WIRELESS PASSENGER NOTIFICATION SYSTEM (PNS) FOR TRICYCLE TERMINAL AND STREET

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CERTIFICATE OF ORIGINALITY

We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material to which to a substantial extent has been accepted for award of any other degree or diploma of a university or other institute of higher learning, except where due acknowledgement is made in the text.

We also declare that the intellectual content of this thesis is the product of our work even though we may have received assistance from others on style, presentation, and language expression.

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DEDICATION

This technical research is humbly dedicated to all the valuable people who have been part of my journey:

To my mother in Heaven, ***Mommy Glenda****, whose love and care are incomparable and boundless, for being my motivation and inspiration in my education with her only wish for me to be successful in life;*
To my ***Lolo*** *in Heaven and* ***Lola*** *who have taken care of me and taught me about life when both of my parents were abroad;*
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To ***my friends*** *who accept me even when I am eccentric at times, for supporting me as we grow into better persons;*

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*To **Mama Gina** and **Daddy Billy**, my inspiration in doing my best, to whom this work is highly dedicated as it signifies another stepping stone towards my dream of becoming an engineer, for giving me consistent love and guidance;*

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Abstract

Title : Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street

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Public transportation is an important part of livelihood of most Filipinos. Every day, Filipinos use public transport for traveling to their workplace, school or university, leisure, and other recreational activities, especially for those who cannot afford private vehicles. This study was conducted to develop a way of communication between passengers and drivers that will ease some difficulties for both parties. The system allows passengers on a particular street to notify a tricycle terminal of how many tricycles should fetch them. Applied type of research method and experimental approach for testing the device using a survey questionnaire were employed in the study. A total of 30 individuals composed of 10 tricycle drivers and 20 local passengers served as respondents. Transmission range and time were gathered through simulations and series of walk testing. Using LoRa as the radio module gave a decent transmission range and obtained a working device that sends and receives data from each station. The PNS received a highly rated positive feedback among the chosen respondents in terms of appearance, usability, functionality, and reliability.

Keywords: *wireless communication, transportation, tricycle, passengers, long range, LoRa*

Chapter I

INTRODUCTION

Nowadays, next to jeepneys, the tricycle or trike is the most common mode of public transportation in the Philippines. According to the 2016 public transportation profile in the Philippines, more than 55% of the country's registered motor vehicles were tricycles and motorcycles; 23% of which were around 1.2 million tricycles from a total of 5,175,303 tricycles and motorcycles (EGV, 2016).

Public transportation signifies a vital part of livelihood for most Filipinos. Every day, Filipinos use public transport for traveling to their everyday workplace, school or university, leisure, and other recreational activities, especially for those who cannot afford buying private vehicles. As noted in the Senate Bill 775 filed by Pangilinan (2019), in collaboration with transport advocacy group AltMobility PH, commuters who travel using public transportation services and active transport comprised 70% of the total trips in Metro Manila. This addressed that majority were using public transport which calls for a systematic and efficient mode of transport for drivers and passengers.

The tricycle or trike is a three-wheeled and gasoline-run motorized vehicle. Its design is made up of a motorcycle joined to a sidecar with multiple seating and a covered roof. The roof is often used as a baggage compartment and the back is often extended to serve the same purpose (FFE, 2016). In most cities and provinces in the Philippines, residents tend to rely on tricycles for them to travel point-to-point and transport the bulk of their luggage. Unfortunately, in some locations around cities and provinces such as in some parts of Tayabas, Quezon, commuters are usually far from the vicinity of the tricycle terminal that it requires walking a certain distance to reach it.

Background of the Study

With a growing population that demands the public transport system, an organized way of commuting will be a huge help to commuters as well as drivers. A way of communication between passengers and drivers will ease some of the difficulties for both parties.

In some cities and towns, some commuters are far from the location of the terminals. This leaves them no choice but to hope that a vehicle (such as a tricycle) will pass by which takes up too much time. Otherwise, they will have to walk to the terminal which may be stressful especially if they are carrying some luggage.

These are sometimes caused by the wide area of coverage of specific terminals such as the Tricycle Operators' and Drivers' Association (TODA) with a limited number of terminals to cater to that boundary. To somehow ease the problem, some tricycle drivers roam around the vicinity of the boundary to locate passengers. Doing so may somehow solve the problem except when they cannot find passengers at all which can be a waste of their effort, time, and gasoline.

Objectives of the Study

The main objective of this technical research was to develop "Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street". The researchers intended to use it for the convenience of the tricycle operators and passengers in Tayabas, Quezon.

Specifically, it sought to achieve the following objectives:

1. To identify the appropriate materials/components used in designing wireless notification stations for point-to-point transportation;
2. To assess distance and time of transmission using the LoRa Module; and
3. To determine the effectiveness of the prototype.

Significance of the Study

The proposed study promoted a prototype that could ensure convenient and secure transportation, especially for passengers who have a hard time transporting their luggage and those who are far from the main road. The results of the study and the prototype will be beneficial to the following:

Passengers will benefit from the study as it focused on their main problem regarding safe, convenient, and reliable commuting.

Tricycle drivers will be beneficiaries of the study for it will aid them to be more organized. In some cases of implementation, traffic could be reduced and gasoline consumption would drop because they will not need to roam the streets in search of possible passengers.

Government will also benefit from the study as this idea can help them establish systematic transportation for their locality. It can bring the concept of removing random terminals scattered around the streets.

Researchers will learn in this study involving the technologies of wireless communication and how to apply them to society's problems such as in the transportation sector.

Scope and Limitations

The study used a prototype that promotes convenience in transportation. The prototype provides wireless connectivity that notifies users at a certain location for transportation purposes. It uses LED lights and buzzers to notify users in both the master node and slave node of sent and received messages as well as LCD where some basic information about the number of service requests and acceptance of the tricycle are indicated. The testing of the prototype covered at least three days of deployment for testing and optimization, accumulating the expected number of respondents, and introducing it to the locals. The effectiveness of the prototype was tested after the implementation through a survey among the respondents (the passengers and the trike drivers) to identify the flaws of the device and the satisfaction of the users.

The prototype was limited to a simple notification service and would not provide Internet-based access like Wi-Fi access. Only one slave and master node (two transceivers) stations were tested in the study. The prototype could cover a 500m to 1km transmission range and function, simultaneously. Second, the prototype is powered by a chargeable battery for the portability of the device. The prototype uses a pushbutton and a potentiometer for actuators of the system in sending and changing data.

Definition of Terms

The following terms are conceptually and operationally defined for the readers to have a better understanding of the research:

Air interface is the connection that transmits signals from one LoRa module to another.

Data communication is the communication between two modules or transceivers through data transmission.

Data are the information transmitted throughout the process of station communication.

Deployment is the implementation of the prototype in the area of testing.

End nodes are the end-to-end points for the device/prototype.

ISM band (Industrial, Scientific, and Medical band) is part of the radio spectrum that can be used for any purpose without a license in most countries.

LoRa stands for "long range" and it was the module used in the study and the prototype.

Master node is the head endpoint of the communication. It is the system in the tricycle terminal.

Node is the communication endpoint of the transmission.

Packet is a block of data transmitted across a network.

Passengers are individuals who use tricycle as a mode of transportation in the area of implementation of the prototype.

Passenger Notification System (PNS) is the device intended for tricycle drivers to be notified if there is a passenger on other stations and for passengers to relay the information that they are in need of a tricycle.

Receiver is the module or device that receives data information.

Respondents are the individuals to whom the prototype was intended, specifically the passengers, users, and the tricycle drivers.

Slave node is the supporting endpoint of the communication. It is the system in the passenger station.

Telecommunications are the exchange of signal transmission carrying the information from point-to-point stations.

Terminals refer to the places where tricycle drivers stay and wait for possible passengers which are normally located in populated areas.

Transceivers are devices or modules used to receive and transmit signals.

Transmission distance is the distance of the data transmitted from a point-to-point transmission.

Transmission time is the time taken for data to be transmitted from a node and to another node.

Transmitter is a module or device used to send data signals onto the receiver.

Tricycle, also called trike, is a three-wheeled, gasoline-run motorized vehicle.

Tricycle driver is one who operates or drives a vehicle called a tricycle.

Walk testing is a method of collecting samples and measuring and assessing signal strength, signal-to-noise ratio, and range of the LoRa network.

Chapter II

REVIEW OF RELATED LITERATURE AND STUDIES

Following the researchers' thorough study, this chapter covers the relevant literature and studies. For a better understanding and additional knowledge about the technology utilized to develop and construct the study, books and sources from the Internet were consulted. For better understanding of the investigation, the conceptual framework is also presented.

Related Literature

Telecommunications

As stated by Stark (2021), telecommunication is the application of science in transmitting of data through electronic means. Telecommunications have evolved through the years addressing issues such as severe loss caused by the noise and interventions when transmitting huge amounts of data over long distances. Today's telecommunications system evolved into digital wherein the core components are now capable of transferring voice, data, radio, and television signals.

Source: *https://www.360cities.net/es/image/parabolic-satellite-communication-antenna-in-raisting*

Figure 2.1 Parabolic Satellite Antenna in Bavaria, Germany

Also, digital transmission was built to achieve high reliability with the business perspective that digital switching systems are much cheaper than the cost of analog systems. However, majority of the signals are analog forms such as voice, radio, and television communication that are converted into digital signals to be transmitted digitally. Some transmitted data skip this stage when the signals are already digital. In many circumstances, the method will proceed with the digitized signal processed in a source encoder which uses a series of formulae to remove redundant binary data. Next, the signal is moved in a channel encoder which introduces redundant information that will enable error detection and correction. The encoded signal will be modulated through a carrier wave that will make it suitable for transmission, as mentioned, with the additional steps of multiplexing allowing it to become part of a larger signal. The multiplexed signal will be delivered through a multiple-access transmission channel. The preceding process is reversed at the receiving end after transmission, then the information is extracted.

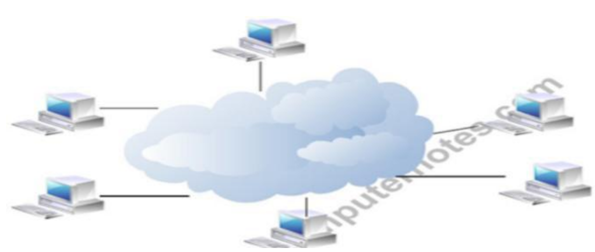
Data Communications

As studied by Thakur (2021), the interchange of data between a source and a receiver within a transmission medium such as a wired connection or air interface is called data communication. The data communication process revolves around a device sending data, known as the source, and a device that receives the data, known as the receiver. Data transmission's objective is to transport data and keep it safe throughout the process, not to generate data at the source and receiver. Datum refers to facts, information, statistics, and the like that are derived through computation or testing. The facts and information acquired are dependent on the process or procedures of extracting it. Data can take on different forms, such as numbers, text, bits, and bytes. A rudimentary data communication system is depicted in the diagram.

Source: *https://ecomputernotes.com/computernetworkingnotes/communication-networks/what-is-data-communication*

Figure 2.2 Simple Data Communication System

Moreover, through data transmission circuits, a data communication system may collect data from far places and then output processed results to remote sites. Figure 2.2 illustrates the comprehensive diagram of data communication networks. There are a lot of emerging data communication techniques that are currently commonly used either to improve or to replace older data communication techniques with better options of results and capabilities.

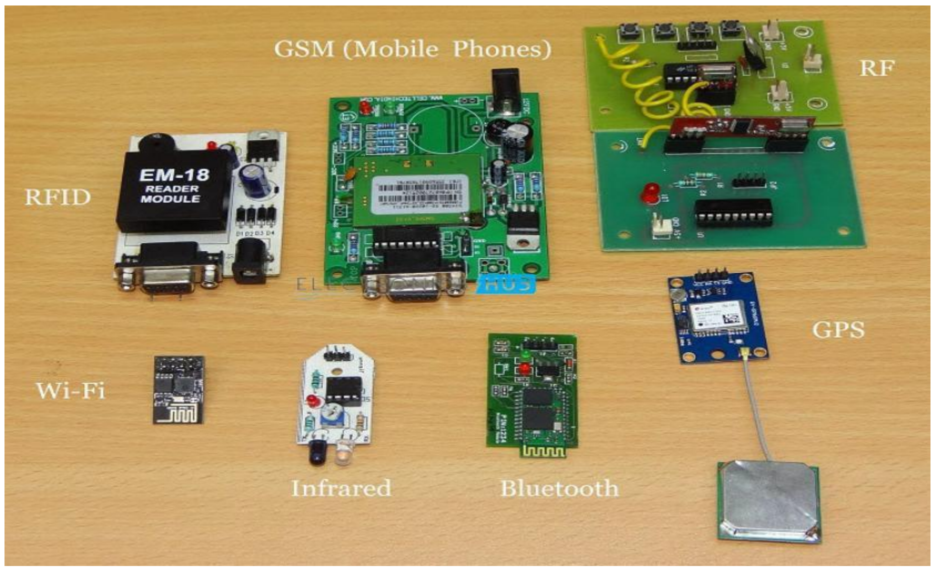


Source: *https://ecomputernotes.com/computernetworkingnotes/communication-networks/what-is-data-communication*

Figure 2.3 Data Communication System Using Remote Locations

Wireless Communications

Teja (2021) stated that wireless communication is the most common communication technology in the present era, because of its much better capability of transferring data from one point to another without using connections such as cables, wires, or any kind of physical medium.



Source: *https://www.electronicshub.org/wireless-communication-introduction-types-applications/*

Figure 2.4 Types of Wireless Communication Systems

Furthermore, the transmission of information from a transmitter to a receiver has a limited distance in most common communication systems. But through the advent of wireless communication, the transmission between the sender and a receiver can now be between a few meters, like a TV remote control, and between a few thousand kilometers, such as satellite communications and cellular communications.

LoRa Versus Other Wireless Technologies

Cellular

As researched by BEHRTECH (2021), cellular networks become the go-to wireless technology at present because of its established and reliable connection that supports the transfer of different varieties of information, such as phone calls, videos, data, photos, video calls, streaming apps, etc. The downside of this technology revolved around the extreme cost of operations and high-power requirements.

These downsides become an incompatibility for IoT applications, which require low-power transmission since most devices for IoT use battery-operated sensors in transmission. However, cellular is well-suited for special cases that require high bandwidth and better connectivity, such as in transportation and logistics like linked cars or fleet management, and other applications such as traffic routing, in-car infotainment, fleet telematics, advanced driver assistance systems (ADAS), advanced driver assistance systems (ADAS), and others.

Source: *https://www.techspot.com/news/74480-global-smartphone-shipments-reached-345-million-q1-down.html*

Figure 2.5 Global Smartphones

Zigbee

According to BEHRTECH (2021), Zigbee is a radio technology based on the IEEE 802.15.4, with its low-power but short-range capability frequently used in the application of improving the coverage in mesh topologies through passing sensor data across many sensor nodes. Zigbee offers better data output than the most common LPWAN but has the drawback of lower power efficiency caused by its mesh design.

Zigbee is similar to Z-Wave, Thread, etc. that operate in mesh protocols and are better applied on IoT solutions with a range of 100m and the same node distribution of vicinity within each node. Usually, it is used as supplementary in Wi-Fi technology for application in home automation including home sensor networks, such as security, smart lighting, energy management, and HVAC controls.

Before the widespread usage of LPWAN, mesh networks have been used in industrial settings creating different remote monitoring systems. However, the fixed network setup that can be created in this technology hampers its potential scalability, together with the problems of managing geographical distances and locations.

Source: *https://www.tindie.com/stores/chimer_li/*
Figure 2.6 Zigbee Module

Bluetooth

As cited by Kumari (2017), the Bluetooth technology was invented by Ericsson back in 1994 as a standard wireless technology standard for transmitting data over short distances utilizing the short-wavelength UHF radio waves (range: 2.4 to 2.485 GHz) from stationary and mobile devices, which is not known as Industrial, Scientific, and Medical (ISM) short-range radio frequency spectrum, an internationally unlicensed (but not uncontrolled) frequency for transmitting data.

In addition, it transmits data via a frequency-hopping spread spectrum. Data are separated into packets, which are then sent out on one of 79 channels. With adaptive frequency-hopping, each channel has a bandwidth of 1 MHz and 800 hops per second (AFH). BLE has a channel spacing of 2 MHz and can accommodate 40 channels.

Source: *https://techspirited.com/advantages-disadvantages-of-bluetooth-technology*

Figure 2.7 Bluetooth Technology

WiFi

As studied by Uy (2021), Wi-Fi is a wireless technology and a networking standard based on IEEE 802.11. This standard involves the connection of devices wirelessly or using the air interface as the medium described as wireless local area network (LAN) protocol in the industry.

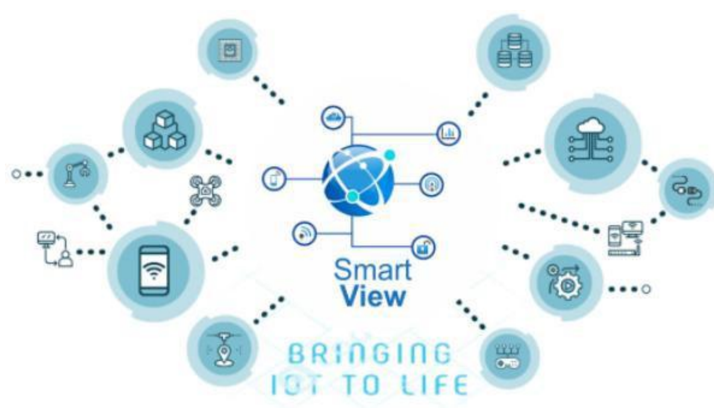
Wi-Fi is an internet connection through a wireless-capable device such as a phone, tablet, or laptop from the user's perspective. Wi-Fi is the most widely utilized method of wireless data communication in a fixed place. It is a trademark of the Wi-Fi Alliance, a non-profit organization dedicated to the advancement of wireless LAN technologies and devices.

Source: *https://www.mobileappdaily.com/future-of-5g-technology*
Figure 2.8 Wireless Technology

Sigfox

Gabriel (2019) stated that Sigfox is wireless communication with its long-range capabilities primarily used for applications of the Internet of Things (IoT) and Machine-to-Machine (M2M) with low throughput. It uses specific base stations with software-defined radios for Sigfox network protocol and transmission using binary phase-shift keying (BPSK) modulation.

In addition, the Sigfox network was created to provide for effective communication while consuming minimal power. Low power consumption ensures that distant devices can operate for an extended period with little or no battery charging or maintenance. Sigfox facilitates IoT connectivity over vast distances, allowing transmission with a small number of base stations. The Sigfox network employs a cellular-style technique to allow remote nodes to communicate with base stations through the Internet.



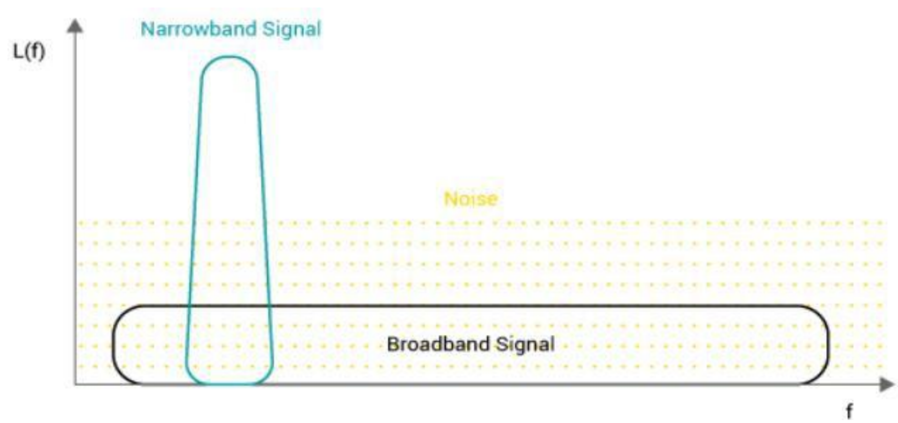
Source: *https://partners.sigfox.com/companies/smartview-technology*

Figure 2.9 Smartview Technology

NB-IoT

As published by Avsystem (2020), NB-IoT (Narrowband IoT), also known as LTE Cat NB, is a wireless technology created in the cellular standards to enable the Internet of Things devices with their architecture to be connected to mobile networks. This technology falls off in the low-power wide-area technology (LPWA) that addresses the power problems of the former cellular technologies.

There are hundreds of different Internet of Things applications available right now. Their diversity necessitates an equally diverse network selection. LTE or the 5G wireless communications standard, for example, is best for crucial machine-to-machine (M2M) connectivity, such as remote device operation. LAN or WiFi connections are sufficient for short-range networks, such as computer networks or connecting smart equipment at home.



Source: *https://www.avsystem.com/blog/narrowband-iot/*
Figure 2.10 NB-IoT Overview

Radio Technology Comparison Summary

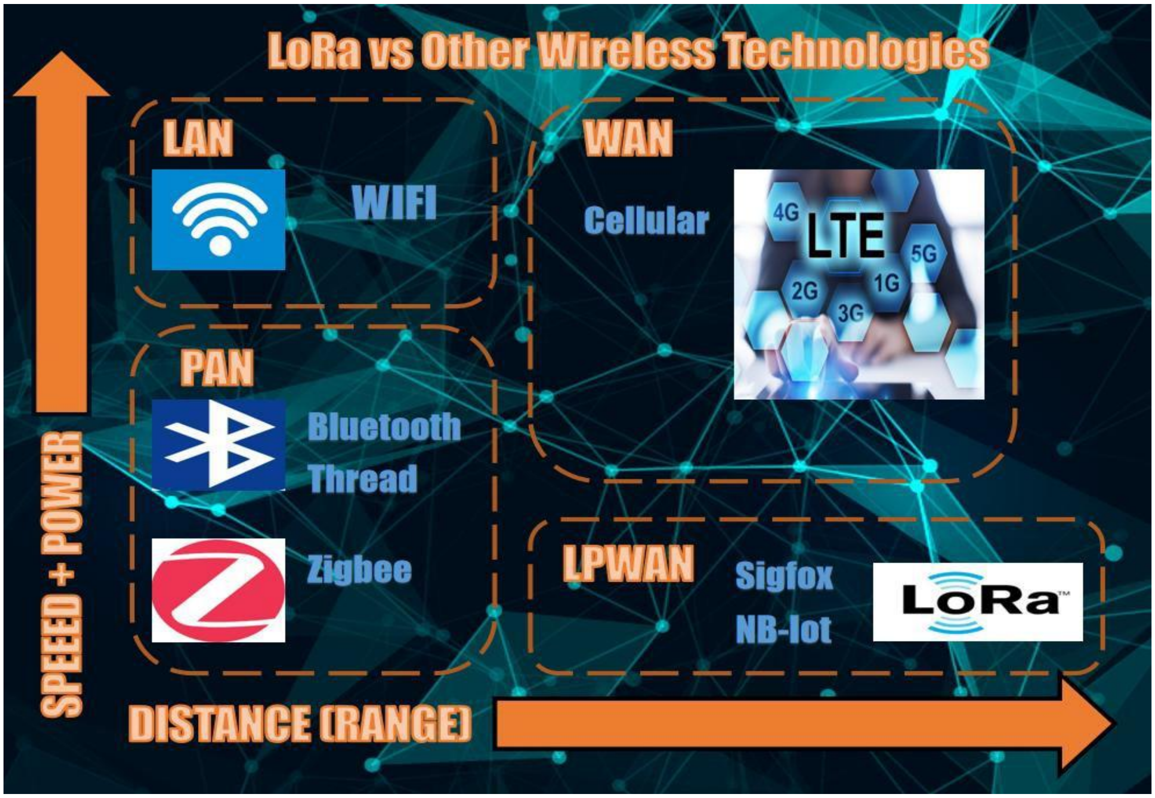


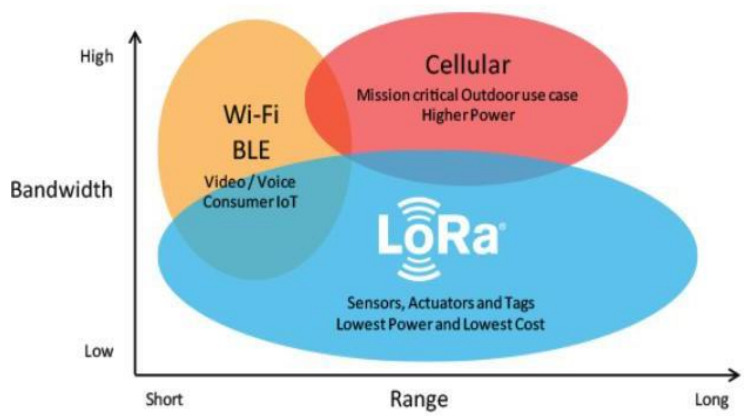
Figure 2.11 Radio Technologies Graphical Comparison

Figure 2.11 illustrates the comparison of different wireless technology in terms of speed, bandwidth, and distance or range. WAN and LPWAN have better range than other technologies, well-suited to the description of the current study. WAN, especially the cellular technologies, has better speed and bandwidth than the LPWAN, but LPWAN has better range and uses low power which makes it the best technology to be applied in this study. NB-IoT uses licensed frequency and costly, making it inappropriate for the study. LoRa technology is ideal in the study with its technology having a standard, more accessible prototyping modules, can be used in long-range communication, and uses low power.

LoRa vs Other Radio Modules

LoRa and LoRaWAN

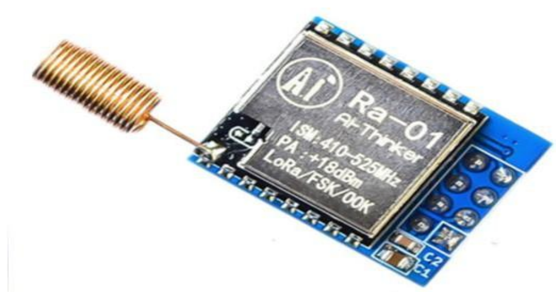
According to Semtech (2020), LoRa (Long Range) is a low-power, wide-area network RF modulation technology (LPWANs). LoRa is a well-known module that refers to the ability of the technology to transport data over extraordinarily long distances. LoRa, which was developed by Semtech to standardize LPWANs, allows for long-range communications of up to three miles (5km) in urban areas and up to 10 miles (15km) in rural areas line of sight. LoRa-based systems' ultra-low power requirements are a key characteristic, which built battery-operated devices for this technology to last up to 10 years.



Source: *https://www.semtech.com/lora*

Figure 2.12 LoRa and LoRaWAN

In addition, LoRa uses the LoRa spread spectrum which is a patented modulation of Semtech which is based on the chirp spread spectrum (CSS). As indicated in The Things Network (2021), CSS technology is how information is encoded into radio waves using chirp pulses, similar to how dolphins and bats communicate. Seneviratne (2019) indicated that LoRa modulated transmission is resistant to interference and can be received over long distances. From this technology, LoRa can provide long-range and low-power consumption, low data rate, and secured transmission along with its end nodes. It can be used in different networks either public, private, or a hybrid of these networks that can exceed the range capability of cellular networks. LoRa technology is mostly used in Internet of Things (IoT) applications due to its efficiency in integrating with other networks, low cost, and being low-powered.



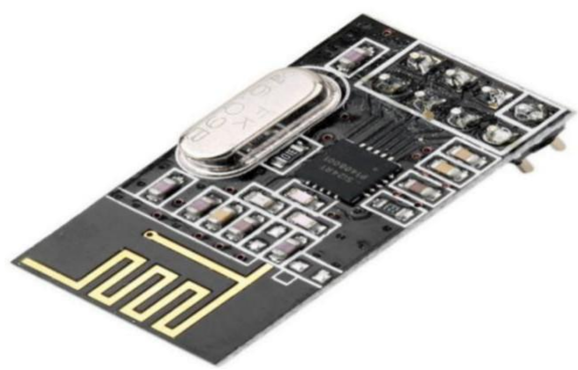
Source: *https://www.joom.com/en/products/5f378f84d784b201066ae1fb*

Figure 2.13 RA-02 LoRa Module

As indicated by Olsson (2017), LoRaWAN™ is a Low Power Wide Area Network (LPWAN), a protocol intended for wireless devices that runs on LoRa modules or chips. LoRaWAN specifications are intentionally created to improve LoRa’s capability in range, with the addition of secured duplex communication, location services, and mobility between the networks around each node, either within regional, national, or global networks. It provides more freedom to users, developers, and businesses.

nRF24

There are numerous wireless radio modules on the market that are regularly utilized in microcontrollers like Arduino and Raspberry Pi. The most well-known of these is nRF24. According to the website The Bright Side (2015), the device called Nordic nRF24 is a silicon-integrated radio transceiver that works at 2.4 GHz in the ISM (Industrial, Scientific, and Medical) band. The most used nRF24 is the nRF24L01.These boards provide proprietary wireless networks between nodes and do not support WiFi 801.11 or Bluetooth both in the 2.5GHz band.



Source: *https://alltopnotch.co.uk/product/nrf24l01-wireless-module-2-4g-transceiver/*

Figure 2.14 nRF24 with wireless module

CC1101

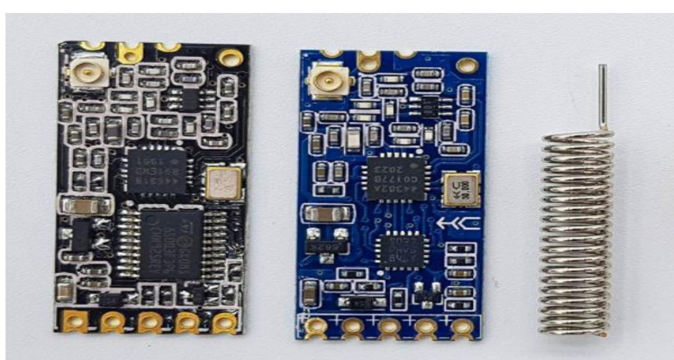
As mentioned in Elecrow (2021), CC1101 is a radio module intended for ISM and SRD (short-range devices) running in the sub-1GHz bands designed for low- powered wireless applications. The frequencies this module uses are 315, 433, 868, and

915 MHz, where some lie within the ISM frequency band, but can also be easily programmed for operation on other frequency ranges such as 300-348 MHz, 387-464 MHz, and 779-928 MHz bands for medium to long-range distances.

Source: *https://www.aliexpress.com/item/32290705850.html*
Figure 2.15 CC1101 Wireless Module SMA Antenna Wireless Transceiver

HC12

One of the most used radio modules next to nRF24 especially for the customized projects in Arduino is the HC12. In accordance with Hughes (2016), HC-12 is a half-duplex wireless serial communication module that works at 100 mW and with a multi-channel wireless transceiver, at 100 channels to be exact, in 433.4 to 437 MHz capable of transmitting in 1km.



Source: *https://wolles-elektronikkiste.de/en/hc-12-radio-module*
Fig. 2.16 Two HC-12 Modules with an Antenna

Raw RF Module

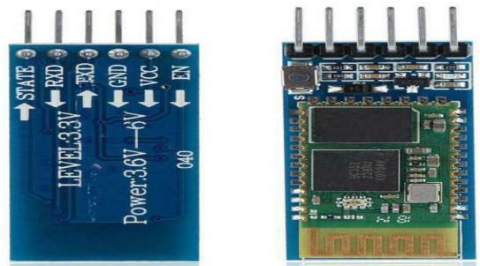
It is the generic RF module used in any microcontroller at the frequency of 433.92 MHz. It is the radio modules mostly found in starter Arduino kits that come in pairs, a transmitter and a receiver, and can be bought for a cheap price at around 100 pesos or less, both with the receiver and the transmitter. In addition to these, it was also stated in Random Nerd Tutorials (2019) site that these modules have only a variable range, mostly a very short range because it only uses ASK modulation. These modules only work in simplex mode or the unidirectional transmission mode.

Source: *https://robu.in/product/433mhz-tx-rx-module/*

Figure 2.17 Raw RF Module

Bluetooth Module HC-05

According to ElectronicWings (2022), Bluetooth module HC-05 is a wireless module with IEEE 802.15.1 interchangeable protocol built for wireless Personal Area Network or PAN. It uses the radio technology of frequency-hopping spread spectrum (FHSS) in sending data over the air. It is widely applied in consumer applications for wireless communications and has a range of fewer than 100 meters depending on factors such as the transmitter and receiver, atmospheric conditions, geographical conditions, and obstructions. The module can be used in either slave or master configuration.

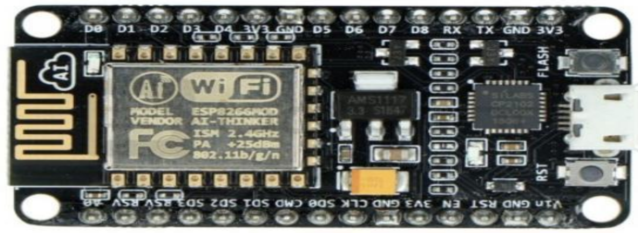


Source: *https://www.ebay.com/itm/1-5PCS-HC-05-Wireless-Bluetooth-Module-BT-Transceive-Serial-Module-Commander-/333573175403*

Figure 2.18 Bluetooth Module HC-05

Wi-Fi Modules

As mentioned in RS Components Corporation (2021), Wi-Fi or wireless fidelity modules are electronic modules used in a lot of devices to access wireless communication to the Internet. The most used Wi-Fi module is the ESP8266 module which is a wireless transceiver commonly applied for Internet of Things or IoT applications. As stated in the datasheets from ElectronicWings (2021), it works on 2.4 GHz Wi-Fi 802.11 b/g/n, supports WPA/WPA2, and transmits in pulse-width modulation (PWM). Tones (2021) added that it comes with factory-installed firmware that allows to control it with standard “AT commands”. This makes the customization easier for programming of controlling devices over the Internet. This module can also work stand-alone which means it can be used to work on its own or be a microcontroller like Arduino.



Source: *https://botland.store/esp8266-wifi-modules/15136-nodemcu-wifi-esp8266-module-4mb-waveshare-16608-5904422343002.html*

Figure 2.19 NodeMCU WiFi ESP8266 module - 4MB - Waveshare 16608

Radio Modules Comparison Summary

Table 2.1 Radio Modules Comparison in Terms of Range, Energy Usage, and Speed

Features	LoRa	nRF24	CC1101 (without/with power amplifier)	HC12	Raw RF module	HC05/Bluetooth 3.0	Wi-Fi module
Range	very long range	medium-high range	medium/very long range	long range	variable range (mostly short range)	short range	short-medium range
Energy Usage	variable energy usage	low energy usage	low/very high energy usage	low energy usage	low energy usage	medium energy usage	medium-high energy usage
Speed	very low speed	high speed	medium speed	low-medium speed	variable speed	medium speed	very high speed
Example Usage	IoT devices	drones, battery-operated IoT devices	walkie-talkies	battery-operated IoT devices, drones	cheap devices	robots controlled with a smartphone, commercial wireless devices (such as mouse, headset, and speaker)	IoT devices, security cameras

Table 2.1 summarizes the features of different accessible and cheapest radio modules in the market depending on their range, energy usage, speed, and example applications.

ISM Band

The Industrial, Scientific, and Medical (ISM) frequency bands are radio frequency bands designated for RF purposes other than telecommunications, which is defined by the ITU Radio Regulations or RR (2012 edition) in Article 5 in footnotes 5.138, 5.150, and 5.280. Individual countries' designation differs depending on their national radio regulations. As stated in Military & Aerospace Electronics (2019), more modulation schemes and communication platforms use ISM bands in the past few years knowing that a lot of emerging potentials for technologies such as The Internet of Things (IoT) and Industry 4.0 applications will more likely rely upon low-power and much better for long-range communications. Some of these new technologies include Thread, Z-wave, LoRa, and NB-IoT.

