	○	○	●
Kapakinabangan (Functionality)					
• Mas maraming nakokolektang cocosap sa tulong ng debays	○	○	○	○	●
• Tamang sukat ng dami nang nakokolektang cocosap	○	○	○	○	●
• Walang nasasayang na cocosap sa paggamit ng debays	○	○	○	○	●
Katatagan (Stability)					
• Ang debays ay kayang tagalan ang anumang uri ng panahon	○	○	○	○	●
• Ang debays ay tuloy-tuloy sa paggana	○	○	○	○	●
Kadalian sa Paggamit (User –Friendly)					
• Ang debays ay madaling gamitin	○	○	○	●	○
• Ang mga instraksyon sa paggamit ng debays ay medaling intindihin	○	○	○	●	○
Panlabas na Kaanyuan (Aesthetics)					
• Ang debays ay may kaaya-ayang pisikal na itsura	○	○	○	○	●
• Ang mga parte ng debays ay nasa tamang ayos at pagkasalansan	○	○	○	○	●

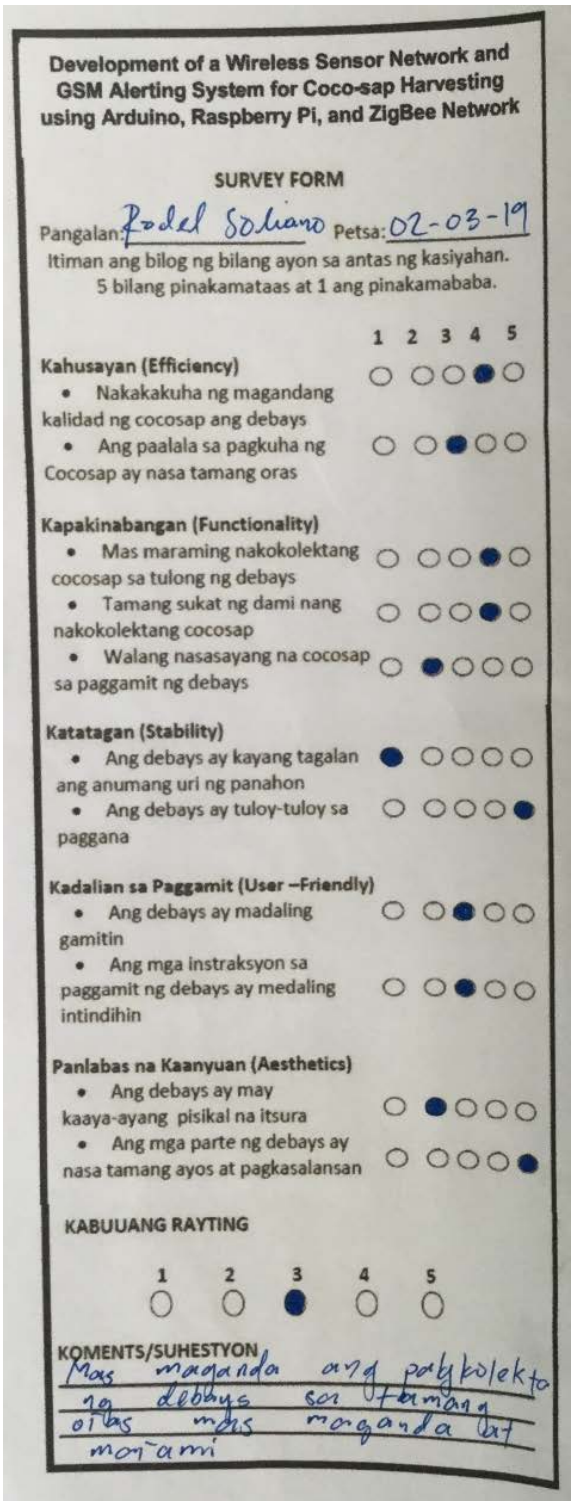
KABUUANG RAYTING

1	2	3	4	5
○	○	○	○	●

KOMENTS/SUHESTYON

Mas makatutulong upang mas madami at quality sap/cocosugar ang ma produce.

