Technological University of the Philippines

Ayala Blvd., Ermita, Manila

College of Engineering

Electronics Engineering Department

A Solar Powered Adaptive Neuro-Fuzzy Inference System (ANFIS)-Based Automatic Generation Controller for Pico-Hydro Power Systems for Off-Grid Rural Areas

Members:

Capulong, Timothy John F.

Lising, John Arvin B.

Loyola, Bryce Hart C.

Ramirez, Adonis L.

Simpliciano, Julia E.

Adviser:

Engr. Gilfred Allen M. Madrigal

Date:

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A Project Study Presented to the Faculty of

Electronics Engineering Department

College of Engineering

Technological University of the Philippines

In Partial Fulfilment of the Course Requirements for the Degree of

Bachelor of Science in Electronics Engineering

Submitted by:

Capulong, Timothy John F.

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Simpliciano, Julia E.

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APPROVAL SHEET

This project study entitled "**A Solar Powered Adaptive Neuro Fuzzy Inference System (ANFIS) - Based Automatic Generation Controller for Pico-Hydropower System for Off-Grid Rural Areas**", has been prepared and submitted by the following proponents:

Capulong, Timothy John F.	Ramirez, Adonis L.
Lising, John Arvin B.	Simpliciano, Julia E.
Loyola, Bryce Hart C.	

In partial fulfillment of the requirements for the degree of **Bachelor of Science in Electronics Engineering** is hereby recommended for approval.

ENGR. GILFRED ALLEN M. MADRIGAL
Project Adviser

E-signature of LEAN KARLO S. TOLENTINO signed August 13, 2020 @ 7:08 PM UTC+8

ENGR. EDMON O. FERNANDEZ
Panel Member

ENGR. LEAN KARLO S. TOLENTINO
Panel Member

ENGR. AUGUST C. THIO-AC
Panel Member

ENGR. EDGAR GALIDO
Panel Member

ENGR. GILBERT HOLLMAN
Panel Member

Accepted and approved in partial fulfillment of the course requirements for the degree of **Bachelor of Science in Electronics Engineering.**

ENGR. EDMON O. FERNANDEZ
Head, ECE Department

ENGR. BENEDICTO N. FORTALEZA
Dean, College of Engineering

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ABSTRACT

Renewable energy sources play a vital role in the technologization of our modern world, especially those who are in rural areas. However, the power system's output voltage and frequency vary from time to time due to the continuous change in load especially in pico-hydro. This study presents Automatic Generation Controller (AGC) which will maintain the voltage and frequency output of the generator in the standard range stated in the Philippine Grid Code. Several sensors were used to measure the variations of the said parameters which are fed to the Arduino Uno that controls the water flow in the turbine through a chain system. The water flow determines the output frequency and voltage of the generator. This paper has conducted a comparative study of various control algorithms namely, Proportional-Integral-Derivative (PID) Controller, Artificial Neural Network (ANN), Fuzzy-logic, and Adaptive Neuro-Fuzzy Inference System (ANFIS). It is found that the ANFIS has the most reliable, fastest, and most efficient response among the four control algorithms. It is for the purpose of which control algorithm will control the frequency and voltage output of the system in the standard range of pico-hydro power systems. The AGC stabilizes the voltage and frequency output of the power system with an average time of 48.425 seconds. This study will provide great help in the renewable energy source industry making their products more reliable to be used in rural areas.

ACKNOWLEDGEMENT

It is our most extreme respect and joy to show our sincerest appreciation to those individuals who made this postulation conceivable:

First and foremost, we would like to extend our biggest thanks to our Lord God. His guidance throughout this journey is overwhelming, despite having some twists and turns, some obstacles and problems we faced, His light of hope is always there for us to keep us on track. Thank you, Lord God, for your blessing, knowledge, and strength that you lent us to finish this project study. We are really honored and blessed with your grace upon us.

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We are truly thankful for everything. Much obliged to you!

Chapter 1

INTRODUCTION

One of the major contributors in this inevitable rise in the earth's temperature is the conventional energy sources that civilization is offering to its people. With the unending needs for energy sources, fossil fuels, coal, petroleum, and natural gases are depleting continuously. These non-renewable energy sources of energy are ones that mainly contribute to the large content of carbon dioxide in our atmosphere. This is one of the reasons why the renewable energy sources had made its way in the trend up to the modern world. Hydro and solar energy will be used to generate electricity in an underserved community of the Philippines as plenty of water bodies are vastly available in such areas. In this study, the researchers will focus on building an Automatic Generation Control (AGC) that will help in optimizing the output of the hybrid and solar energy power system.

Different types of controllers are used in energy power generators such as proportional-integral-derivative, general algorithm, ANFIS, artificial neural network, and fuzzy logic. In the Philippines, the standard voltage is 220 V (Voltage Plug Region, 2019) and the standard or nominal frequency is 60 Hz (Republic of the Philippines, 2016). With these controllers, frequency and voltage variations will be regulated and be specified into the standard value in the country.

1.1. The Background of the Study

Slim province of Aurora is best known for its greenery and coastlines free of bottle caps and plastic debris. However, setting aside its survival from disturbing civilization, it cannot deny the fact that a lot of areas in this pristine place still lacks in power supply.

With the modern trend of implementing power generators, it is now possible to reach such rural areas to be able to provide the power necessities of its community. Considering the threats that global warming imposes, it is more beneficial to the environment and with the people as well to use renewable energy sources rather than conventional energy sources.

