A LOCALIZED DATA LOGGER FOR WATER RELATED DISASTER

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Master of Science in Information Technology

NIKKO ARDEL P. FLORETES

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APPROVAL SHEET

The thesis entitled **"A LOCALIZED DATA LOGGER FOR WATER RELATED DISASTER"**, has been prepared and submitted by **NIKKO ARDEL P. FLORETES**, who having passed the comprehensive examination, is hereby recommended for oral examination.

ENGR. JON ALVIN L. MACARIOLA, MSIT
Adviser

Approved by the Committee on Oral Examination on February 26, 2018 with a rating of **PASSED**.

FELISA E. GOMBA, Ph. D.
Acting Dean, College of Graduate Studies, SSU
Chairman

VIVIAN L. MOYA, Ph. D.
TLISO Director
Member

MARYJES G. CALADES, MSIT
MSIT Instructor
Member

RONALD L. ORALE, Ph. D.
Vice-President, Planning, Research & Extension Services
Member

Accepted and approved in partial fulfillment of the requirements for the Degree, Master of Science in Information Technology.

February 26, 2018
Date of Oral Defense

FELISA E. GOMBA, Ph. D.
Acting Dean, College of Graduate Studies

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- NIKETES

ABSTRACT

The study aimed to develop a localized data logger system for water related disaster. This study used applied development research design because it is focused on the development of a device. Since this was a developmental study, then there were details for the gathering of information on the testing of the device. The following were the significant findings derived from the study. Functionality test was conducted in Antiao River to come up with an assessment on how reliable the data are. A three-day test for the evaluation of the device that operated 24 hours. In addition, an effectiveness test of the mobile application was also conducted. Cost analysis was also presented to have a summary on the expenditure of the project. The following conclusions were considered, The data revealed that the functions of the product conform to the desired purposes of the study which are to log water level variation and flow rate. The product was reliable because on the consistency of its functions especially that it was operated in the Line-of-Sight propagation. The mobile application was also reliable for giving the logged data to the user. The product cost was very minimal on this type of project. he following recommendations were considered significant to enhance the capability of the developed product. To incorporate a sensor that could have a reading on the velocity on the rising of water.

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CHAPTER 1

THE PROBLEM AND ITS SETTING

Introduction

Climate change is happening now, and it grows fast as the earth's gases trap the heat from the sun resulting on not releasing it to the outer space. According to NASA (2017) most climate scientists agree with the main cause of the current global warming trend is human expansion of the "greenhouse effect" – warming that results when the atmosphere traps heat radiating from Earth toward space. Certain gases in the atmosphere block heat from escaping. Long-lived gases that remain semi-permanently in the atmosphere and do not respond physically or chemically to changes in temperature are described as "forcing" climate change.

There are climate change impacts such as environmental, social and economic. These impacts will be adverse and out of its severity, it can cause rise of earth's average temperature. Climate change brings extreme weather conditions and there will be a worldwide experience on it. Most of the impacts are water-related, that is why this is now the focus of this study. According to the study of Grayman (2011), the categorization of water-related disasters are floods, storms, waves, slides, droughts, epidemics, contamination and climate change.

Floods can happen to a place if the drainage system is not totally good or the place is a flood prone area. Sometimes, even if there is no typhoon, there are flooding on some areas because of rains. But, when it comes to river flooding, then there must be a greater force or event that could lead to overflow the river. According to EPA (2016), climate change may cause river floods to become larger or more frequent than they used to be in some places, yet become smaller and less frequent in other places. As warmer temperatures cause more water to evaporate from the land and oceans, changes in the size and frequency of heavy precipitation events may in turn affect the size and frequency of river flooding.

As experienced from the devastating typhoon Haiyan (local name is Yolanda), most people died because of storm surge. This type of water disaster as stated by National Hurricane Center (2017) is an abnormal rise of water level because of a storm and above the predicted astronomical tide. Another disaster is tsunami, wherein it is a giant or powerful waves that most often caused by earthquakes. Like a disaster happened in Japan on March 11, 2011 where a savage tsunami was experienced in the Northeastern Japan because of the magnitude-9 earthquake ("Japan Earthquake," 2017).

There is a flood forecasting and warning system project of National Irrigation Administration (NIA), National Power Corporation, and Philippine Atmospheric, Geophysical and Astronomical Services Administration (JICA, 2017). This project is Flood Forecasting and Warning System for Dam Operation (FFWSDO), wherein it mitigates flood damages by giving warning to the nearby communities because of dam operations. The said project was installed in five dam sites (Ambuklao and Binga dams in Agno River Basin, Magat Dam in the Cagayan River Basin, Angat and Pantabangan dams in the Pampanga River basin). Another project of DOST-PAGASA is Koica Project, wherein it is installed on rivers to monitor flood and it has an operation center as well as it has warning facilities (siren and voice) backed by Korean technology (HMD-PAGASA, 2017). The main drawbacks of the said systems were some of the equipment was not functioning, the system had misconfiguration, there was a slow process of information distribution and a centralized system. Moreover, a problem can occur if there is an upcoming flood then there is a failure to transmit the data going to the equipment in giving warnings. Through this failure of transmitting the data, the data will not be received to give warning. On the other hand, system misconfiguration draws a lot of attention since it can result to miscommunication of the whole system. Large power consumption loss is inevitable because the system transmits data but no one receives it.

From the occurrence of the drawbacks of the equipment mentioned above, the researcher developed a localized flood warning system and has features of smart environmental network and wireless mesh topology with real-time monitoring for fast data access. With this system, the transmission of data is consistent even if one node in the network malfunctions. With the utilization of a smart environment, it offers a stand-alone system for data acquisition and it scans the network first if there are nodes that are not good then there will be no data going to those malfunctioned nodes. It results to less power consumption. The said system can be accessed via mobile application of the users to monitor flood even without Operation Center (Control Office). Therefore, the system is decentralized meaning the user can directly access the network for fast data information. This device can still operate even if there is no power from electric companies and no internet connection. And, the water level was anchored to Project NOAH (2018), as Low is <0.5m, Moderate is 0.5m to 1.4m & High is >=1.5m.

Statement of the Problem

The study aimed to develop a localized data logger system for water related disaster. Specifically, this study was guided by the following questions:

1. What water related disaster parameters in terms:
    1.1. Normal depth;
    1.2. Critical depth; and
    1.3. Greater than critical depth?
2. What data logger can be developed in terms of:
    2.1. Warning system;
    2.2. Data log on water level variations; and
    2.3. Flow rate?
3. What is the acceptability of the developed localized data logger in terms of:
    3.1. Functionality; and
    3.2. Cost?

Theoretical Framework

This study was anchored to Bernoulli Principle which is a Swiss Physicist and Mathematician. His principle defines the relationships between density, pressure and fluid velocity at every point (Serway, 1996).

The application of the said principle in the study was about the flow rate reading. If the flow is smooth, then it is said to be in laminar flow which means that the reading is normal. If the velocity hits above a certain limit, then it is called turbulent flow. If that happens, then there will be an assumption that the water level will increase.

Conceptual Framework

As shown in Figure 1, it is illustrated the conceptual paradigm for the whole system.

The input portion talks about the variables such as precipitation and run-off. Those variables mentioned were the parameters that can cause flood and fast water flow. Rivers are the primarily affected with these events that results to river overflow and fast river current.

The said outcomes from the input variables were the variables to be measured in this study. Water level and water flow monitoring systems were developed to measure water variations, specifically on the water level detection and flow rate. Using a localized type of sensor from an operational amplifier for the detection of water level. And, a water flow sensor for the reading of flow rate.

The results from the reading of the variables were logged in the mobile application installed in mobile phones. There were date, time and data coming from the water level and flow rate readings that were reflected in the said mobile application. The user can now read the data by just accessing the network.

If there are problems, then there would be feedback mechanism in order to correct the said problems by re-designing of the system, and troubleshooting.

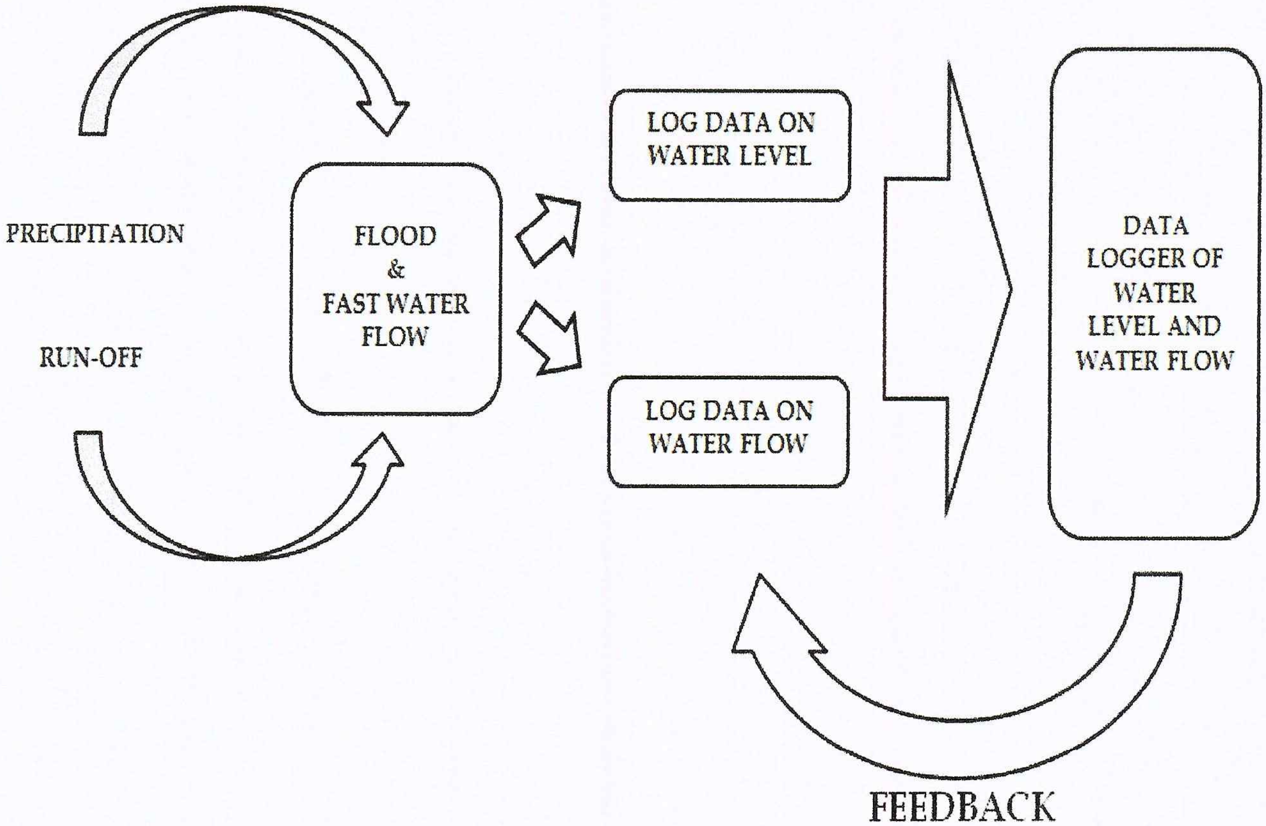

Figure 1. Conceptual Framework of the Study

Significance of the Study

The results of the study would be beneficial to the following:

Leaders in Communities/Barangay Officials. This would be very essential in local communities that are always experiencing flood, especially floods because of rivers. The head of the community can have an access to the system, and if it tells that there is a water level variation or it indicates that it is dangerous then the leader must disseminate the information immediately for evacuation.

Local Communities. With the developed system, the residents of a particular community can be aware if there will be a flood that will happen to their community especially if they are near to a body of water such as sea, rivers etc. They can access the data to the network so that they can be cognizant on disasters that may come to their community.

Fisher Folks. It could provide them information if there is an upcoming water related disaster just like flooding or fast water flow. From that, they can now have an idea that it can be dangerous in their fishing area.

Farmers. This could be beneficial also to them because there are cases that most farms are affected by floods. The system can also detect floods when placed on flood prone areas. There are cases that most farmers are unaware that their farms are prone to floods, therefore this system can help them to harvest early to avoid the loss of crops by way of accessing the data on the network. The system can give warning to them if a particular farm will experience flood.

Disaster Risk Reduction Management Officials/Rescuers. This would be helpful for them in the sense that they can be knowledgeable if there is water related disaster (flood). They can respond immediately if there will be accidents in a particular place.

Future Researchers. Future researchers can use this study as literature for studies similar in nature. Such that, they can solve the problems that the present study have. They can also innovate the study if such problems are addressed correctly in order to give benefits to its users.

Scope and Delimitation

The developed project was tested in Antiao River in order to determine the river's water condition. This was tested for three (3) days for the reliability test and functionality test. The scope of the testing of the system was in the said river since there are communities located near to it. The study was all about river flooding and flow rate. In addition, this system was capable to operate even if there is no power or internet connection.

The power supply for this device can last for at least a month, however it can be depleted, so this can be considered also as a limitation of this study. In addition, the transmission of signal must be in Line-of-Sight propagation. Moreover, the system used Bluetooth so it is limited only to one user at a time and the system requires android mobile phones. The system does not have the velocity on the rise of water level. Lastly, there are limitations on the range of the RF modules.

Definition of Terms

The following terms are given with its definitions to allow the readers to understand the nature of this research.

Base Station. It is responsible for the data transmission of water level readings and flow rate to the Nodes. This was configured as a Router.

Coordinator. It is a special router. In addition to all of the router capabilities, the coordinator is responsible for forming the network (Silicon Labs, 2012). In this study, it is the main component for the connections of the routers.

Data Logger. A compact, battery-powered device equipped with an internal microprocessor, data storage, and one or more sensors, or sensor ports. Data loggers can be deployed in a variety of environments to record measurements at set intervals for up to years at a time, unattended (Onset, n.d.). In this study, it talks about the characteristics of the system that are handy, has sensor on water level and flow rate, operates at DC voltage and can be deployed on remote environments.

Flood. It is the rising of water in a place because of precipitation, run-off etc. It is the main focus of the study.

Flow Rate. Flow is the total volume of a fluid that flows past a fixed point in a river or stream over time. It is comparable to the speed at which a volume of fluid travels (Appropedia, 2017). In this study, it one of the variables that needs to be measured.

Node. Any system or device connected to a network (Techterms, n.d.). In this study, it pertains to the coordinator, routers and mobile phones that are connected to the network.

Router. A hardware device designed to receive, analyze and move incoming packets to another network. It may also be used to convert the packets to another network interface, drop them, and perform other actions relating to a network (Computer Hope, n.d.). In this study, it is where the mobile phones and sensors are connected.

Water Flow Sensor. It is used to measure the flow rate in the river.

Water Flow. – is the amount of water that flows per unit time. It is similar with flow rate. The unit for this is Liters/Hour.

Water Level Sensor. It is used to detect the level of substances that can flow. Such substances include liquids, slurries, granular material and powders. Level measurements can be done inside containers or it can be the level of a river or lake. Such measurements can be used to determine the amount of materials within a closed container or the flow of water in open channels (Rs Hydro, n.d.). In this study, this is the detecting element that can give water level indicators.

CHAPTER 2

RELATED LITERATURE AND STUDIES

Literature and studies cited that were related to the present study had undergone a scrutinized review. The sources of these articles came from books, journals, patent documents, published/unpublished master/s thesis, dissertations, magazines, internet and other media related documents.

Related Literature

Extreme water-related disaster nowadays are all pointing out to climate change. According to Sperling and Szekely (2005), climate change has implications for disaster risk management as it impacts on the exposure to hydro-meteorological hazards (e.g. storms, floods and droughts), and also modulates underlying risk factors, which influence the vulnerability to environmental hazards and therefore the probability of a disaster occurring. In general, the following changes should be recognized in their implications for managing disasters. In addition, climate change is expected to lead to more intense precipitation events for many areas causing a higher probability of floods, landslides, avalanches and soil erosion with associated damages. Since 1975, El Niño events have become more frequent in comparison to La Niña episodes. Climate change is likely to intensify droughts and floods associated with El Niño events (Prizzia, 2015).

Satterthwaite (2011) stated in his editorial article entitled “Why is community action needed for disaster risk reduction and climate change adaptation?” that some organizations cannot design and build the citywide infrastructure that is so important for resilience to storms and heavy rainfall – for instance, storm and surface drains and road and bridge networks that can cope with sudden and much increased volumes of water. On this aspect, the researcher developed a data logger monitoring system that can handle sudden increase of water level.