Client Evaluation Form Respondent 2



Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and ZigBee Network

SURVEY FORM

Pangalan: Rodel Soliano Petsa: 02-03-19

Itiman ang bilog ng bilang ayon sa antas ng kasiyahan.
5 bilang pinakamataas at 1 ang pinakamababa.

	1	2	3	4	5
Kahusayan (Efficiency)					
• Nakakakuha ng magandang kalidad ng cocosap ang debays	○	○	○	●	○
• Ang paalala sa pagkuha ng Cocosap ay nasa tamang oras	○	○	●	○	○
Kapakinabangan (Functionality)					
• Mas maraming nakokolektang cocosap sa tulong ng debays	○	○	○	●	○
• Tamang sukat ng dami nang nakokolektang cocosap	○	○	○	●	○
• Walang nasasayang na cocosap sa paggamit ng debays	○	●	○	○	○
Katatagan (Stability)					
• Ang debays ay kayang tagalan ang anumang uri ng panahon	●	○	○	○	○
• Ang debays ay tuloy-tuloy sa paggana	○	○	○	○	●
Kadalian sa Paggamit (User –Friendly)					
• Ang debays ay madaling gamitin	○	○	●	○	○
• Ang mga instraksyon sa paggamit ng debays ay medaling intindihin	○	○	●	○	○
Panlabas na Kaanyuan (Aesthetics)					
• Ang debays ay may kaaya-ayang pisikal na itsura	○	●	○	○	○
• Ang mga parte ng debays ay nasa tamang ayos at pagkasalansan	○	○	○	○	●