As mentioned in the RP2-1.0.1 LoRaWAN® Regional Parameters released by LoRa Alliance® (2020), the available bands or channels in the Philippines were 915 – 918 MHz, 868 – 869.2 MHz, 869.7 – 870 MHz, and 433.05 – 434.79 MHz, in Channel Plans in accordance with AS923-3, EU863-870, EU863-870, and EU433, respectively.

LPWAN

Qadir et al. (2018) claimed that as the underlying networks for Internet of Things (IoT) applications, low-power wide-area (LPWAN) technologies are strongly suggested. Wide-range coverage, long battery life, and affordable data rates are among the appealing qualities they offer. Their article examined contemporary technological trends, focusing on the services offered and the issues encountered. The industrial concepts for LPWA adoption were discussed. In contrast to previous research in the sector, their study focused on the requirement for integration between different LPWA technologies and suggested the best LPWAN solutions for a variety of IoT application and service use cases.

Arduino

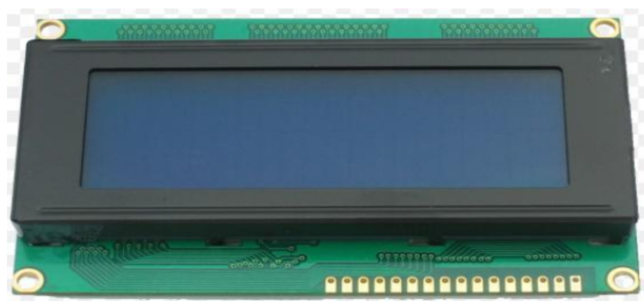
As cited in Arduino's (2021) website, Arduino is an open-source electronics component comprised of their hardware and software, in the form of different types of Arduino boards and the Arduino IDE to program the contents for the microcontroller. Sets of instructions can be programmed in the microcontroller to perform something such as simple blinking of light, automation using a variety of sensors, etc. Arduino is well-known for creating thousands of projects, from simple household items to large scientific projects. Contributions are created from all around the world to improve the applications on Arduino from different sectors such as professionals, programmers, hobbyists, and students.

Source: *https://www.bing.com/search?q=Arduino&qs=n&form=QBRE&sp=-1&pq=arduin&sc=8-6&sk=&cvid=7FA313AFD47A4705B0A69E3AF2A8FB37*

Figure 2.20 Arduino UNO Rev3

Liquid Crystal Display

As indicated by Dunmor (2015), a liquid crystal display (LCD) is an electrical device that displays output by changing the liquid's optical characteristics on each layer using an electric voltage that varies on the symbols to be presented. This technology is used in multiple electronic devices such as games, digital cameras, televisions, projectors, computer monitors, and billboards. There are also different types of LCD panels specifically used for Arduino or other microcontrollers depending on what type of project to create.



Source: *https://www.inventelectronics.com/product/20x4lcd/*
Figure 2.21 20x4 LCD

Push Button

As published by Khatri (2015), a push-button is a mechanical component used as an actuator in different applications, commonly made of plastic and metal. The component works as an on and off button with the operation of remaining off or in an open position when not pressed, and will only allow current through it or close the circuit when it is pressed. Most push buttons are made up of four legs, two on each side, that allow them to control two lines of a circuit. Figure 2.22 shows a push-button that has two legs on each side that are internally joined.

Source: *https://www.alsamra.com/giffex-products.html*
Figure 2.22 Push Button

Potentiometer

According to GFG (2021), a potentiometer is an electrical device that detects both the EMF (electromotive force) and the internal resistance of a cell. It is also used to compare different cells' EMFs. It can also be used as a variable resistor in most applications.

The component potentiometer is made of a long wire with a consistent cross area. The wire is usually made of manganin or constantan. The wire is sometimes divided into several parts and each component is connected to the end through a thick metallic strip. Copper strips are most commonly used. One meter of wire is used for each item. There are six bits of wire for the most part and the total length of the wire is six meters. The wire length varies from 4m to 10m for the most part. The potentiometer's precision improves as the wire length increases.

‘

Source: *https://www.tubesandmore.com/products/potentiometer-alpha-linear-pc-mount-marshall*
Figure 2.23 Potentiometer

Power Bank

As studied by Madaan (2013), a portable energy source that may be carried in one's pocket or backpack is known as a power bank. It has an integrated Lithium-Ion battery that stores energy and can be used to charge portable devices such as smartphones and tablets as needed.

Source: https://www.mdexstore.com/power-bank
Figure 2.24 Power Bank

Related Studies

Wireless Data Communications System for a Transportation Vehicle

As studied by Hettich (2005), the invention was for diverse selection of vehicles like airplane, bus, cruise ships, or railway. An information source containing data content such as text, audio, and video media; a plurality of wireless interfaces; a plurality of individually identifiable electronic devices coupled to the plurality of wireless interfaces; and a wireless local area network (LAN) access point were all part of the wireless communication system. The information source was connected to the wireless LAN access point, also wirelessly connected to many wireless interfaces. The wireless LAN access point could receive data content from the information source, convert it to a wireless transmission format, and selectively distribute the formatted data content to the plurality of wireless interfaces so that it could be reached by at least one of individually identifiable electronic apparatus.

Method for Requesting Transportation Services

Hall (2017) disclosed using mobile communications devices that can track geographic location as a method for acquiring transportation services safely and efficiently. Transportation for individuals and groups may be available; new customers may be efficiently served; and the position of the requester and the transportation provider can be viewed in real-time on mobile devices.

Enhanced Transit Location Systems and Methods

Hanzcor's (2021) electronic apparatus or invention was a wireless device for communication purposes mainly used for transportation, using electronic devices as medium. The said device could decode the encoded data and receive signal number one sent by the second electronic device attached to a vehicle. The second device could give feedback (sends second signal) and transmit data to the first device, wherein the first device determines the location and position of the vehicle with its attached second device. In summary, this electronic apparatus has multiple devices on multiple locations that contribute data to its first device (database).

Locating and Tracking System and Method Based on LoRa Transmission

As proposed by Dacai (2017), the invention was a locating and tracking communication system and procedure based on LoRa transmission. The electronic apparatus included a positioning and display device whereas the locating product included a micro control unit and LoRa-based wireless locating module while the micro control unit was connected to the LoRa-based wireless locating module. The display product included a mobile terminal or a GPRS product and a LoRa RF module arranged on the mobile terminal or the GPRS product which is connected to the mobile terminal or the GPRS product. The wireless locating module based on LoRa could exchange information with the LoRa RF module in a wireless communication mode. When compared to existing locating and tracking devices based on Bluetooth and

GSM, the invention's locating and tracking system could improve locating distance and precision, reduce power consumption, and improve stability.

Localization Tracking System Based on LoRa Transmission

Dacai's (2017) utility model was a location tracking system based on LoRa transmission which included a location product and a demonstration product, wherein the location product included a small control unit based on LoRa's wireless locating module while the demonstration product included a mobile terminal or GPRS product. In comparison to typical location and tracking software based on Bluetooth and GSM, the utility model could enhance positioning distance and precision, reduce and utilize consumption, and maintain stability.

LoRa Wireless Module, Data Transmission System, and Data Transmission Method

In the study by Yue (2018), the invention included a LoRa wireless module in an electronic apparatus used for long distance transmission of data. The main control chip, a security unit, and a LoRa radio frequency unit made up the LoRa wireless module, with the security unit and the LoRa radio frequency unit integrated into the main control chip. Target data are collected by a data acquisition device and sent to the security unit. The security unit then encrypts the target data and sends the encrypted data to the main control chip, and the main control chip calls a LoRa protocol stack and sends the encrypted data out through the LoRa radio frequency unit. The LoRa wireless module given by the application encrypts the data using hardware encryption and sends the encrypted data out via the LoRa radio frequency unit embedded in the main control chip, considerably improving data security.

LoRa and GPRS-Based Remote Data Transmission Communication Technology

Fang (2017) developed a communication control invention that discloses a LoRa and GPRS-based remote data transmission communication technology, solving the problems of low efficiency and high cost caused by performing remote data transmission using GPRS separately as well as the problem caused when a LoRa communication technology is used for data transmission.

Data from various sensors are obtained using the LoRa and GPRS-based remote data transmission communication technology. Using LoRa radio frequency technology and LoRa point-to-point communication technology, data are then sent to a terminal. Data are mainly transmitted remotely by adopting a plurality of LoRa modules and GPRS.

The LoRa modules have the advantage of being able to acquire data at one time, repeatedly in a segmented manner, and continuously in a segmented manner. They also have the advantages of simple structure, far communication range, less consumption of power, and portability.

LoRa Image Acquisition Transmission System

Xiaoming's (2017) utility model was related to the technical field of radio communication, specifically image sensors that use the LoRa technique. The concrete technical scheme included a LoRa image acquisition transmission system. The LoRa image sensor transmits signals through the CAM bus with the micro-controller which transmits signals through the SPI bus with the LoRa radio frequency module. This system used an integrated structure for image acquisition, compression, handling, transmission, and unified processing in power supply, etc. Cost was greatly reduced, the volume was smaller, and the stability was better. The spread spectrum wireless communication technology is used by both the LoRa gateway and the Endpoint for a LoRa image sensor. The star topology structure between the LoRa image sensor and the LoRa gateway addresses the system's real-time communication requirements, allowing for seamless roaming communication across different LoRa gateways.

GPS Position Tracking System and Tag Using LoRa Communication

Jong Ha (2020) came up with a method for tracking location using a LoRa communication network in addition to the existing 3G/4G network. A GPS module calculating location information using GPS information received from a GPS satellite; a LoRa module performing LoRa communication; a control module wirelessly transmitting the location information calculated by the GPS module to the outside through the LoRa module; and a battery supplying driving power to the GPS module, the LoRa module, and the control module are all examples of modern take on technology/inventions.

Large Data Transmission Method, Terminal, and Server in LoRa Communication System

Quan (2018) provided a method for tracking a location using a LoRa communication network in addition to the existing 3G/4G network. A GPS module calculating location information using GPS information received from a GPS satellite; a LoRa module performing LoRa communication; a control module wirelessly transmitting the location information calculated by the GPS module to the outside through the LoRa module; and a battery supplying driving power to the GPS module, the LoRa module, and the control module were the components of the invention. The server end reassembles the communications after the brief messages have been received completely. The server breaks the huge data into short messages of a fixed length that can be delivered by the LoRa communication system in the downstream direction and transmits the short messages to the LoRa terminal in a continuous way using the SX1301. The terminal reloads the packets after receiving them completely from the server. The innovation enables huge data transmission in the LoRa communication system while ensuring that normal application message transmission is not significantly disrupted.

Conceptual Framework

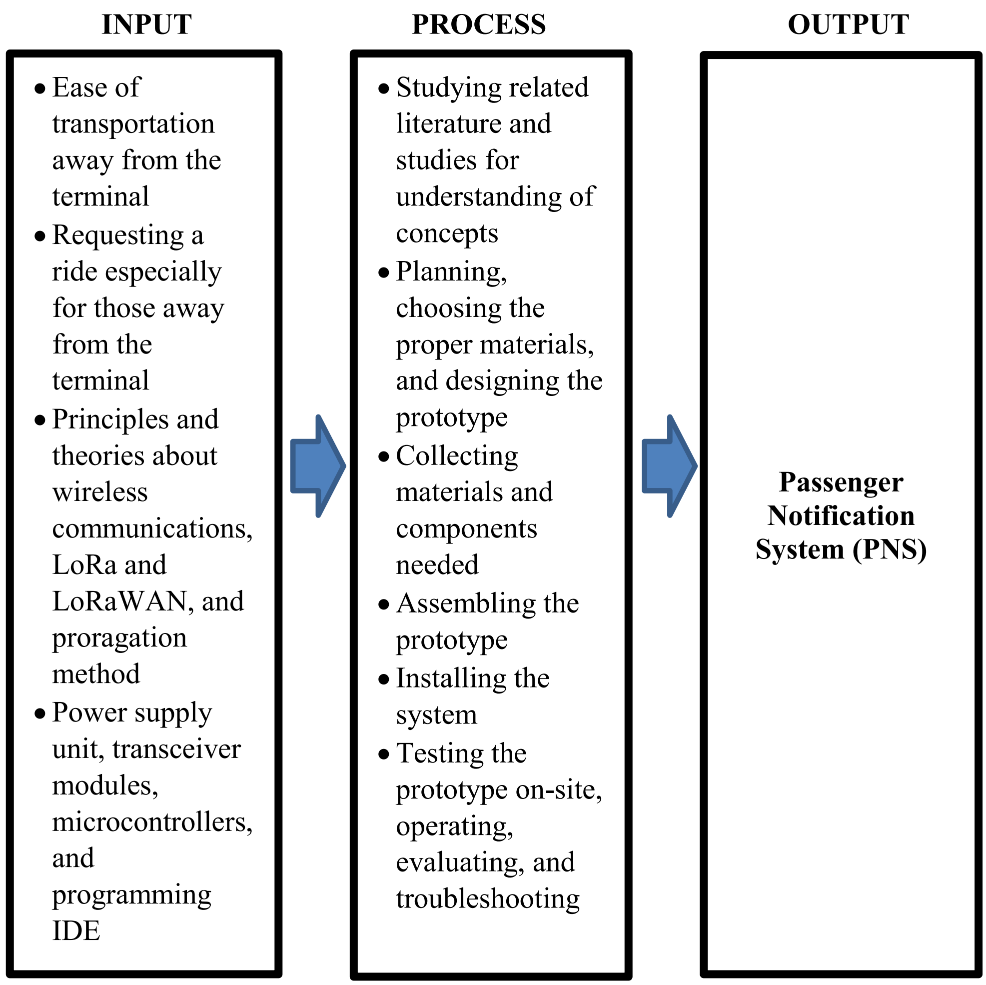


Figure 2.25 Conceptual Framework

Figure 2.25 shows the different inputs and processed involved in the research. The study started with identifying a problem that can be solved through research and innovation, which in this case was to improve a reliable and convenient mode of transportation when requesting a ride, especially for those that are away from the terminal and when drivers are finding passengers. Researching concepts and theories about wireless communications, LoRa and LoRaWAN, and propagation methods helped the researchers in creating a solution for the problem. This was done through reading texts, learning about the topics from webinars, studying programming languages for scripting, and understanding the concepts from the related literature and studies. Planning for the prototype involved choosing the appropriate materials for the prototype and the design of its structure. Choosing the proper materials for the prototype had been important in building a more efficient prototype that could attain the planned features. Assembling the prototype included the construction of the hardware (the electronic circuit and the power supply unit) and the software (the programmed script in the IDE). Testing of the prototype on-site, operation, evaluation, and troubleshooting addressed the problems, flaws, and unexpected features encountered on the prototype and its system. The output of this research will help in improving the transportation system and also help future researchers in creating new ideas regarding this topic.

Chapter III

METHODOLOGY

This chapter presents the methods and procedures used in conducting the research to utilize and provide the readers an essential view of how the research was done and how data were collected to develop conclusions. The sources of information used as reference for the study are also cited. This section also informs about the essential parts of the study, namely research locale, respondents, research design, research instrument, procedures/data collection, and statistical treatment.

Research Locale

The development of the prototype and testing of the system of the transmission module/device was conducted at the residence of one of the researchers in Avida Isabang Tayabas City, Quezon. The geographical area was suited based on definite tests on Radio Planner 2.1. The researchers then proceeded to configure and test the prototype and the transmission system in the determined location.

Respondents

Tricycle drivers and passengers are the key characters in systematic transportation. In this study, the researchers used purposive sampling which is a type of non-probability sampling based on the objectives of the study and the characteristics of the population. Convenience sampling was also used. This is a type of non-probability sampling which involves the sample being drawn from that part of the population that is available and willing to participate in the study. The research was conducted among 30 selected respondents for the researchers to know/discern all the certain advantages, disadvantages, and limitations of the prototype. The definite quantity of the respondents was 10 tricycle drivers and 20 local passengers.

Research Design

The design used in this study was applied type of research. Applied research complemented the researchers' study since it aimed to find a solution for an immediate problem facing the society. Upon identifying the problem, the study was planned in creating experiments to conduct a series of testing. The overall/final performance of the prototype was determined through conducting trials and tests involving observation and analysis of different succeeding outputs. Surveying for improvement and capability testing of the prototype were also considered in the study.

The LoRa module was the key component in producing both the master and slave nodes of the transmission system. Other peripherals like antenna, LCD, power supply, micro-controller, and other components were used to have a user-friendly device.

The researchers constructed the device for convenient use of passengers and tricycle drivers as it projects data digitally which allows viewing of both groups in their separated modules (slave node and master node).

Research Instrument

The researchers used the following tools and resources for the experimentation and gathering of data for the study:

Laboratory Instruments

- Radio frequency tools such as Google Earth and RadioPlanner 2.1 Simulator were used in modeling the radio propagation of the transmission. These were used to lessen the trial and error for the prototype's network coverage and to simulate the best spot to deploy the PNS.
- Arduino IDE was used to create the algorithms, sketches, and codes for the construction of the prototype and the system.

Questionnaire

The researchers used a structured type of questionnaire based on the objectives of the study. It was composed of two (2) parts. The first part was the letter of consent for the selected respondents containing greetings and indicating the researchers' course and title of the study. The second part contained the checklist that the respondents filled out with their name, occupation, signature, and date as well as the series of questions regarding the design, functionality, and effectiveness of the prototype. The respondents were asked to answer the questionnaire respectively and carefully by putting a check sign on the blank spaces corresponding to their responses. There was a total of 15 questions from five (5) questions each in the three categories. The choices were based on the Likert rating scale format with 5 being the highest and 1 being the lowest with equivalent descriptive ratings of strongly agree, agree, fairly agree, disagree, and strongly disagree.

Table 3.1 presents the survey containing questions anchored on the objectives of the study utilized by the 30 respondents upon evaluation of the prototype. The rating scale consisted of 5, 4, 3, 2, and 1 equivalent to Strongly Agree (SA), Agree (A), Fairly Agree (FA), Disagree (D), and Strongly Disagree (SD), respectively. Questions were divided into sub-parts on the following aspects: design, functionality, and effectiveness.

Table 3.1 Survey Questionnaire Form for the Prototype's Design, Functionality, and Effectiveness

DESIGN					
STATEMENT	5	4	3	2	1
1. The design of the prototype is durable/robust.					
2. The prototype itself can be used conveniently or accessed easily.					
3. The design of the prototype is built water-resistant.					
4. The prototype is easy to use and configure.					
5. Information in the LCD is clearly shown and can be read.					

FUNCTIONALITY					
STATEMENT	5	4	3	2	1
1. The transmission of the prototype works properly.					
2. In using both the transceiver, the LCD shows and sends information accurately.					
3. The actuators are seamlessly in sync with the LCD and sending information.					
4. The prototype sends information in long range.					
5. The prototype can transmit data without using cellular or Wi-Fi modules.					
EFFECTIVENESS					
STATEMENT	5	4	3	2	1
1. The prototype gives ease to passengers and tricycle drivers in terms of cost.					
2. Transportation can be accessed in far-flung streets and stationed in tricycle terminals.					
3. The device lessens human effort or promotes convenience for both passengers and tricycle drivers.					
4. The prototype can be used in various places.					
5. The device minimizes common problems encountered in transportation.					

Table for Data Collection

Table 3.2 Transmission Distance and Transmission Time

Distance of Transmission	**Transmission Time (seconds)**					
	Trials					**Remarks**
	1	**2**	**3**	**4**	**5**	
50 m						
100 m						
300 m						
500 m						
800 m						
1000 m						

Table 3.2 shows the table used to log distance and time of transmission between the point-to-point PNS. The time it took for data from the sensor to be received was checked five times for each distance indicated in the table.

Procedures/Data Collection

These are the procedures and plans for data collection done by the researchers in this study:

A. Information Gathering

Wireless communication has been a huge technology vastly used all around the world and has been quickly improving with the emergence of innovations and new technologies. The researchers gathered data and information concerning wireless communications which were used in conceptualizing the project. Due to the pandemic, majority of the data gathered by the researchers were from the Internet, such as eBooks, websites, and online articles. The researchers also attended some webinars about telecommunications to gather ideas for the prototype.

B. Prototype and System Planning

1. Prototype Planning

   The researchers considered the following features in setting up a functional and effective Passenger Notification System:

   a. Wireless non-cellular connectivity

   b. Low-powered

c. Transmission not requiring an internet connection

2. Selection of Materials

The researchers chose which components such as in microcontroller and transmission module would be more effective for the project.

C. Radio Propagation and Network Coverage Simulation

1. Go to https://www.wireless-planning.com/radioplanner and install the 7-day free trial of Radio Planner 2.1. The user manual on this website may help with how to use the simulation software.
2. Fill out the necessary information under the project information tab and settings.
3. Under the base station network, create a base station using the LoRa base station template and input the necessary information such as the coordinates of the location of the base station to be simulated and the frequency of the base station. Another method of creating a base station is to navigate the map and find manually the location of deployment. Right-click and choose to create a base station with the LoRa base station template, then fill out the necessary information.
4. Under the created base station, a sector parameter will be automatically created. The prototype will only be having one sector with an omnidirectional radiation pattern. Input the necessary parameters of the prototype such as Tx power, Rx threshold, cable length, antenna height, antenna gain, and antenna model.

5. Check some important parameters in the propagation model such as propagation model type and clutter loss.
6. Customize the graphical results of the simulation in the Area Study Details section of the simulator.
7. Simulate and adjust the parameters depending on the preferred network coverage. Choose the most efficient place for the site.
8. Import the simulation as a kml file for Google Earth.

D. Circuit Designing and Construction

1. Determine the components, materials, and appropriate circuits needed in constructing the device.
2. Design the circuitry and incorporate the most suitable microcontroller and length of antenna for the prototype and the system. Double-check the connections and wirings.
3. Create a program following the desired output.
4. Save and test the program.

E. Process of Requesting a Tricycle

1. The passenger will use the pushbutton and potentiometer of the PNS to initiate a request for a ride to the terminal. An LED will light up when the message is already sent.
2. The data will be sent to the PNS at the tricycle terminal. The buzzer will beep if data is received, and the data can be seen on the LCD.

3. The driver to pick up the passenger will transmit a signal to the PNS of the passenger to indicate that s/he will be fetched.
4. The driver will arrive at the place where the passenger requested.

F. Testing the Functionality

1. Check the circuits of the prototype if properly installed and connected.
2. Open/start the prototype.
3. Check if there is data transmitted between the two wireless devices.
4. Do several trials to check the PNS data transmission.

G. Testing the Effectiveness

1. Place the master node at a specific place. It will be stationed at the tricycle terminal or place that serves as the tricycles' waiting place for passengers.
2. Conduct drive testing or walk testing for the LoRa network of the two devices.
3. Use the potentiometer to check if there is data being transmitted for a specific interval of distance as the slave node goes far from the master node.
4. Gather the following data: transmission time, transmission distance, RSSI, SNR, and the sample's coordinates.
5. Record the data accordingly in Table 3.2 (see the table in Data Collection under Research Instrument).

Statistical Treatment

The study employed weighted mean as a statistical treatment. Mean was applied to check the average transmission time of the prototype in a specific transmission range. Weighted mean formula was used for the computation of acceptability and satisfaction rating of the respondents on the Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street. Data were analyzed through the Likert scale in the questionnaire.

$$WM = \frac{1f + 2f + 3f + 4f + 5f}{N}$$

where:

1-5 = scale

f= frequency

N= total number of respondents

Table 3.3 Rating Scale and Qualitative Description

Scale	Range Interval	Qualitative Description
5	4.19 – 5.00	Highly Acceptable (HA)
4	3.39 – 4.19	Acceptable (A)
3	2.59 – 3.38	Fairly Acceptable (FA)

2	1.79 – 2.58	Not Acceptable (NA)
1	1.00 – 1.79	Highly Not Acceptable (HNA)

Table 3.3 shows the rating scale used to determine the qualitative description for each of the criteria stated on the questionnaire for the Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street.

Table 3.4 Gantt Chart

Activities	Sept				Oct				Nov				Dec				Jan				Feb				Mar				Apr				May			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Planning and Information Gathering	■	■	■	■	■	■	■	■																												
Gathering of Materials							■	■	■	■	■	■	■						■	■	■	■														
Designing the Circuit													■	■	■	■	■	■	■	■																
Programming													■	■	■	■	■	■	■	■																
Assembly and Construction																					■	■	■	■												
Testing and Observation																									■	■	■	■	■	■	■	■				
Troubleshooting																									■	■	■	■	■	■	■	■				
Recording of Result																									■	■	■	■	■	■	■	■				
Documentation		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Defence														■																						■

The time frame for the prototype and system construction is shown in Table 3.4. It specifies the time covered in various phases of the study: planning, gathering information on the factors considered in constructing the prototype and the system, costing of the components, gathering and canvassing materials, circuit and program designing of the application and the system, assembly and construction of the prototype, installing the system, and collecting data as well as observations. It also displays the span of documentation and the duration of the defense.

Chapter IV

RESULTS AND DISCUSSION

This chapter presents all the important data acquired from various tests that served as the foundation for the completion of the Wireless Passenger Notification System (PNS) for Tricycle Driver and Street. The basic principles of the design system are presented through visual presentations of a block diagram, system flowchart, program flowchart, and schematic diagrams. Data gathered are presented in tables along with their discussions and analysis.

System Overview

Wireless Passenger Notification System (PNS) for Tricycle Driver and Street is a two-way communication device serving as a station that focuses on passengers from a specific street to request-a-ride to the drivers on a tricycle terminal. The device contains radio and transmission components, the control unit system, inputs and display, and the station structure.

LoRa module, a radio module based on spread-spectrum modulation techniques derived from chirp spread spectrum (CSS) technology, was used in the device for distributing the information from a PNS station to another PNS station. Data from the PNS stations were encapsulated into packets sent in a matter of low transmission time and deep penetration through obstacles. To cover a better range in exchange for lower bandwidth and throughput, 433 MHz was used in this study. The included 2 dBi omnidirectional antenna in the module was utilized for the prototype connected at 1.7m from the module and 3m above the ground.

Arduino UNO R3 served as the main processor of the device for taking of data input from the users and sending wirelessly as output into another device.

Inputs from the users were accessed using a push button and potentiometer. The 20x4 LCD displayed both the number of requested tricycles and accepted or the available number of tricycles following the passenger's request. Adjusting the potentiometer changed the values on the LCD while the push button acted as the actuator for sending the entered values to the other devices. The LED was used as the indicator on a PNS if a station transmitted a message and a buzzer if it received a message. A rechargeable power bank served as the power supply of the device.

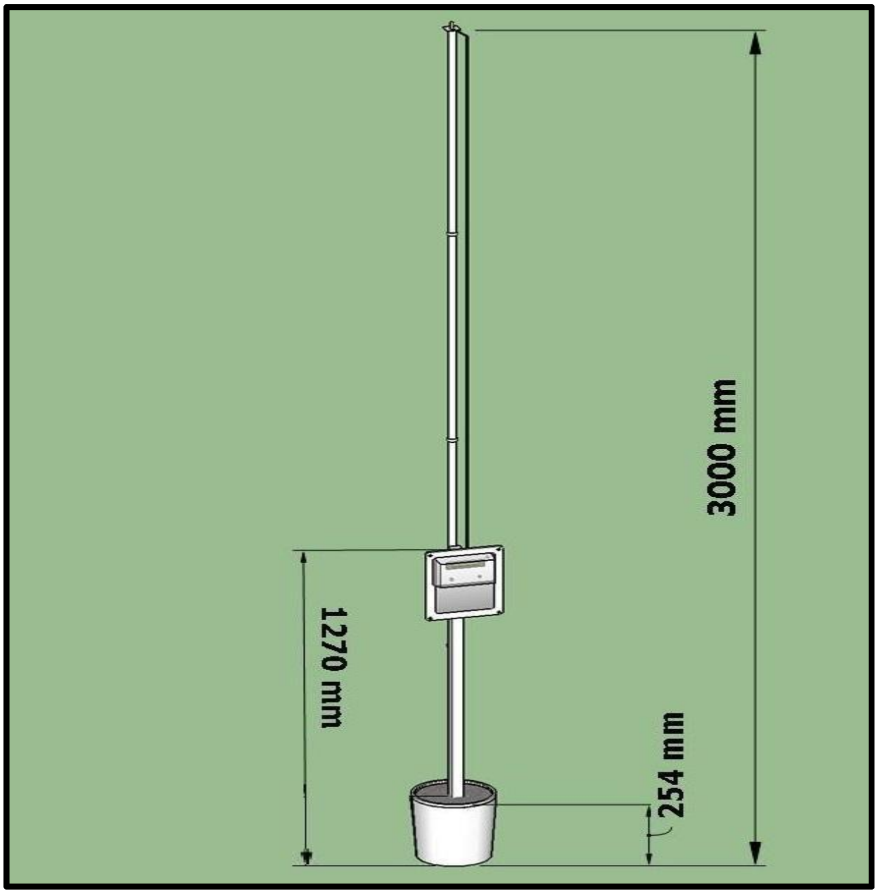


Figure 4.1 Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street's Overall Design and Dimensions (Top to Bottom View)

Figure 4.1 displays the overall design of the prototype (top to bottom) for both the master node and slave node. The bottom part of the prototype shows the bucket-shaped platform used to support the PVC pipes and wood towers. Its dimension is 254 mm in length. Second, the wood tower is used to hold and mount the casing of the prototype. Its dimension is 1270mm in length. Lastly, the dimension of the PVC pipes used to hold the antenna is 3000mm. The materials used are plastic, wood, and cement. The structure is colored white.

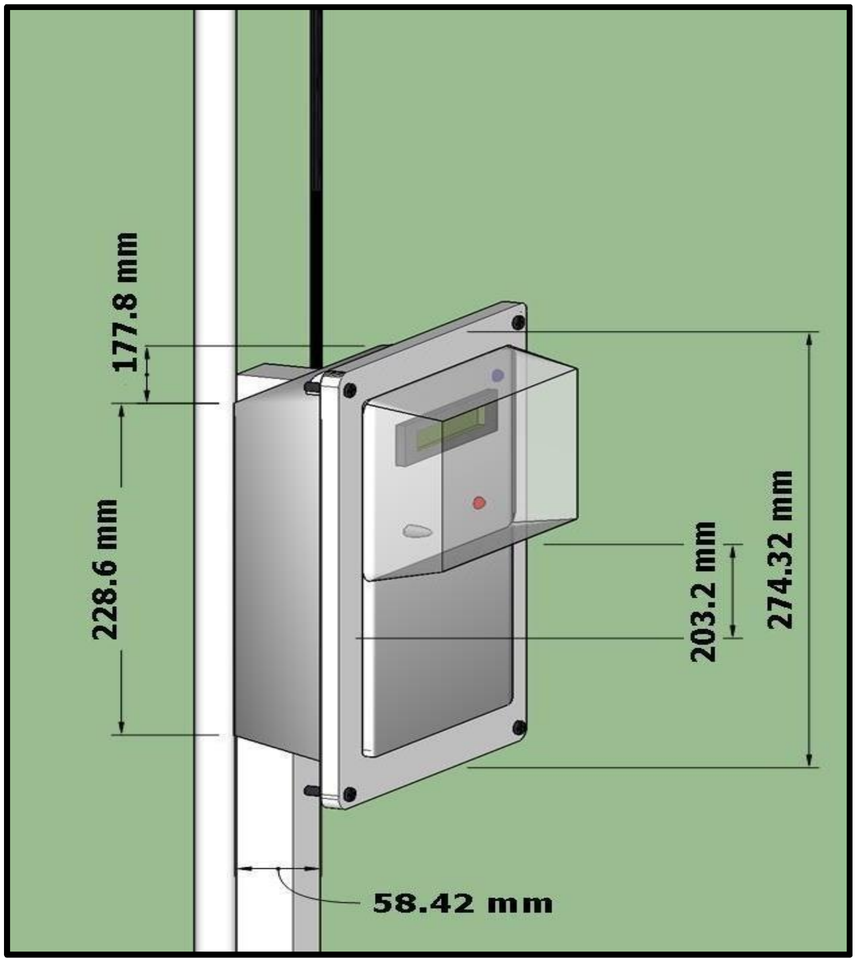


Figure 4.2 Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street's Overall Design and Dimensions (Casing)

Figure 4.2 displays the overall design of the prototype's casing for both the master node and slave node. As for the front structure or cover of the prototype, it serves as a mount for the LCD, potentiometer, and push button. Its dimensions are 274.32mm x 203.2mm in length and width. Second, the dimensions of the rear or back of the prototype are 228.6mm x 177.8mm in length and width. Lastly, for its right side, the dimension is 58.42mm.

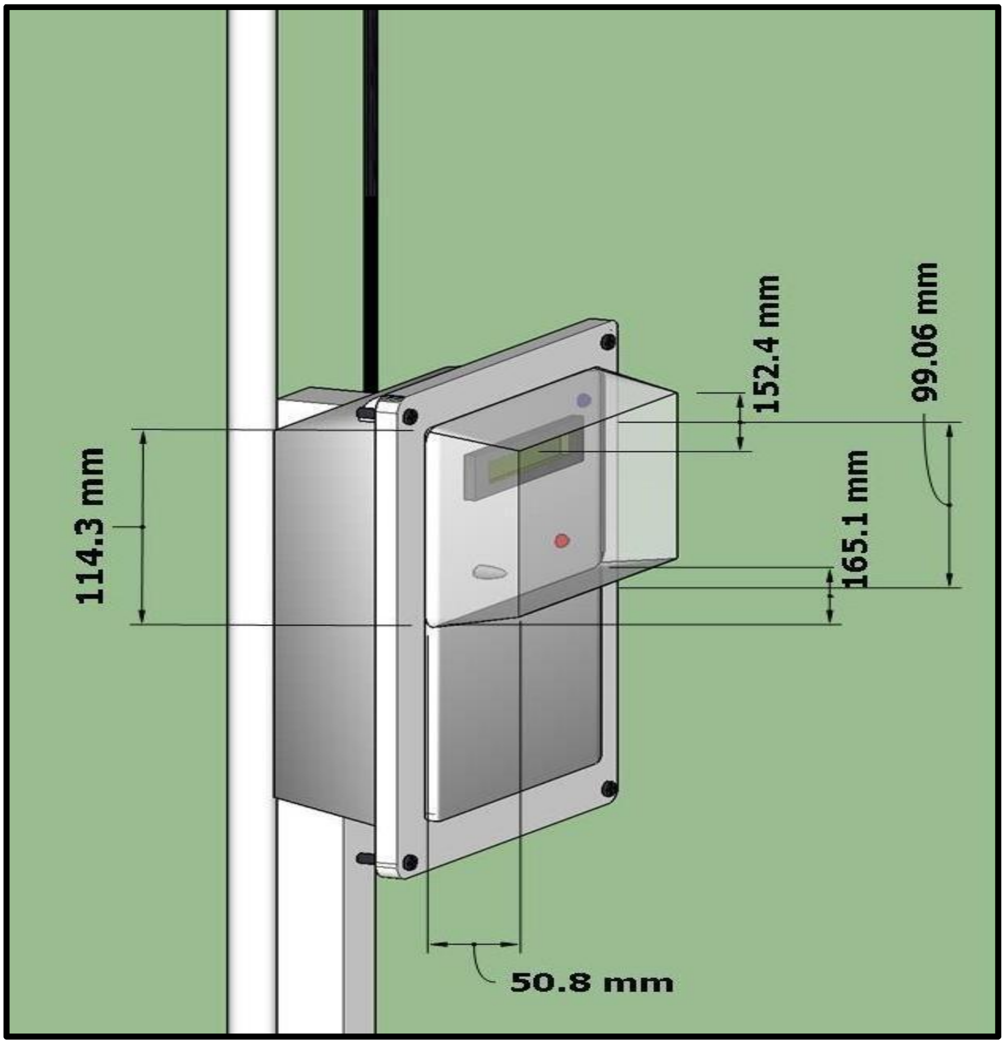


Figure 4.3 Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street's Overall Design and Dimensions (Shield)

Figure 4.3 displays the overall design of the prototype's shield for both the master node and slave node. The shield part of the prototype is used to protect the mounted components on the casing. Its dimensions in the front part are 99.06mm x 152.4mm for length and width. The dimensions of the rear are 114.3mm x 165.1mm in length and width. Lastly, for its right side, the dimension is 50.8mm.