A study of Porio (2011) entitled "Vulnerability, Adaptation, and Resilience to Floods and Climate Change-Related Risks among Marginal, Riverine Communities in Metro Manila" talked about the vulnerability, adaptation, and resilience of households in the three riverine flood prone communities such as a) Pasig-Marikina River basin, b) West Mangahan and c) KAMANAVA area (Kalookan, Malabon, Navotas, Valenzuela). According to the study, about two-thirds suffered losses from typhoons, floods and storm surge highlighting the effect of climate change.

Further, the study of Di Baldassarre, et al. (2014) entitled "Floods and societies: the spatial distribution of water-related disaster risk and its dynamics" implied that the traditional methods on flood protection structures cannot give assessment on reducing the frequency or magnitude of floods or vulnerability to flooding. In this case, the study discussed on giving assessment if there will be an upcoming disasters like flood, fast water current etc. It can also help with the risk reduction related on reducing flood hazard.

Project NOAH (2018) has a website and a mobile application (ARKO) that are accessible by the public for their weather forecasts, landslides, floods, storm surge and many more hazards.

The said projects were all about hazard maps. These would inform the public on what particular place that the hazard will occur. For example about floods, it shows to the website and to the mobile app that these barangays of a certain municipality will be flooded. Obviously, you can access it if there is an internet connection. On the present study, it can still be accessible even if there is no internet connection. Moreover, the device can give accurate reading of water level as well as water flow.

Another project of DOST-PAGASA was all about Flood Early Warning System (HMD-PAGASA, 2017). KOICA Projects 1 and 2 were under this program. Gandara River was one of the beneficiaries which had the installation of this technology to monitor the river. The system has a warning system facilities (siren and voice) for the community and since it is a centralized system, all the data must undergo first to the operation center before distributing it to the public.

The present study differs from the said study mainly in the system itself. The present study used decentralized system wherein it does not have an operation center. The main advantages for this type of system are: a) fast access of data, since the data can be accessed directly to the network instead of going it first to the operation center before disseminating it; b) real-time monitoring, it is when there is an updated information in the system unlike the centralized one, for example the flood is already happening and yet the data is still on its way to the operation center and there would be a process again before distributing it to the public. The said project has a siren that potentially detects high water level. However, it is only limited to the locality that is near to it. Nearby communities will be unaware if there will be flood since they would not be able to hear the siren from the system. Therefore, if one node of the present study will be installed on those communities, the people on those communities would be aware and resilient on the warning signals that there would be flood in their communities.

A study that pertains to the critical flow of river by Magirl, et al. (2009). The study used instruments such as ADCP and an electronic pitot-static tube to measure flow velocities. The tallied a maximum mean velocity of 3.7m/s with ADCP, and 5.2 m/s using the pitot tube with an instantaneous velocities up to 6.5 m/s.

This is helpful to the present study concerning the velocities of the water. However, the present study used flow rate to measure the water flow of the river which is in L/Hr. This is comparable to the velocity of water in which a volume of fluid travels (Appropedia, 2017).

With these studies, it helped the researcher to identify problems related to the area of the study. In addition, the data gathered was added in the formulation of the solution to solve such problems with floods.

Related Studies

A study entitled "Flood Modelling using Artificial Neural Network" by Ruslan et al. (2013), talks about ANN modeling for flood water level for giving warning system by using BPNN with NN Inverse Model. It has a Back Propagation algorithm and it seeks to minimize the value of error function from Artificial Neural Network.

The system has similarity with the present study in the sense that both are related to flood. However, the present study was not about modeling for giving flood warning, instead it is an actual basis for giving flood warning. The use of a smart environment made it different since the present study used it on sending the data to node that if one node is not operational, then the system would decide on which node the data would be transmitted. Then from that, there would be less power consumption of the system. Power consumption is very essential because it gives life to the system and the system must last for at least several months if there will be disasters that would occur. Meanwhile, the previous system used neural network on analyzing the data for flood modeling.

A patent by Azid et al. (2017) entitled "GSM Based Early Flood Warning and Monitoring System", wherein it is about measuring the water level and if it surpasses a certain threshold set by the user, then the device will give alerting message to the populace and authorities by means of SMS (short message system). The user can monitor also the level by calling the device and the device will reply with an SMS that contains the relevant data.

Hence, this device is similar on giving warning if there will be flood. But, it differs on the process of information dissemination. The said device sends the data via SMS, and the present study gives the data via mobile phone. The said device does not have a smart environment network that could give decision on sending data. In addition, if there are disasters, most cases there are no cellphone signal. Therefore, if that is the scenario, accessing the device is impossible. Nevertheless, the present study developed a device that can be accessed even if there is no cellphone signal.

Another patent document by Jiansheng and Xiaoming (2015) with the title "Dynamic Optimization based Neural Network Flood Warning Device and Method" which discussed about a device that can give flood warning based on modeling. It has a historical data that to establish a neural flood forecasting model. It assimilates the normalized data with the information of the GPS satellite and GIS module.

This study was based on modeling from a historical data that is analyzed by a neural network. It has GPS and GIS and it gives information by a short message. Meanwhile, the present study used WSN (Wireless Sensor Network) as the backbone of the system. It gives on-time monitoring of water level regardless of cellphone signal and power from electric companies. Then it has a mobile application for the information of the flood for the users.

Another patent by Zhanhui et al. (2017) entitled "Intelligent Urban Flood Early Warning Management System", it talks about a smart city flood early warning management system. The core sensing device comprises a magnetic field by the base plate and magnet cover and it enhances the actual functions of the system.

The present study used a localized water level sensor made up of operational amplifier. The present study had a smart environment network for the automatic data gathering and sending of data to the nodes. It utilizes Bluetooth technology so that the users can access the data.

A study entitled "Water Level Monitoring and Flood Alert System" by Shivaray, et al. (2014) presented a system that is designed to provide alert using short message system before flood will happen. It has also a database about the history of water level in a certain place and it has a centralized server which can perform all the jobs from data collection to sending message before flood.

The study is similar in the sense that both studies are for giving flood alert, but they differ from the mode of communication. The said study had SMS feature to provide alert messages, while the present study had its own network for giving information to the user. It has a wireless mesh topology network, wherein it can send the information to any nodes of the network. Even though that there is no power on one of the nodes, the system can still send information because of this topology network.

In addition, a developed study "Flood Detector System Using Arduino" by De Guzman, et al. (2016) wherein it states that a flood detection monitoring system that could detect water level rising. Utilizing an ultrasonic sensor for the input sensor, then attached to the Arduino Yun to process the sensor's analog signal into usable digital value of distance. The user can get real-time information on monitoring of flooded roads over the live stream plus SMS based service.

The difference of the said study with the present study is on the utilization of ultrasonic sensor to detect flood or rising of water while the present study used an operational amplifier for a localized water level sensor. In addition, the present study highlights its potential to transmit data even if there is no cellphone signal. SMS based service is relying on the signal provided by the network.

A study conducted by Kato et al. (2015) entitled "Design of an Automated River Water Level Monitoring System by using Global System for Mobile Communications" talks about a system that monitors water level of rivers. If there will be a minimum or maximum values from the threshold value, then an SMS message will be sent to the user. Also, there is a database about the monitoring purposes. After the gathering of data, the Arduino microcontroller would send the data to the database of the head office station via GSM Modem.

The study is similar to the present study when it comes to the process of monitoring. Both studies have certain threshold value for the water level and it will send signal to the concerned user or even to other user. However, the differences are: a) the mode of communication of the present study was wireless mesh topology based network, so it can communicate to any nodes and it does not rely on the signal by the cellphone network provider unlike with the said study since they are using SMS; b) it can send the data to other nodes if the network detects that one of the nodes is malfunctioning, while the said study used a GSM modem for transmitting the data to the database, however if it malfunctions then the data will not be transmitted; c) the present study was adaptive to a disaster setting setup since it can still operate even if there is no power; d) the present study uses a localized water level from operational amplifier unlike the said study that uses ultrasonic sensor.

CHAPTER 3

METHODOLOGY

This chapter discusses the methods and materials in order to develop this study.

Research Design

This study used applied development research design because it is focused on the development of a device. Since this was a developmental study, then there were details for the gathering of information on the testing of the device.

Functionality test was conducted by observation on the performance of the developed device. There was a record of the parameters from the observations made in order that they can be subsequently analyzed. Parameters such as multi-level water detection and water flow values were the data to be logged.

Instrumentation

The researcher used programming software, measuring equipment, modules and electronic components for the development of the device.

A measuring equipment such as multi-tester was utilized in order to check the output voltage of the sensors and the microcontrollers. Programming software on the other hand was focused on the syntax for each microcontroller of the system.

Major components and modules were discussed in this chapter for further understanding of the developed device.

System Components

Water Level Sensor

Figure 2 shows a localized sensor that was made out of an operational amplifier that served as the water level sensor. It was connected to a microcontroller for data analysis. It has a digital output wherein the microcontroller of this study only accepts digital signals as its input.

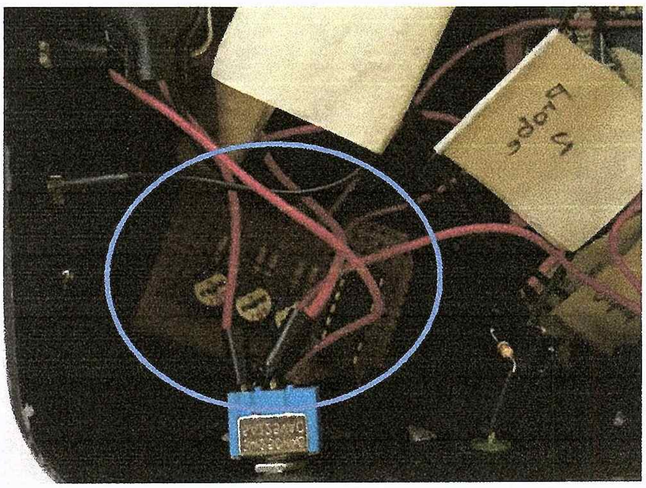

Figure 2. Localized Water Level Sensor

Control Unit

Figure 3 shows the microcontroller (Atmega328P-PU) used in the study. It served as the head of the system, wherein all data must go first to this controller for data processing.

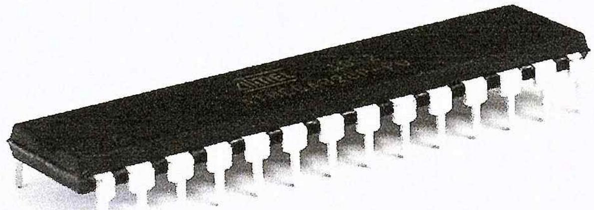

Figure 3. Microcontroller

Transmitting Module

This study used XBee modules (Fig. 4) that operates in Zigbee protocol (802.15.4). This handled the long range communication between the Base Station and the nodes for the transmission of data. It operates an Outdoor/RF Line-of-Sight range of 1200 meters.

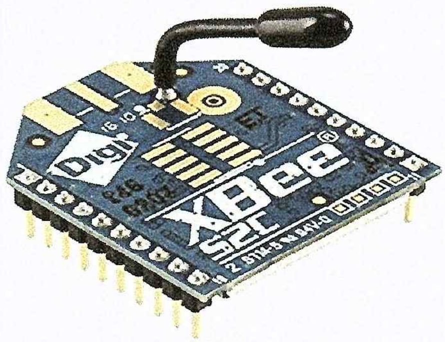

Figure 4. XBee module

Communication Module

This study utilized Bluetooth technology (Fig. 5) to serve as the gateway of the users to access the data. They can connect their mobile phones with the mobile application installed that is exclusively dedicated to the device. Then, they can now have the access to the device with the monitoring of water level. The range is approximately 10 meters.

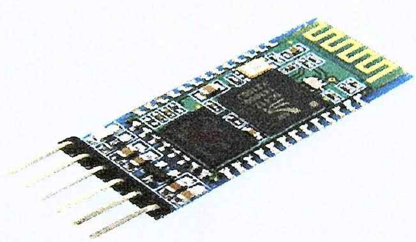

Figure 5. Bluetooth Module

Water Flow Sensor

The study used water flow sensor as shown in figure 6 in order to have a reading on the flow rate. It was connected to the microcontroller for data processing. The unit for the water flow is in L/Hr.

Figure 6. Flow Sensor for Water

Validation of the Instrument

The researcher calibrated and validated the materials by conducting tests. For the water level sensor, it was tested on a container that has water if it can detect water variations. Water flow sensor was also tested by making the motor rotate and watch over the readings. For the RF modules, they were first configured in order to communicate with the same network by using a software (XCTU). Bluetooth module was also configured together with the microcontroller if it can be detectable by mobile phones and can be connected as well.

Sampling Procedure

For the evaluation of the product, it was tested during the first week of March, 2018. The researcher tested the functionality and reliability of the device for three (3) days. The product was placed at the side of the Antiao River to gather data without human intervention for seventy-two (72) hours.

For the effectiveness test under the functionality test, the researcher distributed the questionnaires for the assessment of the mobile application if it served its purpose.

Data Gathering Procedure

As for the data gathering, the researcher conducted the testing on the functions of the device such as to detect water level and water flow reading. At first, the researcher set the measurement for each level (Low, Medium and High) according to the Project NOAH's website on the flood tab. The probes of the water level sensor were placed on a blue pipe with designated level of measurement.

The flow sensor was positioned at the bottom of the river. The researcher made a casing that was submersible since the said sensor was not designed for underwater purposes. Flow rate was recorded to the device as well as the water level reading.

Moreover, the Effectiveness Test Questionnaires were distributed to ten (10) respondents. The following respondents were five (5) persons consisting of technical individuals and residents in the locality and five (5) students.

Smart Environment and Wireless Mesh Topology

The researcher used smart environment and mesh topology for the system. According to El-Bendary, et al. (2014), "a smart monitoring system when the environment itself becomes a self-monitoring and self-protecting environment that is aware of its current status with the possibility of an automatic alarm rising if some event occurred."

With the help of this environment, the analysis on transmitting data would be more power efficient if there are nodes that are malfunctioning. If there is a non-operative node, then the system will sense it and it will not transmit the data going to that malfunctioned node. So from that, there would be less power consumption on transmission of data. Therefore, it tells that the network is smart because of its self-monitoring of network function that is also a built-in algorithm of the Zigbee modules. In addition, the system was also automated on the data acquisition of water level and flow rate as inputs.

The system used wireless mesh topology to determine if there are damaged nodes, the transmission will not stop and the network could still transmit the data to other nodes. The network can widen the area of transmission with this type of topology that serves as the backbone by adding additional nodes.

Mesh topology and smart environment gave the system the features that made the reason for deploying it for water level monitoring and water flow reading on remote areas or in harsh environments.

Project Setup

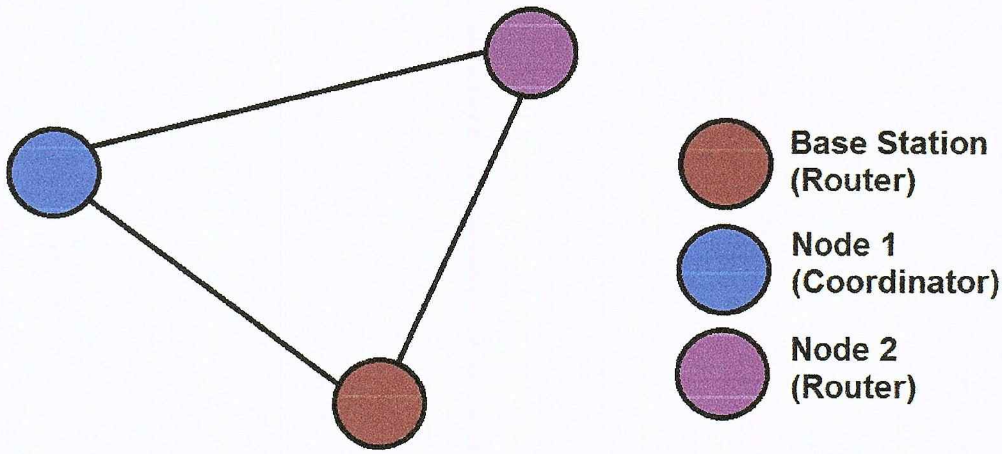

Figure 7. Design Setup of the Whole System

Referring to Figure 7, it starts when the device gathered the data about the water level and flow rate on the Base Station. After which, the device transmitted the data to the nodes (Node 1 and Node 2) so that the mobile phones with the mobile application can access the data. This platform was become public or an open access so that all users can monitor the data about the events happening. Moreover, the normal users such as citizens can access also the data. They could be prepared if there would be an upcoming disaster since there would be a warning on the data stored in the network. There are cases that there are no internet connection, no power, and no cellphone signal and from that the system can cope with it, so the users can still access the data.