Solar, hydro, and wind energy, these are just some renewable energy sources that are being widely used today. These infinite energy sources offer so much potential in the modernization of rural areas. In contrast, these energy sources hold some disadvantages too. Solar energy may vary through day and night, weather and cloud formations. On the other hand, hydro energy may vary with the tides and wind energy with the weather and season. Due to the unpredictable nature of these energy sources, a hybrid renewable energy power system is being developed nowadays to serve as an energy source combining two or more renewable energy. With these hybrid renewable energy power systems, the inconsistencies of each of these energy sources may be smoothen out. When solar energy is out, combining the hydro energy might be a substitute as the energy source considering the high tide during the nights and vice versa when it's low tide and the flow of water is minimal, the solar strength will fulfill the load demand.

Solar energy is a green energy that is vastly available during the daytime. Solar panels contain photovoltaic materials which generate electricity when sunlight touches it. The output electricity of the solar panel will vary depending on the angular strike of sunlight and its intensity. Hydro energy on the other hand, is a renewable energy that is always available given there is water flow. Hydro power systems have blades as the main component that generates electricity rotation. Output electricity of hydro systems depends

on the angular bends of the blades, strength of water flow and various parameters in the system itself.

However, the simultaneous substitution effect of this hybrid renewable energy power system may always not be reliable. Minimal water flow might happen during nighttime. The main drawback of these systems is the unpredictable continuity of the output power that may cause variation in the output frequency and voltage of the system. With that, the need for a control system is palpable. Various parameters must be known and considered to build a reliable Automatic Generation Control that will balance the power output to the demand of the load. Automatic Generation Controllers will maintain the voltage and frequency in the standard value.

There are various methods that can be used in designing an AGC and an example of this is the application of integral control which is the simplest among all (Ravindra Singh, 2015). However, the controller “I” alone does not have the capacity to predict the following mistake in the future. Combining it with a controller “D”, it will succeed at this difficulty. The D controller will anticipate the future behavior of the error. Adding the P controller, there will be a stable operation by giving an output proportional to current error. Combining the three aforementioned controllers, the Proportional Integral Derivative (PID) controller will be implemented. PID Controller is a conventional control loop feedback mechanism wherein the process includes variables such as frequency and voltage are being manipulated.

Firefly algorithm is a method employed to adjust reflectance of the Fuzzy-PID controller in accordance with the Derivative Filter. It is said to be a powerful optimization technique to regulate frequency on a unified power system with a thermal non-reheat type turbine. Step Load Perturbation (SLP) was compiled to take note of the response of the system. The results were examined through Bacteria Foraging Optimization (BFO) adjust the controller “PI” and Hybrid BFO-PSO tuned “PI” controller (Manoj Kumar Debnath, 2015).

The usage of Artificial Neural Network (ANN) controller is another technique that delivers a quick control as measured together with conventional control methods. It is said to be a fast-responding nonlinear controller and can be utilized to enhance the steady state error. One of the best neural algorithms is said to be the back-propagation algorithm. This algorithm aims to modify the frequency and power oscillations since there are load variations that must be lessened to zero to achieve a faster time response for the stable operation (Dahiya, 2015)

Fuzzy Logic Controller (FLC) is known for its numerous applications in the field of controlling the load frequency. It is another way to be in command and be employed in a three interconnected thermal power system. This controller aims to obtain zero-frequency variation of the load. It is one of the significant prerequisites in achieving a well-founded and suitable activity in multi-region control systems. The dynamic execution of Load Frequency Control can be measured with the use of Fuzzy Logic Controller (FLC) that is attached in a three interconnected thermal power system (Sanjiv Kumar Jain, 2015).

1.2. The Statement of the Problem

This research seeks to control the voltage and frequency of a hybrid system using an automatic generation controller. This Automatic Generation Controller (AGC) will help the generated output to match with variations of load demand. To create a reliable AGC, the study attempted to answer the following specific questions:

1. What is the best algorithm to be used in the implementation of the Automatic Generation Controller of Hybrid Solar and Pico-Hydro Power System?
2. What program should be used to regulate the opening and closing of the gate valve?
3. What is the typical range of the variation in the output voltage and frequency of Hybrid Solar and Pico-Hydro Power system?
4. What mechanism should be used to control the water flow in the power system?
5. What is the overall performance of the device?

1.3. Objectives of the Study

1.3.1 General Objective

To develop a Solar Powered Adaptive Neuro Fuzzy Inference System (ANFIS)-based Automatic Generation Controller for Pico-hydropower System for Off-Grid Rural Areas

1.3.2 Specific Objectives

1. To conduct comparative study to determine which among the algorithms namely – (1) Proportional Integral Derivative Controller, (2) Fuzzy Logic,

(3) Artificial Neural Network Controller and (4) Adaptive Neuro Fuzzy Inference System Controller is best suitable and effective for AGC.

2. To develop a program that can control the DC motor that will regulate the opening of the gate valve that will control the water flow.

3. To develop a frequency and voltage sensor circuit/ system that will give input to the program with variations in the frequency and voltage output of the generator.

4. To devise a chain system using gate valve, gear and chain, and DC motor.
5. To test and validate the overall performance of the Automatic Generation Controller.

1.4. Significance of the Study

The study pursues to develop a Solar Powered Automatic Generation Controller for Pico-Hydro Power System. The result of this study will be a great value to numerous recipients.

First, the underprivileged communities, especially in rural areas would greatly benefit from the study since the outcome will provide access to electricity through the alternative source of energy. This study will be advantageous to the communities by assisting them to acquire sufficient electrical power at low cost and create a wider avenue for faster communication in their vicinity. In addition, the electricians in rural areas will

also benefit since this study will find ways to create a solution to an electrical power shortage by creating another methodology in the power generation through maximizing and preserving renewable energy resources.

This research will benefit government agencies such as the Department of Energy together with the Department of Environment and Natural Resources by augmenting their awareness and knowledge with the issues regarding large power consumption, the importance of renewable energy sources and alternative methods to generate electricity. This study will yield a positive impact by having a more productive way of life and establish inspirational and intellectual ideas about preservation and proper management of the environment.