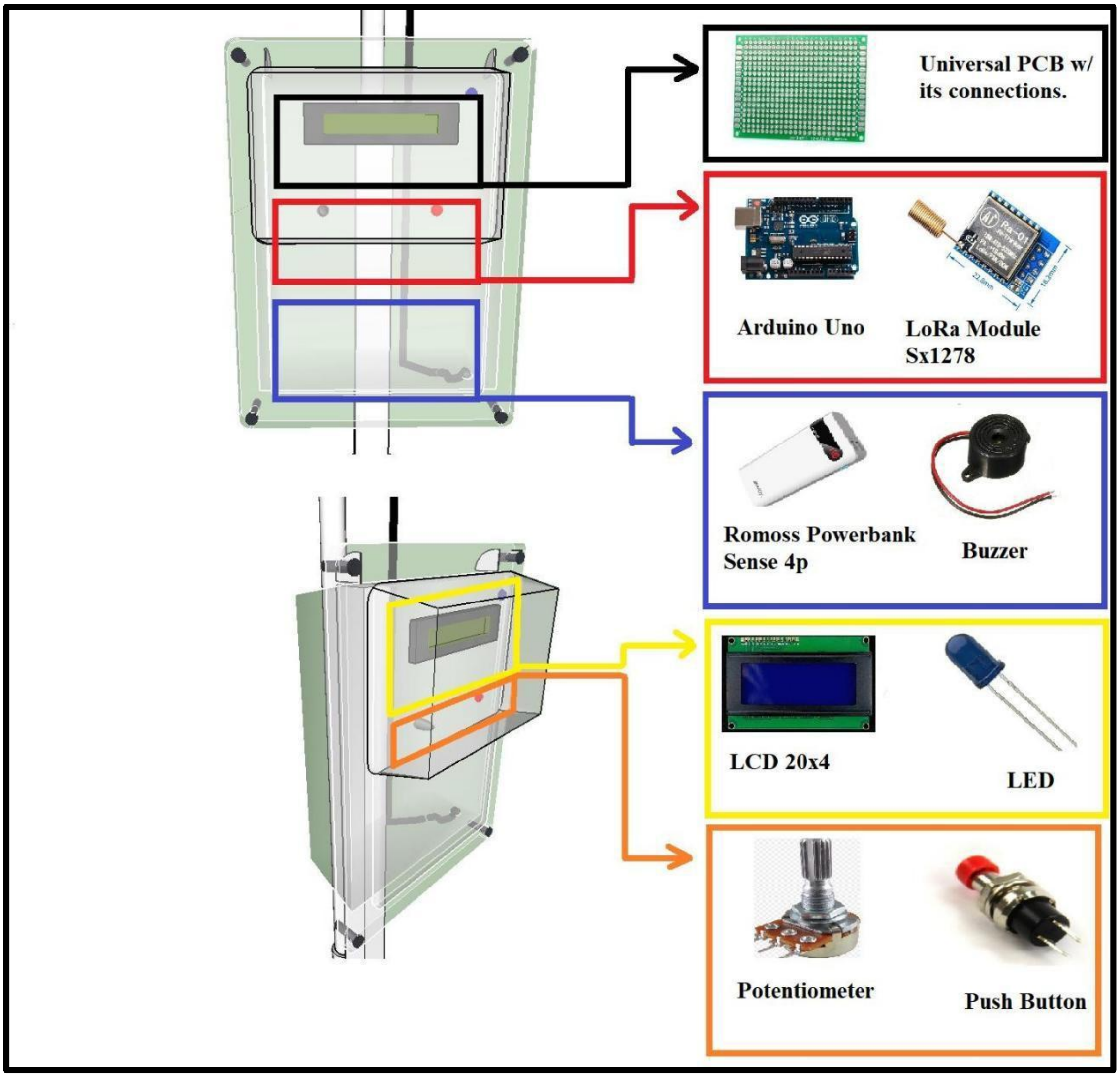


Figure 4.4 Placements of Components Inside the Prototype

Figure 4.4 displays the positioning or placements of components inside the casing. All components are strapped in a cage-like plastic making them fixed and secured. The top part of the prototype is a PCB that holds connections of the components. Below the PCB on the right side and situated in the center is the Arduino Uno. The LoRa module is also in the center part and situated on the left side of the prototype. Below are the Romoss Sense 4p power bank on the right side and the buzzer on the bottom left side.

In addition, components mounted in front of the casing are the 20x4 LCDs above the two components. Then, the actuators, push button, and potentiometer are at the center part of the front casing.

Figure 4.5 Actual Prototype of Wireless Passenger Notification System (PNS) for Terminal Station and Street

Figure 4.5 shows the actual appearance of the two Wireless Passenger Notification Systems (PNS), the slave and the master node. Together with the prototype are the four (4) PVC pipes used for the antenna and the bucket-shaped platforms below.

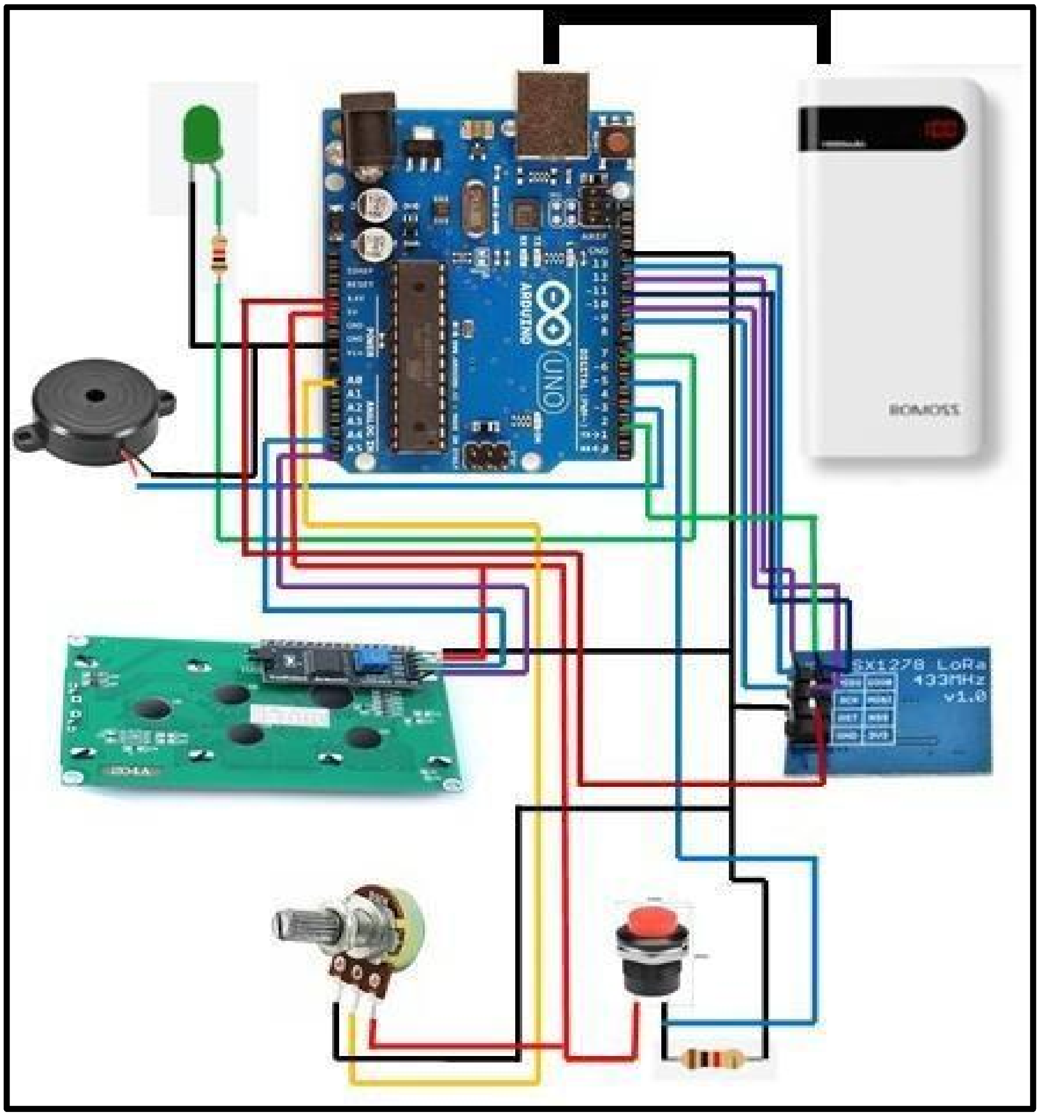


Figure 4.6 Pictorial Diagram of Wireless Passenger Notification System (PNS) for Tricycle Driver and Street

Figure 4.6 shows the pictorial diagram of the system of the Wireless Passenger Notification System (PNS) for Tricycle Driver and Street. Since the device used a duplex data communication, the components of the pictorial diagram are similar for both the slave and master nodes. What differs between the slave and the master node was their algorithm where it was most common that the station for the passenger or the slave node will initiate the course of communication between devices.

A potentiometer operates either the passenger's request or the number of available tricycles from the terminal. The push button serves as the send button for the prototype whenever data is ready to be sent. Arduino UNO R3 processes these data and actions as inputs. Each action on the potentiometer can be viewed on the LCD. When the push button is pressed, the data will be dispatched as packets through the LoRa transceiver module and will be forwarded wirelessly through the antenna to be received by the other device through their antenna and LoRa module. The LED will light up when data is sent successfully. The buzzer will buzz if it receives data from the first device. The second device's Arduino will process and verify the data received which will be successfully printed on the second device's LCD. The sending and receiving of data take the same process and system within both devices.

System Flowchart

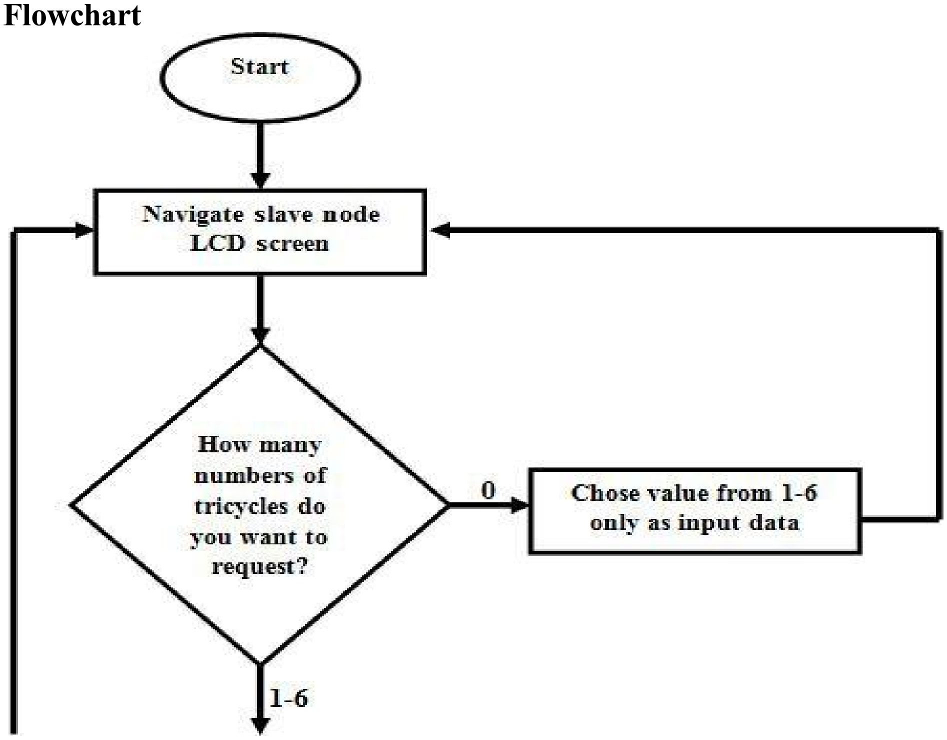


Figure 4.7.1 System Flowchart

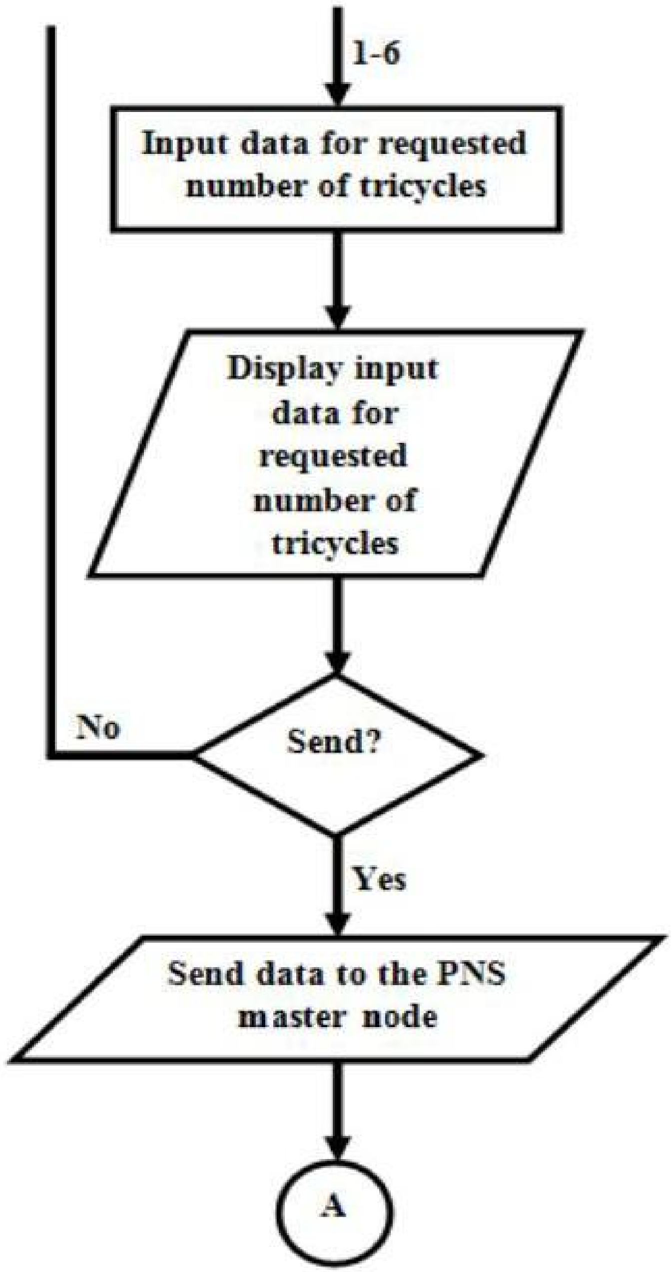


Figure 4.7.2 System Flowchart

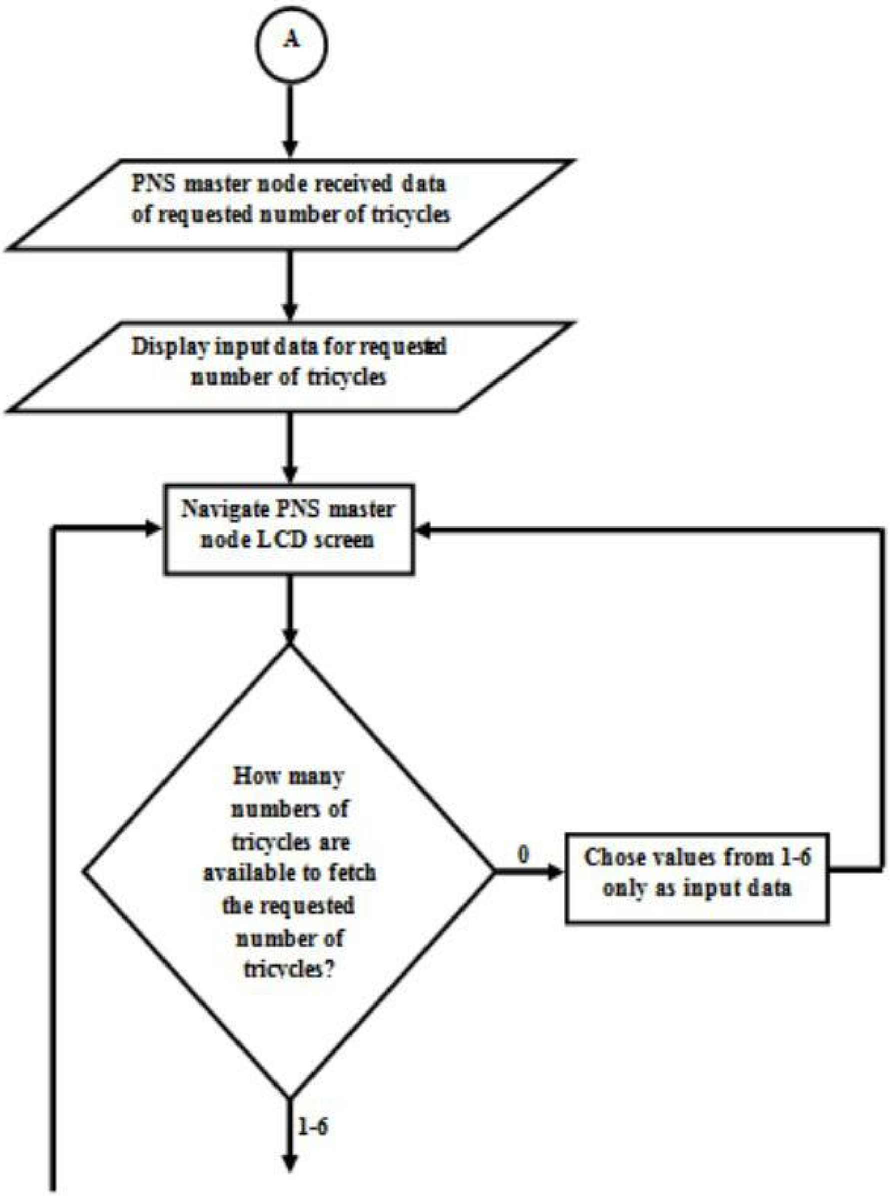


Figure 4.7.3 System Flowchart

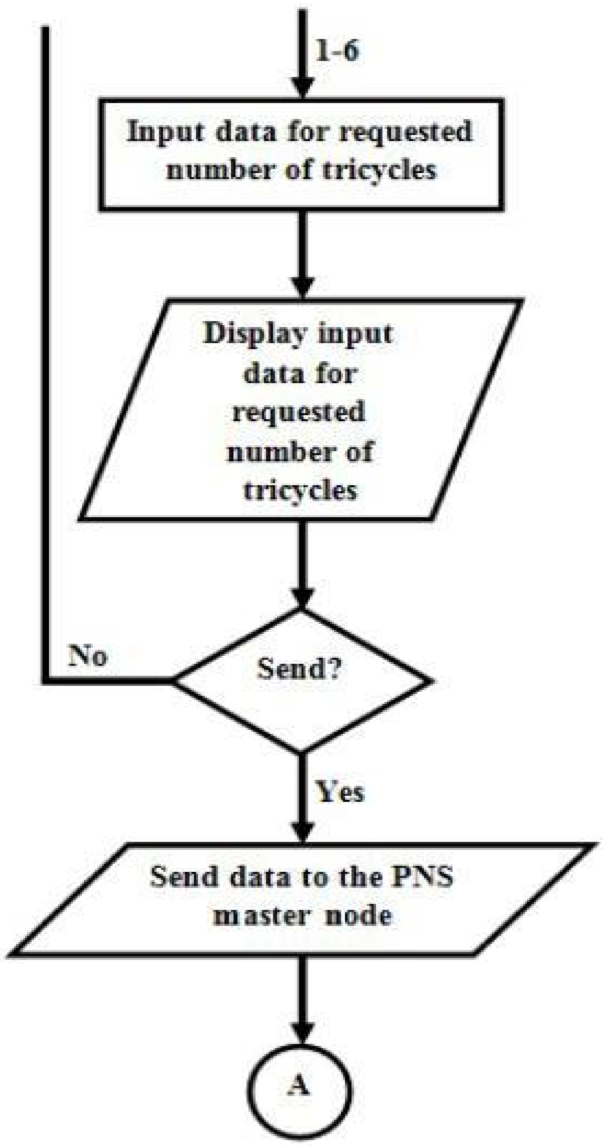


Figure 4.7.4 System Flowchart

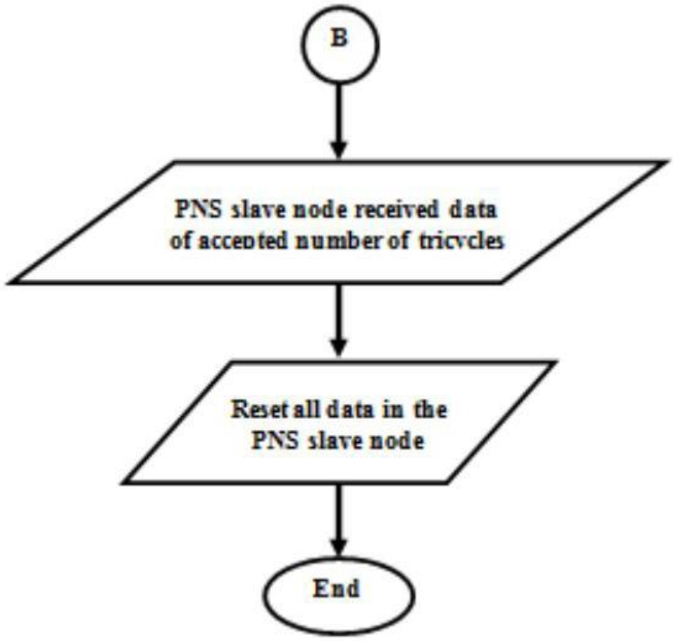


Figure 4.7.5 System Flowchart

The system flowchart in Figure 4.7 shows the step-by-step procedure of how the Wireless Passenger Notification System (PNS) for Tricycle Drivers and Street works. Initially, both master and slave devices must be turned on. The system starts with a user configuring the slave node device. The user will be prompted how many tricycles s/he will request from the tricycle terminal. A value from 1 to 6 indicating the number of tricycles will only be accepted and the system will not be accepting a 0 value. The value is displayed on the LCD screen. The send button will send the value entered to the master node. An LED indicator will light up if the value is sent successfully.

If the master node receives a value from the slave node, the buzzer will make a beep sound and the value for the requested number of tricycles will be seen on the master node's LCD. The user of the master node also needs to navigate the device's buttons to indicate to the passenger the number of tricycles available in reference

To their request. Inputs must be from 1 to 6 to be valid and 0 value will not be accepted, too. The send button will direct the value to the passenger node and the LED will light up. The buzzer will buzz at the PNS slave node when it receives the data from the master node and the transmitted value will show in the LCD. This means that the value they received from the master node will be the number of tricycles available to pick them up. The system will end up with all values being reset.

Program Flowchart

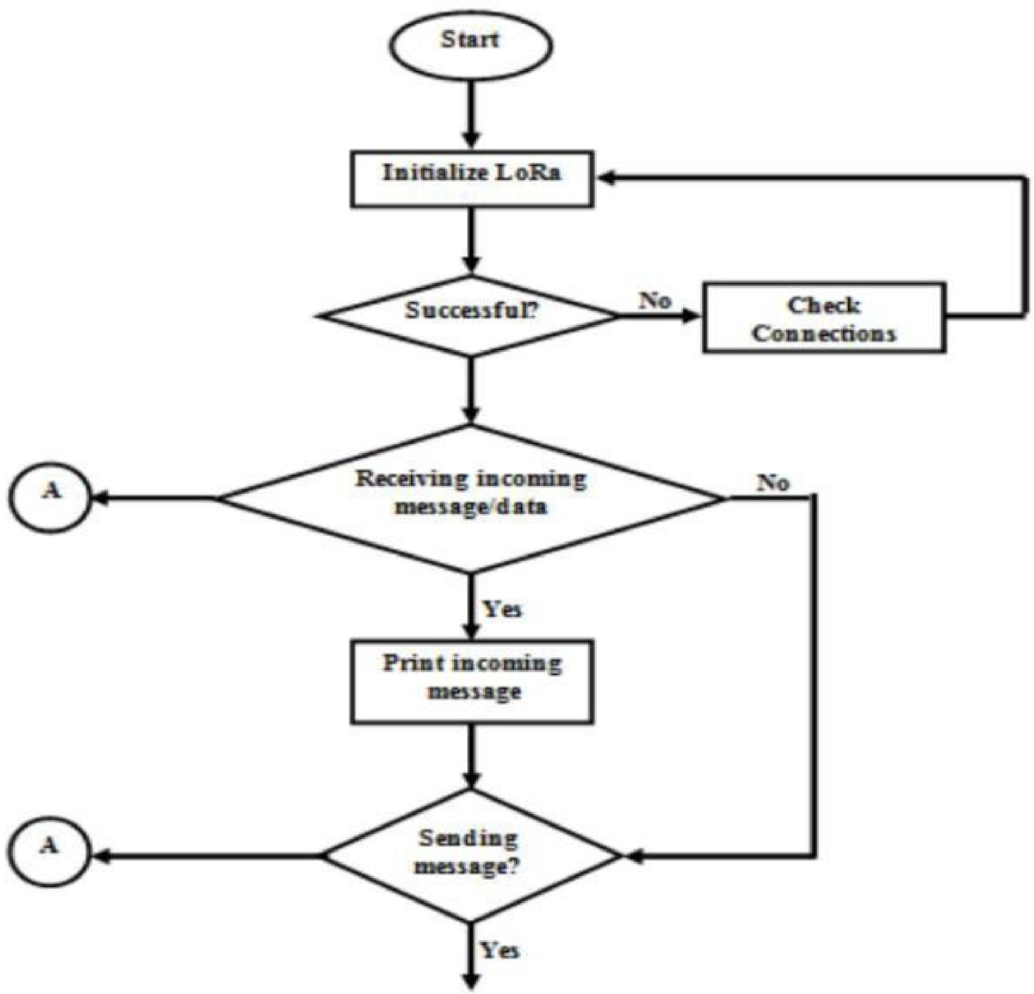


Figure 4.8.1 Program Flowchart

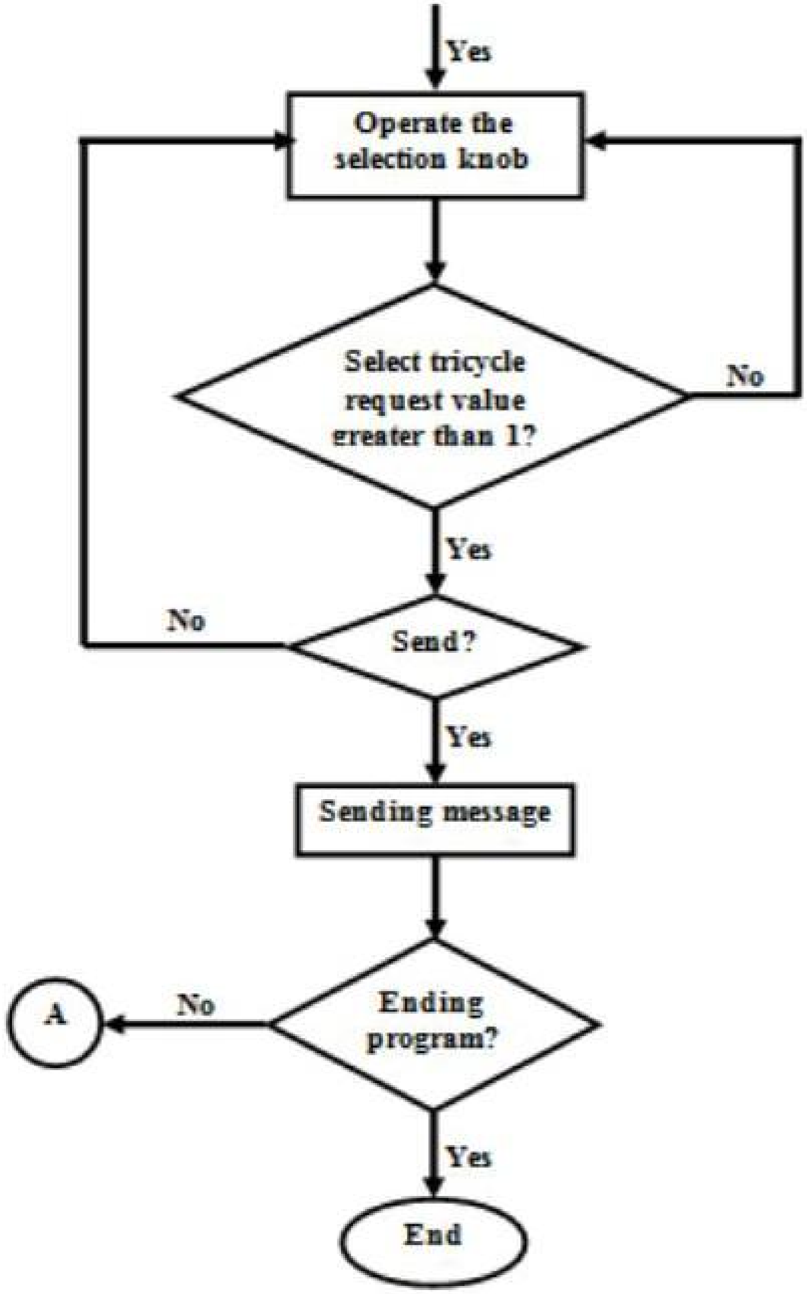


Figure 4.8.2 Program Flowchart

Figure 4.8 shows the program flowchart exhibiting how the Wireless Passenger Notification System (PNS) for Tricycle Driver and Street functions. The program was identical for both PNSs except that the navigation that can be configured on the slave node is the number of tricycles requested compared to the master node's accepted number of tricycles in response to the request of the message from the slave node. The program starts with initializing the LoRa module. If it fails, checking the connections and circuitry of the device might help to fix it. With PNS having a duplex transmission feature, the program executes both receiving and transmitting. The program will always check if there is an incoming message. If there is no incoming message, the program can directly go with the transmitting algorithm. Otherwise, if there is an incoming message, it will be flashed on the display screen and can proceed to the transmitting algorithm. For the transmission algorithm, the selection knob is operated to indicate the response value. Only a value greater than 1 is accepted and using the send button will transmit the value to the other device.

Simulations Results

As part of the planning stage, the researchers used radio frequency simulation tools in this study before deploying and testing the actual prototype. Radio Planner 2.1 is a radio planning tool for different technologies such as 3GPP networks from 2G to 5G, land mobile radio networks, radio and television broadcast networks, air-to-ground communication systems, microwave frequencies, and network-based on wireless IoT technologies such as LoRa and SigFox. This helped in checking the possible radiation pattern from the devices.

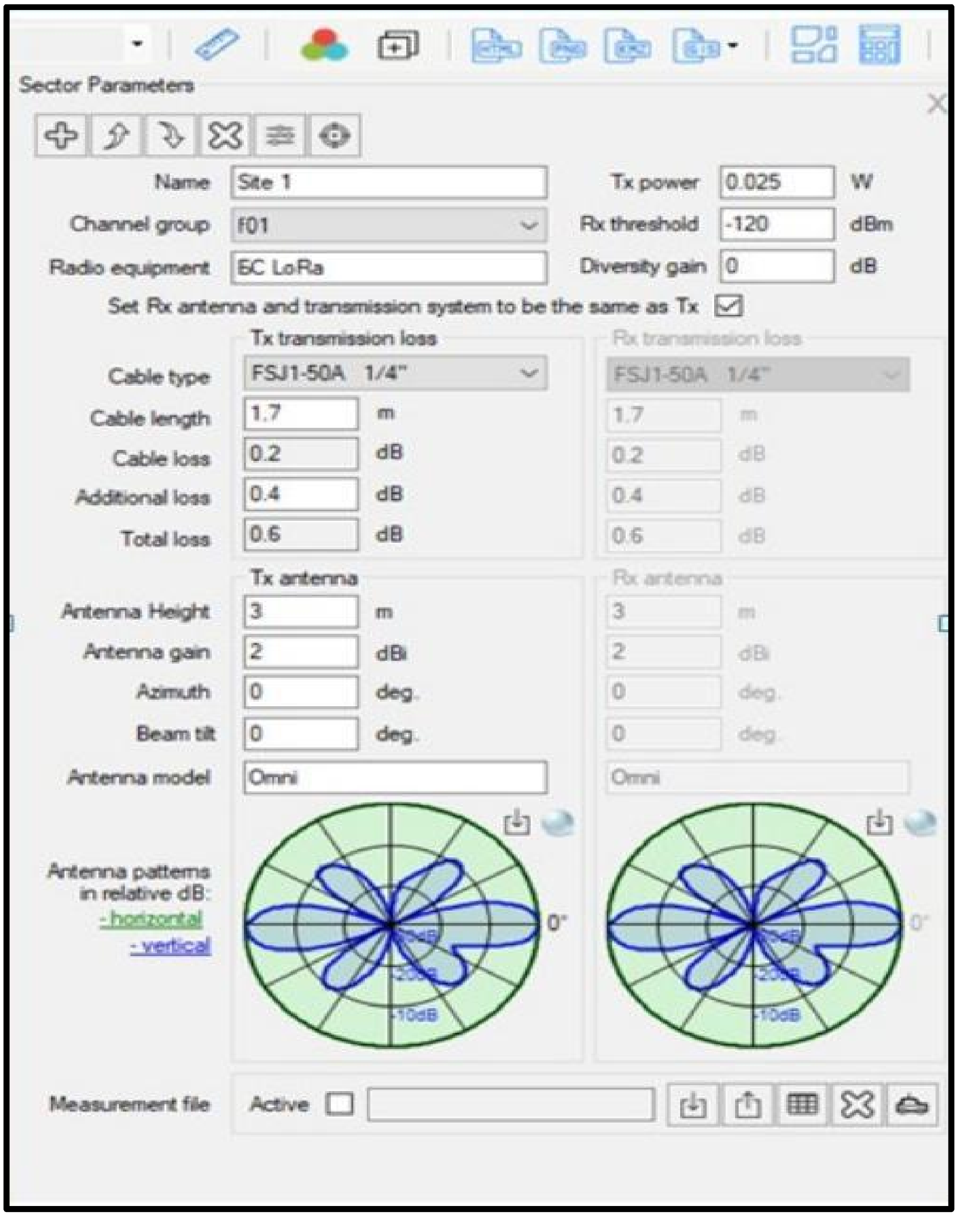


Figure 4.9 Radio Planner 2.1 Base Station Simulation Parameters

Figure 4.9 shows the parameters used for the simulation of the Wireless Passenger Notification System (PNS) for Tricycle Driver and Street. A pre-set configuration for LoRa was used as a network for the base station under the unlicensed frequency of 433 MHz.