In a network there must be only one Coordinator and the rest can be Routers and End-Devices. In this case, if there are children (nodes) that would be added to the network then obviously the family will grow. Therefore, the more children the greater distance for the data transmission. Lastly, the Routers must connect first to the Coordinator.

Statistical Treatment of Data

The statistical tool used in this study was all about the mean on the Effectiveness Test of the Mobile Application. It has an equivalent interpretation for each range of the mean.

CHAPTER 4

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

This chapter shows the in-depth discussion of the project in terms on its findings, analyses and interpretation of results from the tests conducted to evaluate its functionality.

Water Related Disaster Parameters

Normal Depth, Critical Depth and Greater than Critical Depth

The researcher developed a water level measurement prototype that made of a plastic pipe. Figure 8 shows the level of measurement for Low, Medium and High Level. The measurement for Low Level is less than 0.5 m, for Medium Level is 0.5 m to 1.4 m and for High Level is equal or greater than 1.5 m.

The sensors were placed for each level to detect the rising of water. As for the reading of the product, it has three stages. The study adopted the Project NOAH's measurement as to the normal depth which is equal to the low level, critical depth which is medium level and greater than critical depth which is the high level. There are instances during low tide or high tide, the water level is obviously changing. Low tides and high tides have its different measurements, so the water level detection will still depends on the measurement of the said tides.

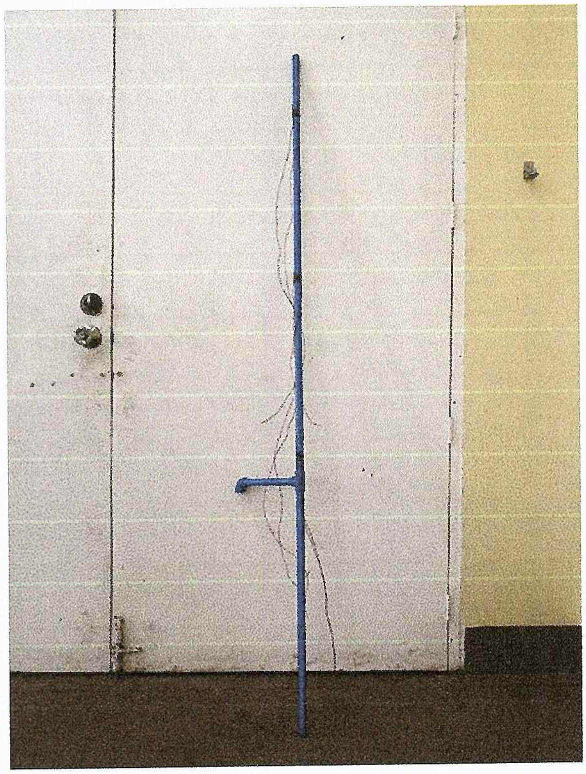

Figure 8. Water Level Sensor Holder

A Data Logger

Warning System

The product has an equivalent message for each water level. In addition, an equivalent color codes were integrated based on Project NOAH's flood hazard warning signs. If the water level is equal to 1.5 meter or exceeds predefined limit, then there will be a warning for the user. Nodes 1 and 2 will light the red LED just to indicate that the water level is above the critical depth.

On the mobile application, if there is a water level reading that indicates "HIGH" then there is an equivalent message that denotes "WARNING". If the reading changes to medium and low, then the warning from the nodes will be removed.

Hardware Design

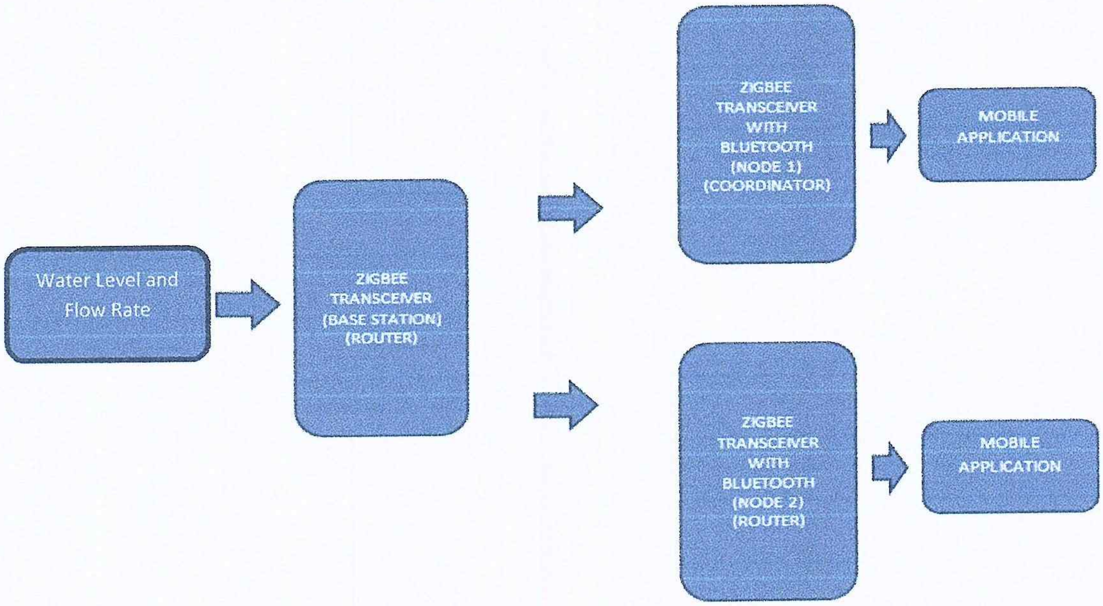

Figure 9. Block Diagram of the System

Figure 9 shows the block diagram of the whole system. The researcher used Zigbee transceiver modules, a localized water level sensor by the use of an operational amplifier, water flow sensor, microcontroller, and Bluetooth module. After gathering the data from the sensors, next is to transmit it to the Base Station to transmit it also to the nodes. Then the nodes processed the data by utilizing microcontrollers and sends it to the Bluetooth modules so that the users can access the data.

The mode of transmission is simplex or unidirectional between the device and the user. It means that the device will just send the data and the user will just receive it.

Software Design

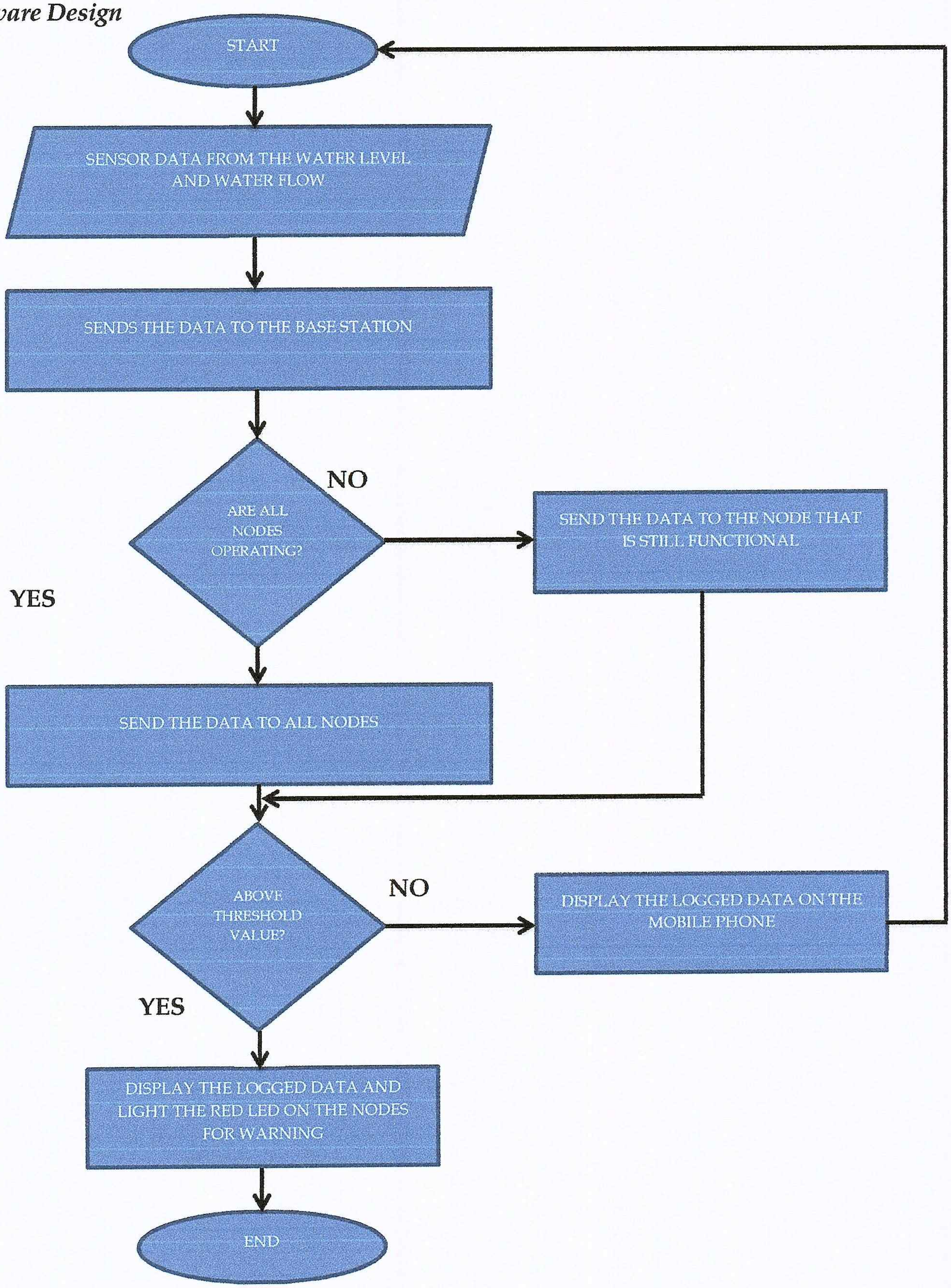

Figure 10. Flowchart of the System

From Figure 10, it started with the reading of the sensor about the water level and water flow or the flow rate since they are the inputs of the Base Station. Next process is to send it to the nodes, however if the system detects that one of the nodes is not functioning, then the base station will not send the data to that malfunctioned node. Then, the microcontroller would now analyze the data if it is above or below the minimum threshold value. If the value is below the threshold then it would just send the logged data on the phone, but if it detects that the value is above the threshold then the red LED on the nodes would light and there would be also a corresponding indicator on the measurement in the mobile application when the water level is high.

Data Log on Water Level Variations and Flow Rate

The mobile application gives the reading of water variations and flow rate to the user. The logging process is every second so that there will be a thorough analysis of the data. There is a complete data on the data logger of the system since it has the actual date and time, the water flow reading that is in L/Hr and water level reading.

By pressing a button (Retrieve) on the mobile application, the logged data will be retrieved. It shows the information from the time it was operated up to the present time. However, it depends also on the memory of the phone.

The data can be also deleted by pressing another button (Delete) on the mobile application. With this, there can be a new room for new data. But, the deleted data cannot be recovered anymore.

Acceptability of the Developed Localized Data Logger

Functionality

The product was tested for three (3) consecutive days to test its functionality. Table 1 shows the data for the testing of the product. The test was conducted last March 6-8, 2018 in Antiao River, Catbalogan City. The results revealed that the data is consistent on giving information to the user via mobile application.

During the 24-hour period per day of testing, the researcher chose to limit the time to the interval of six (6) hours. The data were recorded in the memory storage of the mobile phone, by pressing a button on the mobile application the user can retrieve the logged data.

Table 1. Summary of the 3-Day Functionality Test

FUNCTIONS	First Day				Second Day				Third Day			
	6:00 AM	12:00 NN	6:00 PM	12:00 MN	6:00 AM	12:00 NN	6:00 PM	12:00 MN	6:00 AM	12:00 NN	6:00 PM	12:00 MN
WATER LEVEL VARIATIONS	LOW	MODERATE	LOW	LOW	LOW	MODERATE	LOW	LOW	LOW	MODERATE	LOW	LOW
FLOW RATE (L/Hr)	8	24	24	20	9	20	23	27	12	18	23	35

This graph in Figure 11 presents the water level reading on the 3-day testing of the device. In this scenario, the water level variation depends on low tide and high tide. During the evaluation, the weather was fine. The medium level were reached during the 12 noon throughout the evaluation days. As referring to the calendar for the record of low tide and high tide, it tells that during those time the water level in the river starts to rise until it reached its maximum level. Moreover, after the High tide, the water level decreases and it started to Low tide.

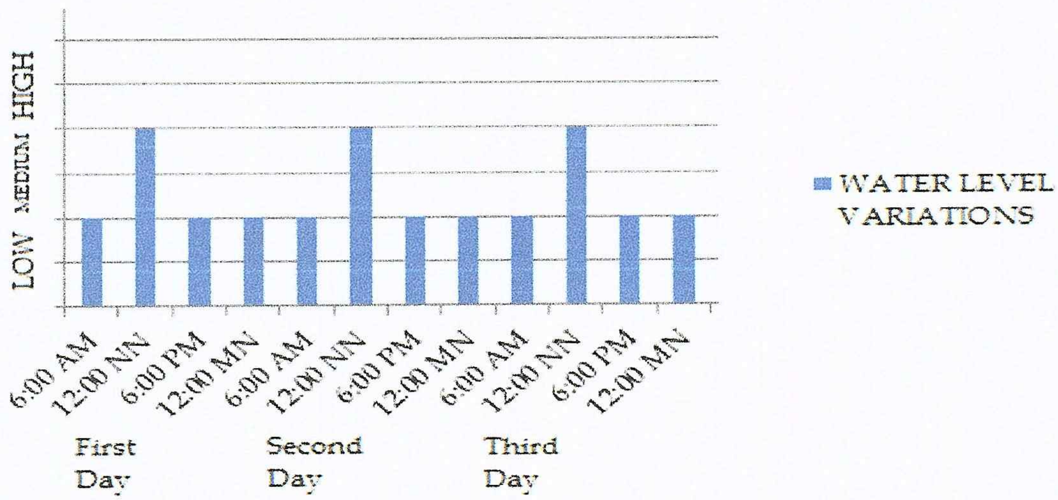

Figure 11. Logged Data for Water Level

Figure 12 shows that different readings of the flow rate since Day 1 to Day 3. During the reading process, the value got zero in terms of its water flow because the river became still.

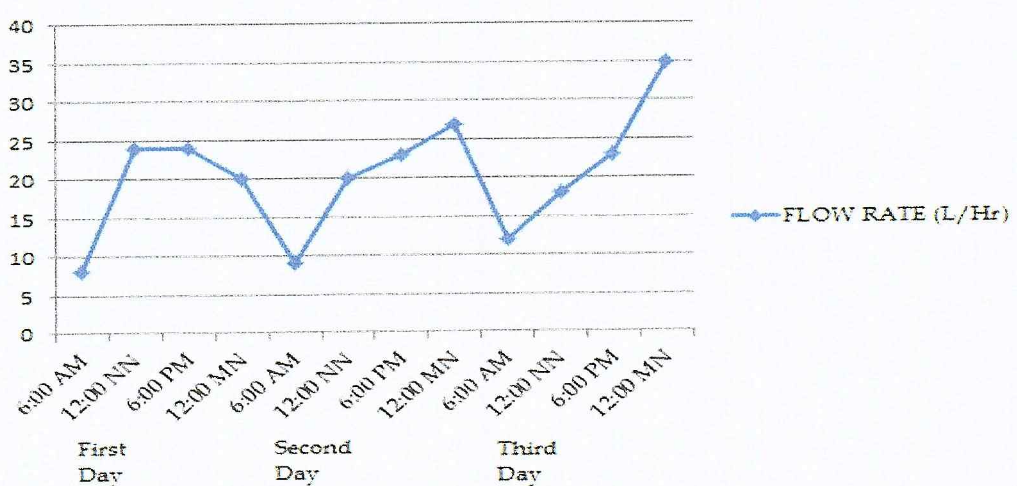

Figure 12. Logged Data for Flow Rate

In addition, the effectiveness test of the mobile application was conducted. The tally of the results were recorded and interpreted.

