Surigao City Campus

Bachelor of Science in Electrical Engineering

SURIGAO STATE COLLEGE OF TECHNOLOGY

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APPROVAL SHEET

This Project Study entitled "**AUTOMATED WATER PUMPING SYSTEM FOR RICE PADDY**" prepared by **Leevan Joey U. Tandan, Sweethy M. Wenceslao, Menchie Rose P. Madelo, Syrose Rex B. Hingpit, James Mark T. Florino,** in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical Engineering** has been examined and is recommended for acceptance and approval for ORAL EXAMINATION.

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DEVELOPMENT OF SCOTINOPHARA COARCTATA BUSTER UTILIZING PELTON WHEEL TYPE HYDRO GENERATOR

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Abstract: The study focuses on the utilization of Pelton wheel type hydro generator as a source that generates electricity and the development of Scotinophara coarctata [black bug] buster design as a load that is use to attract these insects using 12V bulb and electrocute them employing the screen that surrounds the bulb. This study employed applied developmental research design. It aims to minimize the number of destructive black bugs in the rice field to alleviate the rice production of the farmers. The study is develop through field investigation and data gathering, hydraulic and load analysis. It also use quantitative and qualitative instruments to ensure the accuracy of the results. The project is to be evaluated according to its applicability, performance, durability and conformance to standard. The system starts from Pelton wheel to be installed in the river where impulsive force rotates the wheel. Then, the generator will produced 12V by rotating the shaft through the Pelton wheel. Then, to the 12V battery that regulates the generator's output and will be charge through the generator. And lastly, to the Black bug buster with input 220V AC and outputs 2kV DC when short circuited and caused electrocution. Furthermore, the river in Timamana, Tubod possess power about 0.288kW enough to rotate the Pelton wheel as well as the shaft of the generator that sustain the Black bug buster circuit. The design of the project has a correlation to its parts, the power generated has been used efficiently and accordingly to the circuit. Finally, the project's overall output has meet the desired requirements and in addition with respect to its financial feasibility the selling price of the project which is ₱11,411 is reasonable for the farmers to purchase and has a break-even point of 11.

Keywords: Pelton, Generator, Buster, Hydro, Bulb

1. INTRODUCTION

Pelton wheel is known as a tangential flow impulse water turbine suitable for power extraction when water energy is available. This energy is used in running an electric generator which is directly coupled to the shaft of the turbine. Thus, the mechanical energy is converted to electrical energy. Moreover, the electricity produce is utilize by the black bug buster that minimizes the amount of damage that black bugs can do to the fields by means of electrocution.[1]

Nowadays, power consumption demand is increasing. Renewable energy remains the only viable long term alternative to deflectable and polluting oil, gas and coal. [2] Most of the power plants use diesel and coal which convey some environmental issues and are very expensive. Since Pelton wheel hydro generator is considered as renewable energy converter it is significantly feasible and beneficial to the nature and less expensive because the source is readily accessible. Furthermore, it is of great contribution to the farmers and to field of agriculture since it can help elevate the production of rice.

On the other hand, Pelton wheel type hydro generator is ideal for high quantity of pressure and for the time being finding a river as the source is formidable since some of them are slowly drifting due to extreme heat and infrequent raining. Moreover, the construction of Pelton wheel and the buster should be done carefully in order to maximize the river's energy and to certainly minimize the black bugs, respectively. In accordance, the generator and the loads shall coordinate to each other so that the output will be fully utilized.

In order to ascertain that the river is capable, evaluating its characteristics and enhancing its vicinity is significant. The use of different approach like floating method is highly advisable to evaluate the river's capability of turning the wheel. As a result, the type of generator to be used along with its characteristics and the total power of the load is to be based on the findings acquired after the evaluation of the river's attributes.

During the visit in Brgy. Timamana, Tubod the researchers observe that the river possesses qualities enough to operate a hydro generator. Moreover, the researchers also interview some of the residents living in the vicinity of the river and confirm that even in the extreme heat of the sun and occasional rain the river will remain to flow constant. In addition to that, researchers also take advantage of the rice field nearby and attest that the common problem arises during the production of rice crops is the invasive black bugs that brought damage, this is according to the field owner. Indeed, the barangay captain allows the researchers to conduct the study. The development of this project can be effective to minimize insects through the use of ultraviolet LED bulbs with electrocuted screens. The streetlight pole is made up of wood that is 4 meters high and in the electric black bugs buster is installed on top with the 12V LED lights.

The researchers compelling justification for conducting the study is to help the community especially to those who are involve in agricultural business particularly in rice fields in terms of suppressing the very destructive black bugs in order to increase their production while offering them free and eco-friendly electricity.

Review of Related Literature

This section reviews some of the existing literature concerning the equipment used for suppressing the bugs in the rice field.

Rice is known to be vital and necessary food in the Philippines. Most farmers who engage in this kind of agricultural business face a lot of problems from the high cost of inputs, labor problem, lack of postharvest facilities, and irrigation system. Aside from these are the black bugs that damages the crops and significantly affects the amount of the production of rice. [3]

Black bugs, in general, are frowned upon by many, primarily because of the way they appear and the potential diseases that can be contracted through them. Some bugs are

completely harmless to both humans and nature, but others are either harmful to one or the other—sometimes both. They have always been a problem in the side of many farmers.

In the early '80s, one of the methods in suppressing the bugs is putting water underneath the light bulb that uses power coming from their houses. The moment black bugs are attracted to light they fall and touch the water surface, trapping and sticking them to the water surface and eventually die. [4]

Another method is to place sticky traps. When you pour rice to some tray under the light bulb, the bugs tend to be attracted and somehow sticks to the traps being prepared around the edges of the tray. When the insects try to run out of the tray, they will automatically stick to the trap. These pests are not vigorous enough to free themselves from the trap. Hence, they will die sticking to the trap. [5]

The common method is by using pesticides. This a substance used for destroying insects or other organisms harmful to cultivated plants. But can also harm the consumer when not properly handled and cleaned. [6]

Lights and electrocuted screens as a method to suppress the bugs in the field are also used wherein the moment black bugs touch the screen they will be grounded and eventually die. This method uses a household outlet as their source of electricity for the light and the screen to function. Some uses solar panels to power the system which is known to be very expensive. [7]

These methods are related and similar to suppressing, controlling and managing the bugs in the rice field wherein it helps the farmers in their rice production and the community's health and environment. According to the Department of Agriculture Philippine Rice Research Institute when not properly controlled, 10 adult rice black bugs per hill can cause loses of up to 35 %. Imagine farmers lose 35% of the harvest that they should have and at the same time loses 35% income that they should have earned. [8]

Unlike the other methods mentioned wherein, some of them are manual such as replacing sticky traps and renewing water traps and other offers are not so environment friendly such as pesticides, the method of using light and electrocuted screens requires less supervision, environmental-friendly and inexpensive enough, knowing that farmers can't take another burden. For these reasons, farmers should have an alternative and effective way in suppressing these pests. This project offers solution to the problem regarding on minimizing these destructive black bugs to the farmer's crops while offering an eco-friendly and free source of electricity. This will greatly help the farmers in terms of their production and expenses. With this, rice can grow abundantly and healthy without the idea of spending much money to make it possible, just collecting the potentials of the nature to help. Furthermore, there are no emissions coming from the system that could harm the environment because Pelton wheel type hydro generator uses river as its source which is renewable and free. On the other side, the load which is the black bug buster is economical since it is just a combination of bulb and a screen which we can recover from scraps. It doesn't need to be expensive because the result is still the same.

Theoretical Framework

The Pelton turbine is the most visual example of an impulse machine and therefore associated with considerable changes in kinetic energy. This study is engaged and reliant on the knowledge of Impulse Turbine, Newton's Second Law of Motion, Hydraulics, Electrical AC Generator, Electric Power Distribution, Electric Black Bug Buster Design, Illumination, Power, Hydropower Principle and Floating Method.

Impulse Turbine is a turbine that is driven by high velocity of water directed on to vanes or buckets attached to a wheel and defined as product of velocity and mass ($j = m \cdot v$).[9]

Newton's Second Law of Motion states that the acceleration of an object is dependent to the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object. [10]

Hydraulics covered the study of the physical behavior of water at rest and in motion. The use of the hydraulic concept in this study is concerning with the flow of the river that causes the movement of the Pelton wheel. [11]

$$\mathbf{P = YQh} \quad [1]$$

Where, P is the theoretical power, watts
Y is specific weight of water, N/s^3
Q is volumetric discharge water, m^3/s
h is the head of the water, m

$$\mathbf{Q = AV} \quad [2]$$

Where, Q is the theoretical volume discharge
A is the cross-sectional area of the water source
V is the velocity of the surface water

Electrical AC generator is the principle of rotating a conductor in a magnetic field to generate current. A generator converts mechanical energy (motion) into electrical energy.[12]

Electric power distribution is the final stage in the delivery of electric power. From the Pelton wheel to the loads place in the rice field.

Electric Black Bug Buster Design is an alternative way to kill the black bugs employing the electrocuted screens surrounding the bulb.

Illumination is the act or process of making something clearer or brighter or a device for doing so. An artificial source of light is used for illumination. [13]

Power is the rate at which work is done, or the rate at which energy is consumed. The higher the rate at which work is done, the faster the work is done, and at the same time the faster the energy is used up. [14]

Hydropower Principle uses the energy of flowing water. Hydropower is a highly flexible energy source, since the water can be stored in the reservoirs until needed. Hydropower schemes without reservoirs are often called run-of-river. [15]

Floating Method an indirect method for measuring a river discharge. The measurement is made by measuring the time that it takes a floating object to travel a specified distance downstream. [16]

Conceptual Framework

The project study focuses on the goal of producing power or generating electricity by the Pelton Wheel type hydro generator and the load is an electric black bug buster with the help of the theories mentioned above.

The conceptualization of the project that is shown in Figure 1 illustrates the flow of the project study throughout its completion. It starts with a preliminary site visit where the project study is to be conducted.

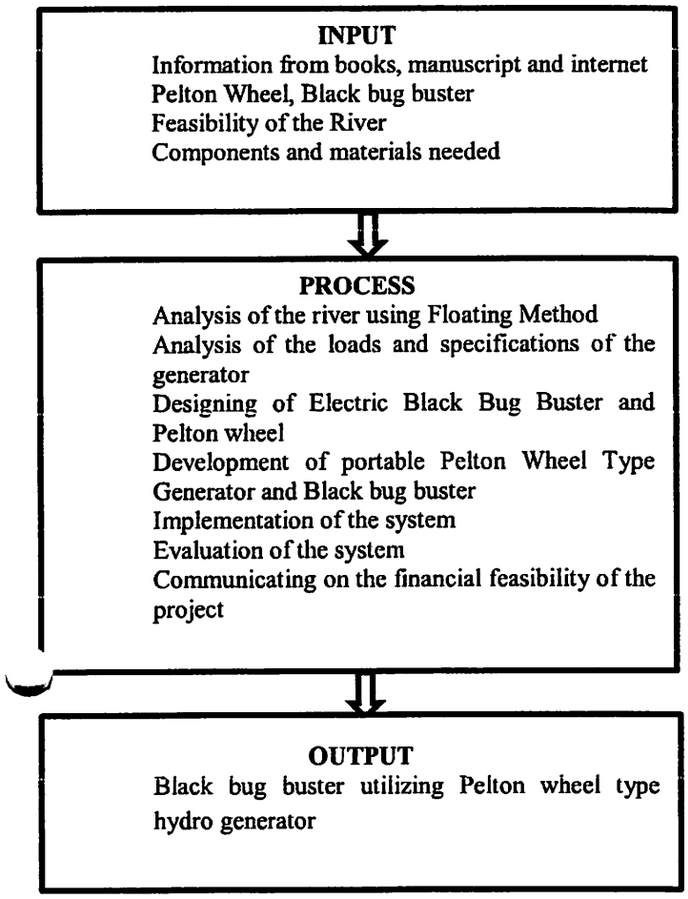

Figure 1. ***IPO Diagram of the Project***

Figure 1, shows how the researchers come up to develop a device that will eliminate and control rice black bugs in the easiest way. The input contains the materials used in developing the device. Books, unpublished manuscripts, internet, and other references were used by the researchers in gathering data to construct the system with the exact correlation of the equipment needed. These information are the basis in constructing the Pelton wheel considering its size, characteristics and structure.

The process is the foundation of the system. It consists of the analysis of the river using Floating Method where the length, width and depth is to be evaluated in order to know the power possessed by the river. Moreover, in the development of the Pelton wheel and the black bug buster, analysis of the load, specification of the generator as well as its design should be taken in to account in order for the system to be efficient in terms of the operation, with output and so with the financial feasibility of the system. Furthermore, the generator should correlate to the total load to maximize the power of the generator while minimizing its cost.

The output is the result of combining the input and the process. The project "Development of Black Bugs Buster Utilizing Pelton type Hydro Generator" is designed to attract and kill the rice black bugs. The output device will be evaluated by the experts from the Department of Agriculture of the Municipality of Tubod and the farmers as well.

Objectives

The main objective of the project study is the Development of Black Bugs Buster Utilizing Pelton type Hydro Generator that will help to minimize and control rice black bugs infestation. The following are the key guidelines to achieve this study:

1. To evaluate the Hydraulic Analysis requirement of the river.
2. To design and develop an Electric Black Bugs buster and Pelton wheel type hydro generator.
3. To evaluate the performance and acceptability level of the system.
4. To determine the financial feasibility of the project.

2. METHODS

Project Design

This study employs applied developmental research design. It attempts to develop a system that can minimize the number of these destructive black bugs in the rice field in order to alleviate the rice production of the farmers in Brgy. Timamana, Tubod.

Figure 2 below shows the block diagram of the system.

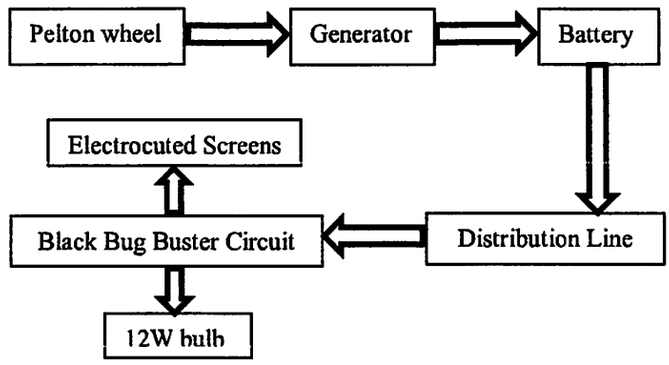

Figure 2. ***Block Diagram of the System***

The Pelton wheel made of dipper clamp around the bicycle wheel is connected to the shaft of the generator via gears and chains. The Pelton wheel will cause the gears to rotate and so with the shaft of the generator then generates 12V DC.

The generator charges the battery which will regulate the output and stores it. The battery will guarantee that the input for the buster circuit is a stable 12V DC in order to avoid malfunction in the buster circuit.

Since the set-up is found in the riverbank the distribution lines mainly composed of 10 meters length wire will be the one to deliver the power to the load which is located in the rice field.

The load consists of 12V bulb connected in parallel with the buster circuit. The buster circuit consists of an inverter which inverts 12V DC into 220V AC which is the input for the buster circuit. It has rectifier diodes and high voltage capacitors which outputs 2kV DC when shorted. This is supported by a wood pole to be placed in the rice field where bugs are usually found.

Project Development

The project development is to install a Black Bug Buster utilizing Pelton Wheel type Hydro Generator to support and help the agricultural producers in the project area by providing hydraulic analysis of the river that would generate the movement of the Pelton wheel and supply the Black Bug Buster that would kill the bugs that infesting the rice field.

Figure 3 below shows the steps in the project making.

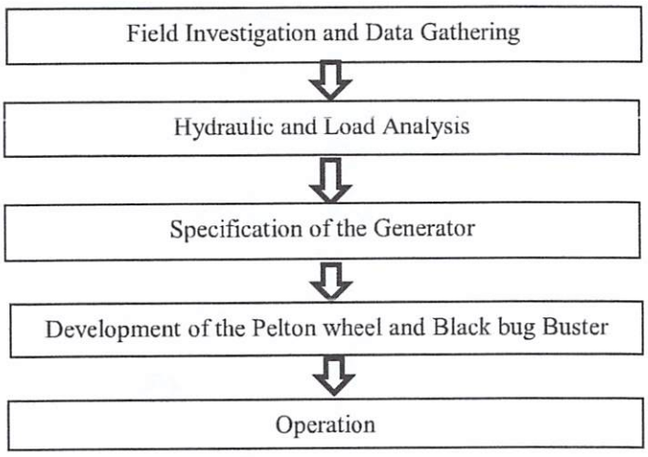

Figure 3. ***Flow Chart of the Project***

Field investigation was conducted upon the permission from the Barangay Captain of Timamana, Tubod. The researchers study the characteristics of the river, knowing its vicinity and enhancing the river flow by arranging the rocks. And in order to gather more data about the river the researchers interview random residents living in the vicinity of the river.

Furthermore, hydraulic and load analysis is also conducted. In studying the physical behavior of the water in rest and in motion employment of the Floating method is necessary. In this method the power produced by the river is identified. Load analysis calculates how much power of the load will be needed. After that is the specification of the generator to be used. The total power needed should be equal or greater than the power that the generator can produce.

In construction of the system careful connections and following proper procedure is prioritized to ensure the safety of the researchers and the efficient operation of the system.

Project Implementation

The researchers, the owner of the rice field together with barangay officials/LGU will be in-charge in the implementation of the Black Bug Buster utilizing Pelton Wheel type Hydro Generator. After having an approval from the barangay officials and from the owner of the field the development of the project will start immediately. And also the researchers would like to finish the project by the time of the planting season because black bugs are likely gathered and destruct the young sprout. Safety and environmental concerns in implementing the project will be assured at all times.

Project Evaluation

The project study will be evaluated with the result obtained throughout the calculation. The following are to be evaluated in the project study:

1. Applicability: Is the designed project study appropriate to the project site condition?
2. Performance: Will the project do the intended job?
3. Durability: How long does the project last?
4. Conformance to Standard: Is the project made exactly as the designer intended like the amount of voltage, current and power?

Ethical Consideration

In conducting the project study, the researchers make sure that violating any legal and environmental issues are prohibited rather they evaluate the human factor as the core of ethical consideration wherein it focuses on the impact of the project design and development on human intervention.

Participants of the Study

The participants of this project study are mainly the project beneficiaries and evaluators. This includes the rice field owner because researchers need a site specifically a rice field with newly sprouted rice crops. The Barangay captain for the legal opportunity to conduct and investigate the river. The Department of Agriculture to evaluate the over-all performance of the system. And the electrical and mechanical engineers to evaluate the construction of the black bug buster and the Pelton wheel, respectively.

Table 1. ***Participants Involved in the Project***

Participants	f(n=6)	%
Rice field owner	1	16.66
Barangay Captain	1	16.66
DA	1	16.66
EE	2	33.33
ME	1	16.66

Project Setting

The project is sited at Timamana Tubod. The lot area of the rice field to be study is 49 square meter and is located at the side of Timamana River.

Figure 4. ***Location Map***

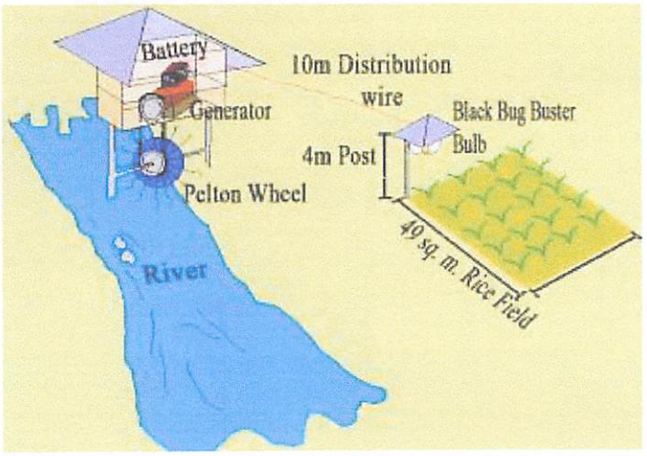

Figure 5. ***Pictorial Diagram of the System***

Instrumentation

In this study, the following qualitative and quantitative applications are used as an instrument for the fulfillment of the study.

Proteus Software is a software suite containing schematic, simulation as well as PCB designing. ISIS is the software used to draw schematics and simulate the circuits in real-time. The simulation allows human access during run time, thus providing real-time simulation. [17]

PCB Wizard Software is an electronics program for Windows PC that covers all the stages of the schematic design and production of printed circuit boards or PCBs.[18]

AutoCAD Drafting Software replaces the paper, pencil, T-squares, and eraser crumbs with a computer screen and a mouse. With it, designers can create technical documentation for products, buildings, and structures quickly and easily, and focus more on concept and creativity, instead of computation and clutter. [19]

Ammeter is a measuring instrument used to measure the current in the circuit in amperes. Instruments used to measure smaller currents, in the milliampere or microampere range, are designated as milliammeters or microammeters

Voltmeter is an instrument used for measuring the potential difference, or voltage, between two points in an electrical or electronic circuit. Some voltmeters are intended for use in direct current (DC) circuits others are designed for alternating current (AC) circuits.

Ohmmeter an instrument used for direct measurement of the electrical resistance of a material or electronic component, usually in ohms.

Survey Questionnaire is a set of questions used in a survey. It is a type of data gathering method that is utilized to collect, analyze and interpret the different views of a group of people from a particular population. [20]

Data Collection Procedures

Figure 6 shows the flowchart in order to obtain the data needed for the system. Researchers visit the site and check the river flow whether the current is capable of generating enough power to drive the load. Aside from that interview with the residents is also conducted to be able to know the physical behaviour of the river and where it came from. After that researchers ask for legal opportunity to the barangay captain of Timamana, to construct the system in the river and in the rice fields nearby. Floating method is then conducted to measure the river's power. Furthermore, the researchers also investigate the nearby rice field by measuring its distance to the river and checking if the field is being infested by the black bugs, and also measuring the area to ensure the proper illumination. The exact distance between the pole and the river is also determined considering where it should stand to attain the desired illumination to attract this black bugs. Finally, after knowing all these data development of the project is then started.

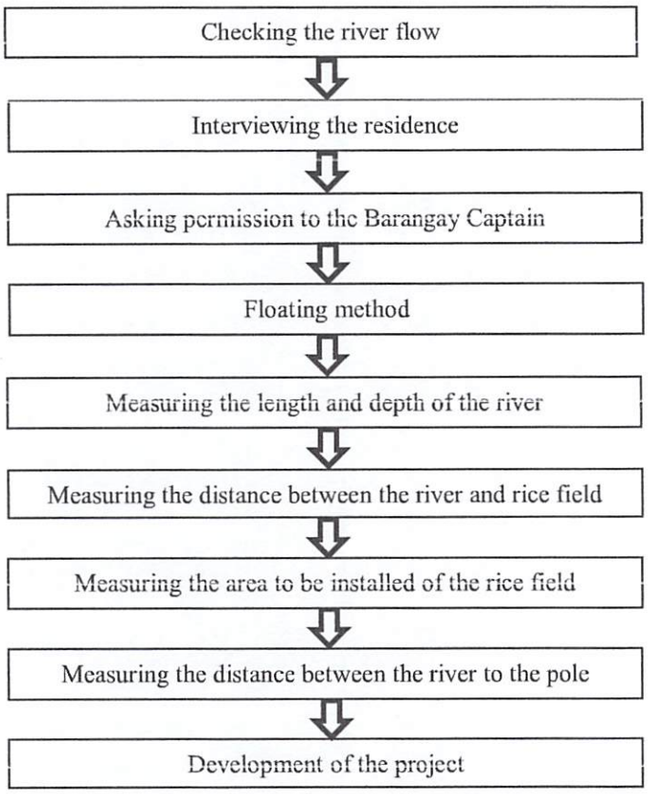

Figure 6. ***Flowchart of Data Collection Procedures***

Statistical Tool

The statistical tool that the researchers use in conducting the study is the Mean wherein this technique is used to derive the central tendency of the data. It is determined by adding all the data points in a population and then dividing the total by the number of points. The resulting number in known as the mean or the average.

3. RESULTS AND DISCUSSION

3.1 Hydraulic Analysis of the River

Table 2. *Floating Method Results*

Trial	Time (sec)
1	1.32
2	2.05
3	1.37
4	2.00
5	1.62
6	2.04
7	2.05
8	2.06
9	2.07
10	1.30
Average Time	1.788

Table 2 above represents the results of the Floating method conducted in the river. The researchers used a blown out water cellophane. It should be as light as possible in order for the object to float in the river. The measurement is made by measuring the time that it takes a floating object to travel a specified distance downstream and in this case researchers marked a 1 meter distance and conducted 10 trials then computed the average time. In addition, the researchers also measure the width and the height of the river using a meter stick. The following are the additional calculations in order to quantify the available power in the river.

Distance = 1m

Width = 0.800m

Height = 0.256m

$$\text{Average Velocity} = \frac{\text{Distance}}{\text{Time}} = \frac{1\text{m}}{1.788\text{s}} = 0.559\,\frac{m}{s} \quad [3]$$

$$\text{Area} = \text{W x H} = (0.8)\,(0.256) = 0.205\ \text{m}^2 \quad [4]$$

$$\text{Q} = \text{Volume discharge} = \text{Area x Velocity} = (0.559)\,(0.205) = 0.115\frac{m3}{s}$$

$$\text{Power} = \text{YQh} = (9810)\,(0.115)\,(0.256) = 0.288\text{kW}$$

3.2 Design of the Pelton Wheel Type Generator and Electric Black Bug Buster

Figure 7 shows the design for the Pelton wheel. The researchers used 16 dipper. As the figure shows the dippers are assembled around a bicycle wheel since a small force can sustain the rotation of the wheel. This would be an advantage in using bicycle wheel. And also along the bicycle wheel is a toothed wheel attached at the side, this is for the chain that will connect the Pelton wheel to the generator as the Pelton wheel rotates due to the impulsive force caused by the river. The shaft of the generator will also rotate producing electricity. The diameter of the wheel is 6" and the height of the dipper is 4.3". The distance between two dippers is 3" and has an angle of inclination of 60°. The dipper is 2" wide and has an overall diameter of 10.5".

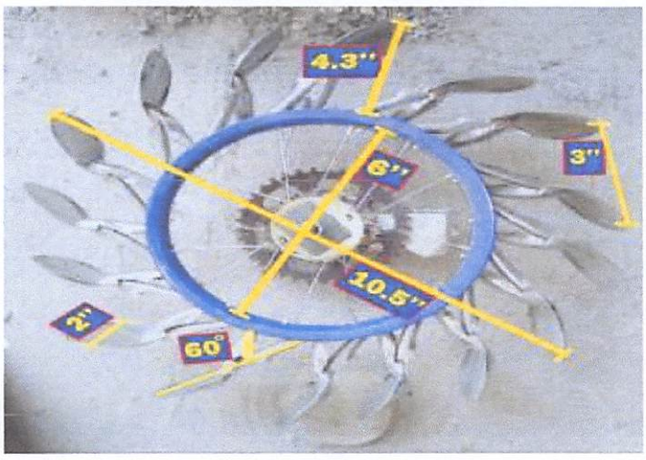

Figure 7. *Pelton Wheel*

Figure 8 shows the generator use in the project. There are 2 types of generator based on its output. These output can either be DC or AC. In this case the researchers used the generator where the output is DC. The kind of generator used in this project study is usually found in multicab called alternator. The chain from the Pelton wheel/bike is attached to the toothed wheel found in shaft of the generator. As the shaft rotates due to the rotation of the Pelton wheel/bike it outputs 12V which will be used to charge the 12V battery. This will also depend on how fast it rotates or in other words the revolution per minute. The required rpm should be attained to output the maximum voltage it can produce.

Figure 8. *Generator*

Table 3 shows the specifications of the generator used in the project.

Table 3. ***Specifications of the Generator***

Specifications	Quantity
Ampere	50
Voltage	12
RPM	500
Construction	Dual Internal Fan
Rotation	Clockwise
Inlet Temperature Limits	105°C
Polarity	Negative ground
Stator Diameter	105 mm
Length	158.2 mm/6.23 in
Weight	3.3 kg/7.27 lbs
Bearing Size	40mm

In a generator increasing under-hood temperatures can cause premature wear of components within the generator potentially shortening service life and reducing amperage output. Dual internal cooling as a heat-reducing design draw air in both sides of the generator, where traditional external fan units draw air across the generator along one pathway. This convective cooling process helps the generator run cooler, which improves operating efficiency and output capability.

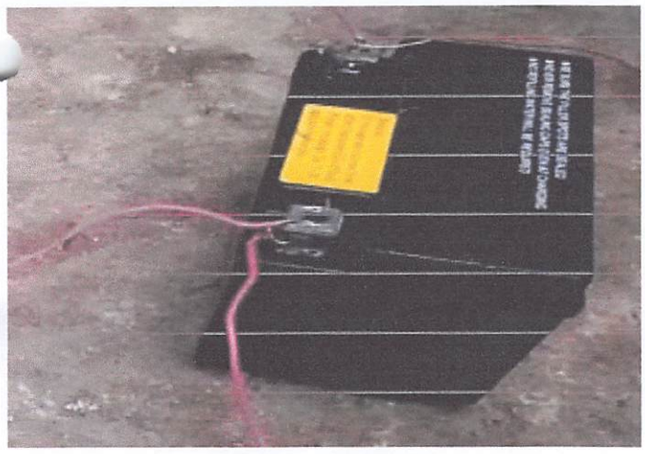

Figure 9. ***Battery***

Hydropower, as a kind of clean energy has the characteristics of rapid response to load changes, and is often used to undertake peak regulation tasks. [21]

Battery is important to regulate and make the output voltage stable for the bulb and the Black bug buster. This is necessary in order to prevent the circuit from malfunction or any problem that may arise with regards to the supply voltage. Researchers decided to use battery because nature is unpredictable so with the river itself even though the residents from the nearby river claimed that the river will flow steadily amidst extreme heat of the sun, researchers still used battery to protect the circuits ahead. And also when the Pelton wheel/bike stopped, the circuit will still function given that the battery is fully charged and also if it is not fully charged the bulb will not glow so with the buster. The overcharge protection circuit for the battery is not included in the design, researchers manually monitor the voltage in the battery using multimeter. Table 4 shows the specification of the battery.