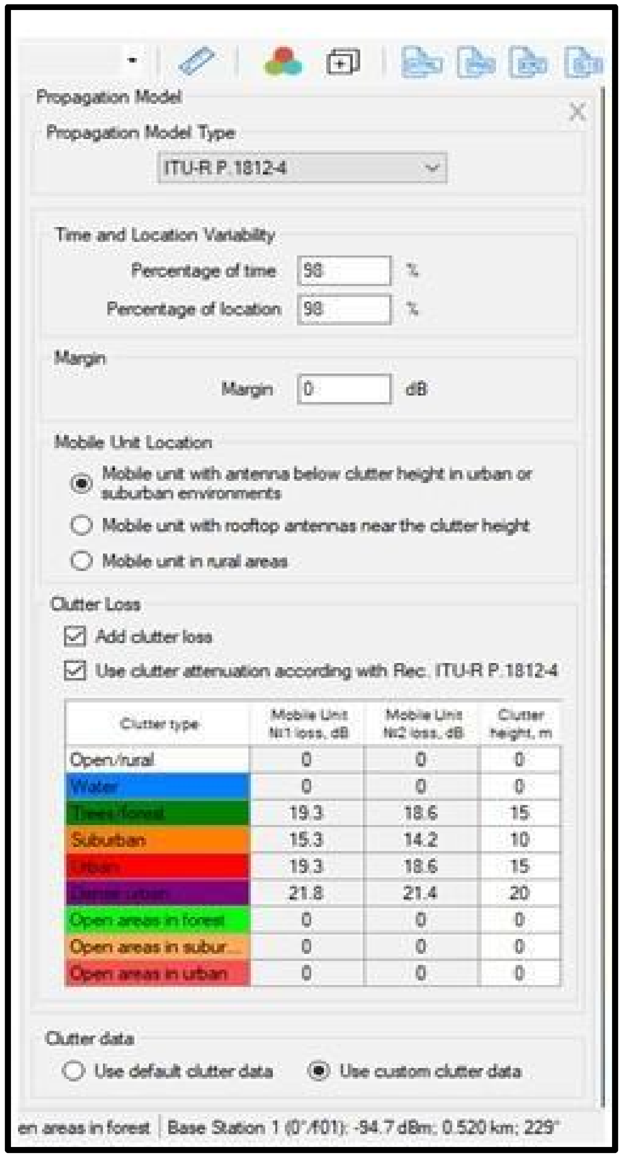


Figure 4.10 Radio Planner 2.1 Propagation Model Simulation Parameters

Figure 4.10 has the Radio Planner 2.1 interface for the propagation model parameters of the simulation. The free feature has only the option for ITU-R P.1812-4 Propagation Model Type. “Mobile unit with antenna below clutter height in urban or suburban environments” is used under the Mobile Unit Location. Clutter loss is added as well as the clutter attenuation according to ITU-R P.1812-4 Propagation Model Type.

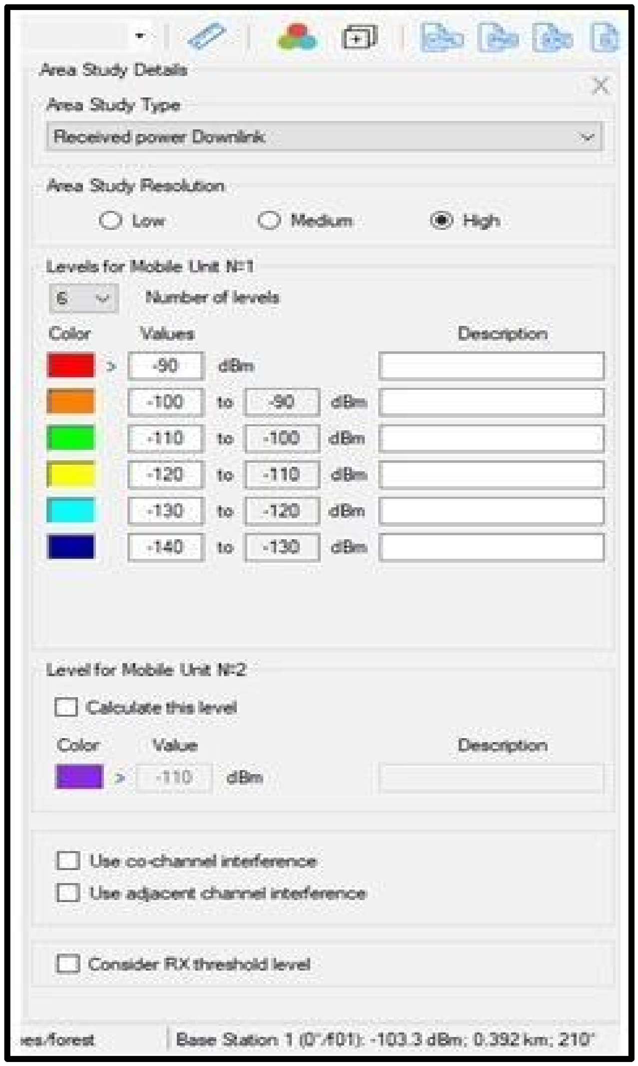


Figure 4.11 Radio Planner 2.1 Area Study Unit Simulation Parameters

For the graphical representation of the received strength, the researchers customized the colors for each level in the Area Study Unit section of the Radio Planner 2.1 as shown in Figure 4.11. Red is used for the level above -90 dBm, orange for -100 to -90 dBm, green for -110 to -100 dBm, yellow for -120 to -110 dBm, light blue for -130 to -120 dBm, and dark blue for -130 dBm and -140 dBm. Area study resolution will be better off at the high settings for better pixelation of the simulated propagation.

Table 4.1 Summary of the Radio Planner 2.1 Parameters for Simulation

Parameters	Value
Base Station	
Frequency	433 MHz
Tx Power	25 mW
Radio Equipment	LoRa
Rx Threshold	-120 dBm
Cable Length	1.7 m
Antenna Height	3 m
Antenna Gain	2 dBi
Antenna Model	Omni
Propagation Model	
Propagation Model Type	ITU-R P.1812-4
Mobile Unit Location	Mobile unit with antenna below clutter height in urban or suburban environments
Add clutter loss	Checked
Use clutter attenuation according to ITU-R P.1812-4	Checked
Area Study Details	
Area Study Resolution	High
Number of Levels	6

Table 4.1 summarizes the parameters the researchers used to perform the simulation of the Wireless Passenger Notification System (PNS) for Tricycle Driver and Street.

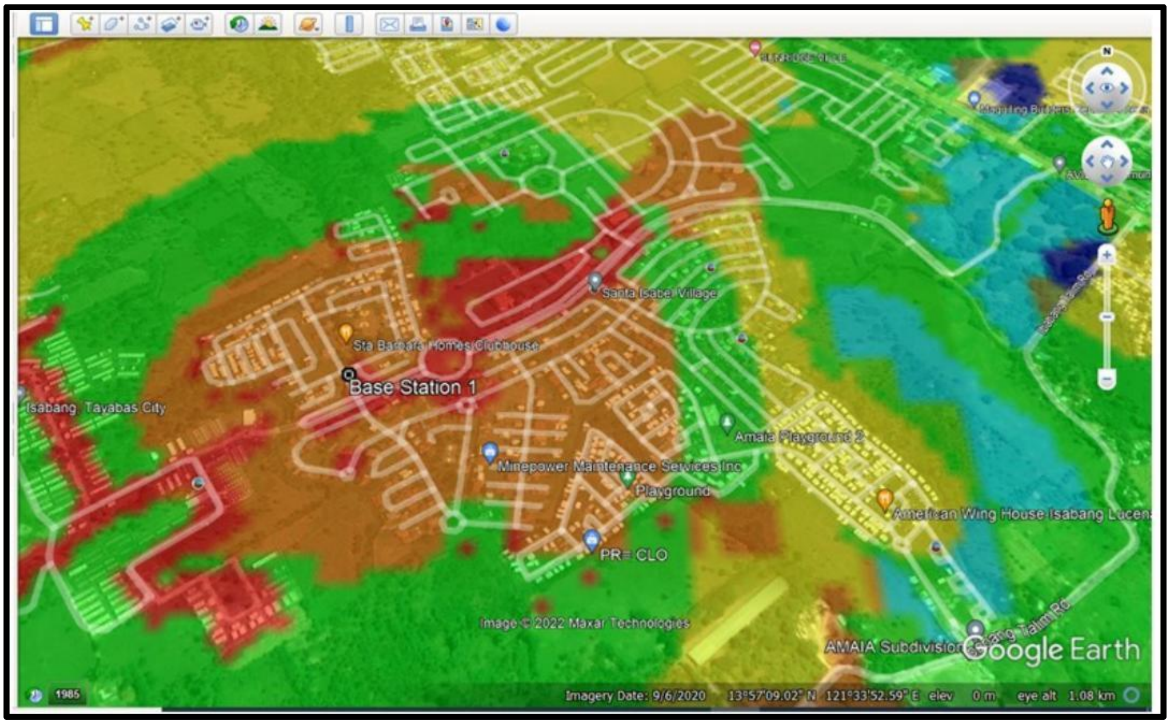


Figure 4.12.1 Testing Area

Figure 4.12.2 Testing Area

The researchers conducted eight simulations in the possible testing area for the actual simulation, found in Appendix H. Figure 4. 12 displays the simulations of the two chosen test areas for the walk testing. Base station 1 is plotted at coordinate 13.95237500 N, 121.56165278 S while base station 2 is plotted at coordination 13.95163611 N, 121.56087500 S.

Walk Testing Data

Walk testing showcases if the system and prototype are functioning well and effective. This assesses the connectivity of the prototype in response to the testing location. The data gathered in the walk testing included the latitude and longitude, displacement and actual distance from the base station, transmission time, Received Signal Strength Indicator (RSSI), and Signal to Noise Ratio (SNR).

The global positioning system was used in the walk testing to gather the latitude and longitude, Google Earth for calculating the displacement and actual distance, and the sketch for walk testing in Appendix I to collect the RSSI and SNR. One trial for transmission time was tested as the average transmission time from slave node to master node and sending back from the master node to the slave node. Three trials were performed for every test location except for the special locations from Table 3.1 with five trials each.

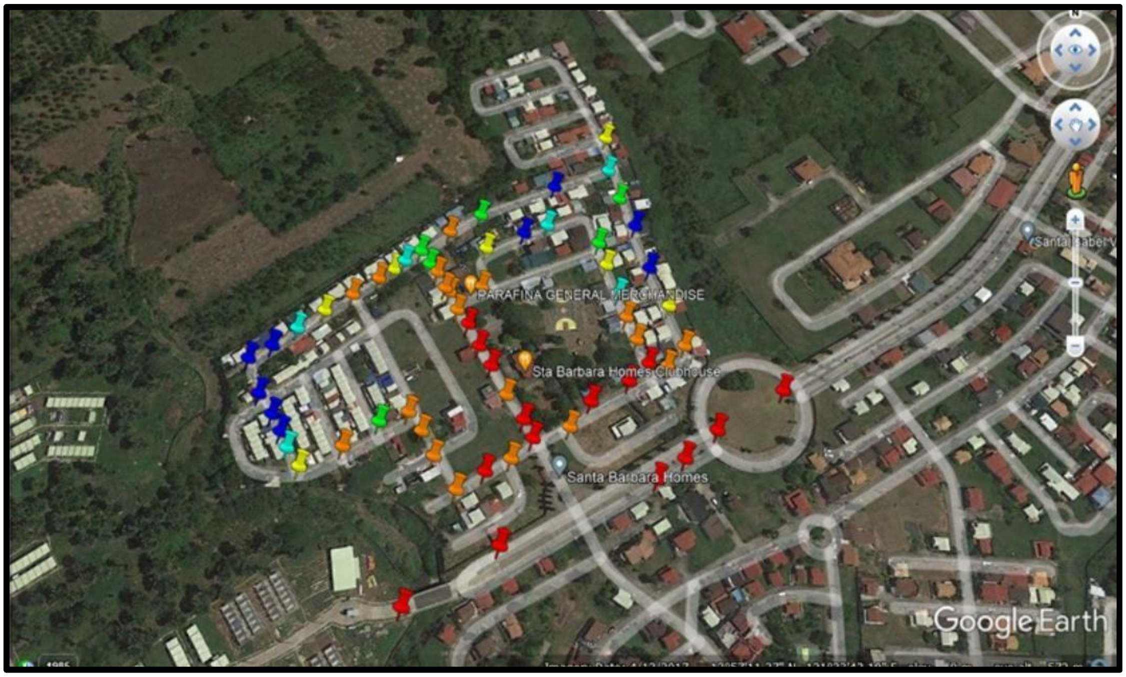


Figure 4.13 RSSI Walk Testing Result on the First Testing Location

Figure 4.13 displays the RSSI results of the walk testing on the first testing site located at coordinates 13.95237500 N, 121.56165278 S, similar to the first location on the simulator. The color representation of each location resembles the customization for the RF Planner 2.1 simulation where red signifies the level above -90 dBm, orange for - 100 to -90 dBm, green for -110 to -100 dBm, yellow for -120 to -110 dBm, light blue for -130 to -120 dBm, and dark blue for -130 dBm and -140 dBm. The geographical feature of the walk testing coverage on the first testing area included a lot of two to three-floor houses which depicts the common classification or sub-urban clutters for the radio propagation.

According to the LoRa documentation master file (2022), RSSI is the value of received signal power in milliwatts that signifies how good a receiver can read or hear data coming from a transmitter, which is measured in dBm. The typical LoRa

RSSI values are within -120 dBm wherein -30 dBm signifies that the signal is extremely strong while less than -120 is a weak signal. In the walk testing on the first test area, 77.78% of the RSSI levels were greater than or equal to -120 dBm.

Figure 4.14 SNR Walk Testing Result on the First Testing Location

On the same testing site, Figure 4.14 shows the SNR results of the walk testing. The following are the colors and their represented SNR values: red signifies the level above 5 dB, orange for 5 to 0 dB, green for 0 to -5 dB, yellow for -5 to -10 dB, light blue for -10 to -15 dB, and dark blue for less than -15 dB.

According to the LoRa documentation master file (2022), SNR is the ratio of the received power signal over the noise power level. LoRa SNR values are typically between -20 dB and +10 dB whereas values closer to +10 dB indicates that the incoming data or signal is less corrupted. SNR values greater than 0 specify that the received signal functions above the noise floor while received signals with SNR under 0 function below the noise floor. LoRa can demodulate signals that are -7.5 dB to -20 dB below the noise floor. From the walk testing, 63.49% of the SNR values were above -7.5 dB.

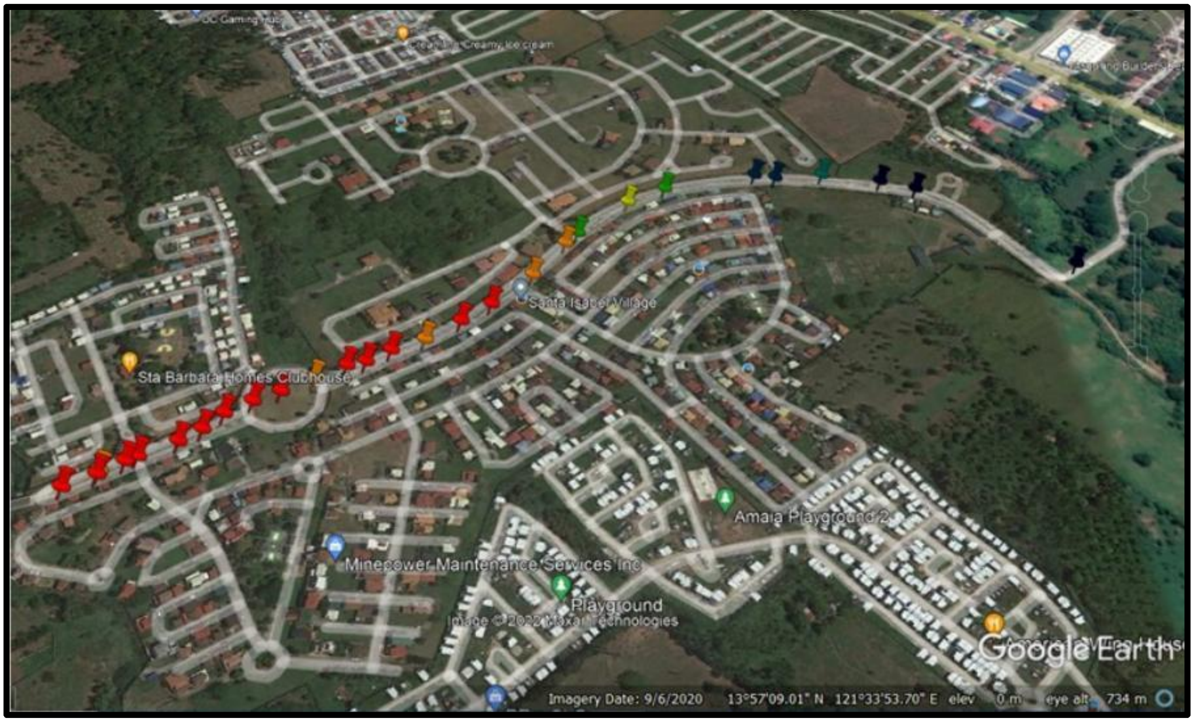


Figure 4.15 RSSI Walk Testing Result on the Second Testing Location

The walk testing on the second testing area was intended to measure the prototype's range and transmission time. Figure 4.15 displays the RSSI results of the walk testing on the second testing site located at coordinates 13.95163611 N, 121.56087500 S, similar to the second location of the simulation. The color representation was alike to the first walk testing with the addition of black if the prototype cannot receive any signal. In the walk testing for the second test area, 78.57% of the RSSI levels were greater than or equal to -120 dBm.

Figure 4.16 SNR Walk Testing Result on the Second Testing Location

The walk testing on the second testing area was intended to measure the prototype’s range and transmission time. Figure 4.16 displays the SNR results of the walk testing on the second testing site. The color representation was alike to the first walk testing. In the walk testing for the second test area, 78.57% of the SNR levels were greater than or equal to -7.5 dB.

Table 4.2 Transmission Time and Range Result

Distance of Transmission (m)	Transmission Time (s)					
	Trials					Average
	1	2	3	4	5	
50	2.12	1.23	2.87	1.46	1.76	1.888
100	3.53	2.13	2.76	2.45	1.70	2.514
300	6.36	3.64	5.63	8.21	5.52	5.872
500	6.81	6.12	6.49	8.67	7.93	7.204
800	20.64	24.43	26.67	21.23	21.94	22.982
1000	No Data Received					

Table 4.2 presents the transmission time for each distance between the PNS gathered during the walk testing in the second test location. The transmission time spiked above 10 seconds around 700-meter distance and above 20 seconds within the 800-meter mark. The last location where the prototype received data was in the 13.95546111 N, 121.5676722 S coordinate which was 845.76 meters displacement away from the master node (870 m actual distance) with an average of 30.23 seconds transmission time.

Results of Data Gathering from Questionnaire

Table 4.3 Results of Data Gathering from Questionnaire

	Number of Frequency					Weighted Mean	Qualitative Description
	5	4	3	2	1		
I. DESIGN							
1. The design of the prototype is durable/robust.	28	2	0	0	0	4.93	Highly Accepted (HA)
2. The prototype itself can be used conveniently or accessed easily.	24	6	0	0	0	4.8	Highly Accepted (HA)
3. The design of the prototype is built water-resistant.	25	5	0	0	0	4.83	Highly Accepted (HA)
4.The prototype is easy to use and configure.	22	7	1	0	0	4.7	Highly Accepted (HA)
5.Information in the LCD is clearly shown and can be read.	29	1	0	0	0	4.97	Highly Accepted (HA)
II. FUNCTIONALITY							
1. The transmission of the prototype works properly.	26	4	0	0	0	4.87	Highly Accepted (HA)
2. In using both the transceiver, the LCD shows and sends information accurately.	26	4	0	0	0	4.87	Highly Accepted (HA)

3. The actuators are seamlessly in sync with the LCD and sending information.	24	6	0	0	0	4.8	Highly Accepted (HA)
4. The prototype sends information in long range.	24	6	0	0	0	4.8	Highly Accepted (HA)
5. The prototype can transmit data without using cellular or Wi-Fi modules.	27	3	0	0	0	4.9	Highly Accepted (HA)
III. EFFECTIVENESS							
1. The prototype gives ease to passengers and tricycle drivers in terms of cost.	25	5	0	0	0	4.83	Highly Accepted (HA)
2. Transportation can be accessed in far-flung streets and stationed in tricycle terminals.	28	2	0	0	0	4.93	Highly Accepted (HA)
3. The device lessens human effort or promotes convenience for both passengers and tricycle drivers.	26	4	0	0	0	4.87	Highly Accepted (HA)
4. The prototype can be used in various places.	26	4	0	0	0	4.87	Highly Accepted (HA)
5. The device minimizes common problems encountered in transportation.	26	4	0	0	0	4.87	Highly Accepted (HA)
Average Weighted Mean						4.86	Highly Accepted (HA)

Table 4.3 shows results gathered from the questionnaire, aiming to address the objective of the study to evaluate the design, functionality, and effectiveness of the prototype. The respondents were 10 tricycle drivers 20 passengers from Avida Isabang, Tayabas City. Based on the gathered data, the researchers tallied the number of frequencies and computed the weighted mean for each of the criteria resulting to the average weighted mean. The researchers used Table 3.3 (in Chapter III) to determine the qualitative description based on the range interval as groundwork for the

interpretation of the 30 respondents. In addition, Likert scale was used for the respondents' options on a scale of 5 to 1, with 5 as the highest rating and 1 as the lowest.

According to the results in terms of effectiveness, the respondents strongly agreed to the Wireless Passenger Notification System for Tricycle Terminal and Street. Most of the respondents agreed that the prototype was effective and convenient. Second, for functionality, the respondents also strongly agreed as the prototype worked, functioned consistently, and transmitted data. For the last criterion which is design, the respondents likewise strongly agreed as it was built durable and the information displayed was clear.

In addition, the Wireless Passenger Notification System for Tricycle Terminal and Street was highly rated based on the gathered data. In terms of design, functionality, and effectiveness, it performed seamlessly. As it was aimed for the convenience of the respondents, the overall criteria were highly rated.

Materials and Tools

This part shows the hardware (components and materials) and the software used by the researchers in the creation and operation of the prototype.

A. Hardware

This contains the physical components and materials for the system.

Table 4.4 Components of the System

Component	**Specification**	**Function**
 **ARDUINO UNO**	• 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 of which 0.5 KB used by bootloader • SRAM: 2 KB (ATmega328) • EEPROM: 1 KB (ATmega328) • Clock Speed: 16 MHz	A microcontroller board based on the ATmega328, Arduino is an open-source, prototyping platform and its simplicity makes it ideal for hobbyists to use as well as professionals. It is connected to the LCD, the LORA module, the pushbutton, the potentiometer, the LED, and the buzzer. It is the main component that runs the system.

 **20x4 LCD SCREEN**	• Display Format: 20 Characters x 4 Lines • Dot Matrix (w x h): 5 x 8 Dots • Character Size (w x h): 2.95 x 4.75 mm • Character Pitch (w x h): 3.55 x 5.35 mm • LCD Driver IC: Sitronix ST7066U (or equivalent) • Interface: 4-bit Parallel and 8-bit Parallel • LCD Module Dimensions (w x h x d): 98 x 60 x 13.6 (MAX) mm • Viewing Area (w x h): 77 x 25.2 mm • Dot Size (w x h): 0.55 x 0.55 mm • Dot Pitch (w x h): 0.6 x 0.6 mm • Driving Method: 1/16 Duty • Operating Temperature: - 20 ~ 70°C	The 20x4 LCD display is essentially a larger version (in terms of number of rows and columns) of the 162 LCD display, which have already been used by the researchers in a lot of projects. It can display 20 columns of characters on four rows, making it ideal for presenting vast amounts of text without having to scroll. It displays the Options and the value to be adjusted by the actuator.
 **LoRa Module**	• Operating Voltage: 3.3V • Half-Duplex SPI Communication • Operating Frequency: 433Mhz • Modulation Technique FSK, GFSK, MSK,GMSK, LoRa	The LoRa SX1278 works with SPI communication protocol so it can be used with any micro controller that supports SPI.

 **PUSH BUTTON**	• Current Rating: 0.5 Amps • Brand: DIYhz • Switch Style: Metal, Push Button Switch • Material: Plastic, Metal • Actuator Type: Push Button • Controller Type: Push Button • Color: Red	The push button was used to send signal between the two prototypes.
 **POTENTIOMETER**	• Type: Single Linear (Type B);Features : Knurled Shaft;Shaft Diameter : 6mm / 0.23" • Shaft Length: 13.5mm / 0.53";Thread Dia : 7mm / 0.27";Base Height : 8mm / 0.31" • Base Diameter: 15mm / 0.6";Material : Metal w Electronic Parts • Weight: 36g; Package: 5 x Potentiometer	The potentiometer was used as the actuator that adjusts the value presented in the LCD.
 **BUZZER**	• Rated Voltage: 6V DC • Operating Voltage: 4-8V DC • Rated Current: <30mA • Sound Type: Continuous Beep • Resonant Frequency: ~2300 Hz • Small and neat sealed package • Breadboard and Perf board friendly	The buzzer served as an indicator of data transferred.

 **LED**	• Max. Forward Voltage: 1.8-2.1V • Max. Reverse Voltage: 5V • Max. Forward Current: 220mA • Max. Reverse Current: 10 UA • Foot Type: long foot • Size: 5mm	The LED Lights up for every transmission of data.
 **POWER BANK**	• Brand: Romoss • Power Bank Capacity Size: 10001 - 20000mAh	The power bank served as the power supply for the prototype.

The components used in the system are listed in Table 4.4. The image and name of the components are displayed in the first column. The components' specifications are listed in the second column. The explanation of how the component was utilized in the system and prototype appears in the third column.

B. Software

Software is the program which commands the specific components to perform specific tasks. It functions as the hardware's brain and the conduit for user applications to the system.

Table 4.5 Software Tools

SOFTWARE	DESCRIPTION
ARDUINO IDE	Arduino IDE is a software application used to program the LCD, LoRa module, the indicators, and the actuators.
Google Earth	Google Earth is a software that replicates the Earth based on 3D representations of satellite imageries. This was used in the study as the mapping tools of the simulation and walk testing results.
Radio Planner 2.1	A simulation software from Center of Telecommunication Technologies, LLC that simulates different wireless technologies' radio propagation, this was used in the study to simulate possible radio propagation of different parameters in a specific location.

Chapter V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter discusses the summary, findings, and conclusions obtained by the researchers upon undertaking the necessary tests, observations, analysis, and interpretations of results as obtained from the investigations in the study. Recommendations were also formulated for further improvement and development of the study.

Summary

“Wireless Passenger Notification System (PNS) for Tricycle Driver and Street” aimed to develop a system and device that can notify tricycle terminals that a passenger is waiting on a certain street. The research was conducted among 30 selected respondents based on purposive and convenience sampling to evaluate the overall performance and quality of the prototype. Specifically, these respondents were 10 tricycle drivers and 20 local passengers. This study covered a period of nine (9) months, starting from the latter part of September 2021 up to May 2022.

Findings

After obtaining the desired results from the whole process of the study, the researchers came up with the following findings:

In designing the prototype, a lot of factors were considered in choosing the materials, such as the type of LoRa module to be used, available and legal frequency to be used in a specific area, antenna type and specifications, microcontroller, and other materials like for the exterior and structural design. Choosing what works for a location was crucial to the prototype's effectiveness.

The main function of the Wireless Passenger Notification System (PNS) for Tricycle Driver and Street was to send data to their end-to-end nodes. Checking which location was most suited to place the nodes had been vital to conduct a walk test that included measuring the parameters Received Signal Strength Indicator (RSSI) and Signal to Noise Ratio (SNR) of the prototype's LoRa network. These parameters varied on the location and simulating radio propagation aided in improving the preparations in choosing a better testing area.

With a master node PNS at coordinates 13.95237500 N, 121.56165278 S, the result for the walk testing for the first test location showed 77.78% of the RSSI levels were greater than or equal to -120 dBm while 63.49% of the SNR values from the walk testing were above -7.5 dB. The second test location was used for range testing where master node PNS was stationed at coordinates 13.95163611 N, 121.56087500 S.

In this walk testing, 78.57% of the RSSI levels measured were greater than or equal to -120 dBm while 78.57% of the SNR levels were greater than or equal to -7.5 dB. The transmission time for the first 700 meters was less than 10 seconds and increased to 20 seconds within the 800-meter distance. The prototype received its last data 845.76 meters displacement away from the master node (870 m actual distance) with an average of 30.23 seconds transmission time.

Thirty (30) people sampled the prototype deployed in Tayabas, Quezon to check its functionality, efficiency, and convenience in using it. Most of the respondents agreed that the prototype was effective and easy to use.

Conclusions

Based on the findings, it was concluded that a device which can assist in transportation by notifying tricycle terminals when a passenger requests for a tricycle on a certain street has been developed. Operating the device was easy to understand making the prototype usable for people of almost all ages.

The range and transmission time of the prototype depended on the materials used and the location of deployment. Factors considered were choosing the LoRa module for configurations with and without LoRaWAN, the unlicensed frequency with a bigger range with lower bandwidth or with a smaller range and higher bandwidth, high-gain antenna or low-gain antenna, Arduino or Raspberry Pi, etc.

Simulating and walk testing had been useful in determining the best location to deploy the PNS and it enabled determining if the prototype and its system were effective and functioning well.

Recommendations

For the improvement and development of the study, the following are hereby recommended:

1. Improvements can be done with the modification of using a better antenna, higher antenna height, and LoRa module to improve the functionality of the prototype and its parameters such as transmission range and time.

2. Future researchers who might want to immerse in this kind of technical research in the future could study the application of LoRaWAN in this prototype to maximize the transmission range and time of the LoRa technology.

3. A more complex network architecture may be created using multiple slave nodes and master nodes that will cater to more requesting stations for passengers and multiple terminals.

4. User experience may be enhanced by improving the button and screen operability. The use of a better screen such as a touchscreen LCD with a good UI can give ease to the device's user. A guide on how to use the prototype must also be printed on the device so that new users can quickly understand how the device works.

5. Solar energy can be used as the power source of the device so that the recharging of the battery can be automated using solar panels.

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APPENDICES

APPENDIX A

Letters

Republic of the Philippines
Southern Luzon State University
College of Engineering
Lucban, Quezon

To whom it may concern,

Good Day!

We, fourth year students currently taking up Bachelor of Science in Electronics Engineering at Southern Luzon State University, are conducting our research study entitled **"Wireless Passenger Notifier System (PNS) for Tricycle Terminal and Street".**

The purpose of this letter is to request the data from tricycle drivers, and passengers in Tayabas, Quezon. Using a structured type questionnaire, it aims to gain data in regards to its design, functionality, and effectiveness. Wireless communication brings so much significance in modern communication, with the help of the tricycle drivers, and passengers' data, they will serve as the major respondents for our wireless device, and greatly improve the study. Rest assured that the information that you have provided will be kept confidential, and will be used in this scope of this study only.

We are looking forward on your supportive response regarding this subject. Thank you. Much appreciated.

Sincerely,

JEAN AIRES C. PARADO
KYL JUSTIN V. PEREZ
MICHAEL TROY R. MANALO
Researchers

Noted:

PITZ GERALD G. LAGRAZON
I am approving this document
2022.04.15 09:59:00 +08'00'

ENGR. PITZ GERALD G. LAGRAZON
Research Adviser

ENGR. TEN M. SACOPLA
Chairman, ECE

Read carefully the statements provided and put a check (/) on the space provided for the desired rating.

DESIGN					
STATEMENT	5	4	3	2	1
1. The design of the prototype is durable/robust.					
2. The prototype itself can be used conveniently or accessed easily.					
3. The design of the prototype is built water resistant.					
4. The prototype is easy to use and configure.					
5. Information in the LCD is clearly shown, and can be read.					
FUNCTIONALITY					
STATEMENT	5	4	3	2	1
1. The transmission of the prototype works properly.					
2. In using both the transceiver the LCD shows, and sends information accurately.					
3. The actuators is seamlessly in sync with the LCD, and sending information.					
4. The prototype sends information in long range.					
5. The prototype can transmit data without using cellular or Wi-Fi modules.					
EFFECTIVENESS					
STATEMENT	5	4	3	2	1
1. The prototype gives ease to passengers and tricycle drivers in terms of cost.					
2. Transportation can be accessed in far-flung streets, and placed in tricycle terminals.					
3. The device lessens human effort or promotes convenience for both passengers and tricycle drivers.					
4. The prototype can be used in various places.					
5. The device minimizes common problems encountered in transportation.					

Rating Scale:

5 - Strongly Agree (SA)
4 - Agree (A)
3 - Fairly Agree (FA)
2 - Disagree (D)
1 - Strongly Disagree (SD)

Permission request to conduct a research study/thesis in Avida, Tayabas. External Inbox ×

Michael Troy Manalo <mtmanalo@slsu.edu.ph>

to delacruz.misty

Wed, Apr 13, 1:23 PM

Good Day! Ma'am

We the fourth year students of Southern Luzon State University - College of Engineering endeavors to conduct our research within your jurisdiction "the spine road of Avida, Tayabas", thus we humbly request permission of the said area. We hope to achieve mutual understanding, respect and abide the laws of this community.

We look forward to your supportive response. Thank you. Much Appreciated

The attach file is the letter of consent for our ongoing thesis.

Letter of Consent.p...

Figure A.1 Letter of Request for Data Gathering

APMC Dela Cruz, Misty V.

to me

Wed, Apr 13, 1:40 PM

Good Day Mr. Manalo,

This is to acknowledge receipt of your request e-mail. Please observe basic health protocols (wearing of face masks) during your activity.

Thank you and have a great day ahead.