A shown in Table 2, it shows the results of the evaluation which resulted to two interpretation as "Strongly Agree" and "Agree". It summarizes that the product was acceptable and in-line with its desired objectives since the total interpretation was "Strongly Agree".

Table 2. Results from the Effectiveness Test of Mobile Application

EFFECTIVENESS OF THE MOBILE APPLICATION	SCALE					WEIGHTED MEAN	INTERPRETATION
	5	4	3	2	1		
I can easily use the Mobile Application	8	2	0	0	0	4.8	Strongly Agree
I can understand the message clearly	6	2	2	0	0	4.4	Agree
I found that this Mobile Application is necessary	9	1	0	0	0	4.9	Strongly Agree
I think that some people can learn to use the Mobile Application quickly	7	1	2	0	0	4.5	Agree
TOTAL						**4.65**	**Strongly Agree**

4.51 – 5.00 Strongly Agree
3.51 – 4.50 Agree
2.51 – 3.50 Undecided
1.51 – 2.50 Disagree
1.00 – 1.50 Strongly Disagree

Test Installation of the Product

This figure shows the test setup of the whole system in Antiao River. The Base Station was installed beside the riprap in order to compound its foundation. It was limited to that part of the river.

The setup was conducted for three (3) days for the evaluation of the functions. Moreover, the actual installation was conducted during the first day of the evaluation.

Preferably the installation of the Water Level Sensor Holder with the Water Flow Sensor will be on the middle part of the river. It is because the variable of water flow is much greater on that part of the river.

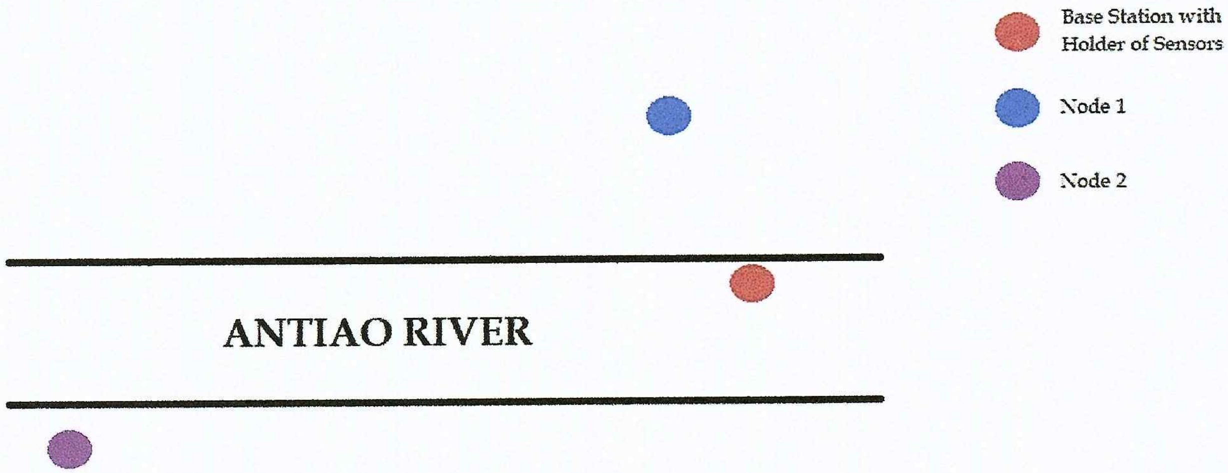

Figure 13. Test Setup in Antiao River

Cost Analysis

This section presents the cost for each materials used in the development of the product.

Table 3. Project Cost

COMPONENTS	QUANTITY	UNIT PRICE	TOTAL PRICE
Gizduino	1	735.00	735.00
Arduino UNO	2	450.00	900.00
Bluetooth Shield	1	785.00	785.00
Bluetooth Module	1	485.00	485.00
Water Flow Sensor	1	345.00	345.00
Xbee Adapter	3	221.00	663.00
Xbee (S2C)	3	1002.75	3008.25
Operational Amplifier	1	50.00	50.00
Sensor Connectors	4	35.00	140.00
Connecting Wires	30 (meters)	12.00	360.00
LED	5	5.00	25.00
PCB	1	45.00	45.00
Switch	1	35.00	35.00
Battery	3	25.00	75.00
Battery Cover	3	25.00	75.00
Male Input Plug (to Arduino)	3	15.00	45.00
Toggle Switch	3	35.00	105.00
Casing	4	45.00	180.00
TOTAL			**8056.25**

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the significant findings, conclusion and recommendations of the study.

Summary of Findings

The following were the significant findings derived from the study.

1. The study identified the water related parameters in terms of its Normal Depth which is Low Level that has a measurement of less than 0.5 meters; for Critical Depth or Medium Level that ranges from 0.5 meters to 1.4 meters and for the Greater than the Critical Depth or the High Level which is equal or greater than 1.5 meters.
2. A data logger was developed for giving warning to the user if the water level equals or exceeds the critical value. It can log data on water level variations and flow rate. In addition, there were date and time for the real-time monitoring.
3. Functionality test was conducted in Antiao River to come up with an assessment on how reliable the data are. A three-day test for the evaluation of the device that operated 24 hours. In addition, an effectiveness test of the mobile application was also conducted. Cost analysis was also presented to have a summary on the expenditure of the project.

Conclusions

Based on the abovementioned findings, the following conclusions were considered:

1. The identified water related parameters such as Normal Depth (Low Level), Critical Depth (Medium Level) and Greater than Critical Depth (High Level) helped the study on what water level indicates that it is still safe or dangerous.
2. The product logged the data and gave warning every time it is equal or greater than the predefined values in water level. It gave signal from the Base Station to the Nodes by lighting the red LED to indicate a warning signal. Moreover, the user could still access the information by just pressing a button (Retrieve) on the mobile application to access the stored data. With these features, it showed that the product could give warning and could log data on water level and flow rate with actual date and time.
3. The data revealed that the functions of the product conform to the desired purposes of the study which are to log water level variation and flow rate. The product was reliable because on the consistency of its functions especially that it was operated in the Line-of-Sight propagation. The mobile application was also reliable for giving the logged data to the user. The product cost was very minimal on this type of project.

Recommendations

Based on the results of the study, the following recommendations were considered significant to enhance the capability of the developed product.

1. To incorporate a sensor that could have a reading on the velocity on the rising of water.
2. Install a solar panel or any renewable energy to enhance the power supply of the system.
3. Provide another type of power supply like batteries that can last for months.
4. To integrate an external memory like SD card for additional data storage.
5. Change the mode of communication from Bluetooth to any other type of data transmission since it is only limited to one user.
6. Develop a better stand support for the water level sensor holder and Base Station.
7. Add more nodes for multiple data gathering.
8. Present the data gathered in tabular form.

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APPENDICES

SCHEMATIC DIAGRAMS

Receiver

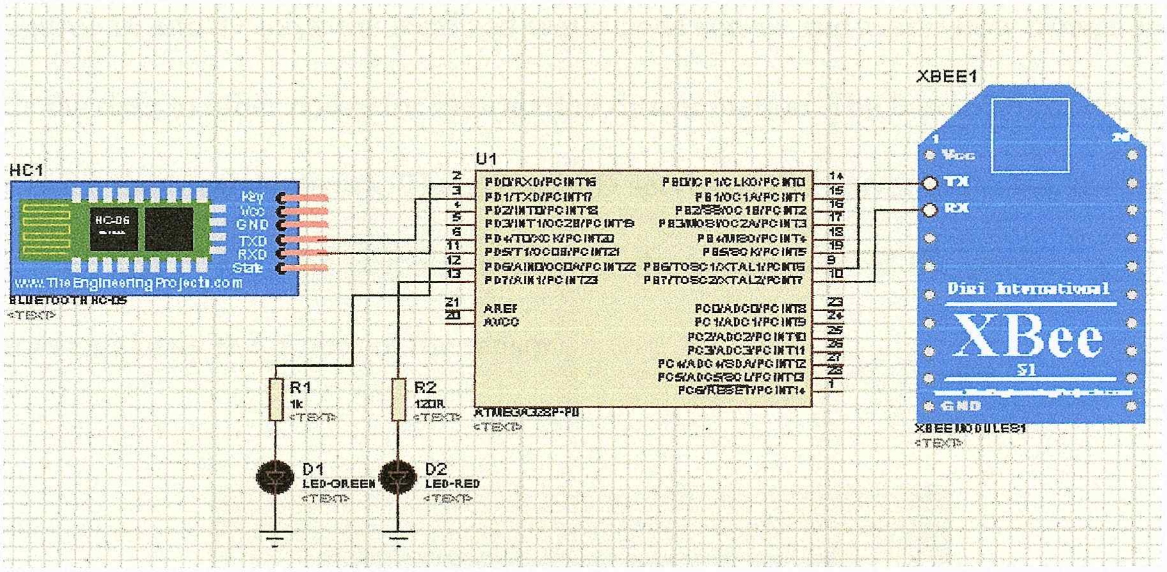


Figure 14. Receiver Circuit

Transmitter

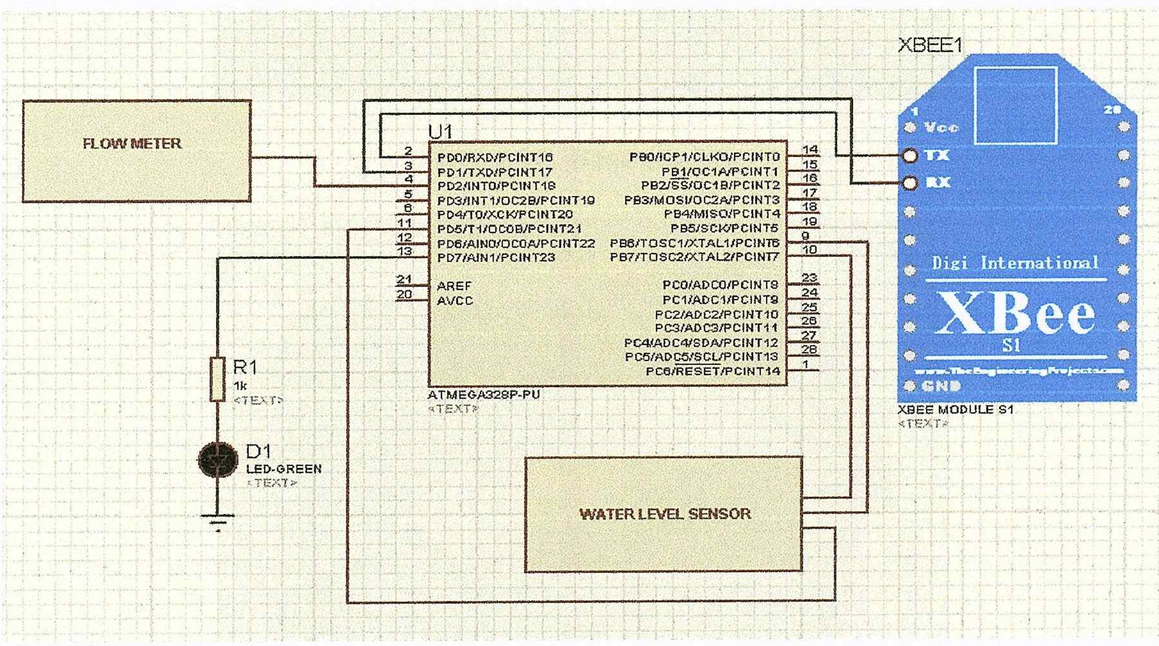


Figure 15. Transmitter Circuit

Node 1 in Figures 18 and 19 serve as the gateway of the information from the Base Station going to the user. It is responsible for the readable data going to the mobile application. This node was configured as Coordinator. The toggle switch for the power, green LED for the power indicator and red LED for the detection of high water level.

Figure 18. Node 1

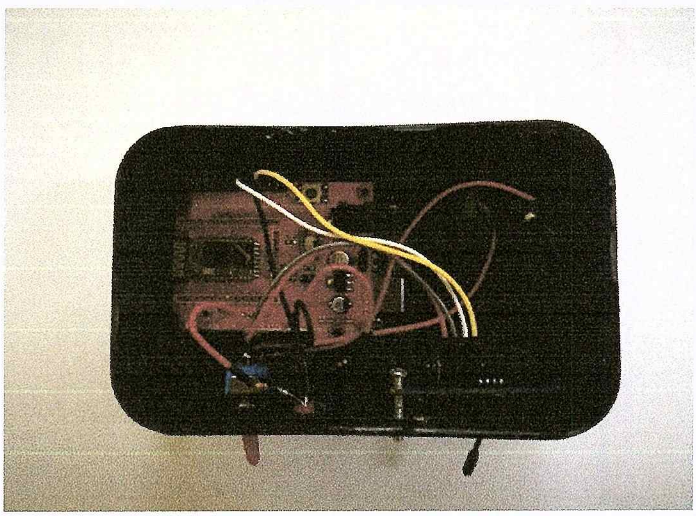


Figure 19. Components View of Node 1

The other node, which is Node 2 in Figures 20 and 21 serve also as the gateway for the data from Base Station. This node was configured as well, however it was not the same as Node 1 since this is also a Router same as the Base Station. The toggle switch for the power, green LED for the power indicator and red LED for high water level.

Figure 20. Node 2

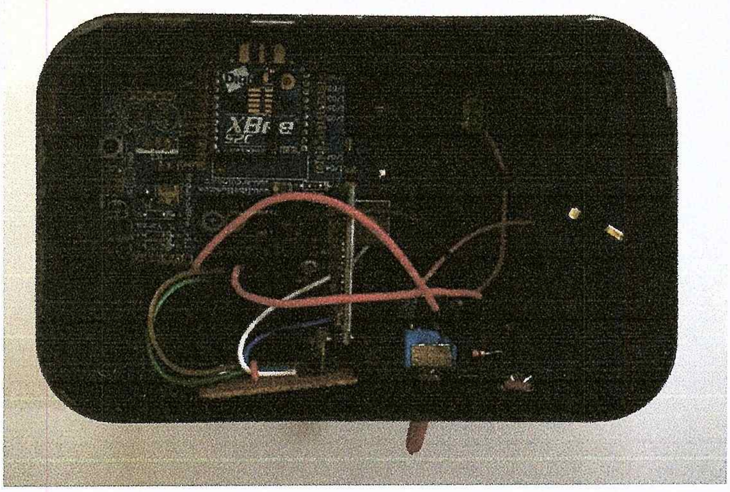


Figure 21. Components View of Node 2

<u>**Mobile Application**</u>

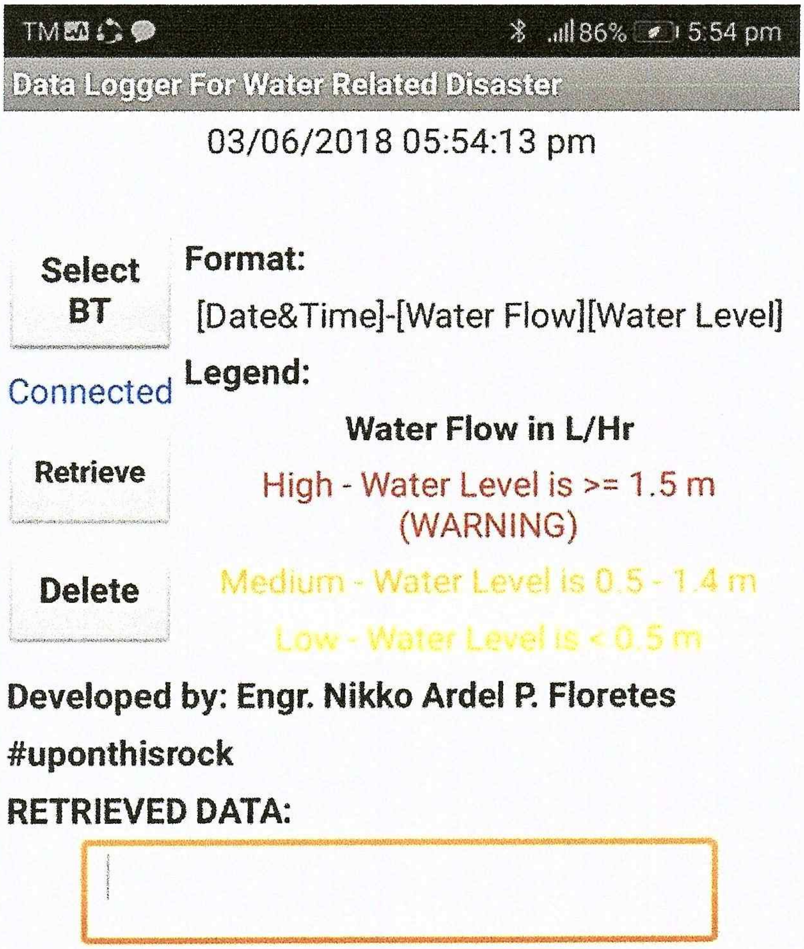


Figure 22 Mobile Application Appearance

This is the actual data logger appearance (Fig. 22) on the mobile phone. It has the color-coding that represents for each water level. A warning indicator was placed in order for the user to know that if the water level reading goes HIGH, then it is a warning that there will be flood in the area.