Furthermore, the findings from this study will be valuable to the electricity sector of the Philippines such as power plants and corporations because the result will serve as their guide to develop and administer a more comprehensive energy control system that is both realistic and practical in contributing to enrichment in lives. This will open a new avenue for concepts and ideas in innovating hybrid power systems and automatic generation controllers. Lastly, the data from this study can be utilized by the future researchers for a similar future research. This can be replicated in terms of finding other appropriate variables to dig deeper into other aspects of the topic.

1.5. Scope and Limitations

The scope in this study is centered at Automatic Generator Controller that adjusts the power output of a generator in response to the changes in the load. The location for this study is at Sitio Singawan, Barangay, Umiray, Dingalan, Aurora, approximately 5-hour drive from Manila, which is the biggest barangay in the municipality in terms of area (Medical Ambassadors Philippines, Inc., 2016; Medical Ambassadors Philippines, Inc., 2016). This study limits Automatic Generation Controller (AGC) to control the voltage and frequency of hybrid power generators with maximum output power of 2kW.

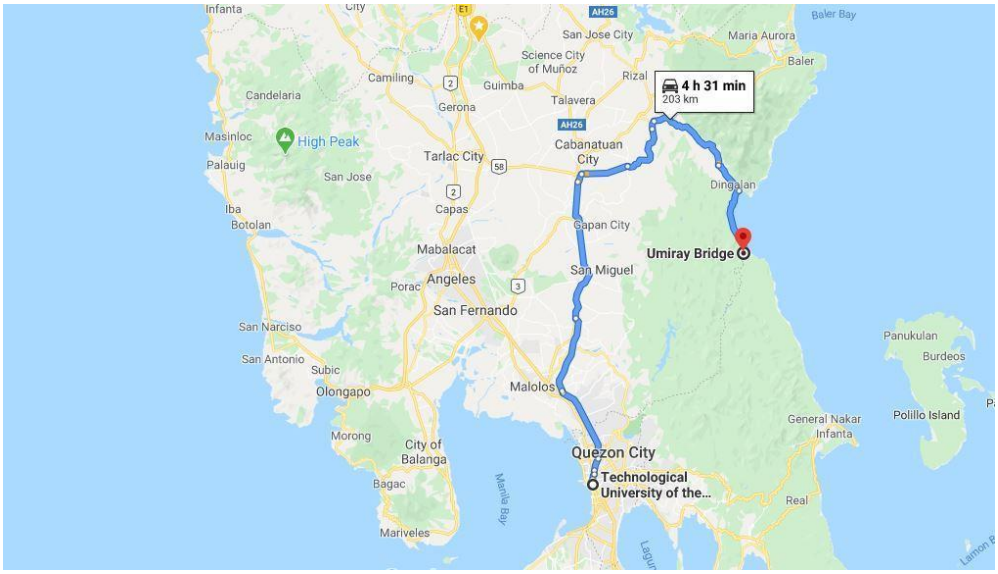

Figure 1.1 Vicinity Map: Barangay Umiray, Dingalan, Aurora (Google Maps)

1.6. Assumptions

This study aims to propose and develop a renewable energy system that works continuously without battery storage, where it is the most cost productive answer for

supplying electrical vitality especially for the underserved areas. The proposed renewable energy in this study is a pico-hydropower system that will provide rural areas a supply of electricity. The pico-hydro system is designed for the underserved community in Aurora Province.

1.7. The Definition of Terms

Adaptive Neuro – Fuzzy Inference System - is a Hybrid control technique, combining neural networks and Fuzzy logic. This combination may help fuzzy to adapt the changes of the system and adjust its function for better output.

Arduino – a type of Microprocessor and controller that is programmable

Artificial Neural Network – is another type of control technique that is more likely a simplified mathematical model of the brain systems. ANN can automatically adjust their function to optimize their behavior as pattern recognizer, decision makers, system controllers and predictors.

Automatic Generation Controller (AGC) - is a system that automatically adjusts and controls the output of the system. In this project it controls the output electricity produced by Hybrid Solar and Pico-hydro Power System.

Automatic Voltage Regulator – it is used to control voltage variation. It gathers the fluctuated voltages and changes them into a single yet constant voltage.

DC Motor – it is a type of a rotary electrical motor that converts electrical energy to mechanical energy in a form of rotation. It has inductors inside that generate magnetic fields used to provide movement.

Fuzzy Logic – is a control technique which uses a set of functions defining a degree or set. It uses many different functional blocks including rule-base, fuzzification, database, interference and defuzzification.

Gate Valve – it is a type of valve with a sliding disc to control the flow of the liquid where its gate opens upward or downward

Generator - a mechanical device used to convert mechanical energy to electrical energy.

MATLAB – stands for Matrix Laboratory which is a high-performing language for technical computing.

Proportional Integral-Derivative Controller- is a control technique that is widely used in the industrial control system. A control system that is automatically adjusted when the desired output is not achieved.

Sensors - a device used to detect or measure a physical property and records its changes. It can also be used as automatic switching.

Chapter 2

REVIEW OF RELATED LITERATURE

This chapter covers the background studies, basic functions and applications of all the elements in the system of the study. This will help to further understand the entirety of the study.

2.1 Conceptual Literature

2.1.1 Algorithms

2.1.1.1Proportional Integral Derivative

According to Hidayat (Hidayat, 2015), PID or Proportional Integral Derivative has the main characteristic of flexibility and reliability and is considered to have a classical control which is made to manipulate parameters so as to achieve the desired outcome. It has only two control behaviors like fully ON or fully OFF and can be constructed by using a low-cost simple ON or OFF controller. PID controller exhibits a unique characteristic that upholds the output by achieving zero errors in process variables and set point output by closed loop operations. The controller has a good response rate and is simple in structure yet sturdy. The main components of PID are error signal (e (t)), control signal (u (t)) and reference input signal (r (t)). Kp, Ti, and Td values are important to analyze the performance of this controller.