Warm Regards,

Misty V. Dela Cruz | Property Manager
Residential Business Group
Ayala Property Management Corporation
2nd Floor, MSE Bldg., Ayala Avenue Makati City, Philippines

Figure A.2 Letter of Approval

APPENDIX
B

Isometric View

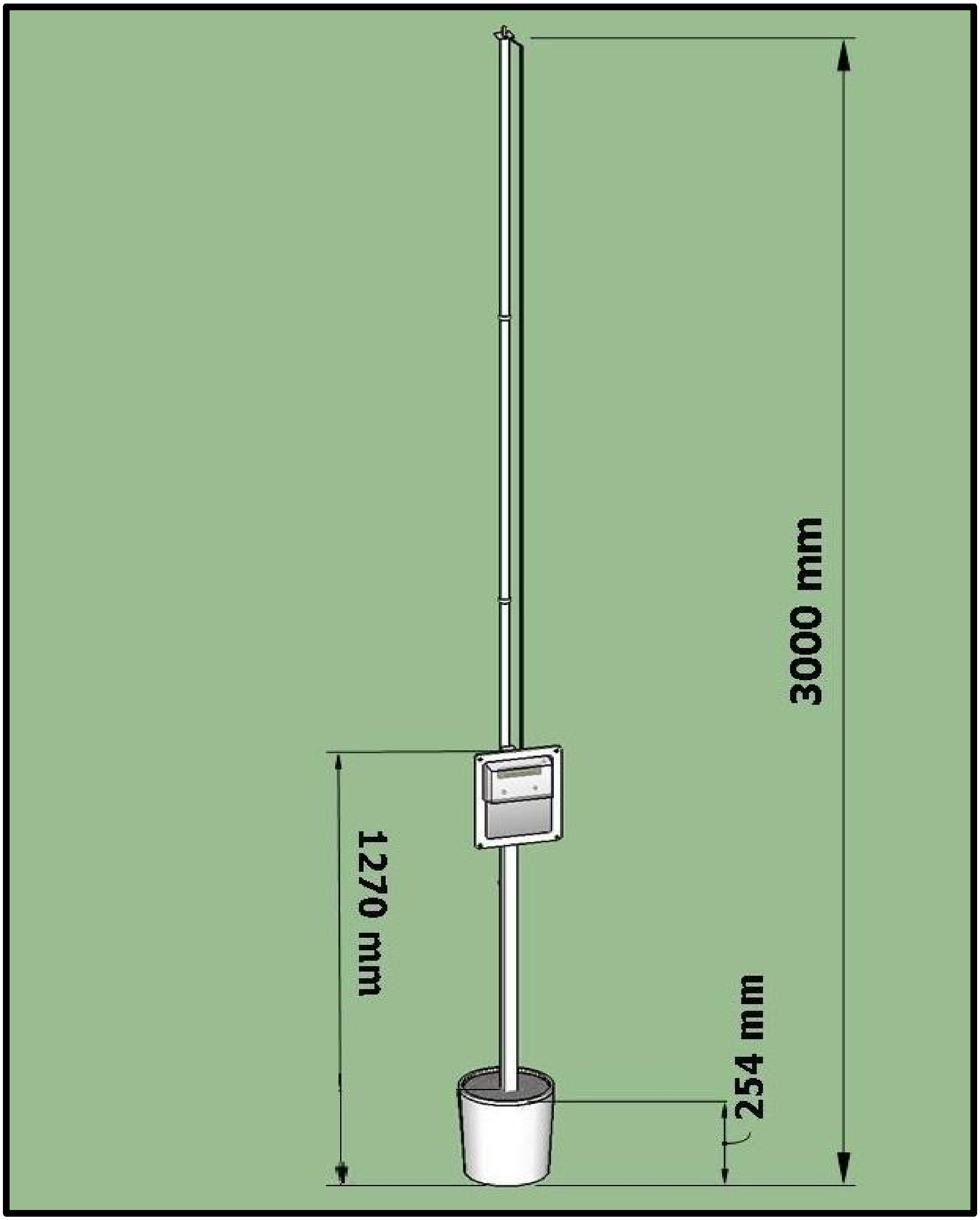


Figure B.1 Overview Design of the Prototype (Top to Bottom)

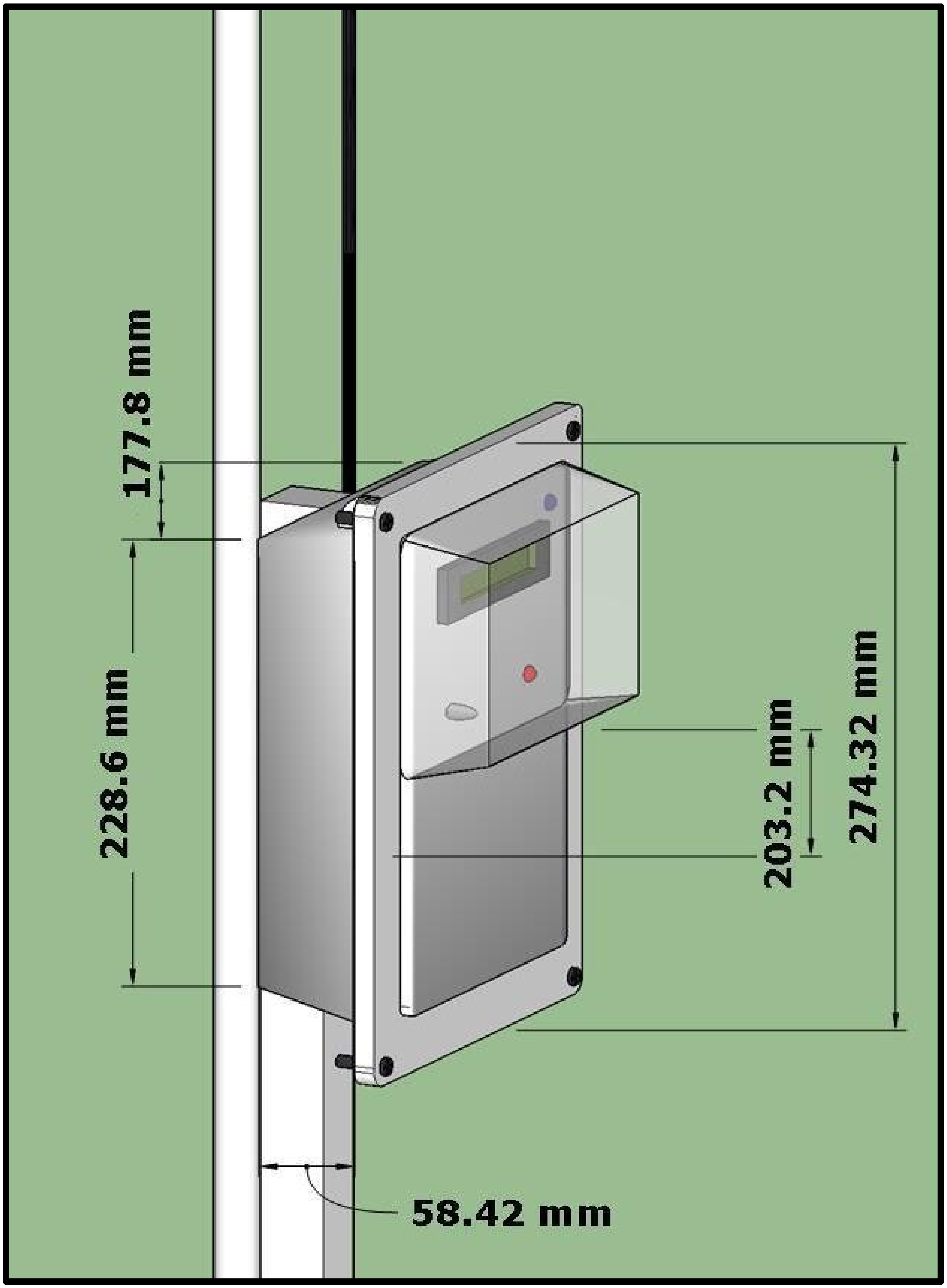


Figure B.2 Overview Design of the Prototype (Casing)

Physical Dimensions of the Prototype

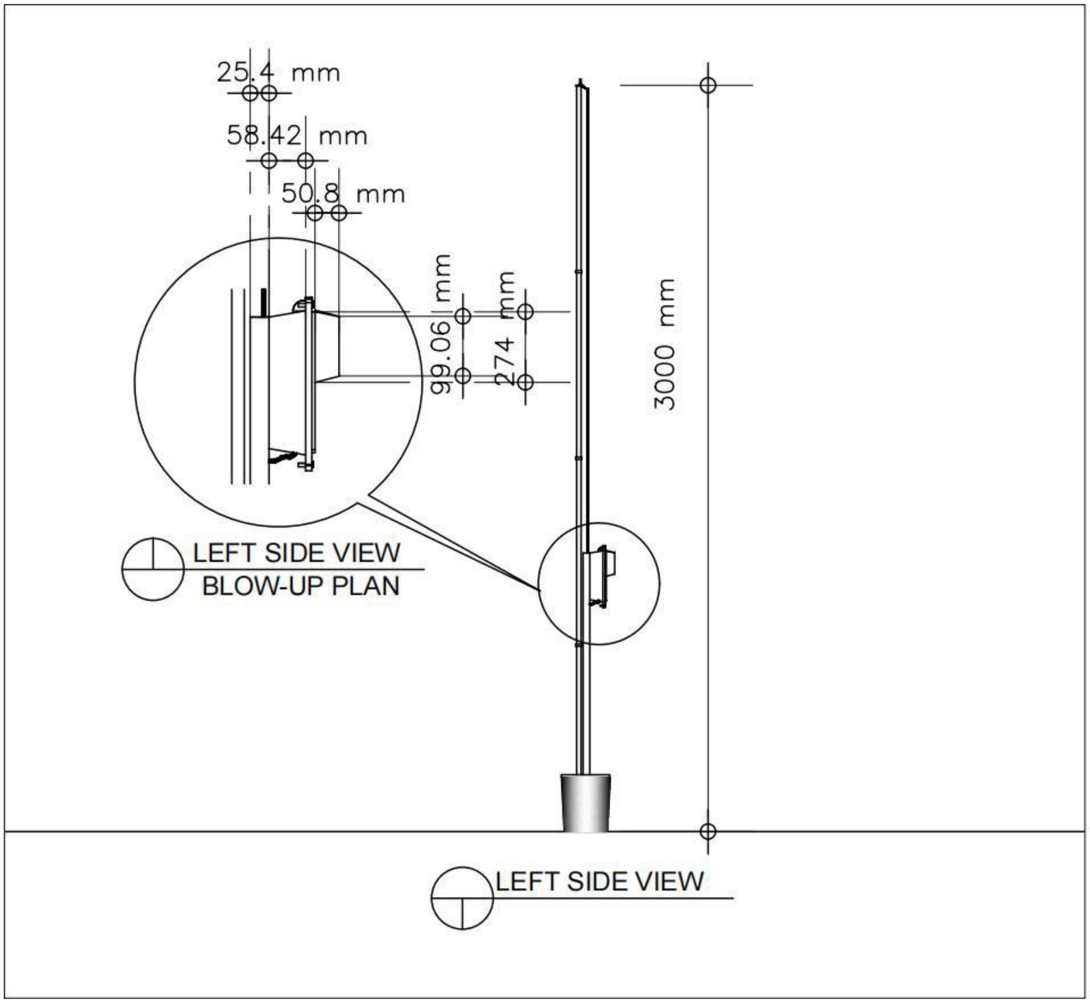


Figure B.3 Left Side View

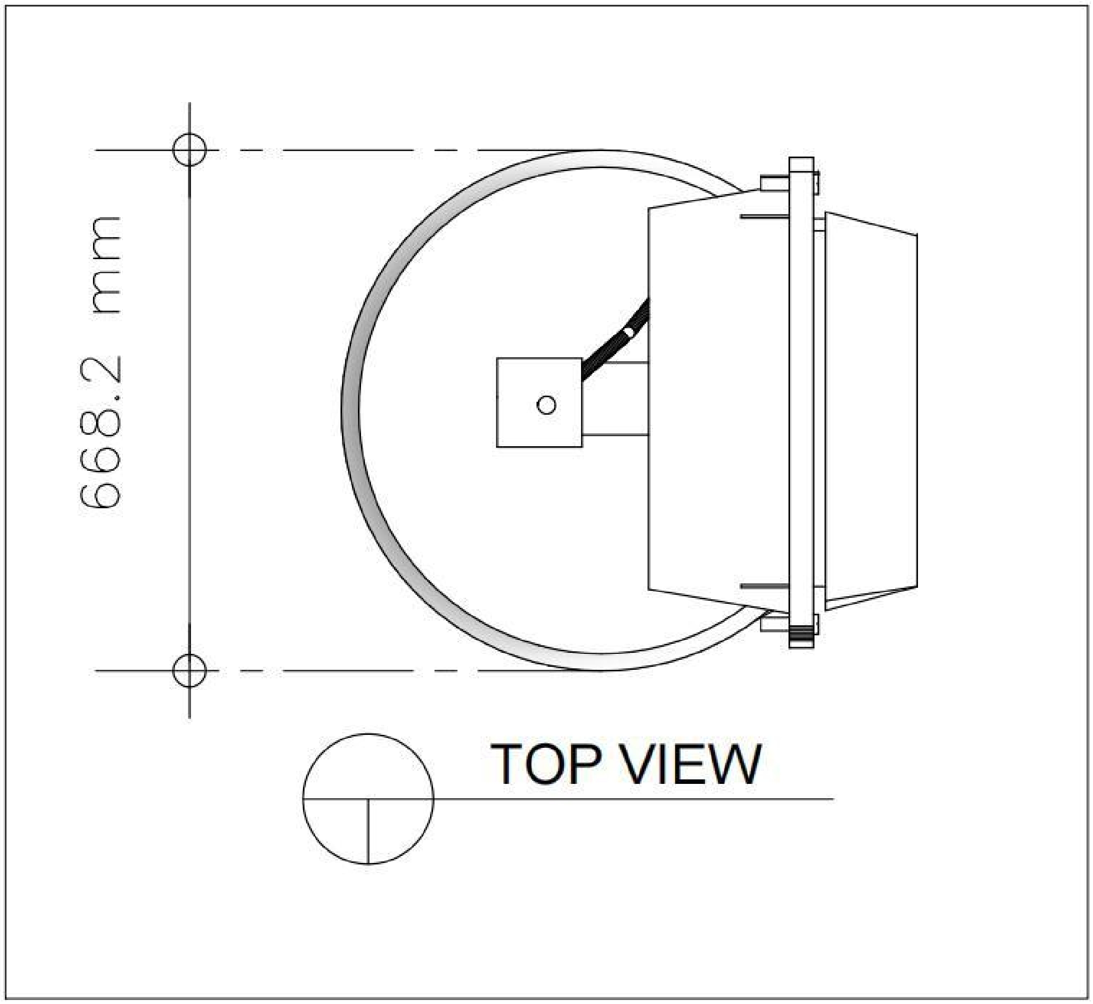


Figure B.4 Top View

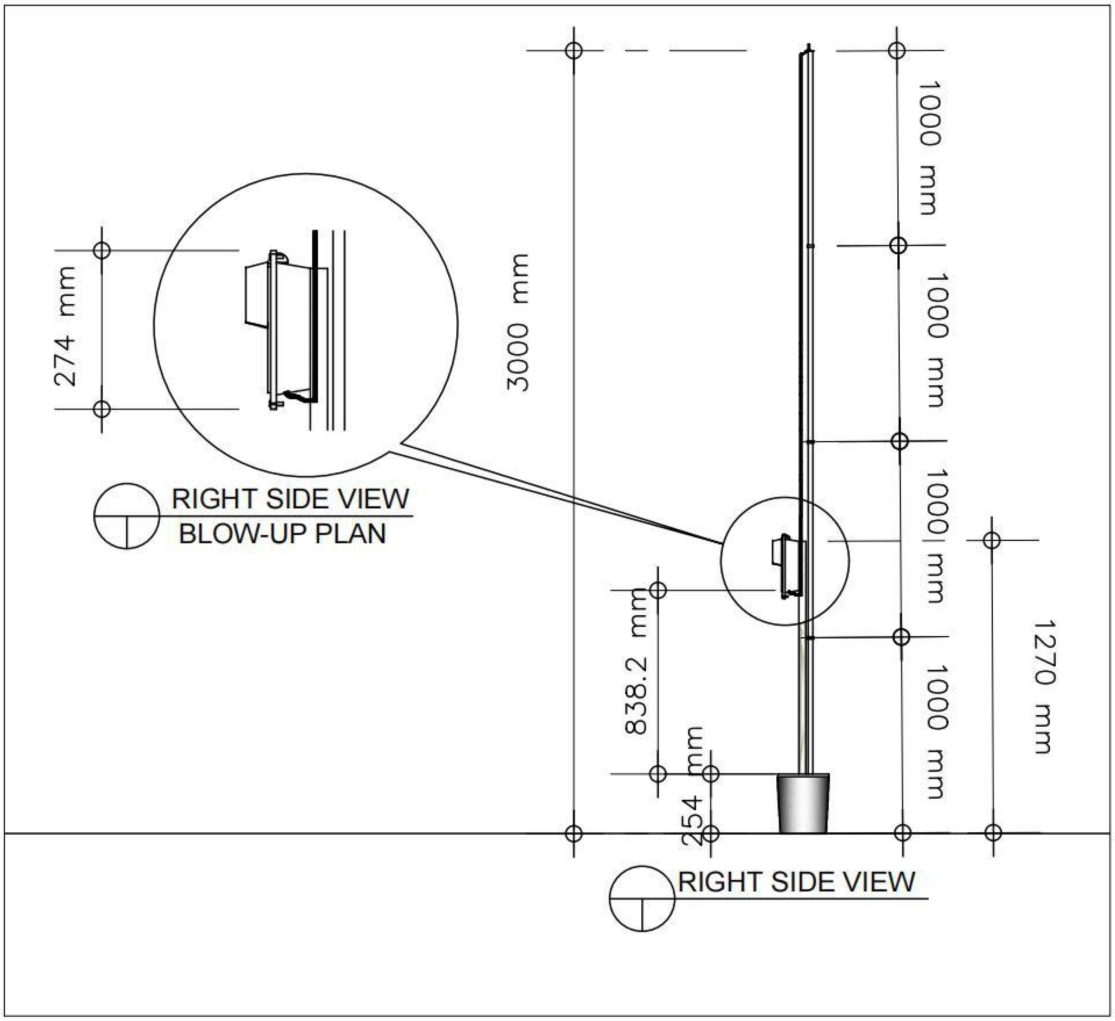


Figure B.5 Right Side View

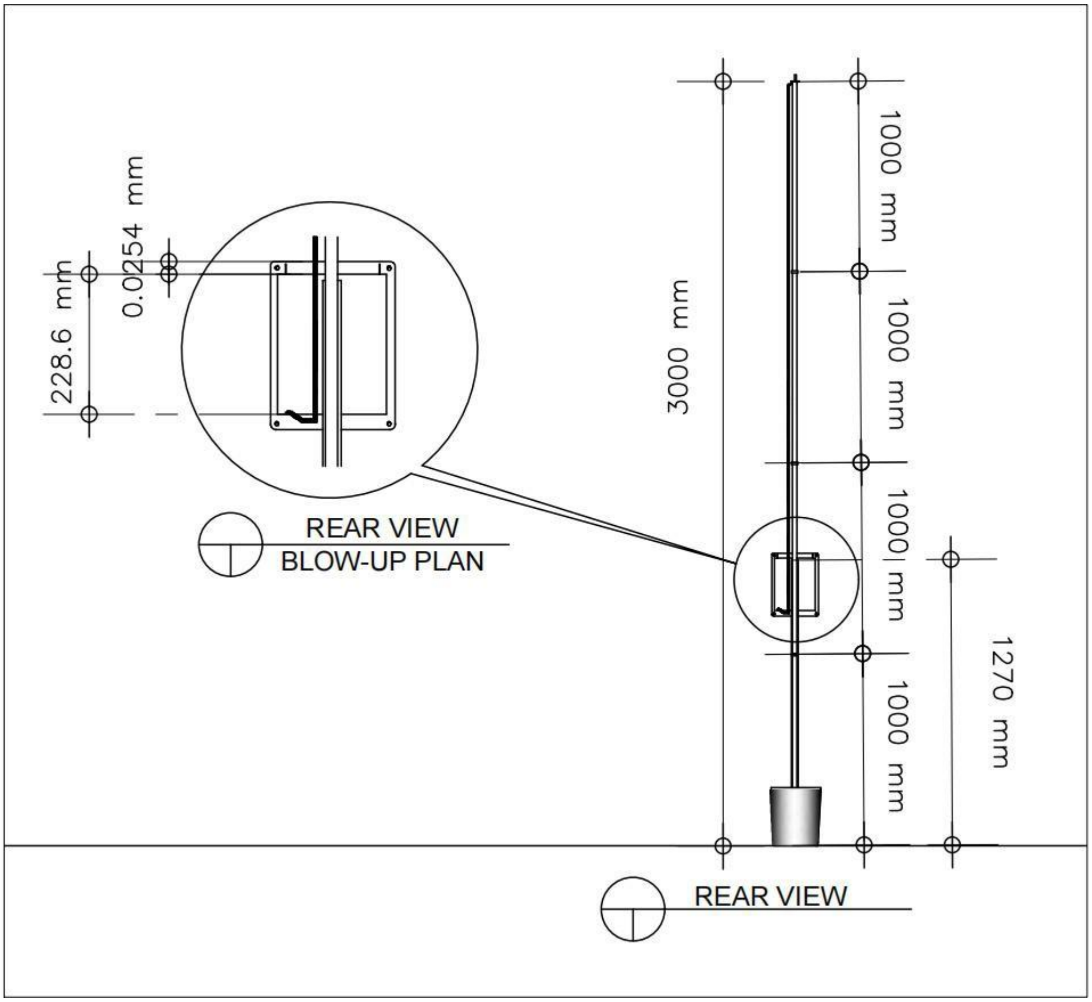


Figure B.6 Rear View

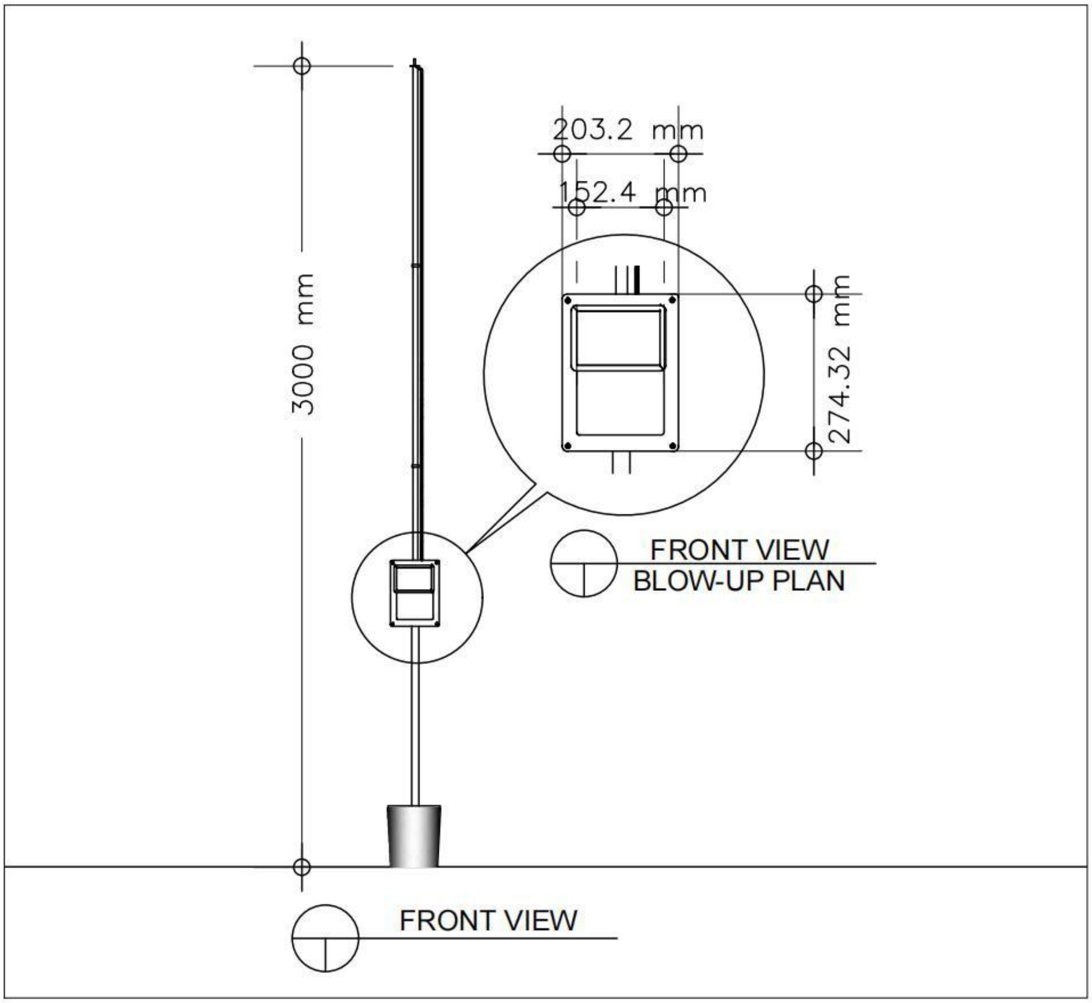


Figure B.7 Front View

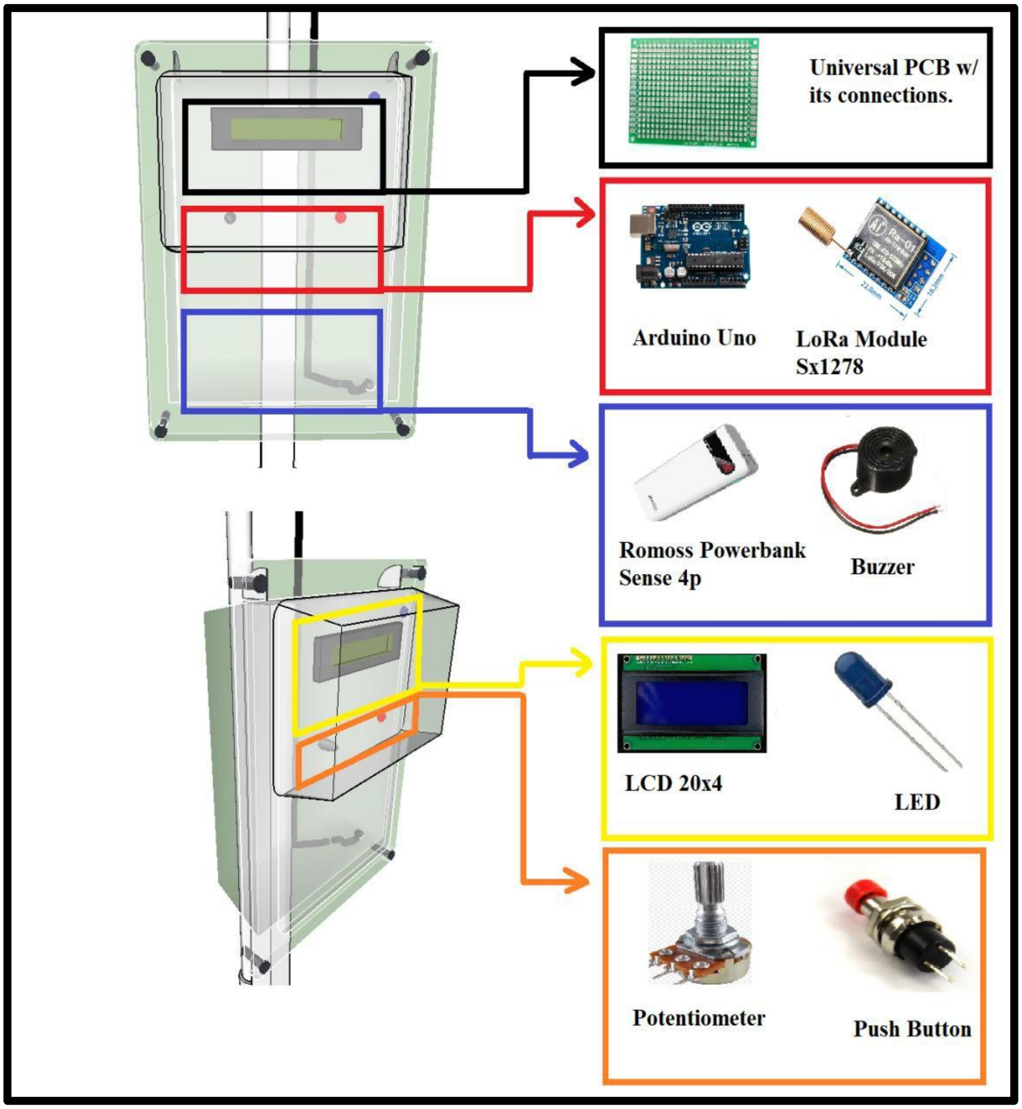


Figure B.8 Placement of Components Inside the Prototype

Figure B.9 Actual Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street

APPENDIX
C

Data Sheets

Arduino UNO

Product 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 crystal oscillator, 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 Atmega8U2 programmed as a USB-to-serial converter.

"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 Arduno, 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.

Index

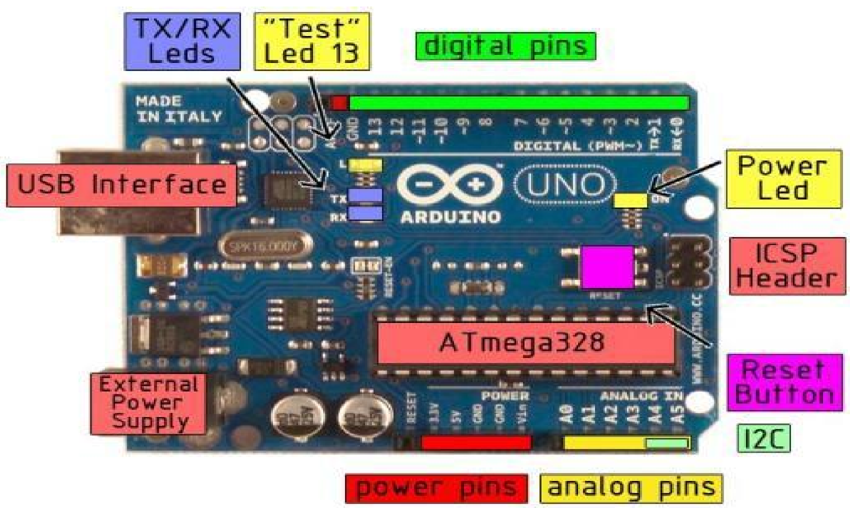
Technical Specification

EAGLE files: arduino-duemilanove-uno-design.zip Schematic: arduino-uno-schematic.pdf

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 of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

the board



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.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **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 of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 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. TThese 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, which, although provided by the underlying hardware, is not currently included in the Arduino language.

- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

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

- **I²C: 4 (SDA) and 5 (SCL).** Support I²C (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.

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 ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an *.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 support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega328 datasheet.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno w/ ATmega328" 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 ATmega8U2 firmware source code is available . The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. 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).

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 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. Three 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.

RS radiospares RADIONICS

How to use Arduino

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

Arduino is a cross-platoform program. You'll have to follow different instructions for your personal OS. Check on the Arduino site for the latest instructions. *http://arduino.cc/en/Guide/HomePage*

Linux Install **Windows Install** **Mac Install**

Once you have downloaded/unzipped the arduino IDE, you can Plug the Arduino to your PC via USB cable.

Blink led

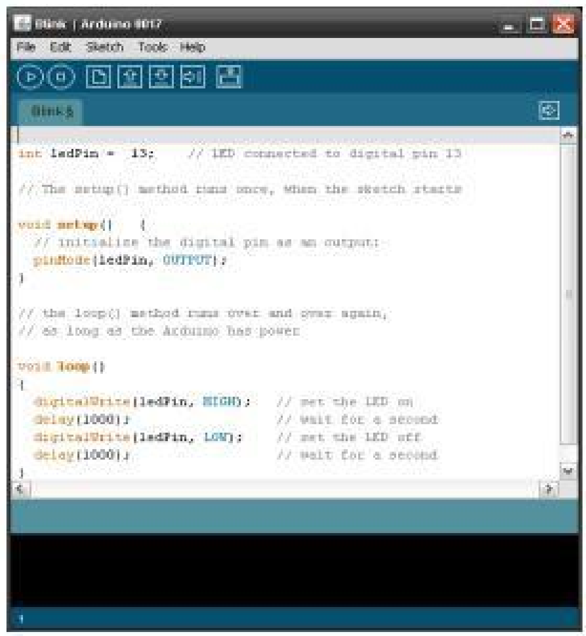
Now you're actually ready to "burn" your first program on the arduino board. To select "blink led", the physical translation of the well known programming "hello world", select

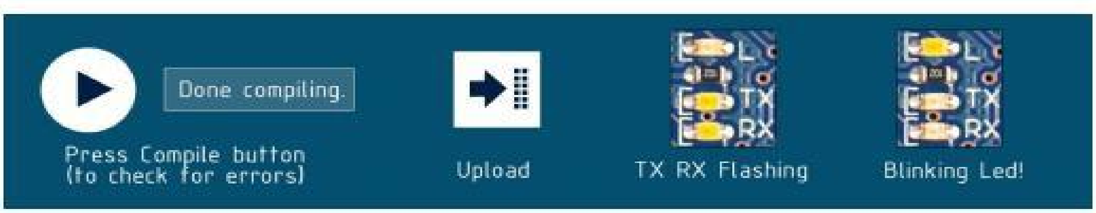
File>Sketchbook>
Arduino-0017>Examples>
Digital>Blink

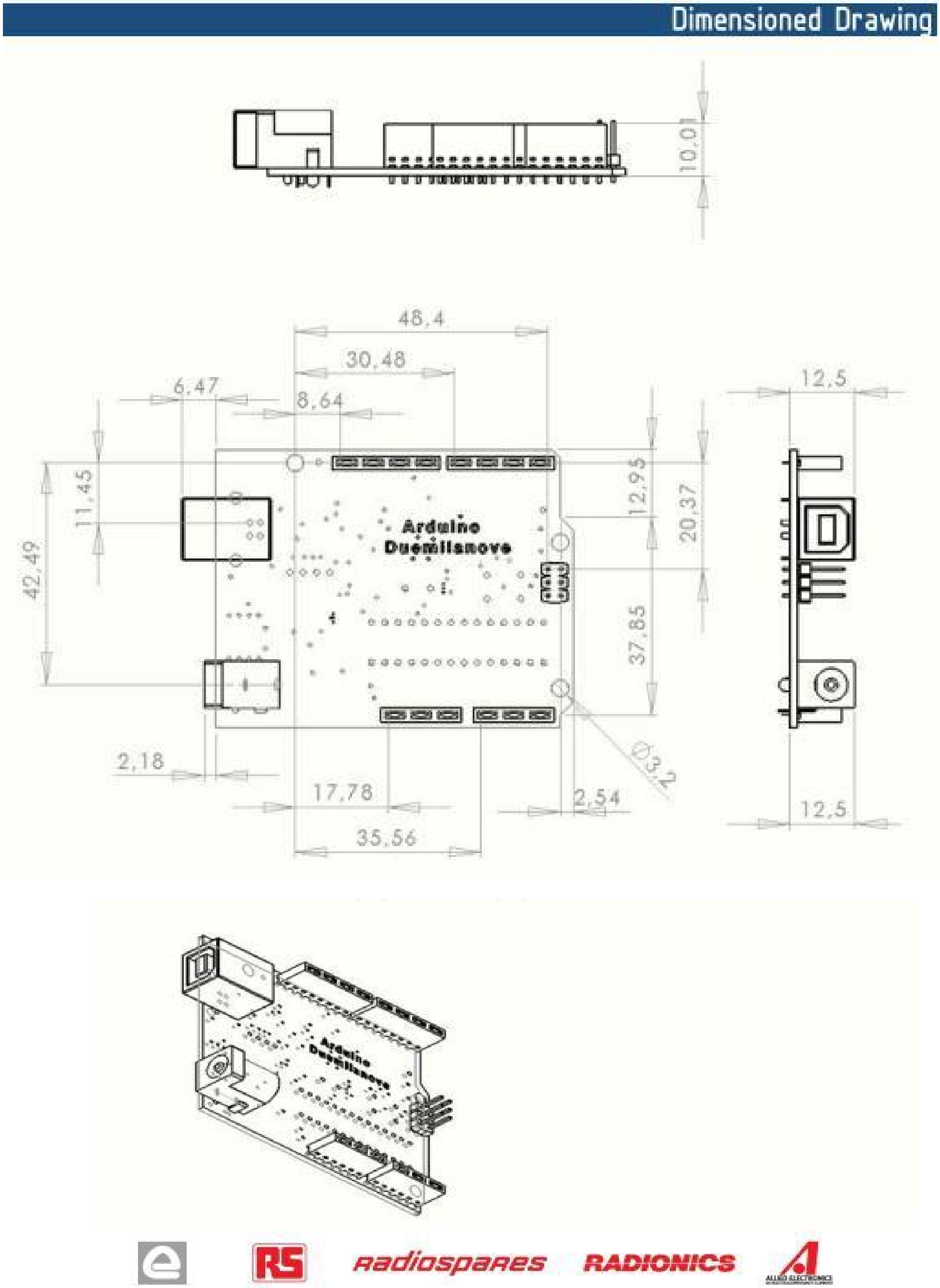
Once you have your skecth you'll see something very close to the screenshot on the right.