<u>**Example of Logged Data**</u>

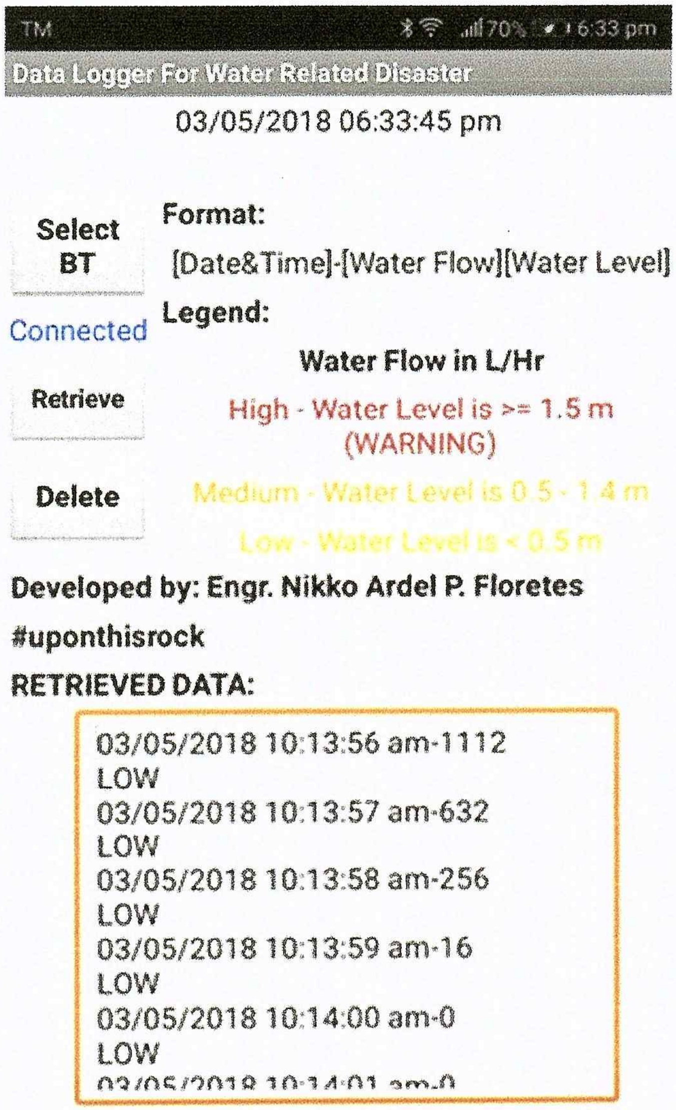


Figure 23. Sample Data Logged

Figure 23 shows that the data can still be retrieved any time of the day as long as it is not deleted. The time that the researcher retrieved the data was around 6:30 PM, and the data from 10:00 AM in the morning were still retrieved.

This figure was intended for demo purposes just to show that the system can log data.

Actual Logged Data from the Functionality Test

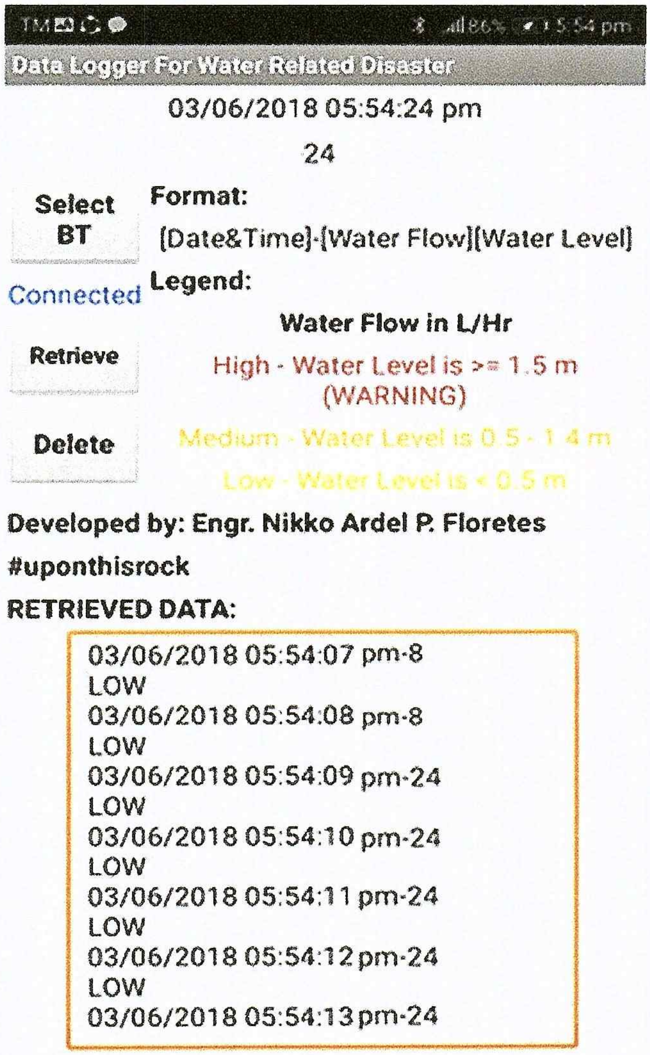


Figure 24. Actual Logged Data

Figure 24 shows the actual reading of the water level and flow rate in Antiao river. The readings were not totally consistent on the water flow since the water during that time was varying.

Water Level Sensor Holder and Water Flow Casing

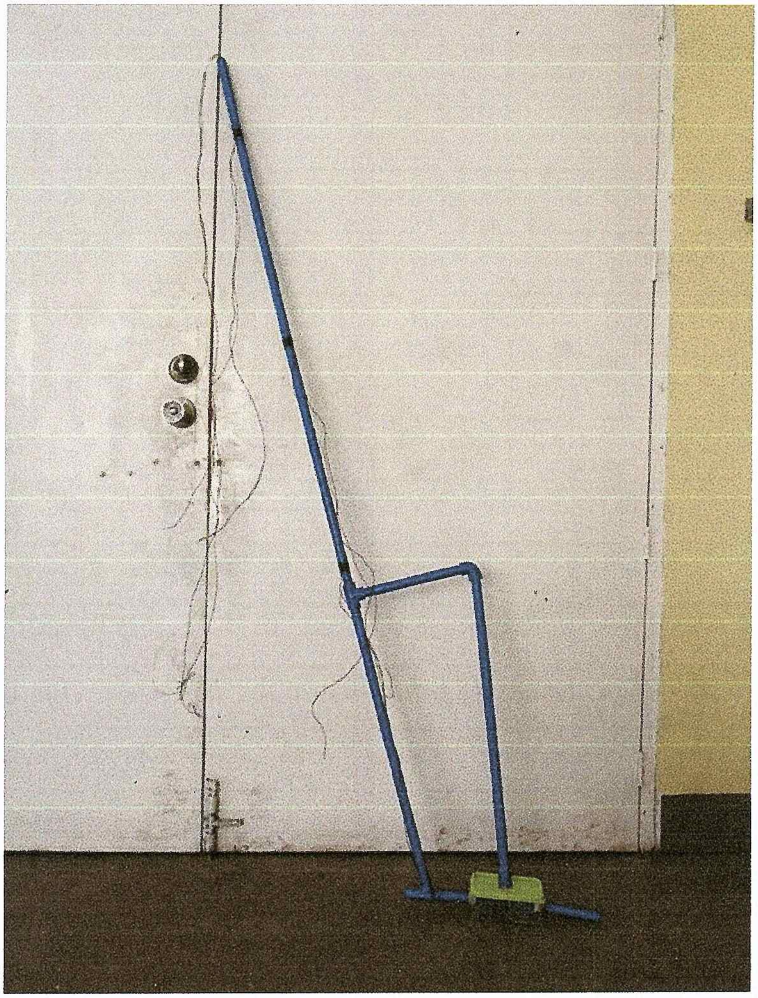


Figure 25. Water Level Sensor Holder and Water Flow Casing

Figure 25 shows where the sensors were placed together with the water flow sensor. Connecting wires were connected to the Base Station.

QUESTIONNAIRE

QUESTIONNAIRE FOR THE EFFECTIVENESS TEST OF THE MOBILE APPLICATION

NAME (optional): ______________________________ **DATE:** ________________

DIRECTION: Please answer the following by checking each item that suits your assessment.

EFFECTIVENESS OF THE MOBILE APPLICATION	SCALE				
	5	4	3	2	1
I can easily use the Mobile Application					
I can understand the message clearly					
I found that this Mobile Application is necessary					
I think that some people can learn to use the Mobile Application quickly					

5 - Strongly Agree
4 - Agree
3 - Undecided
2 - Disagree
1 - Strongly Disagree

Figure 26. Sample Questionnaire for the Mobile Application Effectiveness Test

SOFTWARE

TOOLS

Arduino IDE

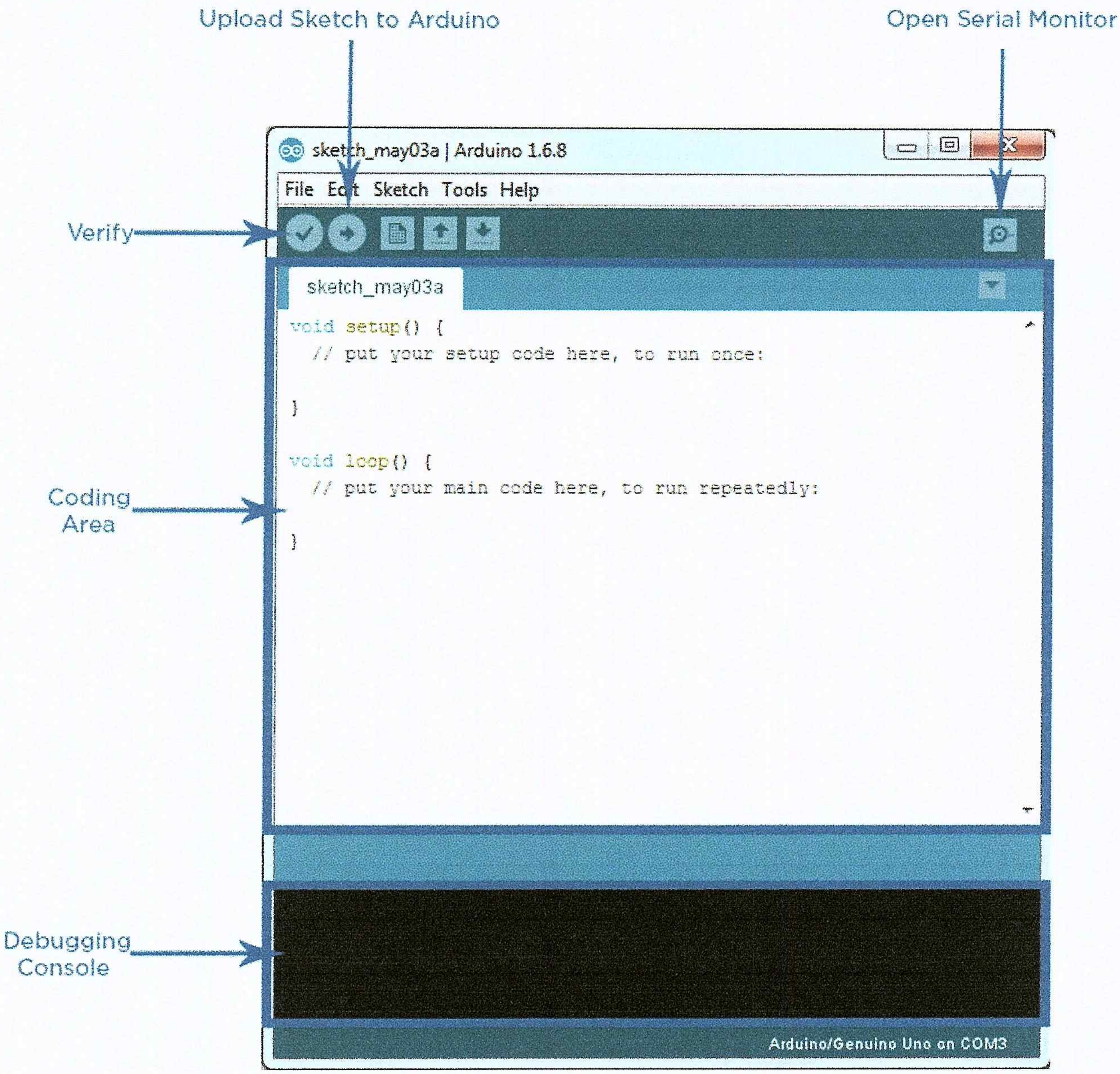


Figure 27. Arduino Programming Environment

This software IDE inputs the syntaxes to the microcontroller. It served as the gateway to the board.

<u>**MIT App Inventor 2**</u>

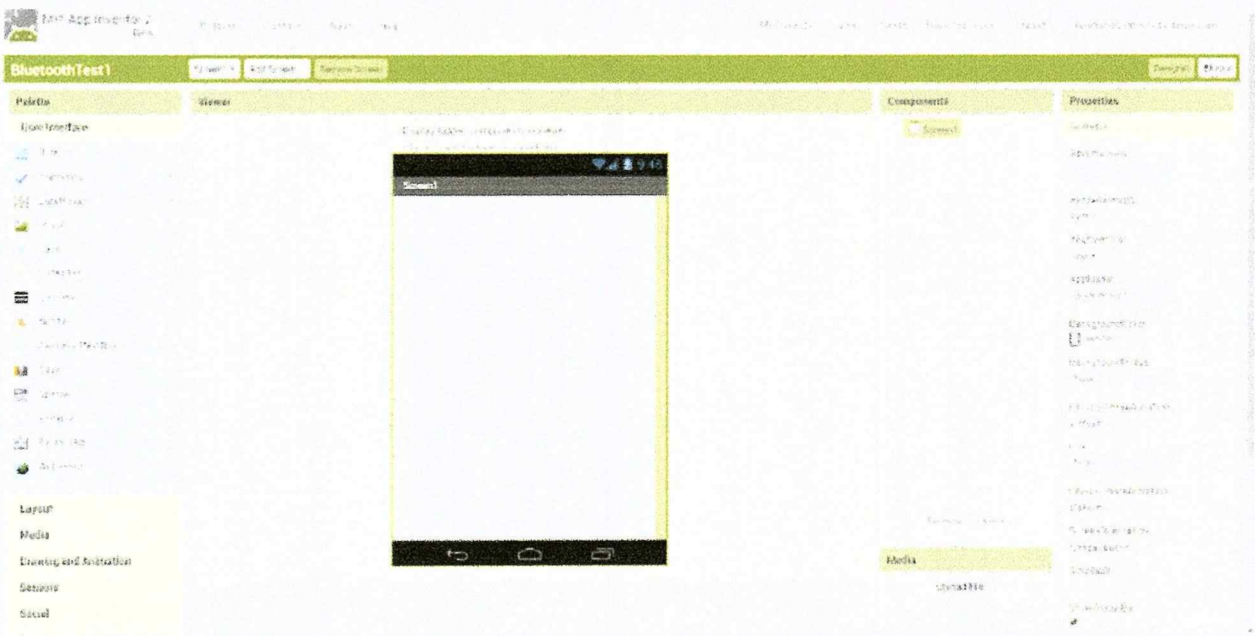


Figure 28. Android IDE

The researcher used this environment to develop the android application for the product. It has an emulator if ever there is no android phone available.