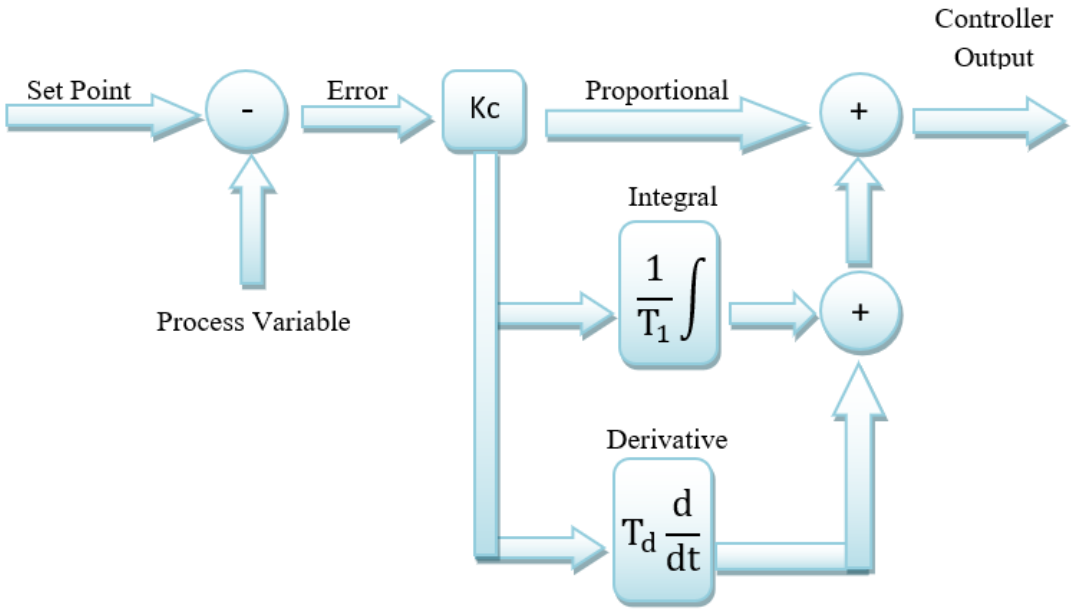

Figure 2.1 Proportional Integral Derivative Diagram (ElProCus, 2018)

As stated on ElProCus (ElProCus, 2018), the three basic control behaviors in PID Controller are P-Controller, I-Controller and D-Controller. P-Controller has a stable operation and always preserves the steady state error. The speed of the response is directly proportional to the proportional constant Kc. This controller provides an output that is proportional to current error e (t). It evaluates the set point to process variable then the resulting error is multiplied to the proportional constant Kc down to the output. The controller output is zero when the error value is zero.

True to its name, I-controller is used to integrate the error over a period of time until the error value reaches to zero. The role of I-Controller is to fill the inadequacy of P-Controller since offset is present between the

process variable and set point and removes the steady state error in the P-Controller. It provides storage for the value to the final control device that makes the error become zero. The controller is added to the P-Controller system between proportional constant and controller output. Negative error is lessened by the integral control as it restricts the speed response and it will influence the stability of the system. Reducing the integral gain Ki will improve the speed response.

D-Controller predicts the future behavior of error and by that it overcomes the inability of I-Controller to predict future behavior of error. The rate of change of error with respect to time multiplied by derivative constant will yield output. Enlarging the value of the system response will fire the start for the output. The speed response will be enhanced by augmenting the derivative gain. We can achieve the desired response for the system by mixing the three controllers.

There are different types of tuning methods of PID controllers that include trial and error method, process reaction curve technique, and Zeigler-Nichols method. We can adjust it by using Ziegler-Nichols tuning formula. There are two categories of Ziegler-Nichols tuning formula namely base on step response and frequency response. Base step response should consist of L and T where the specific waveform must be achieved. Base on frequency response should consist of Kc and be verified by Pc.

2.1.1.2 Adaptive Neuro-Fuzzy Inference System

Alhasa (Alhasa, 2016) stated that the Adaptive Neuro – Fuzzy Inference System (ANFIS) or Adaptive Network-based Fuzzy Inference System is considered as a learning algorithm based on supervised learning. The controller is used in Sugeno fuzzy models in which composed of five layers and each layer consists of a node and plays an important role. The nodes are categorized in two namely adaptive nodes (square symbol) and fixed node (circle symbol).

As mentioned by Hidayat (Hidayat, 2015), layer 1 consists of node i in each node and considered to be an adaptive node. The task of the node is to generate activation of the parameter. The layer becomes accustomed to a function parameter. The input of the membership functions such as Gaussian membership function and a generalized bell membership function include the degree of membership value and from that we can attain the output from each node.

The node in layer 2 is described to be a fixed node or non-adaptive that corresponds to the firing strength and circle node is tagged as Π. Combining signals from the node together with the next node will result in output of the node. The output will come from the second layer since the T-norm operator is present in this layer. Firing strength for each rule corresponds to each node in this layer and it stands as output.

Furthermore, Hidayat (Hidayat, 2015) and Alhasa (Alhasa, 2016) discussed that the node in Layer 3 is called a fixed node and will yield to normalized firing strengths and circle node is coined as N. Ratio between the i-th rules and the summation of rules' firing strengths must be solved in order to attain the firing strength in each node. The outcome from this is referred to as the normalized firing strength.