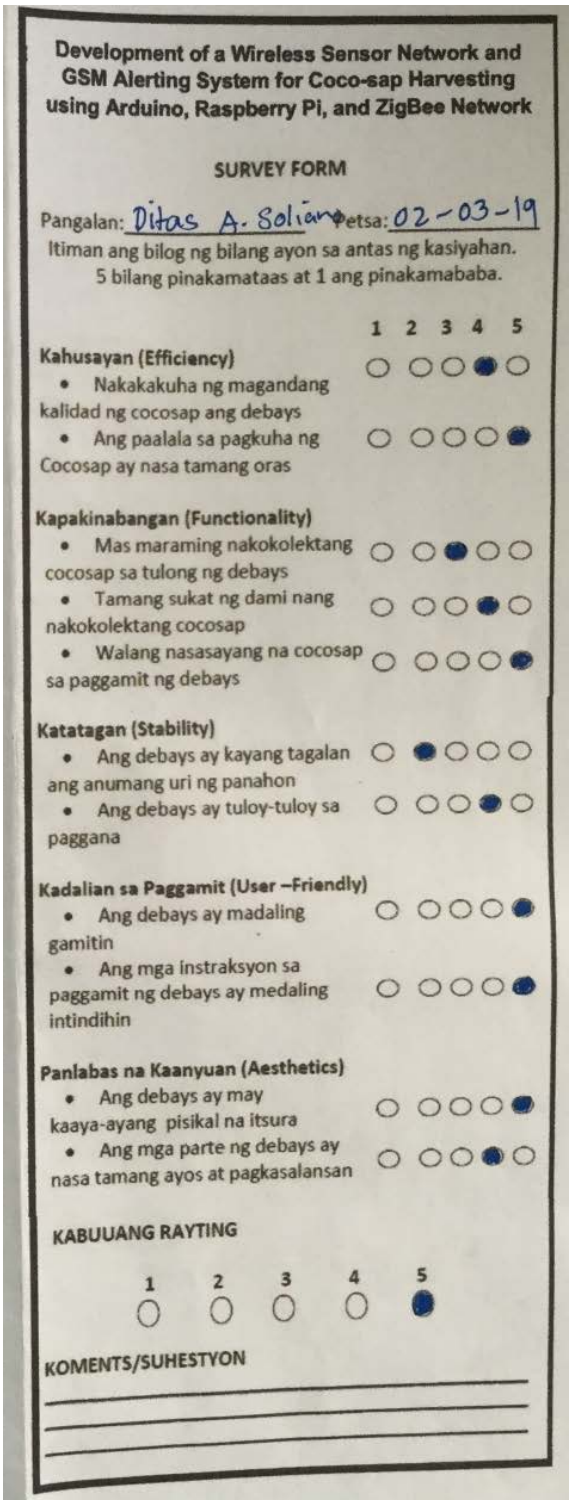
KABUUANG RAYTING

1	2	3	4	5
○	○	●	○	○

KOMENTS/SUHESTYON

Mas maganda ang pagkolekto ng debays sa tamang oras mas maganda kay mamimi

Client Evaluation Form Respondent 3



Development of a Wireless Sensor Network and GSM Alerting System for Coco-sap Harvesting using Arduino, Raspberry Pi, and ZigBee Network

SURVEY FORM

Pangalan: Ditas A. Soliano Petsa: 02-03-19

Itiman ang bilog ng bilang ayon sa antas ng kasiyahan.
5 bilang pinakamataas at 1 ang pinakamababa.

	1	2	3	4	5
Kahusayan (Efficiency)					
• Nakakakuha ng magandang kalidad ng cocosap ang debays				●	
• Ang paalala sa pagkuha ng Cocosap ay nasa tamang oras					●
Kapakinabangan (Functionality)					
• Mas maraming nakokolektang cocosap sa tulong ng debays			●		
• Tamang sukat ng dami nang nakokolektang cocosap				●	
• Walang nasasayang na cocosap sa paggamit ng debays					●
Katatagan (Stability)					
• Ang debays ay kayang tagalan ang anumang uri ng panahon		●			
• Ang debays ay tuloy-tuloy sa paggana				●	
Kadalian sa Paggamit (User –Friendly)					
• Ang debays ay madaling gamitin					●
• Ang mga instraksyon sa paggamit ng debays ay medaling intindihin					●
Panlabas na Kaanyuan (Aesthetics)					
• Ang debays ay may kaaya-ayang pisikal na itsura					●
• Ang mga parte ng debays ay nasa tamang ayos at pagkasalansan				●	

KABUUANG RAYTING

1	2	3	4	5
				●

KOMENTS/SUHESTYON

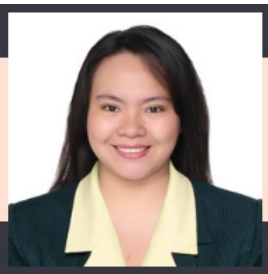
Client Evaluation Form Respondent 4

APPENDIX F

Researchers' Information

Appendix F

Researchers' Profile



ROSE ANNE M. ANGUE, ECT

BACHELOR OF SCIENCE IN ELECTRONICS ENGINEERING

CAREER OBJECTIVE

I am a hardworking person seeking to work on a company where I can apply my knowledge and skills in the field of communications for continuous improvement and to grow as a career professional.

CONTACT

+639 068301616
+639 202011078
roanneangue@gmail.com
Bucal 3A, Maragondon, Cavite

CORE COMPETENCIES

- WRITING SKILLS
- EXCELLENT COMMUNICATION
- PROJECT MANAGEMENT
- RESEARCH DEVELOPMENT
- TECHNICAL COMPETENCE

SKILLS

- ABILITY TO WORK UNDER PRESSURE
- HIGHLY ORGANIZED
- PUNCTUAL
- CRITICAL THINKER
- OPTIMISTIC
- FLEXIBLE
- TEAM PLAYER
- FAST LEARNER
- TRUSTWORTHY

REFERENCE

Engr. Aaron U. Aquino
Faculty, TUP-Manila
aaron_aquino@tup.edu.ph
09285212995

Engr. Nilo M. Arago
College Secretary,
College of Engineering,
TUP-Manila
301 3001 Loc.504

TECHNICAL SKILLS

- MS OFFICE PROFICIENT
- KNOWLEDGEABLE WITH SOFTWARE TOOLS SUCH AS PHOTOSHOP, MATLAB, AND MULTISM
- BASIC KNOWLEDGE IN PROGRAMMING LANGUAGES SUCH AS C/C++, AND JAVA
- FAMILIAR WITH LINUX OPERATING SYSTEM
- KNOWLEDGEABLE IN ELECTRONIC TOOLS SUCH AS MULTIMETER, AND OSCILLOSCOPE