<u>**XCTU**</u>

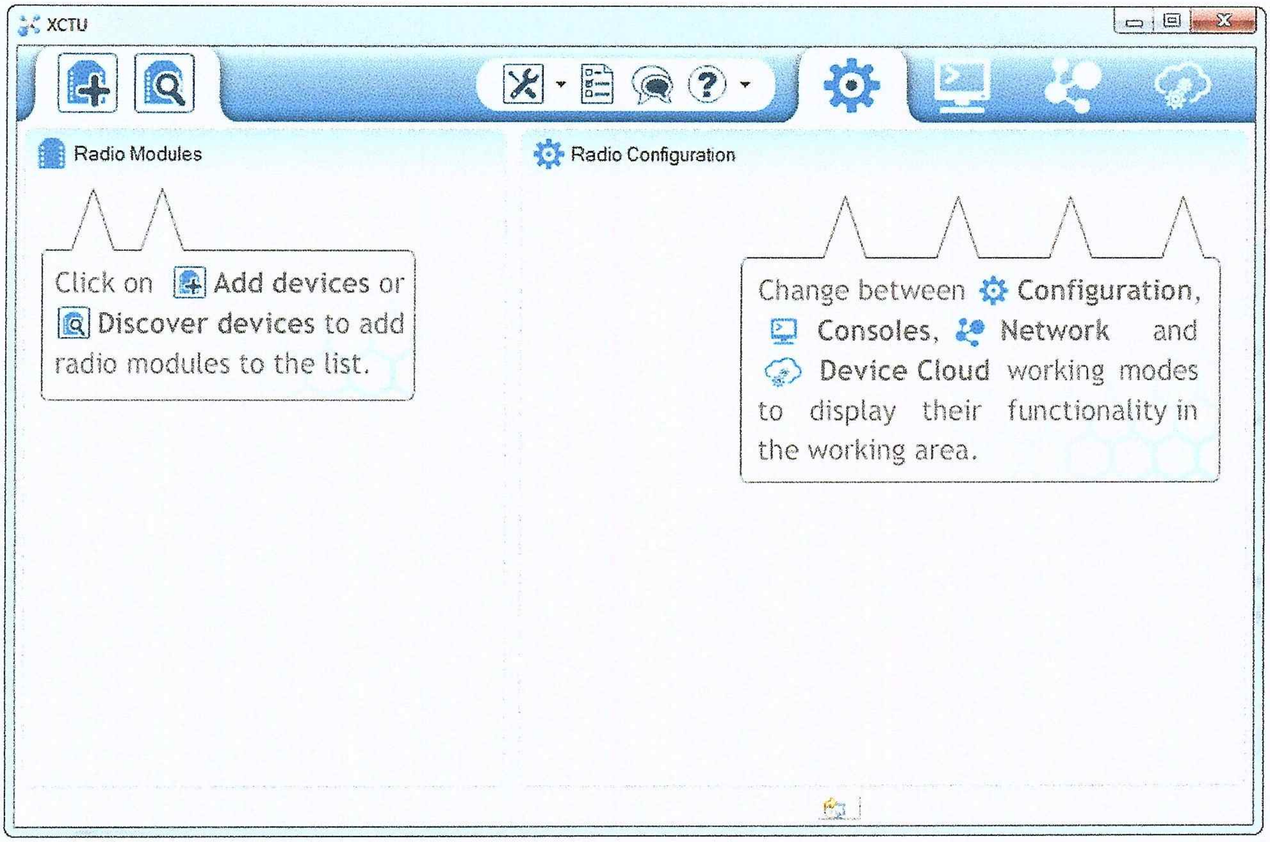


Figure 29. XCTU Configuration Software

This software was responsible for the configuration of XBee transceivers. Here, the parameters were set so that the modules can communicate with each other.

DATASHEETS

DIGI

XBee®/XBee-PRO S2C Zigbee®

RF Module

User Guide

Performance specifications

The following table describes the performance specifications for the devices.

Specification	XBee Zigbee S2C	XBee-PRO Zigbee S2C	XBee Zigbee S2D
Indoor/urban range	Up to 60 m (200 ft)	Up to 90 m (300 ft)	Up to 60 m (200 ft)
Outdoor RF line-of-sight range	Up to 1200 m (4000 ft)	Up to 3200 m (2 mi)	Up to 1200 m (4000 ft)
Transmit power output (maximum)	6.3 mW (+8 dBm), boost mode 3.1 mW (+5 dBm), normal mode channel 26 max power is +3 dBm	63 mW (+18 dBm)	6.3 mW (+8 dBm) channel 26 max power is +1 dBm
RF data rate	250,000 b/s		
Receiver sensitivity	-102 dBm, boost mode -100 dBm, normal mode	-101 dBm	-102 dBm, boost mode -100 dBm, normal mode

Power requirements

The following table describes the power requirements for the XBee/XBee-PRO Zigbee RF Module.

Specification	XBee Zigbee S2C	XBee-PRO Zigbee S2C	XBee Zigbee S2D
Adjustable power	Yes		
Supply voltage	2.1 - 3.6 V 2.2 - 3.6 V for programmable version	2.7 - 3.6 V	2.1 - 3.6 V
Operating current (transmit)	45 mA (+8 dBm, boost mode) 33 mA (+5 dBm, normal mode)	120 mA @ +3.3 V, +18 dBm	45 mA
Operating current (receive)	31 mA (boost mode) 28 mA (normal mode)	31 mA	31 mA
Power down current	< 1 µA @ 25°C		< 3 uA @ 25° C

General specifications

The following table describes the general specifications for the devices.

Specification	XBee Zigbee S2C	XBee-PRO Zigbee S2C	XBee Zigbee S2D
Operating frequency band	ISM 2.4 - 2.5 GHz		
Form factor	through-hole, surface-mount		surface-mount

Serial communication specifications

The XBee/XBee-PRO Zigbee RF Module supports both Universal Asynchronous Receiver / Transmitter (UART) and Serial Peripheral Interface (SPI) serial connections.

UART pin assignments

Specifications	Device pin number	
UART pins	XBee (surface-mount)	XBee (through-hole)
DOUT	3	2
DIN / $\overline{CONFIG}$	4	3
$\overline{CTS}$ / DIO7	25	12
$\overline{RTS}$/ DIO6	29	16

For more information on UART operation, see Operation.

SPI pin assignments

The SC2 (Serial Communication Port 2) of the Ember 357 is connected to the SPI port.

Specifications	Device pin number	
SPI pins	XBee (surface-mount)	XBee (through-hole)
SPI_SCLK	14	18
SPI_$\overline{SSEL}$	15	17
SPI_MOSI	16	11
SPI_MISO	17	4

For more information on SPI operation, see SPI operation.

GPIO specifications

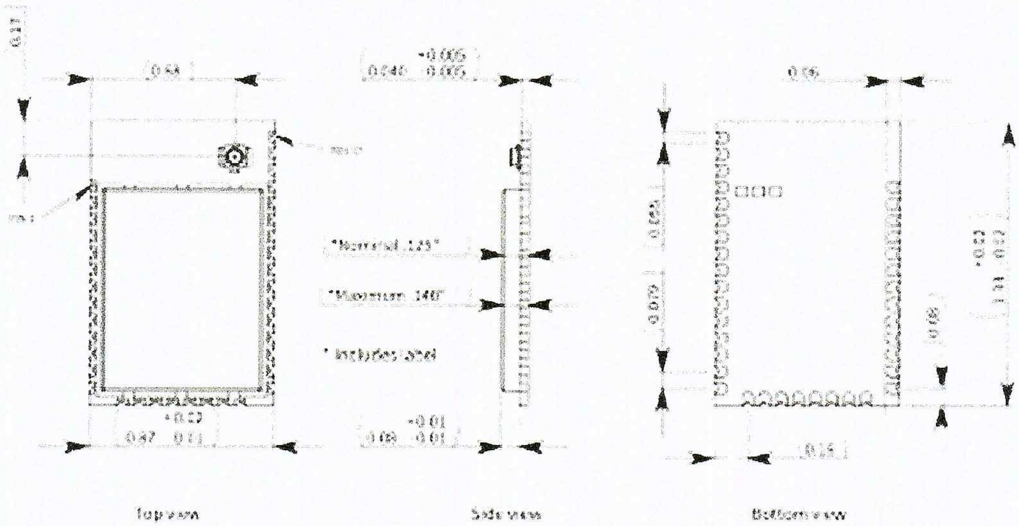
XBee/XBee-PRO Zigbee RF Modules have 15 General Purpose Input / Output (GPIO) ports available. The exact list depends on the device configuration as some GPIO pads are used for purposes such as serial communication.

See Enable GPIO 1 and 2 in the for more information on configuring and using GPIO ports.

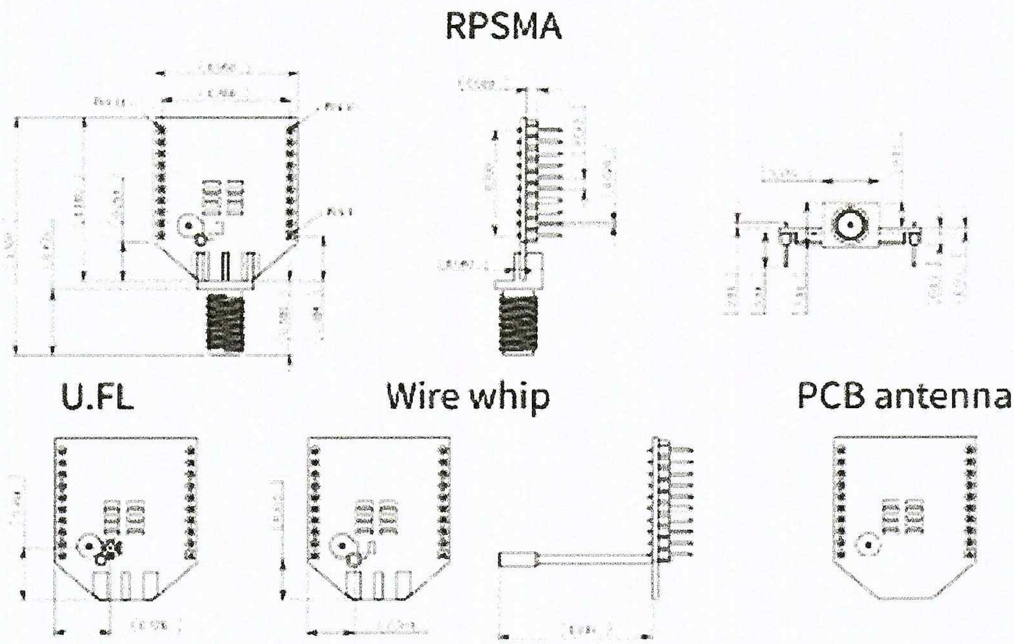
GPIO electrical specification	Value
Voltage - supply	2.1 - 3.6 V

Mechanical drawings

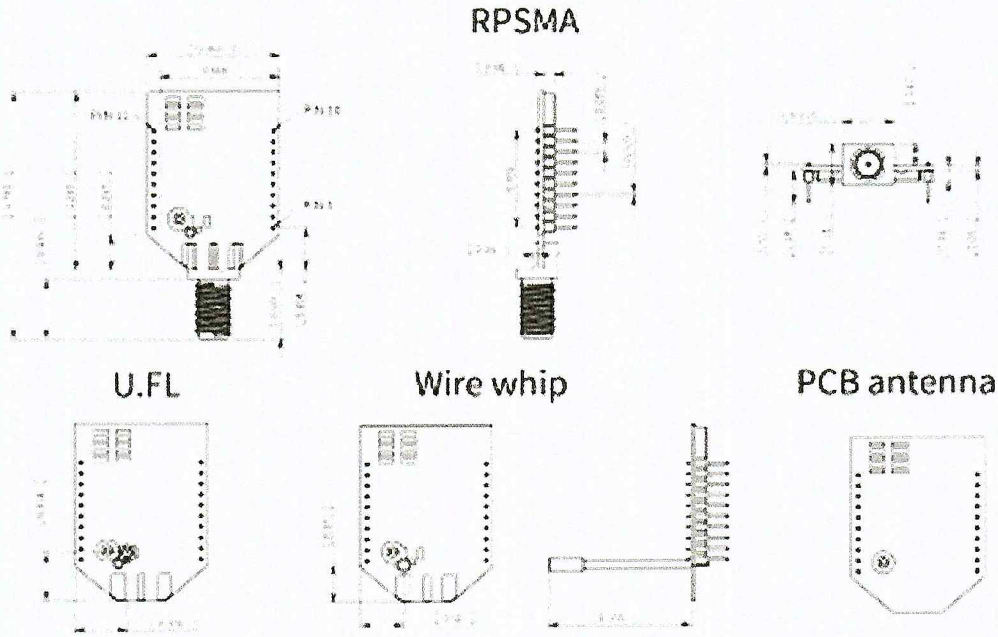
The following mechanical drawings of the XBee/XBee-PRO Zigbee RF Modules show all dimensions in inches. The first drawing shows the XBee/XBee-PRO surface-mount model (antenna options not shown).



The drawings below show the XBee through-hole model.

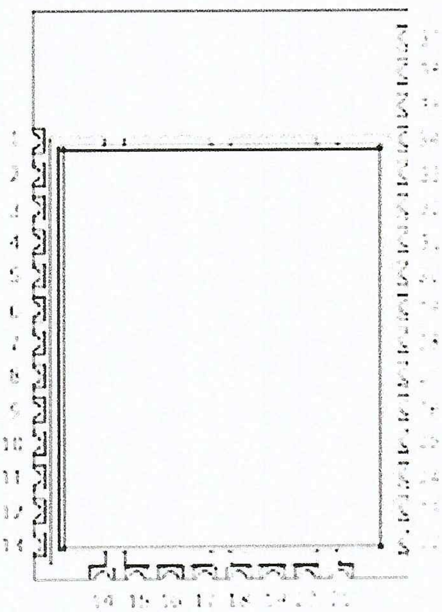


The drawings below show the XBee-PRO through-hole model.



Pin signals for the surface-mount module

The following drawing shows the surface mount (SMT) pin locations.

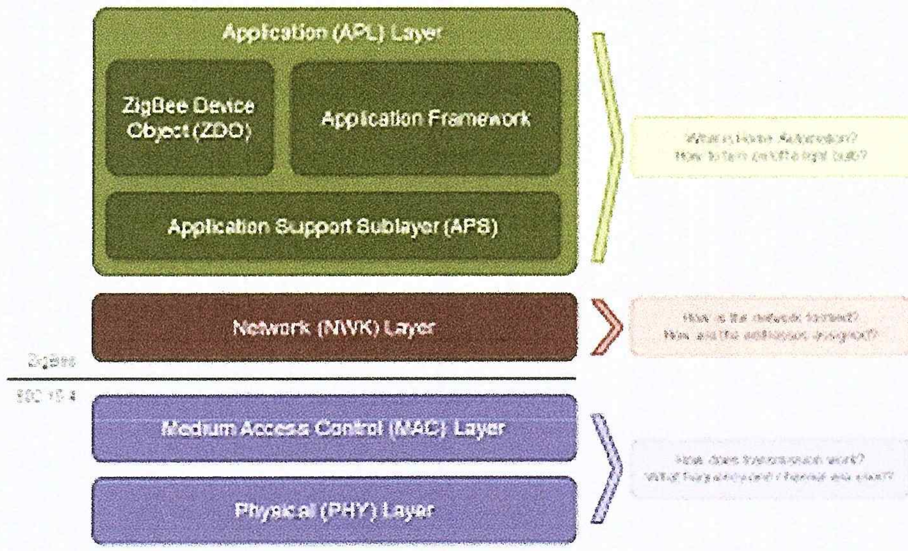


Zigbee stack layers

Most network protocols use the concept of layers to separate different components and functions into independent modules that can be assembled in different ways.

Zigbee is built on the Physical (PHY) layer and Medium Access Control (MAC) sub-layer defined in the IEEE 802.15.4 standard. These layers handle low-level network operations such as addressing and message transmission/reception.

The Zigbee specification defines the Network (NWK) layer and the framework for the application (APL) layer. The Network layer takes care of the network structure, routing, and security. The application layer framework consists of the Application Support sub-layer (APS), the Zigbee device objects (ZDO) and user-defined applications that give the device its specific functionality.



This table describes the Zigbee layers.