Lastly, the node i in layer 4 is called an adaptive node and the circle node is termed as ∑ in which the parameters are termed as consequent parameters. Lastly, there is a single node in layer 5 referred to as a fixed node and performs the summation of all the output of all the incoming signals originated from the prior node.

2.1.1.3 Artificial Neural Network

ANN stands for Artificial Neural Networks. Essentially, it's a computational model. That depends on structures and elements of natural neural systems. Despite the fact that the structure of the ANN is influenced by a stream of data. Thus, neural system changes depend on information and yield.

Essentially, we can consider ANN as nonlinear factual information. That implies a complex relationship characterizes among info and yield. Thus, we found diverse examples. Likewise, we call the ANN a neural system.

It is truly said that the working of ANN takes its foundations from the neural system dwelling in the human mind. ANN works on something alluded to as Hidden State. These shrouded states are like neurons. Every one of these shrouded states is a transient structure which has a probabilistic conduct. A network of such shrouded state goes about as a scaffold between the information and the yield. (Srivastava, 2014)

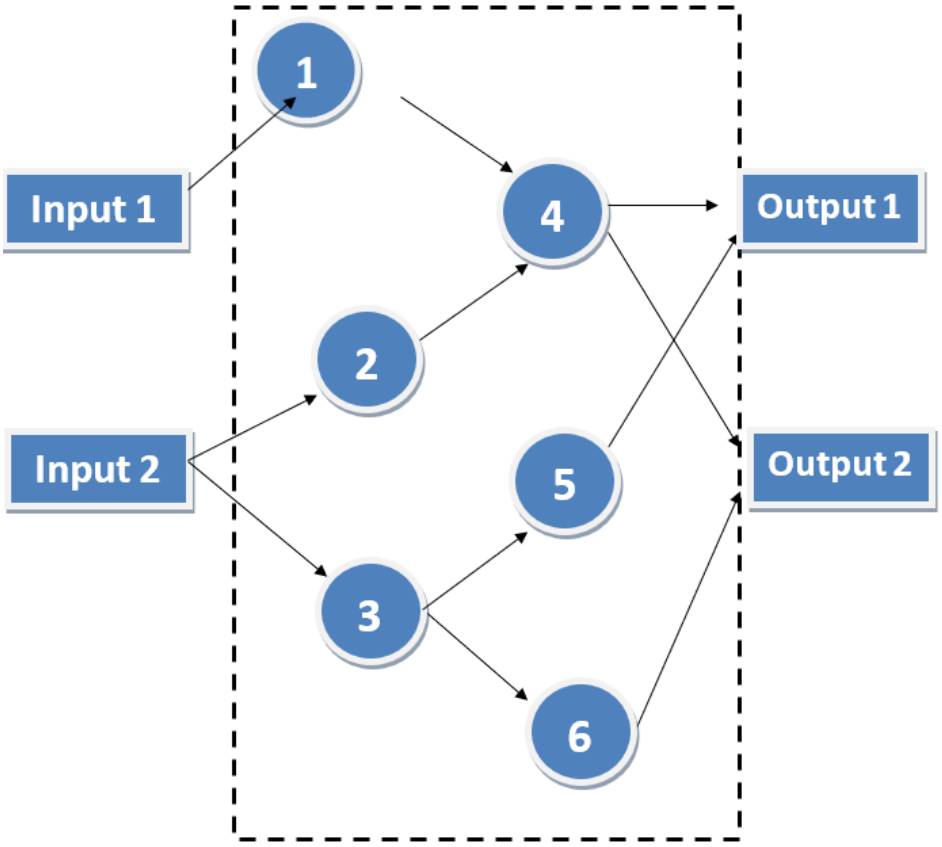

Figure 2.2 Artificial Neural Network Diagram (Srivastava, 2014)

2.1.1.4 Fuzzy Logic

Fuzzy Logic is generally utilized in machine control. The expression "fuzzy" alludes to the way that the logic included can manage ideas that can't be communicated as the "true" or "false" yet rather as "partially true". Albeit elective methodologies, for example, hereditary calculations and neural systems can perform similarly just as fuzzy logic by and large, fuzzy logic has the preferred standpoint that the answer for the issue can be thrown in wording that human administrators can see, so their experience can be utilized in the plan of the controller. This makes it less demanding to motorize errands that are as of now effectively performed by people

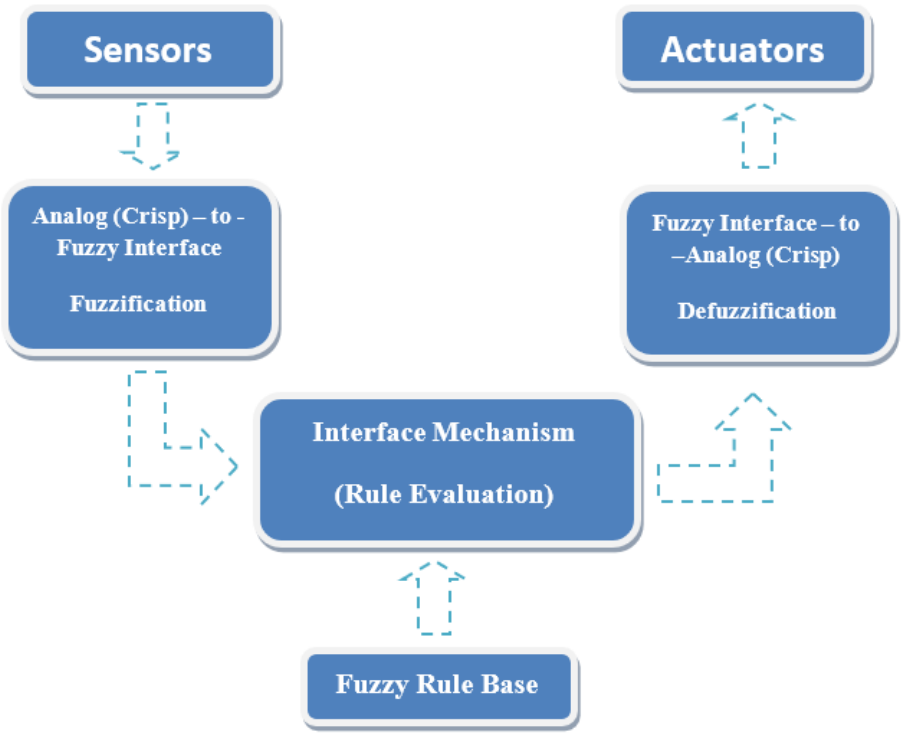

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Figure 2.3 Fuzzy Logic Diagram *Invalid source specified.*