Table 4. ***Specifications of the Battery***

Specification	Quantity
Model	STX4L-BS
Terminal	D
Voltage	12
Ampere Hour	3.5
Polarity	-/+
Length	4.49 mm
Width	3.17 lbs
Height	3.39 mm

Figure 10. ***Black Bug Buster***

The Black Bug Buster is made up of 2 layers of screen one is for the ground and the other is for the live. These screens are separated with a yellow plastic rope to ensure that the screens are not short circuited with each other. The size of the plastic rope is considered enough for the insects to crawl on and get electrocuted once their body short circuited the 2 screens. The 12V DC bulb is placed at the center, the light it emits attracts insects of different kinds as well as black bugs. The set-up is mounted on a piece of wood which is considered as insulators, so the researchers can work on safely. The black bug buster is attached into a 4 meters pole with safety sign to warn the residents specially the children

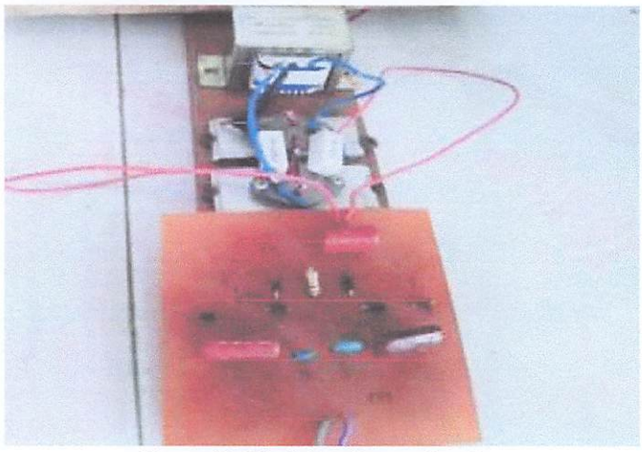

Figure 11. ***Black Bug Buster Circuit***

Figure 11 shows the black bug buster circuit. This circuit is responsible for the electrocution happening in the surrounding screen of the bulb. It has an inverter that inverts the 12V DC from the battery in to 220V AC which will be the input to the second circuit. It uses high voltage capacitors, diodes for rectification and resistor. This elements will produce an output of 2kV DC to the surrounding screens when short-circuited. The grounding wire is connected to the outer layer of the screen while the live wire is connected at the inner layer of the screen. So that, when the body of the insects or bugs touched both screens it offers resistance causing them to be electrocuted. This circuit is in parallel with respect to the 12V DC bulb.

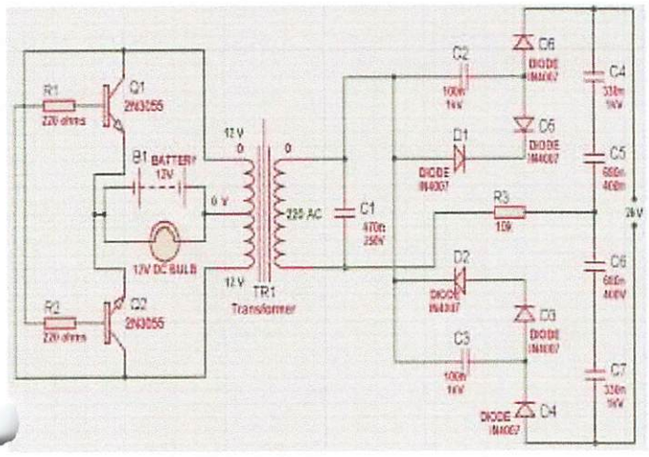

Figure 12. ***Black Bug Buster Schematic Diagram***

Figure 12 shows the schematic diagram of the Black bug buster circuit. It consists of an inverter and the buster circuit.

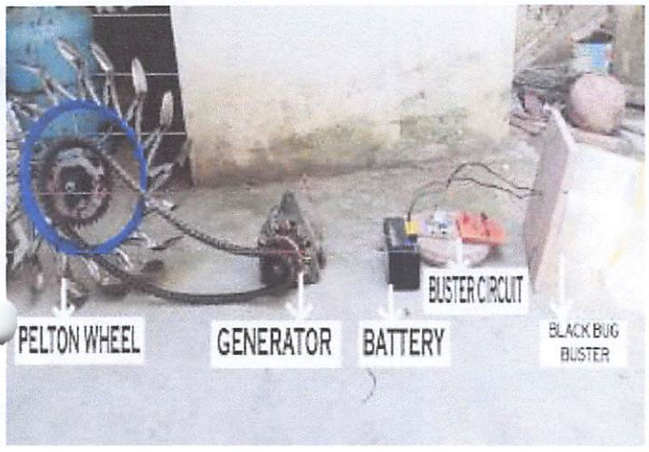

Figure 13. ***Black Bug Buster with Pelton Wheel type Hydro Generator***

This is the complete set-up of this project study. Starting from the Pelton wheel/bike that is supposedly be installed at the river where sufficient impulsive force can rotate the wheel. Using tachometer researchers ensure that the rpm of the bike and the river is approximately the same which is equal to 500.Then, from the generator that will produced the needed voltage with the help of the Pelton wheel/bike connected with a chain/belt. Then, to the battery that regulates the output from the generator and also stores it in case other circumstances occurs. The battery and the generator is connected through a red colored solid wire. And lastly, to the Black bug buster that will greatly help our farmers in minimizing the number of this destructive black bugs in their respective rice fields. Table 5 below shows the test results of the system.

Table 5. ***Test Results***

Time (PM)	Number of Insects Electrocuted
6:00-6:30	8
6:30-7:00	14
7:00-7:30	9
7:30-8:00	12
8:30-9:00	6
9:00-9:30	9
9:30-10:00	10

The testing last for four hours and every 30 minutes researchers record every insects that is attracted and electrocuted. Since researchers cannot go to the rice field and find black bugs any insects that cause a short circuit to the buster is counted and recorded. Most of these insects are mosquitos, moths and small ants. The average number of insects that subject to electrocution is 10.

3.3 Evaluation of the Performance and Acceptability Level

Table 6. ***Evaluation Results of the Project***

Criteria	Mean	Quantitative Discussion
A. Applicability		
Velocity of the River	3.25	Acceptable
Power of the River	3.25	Acceptable
Rice field Location	3.00	Acceptable
Total	**3.17**	**Acceptable**
B. Performance		
Buster Accuracy	3.25	Acceptable
Pelton Wheel Efficiency	3.50	Very Acceptable
Data Gathering Ability	2.75	Acceptable
Total	**3.17**	**Acceptable**
C. Durability		
Portability and Weight	3.50	Very Acceptable
Packaging	3.25	Acceptable
Weatherproof	3.25	Acceptable
Total	**3.33**	**Very Acceptable**
D. Conformance to Standards		
Voltage Sufficiency	3.25	Acceptable
Current Sufficiency	3.25	Acceptable
Power Sufficiency	3.00	Acceptable
Total	**3.17**	**Acceptable**
Grand Total	**3.21**	**Acceptable**

Table 6 shows the evaluation of the project. The researchers conducted a survey about the performance and acceptability level of the system, where the rating scale are, 1 - Not Acceptable, 2 - Less Acceptable, 3 - Acceptable, 4 - Very

Acceptable. And for the quantitative discussion 1.0-1.75 Not Acceptable, 1.76-2.50 Less Acceptable, 2.51-3.25 Acceptable and 3.26-4.0 Very Acceptable. The survey has 4 respondents.

3.4 Financial Feasibility of the Project

Table 7. ***Cost of the project***

PARTICULARS	QUANTITY	AMOUNT
Generator	1 pc.	₱1,500
Pelton wheel	1 pc.	₱200
Battery	1 pc.	₱1,000
Wires	3 meters	₱198
Screen	2 meters	₱250
Bulb	1 pc.	₱250
Socket	1 pc.	₱25
Welding	-	₱1,500
Circuit etc.	-	₱800
Casing	1 pc.	₱100
TOTAL		**₱5,823**

Table 7 above shows the unit cost of the equipment and other cost of this project.

Overhead Cost = Material Cost * 15% [5]
Labor Cost = Material Cost * 35% [6]
Mark Up = Material Cost * 25% [7]

Tax Cost:

Tax = (Material Cost + Overhead Cost + Labor Cost + Mark Up Cost) * 12% [8]

Selling Price:

Price = Material Cost + Tax + Overhead Cost + Labor Cost + Mark Up Cost [9]

Table 8. ***Selling Price***

PARTICULARS	AMOUNT
Material Cost	₱5,823
Overhead Cost (15%)	₱873
Labor Cost (35%)	₱2,038
Mark Up Cost (25%)	₱1,455
Sub-Total	**₱10,189**
Tax (12%)	₱1,222
Selling Price	**₱11,411**

Table 8 shows the selling price and other cost of the project.

Fixed costs are independent of the quality of goods or services produced. Fixed costs (also referred to us as overhead costs) tend to be time related costs including salaries or monthly rental fees.

Fixed Cost:

Fixed Cost = Overhead Cost * 30 days [10]
= ₱873 * 30 days
= ₱26,190/month

Table 9 shows the variable cost. It changes accordingly to the quantity of a good or service being produced. The amount of materials and labor that is needed to make a good increases in direct proportion to the number of goods produced. The cost "varies" according to production.

Variable Cost:

Variable Cost = Material Cost + Labor Cost + Tax [11]

Table 9. ***Variable Cost***

PARTICULARS	AMOUNT
Material Cost	₱5,823
Labor Cost	₱2,038
Tax	₱1,222
Variable Cost	**₱9,083/product**

Break-Even Point:

Fixed Costs = ₱26,190
Variable Cost = ₱9,083
Selling Price = ₱11,411

$$BEP = \frac{Fixed\ Cost}{Selling\ Price - Variable\ Cost} \quad [12]$$

$$BEP = \frac{₱26,190}{₱11,411 - ₱9,083}$$

BEP = 11.2 ≈ 11

The Break-Even point is the basis on how many products must be sold in that particular month in order for the researchers/producers to make a profit.

Cost of Investment = BEP * Selling Price [13]
= 11 * ₱11,411
= ₱125,521

Return of Investment:

$$ROI = \frac{Net\ Return\ on\ Investment}{Cost\ of\ Investment} \times 100\% \quad [14]$$

$$ROI = \frac{₱125,521 - ₱11,411}{₱125,521} \times 100\%$$

ROI = 90.90 %

When an investor purchases the Black Bug Buster utilizing Pelton Wheel type Hydro Generator which value is ₱11,411. After one year, the investor sells it for ₱125,521.

4. CONCLUSION AND RECOMMENDATIONS

Conclusion

The following are the conclusions found after determining the results of the study:

1. Base on the results of the Hydraulic analysis the river has a volume discharge of 0.115m^3/s, a velocity of 0.559m/s and has an available power of 0.288kW.
2. Base on the test results, the design of the project has a correlation to its parts and the Electric Black bug buster can electrocute an average of 10 insects from 6:00pm-10:00pm.
3. Base on the evaluation results, the project's overall output has meet the desired requirements for the performance and acceptability level with an overall mean of 3.21.
4. Base on the financial feasibility result, the project is profitable with a break-even point of 11 and 90.9% of return of investment.

Recommendations

Though the project gives realistic results, the researchers still recommend the following:

1. Use another source of power like solar panels.
2. Application of regulator to the battery where it automatically trip off/on when the battery is full and when it is needed to be charged again, respectively.
3. Connect a switch to the buster circuit for safety.
4. Improve the buster circuit to minimize more black bugs/insects.

5. ACKNOWLEDGEMENT

The accomplishment of this project study was the work and sacrifices of several people to whom the researchers owe a gratitude and forever be cherished.

First of all, praises and thanks to Almighty God for the wisdom He had bestowed, to the guidance throughout the process of the project and to the blessings He had bestowed upon the researchers.

To the loving and ever supporting parents, thank you for the unconditional love amidst our lapses in life, for understanding every decisions we have made and supporting in every steps we take and also in terms of moral and financial aspects throughout the conduction of the project study.

To the co-author, Engr. Vernon Liza, who provided and shared his insights with regards to the electrical wirings and expertise in presenting the project study this is of great help to the researchers, thank you sir for the assistance in our study.

To Engr. Robert R. Bacarro, for giving his time and effort to review, discuss and even conduct a very helpful seminar in accordance to the making of the manuscript and suggested ideas that will suit within this project study.

To Engr. Aldrich B. Calinawan for patiently discussing about some important details especially on hydraulics concept and computations with regards to the power available in the river this helps a lot in this project study.

To Jaymar Asumen for the outstanding support regarding on the making of the black bug buster circuit so with the inverter.

And lastly to the rice field owners and barangay captain for their cooperation in making this study successful.

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DESIGN OF MONITORING DEVICE FOR TURBIDITY AND POTENTIAL HYDROGEN LEVEL IN SETTLING PONDS

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ABSTRACT. A settling pond removes undesirable small particulate suspended matters (sand, silt and clay) and some biological contaminants from water under the influence of gravity. The longer the water is sedimented, the more the suspended solids and pathogens will settle to the bottom of the container. There are two types of settling basins, based on the method of removing solids. With one type, the solids are removed mechanically (after the free water has drained away), usually with a front-end or skid-steer loader. The other type uses hydraulic (pump) removal of the solids. The system are composed of the following materials, Arduino Uno which is the brain of the system, Node MCU the transmitter of the gathered data to the system, turbidity sensor that sense the mud in the water, and lastly the Potential Hydrogen that collect the acidity and alkaline value of the water. And lastly, the researchers came up on a device that is acceptable to the stack holders with lower value of selling price.

Keywords. pH level, settling ponds, turbidity, IoT, Arduino-based

1. INTRODUCTION

Turbidity is an important indicator of the amount of suspended sediment in the water, which can have many negative effects on aquatic life. The suspended sediments that cause turbidity can block light to aquatic plants, smother aquatic organisms, and carry contaminants and pathogens, such as lead, mercury, and bacteria. [1] It is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. [2] A settling pond is a concrete structure using sedimentation to turbidity from wastewater [3], as the researchers monitoring device used to read the following parameters; (a) Turbidity (b) pH Level in settling pond. from the inlet to the outlet of the settling pond.

When the above major causes of turbidity cannot be settled on settling pond it can increase the cost of water treatment for drinking and food processing. It can harm fish and other aquatic life by reducing food supplies. So, the significant impact of turbidity monitoring device is it is used to alert us to current, ongoing, and emerging problems; to determine compliance with transparency of sea water standards, and to protect our aquatic resources. [4]

Collecting water quality data can be expensive. Maintaining and repairing equipment costs can rack up quickly over time. Aging of instruments face a number of issues, some of the common ones are stainless corrosion, bent or broken pins, wiper failure and faulty cables. Significant resources are wasted when data is missing or instruments are not properly configured. This challenge is nothing new and has been around as long as water quality data has been collected. [5] another problem faced by monitoring water parameters is the usual method of testing water quality where gathering samples of water manually and send to the lab to test and analyze. This method is time consuming and wastage of man power.

The researchers offer a solution, a device design for monitoring the turbidity and pH level of the water from the settling pond. Therefore, a continuous series of anomalous measurements would indicate the potential introduction of a water pollutant. Hence, with the successful implementation of this monitoring approach, a water turbidity early warning system can be achieved.

The researchers aim to present a monitoring device in order to help monitor water turbidity and pH level on settling ponds and be able to minimize the danger in our aquatic resources.

Review of Related Projects

This section reviews some of the existing literature concerning with the turbidity and pH level.

Nowadays Internet of Things (IoT) and Remote Sensing (RS) techniques are used in different area of research for monitoring, collecting and analysis data from remote locations. Due to the vast increase in global industrial output, rural to urban drift and the over-utilization of land and sea resources, the quality of water available to people has deteriorated greatly. [6]

Another water quality monitoring, concretely relates to quality of water turbidity monitoring devices need not gather sample monitoring quality of water turbidity, can directly set up this quality of water turbidity monitoring devices in the water pipe, as the water pipe some, through taking notes and gather the turbidity that water was monitored to the light intensity variation that passes through the pipe water-logging, lets then converts the signal of telecommunication into, by these information of master control CPU receipt of water quality monitoring to make

the judgement to the quality of water turbidity, transmit the surveillance center at last to. [7]

It measures the water quality parameter such as pH, conductivity, muddiness of water, temperature. The measured values from the sensors are processed by microcontroller and the processed values are transmitted using GSM to the concerned authority. [8]

Another related project of the researcher's study is a Development of a Calibrated Transducer CMOS Circuit for Water Turbidity Monitoring. A calibrated transducer CMOS circuit for water turbidity monitoring is proposed. The output signal is a pulse stream. It can be easily broadcast over various digital transmission media. In addition, the proposed calibration method can reduce nonlinear errors arising from turbidity sensors. [9]

A novel approach is proposed in this paper to design smart sensor interface for water quality monitoring in IoT environment. Different sensors are available for water quality monitoring which are used to check the quality on following parameters i.e. pH, dissolved oxygen concentration, turbidity and temperature etc. IoT provide interface to monitor and operate remotely from anywhere and anytime. [10]

A WSN-based reconfigurable water quality monitoring system in IoT environment, it presents a reconfigurable smart sensor interface device for water quality monitoring system in an IoT environment. The smart WQM system consists of Field Programmable Gate Array (FPGA) design board, sensors, Zigbee based wireless communication module and personal computer (PC). [11]

This study presents a wireless sensor network architecture that combines low cost sensing nodes and a low-cost multi-parameter sensing probe for reliable monitoring of water quality parameters of surface waters (lakes, estuaries and rivers) in urban areas. [12]

Developing countries have poor wastewater management infrastructure. Wastewater from various sources such as domestic sewage, untreated industrial discharge, agricultural runoff, and animal waste is usually dumped into surface water resources such as canals, streams and rivers. So, the authors have developed a Lagrangian sensor system which is capable of logging and transmitting spatially distributed GPS tagged water quality data in real-time from water bodies such as drains, canals, streams and rivers.[13]

This paper presents a field study of the use of this technology in a project conducted at the campus of the University of Lille within the European project "SmartWater4Europe". The campus is equipped with two types of sensors: S: :CAN and EventLab. S::CAN measures multiple parameters such as turbidity and free chlorine, while EventLab measures the variation of the refractive index. [14]

The application of wireless sensor network (WSN) for a water quality monitoring is composed of a number of sensor nodes with a networking capability that can be deployed for an ad hoc or continuous monitoring purpose. The parameters involved in the water quality determination such as the pH level, turbidity and temperature are measured in the real time by the sensors that send the data to the base station or control/monitoring room. [15]

A common method for measuring water transparency is Secchi depth. In this paper, the researchers present an approach to water quality (Secchi depth and turbidity) monitoring using mobile phones and a small device designed for water quality measurements. [16]

The system includes the collection of data from the water distribution system and from the water treatment facility and from advanced separation processes which are integrated into analytical instruments. Preferred parameters of monitoring include the turbidity and disinfectant such as chlorine, hypochlorous acid, sodium hypochlorite, calcium hypochlorite, ozone, chlorine dioxide, chloramines, hydrogen peroxide, peracetic acid. [17]

This paper describes the "SmartCoast" multi sensor system for water quality monitoring. This system is aimed at providing a platform capable of meeting the monitoring requirements of the Water Framework Directive. The key parameters under investigation include temperature, phosphate, dissolved oxygen, conductivity, pH, turbidity and water level. [18]

Water Sensor Network (WSN) system prototype developed for water quality monitoring is presented. The development was preceded by evaluation of prevailing environment including availability of cellular network coverage at the site of operation. The system consists of an Arduino microcontroller, water quality sensors, and a wireless network connection module. It detects water temperature, dissolved oxygen and pH level. [19]

The system not only can deal the normal detection of the aquaculture environment indicators (temperature, PH, dissolved oxygen, turbidity, ammonia, etc.) in real-time monitoring, but also can detect indicators of data fusion and data mining to establish a history database of aquaculture environmental monitoring indicators.[20]

The researchers monitoring device differs from the other monitoring device by having a Wifi module that will transmit the data gathered from the sensor directly to the website.

The similarity of the researchers monitoring device is that this device monitors water turbidity and pH level same as other devices.

Theoretical Framework

Programming – is the process of creating a set of instructions that tells a computer how to perform a task. Programming can be done using variety of computer language, such as SQL, Java, Python, and C++.[21]

Simulation Analysis – Is a presentation of the functioning of a system or process. Through simulation, a model may be implemented with unlimited variations and producing complex scenarios. The study uses Proteus 7 for simulating the system, to know if the created circuit is functioning or not.

Embedded system – Is a special-purpose system in which the computer is completely encapsulated by the device it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs pre-defined tasks, usually with very specific requirements. Since the system is dedicated to a specific task, design engineers can optimize it, reducing the size and cost of the product. Embedded system is often mass-produced, so the cost saving may be multiplied by millions of items. The project creates a system with an Arduino Uno as the master controller.

Arduino Software (IDE) – Is a software that used for encoding and uploading the program/code to the Arduino.

Proteus 7 – is a virtual system Modeling that combines circuit simulation, animated components and microprocessor models. This is useful for the researchers to test the design before constructing it in real time.

Conceptual Framework

The following figure shows the input-process-output diagram of the project.

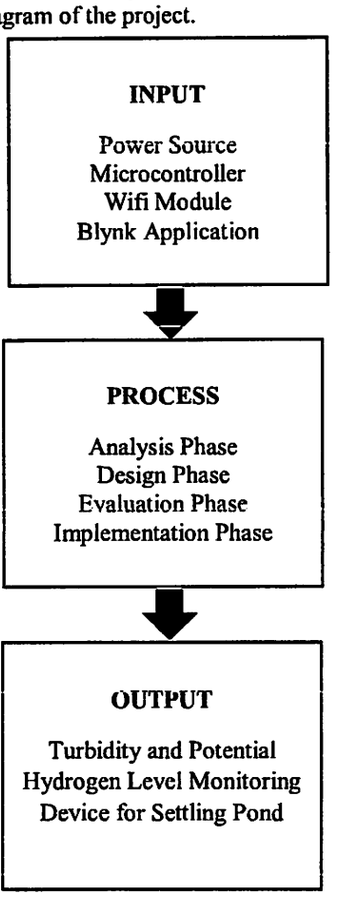

Figure 1. ***Input-Process-Output Diagram of the Project***

The first block of the flow diagram starts with the inputs wherein the researchers determine the materials and equipment necessary to visualize the research project like Power Source, Microcontroller, Sensors, WiFi Module and Blynk Application.

The second block is the process, where the researchers are conducting stage of phases where analysis, design, evaluation, and implementation phase takes place. This stage is the very important, because it may involve complex calculation and lots of trial and errors.

The last block of the flow diagram is the output. The Turbidity and pH level monitoring device for settling, and expected to measure and gathered data that will sends wirelessly through the blynk application.

Objectives

The general objective of the study is to provide a device that read the value of turbidity and pH level on settling ponds, particularly in mining area that do not have monitoring device.

1. To determine the profile of the settling pond.
2. To design and develop a monitoring device for turbidity and pH level
3. To evaluate the acceptability level of the system.
4. To determine the financial feasibility of the project.

2. METHODS

Project Design

The block diagram below shows the flow in research design

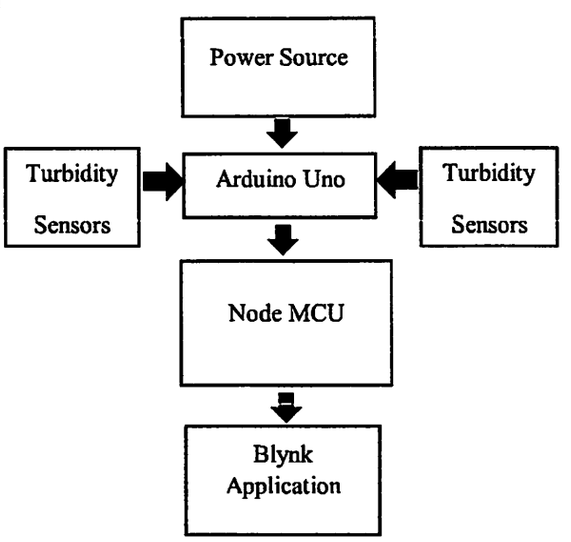

Figure 2. ***Block Diagram of the Project***

In Figure 2, power source is the input supply of the device, followed by the data collectors or the sensors, these sensors are placed in the settling pond inlet and outlet, the sensors convert the physical parameter into equivalent

measurable electrical quantity. Then the microcontroller which is the main control of the desire output for the water turbidity and pH level. Main function of the controller is to read the data from the sensor, optionally process it, and send the same to the application by using appropriate communication technology.

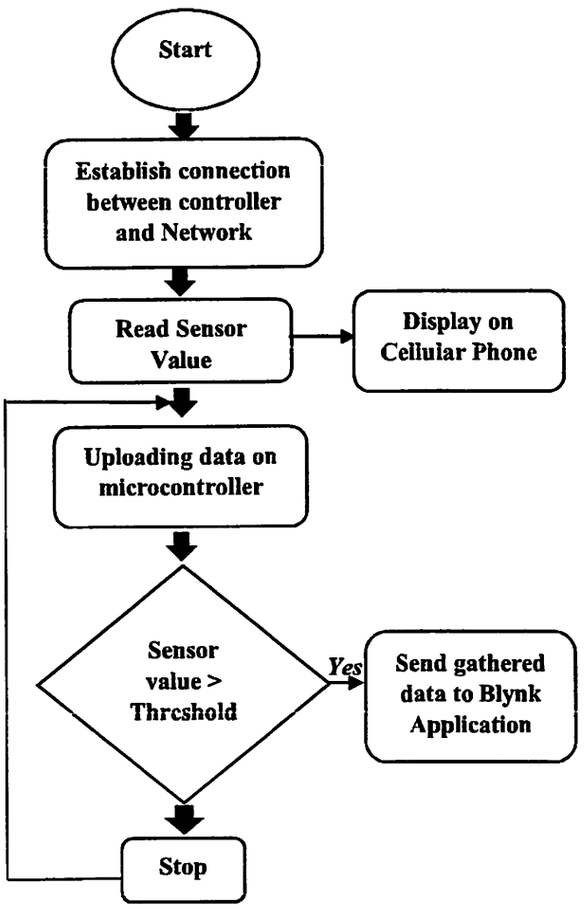

Figure 3. ***Flow Chart of the Project***

The flowchart of the project is shown in Figure 3, where the researchers used this as basis on how the data gathering procedure is done. As shown in the figure, once project starts all the sensors are initializing and the input the sensors will be on the water. The data being collected by the sensor will be then processed and the microcontroller will be used as a tool to process the data and it will be displayed on the blynk application.

Project Development

The project development is to design a Monitoring device for turbidity and pH level in settling ponds.

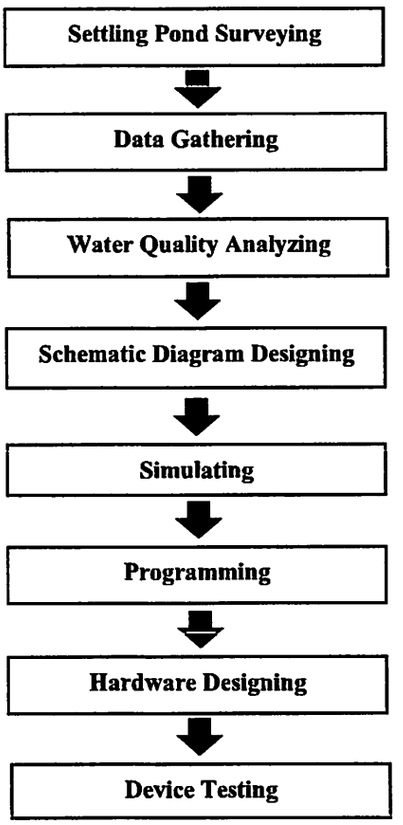

Figure 4. ***Project Development Flow Chart of the Project***

The Flowchart in Figure 4 shows the process on how the researchers developed the project. As shown in the figure, with the permission of the settling pond on Construction and Mining Corporation (CTP) we started our investigation and surveying to the condition of the settling pond. Then, collecting of data will follow through an interview with the company. The researchers will then get some water samples and will analyze the water turbidity and pH level of the water from the settling pond. Then, it is planned to design the schematic diagram for this project and simulate it using simulation software. Programming of the sensors will lead the data being accumulated by the microcontroller will be stored here. Lastly, the hardware design of the device will be sketch based on materials used, the device will be put through in the settling pond input and output for testing the value of every parameter needed.

Project Implementation

The Construction and Mining Corporation (CTP) will be the in-charge in implementing the project study that was conducted by the researchers. Safety and environmental concerns in implementing the project will be assured at all times. Also, with the supervision of Electrical Engineers that will monitor the implementation phase until its completion to ensure the safety and appropriateness of the project.

Project Evaluation

The project study will be evaluated with the results obtained throughout the process. And these are the following to be evaluated in the project study:

Service Ability

Are the value read by the device in this project study satisfies the standard value needed of the settling pond?

Applicability

Is the designed project study appropriate to the project location and application?

Attainment

Does the project study attain the needed demand of the settling pond in order to maintain its water quality?

Accuracy

Does the data receive from the sensor is accurate to standard value of pH level and Turbidity?

Ethical Consideration

In conducting the project study, the researchers make sure that they did not violate any legitimate and environmental issues.

Data Collection Procedure

The data is being collected through surveying the area on what are the dimensions of the settling pond. On the device, it will be tested to determine if there is actually a settling of sediments in the settling pond. The collected data will be shown on the blnyk application.

Participants of the Study

Table 1. ***Participants Involved in the Project Study***

Participants	f(n=7)	%
Chemical Engineer	2	29
Mining Engineer	2	29
Electronics Engineer	1	14
Computer Engineer/IT	1	14
Electrical Engineer	1	14
TOTAL	**7**	100

The participants of the project study are the following people who mainly give much contribution; two Chemical Engineers, two Mining Engineers, one Electronics Engineer, one Computer Engineer or Information Technology. Lastly an Electrical Engineer is required to help the researchers in making the project study and proper execution of the project.

Project Setting

The project is sited at Carrascal, Surigao del Sur. The settling pond of Construction and Mining Corporation (CTP) suit for the device testing.

Figure 5 ***Construction and Mining Corporation Map and Satellite view***

Instrumentation

In this study, the following computer software applications are used as an instrument for the achievement of the study:

Arduino Software. The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board.

Proteus Simulator. It is a software suite containing schematic, simulation as well as PCB designing. ISIS is the software used to draw schematics and simulate the circuits in real time. The simulation allows human access during run time, thus providing real time simulation

PHP Programming. A general-purpose scripting language that is especially suited to server-side

web development, in which case PHP generally runs on a web server. Any PHP code in a requested file is executed by the PHP runtime, usually to create dynamic web page content or dynamic images used on websites.

Cost Estimates. An approximation of the probable cost of a project, computed by estimating the cost of every activity in work breakdown structure summing these estimates and adding appropriate overheads. This provides the estimated economical cost of the design.

Flowchart. It is a visual representation of the sequence of steps and decisions needed to perform a process. Each of these symbols is linked with arrows to illustrate the flow direction of the process. It is a process or operation and includes multiple steps, which the process flows through from beginning to end.

Block Diagram. It is a specialized, high level flowchart used in engineering. It is used to design new systems or to describe and improve existing ones. Its structure provides a high-level overview of major system components, key process participants, and important working relationships. This is the representation of input-output behavior of a system; where the signal into the block represents the input and the signal out of the block represent the output. The flow of the information (the design) is unidirectional from the input to the output. In this study the researchers used block diagrams in presenting the process or flow of the study.

Statistical Tools

In this project study, the researchers used a multi-tester as a tool in measuring voltage on the sensors. Qualitative and quantitative analysis is used to tabulate the data to evaluate the project study.

3. RESULTS AND DISCUSSION

Based on the objectives stated above the following results were determined.