WORK EXPERIENCE

Intern
DEPARTMENT OF SCIENCE AND TECHNOLOGY - ADVANCED SCIENCE AND TECHNOLOGY INSTITUTE (DOST - ASTI)
Research and Development Division
ASTI Bldg., UP Technology Park Complex, C.P. Garcia Ave., Diliman, Quezon City
November 21, 2018 - February 15, 2019

EDUCATION

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES - MANILA
Bachelor of Science in Electronics Engineering
Ayala Blvd., Ermita, Manila City
2014-Present

CAVITE NATIONAL SCIENCE HIGH SCHOOL
(Regional Science High School)
Garita A, Maragondon, Cavite
2010-2014

QUALIFICATIONS

LICENSED ELECTRONICS TECHNICIAN
October 2017
Professional Regulation Commission

CAREER CIVIL SERVICE PROFESSIONAL ELEGIBITY
August 2017
Civil Service Commission

AFFILIATIONS AND AWARDS

INSTITUTE OF ELECTRONICS ENGINEERS OF THE PHILIPPINES (IECEP)
Member
2017 - Present

ORGANIZATION OF ELECTRONICS ENGINEERING STUDENTS (OECES)
Member
2014-Present

CHED, STUDENT FINANCIAL ASSISTANCE
Scholar
2017-Present

INTERNATIONAL SUSTAINABLE WORLD (ENGINEERING, ENERGY, AND ENVIRONMENT) PROJECT OLYMPIAD (HOUSTON, TEXAS, USA)
Bronze Medalist
2014

TRAININGS AND SEMINARS

AUGUST 2018	THE E-WASTE PROJECT ORIENTATION
AUGUST 2018	PHOTOSHOP WORKSHOP
FEBRUARY 2018	CAD WORKSHOP
FEBRUARY 2018	STRENGTHENING THE ENGINEERING RESEARCH FOR A DEVELOPING WORLD

JOHN ALVIC C. DUEÑAS, ECT

MY BACKGROUND

I am an Electronics Engineering student major in Communications at Technological University of the Philippines.

KNOWLEDGE AND SKILLS

Programs (Basic):
MATLAB
NI Multisim
Autodesk Fusion 360
Microsoft Word, Excel, and PowerPoint
Adobe Photoshop
Sony Vegas Pro,
Octave,
LabVIEW

Programing Language (Basic):
C, C++, and HTML

REACH ME AT:

+639265774433
johnacd019@gmail.com
AlvicDuenas
Buhay na tubig, Imus, Cavite

WORK BACKGROUND

Intern
DOST-ASTI | November 2018 - February 2019
- Experienced in using iTOP, OpenDCIM, Linux Ubuntu, CentOS, and OpenStack

CERTIFICATION AND MEMBERSHIP

Passed, Licensure Examination for Electronics Technician
October 2017 - Professional Regulation Commission

CAD Workshop
February 17, 2018 - De La Salle Santiago Zobel University, Muntinlupa

Photoshop Workshop 2018
August 28, 2018 - Technological University of the Philippines

Member, Institute of Electronics Engineers of the Philippines (IECEP)
October 2017 to present

Member, Organization of Electronics Engineering Students (OECES)
2014 to present

REFERENCE

Engr. Aaron U. Aquino
Faculty, TUP-M
aaron_aquino@tup.edu.ph
09285212995

Engr. Nilo M. Arago
College Secretary,
College of Engineering
TUP-M
301 30001 Loc. 504

OTHER SKILLS

- *Music and Video Editor*
- *Animator*
- *High school badminton varsity player*
- *Athlete*
- *Computer literate*

BILL BRYNEE A. PASIA, ECT

2706 Ma. Aurora Street Poblacion Makati City Metro Manila
Contact number: 09162542809
Email Address: bill.brynee@gmail.com

CAREER OBJECTIVES:

- To acquire a career in a competitive industry in line with my field of specialization (Telecommunications), to further develop the knowledge and skills I learned from school, and to grow as a professional utilizing innovative management technologies involving telecommunications.