2.1.2 Sensors

Sensors are advanced devices that are much of the time used to recognize and react to electrical or optical signs. A sensor changes over the physical parameter into a flag which can be estimated electrically. There are several types of sensors but the focus in this study is voltage and frequency sensor.

2.1.2.1 Voltage Sensor

Majority of faults, incidents, and accidents related to electrical hardware and frameworks are because of under voltage and overvoltage. It is significant to know the required or exact measure of current and voltage in a specific system and application as it allows the engineer or technician to form and make safety-critical decisions. Likewise, knowing the measure of current or voltage in a system enables one to check the performance of the different subcomponents in a system.

In the Philippines, the standard voltage rating is 220 Volts (Voltage Plug Region, 2019). In conformity with the Philippine Grid Code, for voltage fluctuation, a range of -+ 3% (Republic of the Philippines, 2016) may be allowed provided that it will not impose risk to the user or the load. One of the best ways to supply the need for electricity in a household or community is Pico Hydro Generator. However, there is still a problem to

make the output voltage stable therefore; there is a need to regulate it again. A voltage regulator is a system intended to consequently keep up a consistent voltage level. A voltage regulator may utilize a straightforward feed-forward structure or may incorporate negative criticism. It may use an electromechanical system, or electronic segments. Contingent upon the plan, it might be utilized to control at least one AC or DC voltages.

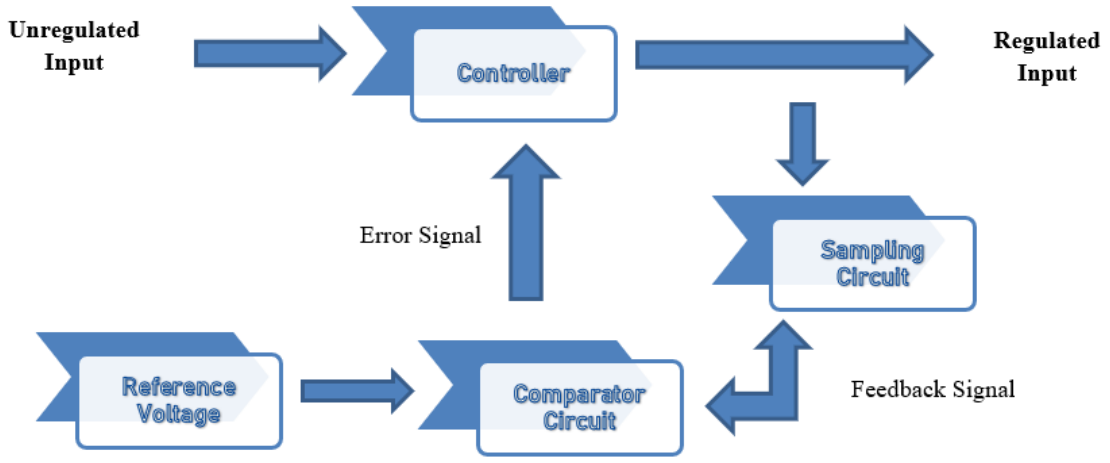


Figure 2.4 Voltage Regulator Diagram *Invalid source specified.*

The voltage-detecting modules are in charge of commencement of activity possibilities and evaluated film potential changes in voltage. The rising basic model for voltage sensor work opens the best approach to improvement for Solar Powered Automatic Generation Controller for Pico-Hydro Power System for off-network provincial zones. The picture shown below is an example circuit for voltage sensors**.**