In **Tools>Board** select

Now you have to go to
Tools>SerialPort
and select the right serial port, the one arduino is attached to.






Dimensioned Drawing
10,01
48,4
30,48
6,47
8,64
12,5
11,45
42,49
12,95
20,37
37,85
Arduino
Duemilanove
2,18
17,78
35,56
2,54
Ø3,2
12,5
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Enviromental Policies

The producer of Arduino™ has joined the Impatto Zero® policy of LifeGate.it. For each Arduino board produced is created / looked after half squared Km of Costa Rica's forest's.

Potentiometer's Data Sheets

17 mm Rotary Potentiometer

P164 Series

TT Electronics PRO AUDIO

TT Electronics

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Features:

- Resistance range 1 kΩ to 1 MΩ
- Temperature range -10°C to +70°C
- Rotational cycles of 100,000 minimum
- Center and multiple detent options
- Vertical and horizontal mount versions
- RoHS compliant

Description:

17mm rotary potentiometer. Options include single or dual gangs, metal shaft; audio and linear tapers; metal bushing; various shaft lengths; flat, knurled or plain shaft types.

Single Gang

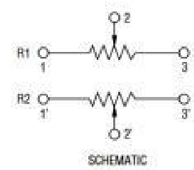
3D Model

To view 3D model:
1) Enable 3D content
2) Click and drag below

If unable to view 3D content, download and save this PDF to your computer and open it in Adobe Acrobat Reader.

Applications:

- Electric guitars
- Amplifiers/mixers/drum machines/synthesizers
- PC's/monitors
- Appliances
- Audio/car radio/TV sets



Dual Gang

Electrical Characteristics

T_A = 25°C unless otherwise noted

Resistance Range	1 kΩ to 1 MΩ
Standard Resistance Tolerance	500 Ω<R<1 MΩ ± 20% R≤500 Ω or R≥1 MΩ ± 30%
Residual Resistance	Term. 1~2: Less than 20 Ω Term: 2~3: Less than 20 Ω
Resistance Taper	A, B, C, D
Maximum Operating Voltage	Linear Taper B: 200 Vac Other Tapers: 150 Vac
Rated Power	Linear Taper B: 0.2W Audio: 0.1W
Dielectric Strength	1 minute at 500 Vac
Rotational Noise	Less than 100 mV
Insulation Resistance	More than 100 MΩ at 500 Vdc
Gang Error (Dual Unit)	-40 dB~0 dB ± 3 dB

TT Electronics | BI Technologies
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Document No.: _______________

17 mm Rotary Potentiometer

P164 Series

OBSOLETE

Mechanical Characteristics

T_A = 25°C unless otherwise noted

Mechanical Travel	300 ° ± 5 °
Rotational Torque	20 gf.cm~100 gf.cm
Rotational Stop Strength	7 kgf.cm minimum
Shaft Torque Strength	8 kgf minimum
Detent Torque	100~300gf.cm
Nut Tightening Strength	8 kgf.cm minimum
Rotational Life	100,000 cycles minimum

Environmental Characteristics

T_A = 25°C unless otherwise noted

Operating Temperature	-10 °C to +70 °C
IP Rating	IP 40
Soldering Condition	Wave Soldering 260 °C maximum for 1-3 seconds Hand Soldering 300 °C maximum for 3 seconds
RoHS	Please refer to TT Electronics website
REACH	Please refer to TT Electronics website

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17 mm Rotary Potentiometer

P164 Series

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Ordering Information

P164	G	1	00	Q	N	C	20	B	102

Part Family

Terminal Configuration
G - PC Pins, Down Facing (12.5 mm)
H - PC Pins, Down Facing (18 mm)
K - Solder Lugs, Rear Facing
M - PC Pins, Rear Facing
N - PC Pins, Front Facing

Gang Number
1 - 1 Gang
2 - 2 Gangs

Detents/ Rotation
00 - No Position
01 - Center Detent
11 - 11 Detents
21 - 21 Detents
41 - 41 Detents

Shaft Style
Q - Metal Knurled Type
P - Metal Plain Type Shaft
F - Metal Flatted Shaft

Switch Option
N - No Switch

Full CCW Position
A/B/C/D/N (see note 1 page 4)

Shaft Length (mm) - L
15/20/25/30/35

Resistance Taper
A - Audio (15A)
B - Linear (0B)
C - Reverse Audio (15C)
D - Audio (10A)

Resistance
See Resistance Table

Resistance Table	
Resistance (Ohms)	Code
1,000	102
2,000	202
5,000	502
10,000	103
20,000	203
50,000	503
100,000	104
200,000	204
500,000	504
1,000,000	105

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17 mm Rotary Potentiometer

P164 Series

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Outline Drawings

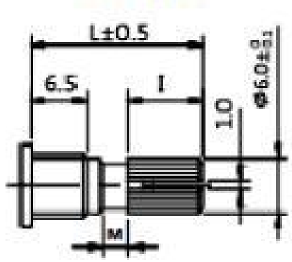
Shaft Style & Length

Q Type				
L	15	20	25	30
	M - 2 I - 6	M - 2 I - 10	M - 2 I - 14	M - 2 I - 19

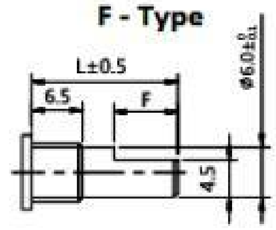
F Type					
L	15	20	25	30	35
	F - 7	F - 12	F - 12	F - 12	F - 12

P Type					
L	15	20	25	30	35

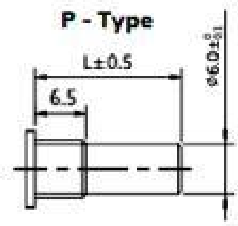
Q - Type



F - Type



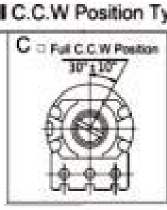
P - Type



Note 1 : Full CCW Position

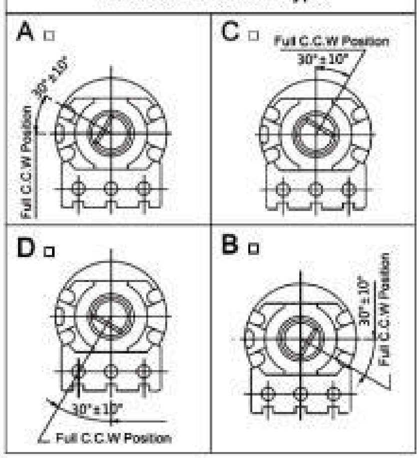
Q-type shaft

Full C.C.W Position Type



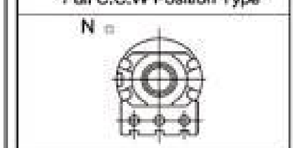
F-type shaft

Full C.C.W Position Type



P-type shaft

Full C.C.W Position Type



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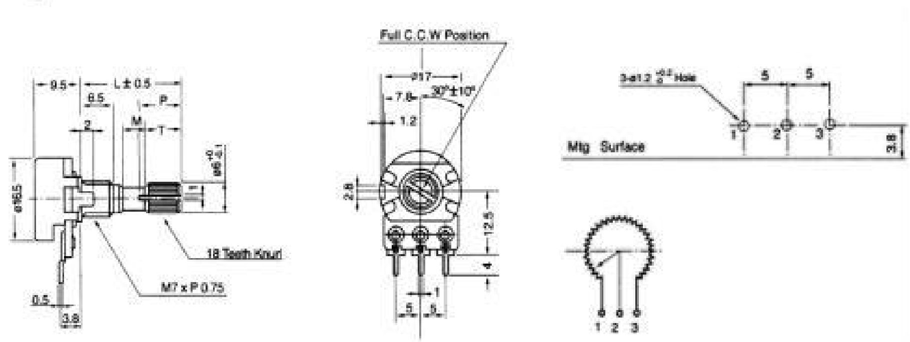
17 mm Rotary Potentiometer

P164 Series

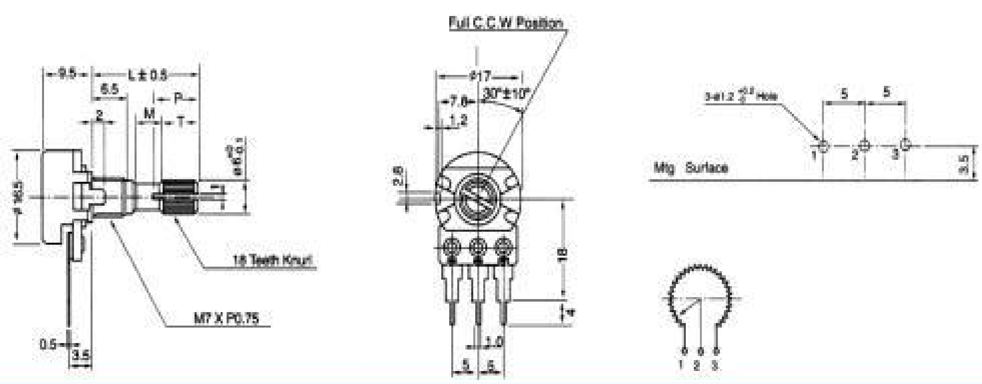
OBSOLETE

Outline Drawings

G - PC Pins, Down Facing (12.5mm), Single Gang



H - PC Pins, Down Facing (18mm), Single Gang



General Note
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Document No.: ______________

Pushbutton Data Sheets

Operation Mode	ON-OFF-ON
Current Rating	1 Amps
Operating Voltage	250 Volts (AC)
Contact Type	Normally Open
Connector Type	Quick Connect
Brand	JWJAN
Switch Type	Ignition Switch
Terminal	Solder
Material	Metal, Acrylonitrile Butadiene Styrene
Circuit Type	1-way

Product Specifications

Color	Black+Red
Connector Type	Quick Connect
Contact Material	Silver
Contact Type	Normally Open
Controller Type	Push Button
Current Rating	1.00 amps
Ean	6934596037581
Enclosure	Stainless Metallic
Material	Metal , Acrylonitrile Butadiene Styrene
Measurement System	Imperial , Metric
Mounting Type	plug_in_mount
Number Of Pins	2
Operating Voltage	250.00
Operation Mode	ON-OFF-ON
Part Number	JJL-55446601
Switch Type	Ignition Switch
Terminal Type	Solder
Voltage	250.00

Specification for this product family

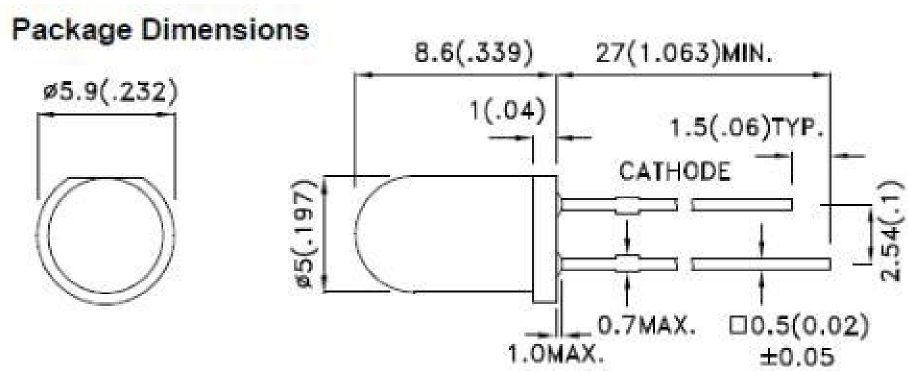
Brand Name	JWJAN
Part Number	JJL-554466
UNSPSC Code	39122216

LED's Data Sheets

Now that we know that even the mighty LED has its limits, we need to make sure we stay below those limits. Being kind to your LEDs will let them last longer and keep them shiny & bright!

Lets examine the specification sheet for a 5mm LED, specification sheets are also called **datasheets**. Datasheets are immensely useful, they have all the information you need for an electronic component. You can download the datasheet we'll be referring to here.

The first useful thing you'll find is the dimensional 'package' information. The 'package' here is the LED itself.



As you can see, the main diameter of the LED is 5mm (its a '5mm LED') and there's a lip that makes it around 6mm. The lip can make it handy if you're gluing the LED into a drilled hole, so it doesnt fall through. The datasheet also tells you which pin is the cathode and other lengths and sizes. Note that the figures are in mm with the inches in ()'s afterwards.

Keep scrolling down. Next you'll find this small table. This section tells you how bright the LED is in **mcd**. Since these are general purpose LEDs, the brightness can vary a bit, these LEDs average around 250 mcd, but the manufacturer may sell you LEDs that are as dim as 180mcd. This variation is pretty standard.

Selection Guide

Part No.	Dice	Lens Type	Iv (mcd) [2] @ 20mA		Viewing Angle [1]
			Min.	Typ.	$2\theta 1/2$
WP7113SRD/D	Super Bright Red (GaAlAs)	RED DIFFUSED	180	250	30°

Later on the same page, is the electrical characteristics table.

Electrical / Optical Characteristics at TA=25°C

Symbol	Parameter	Device	Typ.	Max.	Units	Test Conditions
λpeak	Peak Wavelength	Super Bright Red	660		nm	I_F=20mA
λD [1]	Dominant Wavelength	Super Bright Red	640		nm	I_F=20mA
Δλ1/2	Spectral Line Half-width	Super Bright Red	20		nm	I_F=20mA
C	Capacitance	Super Bright Red	45		pF	V_F=0V;f=1MHz
V_F [2]	Forward Voltage	Super Bright Red	1.85	2.5	V	I_F=20mA
I_R	Reverse Current	Super Bright Red		10	uA	V_R = 5V

Notes:
1.Wavelength: +/-1nm.
2. Forward Voltage: +/-0.1V.

The first two rows talk about the 'wavelength' - this is a specific way of indicating the color. After all, 'super bright red' is a very subjective description. With the wavelength, we can know exactly what color is emitted.
The third row is basically saying 'how much does the color vary from the wavelength'
The forth row isnt so important, we'll skip that

The **fifth** row, however, is what we're looking for...

Buzzer's Data Sheet
A buzzer is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure hence can be easily used on breadboard, Perf Board and even on PCBs which makes this a widely used component in most electronic applications.
There are two types of buzzers that are commonly available. The one shown here is a simple buzzer which when powered will make a Continuous Beeeeeeppp.... sound, the other type is called a readymade buzzer which will look bulkier than this and will produce a Beep. Beep. Beep. Sound due to the internal oscillating circuit present inside it. But, the one shown here is most widely used because it can be customized with help of other circuits to fit easily in our application.
This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V. A simple 9V battery can also be used, but it is recommended to use a regulated +5V or +6V DC supply. The buzzer is normally associated with a switching circuit to turn ON or turn OFF the buzzer at required time and require interval.

Buzzer Pin Configuration

Pin Number	Pin Name	Description
1	Positive	Identified by (+) symbol or longer terminal lead. Can be powered by 6V DC
2	Negative	Identified by short terminal lead. Typically connected to the ground of the circuit

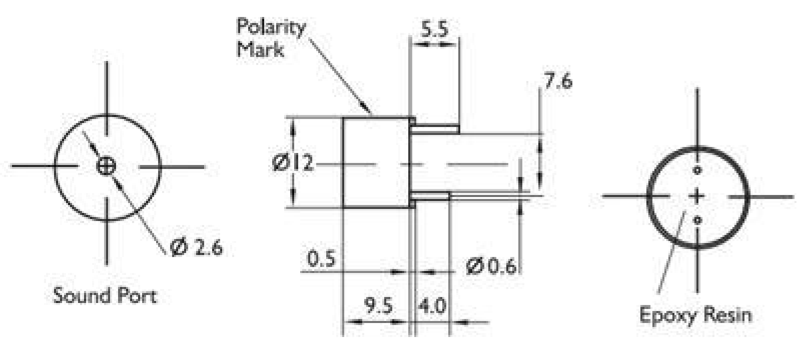
Buzzer’s Features and Specifications

- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA
- Sound Type: Continuous Beep
- Resonant Frequency: ~2300 Hz
- Small and neat sealed package
- Breadboard and Perf board friendly

Applications of Buzzer

- Alarming Circuits, where the user has to be alarmed about something
- Communication equipments
- Automobile electronics
- Portable equipments, due to its compact size

2D Model of Buzzer



Dimensions : Millimetres
Tolerance : ±0.5mm

Systronix 20x4 LCD
Brief Technical Data

July 31, 2000

Here is brief data for the Systronix 20x4 character LCD. It is a DataVision part and uses the Samsung KS0066 LCD controller. It's a clone of the Hitachi HD44780. We're not aware of any incompatabilities between the two - at least we have never seen any in all the code and custom applications we have done.

This 20x4 LCD is electrically and mechanically interchangeable with 20x4 LCDs from several other vendors. The only differences we've seen among different 20x4 LCDs are:

1) LED backlight brightness, voltage and current vary widely, as does the quality of the display

2) There is a resistor "Rf" which sets the speed of the LCD interface by controlling the internal oscillator frequency. Several displays we have evaluated have a low resistor value. This makes the display too slow. Looking at the Hitachi data sheet page 56, it appears that perhaps the "incorrect" resistor is really intended for 3V use of the displays.

At 5V the resistor Rf should be 91 Kohms. At 3V it should be 75 Kohms. Using a 3V display at 5V is acceptable from a voltage standpoint (the display can operate on 3-5V) but the oscillator will then be running too slowly. One fix is to always check the busy flag and not use a fixed time delay in your code, then it will work regardless of the LCD speed. The other option is to always allow enough delay for the slower display.

All Systronix 20x4 LCDs have the 91 Kohm resistor and are intended for 5V operation.

Thank you for purchasing Systronix embedded control products and accessories. If you have any other questions please email to support@systronix.com or phone +1-801-534-1017, fax +1-801-534-1019.

ABSOLUTE MAXIMUM RATINGS

Item	Symbol	Standard Value			Unit
		Min.	Typ.	Max.	
Supply Voltage for Logic	V_{DD}	0	—	7.0	V
Supply Voltage for LCD Driver	V_{DD}-V_{EE}	—	—	13.5	V
Input Voltage	V_I	V_{SS}	—	V_{DD}	V
Operature Temp.	Topr	0	—	50	°C
Storage Temp.	Tstg	-20	—	70	°C

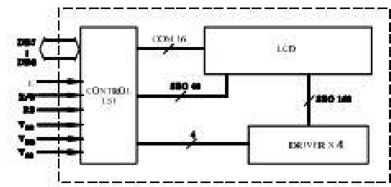
ELECTRICAL CHARACTERISTICS (REFLECTIVE TYPE)

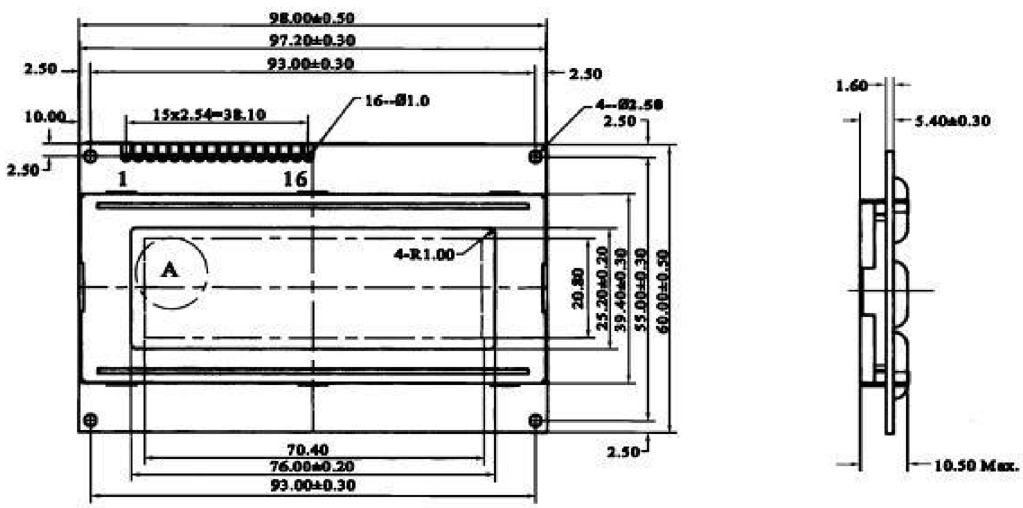
Item	Symbol	Test Condition	Standard Value			Unit
			Min.	Typ.	Max.	
Input "High" Voltage	V_{IH}	—	2.2	—	V_{EE}	V
Input "Low" Voltage	V_{IL}	—	—	—	0.6	V
Output "High" Voltage	V_{OH}	I_{OH}=0.2mA	2.2	—	—	V
Output "Low" Voltage	V_{OL}	I_{OL}=1.2mA	—	—	0.4	V
Supply Current	I_{DD}	V_{DD}=5.0A	—	2.5	4.0	mA

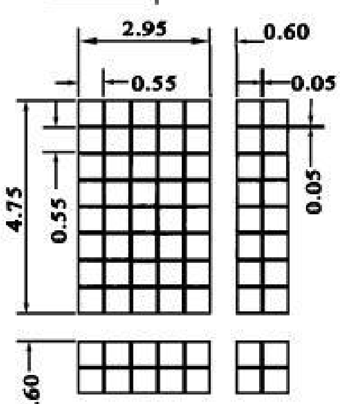
PIN FUNCTIONS

No	Symbol	Function	No	Symbol	Function
1	V_{SS}	GND, 0V	10	DB3	Data Bus
2	V_{DD}	+5V	11	DB4	—
3	V_{EE}	for LCD Drive	12	DB5	—
4	RS	Function Select	13	DB6	—
5	R/W	Read/Write	14	DB7	—
6	E	Enable Signal	15	LEDA	LED Power Supply
7-9	DB0-DB2	Data Bus Line	16	LEDA	

BLOCK DIAGRAM







A BLOCK

Table 4 Correspondence between Character Codes and Character Patterns (ROM Code: A00)

Lower 4 Bits \ Upper 4 Bits	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx0000	CG RAM (1)			0	@	P	`	p				ー	タ	ミ	α	p
xxxx0001	(2)		!	1	A	Q	a	q			。	ア	チ	ム	ä	q
xxxx0010	(3)		"	2	B	R	b	r			「	イ	ツ	メ	β	θ
xxxx0011	(4)		#	3	C	S	c	s			」	ウ	テ	モ	ε	∞
xxxx0100	(5)		$	4	D	T	d	t			、	エ	ト	ヤ	μ	Ω
xxxx0101	(6)		%	5	E	U	e	u			・	オ	ナ	ユ	σ	ü
xxxx0110	(7)		&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ρ	Σ
xxxx0111	(8)		'	7	G	W	g	w			ァ	キ	ヌ	ラ	g	π
xxxx1000	(1)		(	8	H	X	h	x			ィ	ク	ネ	リ	√	x̄
xxxx1001	(2)		)	9	I	Y	i	y			ゥ	ケ	ノ	ル	$^{-1}$	y
xxxx1010	(3)		*	:	J	Z	j	z			ェ	コ	ハ	レ	j	千
xxxx1011	(4)		+	;	K	[	k	{			ォ	サ	ヒ	ロ	^{x}	万
xxxx1100	(5)		,	<	L	¥	l	|			ャ	シ	フ	ワ	¢	円
xxxx1101	(6)		-	=	M	]	m	}			ュ	ス	ヘ	ン	£	÷
xxxx1110	(7)		.	>	N	^	n	→			ョ	セ	ホ	゛	ñ	
xxxx1111	(8)		/	?	O	_	o	←			ッ	ソ	マ	゜	ö	█

Note: The user can specify any pattern for character-generator RAM.

Initializing by Instruction

If the power supply conditions for correctly operating the internal reset circuit are not met, initialization by instructions becomes necessary.

Refer to Figures 25 and 26 for the procedures on 8-bit and 4-bit initializations, respectively.

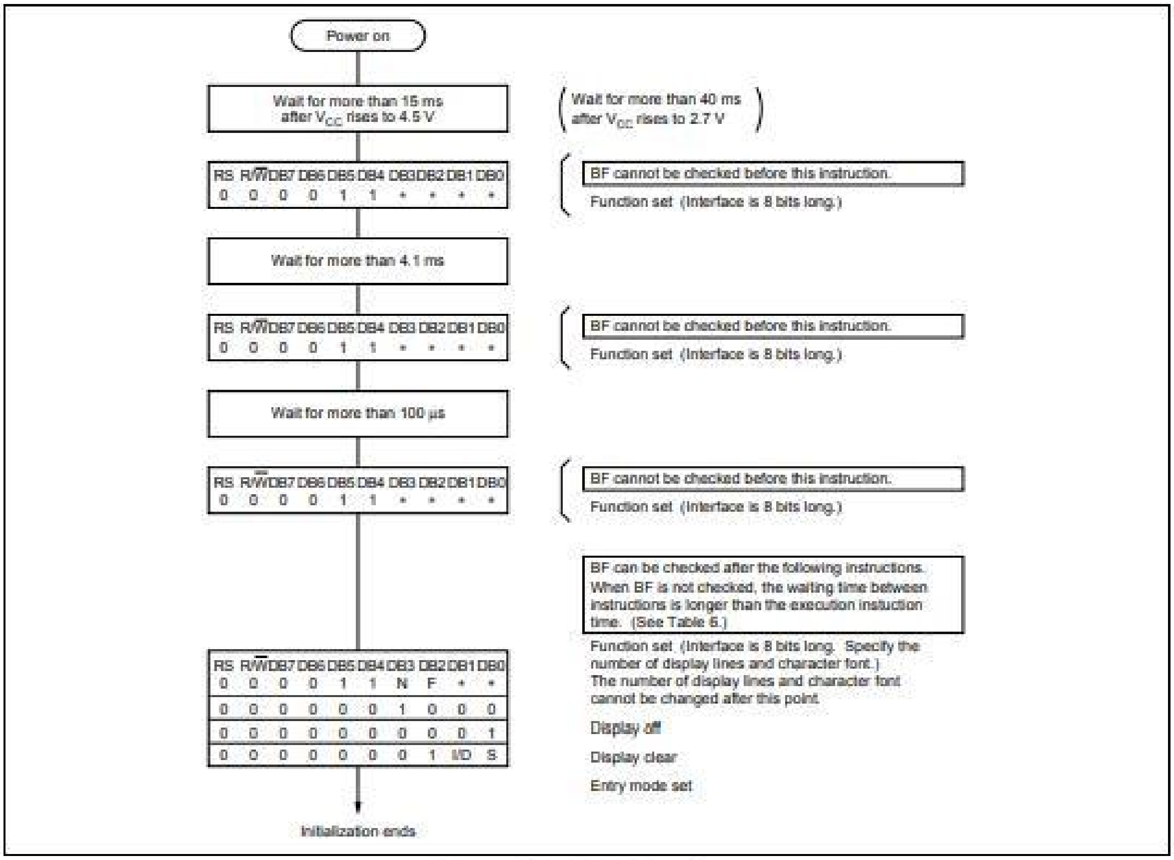


Figure 25 8-Bit Interface

Reset Function

Initializing by Internal Reset Circuit

An internal reset circuit automatically initializes the HD44780U when the power is turned on. The following instructions are executed during the initialization. The busy flag (BF) is kept in the busy state until the initialization ends (BF = 1). The busy state lasts for 10 ms after V_{CC} rises to 4.5 V.

1. Display clear
2. Function set:
   DL = 1; 8-bit interface data
   N = 0; 1-line display
   F = 0; 5 × 8 dot character font
3. Display on/off control:
   D = 0; Display off
   C = 0; Cursor off
   B = 0; Blinking off
4. Entry mode set:
   I/D = 1; Increment by 1
   S = 0; No shift

Note: If the electrical characteristics conditions listed under the table Power Supply Conditions Using Internal Reset Circuit are not met, the internal reset circuit will not operate normally and will fail to initialize the HD44780U. For such a case, initial-ization must be performed by the MPU as explained in the section, Initializing by Instruction.

Instructions

Outline

Only the instruction register (IR) and the data register (DR) of the HD44780U can be controlled by the MPU. Before starting the internal operation of the HD44780U, control information is temporarily stored into these registers to allow interfacing with various MPUs, which operate at different speeds, or various peripheral control devices. The internal operation of the HD44780U is determined by signals sent from the MPU. These signals, which include register selection signal (RS), read/

write signal (R/$\overline{W}$), and the data bus (DB0 to DB7), make up the HD44780U instructions (Table 6). There are four categories of instructions that:

- Designate HD44780U functions, such as display format, data length, etc.
- Set internal RAM addresses
- Perform data transfer with internal RAM
- Perform miscellaneous functions

Normally, instructions that perform data transfer with internal RAM are used the most. However, auto-incrementation by 1 (or auto-decrementation by 1) of internal HD44780U RAM addresses after each data write can lighten the program load of the MPU. Since the display shift instruction (Table 11) can perform concurrently with display data write, the user can minimize system development time with maximum programming efficiency.

When an instruction is being executed for internal operation, no instruction other than the busy flag/address read instruction can be executed.

Because the busy flag is set to 1 while an instruction is being executed, check it to make sure it is 0 before sending another instruction from the MPU.

Note: Be sure the HD44780U is not in the busy state (BF = 0) before sending an instruction from the MPU to the HD44780U. If an instruction is sent without checking the busy flag, the time between the first instruction and next instruction will take much longer than the instruction time itself. Refer to Table 6 for the list of each instruc-tion execution time.

Table 6 Instructions

	Code											Execution Time (max) (when f_{cp} or
Instruction	RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	f_{osc} is 270 kHz)
Clear display	0	0	0	0	0	0	0	0	0	1	Clears entire display and sets DDRAM address 0 in address counter.	
Return home	0	0	0	0	0	0	0	0	1	—	Sets DDRAM address 0 in address counter. Also returns display from being shifted to original position. DDRAM contents remain unchanged.	1.52 ms
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 μs
Display on/off control	0	0	0	0	0	0	1	D	C	B	Sets entire display (D) on/off, cursor on/off (C), and blinking of cursor position character (B).	37 μs
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	—	—	Moves cursor and shifts display without changing DDRAM contents.	37 μs
Function set	0	0	0	0	1	DL	N	F	—	—	Sets interface data length (DL), number of display lines (N), and character font (F).	37 μs
Set CGRAM address	0	0	0	1	ACG	ACG	ACG	ACG	ACG	ACG	Sets CGRAM address. CGRAM data is sent and received after this setting.	37 μs
Set DDRAM address	0	0	1	ADD	ADD	ADD	ADD	ADD	ADD	ADD	Sets DDRAM address. DDRAM data is sent and received after this setting.	37 μs
Read busy flag & address	0	1	BF	AC	AC	AC	AC	AC	AC	AC	Reads busy flag (BF) indicating internal operation is being performed and reads address counter contents.	0 μs

Table 6 Instructions (cont)

Instruction	Code										Description	Execution Time (max) (when f_{cp} or f_{OSC} is 270 kHz)
	RS	R/$\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Write data to CG or DDRAM	1	0	Write data								Writes data into DDRAM or CGRAM.	37 μs t_{ADD} = 4 μs*
Read data from CG or DDRAM	1	1	Read data								Reads data from DDRAM or CGRAM.	37 μs t_{ADD} = 4 μs*
	I/D I/D S S/C S/C R/L R/L DL N F BF BF	= 1: = 0: = 1: = 1: = 0: = 1: = 0: = 1: = 1: = 1: = 1: = 0:	Increment Decrement Accompanies display shift Display shift Cursor move Shift to the right Shift to the left 8 bits, DL = 0: 4 bits 2 lines, N = 0: 1 line 5 × 10 dots, F = 0: 5 × 8 dots Internally operating Instructions acceptable								DDRAM: Display data RAM CGRAM: Character generator RAM ACG: CGRAM address ADD: DDRAM address (corresponds to cursor address) AC: Address counter used for both DD and CGRAM addresses	Execution time changes when frequency changes Example: When f_{cp} or f_{OSC} is 250 kHz, $37\ \mu s \times \frac{270}{250} = 40\ \mu s$

Note: — indicates no effect.

* After execution of the CGRAM/DDRAM data write or read instruction, the RAM address counter is incremented or decremented by 1. The RAM address counter is updated after the busy flag turns off. In Figure 10, t_{ADD} is the time elapsed after the busy flag turns off until the address counter is updated.

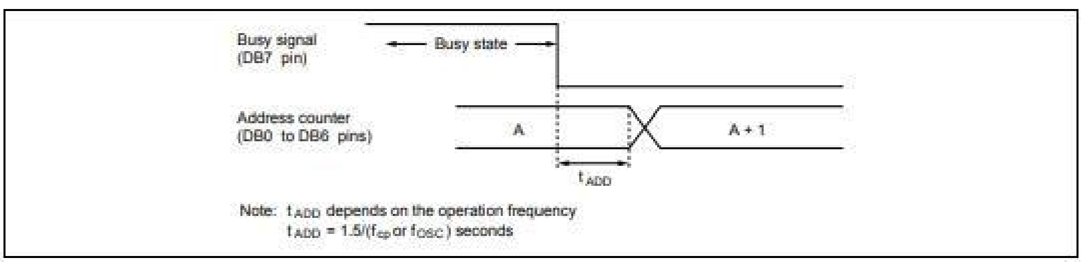


Figure 10 Address Counter Update

Datasheet | Powerbank

20000 mAh | 2x 3.0 + 1x 2.1 A | Number of outputs: 3 | Output connection: 1x USB-C™ / 2x USB-A | Input connection: 1x USB-C™ | QC3.0 / USB Power Delivery Profile (2.25 A - 20 V = 45 W) | Lithium-Polymer

Brand: Nedis | Article number: UPBK20010BK | Product EAN number: 5412810293919

Product specifications	
Accessories	USB-C Cable
Appliance	Smartphone
	Tablet
Battery capacity	20000 mAh
Battery recharging time	200 min
Battery voltage	3.7 V
Colour	Black
Depth	171 mm
Energy density	74 Wh
Flashlight	No
Height	16 mm
Input connection	1x USB-C™
Input current	3 A
Input voltage	20 VDC
Length	171 mm
Material	ABS
	Polycarbonate
Maximum chargingpower at 5 V	14800 mAh
Maximum output current per port	3.0 A
Number of outputs	3
Number of smartphone charges	8
Output connection	1x USB-C™
	2x USB-A
Output current	2x 3.0 + 1x 2.1 A
Output power	63 W
Output voltage	12.0 VDC
	14.5 VDC
	20.0 VDC
	5.0 VDC
	9.0 VDC
Packaging	Window Box with Euro Lock
Supported technology	QC3.0
	USB Power Delivery Profile (2.25 A - 20 V = 45 W)
Technology	Lithium-Polymer
Weight	462 g
Width	102 mm

Packaging information	
Brand	Nedis
Order code	UPBK20010BK
EAN single product	5412810293919
EAN inner carton:	
EAN Outer carton:	
Packaging	
Package contents	Powerbank
	USB-C cable

Quantity	L x	W x	H (mm)	Weight
1	140 mm	30 mm	255 mm	540 g
8	270 mm	155 mm	280 mm	4500 g
16	295 mm	180 mm	545 mm	9420 g

Nedis.com/UPBK20010BK

1. General Description

The SX1276/77/78/79 incorporates the LoRa™ spread spectrum modem which is capable of achieving significantly longer range than existing systems based on FSK or OOK modulation. At maximum data rates of LoRa™ the sensitivity is 8dB better than FSK, but using a low cost bill of materials with a 20ppm XTAL LoRa™ can improve receiver sensitivity by more than 20dB compared to FSK. LoRa™ also provides significant advances in selectivity and blocking performance, further improving communication reliability. For maximum flexibility the user may decide on the spread spectrum modulation bandwidth (BW), spreading factor (SF) and error correction rate (CR). Another benefit of the spread modulation is that each spreading factor is orthogonal - thus multiple transmitted signals can occupy the same channel without interfering. This also permits simple coexistence with existing FSK based systems. Standard GFSK, FSK, OOK, and GMSK modulation is also provided to allow compatibility with existing systems or standards such as wireless MBUS and IEEE 802.15.4g.