PERSONAL INFORMATION:

Date of Birth	October 9, 1997
Age	20
Place of Birth	Lipa City, Batangas
Civil Status	Single
Citizenship	Filipino
Language	Filipino and English
Religion	Roman Catholic

EDUCATIONAL BACKGROUND:

Tertiary Education	**Technological University of the Philippines – Manila (TUP-M)** *Ayala Boulevard Ermita, Manila, Philippines* 2014 – Present
Secondary Education	**San Rafael High School** (Provincial High School, Region IV-B) *Abra de Ilog, Occidental Mindoro, Philippines* 2010 – 2014
Primary Education	**Abra de Ilog Central School** *Abra de Ilog, Occidental Mindoro, Philippines* 2004 -2010

CERTIFICATIONS AND MEMBERSHIPS

- **PASSED**, Licensure Examination for Electronics Technician – October 2017, Professional Regulation Commission
- Member, Institute of Electronics Engineers of the Philippines (IECEP) – October 2017 to present
- Member, Organization of Electronics Engineering Students (OECES) –

SKILLS / CORE COMPETENCIES

- Proficient in communication and maintaining collaborative relationships in organizations
- Efficient in time management
- Proficient in Microsoft Software Programs, such as Word, PowerPoint and Excel, and other like programs
- Knowledgeable in programming

CHARACTER REFERENCE

- **Engr. Nilo M. Arago**
  Technological University of the Philippines - Manila
  College Secretary/Graduate Program Coordinator
  College of Engineering
  301 3001 Loc.504

- **Engr. Aaron Aquino**
  Technological University of the Philippines – Manila
  Faculty Professor – ECE Department
  College of Engineering
  aaron_aquino@tup.edu.ph
  09285212995

- **Atty. Leonid Lee C. Serrano**
  Former Executive Assistant to the Head of Office
  Department of Finance – International Finance Office
  Head Corporate Lawyer
  KMC Savills Group of Companies
  leonidlee.serrano@gmail.com
  09088885155

I hereby certify that the above information are true and correct to the best of my knowledge and ability.

Applicant's Signature

JENNIE DETH R. SARABIA

Blk 3 Lt 8 Brixtonville Subdivision
Diamond Drive Camarin Caloocan City
09465627853
jenniedethriverasarabia@gmail.com

CAREER OBJECTIVE

To acquire a career in a competitive company in lined with my field of specialization, Telecommunications to further develop the knowledge and skills learned from school and to grow as a professional.

SKILLS

- Proficient in communication and leadership
- Efficient in time management
- Proficient in Microsoft Softwares like Word,Powerpoint and Excel

PERSONAL INFORMATION:

Date of Birth	September 13, 1997
Age	21
Place of Birth	Caloocan City
Civil Status	Single
Citizenship	Filipino
Language	Filipino and English
Religion	Roman Catholic

EDUCATIONAL BACKGROUND:

Tertiary Education	Technological University of the Philippines Ayala Boulevard Ermita, Manila, Philippines 2014 – Present
Secondary Education	Camarin High School Cadena de Amor, Barangay 174, Caloocan City , Metro Manila Honorable Mention 2010 – 2014

Primary Education	Mystical Rose School of Caloocan Inc. #15 Ilang-ilang St. Almar Subdivision Camarin Caloocan City Honorable Mention 2004 -2010

CERTIFICATIONS AND MEMBERSHIPS

- Member, Organization of Electronics Engineering Students (OECES) – 2014 to present
- Member, DOST Scholars Club (TUP Manila) - 2014 to 2018
- Scholar, DOST RA 7687 Scholarship - 2014-2018
- Scholar, Caloocan City College Financial Assistance - 2014- present
- Scholar, CHED Student Financial Assistance - 2016 to present