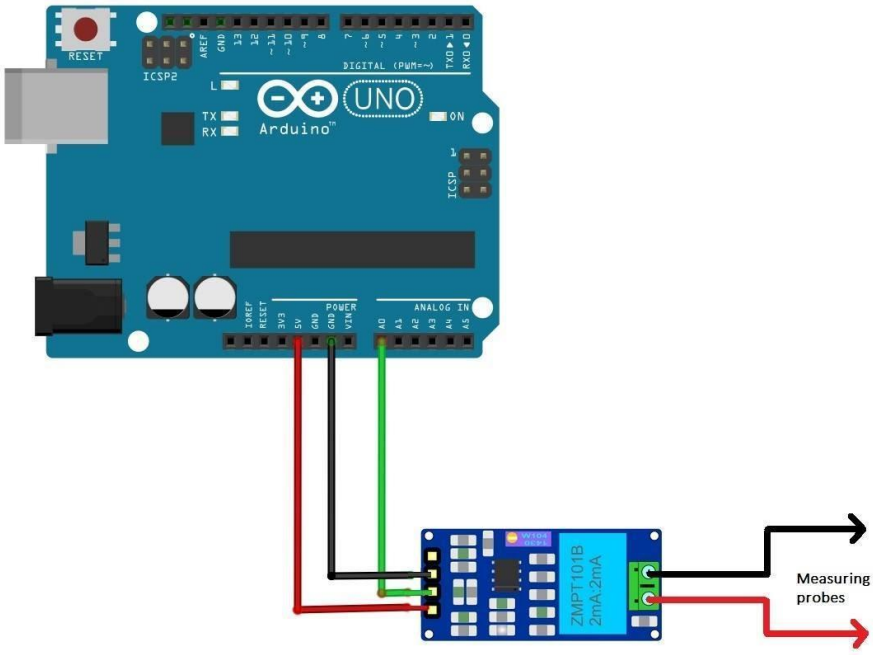


Figure 2.5 Voltage Sensor Circuit Connected to Arduino UNO

2.1.2.2 Frequency Sensor

The standard line frequency in the Philippines is 60 Hz (Republic of the Philippines, 2016, p. 36) which may vary from time to time. Due to the change in frequency, simple and sensitive equipment may begin to be defective that may result in imprecise output. In electronics, a frequency for the most part is a voltage that changes or shifts its extremity number of times each second. For instances such as this, the Philippines Distribution Code states, “the distribution utility shall design and operate its system to assist the system operator in maintaining the fundamental frequency within the limits of 59.7 Hz and 60.3 Hz (Republic of the Philippines, 2016, p. 36)

during normal conditions. The frequencies associated with electronic circuits are in every case low in extent and may not surpass the most extreme working voltage or the supply voltage of the circuit itself. These are utilized to satisfy many convoluted capacities in a circuit and are for the most part created utilizing CMOS logic gates. It frequently winds up important to quantify the rate of these frequencies and in this manner a frequency sensor ends up being a significant imperative instrument for it.

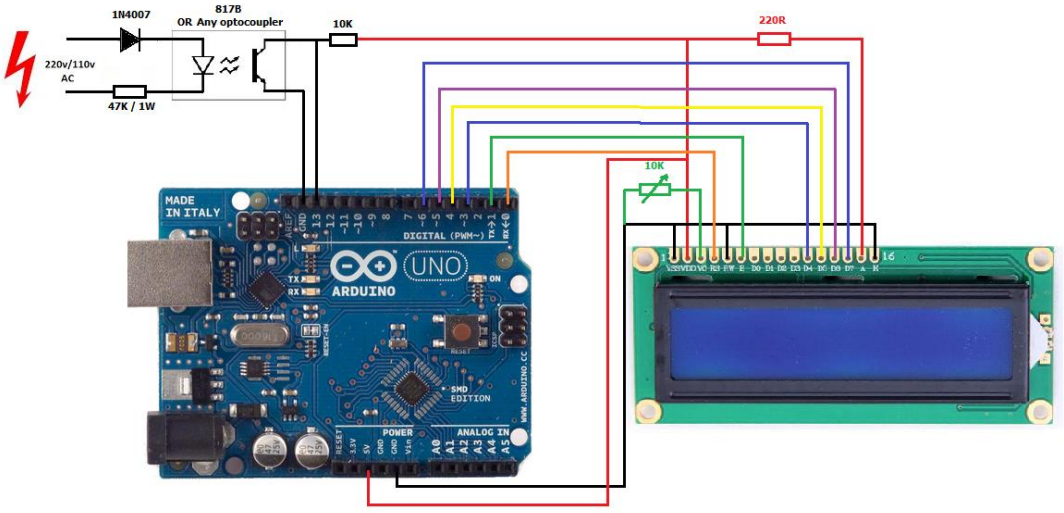


Figure 2.6 Frequency Sensor Circuit Diagram

2.1.3 MATLAB

MATLAB is utilized by specialists and researchers in numerous fields. The multi-worldview numerical figuring condition enables designers to interface with projects created in various languages, which makes it

conceivable to outfit the interesting qualities of every language for different purposes.

MATLAB encourages you to perform "imagine a scenario in which" investigation that causes you affirm the feasibility of a hypothesis. The reason such a significant number of hypotheses are accessible today is to take care of issues. These individuals are locked in with math such that few others can promptly get it.

2.1.3.1 MATLAB Simulink

Simulink® is a block diagram environment for multi-domain simulation and Model-Based Design. It underpins framework level plan, recreation, programmed code age, and constant test and confirmation of implanted frameworks. Simulink gives a graphical editor and customizable block libraries. It is coordinated with MATLAB® (The MathWorks, Inc.)

It enables you to join MATLAB calculations into models just as far as the reproduction results into MATLAB for further examination. Simulink supports system-level design, simulation, automatic code generation, testing and verification of embedded systems. (tutorialspoint)

There are a few other extra items given by MathWorks and outsider equipment and programming items that are accessible for use with Simulink.

The accompanying rundown gives brief portrayal of some of them

- Stateflow permits creating state machines and stream outlines.
- Simulink Coder permits the use of C source code for ongoing execution of frameworks consequently.
- xPC Target together with x86-based ongoing frameworks give a situation to reenact and test Simulink and Stateflow models continuously on the physical framework.
- Embedded Coder supports specific embedded targets.
- HDL Coder permits to consequently produce synthesizable VHDL and Verilog.
- SimEvents gives a library of graphical building hinders for demonstrating lining frameworks. (tutorialspoint)

2.1.4 Arduino

Arduino is an open-source stage utilized for building hardware ventures. Arduino comprises both a physical programmable circuit board (regularly alluded to as a microcontroller) and a bit of programming, or IDE (Integrated Development Environment) that keeps running on your PC, used to compose and transfer PC code to the physical board. (SparkFun Electronics).