3.1 Profile of the Settling Pond

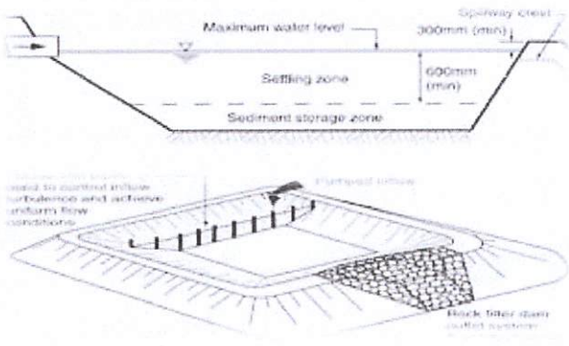

Figure 6. ***Typical profile of a settling pond***

3.2 Design of Settling Pond Monitoring Device

This part shows the different hardware material and their specifications used in the project.

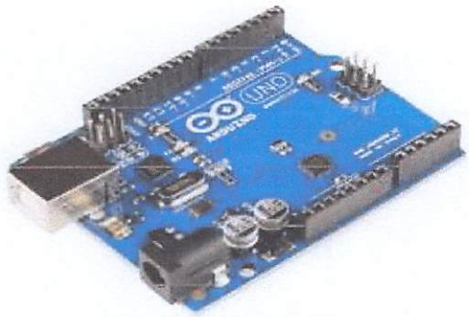

Figure 7. ***Arduino Microcontroller***

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), 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 an AC-to-DC adapter or battery to get started.

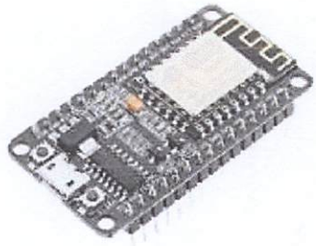

Figure 8. ***Wifi Module***

The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network.
ESP-8266 32-bit
Clock Speed: 80 MHz
USB Converter: CP2102
USB Connector: Micro USB
Operating Voltage: 3.3V
Digital I/O: 11, Analog Inputs: 1
Communications: Serial, SPI. I2C and 1-Wire via software libraries
WiFi: Built-in 802.11 b/g/n

Figure 9. ***Turbidity Sensor***

It uses light to detect suspended particles in water by measuring the light transmittance and scattering rate, which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases. Turbidity sensors are used to measure water quality in rivers and streams, wastewater and effluent measurements, control instrumentation for settling ponds, sediment transport research and laboratory measurements.
Operating Voltage: 5V DC,
Operating Current: 40mA
Response Time: <500ms
InsulationResistance:100M (Min)
Output Method: Analog
Analog output: 0-4.5V
Digital Output: High/Low level signal
Operating Temperature: -30 °C~80 °C
Storage Temperature: -10°C~80°C

Figure 10 ***pH sensor***

pH sensor is commonly used for water measurements, is a measure of acidity and alkalinity, or the caustic and base present in a given solution. It is generally expressed with a numeric scale ranging from 0-14. The value 7 represents neutrality. The numbers on the scale increase with increasing alkalinity, while the numbers on the scale decrease with increasing acidity. Module Power : 5.00V
Module Size : 43 x 32mm
Measuring Range :0 -14PH
Temperature: 0-60 °C
Accuracy : ± 0.1pH (25 °C)
Response Time : ≤ 1min
pH Sensor with BNC Connector
pH2.0 Interface (3 foot patch)

Figure 11. ***Power Boost Rechargeable***

PowerBoost 1000C is the perfect power supply for your portable project! This little DC/DC boost converter module can be powered by any 3.7V LiIon/LiPoly battery, and convert the battery output to 5.2V DC for running your 5V projects.
Contents: Board(s)
Function: Battery Charger
Platform: Arduino
Type: Power Management
Utilized IC / Part: MP73831, TPS61090

Figure 12. ***Lithium Battery***

Lithium ion polymer (also known as 'lipo' or 'lipoly') batteries are thin, light and powerful. The output ranges from 4.2V when completely charged to 3.7V. This battery has a capacity of 500mAh for a total of about 1.9 Wh.
Rated Capacity: 110mAh
Nominal Voltage: 3.70V
Max Charge Current: 1C (110mA)
Normal Charge Current: 0.2C (22mA)

Figure 13. ***Connecting Wires***

Connecting wires are used to extend the firing line or leg wires in an electric blasting circuit.

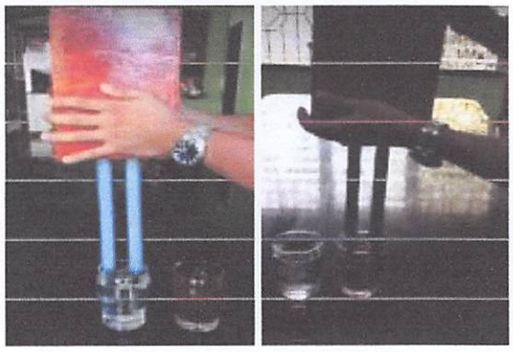

Figure 14. ***Placement of the system on the Pond***

The researchers use samples to test the device, as you can see the figure above there are two glasses that has different value of turbidity and pH level. The project device was planned to be test on Construction and Mining Corporation (CTP) settling pond but due to community quarantine the researchers failed to do so.

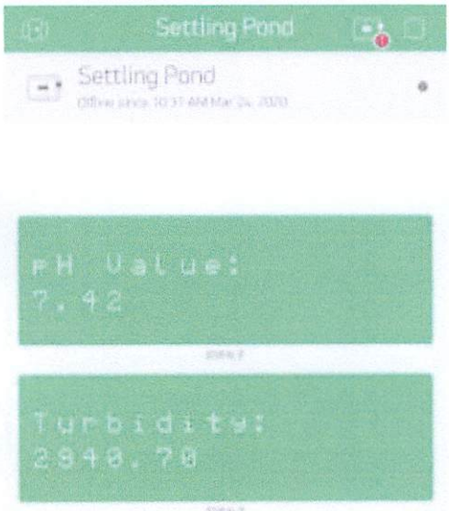

Figure 15. ***Measured Values displayed on Blynk App***

The figure 14 above shows the value of collected data from the test samples and transmit to a cellphone application called Blynk and the phone serve as the monitor of the gathered data of the device.

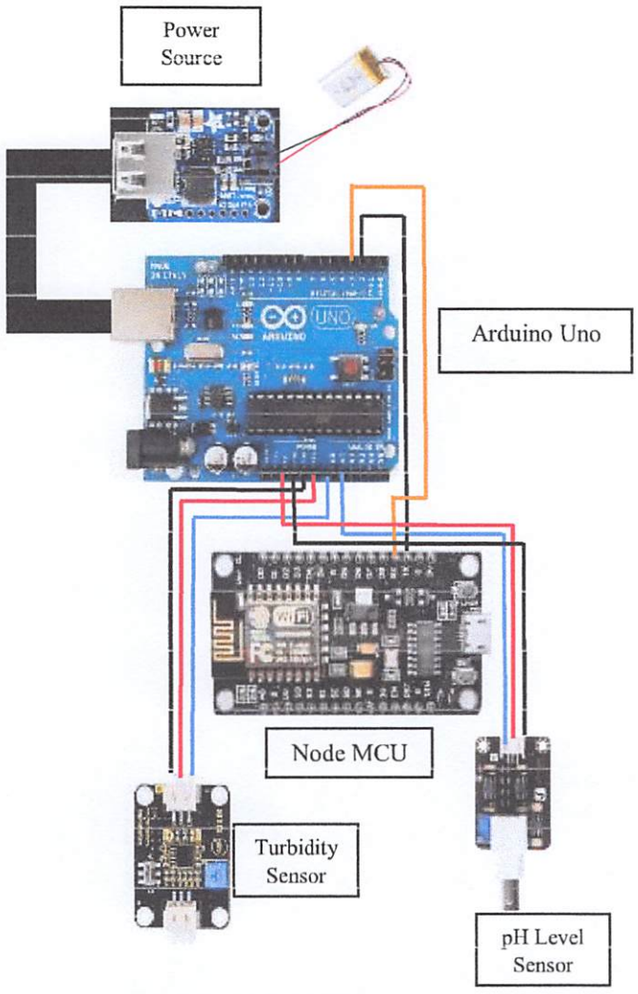

Figure 16. ***Schematic Diagram***

The schematic diagram of the system is shown above. It is composed of analog Potential Hydrogen module, Turbidity module, and dissolved oxygen module. The pH analog/signal pin (blue wire) is connected to analog pin A0 of Arduino Mega, turbidity analog/signal pin is connected to analog pin A1 of Arduino and A2 analog pin is for dissolved oxygen analog pin. The voltage input and ground of different modules were connected to the V_{in} and GND of Arduino Mega microcontroller which is powered by a rechargeable powerboost 500C module shield with 3.7V-5.2V of output power.

The WiFi Module or ESP8266 has its own power supply which has an output of 5V, the TX, RX and GND pins of ESP8266 are connected to digital pins 2,3 and GND respectively.

Table 3. *Software Requirement of the System*

SOFTWARE	DEFINITION
Arduino IDE	Arduino is an open-source electronics platform based on easy-to-use hardware and software.
Blynk	Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things.

Table 3 shows the different software applications used in this project. The first one was the Arduino IDE used for programming the main microcontroller of the system called the Arduino UNO and the Wi-Fi module ESP8266, and the Blynk Application which is used as the webpage of the system where the measured value of pH, turbidity were displayed.

3.3 Acceptability Level of the System

Table 4. *Test Result of the water in the Pond*

Criteria	Mean	Quantitative Discussion
System Accuracy	3.5	Acceptable
Supply Efficiency	3.5	Acceptable
Data Collecting Ability	3.75	Acceptable
Grand Mean	**3.75**	Acceptable

The researchers conducted survey about the acceptability level of the system, where the rating scale are, (1.0-1.75)-Not Acceptable, (1.76-2.50)-Less Acceptable, (2.51-3.25)-Acceptable,(3.26-4.00)-Very Acceptable. The survey has 4 respondents.

3.4 Financial Feasibility of the Device

Table 6 shows the unit cost of the Smart Water Quality Monitoring Device.

Table 6 shows the unit cost of the project it includes the materials, transportation, documentation and printing.

Table 6. Unit Cost of the System

PARTICULARS	QTY	AMOUNT
MATERIALS		
Arduino Uno	1 pc.	₱549.75
ESP8266 WiFi Module	1 pc.	₱210.00
Turbidity Sensor	1 pc.	₱625.00
pH Sensor	1 pc.	₱1,655.00
Battery Lithium Ion (110mAh)	2 pc.	₱425.00
Connecting wires	1 pc.	₱1,40.00
PowerBoost 1000C	2 pc.	₱1,020.85
Material Cost		₱4,624.75
Overhead Cost (10%)		₱462.47
Labor Cost (25%)		₱1,156.19
Mark-up (30%)		₱1,387.43
Total		₱7,630.84
Tax (12%)		₱915.70
Selling Price		₱2,303.13

Table 6 shows the unit cost of the project it includes the material cost, overhead cost, Labour cost mark-up, tax and selling price.

Break-Even Point:

Fixed Costs = ₱4624.75

Variable Costs = Overhead Cost + Labor Cost = ₱1,618.66

Selling Price = ₱1,803.66

$$\mathbf{BEP} = \frac{\textbf{Fixed Cost}}{\textbf{Selling Price} - \textbf{Variable Cost}}$$

$$\mathbf{BEP} = \frac{₱4624.75}{₱2303.13 - ₱1618.66}$$

$$\mathbf{BEP} = 7$$

The break-even point of the device is the basis on how many products must be sold in that particular month/time. In this product, the researchers must sell at least 3 products to make a profit.

Return of Investment:

$$\mathbf{ROI} = \frac{\textit{Selling Price(BEP)} - \textit{Total}}{\textit{Total}}$$

$$\mathbf{ROI} = \frac{16,121.91 - 7630.84}{7630.84} \mathbf{x100}$$

$$\mathbf{ROI} = 111.27\%$$

4. CONCLUSION AND RECOMMENDATIONS

Conclusion

Based on the result of the study, the following conclusions are drawn:

1. A settling pond are used to control water pollution in diverse industries such as agriculture, aquaculture, and mining.
2. The device has two analog sensors the pH and turbidity which the data gathered from the microcontroller will be transmit in the Blynk application with the help of ESP8266 WiFi module.
3. It is concluded that the system is acceptable to the stack holder with a lower value of selling price.
4. It is concluded that the financial feasibility of the project is not so much expensive because the sensors are affordable. The total cost of making the device is ₱7,630.84, with an ROI of 111.27%.

Recommendation

the researchers would like to recommend the following:

1. It is recommended that website is needed to view more accurate gathered data with a graph, and the data will be shown in the website even the monitoring device and the device being use to view data have different Wifi connections.
2. It is recommended that the device should add an LCD monitor to be attach in time of no internet connection near in the settling pond, because the Blynk application need internet connection
3. It is recommended that there will be an AC source supply 24/7 near in the device in case of low battery.

5. ACKNOWLEDGMENTS

The accomplishment of this project study was the work and sacrifice of several people to whom the researchers owe a gratitude, first of all, praises and thanks to the God Almighty for the wisdom, guidance and blessings He had showered upon the researchers. To Engineer Robert R. Bacarro, MECE, MBA, for patiently checking the consistency of the design of the research study and for his effective teaching which made the project study one of the best achievements of the researcher so far. To Engr. Andy Bong Navarro, the researchers' co-author for the ideas, guidance, motivation, reminders, support, patience, and enthusiasm he imparted to the researchers. To the researchers' beloved parents: Mr. and Mrs. Boc, Mr. and Mrs. Palen, Mr. and Mrs. Trajano and family, for the financial, emotional, and spiritual support they have provided to the group. To the researchers' Engineering instructors, classmates and friends who offered their brilliant ideas and advices, inspiration and motivated them during hardships. To the Construction and Mining Corporation, for giving the researchers the opportunity to have a project setting, this project study proposal would be impossible without the company cooperation.

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DEVELOPMENT OF ELECTRIC GENERATOR USING PIEZOELCTRIC HARVESTER

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Abstract. The study is focused on the development of piezoelectric generator and determining the characteristics of noise in terms of response and decibel and design requirements of the electric generator. The project is a solution to minimize the energy consumption such as utilizing different kinds of noise particularly motor noise as a new source of energy. There are factors to be considered in the research design, this includes the type of noise provider that will provides high level sound intensity, other factor to be considered is the type of piezoelectric material that shall produce high electricity output. In this research the 35mm piezoelectric ceramic is used. For the development of the study, it was tested from various distances and analyzed the electricity generated. The characteristics of noise in terms of resonance and decibel level are that sound intensity (dB) affects the performance of piezoelectric transducers in producing the output signal. From the results obtained, the researchers concluded that the motor boat engine has the noise characteristics to generate electricity the higher intensity sound strikes piezoelectric material in the focusing part then it produces comparatively high decibel level and electric energy. It is also concluded that the design requirements of piezoelectric harvester is to have an arrangement of piezoelectric element into series connection. The performance of generator can generate electric energy but in a very small amount and can generate from 0.5 m to 2 m distance from the source.

Keywords. sound energy, piezoelectric sound harvester, resonant frequency, decibel

Introduction

Electric generator is basically a machine that converts mechanical energy to electricity to a transmission and distribution over lines to domestics, commercial and industrial customers and it also produce electrical power for automobiles, aircraft, ship, etc.[1]

Electricity is the most versatile and easily controlled form of energy. Since we're now living surrounded by technologies, innovations and happiness. It is the one of the greatest technological innovations of mankind. Electricity is now an important part of homes and industries particularly in a production industry where all equipments are run with electricity. With the increase of modern world technology has come the increased concern of electricity consumption. According to Global Energy Statistical Yearbook 2019, global power consumption accelerated again with 3.5% as of 2018[2]. Energy demand worldwide grew by 2.3% last year, its fastest pace this decade, an exceptional performance driven by a robust global economy and stronger heating and cooling needs in some regions. Natural gas emerged as the fuel of choice, posting the biggest gains and accounting for 45% of the rise in energy consumption. Gas demand growth was especially strong in the United States and China [3].

In the Philippines, the total energy consumption reaches about 78.30 billion kWh of electric energy per year [4]. The Industrial sector is the largest energy users, the industrial motors uses a major fraction of total energy uses. Electric motor systems account for about 60 percent of global industrial electricity consumption and close to 70 percent of industrial electricity demand. One effort to minimize the electricity consumption is to seek new source of energy.

Vibration and sound are one kind of unconventional mechanical energy source which is common to the industrial facilities. It is a pollutant and a hazard to human health and hearing but it may help to reduce the energy consumption in every industry. Basically, the high intensity sound or noise has sufficient energy for conversion but since in industrial machinery and processes are composed of various noise sources such as rotors, stators, gears, fans, vibrating panels, turbulent fluid flow, impact processes, electrical machines, internal combustion engines etc. can be used to have other source or electricity. The sounds produced by the machines will be converted into electricity and this new form of energy can powered any industry equipment within the capability of the energy transformed. One method is to use piezoelectric materials to obtain energy lost due to vibrations of the host structure. This captured energy could then be used to prolong the life of the power supply or in the ideal case provide endless energy for the electronic devices lifespan.

Thus, the researchers then attempt to investigate the utilization of noise from a motor in

generating electricity by using piezoelectric sound energy harvester. The study attempt investigates the capability of piezoelectric energy harvester in generating electricity with a certain decibel level in a various distance. The outcome of this study could be used by the community and other researchers for recommendations and applications.

Related Literature

Energy harvesting is defined as capturing minute amounts of energy from one or more of the surrounding energy sources, accumulating them to store for a later use. In the view point of energy conversion, human have already used macro energy harvesting technology. On the contrast micro harvesting is used which is based on mechanical vibration, mechanical stress and strain [5] Sound is a form of mechanical energy produced by vibrations. A wave is a disturbance that transfers energy through matter or space. It travels in longitudinal (compression) waves and moves much slower than the speed of light. In engineering, noise is defined as a signal that interferes with the detection of or quality of another signal. Basically, noise is unwanted sound. It is a pollutant and a hazard to human health and hearing. The high intensity sound or noise has sufficient energy for conversion.[6]

The efficiency of mechanical to electrical conversion is a fundamental parameter for the development and optimization of the power generation device. Umeda et al. (1996,1997) have studied the efficiency of mechanical impact energy to electrical energy using a piezoelectric material in a stack configuration for converting mechanical harmonic excitation into electrical energy.[7]

The invention relates to a sound-electricity transducer made of novel piezoelectric materials. Piezoelectric materials are naturally used for energy harvesting from ambient vibration sources, because they can proficiently convert mechanical strain to an electrical charge without any extra power and has a simple mechanical structure. The acoustical-electrical transducer is capable of reducing noise pollution and simultaneously generating electric energy current in shortage and has the advantage of environmental-friendliness.[8] A sound collecting device is designed into a horn and can provide a fixed base for a piezoelectric membrane while effectively receiving sound waves. The angle of an opening of the horn is controlled within 80-85 degrees since the sound is reflected back when being transmitted to a receiving plate and cannot be absorbed by the piezoelectric membrane if the angle is too large, and the sound waves cannot be effectively absorbed if the angle is too small. Meanwhile, a sound receiving device is provided with two active pivots which can be rotated at any angle to receive sound waves from different directions. [9]

Piezo-electric format in human today scientists has prove in their research. Human contains one tone battery in the form of fats may be that fats use to run our small gadgets like mobile. PZT actuator is also a experimental instrument.. [10]The piezoelectric materials that exist naturally as quartz were not interesting properties for the production of electricity, however artificial piezoelectric materials such as PZT (Lead Zirconate Titanate) present advantageous characteristics. The piezoelectric strain coefficients describe the relationship between the applied electric field and the mechanical strain produced.[11]The conversion of mechanical energy into electrical one is generally achieved by converters alternator type or commonly known dynamo. But there are other physical phenomena including piezoelectricity that can also convert mechanical movements into electricity. The piezoelectric effect exists in two domains, the first is the direct piezoelectric effect (discovered by Jacques and Pierre Curie, 1880) that describes the material's ability to transform mechanical strain into electrical charge and the second form is the indirect or converse effect (discovered by Lippmann, 1881), which has the ability to convert an applied electrical potential into mechanical strain energy. As the high output energy is dependent on the high deflection of piezoelectric material so it can be said that if the source sound intensity and pressure can be raised then energy will high.[12]

Previous works discovered that the electrical output from of piezoelectric devices unable to applied directly to some applications since the output power is much lower. For this consequence, there are some circuits have been used to improve the electrical output of piezoelectric devices, such as circuits in Ottman et al. [1921]. It is an approach to harvesting electrical energy from a mechanically excited piezoelectric element. In this circuit, the energy can be stored by using a full-wave rectifier. Ottman analyzed the optimal power flow of piezoelectric device, but the efficiency of energy harvester unable to achieve the maximum point.[13]

Previous works discovered that the electrical output from a piezoelectric devices unable to applied directly to some application since the output power applications is much lower. Most harvesters practically in usable forms can provide low power output, and needs to integrate circuit to harness the higher output power then stored to some applications.

For this consequence, there are some circuits have been used to improve the electrical output of piezoelectric devices. The piezoelectric transducer is connected to three different type of circuitry to improve the power output; Villard voltage multiplier, Dickson voltage multiplier and a full-wave rectifier. In

the recent years, the piezoelectric transduction has received the greatest attention among other energy transduction alternatives. The main advantage of using piezoelectric materials in energy harvesting is their large power densities and ease application. Also piezoelectric devices can be fabricated both macro-scale and micro-scale due to the well-established thick film and thin film fabrication technique [14]

The uniqueness of the experimental study is to utilize the different kinds of sounds such as motor noise as a source of energy. Since energy harvesting is fascinating area of research now that the whole world is looking for green energy as an alternative source. This capturing natural phenomenon for electrical energy generation will be a great contribution for the next years.

Theoretical Framework

This study is supported and anchored with the knowledge of energy harvesting, mechanical vibration, conversion of sound to electrical energy and ohms law.

Energy Harvesting or energy scavenging, is a process that captures small amounts of energy that would otherwise be lost as heat, light, sound, vibration or movement. The use energy harvesting is the collection of input signal for the coverter device[15]

Mechanical Vibration is the motion of a particle or body or system of connected bodies displaced from position of equilibrium. Mechanical vibration usually uses ambient vibration around the power harvesting device as an energy source, and then converts it into useful electrical energy. Vibration occurs frequently in a variety of natural phenomena such as the tidal motion of the oceans, on rotating and stationary machinery, on structures as varied in nature as buildings and ships, in vehicles and combinations of these various elements in larger system. [16]

Energy Conversion is the energy transformation of energy from forms provided by nature to forms that can be used by humans. The term Energy Transformation is used when energy changes forms from one form to another. Whether the energy is transferred or transformed, the total amount of energy doesn't change and this is known as the Law of Conservation of Energy [17].

Ohm's law states that the voltage or potential difference between two points is directly proportional to the current or electricity passing through the resistance, and inversely proportional to the resistance of the circuit The relationship between Voltage, Current and Resistance in any DC electrical circuit was firstly discovered by the German physicist Georg Ohm. [18]. It is use to determine the power delivered by the converter device.

Piezoelectricity is the electricity generated by the piezoelectric element by effect called the piezoelectric effect. It is the ability to of a certain materials to generate an AC voltage when subjected to mechanical stress or vibration.[19]

Mechanical Resonance is the tendency of a mechanical system to respond at greater amplitude when the frequency of its oscillations matches the system's natural frequency of vibration (its resonance frequency or resonant frequency) than it does at other frequencies and it may cause violent swaying motions.[20]

Conceptual Framework

The figure shows below is the input-process-output of the study.

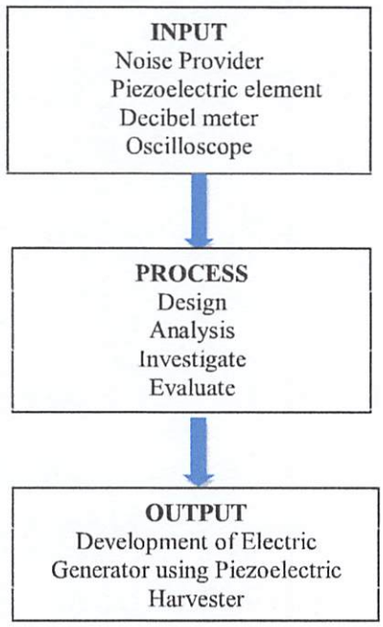

Figure 1. ***IPO of the study***

Figure 1 shows the flow of this experimental study from the beginning up to the end. It starts with the piezoelectric element and noise provider which is the most important factor in this study. The study also includes decibel meter and oscilloscope that is used for data gathering.

It is then followed by the design of the piezo electric generator where piezoelectric elements are connected in various connections such as series and parallel. The process includes the complete analysis of data gathered in every design connection. The data gathered in every connection is investigated, compared and evaluated.

The output of this study is the development of piezoelectric generator using piezoelectric harvester.

Objectives

The general objective of the study is to generate and investigate the capability of piezoelectric in generating electricity. The following are the key guidelines to achieve this study:

1. What are the characteristics of noise in terms of resonance and decibel level?
2. What are the operating characteristics of piezoelectric harvester?
3. What are the design requirements of the electric generator?
4. What is the performance of the project?

2. METHODS

Experimental Design

The figure below show the experimental diagram of the study.

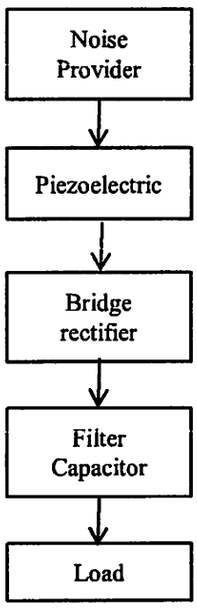

Figure 2. ***Diagram on Experiment Designing***

As shown in figure 2, the first thing to consider is the noise provider that produces a sound or noise. Second stage, an interface circuit is used to increase the output power to become useful to end application. This is due to the condition of the signal generated in piezoelectric transducer is low. A piezoelectric transducer is placed after the function motor absorber from motor and measured the output using decibel meter. The third stage is the bridge rectifier, it converts the alternating current produced by the piezoelectric element into direct current. To reach the maximum output of ac signal, the resonant frequency of all the types of piezoelectric materials must be matched with the sound wave applied. Otherwise, the output will drop significantly. The sound intensity (dB) is also another important parameter that affects the performance of piezoelectric transducer in producing the output signal. Therefore, both parameters will be analyzed to determine the optimum output of dc signal. Next is the filter capacitor to filter the pulsating dc output after rectification so that nearly constant dc will supply to the load. Lastly is load that consumes the electrical source that can generate by the piezoelectric.

Project Development

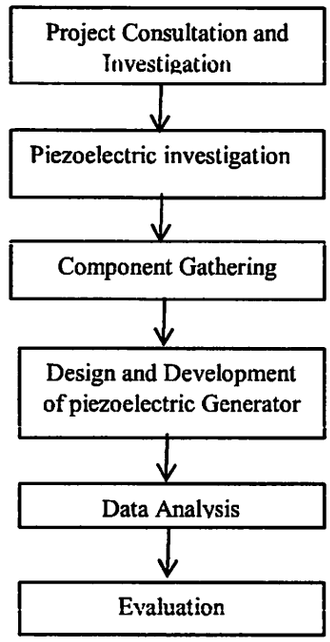

Figure 3. ***Block Diagram of the project development***

In Figure 3 shows the block diagram on how the researchers develop the study. Its start with the project consultation and background check of the study, including the online and offline research related to the project. Researchers then proceed to piezoelectric investigation of what type piezoelectric material is going to used, including the availability of the material. After that, the component gathering is now applied, researchers gathered all the components that will going to use. Throughout these, researchers now are ready to conduct the design and development of the piezoelectric generator and after that the researchers can now conduct the data analysis of the data that will be gathered from the generator. Researchers lastly proceed to the evaluation of results base on the data analysis.

Project Implementation

The owners of the motor together with Barangay Officials/LGU will be the in-charge in implementing the project study that was conducted by the

researchers. Safety and environmental concerns in implementing the project will be assured at all times. Also with the supervision of Electrical Engineer that will monitor the implementation phase until its completion to ensure the safety and appropriateness of the project design.

Project Evaluation

The project study will be evaluated with the results obtained throughout the process. And these are the following to be evaluated in the project study:

1.Performance: Does the generator able to power load?
2. Aesthetics: Is the design of the project approriate base to the usage and its function?
3. Durability: Can the generator withstand any noise provider?

Ethical Consideration

In conducting the project study, the researchers make sure that they did not violate any legal and environmental issues rather they evaluate the human factor as the core of ethical consideration wherein it focuses on the impact of the project design on human intervention.

Instrumentation

In this study, the following components are used as an instrument for the fulfillment of the study:

Oscilloscope is a laboratory instrument commonly used to display and analyze the waveform of electronic signals. In effect, the device draws a graph of the instantaneous signal voltage as a function of time. Oscilloscopes (or scopes) test and display voltage signals as waveforms, visual representations of the variation of voltage over time. The signals are plotted on a graph, which shows how the signal changes. The vertical access represents the voltage measurement and the horizontal (X) axis represents time.

Decibel meter is a measuring instrument used to assess noise or sound levels by measuring sound pressure. Sound level meters look quite simple. They have a pointy stick at the top, which is the microphone that samples and measures the sound. The stick keeps the microphone away from the body of the instrument, cutting out reflections, and giving a more accurate measurement. Inside the square box at the bottom of the meter, electronic circuits measure the sound detected by the microphone and amplify and filter it in various ways before showing a readout on a digital LCD display.

Piezoelectric also called the piezoelectric effect, is the ability of certain materials to generate an AC (alternating current) voltage when subjected to mechanical stress or vibration, or to vibrate when subjected to an AC voltage, or both. The most common piezoelectric material is quartz. Certain ceramics, Rochelle salts, and various other solids also exhibit this effect.

Multimeter is an instrument designed to measure electric current, voltage, and usually resistance, typically over several ranges of value. It can also be used to test continuity between two points in electrical circuit.

Participants of the Study

The participants of this project study are mainly the project beneficiaries, which includes the motor owners. And also with the presence of the professional services of a Mechanical Engineer is needed to help the researchers in making the project study and proper execution of the project.

Table 1. ***Participants Involved in the Project Study***

Participants	F (n = 4)	%
Mechanical Engineer	1	25
Electrical Engineer	1	25
Electronic Engineer	2	50

Project Setting

The project will be conducted at the laboratory of Surigao State College of Technology on engineering building room 203. The school located in Narciso st. Surigao City.

Figure 4. ***Location Map***

Data Gathering Procedure

The researchers asked the co-author for the information related to the study. From there, they ordered the piezoelectric material (35 mm ceramic), voltmeter and decibel meter that will be used in the experiment. As the component arrived, the researchers assemble the piezoelectric elements and went to various loud areas for data gathering.