AWARDS AND RECOGNITIONS

- Consistent Honor Student - Elementary to High School
- The Icon,Official Publication of Camarin High School (2014) - Associate Editor
- The Icon,Official Publication of Camarin High School (2014) - News Editor
- The Icon,Official Publication of Camarin High School (2013)- Photojournalist
- 2014 Division DepEd Radio Broadcasting Competition - Third Place
- 2014 Division DepEd Radio Broadcasting Competition - Best in Scriptwriting

CHARACTER REFERENCE

- Engr. Nilo M. Arago
  College Secretary/Graduate Program Coordinator
  College of Engineering - TUP Manila
  301 3001 loc. 504

- Engr. Aaron U. Aquino
  Faculty
  aaron_aquino@tup.edu.ph
  09285212995

JAIRUS N. ZACARIAS, ECT

27 Marathon St., Brgy. Obrero, Quezon City 1103
+63 9396369781 / +63 9759006616
jairuszac@gmail.com
https://www.linkedin.com/in/jairus-zacarias-17b937143

CAREER OBJECTIVE

To obtain a position in the field of microelectronics/electronic communications/information technology that will harness my skills and to gain experience in which I can impart my knowledge to the growth of the company.

SKILLS & ABILITIES

Technical

- ✓ Programming in Arduino, MATLAB/Octave, C/C++; familiar with Java language
- ✓ Skilled in electronics prototyping
- ✓ Computer literacy: Experienced in using major MS Office applications, NI Multisim, ExpressPCB; with basic knowledge in Autodesk AutoCAD and NI LabVIEW
- ✓ Experienced in using XBee hardware (Zigbee protocol) in creating wireless sensor networks
- ✓ Consumer Electronics Servicing
- ✓ With basic knowledge in PC hardware and software maintenance
- ✓ Woodworking

EDUCATIONAL ATTAINMENT

Tertiary
BS IN ELECTRONICS ENGINEERING WITH MAJOR IN COMMUNICATIONS
Technological University of the Philippines – Manila
June 2014 – March 2019
DOST SCHOLAR – MERIT

Secondary
STRENGTHENED TECHNICAL-VOCATIONAL EDUCATION PROGRAM WITH SPECIALIZATION IN ELECTRONICS
Don Alejandro Roces, Sr. Science -Technology High School
June 2010 – March 2014

WORK EXPERIENCE

Intern, Research and Development Division-Electronics Product Development Center(EPDC) Project, Department of Science and Technology - Advanced Science and Technology Institute
Quezon City, Philippines
November 2018 - March 2018

AFFILIATIONS & CERTIFICATIONS

Professional Regulation Commission, Electronics Technician, 2017 – Present

Institute of Electronics Engineers of the Philippines, Inc., Associate Member, 2017 – Present

Organization of Electronics Engineering Students (OECES), Member, 2014 - Present

CHARACTER REFERENCES

Engr. Aaron U. Aquino
Instructor
College of Engineering
Technological University of the Philippines – Manila
+63 9285212995
aaron_aquino@tup.edu.ph

Engr. Nilo M. Arago
College Secretary/ Graduate Program Coordinator
College of Engineering
Technological University of the Philippines – Manila
301 3001 loc. 504

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Baldovino, R. G., Bautista, M. G., Aquino, A. U., Calilung, E. J., Sybingco, E., & Dadios, E. P. (2017). GA Optimization of Coconut Sugar Cooking Process: A Preliminary Study using Stochastic Universal Sampling (SUS) Technique.

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Aquino, A. (2017). GA Optimization of Coconut Sugar Cooking Process: A Preliminary Study using Stochastic Universal Sampling (SUS) Technique.

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Rogienfisz, M. (2017). Liquid Monitoring System in Industrial Tanks with Ultrasonic Sensor.

Sidik, M. M., & Ghani, S. C. (2017). Volume Measuring System Using Arduino for Automatic Liquid Filling Machine.

Trinidad, T. (2015). *Coconut sap sugar and syrup: a promising functional food/ingredient*. Retrieved from http://www.pca.da.gov.ph/coconutrde/images/sugarpdfs/TPTrinidad_FNRI.pdf

TURNITIN RESULT