Zigbee layer	Descriptions
PHY	Defines the physical operation of the Zigbee device including receive sensitivity, channel rejection, output power, number of channels, chip modulation, and transmission rate specifications. Most Zigbee applications operate on the 2.4 GHz ISM band at a 250 kb/s data rate. See the IEEE 802.15.4 specification for details.
MAC	Manages RF data transactions between neighboring devices (point to point). The MAC includes services such as transmission retry and acknowledgment management, and collision avoidance techniques (CSMA-CA).
Network	Adds routing capabilities that allows RF data packets to traverse multiple devices (multiple hops) to route data from source to destination (peer to peer).

Zigbee layer	Descriptions
APS (AF)	Application layer that defines various addressing objects including profiles, clusters, and endpoints.
ZDO	Application layer that provides device and service discovery features and advanced network management capabilities.

Zigbee networking concepts

Device types

Zigbee defines three different device types: coordinator, router, and end device.

Coordinator

Zigbee networks may only have a single coordinator device. This device:

- Starts the network, selecting the channel and PAN ID (both 64-bit and 16-bit).
- Buffers wireless data packets for sleeping end device children.
- Manages the other functions that define the network, secure it, and keep it healthy.
- Cannot sleep; the coordinator must be powered on all the time.

Router

A router is a full-featured Zigbee node. This device:

- Can join existing networks and send, receive, and route information. Routing involves acting as a messenger for communications between other devices that are too far apart to convey information on their own.
- Can buffer wireless data packets for sleeping end device children. Can allow other routers and end devices to join the network.
- Cannot sleep; router(s) must be powered on all the time.
- May have multiple router devices in a network.

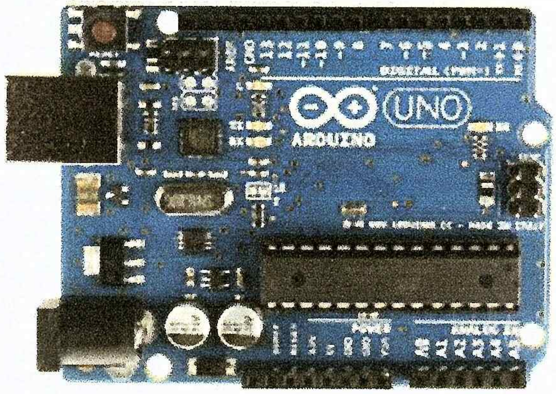
End device

An end device is essentially a reduced version of a router. This device:

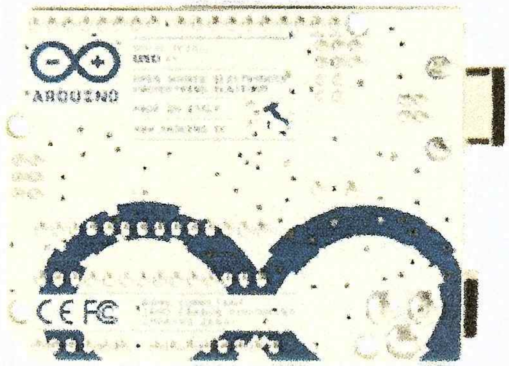
- Can join existing networks and send and receive information, but cannot act as messenger between any other devices.
- Cannot allow other devices to join the network.
- Uses less expensive hardware and can power itself down intermittently, saving energy by temporarily entering a non-responsive sleep mode.
- Always needs a router or the coordinator to be its parent device. The parent helps end devices join the network, and stores messages for them when they are asleep.

Zigbee networks may have any number of end devices. In fact, a network can be composed of one coordinator, multiple end devices, and zero routers.

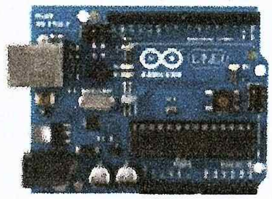
Arduino Uno



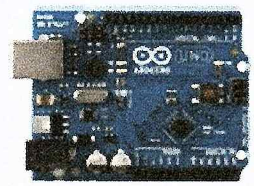
Arduino Uno R3 Front



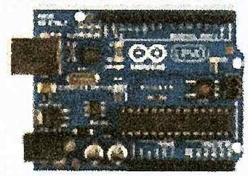
Arduino Uno R3 Back



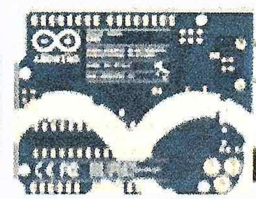
Arduino Uno R2 Front



Arduino Uno SMD



Arduino Uno Front



Arduino Uno Back

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.
Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode.
Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V

Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

Schematic & Reference Design

EAGLE files: arduino-uno-Rev3-reference-design.zip (NOTE: works with Eagle 6.0 and newer)
Schematic: arduino-uno-Rev3-schematic.pdf
Note: The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.
External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.
The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.
The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.**This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

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

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.

- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication using the SPI library.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- **TWI: A4 or SDA pin and A5 or SCL pin.** Support TWI communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and ATmega328 ports. The mapping for the Atmega8, 168, and 328 is identical.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).
A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.
The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the **Tools > Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).
You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.
The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available . The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information.

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.
This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.
The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

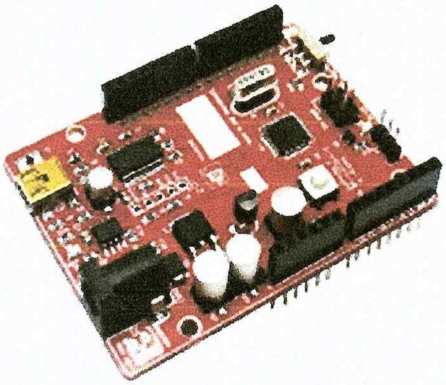
Physical Characteristics

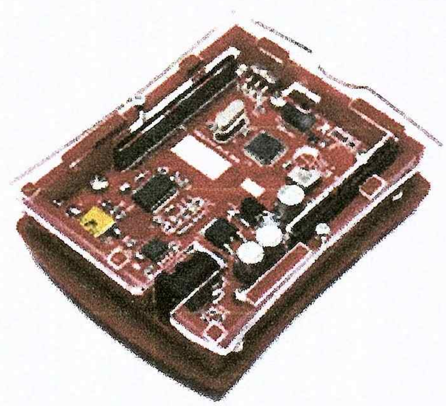
The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

gizDuino 5 with ATmega328P

Technical Manual Rev 1r0

gizDuino 5 is the latest iteration of our continually evolving Arduino compatible series of programmable controllers. It provides added features suggested by users including (see page 3)





FEATURES:

- *Arduino Compatible (Arduino UNO)*
- *Arduino IDE software*
- *20 I/Os*
- *Prolific Driver (PL2303)*
- *USB Power source indicator*
- *Buffered UART TX/RX indicator*
- *UART switch*
- *Buffered I/O 13 indicator*
- *I2C port connections*
- *Additional +5V power port*
- *ICSP header connector*
- *Reset Button*

GENERAL SPECIFICATIONS:

- **Input Supply:**
  - **External Supply:** ***7V to 12VDC***
  - **USB power:** ***+5VDC***
- **Current Limit: 2A**
- **Current per pin:** ***40mA***
- **Digital I/Os:** ***20 (D0-D19)***
- **Analog Input:** ***6 (A0-A5)***
- **PWM pins:** ***D11,D10,D9,D6,D5,D3***
- **Driver IC:** ***PL2303 Prolific***
- **USB connector:** ***miniTypeB***
- **USB cable:** ***miniTypeB to TypeA***
- **Power source on-board:**
  - ***+5V , +3.3V DC , GND***
  - ***+VIN = External Supply***
- **PCB Dimensions: 71mmx54mm**

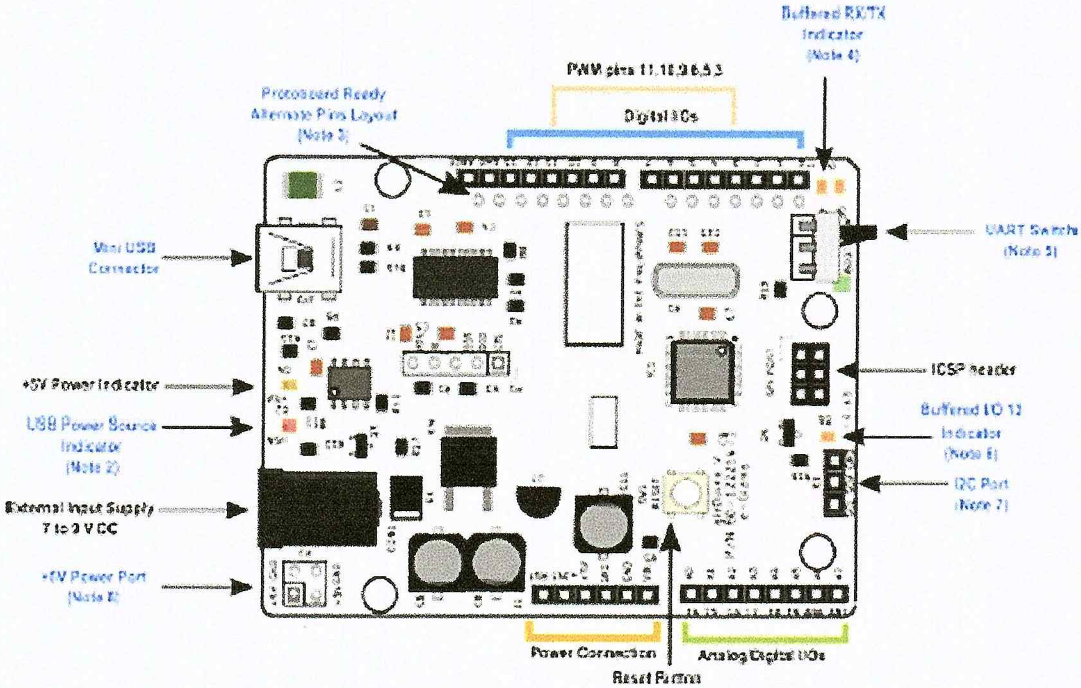


Figure 1. Major parts presentation of gizDuino Version 5.0 with ATmega328P

Important:
Install the latest PL2303 driver in your Windows PC before connecting and using your gizDuino with your PC.

Components Specifications:

IC1 - ATMEGA 328P Microprocessor Chip
U1 - On-Board +3v3 VoltageRegulator
U2 - Supply Dual Operational Amplifier
U3 - PL-2303 USB to RS232 Bridge Controller
U4 - On-Board +5V Voltage Regulator

Table 1. Digital I/O Pin assignments

No.	I.D.	Description
1	AREF	Analog Reference
2	GND	Ground
3	13	Digital I/O (SCK)
4	12	Digital I/O (MISO)
5	11	Digital I/O (PWM/MOSI)
6	10	Digital I/O (PWM)
7	9	Digital I/O (PWM)
8	8	Digital I/O
9	7	Digital I/O
10	6	Digital I/O (PWM)
11	5	Digital I/O (PWM)
12	4	Digital I/O
13	3	Digital I/O (PWM)
14	2	Digital I/O
15	1	Digital I/O (TX)
16	0	Digital I/O (RX)

Tips and Reminders:

Pin 13 is also the pin used by the data transfer LED Indicator.

Table 2. Analog/Digital I/O Pin assignments

No.	I.D.	Description
1	A0	Analog I/O or Digital I/O
2	A1	Analog I/O or Digital I/O
3	A2	Analog I/O or Digital I/O
4	A3	Analog I/O or Digital I/O
5	A4	Analog I/O (SDA) or Digital I/O
6	A5	Analog I/O (SCL) or Digital I/O

Tips and Reminders:

For I2C interface, A4 (SDA) and A5 (SCL) can be used.

In 328P, A6 and A7 has no connections from the microcontroller.

Table 3. Power pin assignments

No.	I.D.	Description
1	Reset	Reset
2	+3.3V	3.3VDC Device Power supply
3	+5V	5VDC Device Power supply
4	GND	Ground
5	GND	Ground
6	Vin	+5V(USB) / Vin(Ext)

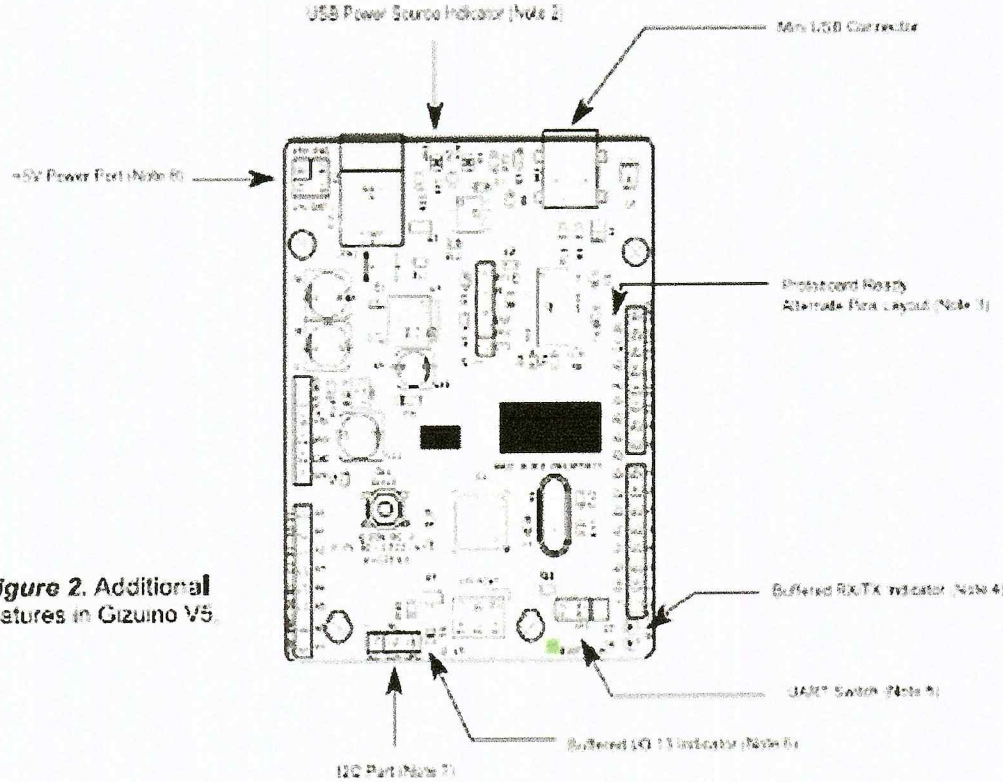


Figure 2. Additional features in Gizuino V5.

NOTE 1
Robust reset circuitry that does its jobs more reliably. Early variants of gizDuino used similar reset circuit as employed in the Arduino Diecemilla and inherited the problems that went with. The reset circuit can be easily overwhelmed by the addition of shields, causing frequent connections problem with the PC during the downloading process. The new reset circuit is expected to minimize that.

NOTE 2
USB Power Source indicator - Tells you when power is drawn from the USB port.

NOTE 3
Protoboard Ready alternate pin layout - At your option, you can solder additional header on this pins. This will allow you to mount and connect your gizDuino5 board to a standard perforated prototyping PCBs.

NOTE 4
Buffered UART TX/RX indicator - Now a visual means to monitor the activity of one of the most used port of your gizDuino. LEDs flashes when data (of sufficient duration) flows through these pins.

NOTE 5
UART Switch - A shield or extension dervice that connects through your gizDuino UART port can interfere with the program downloading process, resulting in those "STK-500" failures. The usual workaround is to remove the shields or expansions during program downloading, and reseat them later after program transfer is completed. With the UART switch, you don't have to go through this inconvenience. Just switch to "BOOT" position during program transfer, and switch back to "RUN" position after program downloading is completed.

LMx24-N, LM2902-N Low-Power, Quad-Operational Amplifiers

1 Features

- Internally Frequency Compensated for Unity Gain
- Large DC Voltage Gain 100 dB
- Wide Bandwidth (Unity Gain) 1 MHz (Temperature Compensated)
- Wide Power Supply Range:
  - Single Supply 3 V to 32 V
  - or Dual Supplies ±1.5 V to ±16 V
- Very Low Supply Current Drain (700 μA) —Essentially Independent of Supply Voltage
- Low Input Biasing Current 45 nA (Temperature Compensated)
- Low Input Offset Voltage 2 mV and Offset Current: 5 nA
- Input Common-Mode Voltage Range Includes Ground
- Differential Input Voltage Range Equal to the Power Supply Voltage
- Large Output Voltage Swing 0 V to V^+ − 1.5 V
- **Advantages:**
  - Eliminates Need for Dual Supplies
  - Four Internally Compensated Op Amps in a Single Package
  - Allows Direct Sensing Near GND and V_{OUT} also Goes to GND
  - Compatible With All Forms of Logic
  - Power Drain Suitable for Battery Operation
  - In the Linear Mode the Input Common-Mode, Voltage Range Includes Ground and the Output Voltage
  - Can Swing to Ground, Even Though Operated from Only a Single Power Supply Voltage
  - Unity Gain Cross Frequency is Temperature Compensated
  - Input Bias Current is Also Temperature Compensated

2 Applications

- Transducer Amplifiers
- DC Gain Blocks
- Conventional Op Amp Circuits

3 Description

The LM124-N series consists of four independent, high-gain, internally frequency compensated operational amplifiers designed to operate from a single power supply over a wide range of voltages. Operation from split-power supplies is also possible and the low-power supply current drain is independent of the magnitude of the power supply voltage.