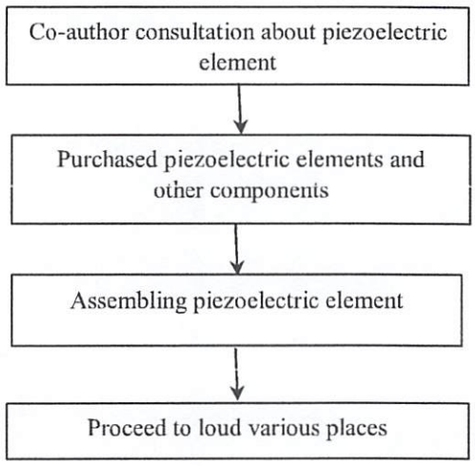

Figure 5. ***Data Collection***

Statistical techniques

In this project study the researchers' uses the following statistical technique:

Mean, in mathematics, a quantity that has a value intermediate between those of the extreme members of some set. Several kinds of mean exist, and the method of calculating a mean depends upon the relationship known or assumed to govern the other members.

Standard deviation is a statistic that measures the dispersion of a dataset relative to its mean and is calculated as the square root of the variance. It is calculated as the square root of variance by determining the variation between each data point relative to the mean. If the data points are further from the mean, there is a higher deviation within the data set; thus, the more spread out the data, the higher the standard deviation.

3. RESULTS AND DISCUSSION

3.1. Noise Characteristics

The following tables and discussions are the results gathered by the researchers throughout the research study. Specifically, the researchers would like to address the following:

Table 2. ***Decibel readings in different noise provider***

Noise Provider	Distance			
	0.5 m	1 m	1.5 m	2 m
Speaker	114.6 dB	99.03 dB	97.1 dB	96.98 dB
Motor Boat	116.3 dB	110.1 dB	94.24 dB	90.05 dB
Public Market	95.78 dB	93.54 dB	84.3 dB	80.3 dB

In the table 2, it shows the decreasing output of decibel at various distances. Among the three noise provider, the Motor Boat is the one that produce greater output of maximum decibel than others. Since the piezoelectric generator was placed in several positions, it gives different kind of results. The closer the material to the vibrations, the more it catches sound waves. The Motor Boat was considered and analyzed for further experimentation.

Thus the intensity of sound has been increased by using this device and more energy can be converted. From the experimental set up depicts that a heavy machine like motor boat releases mechanical energy means of sound and vibration at a time which those are the target for transducing. Sound waves which emit from machine spread around the ambient so it needs to be concentrated in a point to increase its intensity. When the higher intensity sound strikes piezoelectric material in focusing piezoelectric generator, then it produce comparatively high electric energy.

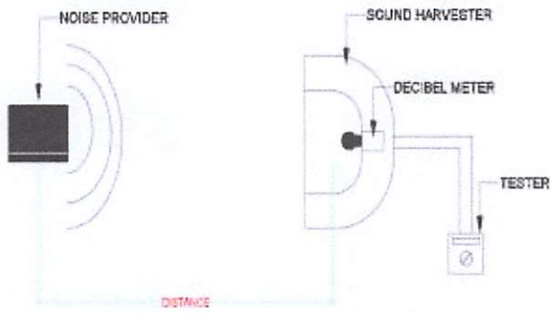

Figure 6. ***Set up of Sound Harvester From Noise provider***

In figure 6 it shows the focusing material was placed in front of the noise provider in several positions from 0.5 m to 2m with the interval of 0.5 m. The noise providers are motor boat, speaker and the public market sounds and vibration.

Figure 7. ***Decibel Meter***

Figure 7 shows the decibel meter serves as the reader to measure the decibel level of sounds from its source.

Pictorial Diagram

Figure 8. ***Multimeter***

Figure 8 shows the multimeter serves as the reader to measure the voltage generated. It used to measure all the output voltage in all different set-ups.

3.2. Operating Characteristics

The sound 35 mm ceramic of piezoelectric were formed and operated in three trials for every noise provider and various distance.

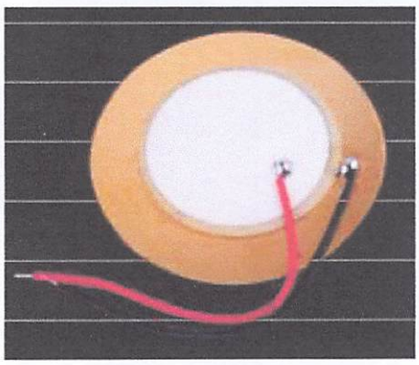

Figure 9. ***35 mm Piezoelectric Element***

Table 3. ***Data Sheet of Piezoelectric***

Part Number	Resonant Frequency (kHz)	Resonant Impedance (ohm)	Capacitance (nF)	Plate Size dia. D (mm)	Element Size dia. a (mm)	Electrode Size dia. b (mm)	Thickness T (mm)	Plate Thickness t (mm)
7BB-12-9	9.0 ±1.0kHz	1000 max.	8.0 ±30% [1kHz]	12.0	9.0	8.0	0.22	0.10
7BB-15-6	6.0 ±1.0kHz	800 max.	10.0 ±30% [1kHz]	15.0	10.0	9.0	0.22	0.10
7BB-20-3	3.6 ±0.6kHz	500 max.	20.0 ±30% [1kHz]	20.0	14.0	12.8	0.22	0.10
7BB-20-6	6.3 ±0.6kHz	350 max.	10.0 ±30% [1kHz]	20.0	14.0	12.8	0.42	0.20
7BB-20-6L0	6.3 ±0.6kHz	1000 max.	10.0 ±30% [1kHz]	20.0	14.0	12.8	0.42	0.20
7BB-27-4	4.6 ±0.5kHz	200 max.	20.0 ±30% [1kHz]	27.0	19.7	18.2	0.54	0.30
7BB-27-4L0	4.6 ±0.5kHz	300 max.	20.0 ±30% [1kHz]	27.0	19.7	18.2	0.54	0.30
7BB-35-3	2.8 ±0.5kHz	200 max.	30.0 ±30% [1kHz]	35.0	25.0	23.0	0.53	0.30
7BB-35-3L0	2.8 ±0.5kHz	200 max.	30.0 ±30% [1kHz]	35.0	25.0	23.0	0.53	0.30
7BB-41-2	2.2 ±0.3kHz	250 max.	30.0 ±30% [1kHz]	41.0	25.0	23.0	0.63	0.40

In table3, it shows the piezoelectric element serve as the main component of the generator since it converts the sound energy to electricity. The datasheet of the 35mm piezoelectric is shown in Table 3.

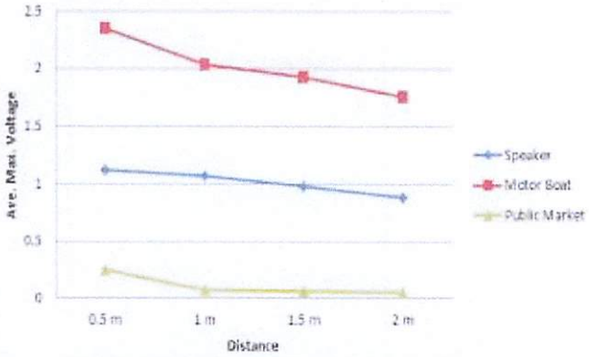

Figure 11. ***Average Maximum Voltage at different point on Noise Provider***

Table 4. ***Voltage output from different noise***

Distance	Speaker	Motor Boat	Public Market
0.5 m	1.114 V	2.352 V	0.251 V
1 m	1.07 V	2.034 V	0.076 V
1.5 m	0.978 V	1.923 V	0.066 V
2 m	0.88 V	1.762 V	0.052 V

The graph on figure 11 shows the average maximum voltage recorded on the basis of generated vibration and sound to the piezoelectric material in Parallel Connection. In table 4 it shows that the highest average maximum voltage 2.352 was found at 0.5 m from the Motor Boat Engine then 1.114V from Speaker and last 0.251V from Public Market. The piezoelectric generator can still generate in 2 m distance from the source.

The focusing material was placed in front of machine in several positions that it can capture several sound waves. Thus the intensity of sound has been increased by using this device and more energy can be converted. The motor boat produces the maximum output because of its constant vibration and sounds since the Hp Beco Diesel Engine as a vibration source running at 1100 rpm. When the higher intensity sound strikes piezoelectric material in focusing part, then it produce comparatively high electric energy.

3.3. Design Requirements of the Electric Generator

The set up for sound harvester has a lot of things to consider. The 35 mm piezoelectric elements, decibel meter and tester are also important. In assembling piezoelectric elements, it was observed in

order to determine the design of the sound harvester whether it was in series or parallel connection.

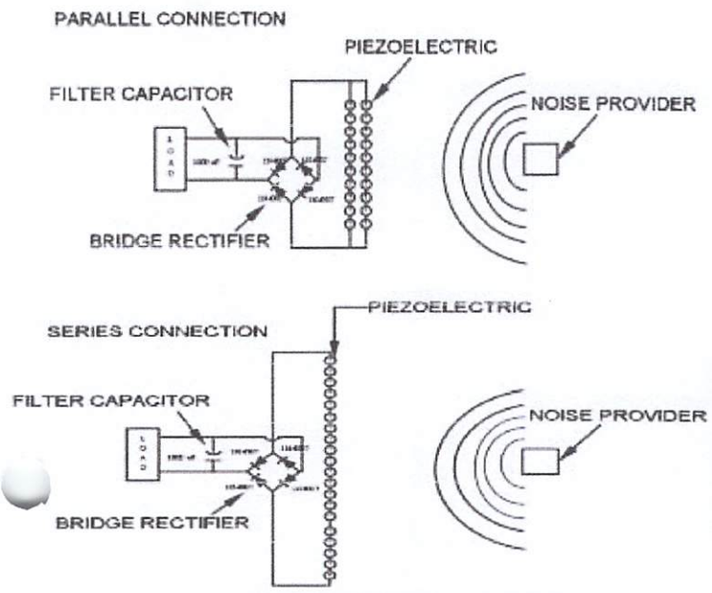

Figure 12. ***Schematic diagram of sound harvester***

The figure 11 shows that the sound harvester composed of 20 elements of piezoelectric. Each element produced electricity, added as one in series connection. For parallel connection, the 10 series elements were connected to other 10 series element.

Table 5. ***Test result from various set-ups***

DISTANCE (m)	SERIES				PARALLEL			
	VOLTAGE		DECIBEL		VOLTAGE		DECIBEL	
	Ave. Min.	Ave. Max.	Ave. Min.	Ave. Max.	Ave. Min.	Ave. Max.	Ave. Min.	Ave. Max.
0.5	2.612	3.963	115.8	120.2	1.142	2.352	98.23	116.3
1	1.832	2.565	98.24	104.52	0.984	2.034	94.92	110.1
1.5	1.12	2.321	95.93	98.24	0.445	1.923	89.78	94.24
2	1.08	1.824	90.87	93.65	0.382	1.435	85.67	90.05

The table 5 shows the output data of voltage and decibel in series and parallel connection. The 0.5 m produced great number than any other distances. In comparison with series and parallel connection, the series connection has a great impact in terms of arrangement and design. The performance of piezoelectric generator depends on the source of sounds, in series connection with the distance in 0.5 m and these are the fair basis to have a fortunate outcome.

In actual performance, there is a resistive load that is the incandescent bulb. The light of an incandescent bulb depends on the power of the motor boat during the operation since the maximum voltage is 3.963V. The voltage generated by the piezoelectric sensor gets rectified and then filtered by filter capacitor. In parallel connection, the incandescent bulb glowed for just a fraction of seconds because of low amount of generated energy. The 35 mm ceramic have the PZT Material that was subjected to high electrical and mechanical stress for vibration.

Pictorial diagram of Testing

The following figure and table shows the testing process made by the researchers with its different distance, set-up and connection.

Figure 12. ***Distance of 1 m from the Sound Harvester to the Noise Provider***

Figure 12 shows the project with a distance of 1 meter from one of the noise provider which is the speaker.

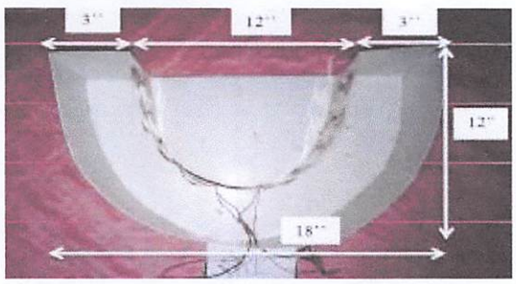

Figure 13. ***Dimension of the sound harvester***

Figure 13 shows the actual dimension of the testing sound harvester.

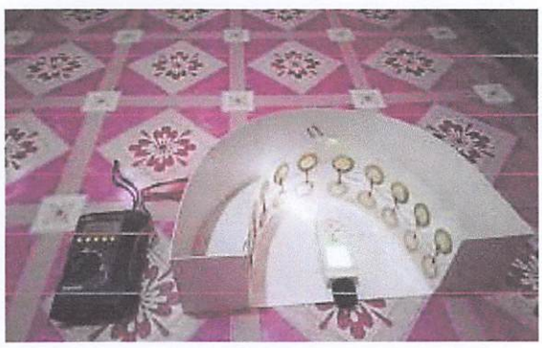

Figure 14. ***Decibel meter reads the decibel level of the noise***

3.4. Performance of the project

Table 6. ***Project Performance Acceptability***

VARIABLES	Mean	Standard Deviation	Quantitative Discussion
Performance			
System Efficiency	2.88	0.6324	Acceptable
Project application in any sound provider	3.00	0.5345	Acceptable
Total	2.94	0.5877	Acceptable
Aesthetics			
Project Designing base to used and function	2.62	0.5175	Acceptable
Clean circuitry	2.87	0.4629	Acceptable
Total	2.74	0.4902	Acceptable
Reliability			
Voltage variation in any noise provider	2.87	0.3535	Acceptable
Reliable power source	2.75	0.7071	Acceptable
Total	2.81	0.5303	Acceptable
Grand Mean	**2.83**	**0.5360**	**Acceptable**

Table 6 shows the evaluation of the device in terms of its performance, aesthetics and reliability. The qualitative description of each mean is based on the following legend: very acceptable 3.26-4.0, acceptable 2.51-3.25, least acceptable 1.76-2.5, not acceptable 1.0-1.75.

4. CONCLUSION AND RECOMMENDATION

Conclusion

From the results obtained, it showed that the electrical energy harvested from ambient vibration and sound was feasible but it still needs further evaluation and testing. Based on the outcome of the results, the following are included.

1. It is concluded that the characteristics of noise in terms of sound and vibration waves which emit from Motor Boat Engine machine produce great amount of decibel and resonance that can generate electricity.
2. It is concluded that the Motor boat Engine produces the maximum voltage with one meter radius to operate the piezoelectric harvester. The higher intensity sound strikes piezoelectric material in focusing part, then it produce comparatively high electric energy.
3. It is concluded that the generator produces its maximum output in series connection in terms of voltage compared to parallel connection.
4. It is concluded that the performance of piezoelectric generator is acceptable in terms of performance, aesthetics and reliability.

Recommendation

Although the project design gives realistic results, the researchers recommend the following:

1. It is recommended to use other piezoelectric sensor that is more 35 mm for the sound harvester. Where it must have both soft ferroelectric for sound conversion and PZT material subjected for vibration.
2. It is recommended to design a new model and add other devices to redirect the sound wave in a specific point on piezoelectric material for getting higher sound pressure.
3. It is recommended to use a vibration tester to measure the displacement, velocity, acceleration of the vibration.
4. It is recommended to implement both sound and vibration converting technology largely and integrate them in a structure for better future success of this project.

5. ACKNOWLEDGEMENTS

This project study proposal has been made successfully through the help and support of many individuals. The researchers would like to extend their sincere gratitude to all them. First and foremost, to the Almighty God for the wisdom He bestowed upon us, strength, patience, good health and guidance He unconditionally gave to the researchers in order to finish this study proposal. We would like to express our gratitude to Engr. Aldrich B. Calinawan for the encouragements, knowledge and support he gave which help to the researchers to complete this paper. To the beloved parents of the reasearchers who gave their full supports, motivation, guidance patience and spiritual support they provide in working this paper. Our thanks and appreciation also goes to the fellow researchers and people who willingly helped out with their abilities

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DESIGN AND DEVELOPMENT OFA DIGITAL ELECTRIC METER WITH GSM TRANSMISSION

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Abstract. Smart meters are tools used to manage and record electricity and performance of electronic devices in a certain household. What makes the meters "smart" is their ability to provide detailed and accurate analytics on electrical usage in real-time or at predetermined intervals, all without a technician. Developmental research will be used in order to develop and make an instrument that is effective for the electric cooperatives and its meter readers. For monitoring system, major programming languages had been introduced to relate the methodologies and execute logical functions.The design and development of a digital electric meter with GSM transmission to electric cooperatives was conceived in energy meter system that can incorporate with embedded controller and GSM modem to transmit the data like consumed energy in kWh. By the development of this study the researchers were able to obtain results like the system based its whole operation on the real time clock which provides the time and day for the system when to transmit the data collected throughout the operation, next is the circuit needs a regulated power supply with a stable output voltage of 6-12V with at least 550mA stable output current because the circuit is dependent on the source provided by the power supply. In addition this project has a very high success rate on returning the investments at the end of the fiscal year with a healthy 65% ROI. This project is very affordable and marketable with its automatic function capabilities.

Keywords. Microcontroller, Electric Meter, GSM, Optocoupler, Real Time Clock(RTC)

1. INTRODUCTION

Electric utilities use electric meter or energy meter to measure electric energy delivered to their costumers for billing purposes. The most common in calibrating to energy is the Kilo-watt hour [kWh]. They are usually read once each billing period.

In electro-mechanical and digital metering system, electric energy is inspected by person and most often they prepared the bill through assumption based on his history of electricity consumption. Maybe the consumer has not utilized the similar amount of electricity in the current month as in the previous months for reasons such as, holidaying elsewhere or being in the hospital, etc. This method of billing is also not suitable for the electricity supply company because it gives an inaccurate account of the overall power consumption in the consumer's area and may ultimately result in [1].

Over the past years, metering devices have gone through many improvements and enhancements and become more complicated with more features and functions. Electromechanical Meter has very little accuracy and lack of configurability. There are so many problems require utility companies to overcome such as electricity theft, meter modifications and more. Meters are limited to provide the amount of energy consumption on consumer's premises.

Meters are read by expensive meter reading device. In remote areas reading electric meter causes danger to meter readers considering bad weather conditions. Meter readers spend the majority of their hours on the clock driving from location to location and in the various backyards of consumers reading physical meter.

The above mentioned problems bring forth the birth of the study. The researcher's project provides a simple avenue of improvising the method that is cost-efficient and time based electrical intervention intertwined with the long term end of a sustainable development plan. It is a very timely study that would hopefully bring aid to meter readers that are constantly facing the issue of wasting majority of their hours such as driving, manual reading, and taking shelter during unpleasant weather conditions.

The design and development of digital electric meter with GSM transmission to electric cooperatives would like to be an effective and efficient instrument that would measure the user's daily power consumption and display it in LCD and will send a message via SMS to the distribution utilities at the end of the month for the awareness of how much power was consumed by the consumer.

Related Literature

There are related articles and released books and other patented projects which are anchored in this project study. One study that this project is based on is about Smart energy metering and power theft control using arduino& GSM this study focuses on Energy theft; a very common problem in countries like India where consumers of energy are increasing consistently as the population increases. Utilities in electricity system are destroying the amounts of revenue each year due to energy theft. The newly designed AMR used for energy measurements reveal the concept and working of new automated power metering system but this increased the Electricity theft forms administrative losses because of not regular interval checkout at the consumer's residence. It is quite impossible to check and solve out theft by going every customer's door to door. In this paper, a new procedure is followed based on MICROCONTROLLER Atmega328P to detect and control the energy meter from power theft and solve it by remotely disconnect and reconnecting the service (line) of a particular consumer. An SMS will be sent automatically to the utility central server through GSM module whenever unauthorized activities detected and a separate message will send back to the microcontroller in order to disconnect the unauthorized supply. A unique method is implemented by interspersed the GSM feature into smart meters with Solid state relay to deal with the

non-technical losses, billing difficulties, and voltage fluctuation complication[2].

Another study that this project was based on was a smart energy meter for an automatic and superior metering and billing system. The integration of the Arduino and GSM Short Message Service (SMS) provide the meter reading system with some automatic functions that are predefined. The proposed energy meter system can incorporate with embedded controller and GSM modem to transmit the data like consumed energy in kWh, generated bill, security services (line Cut/On) over GSM mobile network such as data can be then fed and integrated into existing energy management systems located at power companies or organizations to provide the services among the customers without man-power.[3]

Anotherobjective of this paper is to develop a system which can transmit the meter reading of local area electric meter to the nearest electric meter billing and controlling station. For this we interfaced analog electric meter with the digital circuitry to provide real-time billing & reading to the customers by using Liquid Crystal Display (LCD). There are basically two ends, one is user end and the other is server end. The meter can either be prepaid or postpaid, which is completely monitored and controlled by the server end of a specific area. Each user will be provided by a pin code to access the meter either for recharge the meter bill or to check the balance in case of prepaid meter. The key elements of this research are micro controller, global system for mobile communication (GSM) module, and analog meter with IR module. The whole system is revolving around the GSM module and the micro controller, where GSM module is used for the wireless data transmission and controller controls the whole operation of the system[4].

This project tends to develop a programmed electronic device that computes the power consumption of a device or an appliance showing the computed assumption cost that the device has consume and allows the user to have the idea of monitoring the electric cost of an appliance they are using is to design and develop of electric power and cost monitoring device. Furthermore, it answers the question of many households about the energy consumption of every device while giving them the chance to control their usage and budget their at the same time. The study uses development research for designing and making instructional program for the Electric Power Cost Monitoring Device. It uses an Arduino Uno to perform all the required functions from generating the codes from the computer to perform displaying messages on the LCD. The system provides computation of the used time duration, the power consumption and estimated cost base on the usage of the appliance or device consumption allows them to manage their budgets and be aware of the maximum carrying capacity of their own devices. Based on the result accumulated, the design and development of the monitoring device is accurate, reliable and efficient. [5]

Another project study is about an electronic meter in which they use two micro controllers, sensor, relay, a power supply, LCD Display, an RTC, and an SD card logger. The process of this project study is setting a certain time period or duration in a household which the household appliances must follow. This act or process is the bases of controlling the usage of the electric power consumption of all appliances in a household. This shows that when the time period that has been set is reached the system automatically disconnects or connects.[6]

In some country such as India faces the issue of energy theft at a very large scale. This paper introduces a system that removes human intervention in meter readings and bill generation thereby reducing the error that usually causes chaos and energy related corruption. The proposed system is implemented using a GSM shield module on microcontroller (Arduino®) together with LDR sensor and relay. Existing metering system can be minutely modified to implement the proposed meter. The proposed scheme is to connect an LDR sensor with the blinking LED and send the data to microcontroller via GSM shield. RTC provides delay and acts an interrupt. The system includes a provision of sending an SMS to user for update on energy consumption along with final bill generation along with the freedom of load re-configuration via SMS. The disconnection of power supply on demand or due to pending dues was implemented using a relay. Hardware implementation results suggest that the accuracy of the proposed system is slightly greater than that of existing smart meters. The cost of system has been estimated to be less than the available smart meters, offering the same functionality. Bilateral communication between user and system sets it apart from the commonly available smart meters.[7]

A lot of automatic meter readers today uses relays as a interrupting device in controlling the entire meter however it uses embedded systems to manipulate its functions according to what is being instructed to it. Some systems uses GSM module in triggering the relay however the said concept was used in the present project it uses a GSM module to send SMS through distribution utilities containing how much kilowatt hour was consumed by the consumer it contains embedded systems for manipulating the instructions to over and over again.

The said study has unique abilities to send data's like consumed energy in kilowatt hour through wireless system based on GSM/GPRS to distribution utilities, this system is more user-friendly, reliable, and cost effective.

Theoretical Framework

Programming is a process of taking an logarithm and encoding it into a programmable language to instruct the computer to perform various tasks. It occurs in one or more languages, which differ by application, domain and programming model.[8]

Simulation is a set of techniques of computer to imitate the operations of a real world task or process. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.[9]

Embedded system Embedded systems are designed to carry out one function very well, and will often only be required to repeat this function over and over again; some embedded systems can be designed to control the entire operating system. Embedded system is a controller that sits within a larger system in order to perform a dedicated function. The main difference is that microprocessors are made up of just a central processing unit, with additions like RAM and ROM being added externally. Microcontrollers, however, generally come with a fixed amount

of built-in memory. Embedded systems are required to be highly reliable, as any faults in the unit can have devastating consequences for the larger system. Not only will core functions cease to operate, but accessing and fixing an embedded system can be incredibly difficult depending on the device.[10]

Impulse per kilowatthour (imp/kph) a pulse output corresponds to a defined amount of energy passing through the meter (kWh/Wh).

Calculating Power 3600 seconds per hour = 3600J per pulse i.e. 1 Wh = 3600J therefore, instantaneous power **P = 3600 / T** where T is the time between the falling edge of each pulse.

Conceptual Framework

The block diagram has been used to outline the projects system as shown in Figure 1. It consists of four stages namely: Input, Process, Output and the Evaluation.

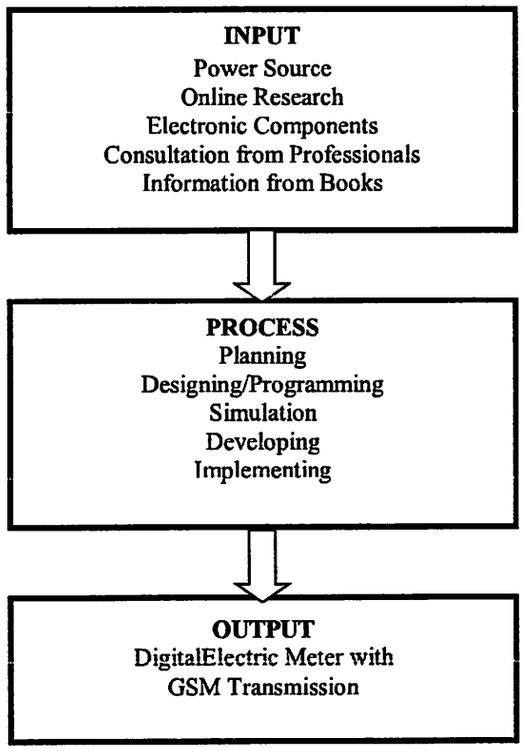

Figure 1. ***The IPO diagram of the study***

As shown in the figure 1, the researchers' starts with input stage wherein all the materials and equipments necessary to visualize the research project was determined like Power source, electronic components, information from books and some consultation from professionals. After determining all the necessary equipments from input stage the researchers then proceed to the process stage where planning, designing/programming, simulation, developing and implementing were involved. The said stage is not easy as it seems because it may involved complex calculation, programming and trial and errors throughout the success of the study. The digital electric meter with GSM transmission is the expected output were it measures the consumed energy by the consumer and sends a message through wireless transmission to electric cooperatives.

Objectives

The general objectives of this study are to design and develop a digital electric meter with GSM transmission to electric cooperatives that wouldreduce the challenges encountered by the meter readers. Specifically, the study would like to address the following:

1. What are the characteristics of a digital electrical meter?
2. What are the design parameters of the system?
3. What is the financial feasibility of the project?

2. METHODS

Research design

Developmental research has been defined as the systematic study of designing, developing, and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness.[11]This research design is used is by the researchers to develop and make an instrument that is effective for the meter readers to reduce the challenges they encountered.

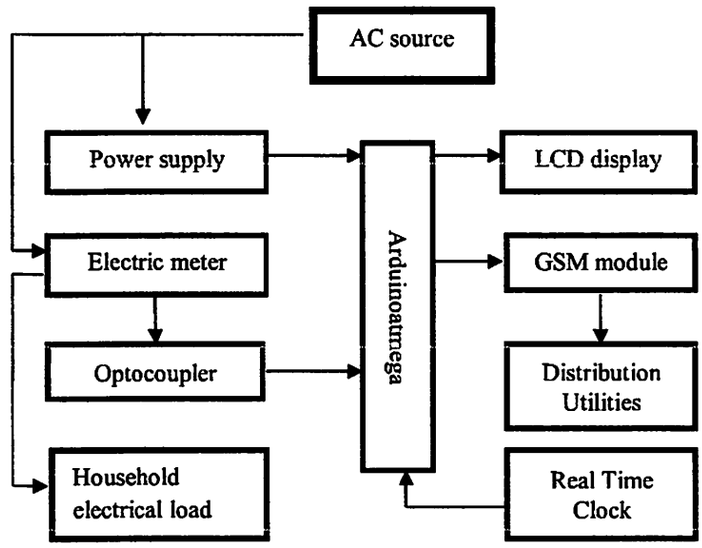

Figure 2. ***The block diagram of the System***

Figure 2 shows the block diagram of the system. From the input stage there are five components namely the AC source, power supply, electric meter, real time clock and optocoupler. AC source means alternating current it is the one who provides power for the whole circuit. Next is the power supply, it converts the AC into DC (Direct Current) since the circuit needs dc supply, power supply is necessary. Third is the electric meter, it provides the most important aspect of the system because it contains a lcd that will display pulse in terms of the load it detects. Fourth is the optocoupler, it has a built-in led and a light dependent resistor connected internally whenever the led detects input from the circuit it provides a blink or pulse that will be counted to the arduino. Fifth is the real time clock it is provides the time and date of the system to remind the system when to transmit data to the monitoring system. For the processing stage it contains only the arduinouno, it serves as the brain of the circuit or the central processing unit it contains

programming languages and logical functions to execute the instructions designed by the researchers. For the output stage it has a LCD display that will allow the consumer to monitor their daily consumption it displays their consumption per pulse. Next is the GSM module it transmits a message through wireless data connection to the distribution utilities.

Project Implementation

The researchers together with the electricians and some of the house owners will be in-charge of implementing the development of a digital electric meter with GSM transmission and the safety concerns of the surrounding community. The said project will measure their daily consumption in terms of pulse per kilowatt hour and sends a message to the distribution utilities through wireless connection in a specified date.

Project Evaluation

The said study will be evaluated based on the product performance. The following statements are the main basis:

1. Applicability: Is the device signal available for the chosen project site?
2. Accuracy: Can the device transmit message at the same time?
3. Durability: Can the device withstand heavy weather condition?
4. Reliability: Is it reliable to use this device for the electric cooperatives?
5. Performance: Will the product do the intended job?
6. Conformance to Standard: Is the product made exactly as the designer intended?

Through these project evaluations with some participants involved in the project study the researchers will be able to produce the desired standard of the product as the designer intended.

Project Development

The researchers tend to design and develop a digital electric meter with GSM transmission to transmit data in a form of messaging method to electric cooperative.

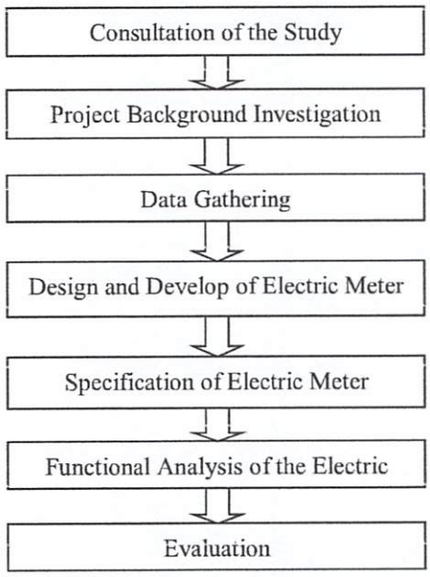

Figure 3. ***Block diagram of project development***

Figure 3 shows the block diagram on how the researchers develop the research study. It all starts from consultation of the study after some consultation the researchers then precede to project background investigation wherein some online and offline researches are conducted. Through these researches data gathering can now be applied for the finalization of the ideas gathered. Through the ideas that are being gathered by the researchers the design and development of electric meter can be visualize. However, specification of electric meter must be taken into consideration since the system depends on the pulse produced by a certain electric meter. Functional analysis and evaluation will be conducted as the product performs its designated functions.