The SX1276 and SX1279 offer bandwidth options ranging from 7.8 kHz to 500 kHz with spreading factors ranging from 6 to 12, and covering all available frequency bands. The SX1277 offers the same bandwidth and frequency band options with spreading factors from 6 to 9. The SX1278 offers bandwidths and spreading factor options, but only covers the lower UHF bands.

1.1. Simplified Block Diagram

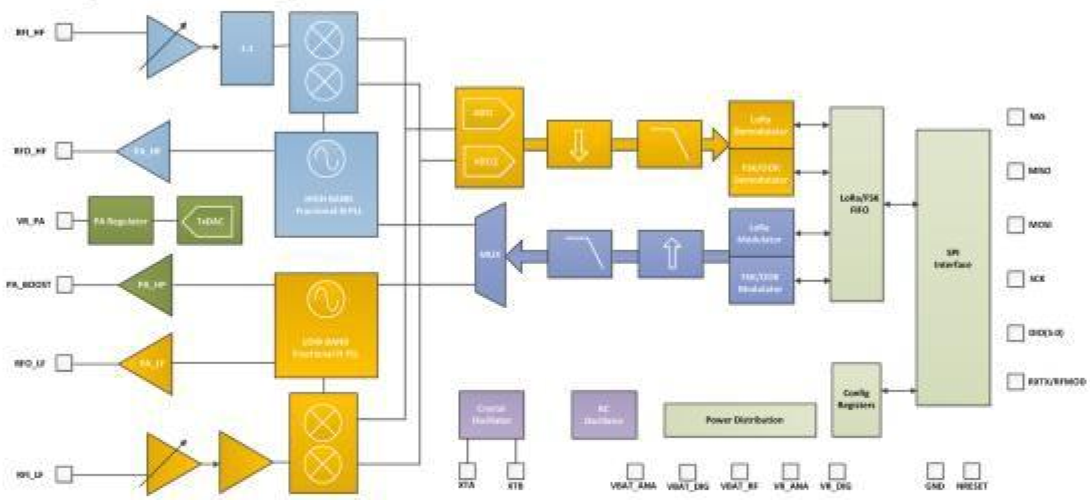


Figure 1. Block Diagram

1.2. Product Versions

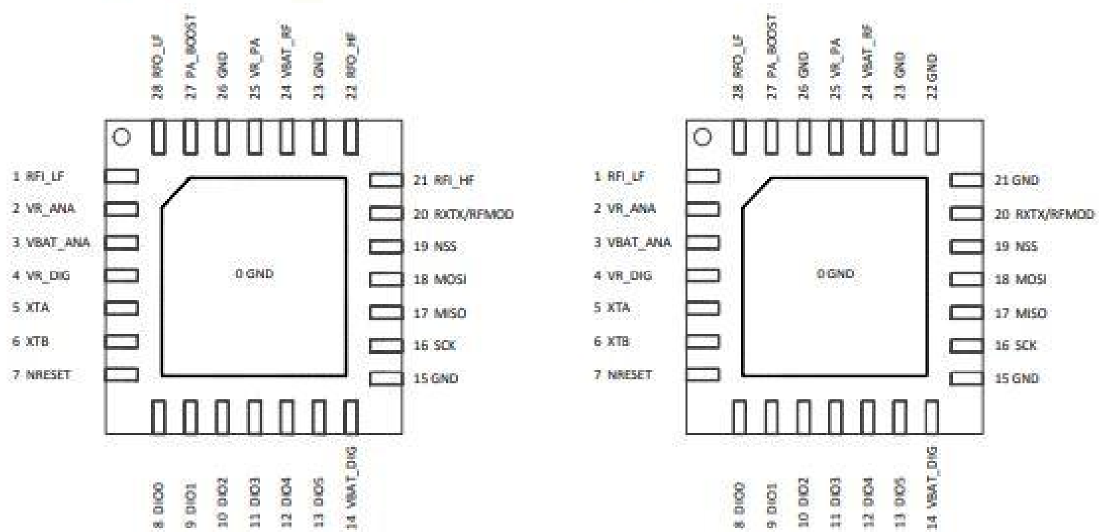
The features of the four product variants are detailed in the following table.

Table 1 SX1276/77/78/79 Device Variants and Key Parameters

Part Number	Frequency Range	Spreading Factor	Bandwidth	Effective Bitrate	Est. Sensitivity
SX1276	137 - 1020 MHz	6 - 12	7.8 - 500 kHz	.018 - 37.5 kbps	-111 to -148 dBm
SX1277	137 - 1020 MHz	6 - 9	7.8 - 500 kHz	0.11 - 37.5 kbps	-111 to -139 dBm
SX1278	137 - 525 MHz	6- 12	7.8 - 500 kHz	.018 - 37.5 kbps	-111 to -148 dBm
SX1279	137 - 960MHz	6- 12	7.8 - 500 kHz	.018 - 37.5 kbps	-111 to -148 dBm

1.3. Pin Diagram

The following diagram shows the pin arrangement of the QFN package, top view.



SX1276/77/79 SX1278

Figure 2. Pin Diagrams

1.4. Pin Description

Table 2 Pin Description

Number	Name	Type	Description
	SX1276/77/79/(78)	SX1276/77/79/(78)	SX1276/77/79/(78)
0	GROUND	-	Exposed ground pad
1	RFI_LF	I	RF input for bands 2&3
2	VR_ANA	-	Regulated supply voltage for analogue circuitry
3	VBAT_ANA	-	Supply voltage for analogue circuitry
4	VR_DIG	-	Regulated supply voltage for digital blocks
5	XTA	I/O	XTAL connection or TCXO input
6	XTB	I/O	XTAL connection
7	NRESET	I/O	Reset trigger input
8	DIO0	I/O	Digital I/O, software configured
9	DIO1/DCLK	I/O	Digital I/O, software configured
10	DIO2/DATA	I/O	Digital I/O, software configured
11	DIO3	I/O	Digital I/O, software configured
12	DIO4	I/O	Digital I/O, software configured
13	DIO5	I/O	Digital I/O, software configured
14	VBAT_DIG	-	Supply voltage for digital blocks
15	GND	-	Ground
16	SCK	I	SPI Clock input
17	MISO	O	SPI Data output
18	MOSI	I	SPI Data input
19	NSS	I	SPI Chip select input
20	RXTX/RF_MOD	O	Rx/Tx switch control: high in Tx
21	RFI_HF (GND)	I (-)	RF input for band 1 (Ground)
22	RFO_HF (GND)	O (-)	RF output for band 1 (Ground)
23	GND	-	Ground
24	VBAT_RF	-	Supply voltage for RF blocks
25	VR_PA	-	Regulated supply for the PA
26	GND	-	Ground
27	PA_BOOST	O	Optional high-power PA output, all frequency bands
28	RFO_LF	O	RF output for bands 2&3

1.5. Package Marking

TOP MARK	
CHAR	ROWS
7/7/7/7/7	5

Marking for the 6 x 6 mm MLPQ 28ld Lead package:

nnnnnn = Part Number (Example: SX1276)
yyww = Date Code (Example: 1352)
xxxxxxx = Semtech Lot No. (Example: EA90101)
xxxxxxx 0101-10)

Figure 3. Marking Diagram

2. Electrical Characteristics

2.1. ESD Notice

The SX1276/77/78/79 is a high performance radio frequency device. It satisfies:

- Class 2 of the JEDEC standard JESD22-A114 (Human Body Model) on all pins.
- Class III of the JEDEC standard JESD22-C101 (Charged Device Model) on all pins

It should thus be handled with all the necessary ESD precautions to avoid any permanent damage.

2.2. Absolute Maximum Ratings

Stresses above the values listed below may cause permanent device failure. Exposure to absolute maximum ratings for extended periods may affect device reliability.

Table 3 Absolute Maximum Ratings

Symbol	Description	Min	Max	Unit
VDDmr	Supply Voltage	-0.5	3.9	V
Tmr	Temperature	-55	+115	° C
Tj	Junction temperature	-	+125	° C
Pmr	RF Input Level	-	+10	dBm

Note Specific ratings apply to +20 dBm operation (see Section 5.4.3).

2.3. Operating Range

Table 4 Operating Range

Symbol	Description	Min	Max	Unit
VDDop	Supply voltage	1.8	3.7	V
Top	Operational temperature range	-40	+85	°C
Clop	Load capacitance on digital ports	-	25	pF
ML	RF Input Level	-	+10	dBm

Note A specific supply voltage range applies to +20 dBm operation (see Section 5.4.3).

2.4. Thermal Properties

Table 5 Thermal Properties

Symbol	Description	Min	Typ	Max	Unit
THETA_JA	Package θ_{ja} (Junction to ambient)	-	22.185	-	°C/W
THETA_JC	Package θ_{jc} (Junction to case ground paddle)	-	0.757	-	°C/W

2.5. Chip Specification

The tables below give the electrical specifications of the transceiver under the following conditions: Supply voltage VDD=3.3 V, temperature = 25 °C, *FXOSC* = 32 MHz, F_{RF} = 169/434/868/915 MHz (see specific indication), Pout = +13dBm, 2-level FSK modulation without pre-filtering, FDA = 5 kHz, Bit Rate = 4.8 kb/s and terminated in a matched 50 Ohm impedance, shared Rx and Tx path matching, unless otherwise specified.

Note Specification whose symbol is appended with "_LF" corresponds to the performance in Band 2 and/or Band 3, as described in section 5.3.3. "_HF" refers to the upper Band 1

2.5.1. Power Consumption

Table 6 Power Consumption Specification

Symbol	Description	Conditions	Min	Typ	Max	Unit
IDDSL	Supply current in Sleep mode		-	0.2	1	uA
IDDIDLE	Supply current in Idle mode	RC oscillator enabled	-	1.5	-	uA
IDDST	Supply current in Standby mode	Crystal oscillator enabled	-	1.6	1.8	mA
IDDFS	Supply current in Synthesizer mode	FSRx	-	5.8	-	mA
IDDR	Supply current in Receive mode	*LnaBoost* Off, band 1 *LnaBoost* On, band 1 Bands 2&3	- - -	10.8 11.5 12.0	- - -	mA
IDDT	Supply current in Transmit mode with impedance matching	RFOP = +20 dBm, on PA_BOOST RFOP = +17 dBm, on PA_BOOST RFOP = +13 dBm, on RFO_LF/HF pin RFOP = + 7 dBm, on RFO_LF/HF pin	- - - -	120 87 29 20	- - - -	mA mA mA mA

2.5.2. Frequency Synthesis

Table 7 Frequency Synthesizer Specification

Symbol	Description	Conditions	Min	Typ	Max	Unit
FR	Synthesizer frequency range	Programmable (*for SX1279) Band 3 Band 2 Band 1	137 410 862 (*779)	- - -	175 (*160) 525 (*480) 1020 (*960)	MHz
FXOSC	Crystal oscillator frequency		-	32	-	MHz
TS_OSC	Crystal oscillator wake-up time		-	250	-	us
TS_FS	Frequency synthesizer wake-up time to PllLock signal	From Standby mode	-	60	-	us

APPENDIX D

Programs

Programs of Wireless Passenger Notification System (PNS) for Terminal Station and Street

Final Output

// SLAVE NODE //

```
/*
  LoRa Duplex Slave

*/
#include <SPI.h>              // include libraries
#include <LoRa.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,20,4);

int POT = A0;
int pushbutton = 5;
int led = 7;
int buzzer = 3;

const int csPin = 7;          // LoRa radio chip select
const int resetPin = 6;       // LoRa radio reset
const int irqPin = 1;         // change for your board; must be a hardware interrupt pin

String outgoing;              // outgoing message

byte msgCount = 0;            // count of outgoing messages
byte localAddress = 0xBB;     // address of this device
byte destination = 0xFF;      // destination to send to
long lastSendTime = 0;        // last send time
//int interval = 2000;        // interval between sends

//----------------
// Generally, you should use "unsigned long" for variables that hold time
// The value will quickly become too large for an int to store
unsigned long previousMillis = 0;        // will store last time LED was updated

// constants won't change:
const long interval = 5000;           // interval at which to blink (milliseconds)
//--------------------------------

void setup() {
  Serial.begin(9600);                   // initialize serial
  lcd.init();                      // initialize the lcd
  lcd.backlight();
  lcd.clear();
  lcd.setCursor(1,0);
  lcd.print("Passenger Notification");
  lcd.setCursor(7,1);
  lcd.print("System");

  pinMode(POT, INPUT);
  pinMode(pushbutton, INPUT_PULLUP);
  pinMode(led, OUTPUT);
  pinMode(buzzer, OUTPUT);

  while (!Serial);

  Serial.println("LoRa Duplex");

  // override the default CS, reset, and IRQ pins (optional)
  // LoRa.setPins(csPin, resetPin, irqPin);// set CS, reset, IRQ pin

  if (!LoRa.begin(433E6)) {             // initialize ratio at 915 MHz
    Serial.println("LoRa init failed. Check your connections.");
    while (true);                       // if failed, do nothing
  }
```

```
  Serial.println("LoRa init succeeded.");
}

void loop() {

  int value = analogRead(POT)/150;
  lcd.setCursor(0,2);
  lcd.print("Option      Request:      "      +
String(value));
  lcd.setCursor(0,3);
  lcd.print("Accepted Option: ");

  if  (digitalRead(pushbutton)  ==  HIGH
&& value != 0){

    unsigned long currentMillis = millis();

    if  (currentMillis  -  previousMillis  >=
interval) {
    // save  the  last  time  you  blinked  the
LED
    previousMillis = currentMillis;

    // if the LED is off turn it on and vice-
versa:
    lcd.setCursor(0,2);
    lcd.print("Option      Request:      "      +
String(value));
    lcd.setCursor(0,3);
    lcd.print("Accepted Option:    ");

    String message = String(value);
    sendMessage(message);

    digitalWrite(led, HIGH); //send
    delay(5000);
    digitalWrite(led, LOW); //ready

  }

  }

  // parse for a packet, and call onReceive
with the result:
onReceive(LoRa.parsePacket());
}

void sendMessage(String outgoing) {
  LoRa.beginPacket();                    // start
packet
  LoRa.write(destination);               // add
destination address
  LoRa.write(localAddress);              // add
sender address
  LoRa.write(msgCount);                  // add
message ID
  LoRa.write(outgoing.length());              //
add payload length
  LoRa.print(outgoing);                  // add
payload
  LoRa.endPacket();                    // finish
packet and send it
  msgCount++;                                 //
increment message ID
}

void onReceive(int packetSize) {
  if (packetSize == 0) return;              // if
there's no packet, return

  // read packet header bytes:
  int  recipient  =  LoRa.read();             //
recipient address
  byte  sender  =  LoRa.read();               //
sender address
  byte incomingMsgId = LoRa.read();      //
incoming msg ID
  byte incomingLength = LoRa.read();     //
incoming msg length

  String incoming = "";

  while (LoRa.available()) {
    incoming += (char)LoRa.read();
  }

  if (incomingLength != incoming.length())
{  // check length for error
    Serial.println("error:    message    length
does not match length");
```

```
    return;                     // skip rest of
function
  }

  // if the recipient isn't this device or
broadcast,
  if (recipient != localAddress &&
recipient != 0xFF) {
    Serial.println("This message is not for
me.");
    return;                     // skip rest of
function
  }

  // if message is for this device, or
broadcast, print details:
  //Serial.println("Received from: 0x" +
String(sender, HEX));
  //Serial.println("Sent to: 0x" +
String(recipient, HEX));
  //Serial.println("Message ID: " +
String(incomingMsgId));
  //Serial.println("Message length: " +
String(incomingLength));
  //Serial.println("Message: " + incoming);
  //Serial.println("RSSI: " +
String(LoRa.packetRssi()));
  //Serial.println("Snr: " +
String(LoRa.packetSnr()));
  //Serial.println();

  digitalWrite(buzzer, HIGH);
  lcd.setCursor(17,3);
  lcd.print(incoming);
  delay(3000);
  digitalWrite(buzzer, LOW);
  lcd.setCursor(17,3);
  lcd.print(incoming);
  delay(10000);
  lcd.setCursor(17,3);
  lcd.print("  ");

}
```

//MASTER NODE//

```
/*
  LoRa Duplex Slave

*/
#include <SPI.h>              // include
libraries
#include <LoRa.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,20,4);

int POT = A0;
int pushbutton = 5;
int led = 7;
int buzzer = 3;

const int csPin = 7;          // LoRa radio
chip select
const int resetPin = 6;       // LoRa radio
reset
const int irqPin = 1;         // change for
your board; must be a hardware interrupt
pin

String outgoing;              // outgoing
message

byte msgCount = 0;            // count of
outgoing messages
byte localAddress = 0xBB;     // address of
this device
byte destination = 0xFF;      // destination
to send to
long lastSendTime = 0;        // last send
time
//int interval = 2000;        // interval
between sends

//----------------
// Generally, you should use "unsigned
long" for variables that hold time
```

```
// The value will quickly become too large for an int to store
unsigned long previousMillis = 0;          // will store last time LED was updated

// constants won't change:
const long interval = 5000;               // interval at which to blink (milliseconds)
//-----------------------------------

void setup() {
  Serial.begin(9600);                     // initialize serial
  lcd.init();                  // initialize the lcd
  lcd.backlight();
  lcd.clear();
  lcd.setCursor(1,0);
  lcd.print("Passenger Notification");
  lcd.setCursor(7,1);
  lcd.print("System");

  pinMode(POT, INPUT);
  pinMode(pushbutton, INPUT_PULLUP);
  pinMode(led, OUTPUT);
  pinMode(buzzer, OUTPUT);

  while (!Serial);

  Serial.println("LoRa Duplex");

  // override the default CS, reset, and IRQ pins (optional)
  // LoRa.setPins(csPin, resetPin, irqPin);// set CS, reset, IRQ pin

  if (!LoRa.begin(433E6)) {               // initialize ratio at 915 MHz
    Serial.println("LoRa init failed. Check your connections.");
    while (true);                       // if failed, do nothing
  }

  Serial.println("LoRa init succeeded.");
}

void loop() {

  int value = analogRead(POT)/170;
  lcd.setCursor(0,2);
  lcd.print("Option Request: ");
  lcd.setCursor(0,3);
  lcd.print("Accepted    Option:    "    + String(value));

  if (digitalRead(pushbutton) == HIGH && value != 0){

    unsigned long currentMillis = millis();

    if (currentMillis - previousMillis >= interval) {
    // save the last time you blinked the LED
    previousMillis = currentMillis;

    // if the LED is off turn it on and vice-versa:
    lcd.setCursor(0,2);
    lcd.print("Option Request:  ");
    lcd.setCursor(0,3);
    lcd.print("Accepted    Option:    "    + String(value));

    String message = String(value);
    sendMessage(message);

    digitalWrite(led, HIGH);
    delay(5000);
    digitalWrite(led, LOW);
  }


  }

  // parse for a packet, and call onReceive with the result:
onReceive(LoRa.parsePacket());
}

void sendMessage(String outgoing) {
```

```
  LoRa.beginPacket();                    // start
packet
  LoRa.write(destination);               // add
destination address
LoRa.write(localAddress);              // add
sender address
  LoRa.write(msgCount);                  // add
message ID  LoRa.write(outgoing.length());
                                          //
add payload length
  LoRa.print(outgoing);                  // add
payload
  LoRa.endPacket();                      // finish
packet and send it
  msgCount++;                             //
increment message ID
}

void onReceive(int packetSize) {
  if (packetSize == 0) return;           // if
there's no packet, return

  // read packet header bytes:
  int recipient = LoRa.read();           //
recipient address
  byte sender = LoRa.read();             //
sender address
  byte incomingMsgId = LoRa.read();      //
incoming msg ID
  byte incomingLength = LoRa.read();     //
incoming msg length

  String incoming = "";

  while (LoRa.available()) {
    incoming += (char)LoRa.read();
  }

  if (incomingLength != incoming.length())
{  // check length for error
    Serial.println("error: message length
does not match length");
    return;                        // skip rest of
function
  }

  // if the recipient isn't this device or
broadcast,
  if (recipient != localAddress &&
recipient != 0xFF) {
    Serial.println("This message is not for
me.");
    return;                        // skip rest of
function
  }

  // if message is for this device, or
broadcast, print details:
  //Serial.println("Received from: 0x" +
String(sender, HEX));
  //Serial.println("Sent to: 0x" +
String(recipient, HEX));
  //Serial.println("Message ID: " +
String(incomingMsgId));
  //Serial.println("Message length: " +
String(incomingLength));
Serial.println("Message: " + incoming);
  //Serial.println("RSSI: " +
String(LoRa.packetRssi()));
  //Serial.println("Snr: " +
String(LoRa.packetSnr()));
  //Serial.println();

  digitalWrite(buzzer, HIGH);
  lcd.setCursor(17,2);
  lcd.print(incoming);
  delay(3000);
  digitalWrite(buzzer, LOW);
  lcd.setCursor(17,2);
  lcd.print(incoming);


}
```

For Walk - Testing

//Slave Node//

```
/*
  LoRa Duplex Slave

*/
#include <SPI.h>                    // include
libraries
#include <LoRa.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,20,4);

int Button1 = 3;
boolean bflag = false;

const int csPin = 7;          // LoRa radio
chip select
const int resetPin = 6;       // LoRa radio
reset
const int irqPin = 1;         // change for
your board; must be a hardware interrupt
pin

String outgoing;              // outgoing
message

byte msgCount = 0;            // count of
outgoing messages
byte localAddress = 0xBB;     // address of
this device
byte destination = 0xFF;      // destination
to send to
long lastSendTime = 0;        // last send
time
int interval = 2000;          // interval
between sends

void setup() {
  Serial.begin(9600);                    //
initialize serial
  lcd.init();                // initialize the lcd
  lcd.backlight();
  lcd.clear();

  pinMode(Button1, INPUT_PULLUP);

  while (!Serial);

  Serial.println("LoRa Duplex");

  // override the default CS, reset, and IRQ
pins (optional)
  // LoRa.setPins(csPin, resetPin, irqPin);//
set CS, reset, IRQ pin

  if (!LoRa.begin(433E6)) {              //
initialize ratio at 915 MHz
    Serial.println("LoRa init failed. Check
your connections.");
    while (true);                // if failed,
do nothing
  }

  Serial.println("LoRa init succeeded.");
}

void loop() {
  if (millis() - lastSendTime > interval)
    { if (digitalRead(Button1) == LOW)
    {
    String message = "Button Pressed";
    sendMessage(message);
    }

    if (digitalRead(Button1) == HIGH)
    {
    String message = "Button Released";
    sendMessage(message);
    }

    lastSendTime = millis();             //
timestamp the message
    interval = random(2000) + 1000;     // 2-
3 seconds
  }
```

```
 // parse for a packet, and call onReceive
with the result:
onReceive(LoRa.parsePacket());
}

void sendMessage(String outgoing)
{ LoRa.beginPacket();                  // start
packet
 LoRa.write(destination);              // add
destination address
LoRa.write(localAddress);              // add
sender address
 LoRa.write(msgCount);                 // add
message ID  LoRa.write(outgoing.length());
                                          //
add payload length
 LoRa.print(outgoing);                 // add
payload
 LoRa.endPacket();                     // finish
packet and send it
 msgCount++;                              //
increment message ID
}

void onReceive(int packetSize) {
 if (packetSize == 0) return;            // if
there's no packet, return

 // read packet header bytes:
 int recipient = LoRa.read();             //
recipient address
 byte sender = LoRa.read();               //
sender address
 byte incomingMsgId = LoRa.read();        //
incoming msg ID
 byte incomingLength = LoRa.read();       //
incoming msg length

 String incoming = "";

 while (LoRa.available()) {
  incoming += (char)LoRa.read();
 }

 if (incomingLength != incoming.length())
{   // check length for error
  Serial.println("error: message length
does not match length");
  return;                        // skip rest of
function
 }

 // if the recipient isn't this device or
broadcast,
 if (recipient != localAddress &&
recipient != 0xFF) {
  Serial.println("This message is not for
me.");
  return;                        // skip rest of
function
 }

 // if message is for this device, or
broadcast, print details:
Serial.println("Received from: 0x" +
String(sender, HEX));
 Serial.println("Sent to: 0x" +
String(recipient, HEX));
Serial.println("Message ID: " +
String(incomingMsgId));
Serial.println("Message length: " +
String(incomingLength));
Serial.println("Message: " + incoming);
Serial.println("RSSI: " +
String(LoRa.packetRssi()));
Serial.println("Snr: " +
String(LoRa.packetSnr()));
Serial.println();

 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("Val: " + String(incoming));
 lcd.setCursor(0,1);
 lcd.println("RSSI: " +
String(LoRa.packetRssi()));
lcd.setCursor(0,2);
 lcd.println("Snr: " +
String(LoRa.packetSnr()));

}
```

//MASTER NODE//

```
/*
 LoRa Duplex Master

*/
#include <SPI.h>                    // include libraries
#include <LoRa.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,20,4); //initialize LCD

const int csPin = 7;          // LoRa radio chip select
const int resetPin = 6;       // LoRa radio reset
const int irqPin = 1;         // change for your board; must be a hardware interrupt pin

int POT = A2;
String outgoing;              // outgoing message

byte msgCount = 0;            // count of outgoing messages
byte localAddress = 0xBB;     // address of this device
byte destination = 0xFF;      // destination to send to
long lastSendTime = 0;        // last send time
int interval = 2000;          // interval between sends

void setup() {
 Serial.begin(9600);                   // initialize serial
 lcd.init();                 // initialize the lcd
 lcd.backlight();
 lcd.clear();
 pinMode(POT, INPUT);

 while (!Serial);

 Serial.println("LoRa Duplex");

 // override the default CS, reset, and IRQ pins (optional)
 //LoRa.setPins(csPin, resetPin, irqPin);// set CS, reset, IRQ pin

 if (!LoRa.begin(433E6)) {             // initialize ratio at 915 MHz
   Serial.println("LoRa init failed. Check your connections.");
   while (true);                       // if failed, do nothing
 }

 Serial.println("LoRa init succeeded.");

}

void loop() {

 if (millis() - lastSendTime > interval)
   { String message = String(analogRead(POT));
   sendMessage(message);
   Serial.println("Sending " + message);
   lastSendTime = millis();            // timestamp the message
   interval = random(2000) + 1000;     // 2-3 seconds
 }

 // parse for a packet, and call onReceive with the result:
onReceive(LoRa.parsePacket());
}

void sendMessage(String outgoing)
{ LoRa.beginPacket();                  // start packet
```

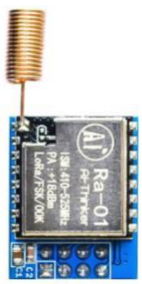
```
  LoRa.write(destination);              // add
destination address
LoRa.write(localAddress);             // add
sender address
  LoRa.write(msgCount);                 // add
message ID  LoRa.write(outgoing.length());
                                          //
add payload length
  LoRa.print(outgoing);                 // add
payload
  LoRa.endPacket();                     // finish
packet and send it
  msgCount++;                           //
increment message ID
}

void onReceive(int packetSize) {
  if (packetSize == 0) return;          // if
there's no packet, return

  // read packet header bytes:
  int recipient = LoRa.read();          //
recipient address
  byte sender = LoRa.read();            //
sender address
  byte incomingMsgId = LoRa.read();     //
incoming msg ID
  byte incomingLength = LoRa.read();    //
incoming msg length

  String incoming = "";

  while (LoRa.available()) {
    incoming += (char)LoRa.read();
  }

  if (incomingLength != incoming.length())
{   // check length for error
    Serial.println("error: message length
does not match length");
    return;                             // skip rest of
function
  }

  // if the recipient isn't this device or
broadcast,
  if (recipient != localAddress &&
recipient != 0xFF) {
    Serial.println("This message is not for
me.");
    return;                             // skip rest of
function
  }

  // if message is for this device, or
broadcast, print details:
Serial.println("Received from: 0x" +
String(sender, HEX));
  Serial.println("Sent to: 0x" +
String(recipient, HEX));
Serial.println("Message ID: " +
String(incomingMsgId));
Serial.println("Message length: " +
String(incomingLength));
Serial.println("Message: " + incoming);
Serial.println("RSSI: " +
String(LoRa.packetRssi()));
Serial.println("Snr: " +
String(LoRa.packetSnr()));
Serial.println();

  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Val: " + String(incoming));
  lcd.setCursor(0,1);
  lcd.println("RSSI: " +
String(LoRa.packetRssi()));
lcd.setCursor(0,2);
  lcd.println("Snr: " +
String(LoRa.packetSnr()));

}
```

APPENDIX
E

Photo Documentation

Table E.1 Components of the System

Component	Specification	Function
 **ARDUINO UNO**	• 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 of which 0.5 KB used by bootloader • SRAM: 2 KB (ATmega328) • EEPROM: 1 KB (ATmega328) • Clock Speed: 16 MHz	A microcontroller board based on the ATmega328, Arduino is an open-source, prototyping platform and its simplicity makes it ideal for hobbyists to use as well as professionals. It is connected to the LCD, the LORA module, the push button, the potentiometer, the LED, and the buzzer. It is the main component that runs the system.
 **LCD SCREEN**	• Display Format: 20 Characters x 4 Lines • Dot Matrix (w x h): 5 x 8 Dots • Character Size (w x h): 2.95 x 4.75 mm • Character Pitch (w x h): 3.55 x 5.35 mm • LCD Driver IC: Sitronix ST7066U (or equivalent) • Interface: 4-bit Parallel and 8-bit Parallel • LCD Module Dimensions (w x h x d): 98 x 60 x 13.6 (MAX) mm • Viewing Area (w x h): 77 x 25.2 mm	The 204 LCD display is essentially a larger version (in terms of number of rows and columns) of the 162 LCD display, which has been used by the researchers in a lot of projects. It can display 20 columns of characters on four rows, making it ideal for presenting vast amounts of text without having to scroll. It displays the Options and the value to be adjusted by the actuator.

	• Dot Size (w x h): 0.55 x 0.55 mm • Dot Pitch (w x h): 0.6 x 0.6 mm • Driving Method: 1/16 Duty • Operating Temperature: -20 ~ 70°C	
 **LoRa MODULE**	• LoRa Modem • Operating Voltage: 3.3V • Operating Frequency: 433Mhz • Half-Duplex SPI Communication • Modulation Technique FSK, GFSK, MSK,GMSK, LoRa • Packet Size: 256 bytes • Sensitivity: -148db	The LoRa SX1278 works with SPI communication protocol so it can be used with any microcontroller that supports SPI. It is mandatory to use an Ariel (antenna) along with the module else it might damage the module permanently. The module should be powered only with 3.3V and the SPI line can be connected to uP/uC. It was used for the point-to-point communication between the two prototype nodes.
 **PUSH BUTTON**	• Current Rating: 0.5 Amps • Brand: DIYhz • Switch Style: Metal, Push Button Switch • Material: Plastic, Metal • Actuator Type: Push Button • Controller Type: Push Button • Color: Red	The push button was used to send the signal between the two prototypes.
	• Type : Single Linear (Type B); Features : Knurled Shaft; Shaft Diameter : 6mm / 0.23" • Shaft Length : 13.5mm / 0.53";Thread Dia : 7mm / 0.27";Base Height : 8mm /	The potentiometer was used as the actuator that adjusts the value presented in the LCD.

POTENTIOMETER	0.31" • Base Diameter : 15mm / 0.6";Material : Metal w Electronic Parts • Weight : 36g;Package : 5 x Potentiometer	
 **BUZZER**	• Rated Voltage: 6V DC • Operating Voltage: 4-8V DC • Rated Current: <30mA • Sound Type: Continuous Beep • Resonant Frequency: ~2300 Hz • Small and neat sealed package • Breadboard and Perf board friendly	The buzzer served as an indicator when data was transferred.
 **LED**	• Max. Forward Voltage: 1.8-2.1V • Max. Reverse Voltage: 5V • Max. Forward Current: 220mA • Max. Reverse Current: 10 UA • Foot Type: long foot • Size: 5mm	The LED lights up for every transmission of data.

Table E.2 Software Tools

SOFTWARE	DESCRIPTION
ARDUINO IDE	Arduino IDE is a software application used to program the LCD, LORA module, the indicators, and the actuators.
Google Earth	Google Earth is software that replicates the Earth based on the 3D representations of satellite imageries. This is used in the study as the mapping tools of the simulation and walktesting results.
RadioPlanner 2.1	A simulation software from Center of Telecommunication Technologies, LLC that simulates different wireless technologies' radio propagation. This is used in the study to simulate possible radio propagation of different parameters in a specific location.