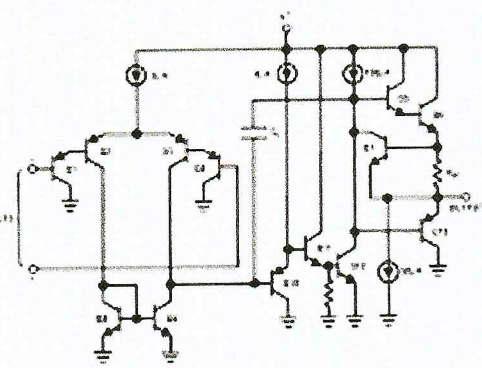
Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124-N series can directly operate off of the standard 5-V power supply voltage which is used in digital systems and easily provides the required interface electronics without requiring the additional ±15 V power supplies.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM124-N	CDIP (14)	19.56 mm × 6.67 mm
LM224-N		
LM324-N	CDIP (14)	19.56 mm × 6.67 mm
	PDIP (14)	19.177 mm × 6.35 mm
	SOIC (14)	8.65 mm × 3.91 mm
	TSSOP (14)	5.00 mm × 4.40 mm
LM2902-N	PDIP (14)	19.177 mm × 6.35 mm
	SOIC (14)	8.65 mm × 3.91 mm
	TSSOP (14)	5.00 mm × 4.40 mm

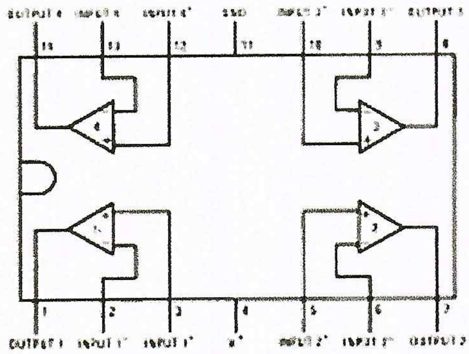
(1) For all available packages, see the orderable addendum at the end of the datasheet.

Schematic Diagram

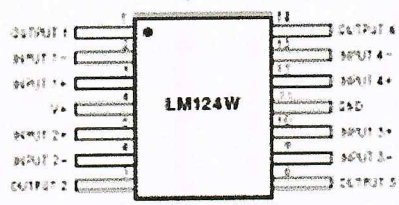


5 Pin Configuration and Functions

J Package
14-Pin CDIP
Top View



D Package
14-Pin SOIC
Top View



Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO.		
OUTPUT1	1	O	Output, Channel 1
INPUT1-	2	I	Inverting Input, Channel 1
INPUT1+	3	I	Noninverting Input, Channel 1
V+	4	P	Positive Supply Voltage
INPUT2+	5	I	Noninverting Input, Channel 2
INPUT2-	6	I	Inverting Input, Channel 2
OUTPUT2	7	O	Output, Channel 2
OUTPUT3	8	O	Output, Channel 3
INPUT3-	9	I	Inverting Input, Channel 3
INPUT3+	10	I	Noninverting Input, Channel 3
GND	11	P	Ground or Negative Supply Voltage
INPUT4+	12	I	Noninverting Input, Channel 4
INPUT4-	13	I	Inverting Input, Channel 4
OUTPUT4	14	O	Output, Channel 4

Wiring connections

gizDuino		Bluetooth Module HC-05
+5V	——>	+5V
GND	——>	GND
TX	——>	RX0/D0
RX	——>	TX0/D1

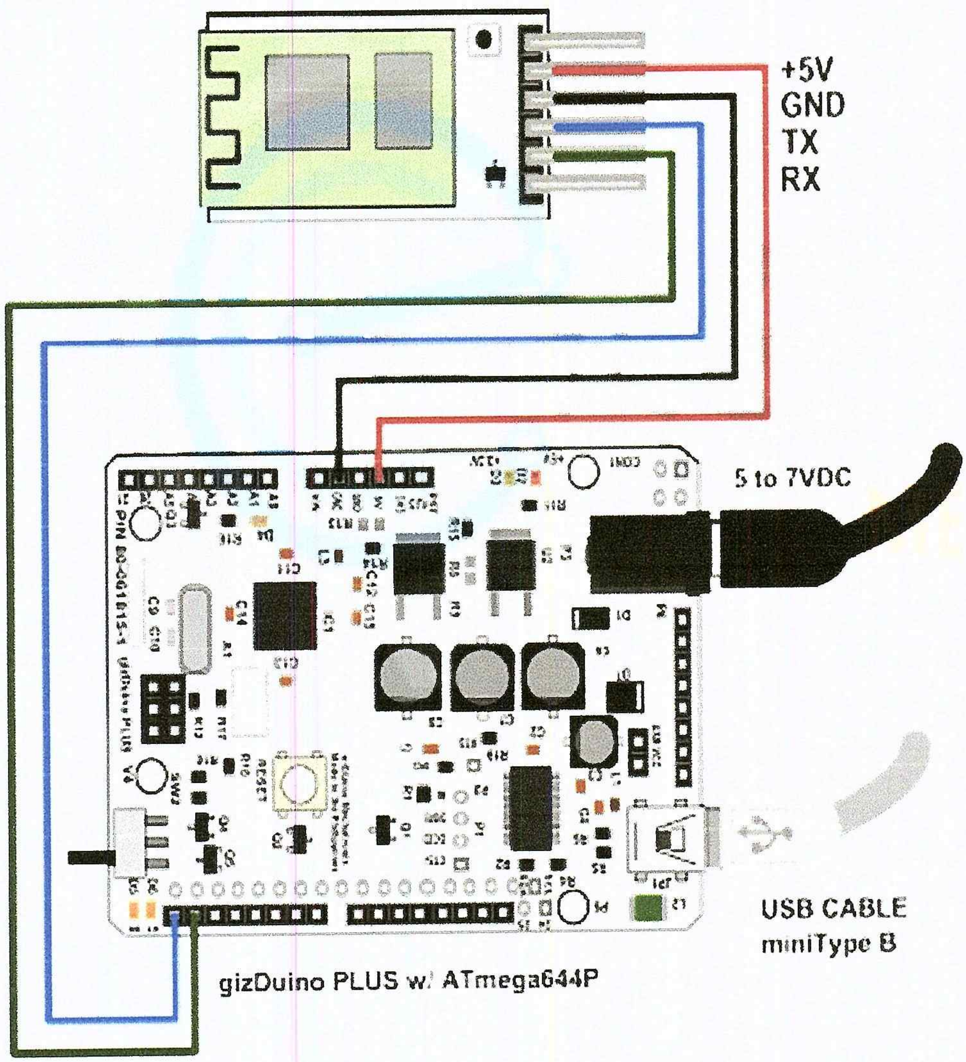


Figure 2. Sample connections

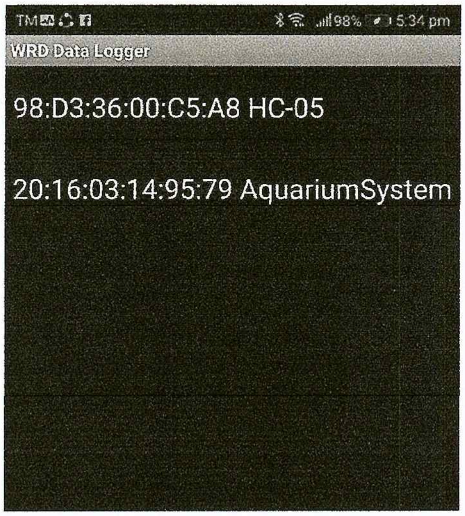
CODES

RECEIVER

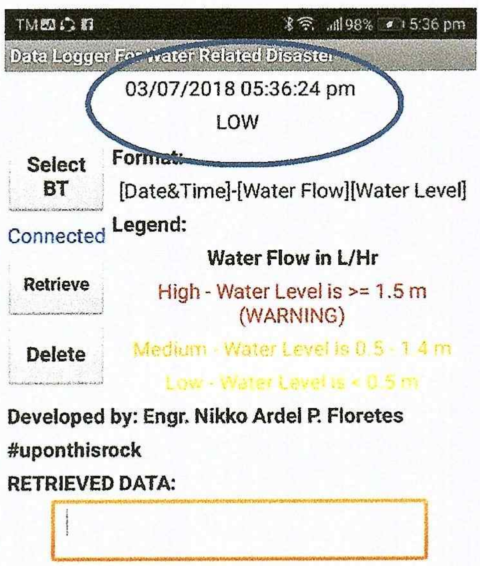
```
#include <SoftwareSerial.h>
SoftwareSerial XBee(9, 10);
int LED = 8;
int a;
const int ledPin = 13;
bool started= false;
bool ended    = false; char incomingByte ;
char msg[4];
byte index;

void setup() {
        XBee.begin(9600);
        Serial.begin(9600);
        pinMode(ledPin, OUTPUT);
        pinMode(LED, OUTPUT);
}
void loop() {
digitalWrite(ledPin, HIGH);
while(XBee.available() > 0){
 incomingByte = XBee.read();
if(incomingByte == '//character') //Read the incoming data
  {
   started = true;
   index = 0;
   msg[index] = '\0';  }
  else if(incomingByte == '//character')
  {
   ended = true;
break;  }
else if (incomingByte == 'H') {  a = 0;}
else if (incomingByte == 'I') {  a = 1;}
else  if (incomingByte == 'J') {  a = 2;}
else  if (incomingByte == 'K') {  a = 3;}
 else
  {
   if(index < 4)
   {
    msg[index] = incomingByte;
    index++;
    msg[index] = '\0';
   }
  }
```

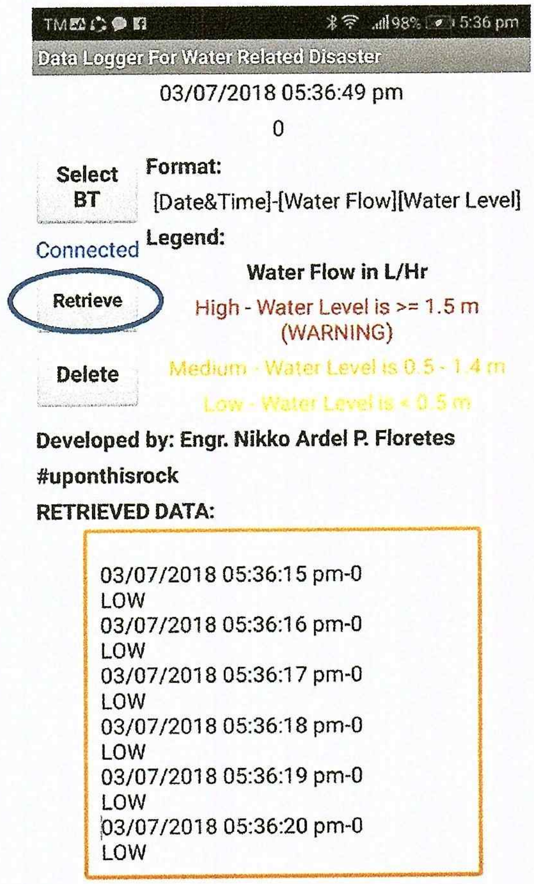
5. Select the Bluetooth for each of the Nodes by clicking the Select BT button.



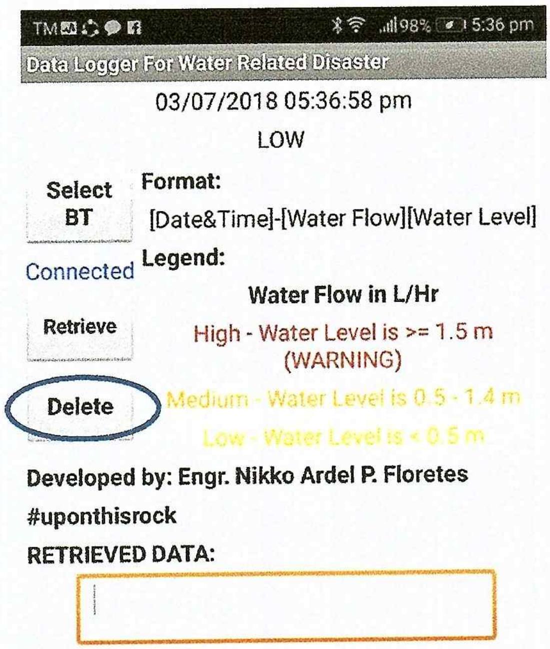
6. There will be reading of water level and water flow rate.



7. To view the logged data, just press the Retrieve button.



8. To erase the logged data, just press the Delete button.



RECOMMENDED INSTALLATION OF WATER LEVEL SENSOR HOLDER AND WATER FLOW CASING

CURRICULUM VITAE

CURRICULUM VITAE

Name	:	NIKKO ARDEL P. FLORETES
Age	:	26 years old
Sex	:	Male
Date of Birth	:	January 28, 1992
Citizenship	:	Filipino
Status	:	Single
Height	:	5'5"
Weight	:	57 kls.
Religion	:	ROMAN CATHOLIC
Home Address	:	Brgy. Muñoz, Catbalogan City, Samar
Eligibility	:	Electronics Engineering Board Passer

EDUCATION

Graduate Studies	:	Master of Science in Information Technology Samar State University Catbalogan City, Samar 2015 – 2018

Undergraduate Studies	:	Bachelor of Science in Electronics Engineering Samar State University Catbalogan City, Samar 2007 – 2012
Secondary Education	:	Samar College Catbalogan City, Samar 2003 - 2007
Elementary Education	:	Catbalogan III Central Elementary School Catbalogan City, Samar 1997 – 2003

POSITIONED HELD (SCHOOL DESIGNATION/ORGANIZATIONS)

ITSO Technical Expert
Samar State University
Catbalogan City, Samar
June 22, 2016 – Present

Instructor 1
Samar State University
Catbalogan City, Samar
July 1, 2014 – Present

Electronics Engineer (CATV Engineer)
Filproducts Cable Company (FPSTI)
Calbayog City, Samar
November 4, 2013 – April 4, 2014

Electronics Engineer (Volunteer)
DYMS (FM / AM)
Catbalogan City, Samar
May 3, 2013 – November 3, 2013

TRAININGS/SEMINARS/CONFERENCES/WORKSHOP ATTENDED

KTTO Huddle Workshop
Mercure Hotel
Metro Manila
February 21 – 23, 2018

IECEP National Convention
Subic Freeport
Olongapo City
November 23 – 25, 2017

SSU Patent Seminar
Resource Speaker
Samar State University
Catbalogan City
October 26 – 27, 2017

Synergy 2017 (Pitching Competition)
Pitcher
Manila Hotel
Metro Manila

SLSU Patent Draft Seminar and Workshop
Resource Speaker
Southern Leyte State University
Sogod, Southern Leyte
June 21 – 23, 2017

17th Conference of the Science Council of Asia
Poster Presenter
PICC, Pasay City
June 14 – 16, 2017

UCLG – ASPAC Paper Presentation
Poster Presenter
Samar State University
Catbalogan City
April 4 – 7, 2017

9th International Conference and Scientific Meeting
Oral Presenter
Surigao Del Sur State University
Tandag City
August 23 – 25, 2016

Inferential Statistics Seminar
Alta Resort
Cebu City
June 20 – 22, 2016

In-House Seminar Workshop for SSU Academic Personnel
Samar State University
Catbalogan City
May 4 – 8, 2015

1st Annual Regional Conference on Climate Change R/D&E
Visayas State University
Baybay, Southern Leyte
October 14 – 16, 2015

ICT for Disaster Risk Reduction, Climate Change, Green Growth and Sustainable Development Seminar
University of the Philippines – Open University
Quezon City
November 5 – 7, 2014

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