Ethical Consideration

In conducting the project study, the researchers make sure that they did not violate any legal and environmental issues rather they evaluate the human factor as the core of ethical consideration wherein it focuses on the impact of the project design and development on human intervention.

Participants of the Study

The participants of the said study are mainly the electric cooperatives personnel and the researchers together with the household owner.

Table 1. ***Participants Involved in the Project Study***

Participants	f (n=20)	%
Electricianrepresentatives	5	25%
Household owner	13	65%
Computer Engineer	1	5%
Electrical Engineer	1	5%

Project Setting

This project is sited at Mr. Nico Lloyd F. De Guzman's household located at Peñaranda St. Brgy. Taft, Surigao City.

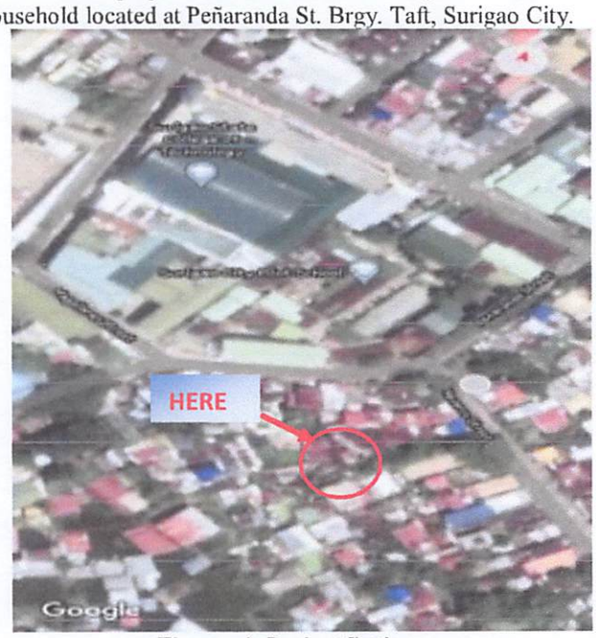

Figure 4. ***Project Setting***

Instrumentation

In this study, the following computer software applications and electronic based components are used as an instrument for the fulfillment of the study:

Power Supply is a hardware component of a computer that supplies all other components with power. The power supply converts a 110-115 or 220-230 volt AC (alternating current) into a steady low-voltage DC (direct current) usable by the computer and rated by the number of watts it generates[13].

Arduino Uno it is a microcontroller board developed by Arduino.cc and based on Atmega328. It is a very valuable addition in the electronics that consists of USB interface, 14 digital I/O pins, 6 analog pins, and Atmega328 microcontroller. It also supports serial communication using Tx and Rx pins[14].

Liquid Crystal Display (LCD) is a flat, thin display device that has replaced the older CRT display. LCD provides better picture quality and support for large resolutions.Generally, LCD refers to a type of monitor utilizing the LCD technology, but also flat-screen displays like those in laptops, calculators, digital cameras, digital watches, and other similar devices[15].

Real time Clock(RTCs)must accurately keep time, even when the device is powered off because, it is often used as a trigger for turning the device on or triggering events such as alarm clocks. RTC ICs run on an alternate power source, which allows it to continually operate under low power or even when the computer is turned off. ICs on older systems utilize lithium batteries, whereas newer systems make use of auxiliary batteries or supercapacitors. RTC ICs that use supercapacitors are rechargeable and can be soldered. But in most consumer-grade motherboards, the RTC is powered by a single battery that, when removed, resets the RTC to its starting point[16].

Photocouplers or optocouplers are used to provide many functions: they can be used to link data across two circuits, they can be used within optical encoders, where the optocoupler provides a means of detecting visible edge transitions on an encoder wheel to detect position, etc., and they can be used in many other circuits where optical links and transitions are needed.They even form the essential element in solid state relays where an optical coupling is used to isolate the input and output electrically, whilst enabling the output to be switched according to the input state.. As a result, optical couplers or photocouplers are found in a surprisingly high number of circuits.[17]

GSM module it stands for global system for mobile communication (GSM). The idea of GSM was developed at Bell Laboratories in 1970. It is widely used mobile communication system in the world. GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands.GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates[18].

Nano Connectors is used for connecting the components to the arduino microcontroller and also connecting other components to one another in its designated area.Ulti-Mate Connector is the leading manufacturer for high density, lightweight Nano wired connectors. Our Nano connectors are offered as metal or plastic shells, with metal shell materials such as: aluminum, stainless steel, and titanium[19].

Proteus 7is software for microprocessor simulation, schematic capture, and printed circuit board (PCB) design.vThe Proteus Professional demonstration is intended for prospective customers who wish to evaluate professional level products.

Data Collection Procedures

The data is being collected in terms of the systems performance by comparing the value of standard parameters to the data gathered by the sensor being used. The result will be recorded and its differences will be evaluated.

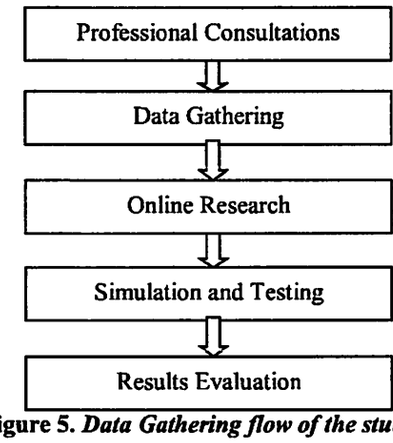

Figure 5. ***Data Gathering flow of the study***

The researchers started the data gathering through consultations from professionals who are experts in the chosen field. Also, researches from online for the material specifications to be use and sample programs to serve as guide for the simulation of the project. Through simulation and testing the researches will be able to gather results and perform some evaluations.

Statistical techniques

In this project study the researchers' uses the following statistical technique:

Mean, in mathematics, a quantity that has a value intermediate between those of the extreme members of some set. Several kinds of mean exist, and the method of calculating a mean depends upon the relationship known or assumed to govern the other members.

Standard deviation is a statistic that measures the dispersion of a dataset relative to its mean and is calculated as the square root of the variance. It is calculated as the square root of variance by determining the variation between each data point relative to the mean. If the data points are further from the mean, there is a higher deviation within the data set; thus, the more spread out the data, the higher the standard deviation.

3. RESULTS AND DISCUSSION

The following tables and discussions are the results gathered by the researchers throughout the research study. Specifically, the researchers would like to address the following:

3.1 Characteristics of a Digital Electric Meter

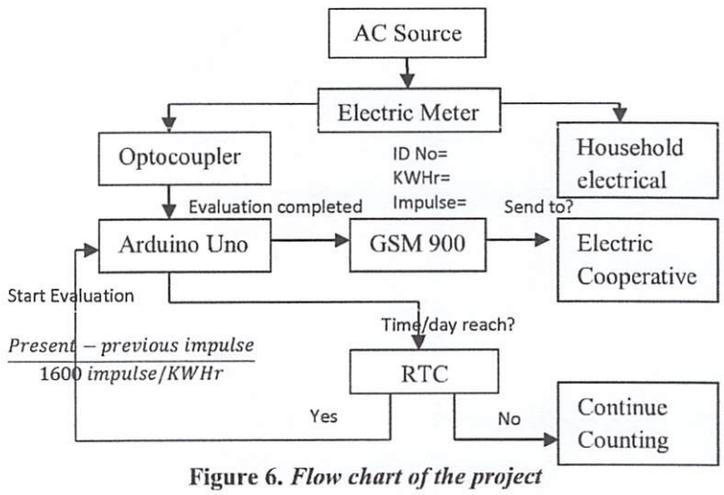

Figure 6. ***Flow chart of the project***

Figure 6 shows the flow chart of the Digital Electric Meter it starts with the AC source which provides power to the electric meter next is the optocoupler and the household electrical load this household represents the consumer while the optocoupler senses the impulse produced by the electric meter which is dependent on the load of the household. The impulse sensed by the optocoupler was then sent to the arduino it shows that RTC is connected to the arduino. Real Time Clock (RTC) provides time for the system of when to evaluate the impulse counted in the arduino. When the time is reached the arduino will evaluate the impulse counted and then after the evaluation the GSM will send this data to the electric cooperative.

3.2 Design Parameters of the Digital Electric Meter

Table 2. ***Software Requirement of the System***

Components	Equivalent Arduino libraries
GSM-900	GPRS_SIM900-master
Real Time Clock (RTC)	DS3231M DS3231
Liquid Crystal Display (LCD)	LiquidCrystal_PCF8574
Ardino UNO	Arduino.cc

Table 2 shows the main electronic components of the system with its equivalent arduino libraries. These libraries are necessary to be added to the library of the arduino because the arduino software cannot identify the program if these so libraries are not included. These libraries serve as guide in putting all the programs altogether, it contains programs to test and to set the said components.

Table 3. ***Hardware Requirement of the System***

Components	Uses
Arduino UNO	Brain of the system
GSM-900	Transmits message
Real Time Clock (RTC)	Provides time
Liquid Crystal Display (LCD)	Displays output
Electric meter	Provides impulse
Opto-coupler	Senses impulse
Nano connectors	Connects components
Acrylic glass	Serves as casing

Table 3 shows the hardware requirement of the system. It contains the components and its equivalent uses for the system to operate as the designer intended. Starting from arduino it serves as the brain of the system it performs logical and arithmetical functions for the whole system. Next is GSM-900 it transmits data like SMS through wireless data connections to another GSM. Next is real time clock it provides a real time for the system it is where the GSM based on when to transmit message to any power provider. Liquid Crystal Display it displays output through the display it allows the consumer to monitor their daily consumption. Electric meter provides impulse for the optocoupler whenever the meter detects different kinds of loads it produces impulse per kilowatthour. Every impulse produced by the electric meter it was counted by the optocoupler it was made with ldr and a led connected internally, whenever it counts a pulse this pulse will be counted to the arduino and then it will be displayed to the LCD. Next are the Nano connectors or the jumper wires it connects all the electronic components it allows the components to work altogether and to work as one. For the finalization acrylic glass is necessary to cover all the components it acts as the casing of the sytem.it protects the whole circuit from external and environmental disturbances. Through these hardware requirements the system will provide the output as what the designer expected.

Pictorial Diagram

Figure 7. ***Arduino Uno***

Figure 7 shows the arduinouno it serves as the brain of the systemit performs logical and arithmetical functions for the whole system.

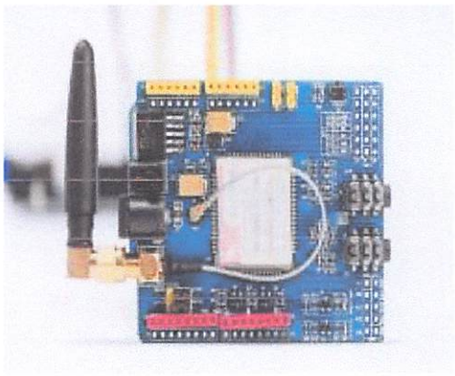

Figure 8. ***SIM900 GSM Shield***

Figure 8 shows the SIM900 GSM Shield it transmits data like SMS through wireless data connections to another Subscriber Identity Module (SIM).

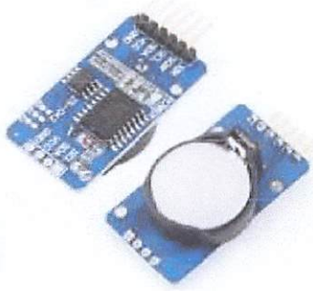

Figure 9. ***DS3231 Real Time Clock***

Figure 9 shows the DS3231 Real Time Clock of the system it provides a real time for the system it is where the GSM based on when to transmit message to any power provider.

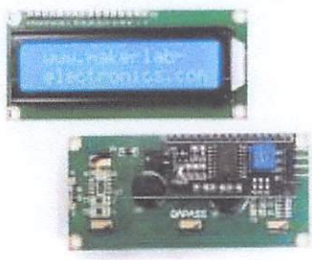

Figure 10. ***16x2 LCD display***

Figure 10 shows the liquid crystal display used in the system it displays output through the display it allows the consumer to monitor their daily consumption.

Figure 11. ***Digital Electric Meter***

Figure 11 shows the electric meter provides impulse for the optocoupler whenever the meter detects different kinds of loads it produces impulse per kilowatthour.

Schematic diagram

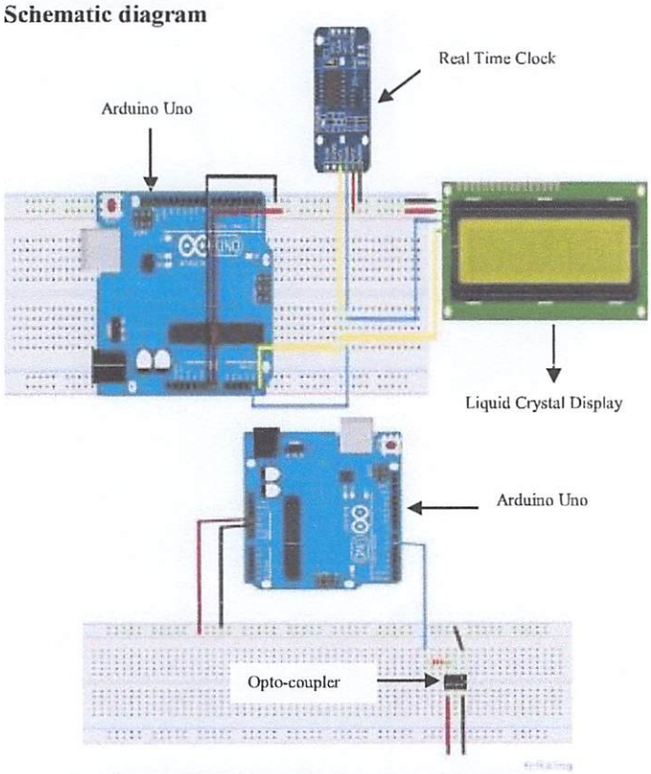

Figure 12. ***Schematic diagram of the project***

Figure 7 shows the schematic diagram of the project it shows the components used by the researchers in designing and developing a digital electric meter with GSM transmission. The components used by the researchers are the latest designed module for arduino to easily attach the said components in actual assembly.

Pictorial diagram with Test Results

The following figure and table shows the testing process made by the researchers with its different power supply and its characteristics in sending SMS.

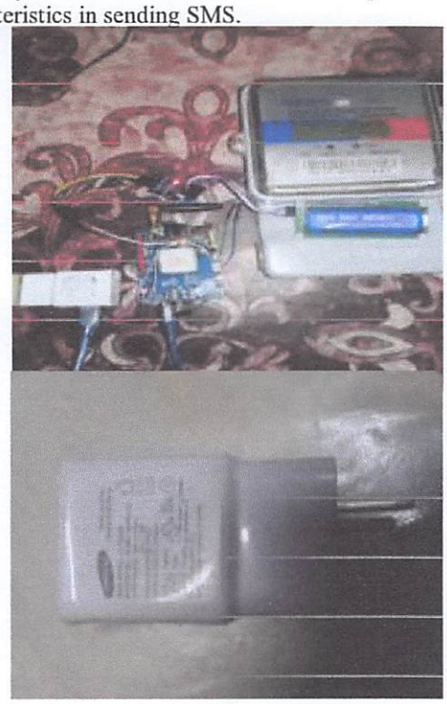

Figure 13. ***Project using multiple AC/DC adaptor***

Figure 13 shows the project using a cellphone adaptor with output voltage of 5V, 2A. This power supply can power on the circuit but it cannot sustain the whole operation of the project it makes the system unstable and produces negative results.

Figure 14. ***Project using AC/DC adaptor***

Figure 14 shows the project using AC/DC adaptor with 5V, 2A power supply. This power supply can power on the arduino and RTC but the LCD wasn't able to display its characters because the supply delivered from the arduino wasn't enough.

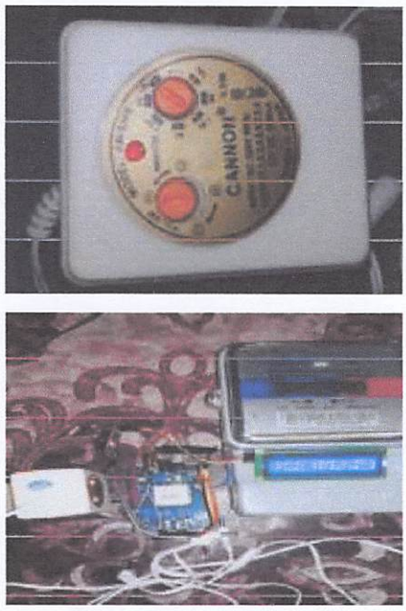

Figure 15. ***Project using multiple AC/DC adaptor***

Figure 15 shows the project using multiple AC/DC adaptor with polarity switch this power supply has 6, 7.5, 9, 12V stable output voltage with 550mA output current. This power supply can sustain the whole operation of the project. The researchers were able to obtain reasonable and error free results.

Table 4. ***Time Elapse between Sent SMS***

Wattmeter	Load(W)	Time(s)
Wattmeter #1	50W	11.42 seconds
	1000W	06.70 seconds
	2000W	09.69 seconds
Wattmeter #2	50W	10.80 seconds
	1000W	12.38 seconds
	2000W	08.21 seconds
Wattmeter #3	50W	11.35 seconds
	1000W	08.31 seconds
	2000W	07.52 seconds

Table 4 shows the intermittent time between sent SMS with different loads. After the researchers assigned loads for every digital electric meter with GSM transmission they also scheduled the time in terms of minutes to properly observe the characteristics of the digital electric meter in sending SMS to the power provider. After every five minutes the digital electric meter will send a message to the power provider having different kinds of loads. After obtaining different values of results from the testing process, it can be inferred from the table that having different kinds of loads in a given digital electric meter cannot affect the transmission of the GSM, however the one that will affect the transmission of the GSM is the cellular phone signal

that will allow the GSM to transmit message to the power provider. In addition another factor that may affect the transmission of the GSM is the speed of the Subscriber Identification Module (SIM) card to receive sent messages. The above table will show the results gathered by the researchers.

3.3 Financial feasibility of the Digital Electric Meter

The table below shows the financial expenses and breakeven analysis of the researchers to design and develop a digital electric meter with GSM transmission.

Table 5.*Financial analysis of the project*

PARTICULARS	QTY	AMOUNT
❖ MATERIALS		
SIM900 Wireless Module GSM GPRS Shield Arduino	1pc.	P1,700.00
Arduinouno R3 atmega328p microcontroller + USB cable	1pc.	P400.00
I2C RTC real time clock module for arduino memory module	1pc.	P105.00
I2C LCD 16x2 liquid crystal display module for arduino	1pc.	P131.00
40pcs. In row dupont cable 10cm 1pin male to male jumper wire	1pc.	P71.00
40pcs. In row dupont cable 10cm 1pin female to female jumper wire	1pc.	P67.00
Digital electric meter	1pc.	P800.00
SIM module	1pc.	P30.00
LDR module for arduino	1pc.	P30.00
Acrylic glass casing	1pc.	P200.00
Sub-total		**₱3,534.00**
❖ LABOR COST (35%)		
Programming Cost		P1,237.00
❖ OVERHEAD COST (15%)		
Travel, maintenance, food and others.		P530.00
GRAND TOTAL		**₱5,301.00**

Table 5 shows the unit cost of the project it includes the materials, labor and overhead cost with a total of ₱5,301.00.

Selling price:

Price= Material cost + Tax(12%) + Mark-up cost(35%)

Price= P3,534.00 + P424.00 + P1,855.00

Price≈ ₱5,813.00

The material cost is the expenses for all the materials used in the project excluding the labor cost and overhead cost and the mark up is multiplied to 35%.

The selling price of the device is based on the above formula, it includes all the materials used in the device itself plus the mark-up cost multiplied by 35% plus the tax with 12%.

Return on Investment:

ROI = (Net profit/total investment)*100

ROI = (P2,279.00/P3,534.00)*100

ROI = 65%

The net profit is going to be the price of the product (₱5,813.00) in its first release minus the material cost (₱3,534.00) so it is ₱2,279.00. The total investment is also the material cost.

So the profit made in a fiscal year expressed in terms of percentage of increase in the value of investment during the year in question is a healthy 65%.

Break-Even Point:

Fixed Cost = ₱5,301.00

Material Cost = ₱3,534.00

Selling Price = ₱5,813.00

$$BEP = \frac{\text{Fixed Cost}}{\text{Selling Price} - \text{Material Cost}}$$

$$BEP = \frac{₱5{,}301.00}{₱5{,}813.00 - ₱3{,}534.00}$$

BEP = 2.3≈ 3

The break-even point of a certain product is the basis on how many products must be put into sales in that particular time or month before any profits are realized.

4. CONCLUSION AND RECOMMENDATIONS

Conclusions

Based on the outcome of the results, the following are concluded:

1. It is concluded that the system based its whole operation on the real time clock which provides the time and day when to transmit the data collected throughout the operation. In addition the kilowatt hour evaluation was based on the standard counting of the electricity bill which is currently used in the present.
2. Therefore, the circuit is dependent on the power supply used in the operation. When using a power supply with unregulated output greatly affects the operation of the circuit however the project works perfectly when a regulated power supply voltage higher than 5V with at least stable output current of 550mA is used.
3. Based on the financial analysis performed by the researchers it is concluded that the product is marketable with its very affordable price and automatic function capabilities. In addition the investors had a very high success rate in investing this product because of its high value of return on investment during the year in question with a healthy 65% ROI.

Recommendations

Furthermore, the following recommendations were formulated:

1. For further development of the said research study it is recommended to have another research study that will serve as the server end like database in this server all information about the consumer are stored.
2. When installing the Digital Electric Meter with GSM transmission it is recommended for everyone to use a regulated power supply with a stable output voltage of 6-12V and an output current of 550mA to avoid negative and erroneous results.
3. It is recommended for everyone to check and observe the behavior of the GSM signal before testing the product so that it can minimize the probability of having unexpected results.

5. ACKNOWLEDGEMENTS

The researchers' wishes to extend their heartfelt and sincerest gratitude to all individuals who have given their support, be it moral, spiritual, and financial which are contributory for the success of this study. The Almighty God who unceasingly provides immeasurable blessings of wisdom, patience and perseverance in all their undertakings. Their deepest gratitude to their co-author, Engr. Andy Bong Navarro for his continuous advice and valuable comments and suggestions towards the realization of this manuscript.Their families, who served as the researchers' source of strength to overcome the challenges that comes along their way in making this study.To the researchers' Engineering instructors, classmates and friends who offered their brilliant ideas and advices, brought constant happiness, inspiration and motivated them during hardships. This project study proposal would be impossible without your cooperation.

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ANALYSIS OF VOID SPACE IN CONCRETE: A CASE STUDY IN SSCT BUILDING

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Abstract: The purpose of this study is to detect the void space in a concrete using the impulse radar, in which this study is located at SSCT building, with the advancement in GPR technology, especially the increase in frequency of commercially available GPR antennae and better data processing software, GPR can now be used for subsurface condition assessment in materials consisting of thin layers[1]. On the other hand, a ground coupled 1.5 GHz antenna was found to offer higher penetration capability, which is crucial for testing thick decks[2]. There are about five developing stages in this study which are, research design, project design, project development, project setting, and data collection procedure[3]. This study is to locate and analyse the void space in concrete providing more relevant and accurate data by simulating raw data collection[4]. GPR offers more penetrating power and so can detect concrete defects or deteriorations at greater depths[5]. As the result of this study the GPR technology has an accurate and sensitive sensor that could cause difficulties during the experiment but by using an accurate algorithm it could be possible to identify the void space[6].

Keywords: Radar system, Ground Penetrating Radar (GPR), Void Space

1. INTRODUCTION

The inspection and analysis of ageing infrastructure assets or those newly installed rely on reliable quantitative data to make informed decisions concerning condition and integrity. Concrete, and other human-made composites (such as asphalt), are widely used as construction materials. As a non-destructive method, GPR can be used to scan these penetrable materials before cutting or coring, or other non-destructive testing.

GPR can see into a structure to provide accurate information showing orientation and depth to subsurface features and objects, an advantage over the more traditional manual and visual inspection methodologies. The information provided by GPR is routinely used to help priorities repair or rehabilitation works according to their importance.

Ground-penetrating radar (GPR) technology has been commercially available since the early 1970s. From the start, operators noticed that the radar image generated around damaged concrete showed increased signal attenuation, sometimes distorted bar reflections, and even direct evidence of delamination cracks.

The development of high frequency antennas, the ability to digitize the collected data, and powerful analysis and imaging software have aided tremendously in the interpretation of test results. In spite of the steady improvement in technology, the main use of high frequency GPR is to locate embedded objects. However, GPR's potential for the condition assessment of concrete structures has been recognized for at least 30 years.

This paper will examine the GPR as a tool for detecting defects in concrete, identify the common numerical method of condition analysis as the main obstacle, and propose an alternative methodology for computer-assisted visual analysis of GPR images capable of producing more accurate deterioration maps of concrete structures.

1.1 Related Literature

Using Ground Penetrating Radar Methods to Investigate Reinforced Concrete Structures. In this paper, an overview of the existing literature within the subject area of ground penetrating radar (GPR) methods for the investigation of reinforced concrete structures is reported. Six major application areas had been identified where experimental, numerical and theoretical research on GPR has been developed. The review demonstrates that the applications of GPR to reinforced concrete structures are continuously growing. It was also observed that research in some application areas has been mostly or exclusively carried out at the laboratory scale and, similarly,

some application areas have been investigated on real-life structures only.

Automatic De-lamination Detection of Concrete Bridge-Decks Using Impact Signals. An AIDD system is described in this paper. In this system, the traffic noise was eliminated by a physical barrier, as well as a modified ICA algorithm. The MFCCs of the filtered signals were extracted, and the most effective ones were selected as features. The mutual in- formation between the MFCCs and the condition of the concrete from which the signal was calculated was used to select the most effective features. The selected features were used to detect the de-lamination and to train a classifier for future use.

An automatic impact based de-lamination detection system for concrete bridge-decks. Even though sounding methods are simple, fast and inexpensive for detecting de-lamination in concrete bridge decks, their performance can be undermined by traffic noise in adjacent lanes and the subjectivity of the operator. To improve the performance of traditional sounding methods, this study addressed the two factors that reduce their performance and an automatic impact- based de-lamination detection (AIDD) system consisting of hard- ware and software components was developed.

Laboratory validation of corrosion induced delamination in concrete by ground penetrating radar. From this laboratory experiment, it is concluded that the peak amplitude of the reflected signal from the rebar is an effective indicator for corrosion assessment when the defects are not visible on the concrete surface. The presence of surface crack and its development are highly associated with the change in amplitude. Further studies on the effect of varying the samples moisture content to the reflected signals are worthwhile, in order to evaluate the feasibility of applying GPR in corrosion assessment in RC structures in the field, where moisture content varies among different field structures.

Condition assessment of concrete structures using a new analysis method. Ground penetrating radar computer-assisted visual interpretation. GPR (radar) is an efficient tool for condition assessment of concrete. It is especially sensitive to the increase in conductivity caused by reinforcing bar corrosion, while delamination cracks and moisture, have little influence on the attenuation of radar data. The main issue is how to extract this information from the data. In the past, the widespread acceptance of numerical amplitude analysis as the only method of data processing has led to mediocre results.

Amplitude analysis ignores most of the information contained in radar images and leads to errors. GPR

The presented case study well illustrate possibilities of the GPR technique in interpretation of complex pavement structures and possible mechanisms of cracking process. In this work, a prototype of an impulse RADAR sensor is developed and studied. Based on the concept of ground penetrating RADAR (GPR).

1.2 Theoretical Framework

Theory 1. Attenuation

Concrete is classified as a dielectric material and can behave either as an insulator or conductor of electromagnetic waves. From the fundamental theory for electromagnetic wave propagation it can be shown for conductive dielectric materials that:

$$\alpha = \omega[\frac{\mu\varepsilon'}{2}(\sqrt{1+\tan^2\delta}-1)} \quad [1]$$

where: a = attenuation coefficient OJ = 2m - angular frequency Theory 2. Wave Velocity

In most practical applications, geological and building materials are classified as low loss materials (tano« \) at radar frequencies and therefore the general equation for wave velocity is often simplified to:

$$v = \frac{c}{\sqrt{\varepsilon_r}} \quad [2]$$

Which is independent of frequency and conductivity. Theory 3.Vertical Resolution

The vertical resolution is a measure of the ability to recognize individual closely spaced reflectors, or to distinguish two signals in the time domain. For a reflected pulse represented by a simple wavelet, the maximum resolution possible is between one quarter and one eighth of the dominant wavelength of pulse. For the present analysis it was assumed one quarter as usually adopted in GPR practical applications. The wavelength can be calculated in general by equation:

$$\lambda = \frac{v}{f} \quad [3]$$

Where v = wave velocity f = frequency Theory

4.Clutter Reduction

Clutter in GPR systems refers to the radar signals returned from material heterogeneity. In the case of concrete it would be mainly the energy

scattered by the larger aggregates. To minimize the clutter effect, the dominant signal wavelength should be much larger than the characteristic dimension of the heterogeneity in the host environment. However for concrete, since it is an artificial material obtained by the mixture of other known materials, there is some control over their size. For this reason, this analysis was carried out assuming only five times the characteristic dimension of the heterogeneity.

$$f < \frac{60}{d' \sqrt{\varepsilon_r}} \qquad [4]$$

d' represents the characteristic dimension of the heterogeneity. Theory 5. Horizontal Resolution There are two main controls on the horizontal resolution of a reflection survey, one being intrinsic to the physical process of reflection and the other being determined by the transducer spacing in the case of bistatic mode operation. Since GPR applied on structures usually involves using transducers which act as transmitter and receiver simultaneously, the bi-static mode was not considered in this study

1.3 Conceptual Framework

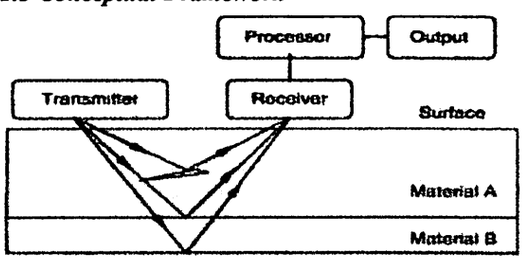


Figure 1. ***Principle of testing with the GPR system.(Dong, Y.Ansari, F, 2011)***

Ground penetrating radar (GPR) operates by transmitting electromagnetic waves (in the range of 10 ~ 10 00 Hz) into the probed material and receiving the reflected pulses as they encounter discontinuities. The discontinuity could be a boundary or interface between materials with different dielectrics or it could be a subsurface object such as de-bond or delamination.

The amplitudes of the received echoes and the corresponding arrival times can then be used to determine the nature and location of the discontinuity.