Testing

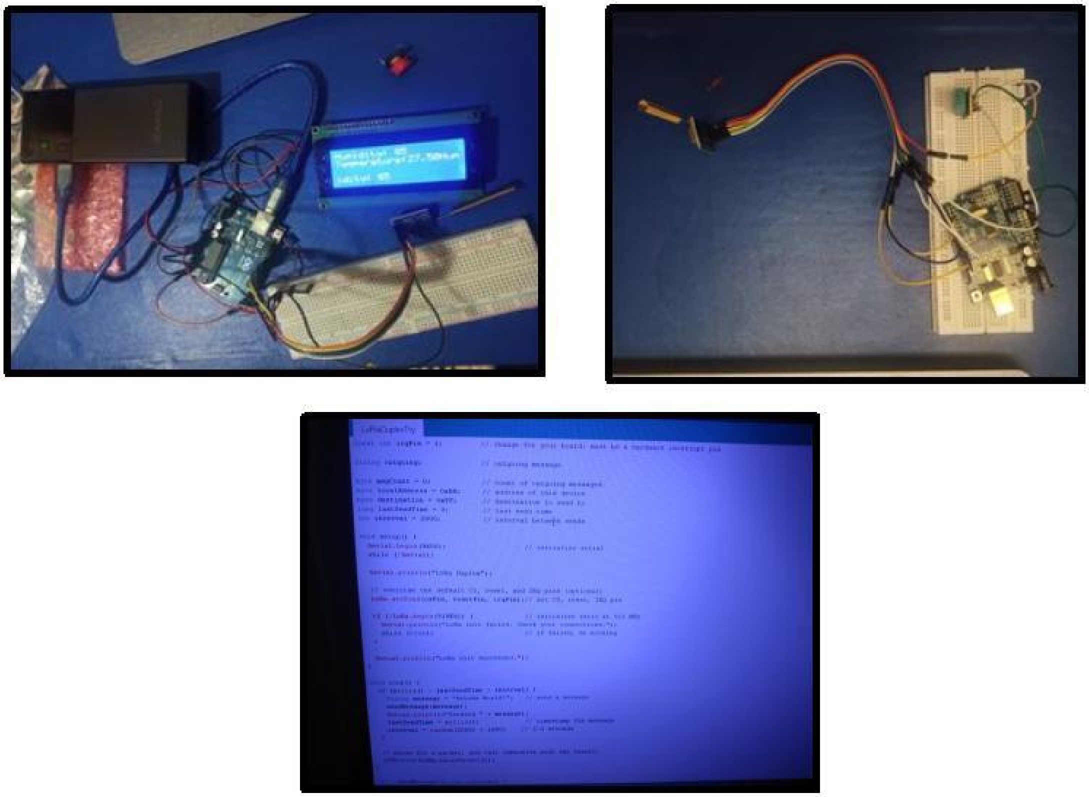


Figure E.1 Testing of the Lora Module

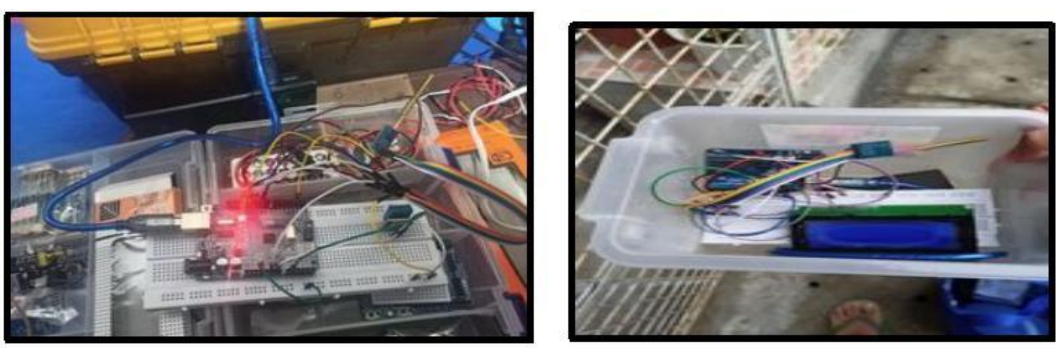


Figure E.2 Connecting the other Components

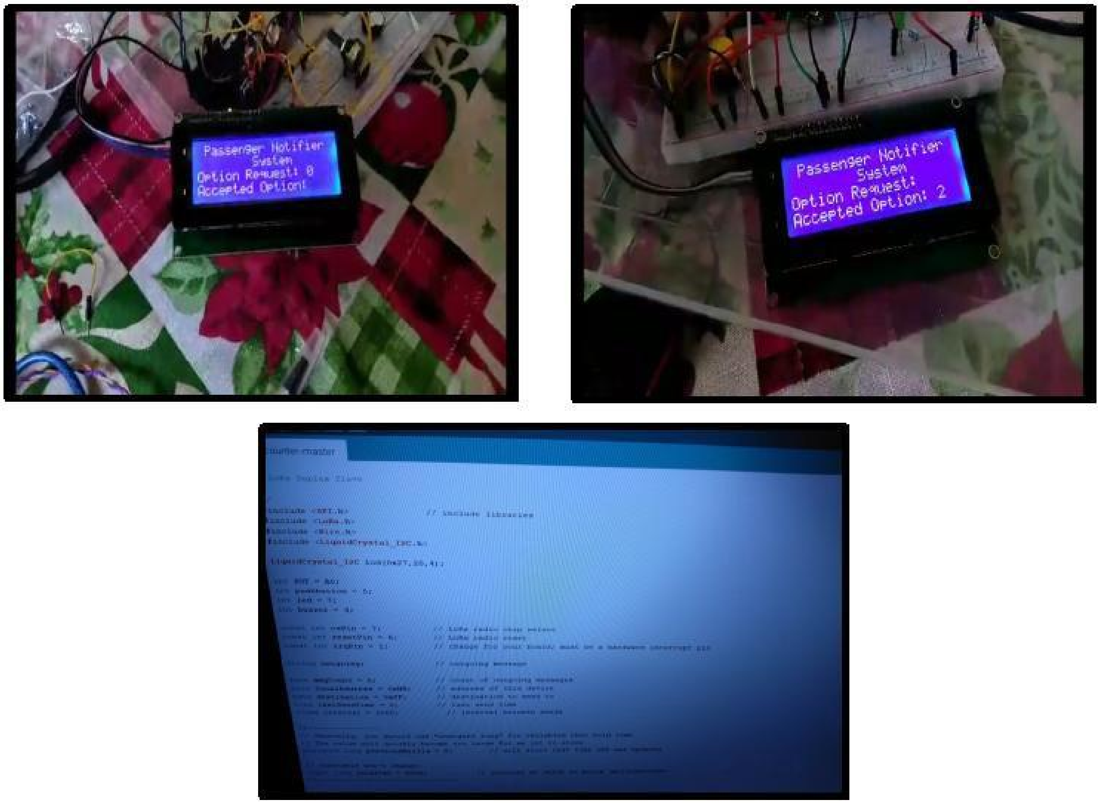


Figure E.3 Overall Connection of the Prototype

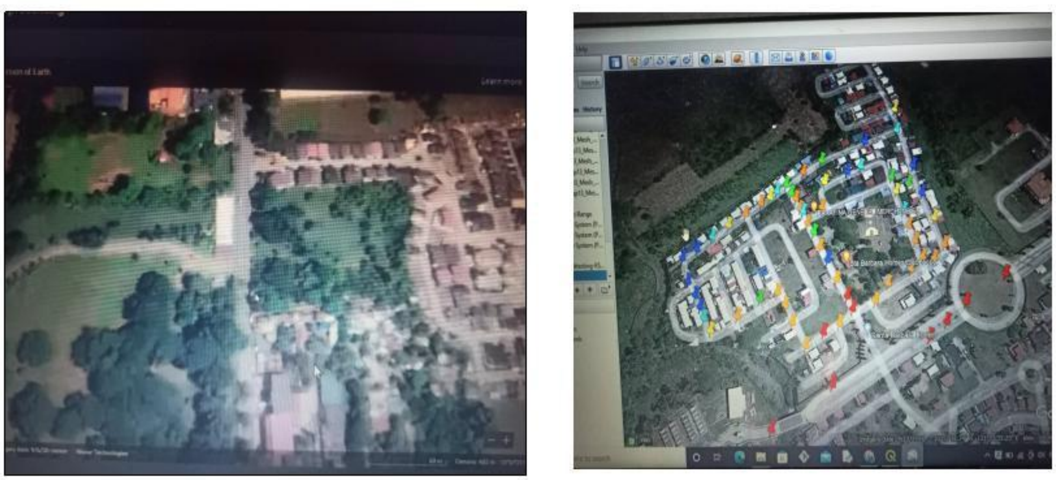


Figure E.4 Mapping Test Sites

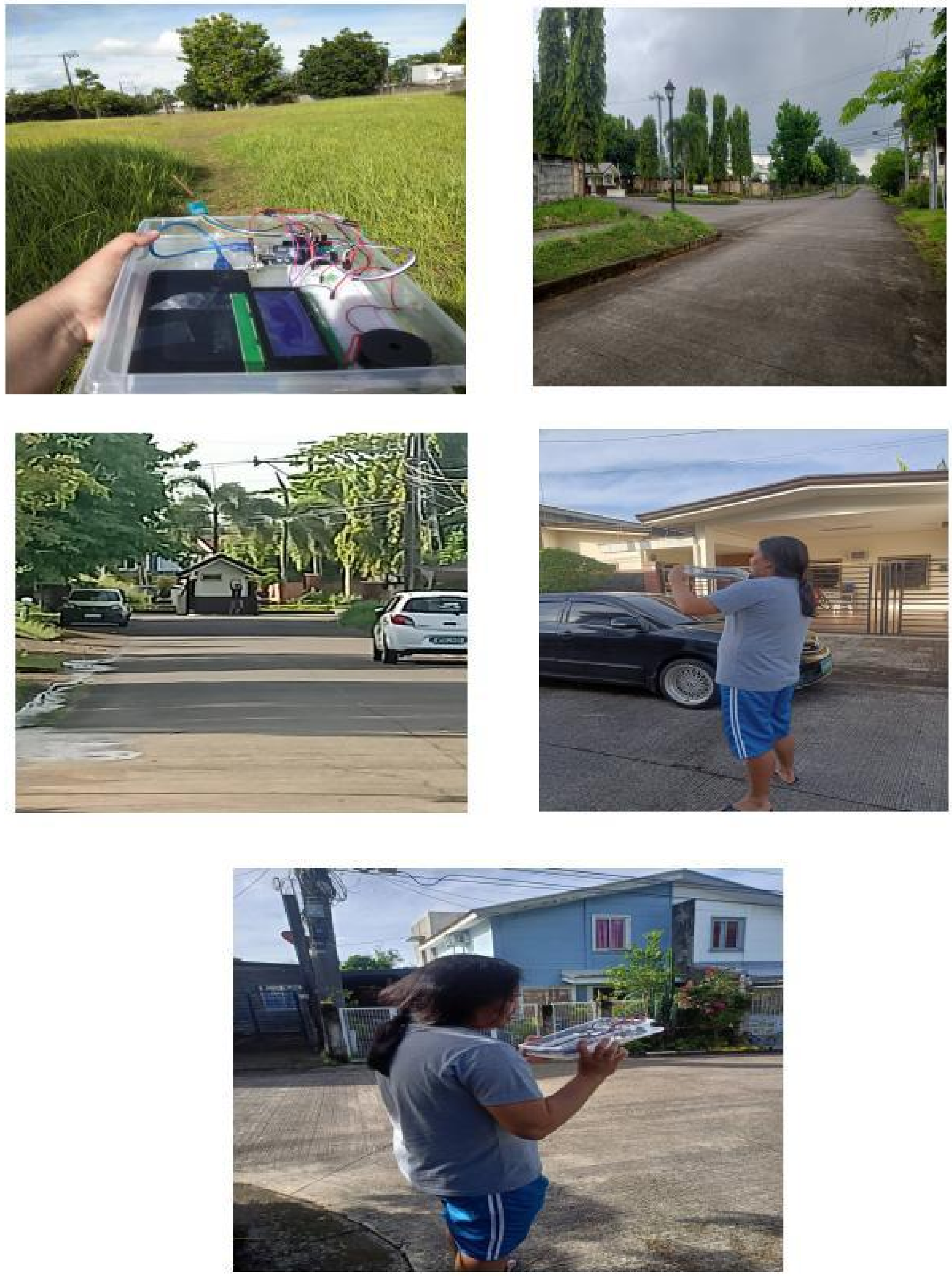


Figure E.5 Walk-Testing

Casing and Structure Design

Figure E.6 Casing

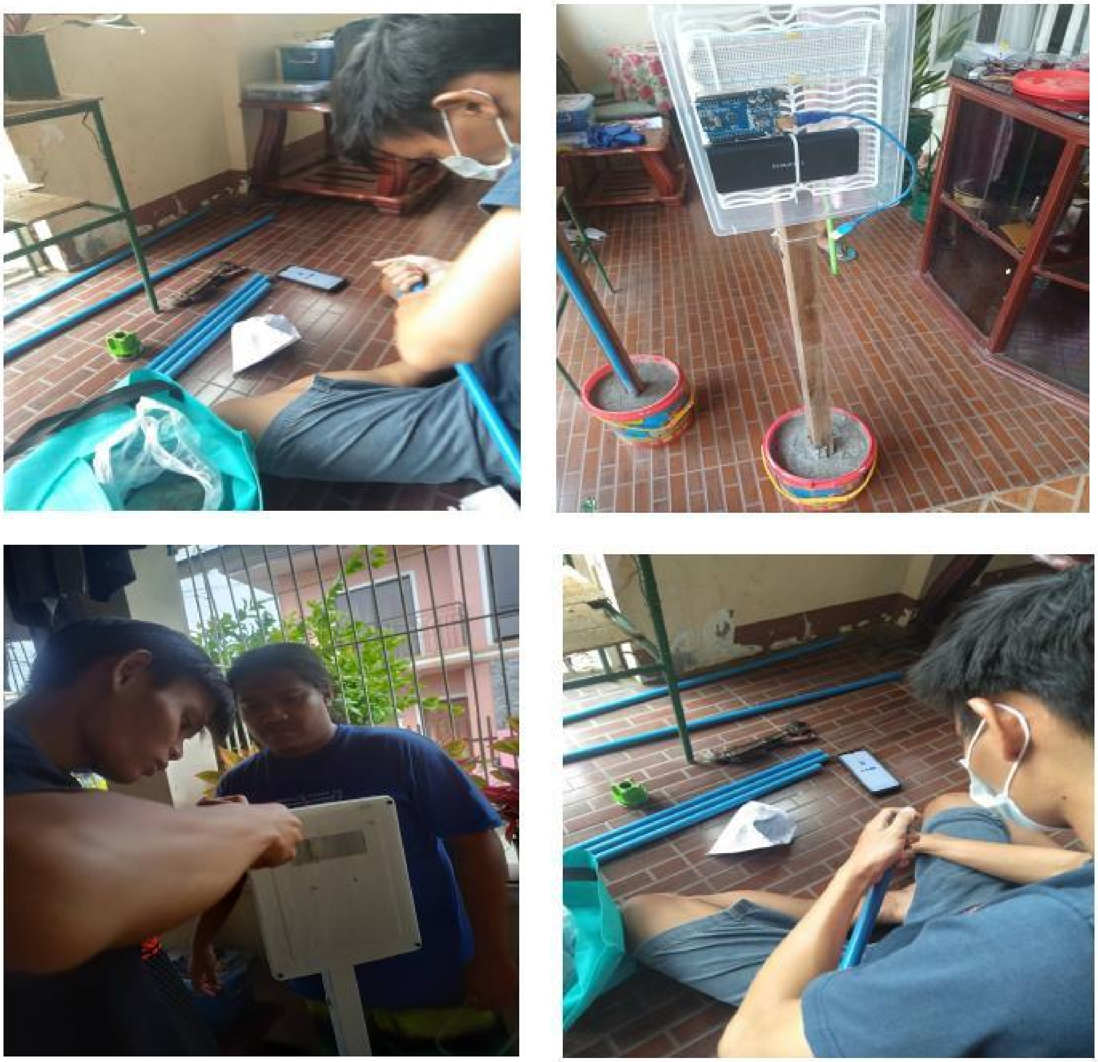


Figure E.7 Structure

Figure E.8 Assembled Prototype

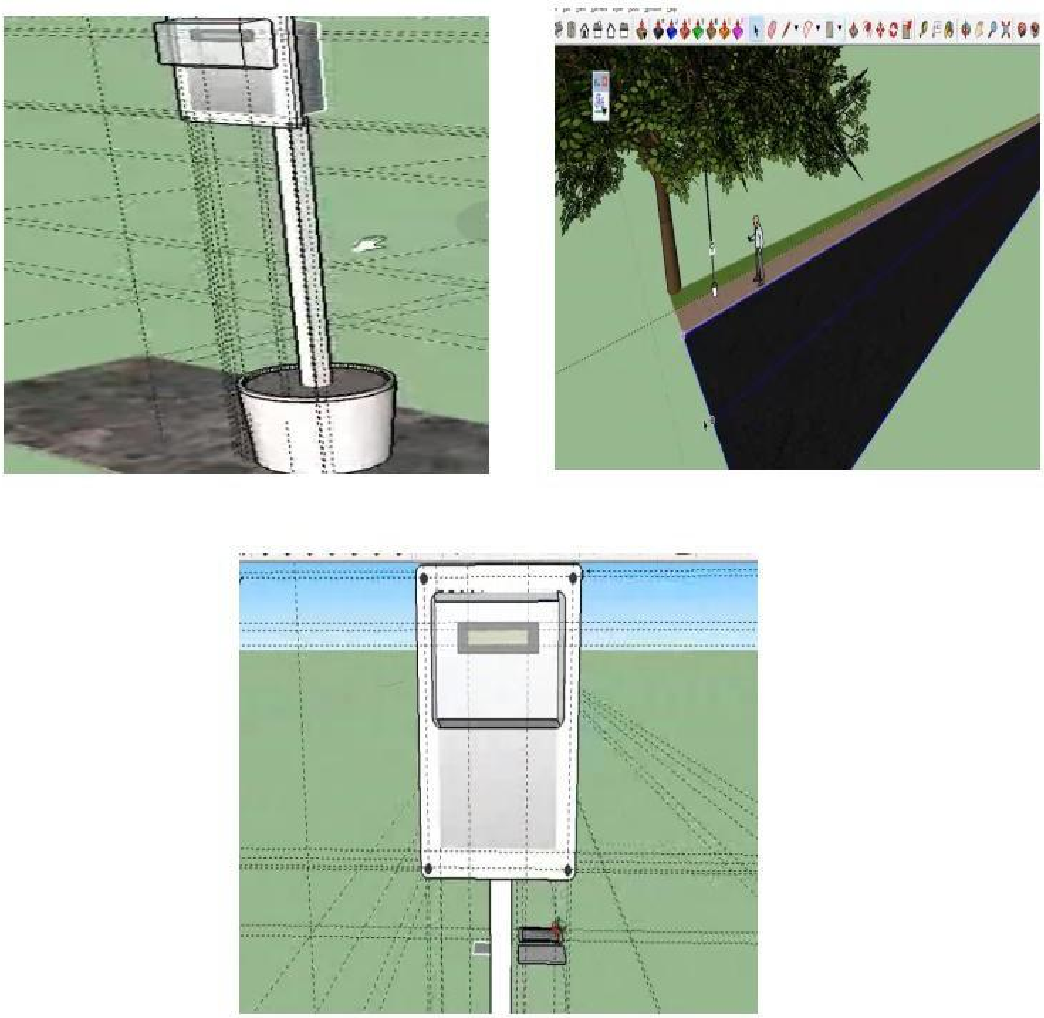


Figure E.9 Sketch up Design

Data Gathering

.

E.10 Data Gathering from Respondents

E.11 Final Output of Prototype

APPENDIX F

Billing Statement

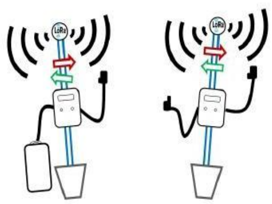
Table F.1 Total Cost of Components and Materials

Materials	Cost (PHP)
2 pcs. 2x4 LCD Display I2C	430.00
2 pcs. Arduino UNO R3	800.00
5 meters Solid Wire 22 AWG (red)	45.00
5 meters Solid Wire 22 AWG (black)	45.00
2 pcs 433 MHz LoRa Module Sx1278	1200.00
2 pcs. Casing/Enclosure for Prototype	120.00
30 meters Solid Wire #22 (red & black)	240.00
2 pcs. Push Buttons	50.00
6 pcs. C-Clamp	120.00
2 pcs. 1/2 PVC pipe Schedule 40 (3 Meters)	170.00
12 pcs. Black screw wood	18.00
4 pcs. Coupling PVC adaptor 1/2 blue	80.00
2 pack of Cement (2kg)	80.00
1 sack of Sand	100.00
Spray Paint (Grey)	200.00
1 Liter White Paint	100.00
5 pcs. Glue Stick	25.00
20 pcs. Cable Tie	20.00
3 meter Lead	75.00
2 pcs. PCB Universal (small)	50.00
2 pcs. SW 800 Switch	40.00
2 pcs. Buzzer	80.00
2 pcs. Romoss Powerbank	300.00
2 pcs. Potentiometer	80.00
Jumper Wire	100.00
2x2 Lumber	200.0
2 pcs. Bucket	120.00
Electric Tape	90.00
Scotch tape	30.00
TOTAL	5008.00

APPENDIX
G

Instruction Manual

PNS MANUAL



Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street

 # The Prototype (PNS)

There are two prototypes, one for the tricycle terminal and one for the street station. The two prototypes communicate with each other in less than or equal to 500 meters apart.

The menu box has an LCD screen to present the information, an actuator made up of a potentiometer for adjusting the value, a pushbutton for sending the data, and lastly, an LED that glows whenever the pushbutton was pressed.

Note: The use of the prototype requires patience and attention to details presented to the screen.

Operating the Prototype

A.) Street Station

> Read the text presented on the LCD screen.

> The row with the Option Request has an adjustable number which can go from 0-6. Lift the protective casing gently to reach the actuator and the pushbutton. Adjust the value using the actuator; the number that you should select is the number of tricycle you would request from the terminal.

> After selecting a number, wait for 5 seconds then press the pushbutton to send your request to the other prototype located at the tricycle terminal, the data will then be presented on the other prototype's LCD screen. The LED will light up indicating that the request was sent.

> Wait for the response of the user from the tricycle terminal station.

> When the response from the tricycle terminal was received the buzzer will activate and the number of available tricycle in the terminal matching your request will be presented in the Accepted Option row. Make sure to pay attention to the reply from the terminal station because it may disappear shortly for the resetting of the process.

> Kindly set the value back to zero for the next passenger to use the prototype and close the protective casing for its purpose. Wait for at least more or less than 3 mins for the arrival of the tricycle/s you requested.

B. Tricycle Terminal Station

> Wait for a request from a street station.

> A buzzer will activate when the prototype receives a request from the street station.

> Read the text presented on the LCD screen. In the Option Request row, the value presented on the right was the passenger's requested number of tricycle for the service.

Note: wait for 20-30 seconds after receiving the request before using the actuator and the pushbutton.

> Now in the Accepted Request, indicate the number of tricycles available at the terminal matching the number of tricycle requested. Lift the Protective casing gently to reach the actuator in the left for the adjustment of the value.

> Wait for 10 seconds

> Press the pushbutton to send the reply to the street station. The LED will light up when the reply/data was sent.

Note: If the Option request value exceeds the number of available tricycle/s in the terminal, indicate the available number tricycles regardless of matching what was requested by the passenger.

> After sending the reply, set the actuator value back to 0 for the next use of the prototype. Close the protective casing for its purpose.

TROUBLESHOOTING GUIDE:

If the LCD was off and pressing the pushbutton does not light up the LED, you must open the casing of the menu box and check if the power bank was plugged in or still has power left.

If you accidentally pressed the pushbutton too early then the operation of the prototype could not transmit well, you must wait for 5 minutes for the prototype to reset or open the casing of the prototype menu box then press the reset button in the Arduino.

If the wire connected to the antenna was snapped, reconnect it by splicing.

APPENDIX
H

Radio Planner 2.1 Simulation Results of Different Testing Areas

Legend

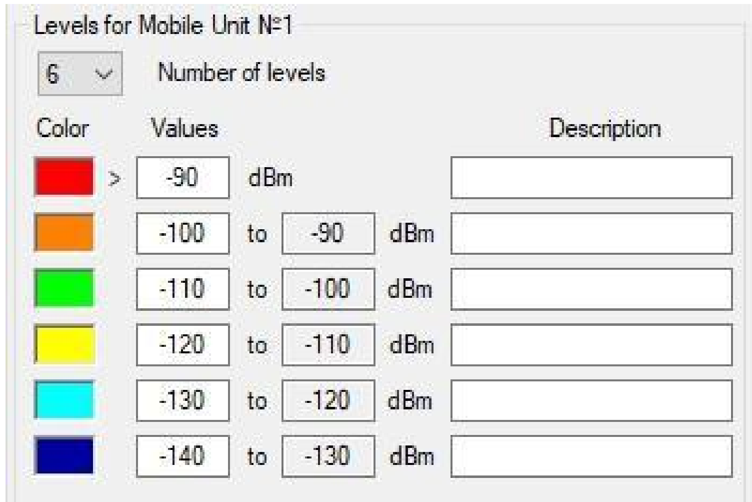


Figure H.1 Legend

Testing Area 1 Simulation Result

Figure H.2 Coordinates: 13°57'8.53"N, 121°33'41.95"E

Testing Area 2 Simulation Result

Figure H.3 Coordinates: 13°57'6.18"N, 121°33'40.02"E

Testing Area 3 Simulation Result

Figure H.4 Coordinates: 13°57'9.83"N, 121°33'46.18"E

Testing Area 4 Simulation Result

Figure H.5 Coordinates: 13°57'14.68"N, 121°33'53.43"E

Testing Area 5 Simulation Result

Figure H.6 Coordinates: 13°57'15.55"N, 121°33'43.20"E

Testing Area 6 Simulation Result

Figure H.7 Coordinates: 13°57'14.19"N, 121°33'42.60"E

Testing Area 7 Simulation Result

Figure H.8 Coordinates: 13°57'10.93"N, 121°33'37.27"E

Testing Area 8 Simulation Result

Fgure H.9 Coordinates: 13°57'17.24"N, 121°33'42.66"E

APPENDIX I

Walk Testing Result Databases

Testing Area 1 Walk Testing Results

Table I.1 Coordinates: 13.95237500 N, 121.56165278 S

Latitude	Longitude	RSSI	SNR	Displacement	Actual Distance	Transmission Time	RSSI Color Level	SNR Color Level
13.95253	121.5615	-80	7.23	22.7	22.7	1.4	RED	RED
13.95264	121.5615	-83	4.65	35.41	35.41	1.25	RED	ORANGE
13.95279	121.5614	-91	-0.252	57.19	57.19	2.06	ORANGE	GREEN
13.95296	121.5613	-88	-4.25	77.72	77.72	6	RED	GREEN
13.95309	121.5612	-87	-3	94.88	94.88	4.86	RED	GREEN
13.95323	121.5611	-88	-1	113.18	113.18	2.45	RED	GREEN
13.95332	121.5611	-96	-14	125.34	125.34	10	ORANGE	LIGHT BLUE
13.95344	121.561	-99	-7	140	140	7.49	ORANGE	YELLOW
13.95346	121.561	-93	1.23	141.38	141.38	3.45	ORANGE	ORANGE
13.95357	121.5609	-92	-0.124	153.9	153.9	5.47	ORANGE	GREEN
13.95363	121.5609	-100	-1.42	162.09	162.09	5.34	GREEN	GREEN
13.95372	121.5608	-102	-2.43	174	174	6	GREEN	GREEN
13.95365	121.5607	-125	-12.43	172.71	185.71	9.5	LIGHT BLUE	LIGHT BLUE
13.95359	121.5607	-115	-7	173.73	196.61	8.43	YELLOW	YELLOW
13.95353	121.5606	-97	-5.38	175.09	206.76	3.28	ORANGE	YELLOW
13.95342	121.5604	-98	-6.38	177.43	229.49	3.79	ORANGE	YELLOW
13.95331	121.5602	-118	-11.42	186.58	257.04	6.83	YELLOW	LIGHT BLUE
13.9532	121.5601	-121	-14	192.61	270	12.23	LIGHT BLUE	LIGHT BLUE
13.95309	121.56	-134	-16	201.12	288.88	15.23	BLUE	BLUE
13.95301	121.5598	-134	-15.37	210.12	294.75	14.47	BLUE	BLUE
13.95279	121.5599	-130	-12.34	194.34	268.7	17.42	BLUE	LIGHT BLUE
13.95267	121.56	-134	-13.64	182.7	254.9	14.87	BLUE	LIGHT BLUE
13.95257	121.5601	-136	-15.34	172.41	238.65	14.25	BLUE	BLUE
13.95248	121.5601	-120	-11.24	165.9	222.54	11.23	LIGHT BLUE	LIGHT BLUE
13.95237	121.5602	-112	-9.4	155.06	209.01	6.76	YELLOW	YELLOW
13.95248	121.5604	-93	-10.42	129.64	178.22	7.97	ORANGE	LIGHT BLUE
13.95263	121.5606	-104	-5.33	112.38	159.83	5.78	GREEN	YELLOW
13.95268	121.5608	-96	-3.42	94.69	133.14	6.34	ORANGE	GREEN
13.95257	121.5609	-95	-7.43	84.59	117.41	3.65	ORANGE	YELLOW
13.95243	121.561	-93	-10.42	72.44	84.46	5.32	ORANGE	LIGHT BLUE
13.95224	121.5611	-94	0.125	58.59	74.71	1.23	ORANGE	ORANGE

13.95234	121.5613	-89	2.45	40.89	57.02	1.89	RED	ORANGE
13.95241	121.5614	-92	5.34	28.54	40.75	1.32	ORANGE	RED
13.9526	121.5618	-92	6.42	27.08	40.29	1.08	ORANGE	RED
13.95275	121.5619	-86	7.32	47.77	61.5	1.79	RED	RED
13.95287	121.5621	-88	3.24	73.91	89.95	2.43	RED	ORANGE
13.95298	121.5622	-89	-0.13	93.03	111.25	6.86	RED	GREEN
13.95313	121.5622	-96	-2.24	100.36	128.25	6.3	ORANGE	GREEN
13.95327	121.5621	-98	-1.74	111.56	144.59	8.33	ORANGE	GREEN
13.95343	121.5621	-121	-2.45	128.53	170.15	18.42	LIGHT BLUE	GREEN
13.95362	121.562	-115	-6.83	143.76	189	10.45	YELLOW	YELLOW
13.95377	121.562	-104	-3.53	156.4	203.36	9.35	GREEN	GREEN
13.95409	121.5621	-103	-8.87	177.6	223.15	9.64	GREEN	YELLOW
13.95389	121.5616	-124	-16.34	167.67	254.93	17.35	LIGHT BLUE	BLUE
13.95384	121.5615	-136	-18.23	163.4	212.76	15.86	BLUE	BLUE
13.95373	121.5612	-115	-4	155.58	190.53	5.38	YELLOW	GREEN
13.95347	121.5612	-97	-6.88	134.33	151.76	1.67	ORANGE	YELLOW
13.95296	121.5624	-93	-13.88	101.29	117.39	4.55	ORANGE	LIGHT BLUE
13.95309	121.5625	-97	-3.4	116.57	134.03	3.24	ORANGE	GREEN
13.95334	121.5624	-115	-12	133.92	168.32	16.78	YELLOW	LIGHT BLUE
13.9536	121.5623	-134	-14.66	156.58	198.01	20.23	BLUE	LIGHT BLUE
13.95389	121.5622	-136	-10.34	178.12	230.48	25.67	BLUE	LIGHT BLUE
13.95429	121.562	-122	-9.67	225.64	285.52	8.57	LIGHT BLUE	YELLOW
13.95454	121.562	-116	-9.45	245.99	307.1	3.77	YELLOW	YELLOW
13.95417	121.5617	-135	-10	200.34	263.49	14.57	BLUE	LIGHT BLUE
13.95397	121.5612	-101	-4	183.79	214.7	5.34	GREEN	GREEN
13.95385	121.561	-98	-4.67	179.83	198.99	5.77	ORANGE	GREEN
13.95194	121.5614	-84	8.33	59.67	75	1.23	RED	RED
13.95163	121.5609	-85	6.23	134.36	153.3	2.19	RED	RED
13.9523	121.5623	-84	6	66.74	71.75	2.1	RED	RED
13.95242	121.5624	-88	5.35	85.13	92.72	3.4	RED	RED
13.95258	121.5626	-85	0.14	108.04	122.03	5.69	RED	ORANGE
13.95281	121.563	-88	2.31	157.11	173.64	8.34	RED	ORANGE

Testing Area 2 Walk Testing Results

Table I.2 Coordinates: 13.95163611 N, 121.56087500 S

Latitude	Longitude	RSSI	SNR	Displacement	Actual Distance	Transmission Time	RSSI Color Level	SNR Color Level
13.95193	121.5616	-90	7	22.7	22.7	1	ORANGE	RED
13.95178	**121.5613**	**-88**	**6**	**50**	**50**	**1.89**	**RED**	**RED**
13.95189	121.5616	-89	8	83.78	83.78	1.45	RED	RED
13.95202	**121.5618**	**-89**	**5.79**	**100.51**	**100.51**	**2.51**	**RED**	**RED**
13.95206	121.5618	-89	8.75	111.08	111.08	1.18	RED	RED
13.95221	121.5621	-88	7	146.27	146.27	1.14	RED	RED
13.95233	121.5623	-88	7.46	166.17	166.17	1.24	RED	RED
13.95248	121.5624	-86	5.35	186.33	186.33	1.75	RED	RED
13.95261	121.5626	-83	8.5	212.95	212.95	1.22	RED	RED
13.95271	121.5628	-89	5.15	240.27	240.27	3.6	RED	RED
13.95285	121.5631	-91	4	273.19	273.19	2.45	ORANGE	ORANGE
13.95299	**121.5633**	**-89**	**5.25**	**302.33**	**302.33**	**5.87**	**RED**	**RED**
13.95303	121.5635	-87	1.34	326.18	326.18	3.65	RED	ORANGE
13.95316	121.5637	-88	1	344.49	344.39	4.73	RED	ORANGE
13.95328	121.5639	-90	2.75	374.36	374.36	5.32	ORANGE	ORANGE
13.95349	121.5642	-89	4	418.15	418.15	4.23	RED	ORANGE
13.95369	121.5645	-88	4	452.01	452.01	8.78	RED	ORANGE
13.95406	**121.5648**	**-93**	**-0.25**	**506.02**	**506.02**	**7.2**	**ORANGE**	**GREEN**
13.95448	121.5651	-95	2.5	558.63	558.63	10.42	ORANGE	ORANGE
13.95461	121.5653	-100	-1.88	576.86	586.51	12.28	GREEN	GREEN
13.95506	121.5657	-115	-3.55	648.77	649.83	10.48	YELLOW	GREEN
13.95525	121.5661	-107	-4	694.51	701.58	12.34	GREEN	GREEN
13.95546	121.567	-130	-12	783.07	801.42	22.3	BLUE	LIGHT BLUE
13.95542	**121.5672**	**-135**	**-16**	**801.95**	**813.58**	**22.98**	**BLUE**	**BLUE**
13.95546	121.5677	-128	-15	845.76	870	30.23	LIGHT BLUE	BLUE
13.95536	121.5682	-145	-20	889.52	924	NaN	BLACK	BLUE
13.95525	121.5686	-145	-20	923.24	980.54	NaN	BLACK	BLUE
13.9542	**121.5698**	**-145**	**-20**	**1000.09**	**1164.44**	**NaN**	**BLACK**	**BLUE**

APPENDIX
J

Plagiarism Result

Southern Luzon State University
Innovation and Technology Support Services Office (ITSSO)
Lucban, Quezon

CERTIFICATE OF MANUSCRIPT ORIGINALITY

This is to certify that the research paper entitled,

"Wireless Passenger Notification System (PNS) for Tricycle Terminal and Street"

Title of the Manuscript

submitted by **Michael Troy R. Manalo, Jean Aires C. Parado, Kyl Justin V. Perez**

Faculty / Student-Author/s

of the **College of Engineering**

College / Unit

program under the **Bachelor of Science in Electronics Engineering**

Course / Program

is an outcome of an independent and original work. The manuscript received a text

similarity / plagiarism score of **12%** with Turnitin Paper ID **1857687298**

which is an acceptable originality score based on our school policies. Furthermore,

the work has also not been submitted elsewhere for publication.

GERI MAE A. TOLENTINO, MSc
Director, ITSSO

June 20, 2022

PRE-PPA-1.01A3, Rev. 0

APPENDIX K

English Critic

Southern Luzon State University

COLLEGE OF ENGINEERING

Lucban, Quezon

This is to certify that **MICHAEL TROY R. MANALO, JEAN AIRES C. PARADO,** and **KYL JUSTIN V. PEREZ** sought assistance from the undersigned in editing the manuscript entitled **"WIRELESS PASSENGER NOTIFICATION SYSTEM (PNS) FOR TRICYCLE TERMINAL AND STREET"**.

This further certifies that the said thesis has been checked for grammatical and documentation-related (i.e. – referencing) concerns and is now ready for serving other academic purposes.

Issued this 26th of June, 2022

Ms. JOSEPHINE V. CABULONG

SST-III, Luis Palad Integrated High School

Language Critic