Compared to other non-destructive techniques such as infrared thermographs, ultrasonic or microwave, GPR offers more penetrating power and so can detect concrete defects or deteriorations at greater depths.

1.4 Objectives

This study is to locate and analyse the void space in concrete providing more relevant and accurate data by simulating raw data collection.

The specific objectives are:

1. To document the system design.
2. To identify void space in concrete.
3. To apply impulse radar to detect the void space in concrete.
4. To analyse data base on radar gram results.

2. METHODS

2.1 Research Design

With the advancement in GPR technology, especially the increase in frequency of commercially available GPR antennae and better data processing software, GPR can now be used for subsurface condition assessment in materials consisting of thin layers. Careful analysis of GPR waveforms can potentially help detect subsurface de-bond sand delaminations within the deck. Compared to other nondestructive techniques such as infrared thermography, ultrasonic or microwave, GPR offers more penetrating power and so can detect concrete defects or deteriorations at greater depths. Results from the literature review show that the lower frequency GPR antenna (1 GHz) cannot detect shallow defects such as de-bonding in FRP wrapped members, but a phase higher frequency antenna (2 GHz) can detect those defects (Jackson *et al.*, 2000). On the other hand, a ground coupled 1.5 GHz antenna was found to offer higher penetration capability, which is crucial for testing thick decks (Halabe *et al.*, 2006).

2.2 Project Design

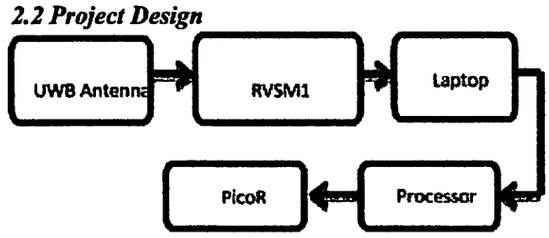


Figure 2: ***Block diagram of the proposed project***

An impulse radar-based system working with a series of discrete sinusoidal pulses within a specified broad-frequency band and a signal repetition rate. Using PicoR-2k evaluation kit for UWB short-range radar development allows to reveal the possibilities of technologies of generation, emission, reception and processing of impulse UWB signals. It is

used to develop portable short-range radar systems, including GPR (ground penetrating radar), inspection of building structures (search for reinforcement, irregularities in the structure of the material, determination of any concrete de-lamination).

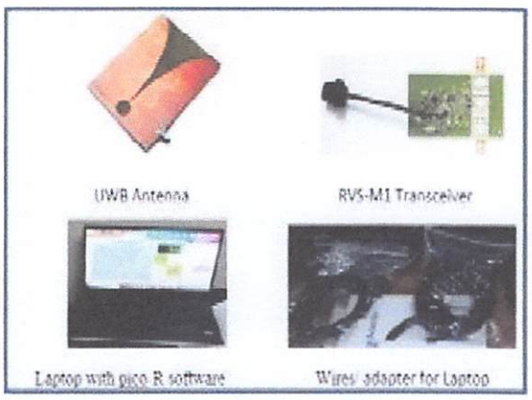


Figure 3. ***System Component***

2.3 Project Development

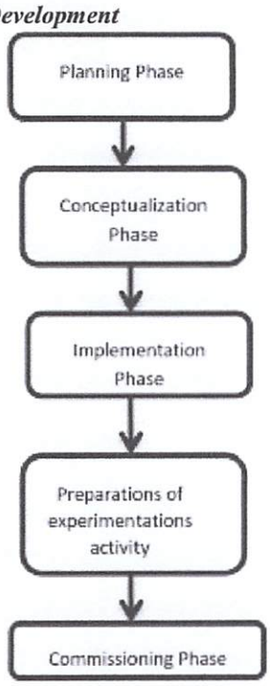


Figure 4. ***Development process of the study***

Planning Phase- The planning will be done with the team for right acquisition of electromagnetic wave radar which can be modified and upgrade. Materials on the fabrication of the antenna are also considered base on local market availability.

Conceptualization Phase - Designing of structural, mechanical, and architectural components. The design is simulated and rendered in the computer for optimization.

Implementation Phase - Antenna simulation using CST software, fabrication of antenna, signal processing design based on raw data extracted from the electromagnetic radar and GUI design will be implemented in MATLAB.

Preparation of experimental activity - A concrete slab will be prepared where it will be exposed to 28 days curing, a DC current injected on three rebar to expedite the corrosion while submerging to NaCl solution to simulate corrosion. Observation of infrared thermograph will be observed and the electromagnetic radar wave behavioural analysis.

Commissioning Phase - Performance testing to the detection of de-lamination in building structure. Refinement and adjustment based on actual problems encounter during the actual scenario of assessment.

2.4 Project Implementation

To accomplish this study, the prototype model of an experimental cart made with ½ inches diameter PVC pipe has been designed and constructed. The cart is pushed and pulled through a flat surface or railing to provide smoothness and avoid shaking of the antenna. The experiment was to detect void space in concrete. Two types of concrete was experimented, with void space and without void space. The scanning trial of each area is tested by pushing and pulling the impulse radar. The scanning trial was conducted in three areas. First area of scanning is conducted at SSCT main campus building, selecting two specific area where there is void space, and without void space, marking it of white tape with the dimension 100x100 cm and 20 cm thickness. The same as in the second area, conducted at Brgy. Cayutan Surigao City basketball court, selecting specific area to be test with void space and without void space, marking with the dimension 100x100 cm and 10 cm thickness. The experiment was done using the impulse radar 1GHz antenna.

The third experiment was conducted using two specimens of concrete block and concrete block with void space. One specimen is purely concrete block with a size 10x100x100cm, another specimen with glass bottle mixed in the concrete block with the size of 10x100x100 cm. The movement of the cart is perfectly perpendicular to position of the buried glass bottle.

2.5 Project Setting

Figure 5. ***Location of the Case Study (Google Maps)***

Surigao State College of Technology (SSCT) is located at Magallanes Street, Surigao City, 8400 Surigao Del Norte. It was built in the year 1960's, an earthquake of magnitude 6.7 hit Surigao City in the night of February 10, 2017, Friday. The school was badly hit by the earth quake which is a perfect location for studying any de-lamination in the concrete structure of the buildings.

2.5 Instruments

In this study, the following components are used as an instrument for the fulfilment of this experimental study:

1. PicoR software
2. Computer/ laptop
3. Transmitting and 1GHz receiving antennas
4. Push cart
5. Measuring tape
6. Marking tape

2.6 Data Collection Procedure

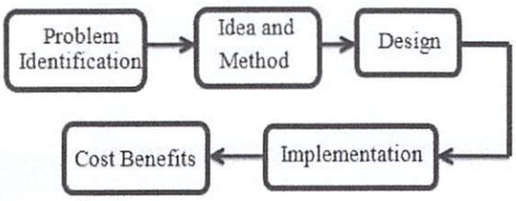


Figure 5. ***Quantitative and qualitative data collection***

Problem Identification - Understanding the behavior based on the signal processing representation from the simulated delaminated reinforced concrete, crack, voids, or moisture content. Antenna consideration and program adjustments will be explored until evidence of the target of interest will be distinguished and proven. **Idea and Method -** The GPR is used to image the subsurface, it may use on a host of different penetrable materials to detect and map features or objects within, GPR is the idea way to investigate the subsurface for a wide range of applications, deploying GPR in the field is easy, and sites can be scanned rapidly, which also makes it an economical choice, With the advancement in GPR technology, especially the increase in frequency of commercially available GPR antennae and better data processing software, GPR can now be used for subsurface condition assessment in materials consisting of thin layers.

Design - The traditional electromagnetic wave radar sensor which has separate monitor, data acquisition unit, long transmission and power cables, backup battery, rf amplifier, transmit/receive antenna and cart with manual picoR.

Cost Benefits - The cost benefit analysis well be computed based on commercially available electromagnetic wave radar and develop portable electromagnetic wave radar. Market analysis is also presented to this report where there will be a survey to the construction firm companies and building owner for future commercialization.

3. RESULTS AND DISCUSSIONS

3.1 Documentation of the system design

Figure 6. ***Preparation and making concrete slab***

Figure 6 shows the preparation and making of two concrete slab one with void and one without void space for experimentation, mixing 3 sacks of gravel and 3 sacks of sand with 1 sack of cement to form two concrete block with the size of 6x100x100 cm.

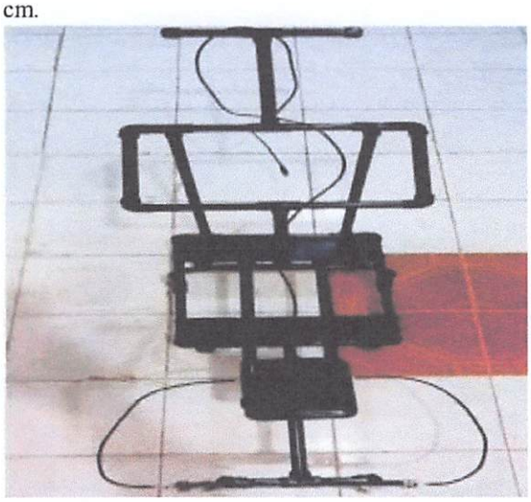
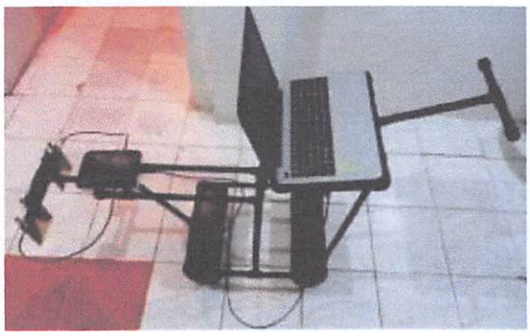


Figure 7. ***Top view of system design*** Figure shows the top view of the cart for the picoR system.



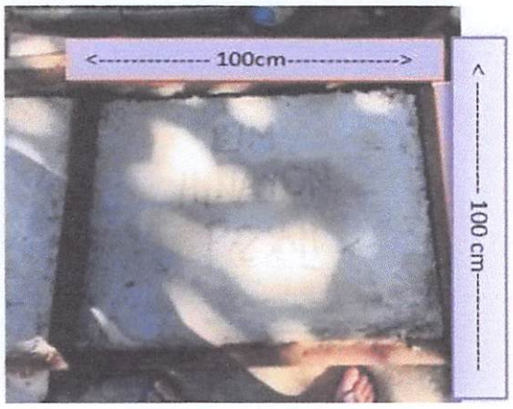


Figure 8. ***Right side view of system design***

Figure 8 shows the right side view of the system design where the installed picoR system.

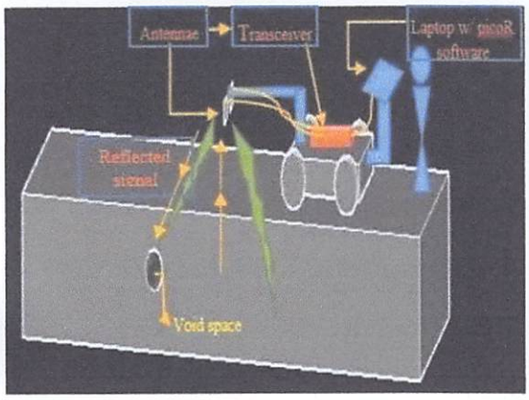


Figure 10. ***Concrete Slab without Void Space***

Figure 9. ***Test Principle of the GPR system***

Figure 9 shows the scanning principle of the Ground Penetrating Radar(GPR) forward and backward movements.

3.2 Simulated Space Void Using Concrete with Space Void Inside

Experiment was conducted using two specimens of concrete block and concrete block with void space to examine the impulse radar capability in detecting the void space. One specimen using

purely concrete block with a size 6x100x100cm as shown in the Figure 10. Another specimen with glass bottle mixed in the concrete block with the size of 6x100x100 cm as shown in the Figure 11.

Figure 11. ***Preparation of void space***

Figure 12. ***Concrete Slab with Void Space***

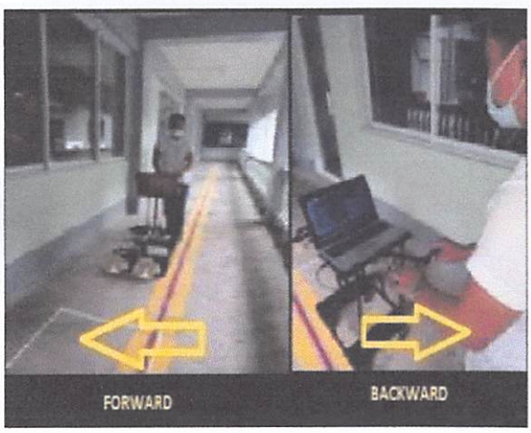


Figure 13. ***Scanning***

The figure above shows the one backward and one forward scanning of specimen using the Develop Impulse Radar at SSCT building main campus.

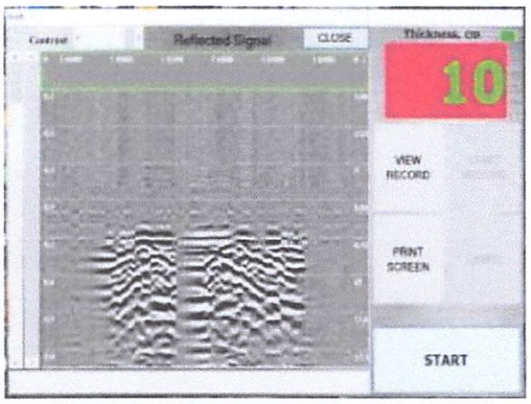


Figure 15 shows the analysis of the behavior of the develop impulse radar using the radar-gram for concrete slab without void space.

3.3Actual Testing

3.3.1 SSCT Main Campus

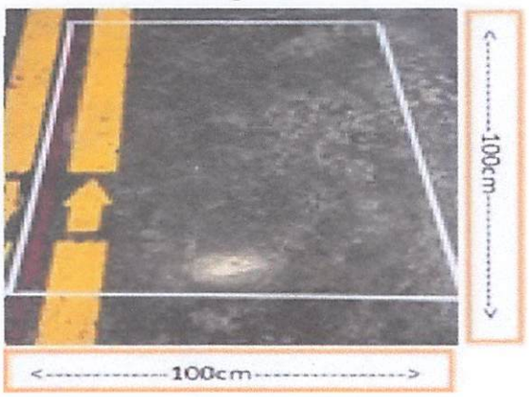


Figure 16. ***Specimen without void space at SSCT***

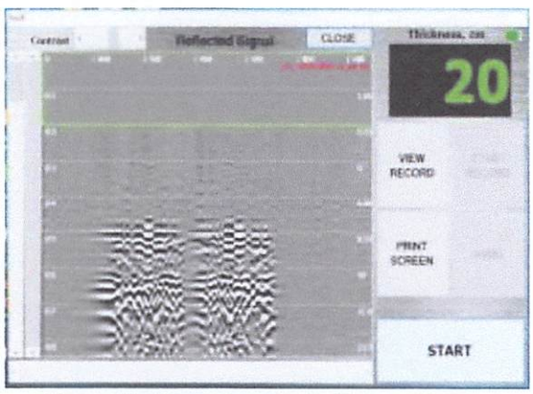


Figure 17. ***Simulation result without void space***

Figure 14. ***Simulation result with void space***

Figure 16 and 17 shows the application and

The figure above shows the analysis of the simulation using a radar-gram of developed behaviour of the develop impulse radar using the Impulse Radar of a specimen without void space at radar-gram for concrete slab with void space. SSCT Main campus.

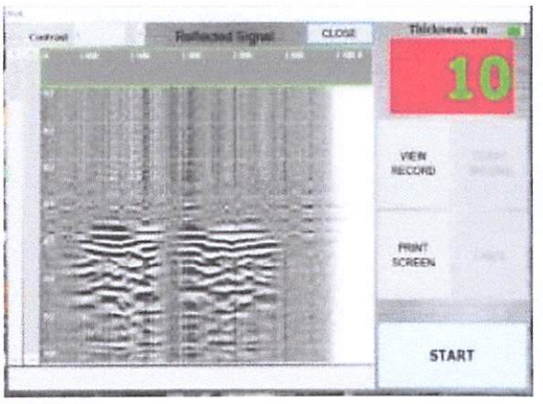


Figure 15. ***Simulation result without void space***

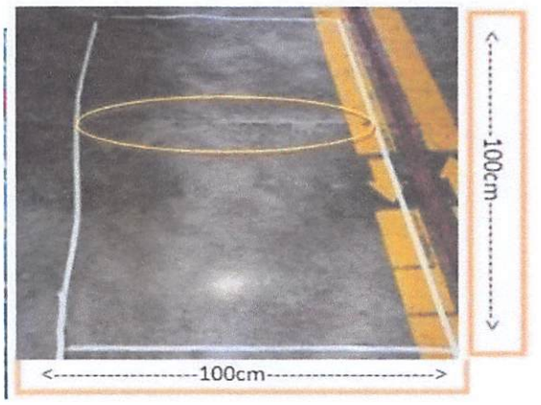


Figure 18. ***Specimen with void space at SSCT***

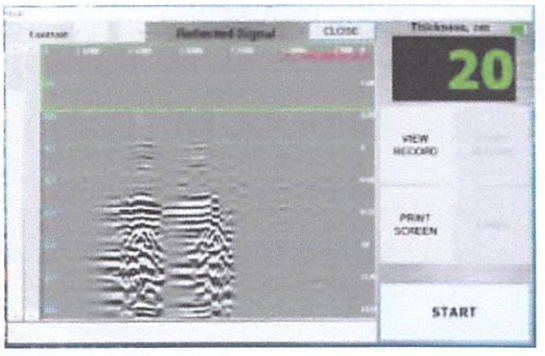


Figure 19. ***Simulation result with void space***

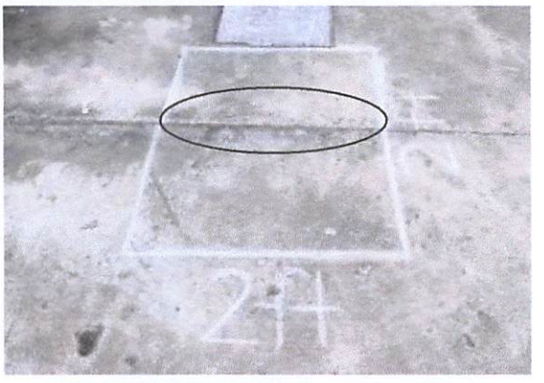
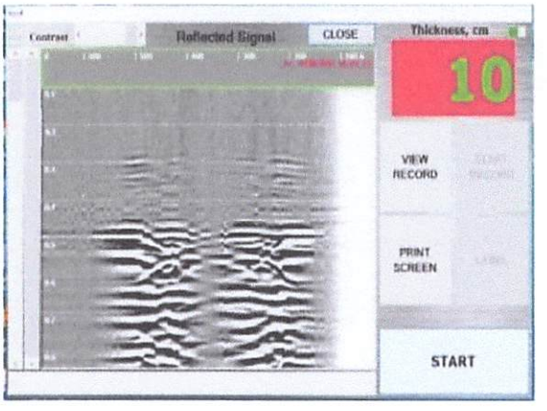


Figure 22. ***Specimen with void space at Basketball***

Figure 18 and 19 shows the application and simulation using a radar-gram of developed Impulse Radar of a specimen with void space at SSCT Main campus.

3.3.2 Basketball Court at Brgy. Cayutan, Surigao City



court

simulation using a radar-gram of developed

Figure 20. ***Specimen without void space at Basketball***

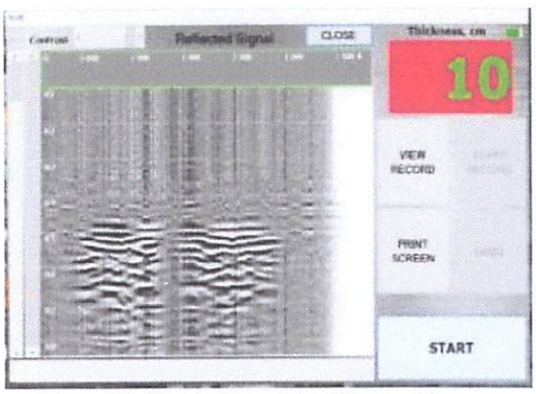
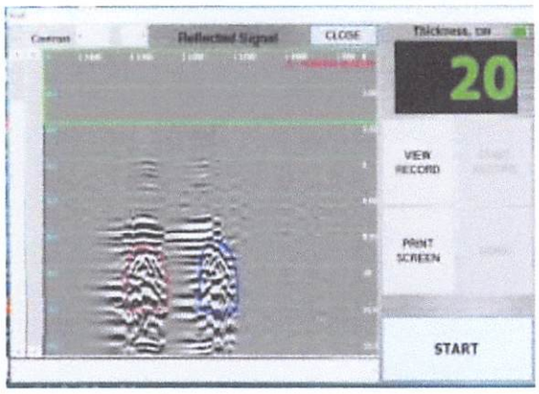


Figure 21. ***Simulation result without void space***

Figure 20 and 21 shows the application and simulation using a radar -gram of developed Impulse Radar of a specimen without void space at the basketball court of Brgy. Cayutan.

Figure 23. ***Simulation result with void space***

Figure 22 and 23 shows the application and Impulse Radar of a specimen with void space at the basketball court of Brgy. Cayutan Surigao city. ***court***



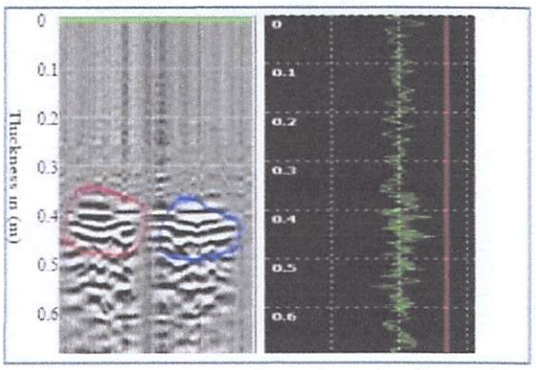
3.4 Radar-gram Interpretation Analysis

The data is signifying the result of the applied impulse radar; it identifies the forward and backward movement of impulse radar.

Figure 24. ***Test result in SSCT Without void Space***

Base on the screen reflected signal you can see the blue circle on the screen is indicated as forward

Figure 26. ***Test result in Basketball Court Without void Space*** Figure 20 is the location is at basketball court, to find another the glass of battle is buried with a thickness of 10 cm concrete slab.



result, the second location that also has void space, as the data shows, the forward and backward movement is always consistent through the data result.

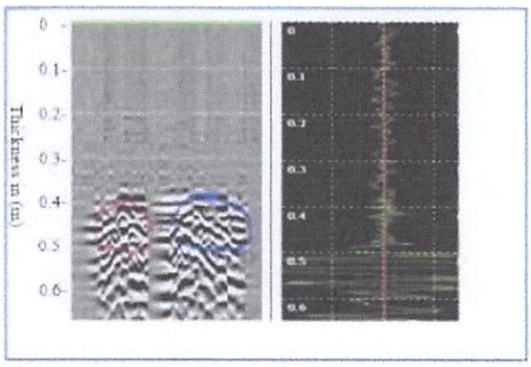


Figure 29. ***Concrete Slab Testing With Void Space*** The data above shows a red mark indicates that void space was detected in the concrete slab where

Figure 32. ***Basketball Court Result with Void Space***

The figure above shows the location of void

Figure 30. ***Concrete Slab Testing Without Void Space*** space of the concrete 10 cm thickness detected in Base on the radar gram result in the figure the basketball court as indicated in the sine wave on shown above, it shows that there is no void space the right part of the figure. detected in a solid concrete slab.

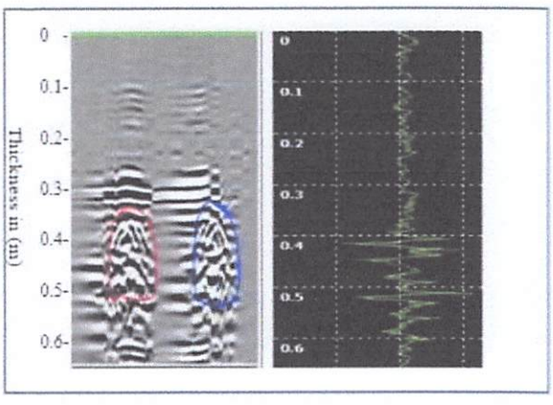


Figure 31. ***SSCT building Testing with Void Space***

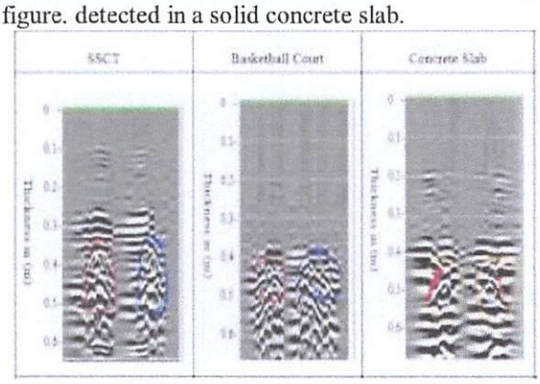


Figure 33. ***Data Collection of the radar-gram with void space***

The figure above shows the comparison of data

The figure above shows the location of the 20 results in the radar-gram in different area location cm thick

concrete with void space detected in the during experiment which has void space detected. SSCT building as indicated in the sine wave on the The gathered data are conducted in SSCT main right part of the figure. campus building, Brgy. Cayutan basketball court,

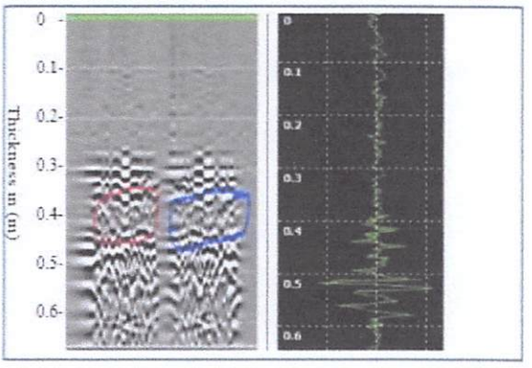
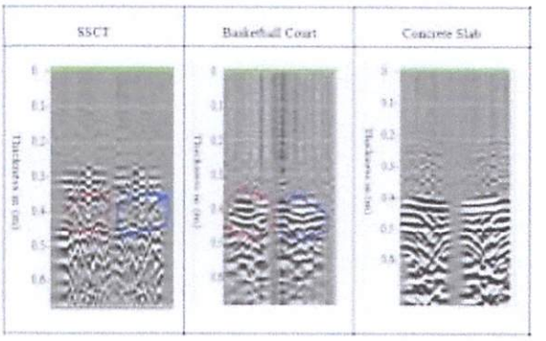


Figure 31. ***SSCT Building Testing Without Void***



and the experimented concrete slab with buried glass battle as void space.

Space

Figure 34. ***Data Collection of the radar-gram***

The figure above shows the test result in radar ***without void space*** gram indicating that there is no void space detected.

The figure above shows the comparison of data results in the radar-gram in different location without void space conducted in SSCT main campus building, Brgy. Cayutan basketball court, and the experimented concrete slab without void space.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The documentation of the system design is proper with all its eco-friendly materials, also the picoR is easy to assemble in the cart. Both transmitting and receiving antennas are easy to attach to its transceiver module. The user interface of the software is easy to operate. The experiment are conducted in different areas to gather and analyse data since this study is just only an experimental. To identify void space in the concrete by selecting specific areas in SSCT building, basketball court in brgy. Cayutan Surigao City, and making concrete slab for the experiment that has void space and without void space with measurements of length, width, and thickness. As the result of this study, the GPR technology has an accurate and sensitive sensor. It is a very high standard for detection, it can see into a structure to provide accurate information showing orientation and depth to subsurface features and objects. During simulation, data readings from the impulse radar is detected easily in moving the cart with forward and backward smooth motion in the selected areas of the study.

The result of the experiment shows that the pyramidal curve data in the radar-gram indicated as void space in the concrete. Compared to the data that

has no void space which has no pyramidal curve in the radar-gram result. Data processing and interpretations have been applied relatively successfully an advantage over the more traditional manual and visual inspection methodologies, in detection of void space it also have a prevention to present that the concrete has less strength and need an improvement to be more preventable. The impulse radar will be an accurate technology to be used to determine the strength of a concrete.

Recommendations

Base on the findings and conclusions presented, the following recommendations are suggested,

1. It must not have a person near at the antenna because it will cause an interruption to a reflected signal.
2. This GPR is applicable for dry area only, since there is an interrupted signal through dye electric.
3. The cart should not cause vibration to the picoR because it could cause signal interruptions.

5. ACKNOWLEDGEMENTS

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged.
However, the group would like to express their deep appreciation and indebtedness particularly to our coauthor: Engr. Vrian Jay V. YLaya for his endless support, kind and understanding spirit during our case presentation. Also, the dean Engr. Robert R Bacarro, for extending his effort and giving time to enhance our thinking on making a very detailed and concise research study. To all relatives, friends and others who in one way or another shared their support, either morally, financially and physically, thank you. Above all to the great almighty the author of knowledge and wisdom, for his countless love. We thank you.

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1.4.2

APP-BASED FLOOD MONITORING AND WARNING SYSTEM IN SURIGAO RIVER

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Abstract: Flood monitoring and warning system is developed to monitor the changes in water level of Surigao River that can be viewed through mobile application and alerts people through SMS for a possible flooding event[1]. This study uses Arduino Mega 2560 as the microprocessor where all the data gathered by the ultrasonic sensor is processed and computed. It also uses NodeMCU ESP8266 to transfer the data online[2]. This project uses Rapid Application Development or RAD model to put emphasis on the rapid prototyping and testing of the system which allows the researchers to perform multiple iterations without having restarted the development from the scratch[3]. The result of the study shows the prototype of the system in which the trial shows that the system is quick enough to send SMS if the river is in critical level and it shows real-time data[4]. It is also concluded that the mobile application is easy to access and displays the average of the two sensors used to measure the water level[5]. The project's price is high but it is worthy to invest because of its feature to alert people that can save lives during calamities[6].

Keywords: Flood monitoring, Ultrasonic, GSM, Application, SMS, NodeMCU ESP8266, wireless

1. INTRODUCTION

Flood monitoring and warning system intend to lessen the risk of lives and economic growth. This system supports analysis, data collection, monitoring, and warning. A wireless sensor network is being used for the collection of raw data and is going to be processed and analyzed by the microprocessor and generates flood monitor in the mobile application and sends warning through SMS [1].

Flood monitoring and warning system require three basic factors that need to look into: data collection through gaging, data processing, hardware and software to be used, and the dispersion of flood warning information throughout the community [2].

Overflowing of Surigao River have affected many barangays including Bonifacio Purok 2 and Purok 7 affected 31 houses, all purok of Luna along Surigao River, San Juan which 50 houses were affected, San Roque in which 24 houses were affected due to floodwaters reaching 200 meters from the banks, and in Barangay Washington specifically in Kaskag riverside in which the flood height ranges from 2.0 to 3.2 meters [3].

The flood monitoring and warning system will inform the subscribed residents through SMS that a flood potentially occurs and/or the result of the system can be viewed through a mobile app developed by the researchers. With the system installed, there will be no reason for people and authorities to have not prepared during heavy rainfalls.

App-based flood monitoring and warning system is relevant and important as it is needed for the safety and welfare of the community. It is encouraging to make a project related to the pursue course which is electrical engineering that can save uncountable properties and lives. It is also a big contribution to the local and national government of the country for helping communities during disasters.

1.1 Related Literature

Flooding is a hazard that perennially occurs in the mainland of Surigao City affecting 5 urban barangays, 12 coastal barangays, rural districts southeast and northwest of the urban area, and 10 barangays along Surigao River. Surigao River is the main source for river flooding along with its tributaries Kinabutan and Tumanday Rivers. The volume and magnitude of rainfall, current morphology of river, and obstruction of river flow contributes in the occurring of flood in the area. Flood occurrence averaged around one to three per year with a higher frequency as much as five events. Flood level ranges from 0.5 meters along urban streets to 3 meters along river plains [3].

A real-time flood monitoring is achieved by the accuracy feedback of ultrasonic sensor. To design an effective flood monitoring system monitoring flood using reliable water level monitoring, early flood warning, real-time monitoring of flood development, and accurate data are needed. Ultrasonic sensor works properly in detecting water level changes. The using of multiple

sensors (ultrasonic sensor) can improve the accuracy of the system especially when the river is at moving-surface condition. Continue usage of ultrasonic sensor for the development the system will accurately measure and determine in real-time the flood water level of the river. With Arduino, researcher is allowed to make program on interfacing the devices like GSM module to web-monitoring and allow editing the program on any changes to make [4][5][6][9].

Flood-prone areas in the Philippines require flood monitoring. Specific technologies like water sensors, web monitoring, and SMS notification will be beneficial to the locals because of the enhanced decision-making due to timely flood warnings and information. Many local studies have been made to monitor floods. Cabad et.al (2014) conducted a water level monitoring system that can detect four levels of the water in rivers of Davao City that uses UTP wires to measure it and can alarm a siren with the fast-rising of water [7]. Natividad and Mendez (2017) conducted a study by developing a real-time flood monitoring and early warning system in Isabela, Philippines that uses ultrasonic sensors and warns the community through SMS [8].

In a study by Yumang et.al, the system uses Arduino Uno, GSM shield, sensors, and powered by solar panel with a generator with early warning LED device sends out SMS notification in real-time [10]. Another study by A. Supani et. al. uses a fuzzy logic algorithm in artificial intelligence with input variables rainfall and water level to predict flood. The system uses WiFi wemos module D1 R2 based on module ESP8266-12 and the graph of the data can be viewed in the blynk application uses blynk server [11].

As compared to the studies stated above, researchers developed a mobile application as a flood monitoring and warning platform. The proposed project uses Arduino Mega 2560, ultrasonic sensor, GSM module, ESP8266 Wi-Fi module, and powered by a solar panel. Using SMS notification as a flood warning can be interrupted due to weather conditions so the project is a mobile application where the water level can be monitored, and it also displays a warning when the flood will most likely happen.

1.2 Theoretical Framework

The ultrasonic sensor will emit the signal from the trigger pin and receive the pulse to the echo pin. Trigger and echo pin sends a digital reading to the microcontroller module to be computed. The ultrasonic sensor will be utilized to detect the water level of the river. The original reading that is received by the microcontroller will be converted to time durations after the pulse is transmitted using the formula:

$$time = \frac{distance}{speed}$$

where;

speed of ultrasonic sensor = speed of soundwave = 340 ms

When the time difference is known, the distance of the obstacle from the sensor can be calculated as:

$$speed = \frac{distance}{time}$$

$$distance = speed\ x\ time$$

Since the sound travels the same distance twice, distance can be measured as [12][13]:

$$distance = 340\ x\ \frac{time}{2}$$

The transmitted ultrasonic signal engenders with a certain radiation angle and the shape of propagation was the beam patterns of the sensor and the beam angle can be expressed as:

$$\theta_{\circ} = sin^{-1}\frac{0.61\lambda}{r}$$

where λ is the wavelength of the ultrasonic signal and r is the radius of the transmitter [14].

An equation developed by Panda et.al to make up for heat and moisture effects on the air's speed of sound was used to enhance the reading certainty by the equation:

$$C_s = (331.296 + [0.606\ x\ \theta])x(1 + [RH\ x\ 9.604\ x\ 10^{-6}\ x\ 10^{0.032x(\theta - 0.004x\theta^2}])$$

where C_s is the speed of sound in the air after compensation, θ is the air's temperature, and RH is the air's relative humidity [15].

The ultrasonic sensor uses sonar to determine distances. In this study, the use of a sensor is to detect floods when the water level of the river rises.

1.3 Conceptual Framework

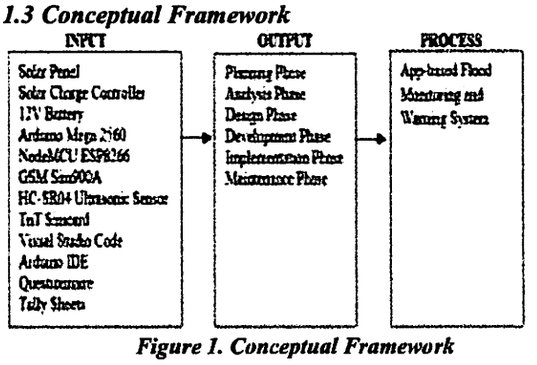

Figure 1. Conceptual Framework

The block presented in Figure 1 states the input of the study that consists the materials needed for the project like the software for the programming, components for the development of the system, and tools for gathering the data to assess the system.

In the process part, this is where the researcher executes all the plans to reach the objectives of the project. This is the phase where the researcher test and implement the system such as gathering data through observation, interview, and survey.

The last part is the output where the researcher accomplished the desired outcome of the study

1.4 Objectives

The general objective of this project is to develop a system wherein people can be warned if flood will occur and for them to monitor the water level through a mobile application.

The specific objectives of the study are:

1) to develop hardware for flood monitoring system,
2) to develop a mobile application from the hardware of flood warning and monitoring system,
3) to test the operability of the system
   - 3.1) Time span to send SMS warning
   - 3.2) Time span of change in real-time data
   - 3.3) Functionality of output in terms of the mobile app's interface
   - 3.4) Functionality of output in terms of SMS warning
4) To determine the economic feasibility

2. METHODS

2.1 Research Design

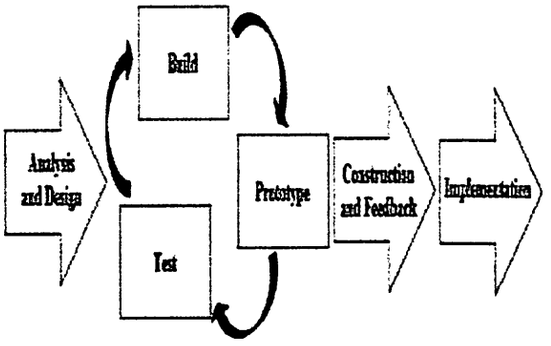

Figure 2. RAD model of the system

The researchers used the Rapid Application Development Model for the system wherein changes are adaptable in every stage. This process puts emphasis on rapid prototyping and testing cycle which makes it possible for the researchers to perform multiple iterations and updates to the system without having restarted the development from scratch.

2.2 Project Design

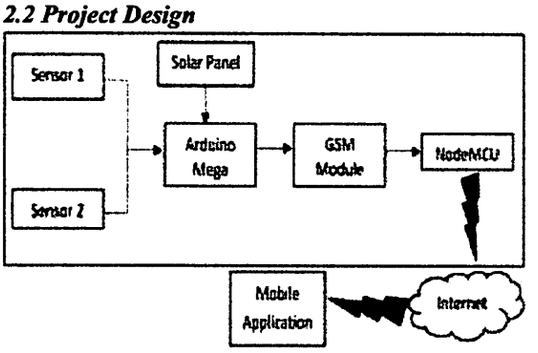

Figure 3. Project Design

An ultrasonic sensor was used to determine the height between the water and the sensor. HC-SR04 sends out a soundwave to the surface of the water and it will bounce back and received as an echo by the transducer of the sensor. The distance can be determined by measuring the time lapses of the sending and receiving the pulse sends out by the ultrasonic sensor.

The gathered data from the sensor will be processed by the microprocessor of the system which is the Arduino Mega powered by a solar panel. The system sends out an SMS warning when the water is in critical range through the GSM module. NodeMCU ESP8266 is used to transfer the data to the web. As for mobile app users, there will be advice shown in the interface as the flood would likely happen in that distance range.

2.3 Project Development

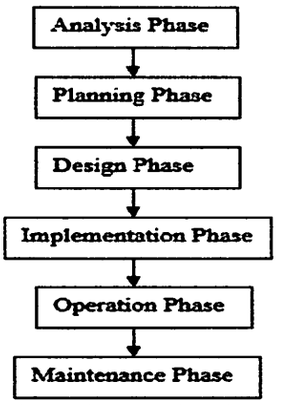

Figure 4. Project Development

Project Development shows the whole process of conducting the study from the beginning until the end. First, the researcher must identify a certain problem in the community that needs to be solved. Second, is planning on how to solve that certain problem. Next, is to design a system by applying engineering technology to create a solution. Next, is to implement the system and test the effectiveness

and functionality. Lastly, keep the system operated and maintained to serve people in the community.

2.4 Project Implementation

Flood Monitoring and Warning System in Surigao River was implemented to test the functionality. Furthermore, the quality of the proposed project was determined by its performance.

The implementation of the proposed project would undergo three phases for efficient and optimal operation. The first phase is the set-up, which includes the hardware and software set-up, project orientation, and training of personnel. The second phase is the trial run of the project's system and its full functional implementation. The last phase is the maintenance. This involves the enhancements and adjustments of project's program for the users. This also involves the adding new features expansions or the project's program system to another function as requested by the user.

The proposed project is powered by a 12 V supply. Program codes are being loaded in the Arduino such as the distance of water from the sensor and warning messages sent by the GSM module. The ultrasonic sensor is positioned perpendicular to the water level of the river to avoid wrong measurements of the distance between the sensor and the water. If the water level rises and the sensor triggers by a critical range of the water level, it will automatically send a warning message to people that flood will likely happen and so on. The water level and warnings may also be viewed through a mobile application provided by the researcher.

2.5 Project Setting

Figure 5. Location Map

Figure 5 shows the location of the study which is the Surigao River in Surigao City. It also showed some of the near barangays that are flood-prone located near the river.

2.6 Participants of the Study

Participants	f(n=10)	% of involvement
Residents	10	100%
Total	10	

Figure 6. Participants of the Study

This study uses Purposive sampling. The residents were purposively chosen to evaluate the study as to its reliability and functionality of the mobile app. The researchers invited 10 people to assess the project.

2.7 Instruments

1.) Survey Questionnaire
2.) Tally and Rating sheets

The researcher will use a survey questionnaire and interview questionnaire for the qualitative data and assess the effectiveness and functionality of the project. The researcher will use the tally and rating sheets for collecting qualitative data and to write down all the observations made to the project.

2.8 Research Ethics

These are the following research ethics that the researchers will use in conducting the study. First is honesty where the researcher must be honest in reporting the data gathered and does not falsify the information being presented. Next is objectivity to avoid bias in experimental design, data interpretation, and personal decisions among colleagues. Next is integrity for the researcher to be consistent in thoughts and in taking actions throughout the project making. Carefulness in keeping good records of the activities done to avoid error and negligence. Also, intellectual property to give proper acknowledgment to all who have contributed the research especially the author's work being used as a reference. Respect for a colleague will make the researcher getting along and have a good relationship with the co-researcher is one of the aspects to have successful research. And lastly, competence to help the researcher in improving his competence and expertise through the whole process in conducting the study.

2.9 Data Collection Procedure

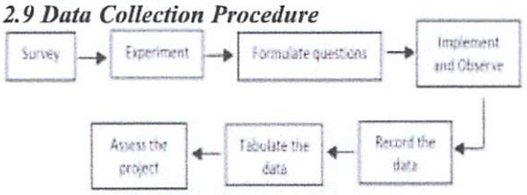

Figure 7. Data Collection Procedure

Figure 7 shows the procedure of data collection. The first thing that the researcher must do is to survey the location. Next, is to install the project in the area and start the experiment. Then, formulate a question that will assess the system. Next, implement the trials intended and observe. Record the data gathered from each trial conducted. Record and tabulate all the gathered data and the researcher must use it to assess the project.

2.10 Statistical Tools

1.) Mean

Getting the mean shall be used as a statistical tool in our project. This tool will get the average time span for the sending of warning through SMS notification to the participant after the Arduino received a signal that the water is at a critical level, and the average time span the monitor displays if there's a change in water level.

2.11 Financial Analysis

1.) Regulation under market analysis
2.) Product costing

If the project study will be commercialized, the financial analysis tool that applies in our study is regulation under the market analysis. The researcher will look for an investor, for example, the government, to give funds to the project and when all is done, the system will be installed in the rivers and other flood-prone areas.

3. RESULTS AND DISCUSSIONS

3.1 Hardware Design of the System

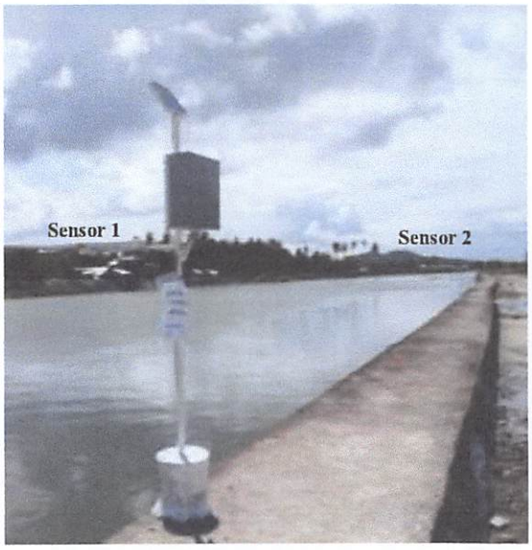

Figure 8. System installed alongside Surigao River

Figure 8 shows the system being install at the riverside of Surigao River at Barangay Luna. There are two sensors used in the system placed 20 meters apart as you can see in the figure it was labeled sensor 1 and sensor 2.

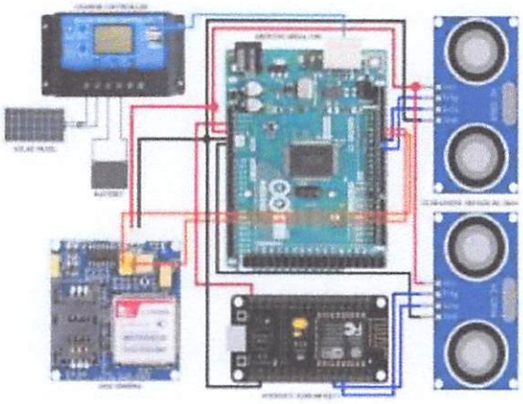

Figure 9. Pictorial Diagram

Figure 9 shows the pictorial diagram of the system in which the wiring connection of the components is shown.

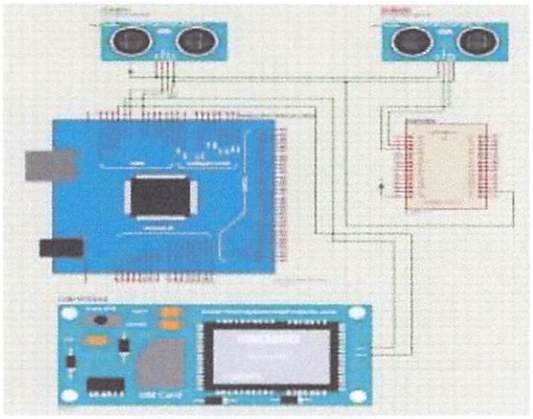

Figure 10. Schematic Diagram

Figure 10 shows the schematic diagram of the system.

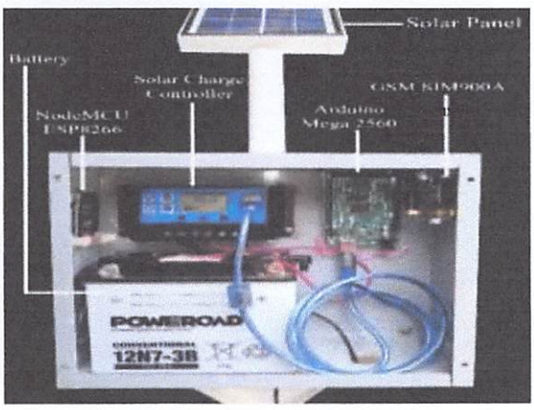

Figure 11. Project Prototype

The figure shows the connection of components of the project. On the upper part is the solar panel connected to a battery and charge

controller to avoid over-charging and protects from over-voltage. On the inside of the casing are Arduino Mega, NodeMCU ESP8266, and GSM module.

3.2 Mobile Application of the System

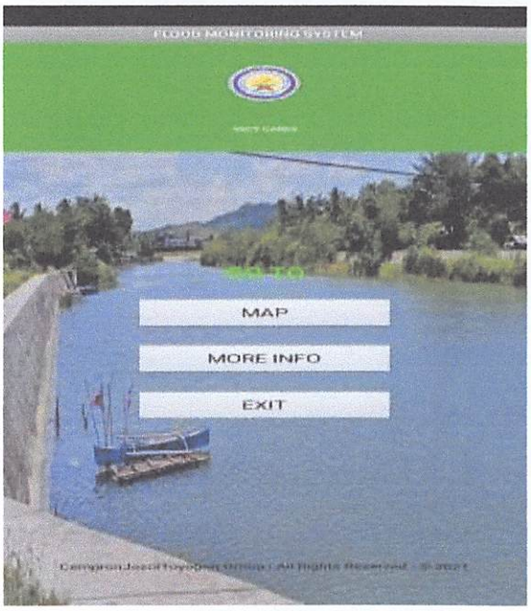

Figure 12. Home of the Mobile App

The figure shows the screenshot of the home of the mobile in which there are options such as the map, more info, and exit for the users to click.

Figure 13 Surigao River Map

The figure shows the screenshot of the map of the river wherein the user can click which map of the river to monitor.

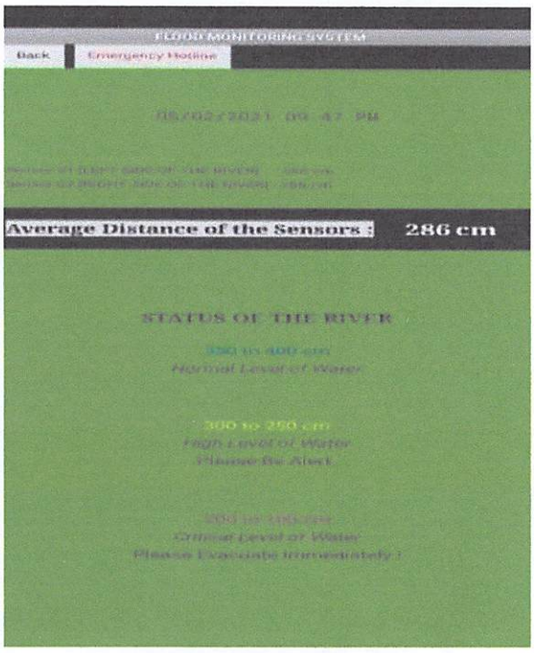

Figure 14. Status of the River

The figure shows the river status in the mobile app in which it states the average distance detected by the two sensors labeled as left and right.

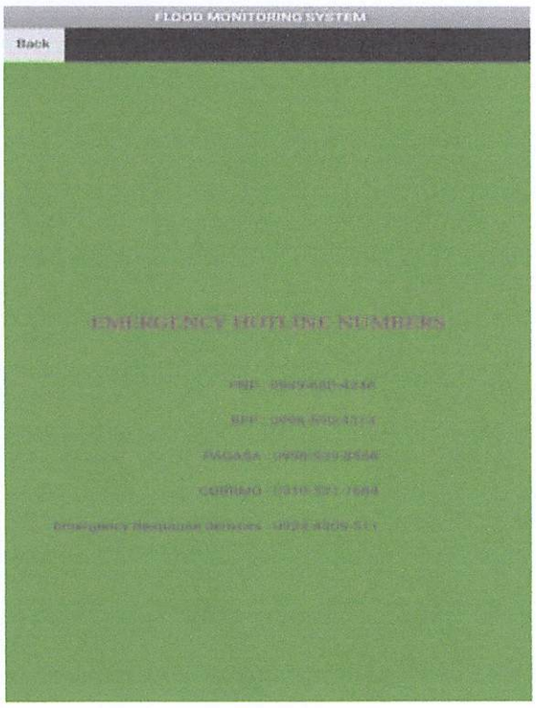

Figure 15. Emergency Hotlines

The figure above shows the screenshot of the emergency hotlines in Surigao City which can be found on the app.

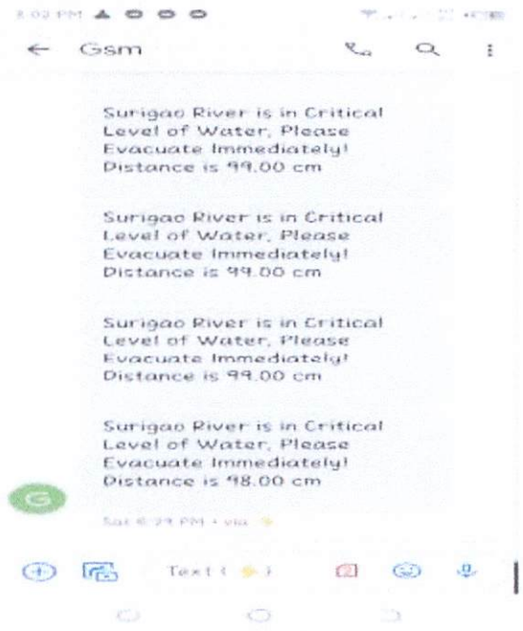

Figure 16. Warning SMS

The above figure shows the warning SMS sent by the system to an individual when it reaches the critical level indicates the distance of the water level in centimeters.

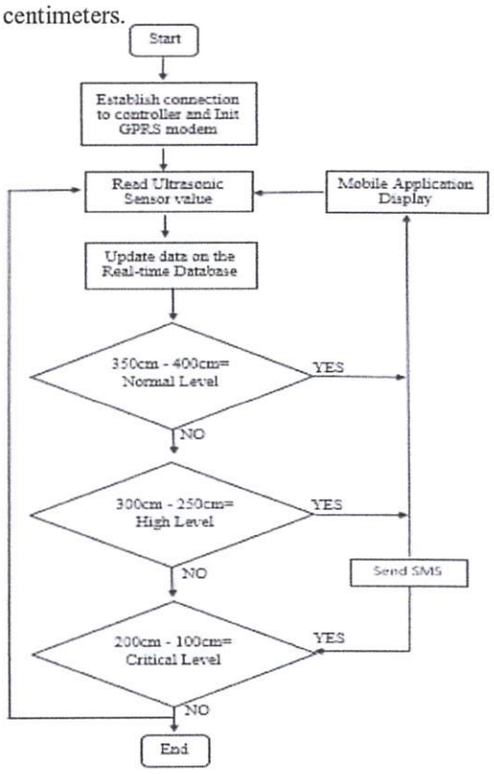

Figure 17. Flowchart of the System

Figure 17 shows the flowchart of the system. There will be an established connection between the controller and GPRS modem. The data gathered by the sensor will be uploaded to the system's database and will be displayed in the mobile application. If the data falls to the critical level, the system will send an SMS to the user.

3.3 Test Result of the System Operation

Table 1. Time span before a warning message delivered to a user

Trial no.	Time (seconds)
1	8.51
2	7.46
3	4.68
4	7.30
5	7.73
6	3.78
7	7.95
8	7.61
9	7.95
10	7.51
Mean	7.05

Table 1 implies that the time span of delivering a message to a user is short which means that the text warning is quick enough to warn people if the river is in critical range.

Table 2. Time span of the change of real-time data on app display if there are changes on the distance of water level

Trial no.	Time (seconds)
1	1.00
2	0.84
3	0.41
4	0.44
5	0.40
6	0.41
7	0.59
8	0.69
9	0.97
10	0.87
Mean	0.66

Table 2 shows the time span of the change of real-time data in an app and the data implies that the change is short which means that the system shows real-time data.

Table 3. Water Level Distance of the River

Time	Water level distance (cm)	Status
9:00 am	386	Low
10:00 am	357	Low
11:00 am	305	Normal
12:00 pm	256	Normal
1:00 pm	205	Normal
2:00 pm	211	Normal
3:00 pm	253	Normal
4:00 pm	282	Normal
5:00 pm	322	Normal
6:00 pm	354	Low
7:00 pm	371	Low
8:00 pm	386	Low
9:00 pm	397	Low

Table 3 shows the water level status of the river from 9:00 am until 11:00 pm. It shows that from 9:00 to 10:00 am the river is at a low level. From 11:00 am the water level starts to rise until 5:00 pm indicating that the river is in high tide. From 6:00 pm until 9:00 pm the water level status is at a low level.

Table 4. Interface of the mobile app functionality

Functionality	Mean	Description
1. Displays the average distance of two sensors	4.00	Very high
2. App is easy to access	3.6	Very high
3. Displays the indicator of the distance of water level range	4.0	Very high
Overall mean	**3.87**	**Very high**

Table 4 shows the data of the functionality of the mobile app as evaluated by 10 evaluators. The first item got a mean of 4.00 which is equivalent to a descriptive rating of very high which means that the mobile app displays the average distance of the two system sensors. The second item got a mean of 3.6 which falls into a descriptive rating of very high meaning that the app is easy to access. The third item got a mean of 4.0 which has a descriptive rating if very high that means there is an indicator of the distance of the range of water level. The overall mean got 3.87 which is equivalent to descriptive rating of very high which implies that the interface of mobile app serves its function well.

Table 5. Functionality of output in terms of SMS warning

Functionality	Mean	Description
1. Sends SMS immediately when reaches critical level	3.8	Very high
2. SMS indicates flood warning and advice	3.9	Very high
3. SMS is readable and understandable	4.0	Very high
Overall mean	**3.9**	**Very high**

Table 5 shows the data of the accuracy of output in terms of SMS warning as evaluated by 10 evaluators. The first item got a mean of 3.80 which is equivalent to a descriptive rating of very high. This means that the system sends an SMS warning immediately if the water reaches its critical water level range. The second item got a mean of 3.9 which falls into a descriptive rating of very high meaning that the SMS warning indicates flood warning and advice people to evacuate. The third item got a mean of 4.0 which has a descriptive rating of very high which means that everything on the SMS warning is understandable. The overall mean got 3.9 which is equivalent to a descriptive rating of very high which implies that the SMS output of the system works well.

3.4 Economic Feasibility of the System

Table 6. Cost Analysis of the System

Components	Quantity	Amount	Total
Materials Cost			
5W, 12V Solar Panel	1	800.00	800.00
12V, 7Ah Battery	1	1200.00	1200.00
Arduino Mega2560	1	1615.00	1615.00
NodeMCU ESP8266	1	270.00	270.00
HC-SR04 Ultrasonic Sensor	6	83.00	498.00
Wires	100m	8.00	800.00
Total			5183.00
Labor Cost			
Labor		2000.00	2000.00
Total			2000.00
Factory Overheads			
Electricity		1500.00	1500.00
Boarding Rent		1000.00	1000.00
Total			2500.00

Table 6 shows the cost analysis of whole system. The cost of the product can be obtained through this formula:

$$cost = Cost\ of\ Materials + Cost\ of\ Labor + Cost\ of\ Factory\ Oerheads$$

$$final\ product\ cost = cost + Desired\ profit\ (20\%)$$

$$cost = 5183 + 2000 + 2500 = 9683.00$$

$$final\ cost = 9683 + (9683\ x\ 20\%) = 11{,}619.60$$

Product cost: 11700.00

If this project will be commercialized, the product cost of it will be 11700.00 php.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Hardware of the flood monitoring and warning system was developed using Arduino Mega 2560, NodeMCU ESP8266, GSM Sim900A, ultrasonic sensor, and a set of solar panel.

MIT App Inventor was used to develop the Graphic User Interface (GUI) of the mobile application. Initializing global distance to get the data through firebase real-time database and inserting map pictures to app's interface and the specific function of the buttons. The system uses GSM GPRS connection to sync data from the hardware to the mobile application.

The system uses real-time monitoring through the mobile application and a warning system through SMS. During the several trials conducted, it can be concluded that the sending of SMS is quick enough to give warning to the users and the mobile app displays real-time data.

The product cost of the system is high due to the labor cost and factory overheads, but it is worth to invest since the system is reliable in times of calamity as shown in the data presented.

Recommendation

Base on the findings and conclusions presented, the following recommendations are suggested,

1. The mobile application displays only the water level in the interface so the researchers recommend that a further research should use other ways to interpret the data display like using of bar and line graphs.
2. The project setting on this study is located on one river, so the researchers recommend a further research to cover more locations to monitor by the system.

5. ACKNOWLEDGEMENTS

The researcher would like to express the deepest and sincere gratitude to the following who helped in this project study. First, to Almighty God for giving the gift of life, knowledge, and wisdom. He gave so many blessings especially to the researcher's family during this hard time. To Engr. Vrian Jay Ylaya, Engr. Robert Bacarro and Engr. Darwin Mangca, for giving guidance and more knowledge regarding the write-ups and project. To the institution, for allowing the researchers to conduct the project study. To the researcher's family and friends, for the undying love and financial support to bring this project a success. And lastly, to those who have helped, supported, and offered deep insight into the project, the researchers would like to extend their deep and sincere gratitude. All glory belongs to Him!

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1.4.2

PORTABLE POWER THEFT DETECTOR USING ELECTROMAGNETIC WAVES

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Abstract: Portable power theft detector is a detection device that is used to detect power theft. It is also able to determine the current consumption on the consumer side of the distribution system. The device uses one type of electromagnetic wave which is the Radio Frequency that helps to transmit and receive data wirelessly. The study uses an Arduino Uno as a microcontroller that serves as the brain of the device. Various stages were made to develop this project study, first is to identify all the components needed for this study, the next is to prepare the components, then the encoding of the program for the software, and lastly is to test its functionality. The design of the device consists of SCT-013 current sensors that are connected to the analog pin of the Arduino Uno, an LCD that displays the data that comes from the current sensor, and the RF module that transmit and receives data are also connected to the digital pins of the microcontroller. The development of the device was successful, wherein it can read the current consumption from the consumers' side and to the source line of the distribution system under normal and abnormal conditions and is also able to detect power theft. The performance of the device exceeds the expectation of the researcher, where it can detect power theft and read current with various loads. Also, it was able to read current under different kinds of load, such as inductive and resistive load.

Keywords: Power theft detection, Arduino, Theft of electricity, Electromagnetic wave, Portable

1. INTRODUCTION

Electromagnetic waves or EM waves are waves that are created as a result of vibration between an electric field and a magnetic field. In other words, EM waves are composed of oscillating magnetic and electric fields. Electromagnetic waves are formed when an electric field comes in contact with a magnetic field. They are hence known as electromagnetic waves. The electric field and magnetic field of an electromagnetic wave are perpendicular to each other. They are also perpendicular to the direction of the EM wave. [1]

Electromagnetic waves are used to transmit long, short, FM wavelength radio waves, and TV, telephone, wireless signals or energies. They are also responsible for transmitting energy in the form of microwaves, infrared radiation, visible light, ultraviolet light, x-rays, and gamma rays. The behavior of an electromagnetic wave in a substance depends on its frequency or wavelength l. The differing behavior of different groups in the electromagnetic spectrum makes them suitable for a range of uses. [2]

Frequently, stealing electricity is a major problem for electricity distribution companies. Electricity theft is responsible for economic problems for the electric utilities due to revenue loss caused by electricity consumers that are not paying for it. The most commonly used methods for stealing power are to bypass the phase line, cut the neutral line, bypass the entire meter and distort the energy meter to avoid the enormous electricity bill, consumers make an illegal and unethical connection. [3]

The value of electricity cannot be undermined in the technology-driven world where are our daily lives are dominated by appliances and gadgets. Yet there are still places where electricity is not available yet, and their people are still who do not enjoy this fundamental right as we do. There is a various reason for this, such as the insufficient power generation, lose, various, geographical terrain. But among these one of the major reasons is electricity theft [4].

The existing technology uses a simple power theft algorithm to monitor and detect power theft, alert the consumer by the use of GSM communications, and cut off the supply accordingly. Illegal actions are detected, and a separate message is sent back to the microcontroller to remove the illegal supply, an SMS is sent automatically to the user via the GSM module [5], whereas in [6] introduced the Prepaid Electricity System, when the prepaid load units purchased became equal to the units consumed, the warning message sent to the user's mobile using GSM module to cut-off the power supply.

1.1 Related Literature

Electricity plays an essential part in our daily lives. The loses of electricity is often occurs in the

generation, transmission, and distribution system. Electricity losses are categorized into two; Technical Loses (TL) and Non-Technical Losses (NTL). The most common cause of Non-Technical Losses in the power system is electricity theft. Electricity theft is a crime or malicious behavior of stealing electricity that can be done by meter tampering, bypassing the electricity meter, or hacking the meter [7]. Power theft is most likely the big problem facing by developed and developing countries all over the world. In India on the July 30th and 31st dates of the year 2012, the country experienced the worst blackout that occurs on the two separate dates. This blackout had affected over 620 million people in India and about a 9% of the world's population [8].

Due to the surge of power losses on the power system, different approaches and methods were conducted to counter the power theft anomalies. In[5], a study was conducted to detect power theft, alert consumers, and cut off the supply accordingly. The system developed in the study is Arduino GSM based, in which a Short Message Service (SMS)is delivered to the consumers via GSM module when power theft is detected. Also in the study [6], the author stated that some problems are discovered by the electricity companies regarding the process of monitoring electricity consumption on every meter. The method they used such as the conventional credit metering and billing system is way more time-consuming, wrong meter reading, unproductive recollection, incompetent monitoring consumption, and use less energy used. Thus to address this problem, the author comes up with a different approach. The development of a theft detection-based GSM prepaid system is a system used to overcome electricity consumption problems, avoid bill dues, avoid mistake taking meter readings, and overcome power theft problems.

There are also different methods to determine and monitor power theft anomalies. Using webpage monitoring systems, algorithms methods and real-time detection scenarios are also convenient methods to use. Due to the development of technology, an advanced monitoring system is used to monitor electricity theft. IoT (Internet of Things) is used to prevent and monitor electricity theft without human intervention. IoT was selected due to the rapid growth in technology and utilization of IoT has become drastic [9]. Internet of things-based power theft detection was designed as a means to detect unauthorized tapping of conductors through a controller that receives current signals from the current transformer through a bridge rectifier and a conditional operator that compares the current magnitude [7].

The authors of [10], focuses on an effective and economic approach to solving the problem of power theft in the distribution system. The power theft and power theft location can be determined by calculating the voltage drop and additional flow of current in the distribution line due to power theft. Electricity theft is one of the key concerns in AMI, causes million dollar revenue loss every year in a developed and developing country. To solve the problem regarding power loss and power theft activity on the Advanced Monitoring Infrastructure (AMI), a principal component analysis method was an approach given in the study [11]. A quantitative analysis was conducted to determine the sensitivity, specificity, and success rate to measure the theft magnitude determination accuracy was proposed in the study [6]. A wide and deep neutral network was presented on the paper [7]. The method consists of two components: the Wide component and the Deep CNN component. The Deep CNN component can accurately identify non-periodicity usage based on two-dimensional electricity consumption data. While on the other hand, a Wide component can capture global features of 1-D electricity consumption data.

The authors of [13], design and implement a device that is capable of detecting electricity theft by identifying the small changes between the real-time measurements that of a trained model. The energy metering system consists of voltage and current sensors, while the theft detection algorithm consists of a Support Vector Machine (SVM) model trained and used to classify as either a clean or fraudulent user. The authors of [12], used a network analysis model and implemented four major components to detect the current rating of the meter and isolation device to prevent theft in electrical power systems.

The uniqueness of the project study is it uses electromagnetic waves and the device which is to develop is portable that will be easy to carry and accessible.

1.2 Theoretical Framework

Theory 1: In electromagnetic waves theory, the electric and magnetic field travels through space as waves

moving at the speed of light. Later years Hert (1887) demonstrated that the electromagnetic have truly existed. And he showed that the velocity and length of the electromagnetic waves can be measured [14]

Theory 2: The incident beam is characterized by its wavelength λ_i, its frequency v_i, and its velocity c_0, and the refracted beam is characterized by its wavelength λ_s, its frequency v_s and its velocity c, the simple dispersion relation for vacuum. The speed of light in a medium is related to the electric and magnetic properties of the medium, and the speed of light in a vacuum can be expressed as;

$$c_0 = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

ε_0 is equal to the electric permittivity

μ_0 is equal to the magnetic permeability [15].

The speed of light in a material to the material "constant" ε_s and the corresponding magnetic permeability μ_0 of a vacuum and μ_s of the material is

$$c = \frac{1}{\sqrt{\mu_s \mu_0 \varepsilon_s \varepsilon_0}}$$

Theory 3: When the generated fields pass through magnetic materials which themselves contribute to internal magnetic fields, ambiguities can arise about what part of the field comes from the external currents and what comes from the material itself. It has been common practice to define another magnetic field quantity, usually called the "magnetic field strength" designated by H. It can be defined by the relationship [15].

$$\mathbf{B} = \mu \mathbf{H} + \mathbf{M}$$

M= magnetization. Normally, the M=0 for nonmagnetic material if in air, $\mu_0 = 1.26 \times 10^{-6} H/m$

Theory 4: The magnetic flux out of any closed surface is zero. This amounts to the statement about the sources of the magnetic field. For a magnetic dipole, any close surfaced magnetic flux directed inward toward the South Pole will equal the flux outward from the North Pole. The net flux will always be zero for dipole sources. If there were a magnetic monopole source, this would give a non-zero area integral [15].

$$\nabla \cdot \mathbf{B} = 0$$

B is the magnetic flux density (Web/m^2, T)

Theory 5: The electric flux out of any closed surface is proportional to the total charge enclosed within the surface. The integral form of Gauss's Law finds application in calculating electric field charge objects. In applying Gauss's Law to the electric field of a point charge, one can show that it is consistent with the coulombs law. While the area integral of the electric field gives a measure of the net charge enclosed, the divergence of the electric field gives a measure of the density of the source. It also has implications for the conversion of charge [15].

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

E is equal to the Electric Field (V/m)

ρ is the charge density (c/m^3)

ε_0 is equal to the electric permittivity

1.3 Conceptual Framework

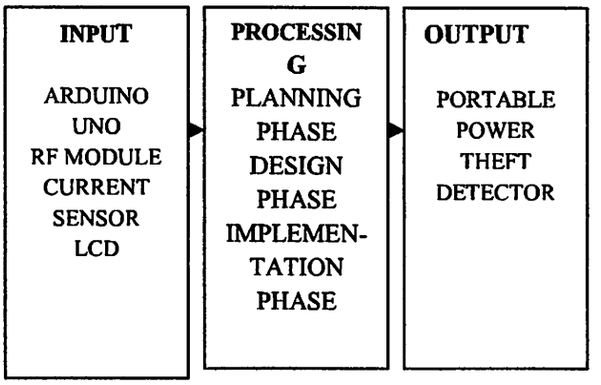


Figure 1.Block diagram of the IPO

The figure shows the Input, Processing, and Output block diagram of the conceptual framework, wherein it is the diagram of the study.

1.4 Objectives

The general objective of this project study is to detect illegal connections to electrical lines and to avoid Non-Technical loss of the system.

Specifically, it aimed to;

1.) Design a device to detect power theft
2.) Develop the device
3.) Test the performance of the device

2. METHODS

2.1 Research Design

The researchers used the observational design, this type of research design concludes by comparing subjects against a control group. It allows the researchers to see what their subjects do when confronted with various choices or situations. The term refers to the study of a non-experimental situation in which behavior is observed and recorded.

2.2 Project Design

Device 1

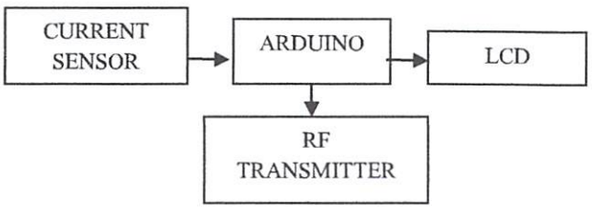


Figure 2. Block Diagram of device 1

Device 2

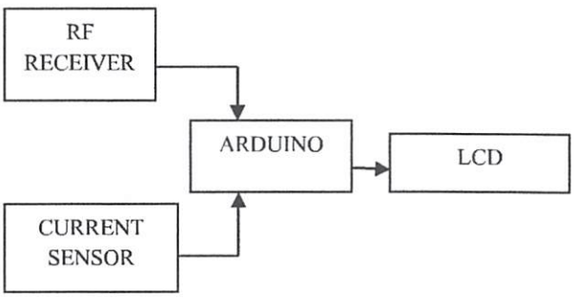


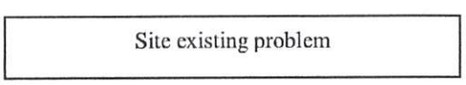
Figure 3. Block Diagram of device 2

The block diagram presented is the diagram of the study of the researchers. The first circuit consists of Arduino, Current sensor, LCD, and Rf transmitter. The second circuit consists of Arduino, LCD, RF Receiver, Current sensor, and the Load for the consumer.

The system works when the first circuit is being clamped in the distribution lines and the second circuit clamps in the electric meter of the consumer. The Arduino in the first circuit will detect by the use of the current sensor and calculate the electricity theft consumed and transmit the data by the use of an RF transmitter. This system uses RF modules that use an electromagnetic wave for transferring information.

The receiver in the second circuit receives data. The Arduino configures the used amount of electricity on the consumer and the consumed amount of the theft. Then it displays on the LCD. For the normal situation, the second circuit sends data to the first circuit about the current consumption, and then the first circuit is going to compare in its measure line currents. And if both data are similar the LCDs no theft detected.

2.3 Project Development



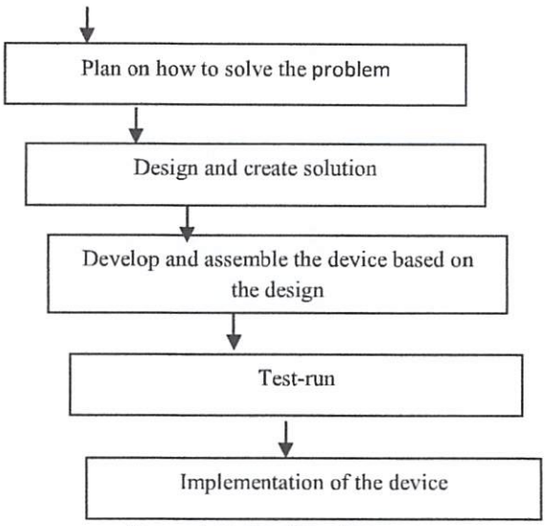


Figure 4. Project Development

The development of the project shows the process and how will be the actual device will be developing from the start of the process and on how it ends. In this process, the researcher must find an existing problem within the community to be solved. After determining the problem, the researcher will design and create a proper solution based on the problem that has been observed. Then, the researcher will gather all the materials needed and start to develop and assembling the device. The device will be tested for its functionality after it is assembled and later on the device will be implemented in the selected area.

2.4 Project Implementation

To accomplish this goal, the researchers create a simple distribution system to test the effectiveness of the device. The purpose of this simple distribution system is to ensure the safety of the researchers in conducting the study. The simple distribution system consists of circuit breakers, a switch, a load, and an electric meter. The test was divided into two-part. The first is to set up the device into the distribution line under normal conditions where the data that is gathered on the process is recorded. Next is the second part, where a load is being bypassed to the electric meter. At this point an electricity theft is occurring, the device will be set up to the distribution line and the data will be recorded. After the two tests were done the two data that were recorded need to be compared to assure that the device will be able to detect power theft.

2.5 Project Setting

Figure 5. Location Map

Figure 5 shows the location of the project that will be implemented. The study will be conducted at P-Paradise, Penaranda Street, Brgy. Taft, Surigao City.

2.6 Participants of the Study

Participants	f(n=10)	% of Involvement
Residents	7	70
SURNECO	3	30
Total	10	100

Table 1. Participants of the Study

The study uses Purposive Sampling. The Residents and some members of SURNECO were selected for the purposive sampling to ask whether what are their knowledge and opinion about the theft of electricity. The 3 members of the SURNECO were also selected for the purposed of consulting about the project because they are more expert and reliable regarding this project. Thus the researchers invited 10 people to help them with their project.

2.7 Instruments

1.) Simulation
2.) Tabulation

The researcher used simulation to test the device. Where a simple distribution system was made and where the device is being tested to read current under normal conditions and detect power theft under abnormal conditions. The researcher used tabulation of data to test the functionality of the device to detect current on deferent loads such as resistive loads, inductive loads, and capacitive loads.

2.8 Research Ethics

The researchers choose the objectivity and respect for intellectual property ethics applies in the proposed project. Objectivity is to avoid bias in experimental design, data analysis, data interpretation, peer review, personal decisions, grant writing, expert testimony, and other aspects of research. It discloses personal or financial increases that may affect research. Respect for intellectual property refers to honor patents, copyright, and other forms of intellectual property. Always give credit to the author where the information gets and to avoid plagiarism.

2.9 Data Collection Procedure

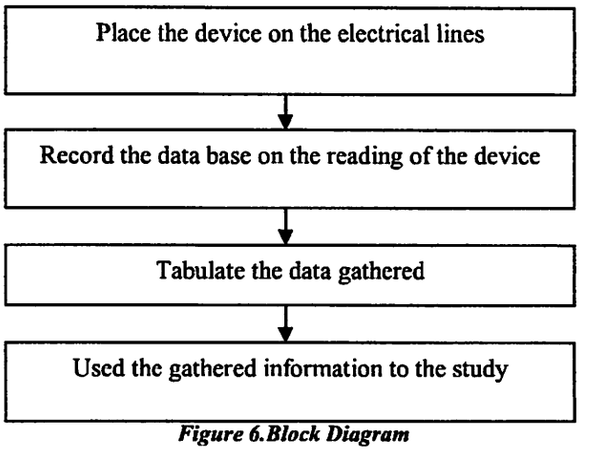


Figure 6.Block Diagram

The data collection is used to collect data based on the output of the developed devices. The researchers will first test the device on the electrical lines under normal condition base on the consumption power of the consumers then after that, the researchers will proceed on testing their device under a condition when an illegal connection is present and later on, the researchers will compare the two data that is collected.

2.10 Statistical Tools

1.) Mean

The researcher used the mean as a statistical tool. This tool is used to evaluate the functionality of the device. Using the data gathered that come from the 10 participants of the study who evaluate the device, the researcher used the data to get the overall mean and achieve a very acceptable rating.

2.11 Financial Analysis

The financial analysis tool that is used on the project that too is commercialized is product costing. The product costing tool will be used to ensure transparency of the project and determine all the expenses about the creation of the project with its labor costs. With the use of the formula:

$$\textbf{product cost} = \frac{(\text{total DM}) + (\text{total DL}) + (\text{total overhead})}{No.of\ units}$$

Direct materials	Amount

Arduino	₱ 1000
RF Modules	₱ 100
LCD	₱ 390
Connecting Wires	₱ 200
Arduino Acrylic Case	₱ 90
Current Sensor	₱ 1000
Resistor	₱ 24
Capacitor	₱ 40
Battery 9V	₱ 120
Potentiometer	₱ 40
PCB	₱ 80
Device casing	₱ 150
Antenna	₱ 100
Total	₱ 3334
Direct Labor Cost	₱ 1000
Manufacturing overhead	
Others	₱ 1500

Product Cost

$$= \frac{(\text{total DM}) + (\text{total DL}) + (\text{total overhead})}{No.of\ units}$$

$$product\ cost = \frac{(3334) + (1000) + (1500)}{1}$$

Product Cost = ₱ 5834

So the product cost in commercial is 5834 pesos.

3. RESULTS AND DISCUSSIONS

3.1 Design of the Power Theft Detector

Figure 7. Hardware Design of the System

The figure shows the hardware design of the system for the project study.

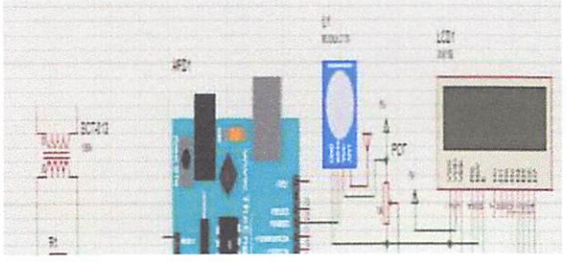


Figure 8. Schematic Diagram of Device 1

The figure shows the schematic diagram of device 1 that consists of all of its components. From the left is the SCT- 013 current sensors were some resistor are used as a burden resistor which offers a resistance of a few ohms and prevents the influence of inrush current to the device that the power unit connects to. Then, the current sensor is connected to the A0 of the analog pin of the microcontroller. The data pin of the RF module transmitter is connected to the digital pin side of the microcontroller and also the 16 by 4 LCD that display and print the data to the screen is connected to this site as well.

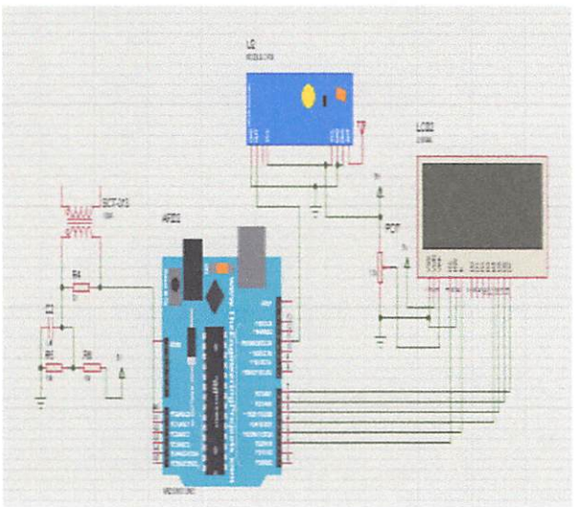


Figure 9. Schematic Diagram of Device 2

The design of device 2 is the same as the previous device. The only difference is it used a receiver RF module that receives data from the other

device and it also used a 20 by 4 LCD to display more variables on the screen.

3.2 Simulation of the Develop System

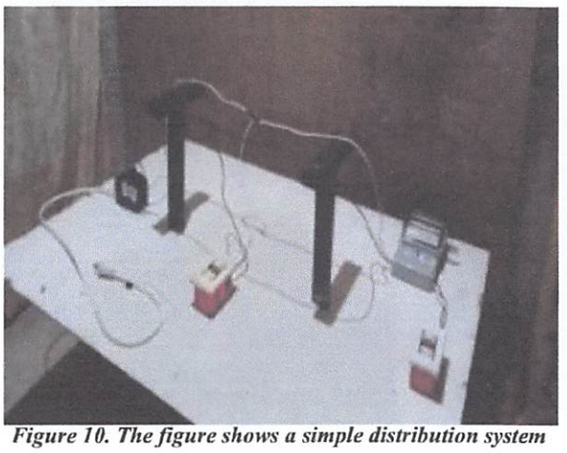


Figure 10. The figure shows a simple distribution system

Figure 10 shows a simple distribution system. The researchers used this simple distribution system to test the affectivity of the device if it can detect a power theft under abnormal conditions.

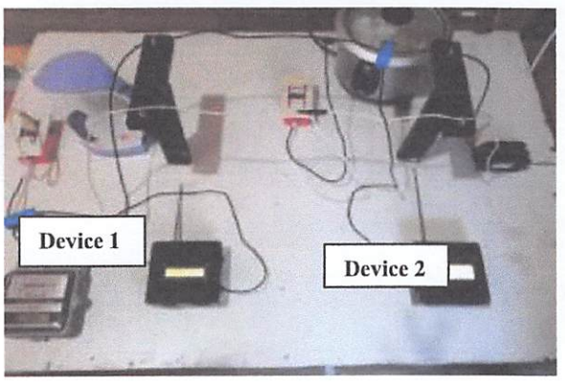


Figure 11. The figure shows the device was being tested

The figure in 3.2 shows two devices connected on the simple distribution line. Device 1 is the device used to reads current consumption on the consumer's side. Device 2 is connected to the distribution line that reads the consumer current and detects power theft. The figures show the two devices were tested under normal conditions. The researchers assigned a water heater as a load that has 60 hertz and 900 watts of power.

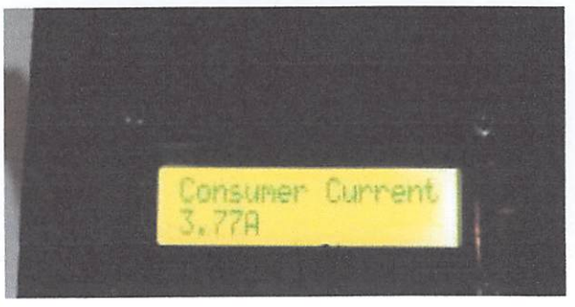


Figure 12. Shows the device 1

The figure shows device 1 reads the current consumption on the consumer"s side. The device reads the current when the heater was turned on.

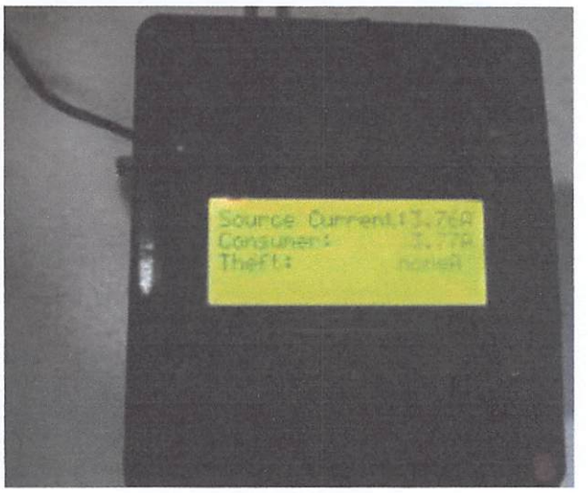
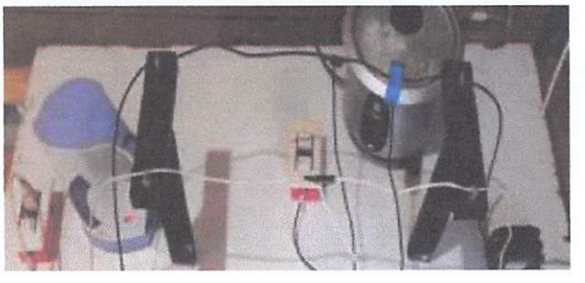


Figure 13. Shows The Device 2

The figure shows that device 2 reads the current from the source and the current reading from device 1 was transmitted to device 2 and displayed on the LCD. Since the researchers tested the device under normal conditions means there is no power theft occurring at the moment and the device reads none theft.



Device 1 Device 2

Figure 14. The figure shows the device tested under abnormal condition

In this figure, the researcher tests the functionality of the device under abnormal conditions, wherein an electricity theft is occurring. At this point, a rice cooker is tap on the source line as an act of power theft. On the consumer side, a water heater is placed as a load.

Figure 15. Shows the device 1

The figure shows device 1 reads the current consumption on the consumer side under abnormal condition

Figure 16. Shows the device 2

The figure shows that device 2 reads the current from the source and the current reading from device 1 was transmitted to device 2 and displayed on the LCD. Since the device was tested under abnormal conditions, the device detect power theft and displayed it on the LCD.

3.3 Test the Performance of the System

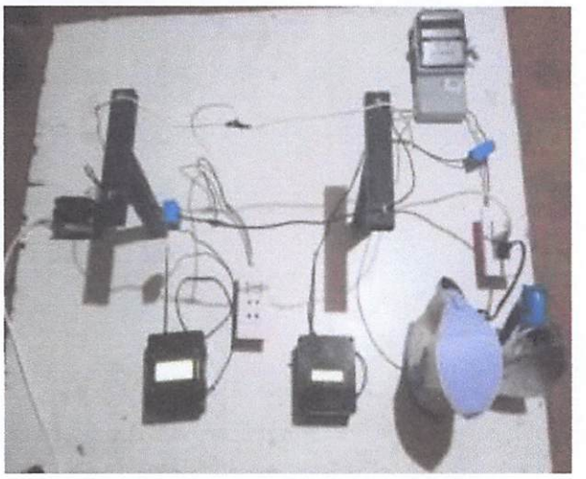


Figure 17. The System is Tested Using more Loads

The figure shows the system is tested using two more loads to test its performance under this condition. The load consumption of the consumer side was applied by load number 1 which is the flat iron and load number 2 which is the water heater.

Figure 18. Reading of the Actual Device

The figure shows the device that reads the total current consumption of both loads connected on the consumer side

	POWER(KW)	VOLTAGE	CURRENT
LOAD 1	1000	230	4.34 A
LOAD 2	900	230	3.91 A
TOTAL	1900	460	**8.25 A**
DEVICE READING			**7.87 A**

Table 2. Tabulation of Data Under normal condition

The table shows the configuration of the loads used in the study to test the performance of the system. Here it shows the calculation of both loads compared to the reading of the developed device.

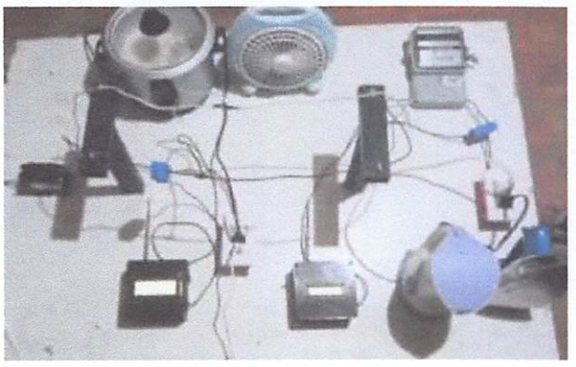


Figure 19. The System tested under the abnormal condition with more loads

The figure shows the system is tested under the abnormal condition with more loads are put together on the distribution line. Here the load consumption on the consumer side is applied by load 1 which is the flat iron and load 2 which is the water heater. The load consumption on the theft side is applied by load 3, the rice cooker, and load 4 which is the electric fan act as an inductive load.

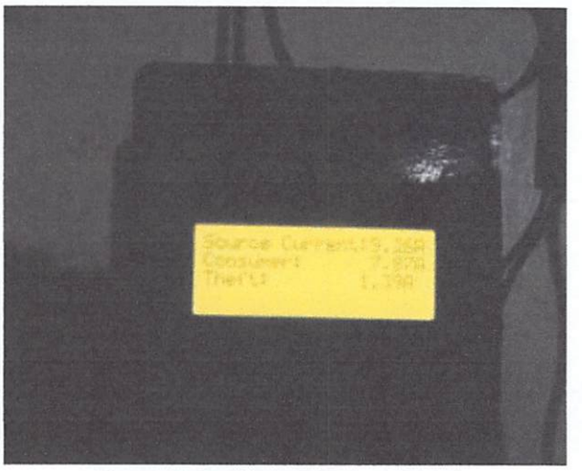


Figure 20. Reading of the Actual Device

The figure shows the actual reading of the device which read the current under abnormal condition for both on the source line and the consumer side of the distribution system and it also detects power theft

CONSUMER'S LOAD	POWER (KW)	VOLTAGE	CURRENT
LOAD 1	1000	230	4.34 A
LOAD 2	900	230	3.91 A
TOTAL	1900	460	**8.25 A**
DEVICE READING			**7.87 A**
SOUCRE LOAD			
LOAD 3	400	230	1.74 A
LOAD 4	20	230	0.08 A
TOTAL	420	460	**1.82 A**
DEVICE READING			**1.39 A**

Table 3. Tabulation of Data Under Abnormal Condition

The table shows the configuration of all the devices used to test the performance of the system under abnormal conditions. Its shows the total current for both on the consumer side and source line of the distribution system compared to the actual reading of two devices.

FUNCTIONALITY	MEAN	DESCRIPTION
1.) Reads current on both sides of the	4	Very Acceptable

distribution line		
2.) Detects and calculate the consumption of current from the source load to the consumer's load	4	Very Acceptable
3.) Transmit data wirelessly	3.6	Very Acceptable
4.) The device read an actual reading based on the configuration of the load used	3	Acceptable
Overall Mean	**3.6**	**Very Acceptable**

Table 4. The functionality of the Device

Table 4 shows the data of the functionality of the device as evaluated by 10 evaluators. The first item got a mean of 4 which means it has very high acceptability. The device was able to read the current consumption for both sides of the consumer and the source of the distribution system. The second item also got a mean of 4 which falls to the descriptive rating of very acceptable. The next item got the mean of 3.6, the device has a very acceptable rating for transmitting data wirelessly. Then the last item got an acceptable descriptive rating that has a mean of 3. The overall mean is 3.6 is equivalent to the descriptive rating of very acceptable. With this, it implies that the device is functioning well.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

To design the device, the researcher used the Proteus software for its schematic diagram. The components for the design are a microcontroller using an Arduino Uno, SCT-013 current sensors, Radio Frequency module, and LCDs.

The developed device was successful for it was able to read the current reading for both the consumer side and the distribution line under normal and abnormal conditions. In addition it also able to detect power theft when an illegal connection is occurring.

The performance of the device is very good regarding detecting and reading current with various loads connected on the distribution line. It is also able to read currently on different kinds of loads such as inductive and resistive load.

Recommendation

1.) A further study which allows the device to transmit and receive data within a 100-meter range

2.) Research that includes an alarm system for the device when it detects power theft.

5. ACKNOWLEDGEMENT

The researchers wish to extend their sincerest appreciation to the following people who help with this project study. They are the people who helped and contributed much to the success of this endeavor. To God, for the gift of knowledge and wisdom, He gave, for answering prayers in time, and also for keeping them safe amidst this coronavirus pandemic. To their parents and family members, for the undying love and support that they gave, especially for the financial support despite the crisis that they are facing right now. To the institution for giving them a chance to conduct this project studies. Lastly to all those who were part of this work, the researchers would like to extend their deepest thanks

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