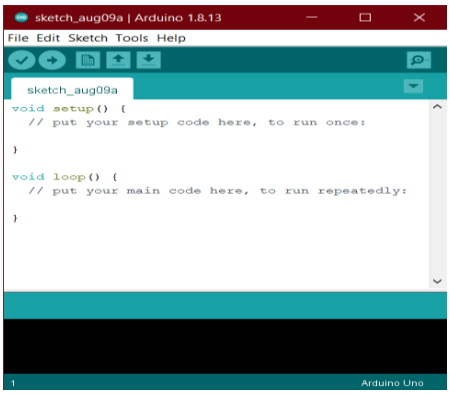


Figure 2.7 Arduino IDE

The Arduino IDE is open source programming which is written in Java and will chip away at an assortment of stages: Windows, Mac, and Linux. The IDE empowers you to compose code in an extraordinary domain with punctuation features and different highlights which will make coding simpler, and afterward effectively load your code onto the gadget with a straightforward snap of a catch.

Each Arduino board needs an approach to be associated with a power source. The Arduino UNO can be fueled from a USB link originating from your PC or a divider control supply (this way) that is ended in a barrel jack. In the image over the USB association is named (1) and the barrel jack is marked (2) (SparkFun Electronics).

2.1.4.1 Arduino Uno (R3)

The Uno is an extraordinary decision for your first Arduino. It has all that you have to begin, and nothing you don't. It has 14 advanced information/yield pins (of which 6 can be utilized as PWM outputs), 6 simple data sources, a USB association, a power jack, a reset catch and that's only the tip of the iceberg. It

contains everything expected to help the microcontroller; just interface it to a PC with a USB link or power it with an AC-to-DC connector or battery to begin.

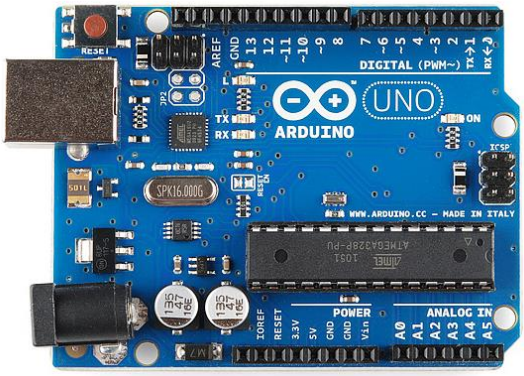


Figure 2.8 Arduino UNO

2.1.4.2 Arduino Mega (R3)

The Arduino Mega resembles the UNO's big brother. It has lots (54!) of digital input/output pins (14 can be utilized as PWM yields), 16 simple sources of info, a USB association, a power jack, and a reset catch. It contains everything expected to help the microcontroller; basically, interface it to a PC with a USB link or power it with an AC-to-DC connector or battery to begin. The extensive number of pins make this board exceptionally convenient for tasks that require a cluster of advanced data sources or yields (like bunches of LEDs or catches). (SparkFun Electronics)

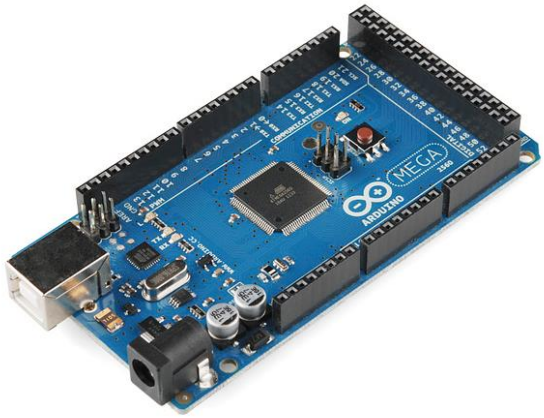


Figure 2.9 Arduino MEGA

2.2 Related Studies

2.2.1 Comparative Study of Different Controllers for Automatic Generation Control of an Interconnected Hydro-Thermal System with Generation Rate Constraints

An interconnected power system comprises a few areas. In every area, an Automatic Generation Controller (AGC) screens the system frequency and tie line streams, registers the net change in the age required furthermore, and changes the set places of the generators inside the territory to keep the time normal of the Area Control Error (ACE) at low esteem. AGC capacity can be seen as a supervisory control work which endeavors to coordinate the age pattern inside a region to the pattern of the arbitrarily changing load of the region, in order to keep the framework recurrence and the tie line control stream near booked esteem. The development in size and intricacy of electric power systems alongside increment in power request has required the utilization of canny systems that join learning, procedures and strategies from different hotspots for the ongoing control of intensity frameworks. The impediments of traditional indispensable controllers are their modera

2.2.3 Voltage and Frequency Regulation with Load Leveling of a PMSG Based Pico-Hydro System Using SLMS Control Algorithm

This work manages voltage and frequency control (VFC) of a permanent magnet synchronous generator (PMSG) based pico-hydro system with the load leveling. In this proposed system, a bi-directional DC-DC converter (BDC) with battery energy storage (BES) is coupled to voltage source converter (VSC). A bi-directional converter, whose input is BES, is utilized to control the DC-interface voltage of the VSC. Alongside the DC-interface voltage, it likewise keeps up dynamic power balance in the system. The BDC empowers to utilize a BES with diminished rating of 250V, while the DC-interface voltage is constantly kept up at 380 V. The battery gives load leveling by charging amid delicately stacked conditions. At the point when the associated burden surpasses more than PMSG based pico-hydro age, at that point the abundance control is conveyed by the BES. The power quality improvement of the system alongside VFC is acknowledged utilizing a VSC. The VSC alongside VFC likewise deals with other power quality issues like sounds and burden unbalancing.

A sparse least mean square (SLMS) based control calculation is utilized to assess principal part of burden flows and to produce reference source flows for VSC control. The voltage and frequency control (VFC) of such pico-hydro systems is required as it is consistently differing with the adjustment in the load. Any adjustment in load can cause frequency changes that should have been limited. The frequency dependability of this system can be gotten by controlling the dynamic power or by keeping up a consistent speed of the prime mover dynamic power or by keeping up a steady speed of the prime mover. Be that as it may, the inflow of

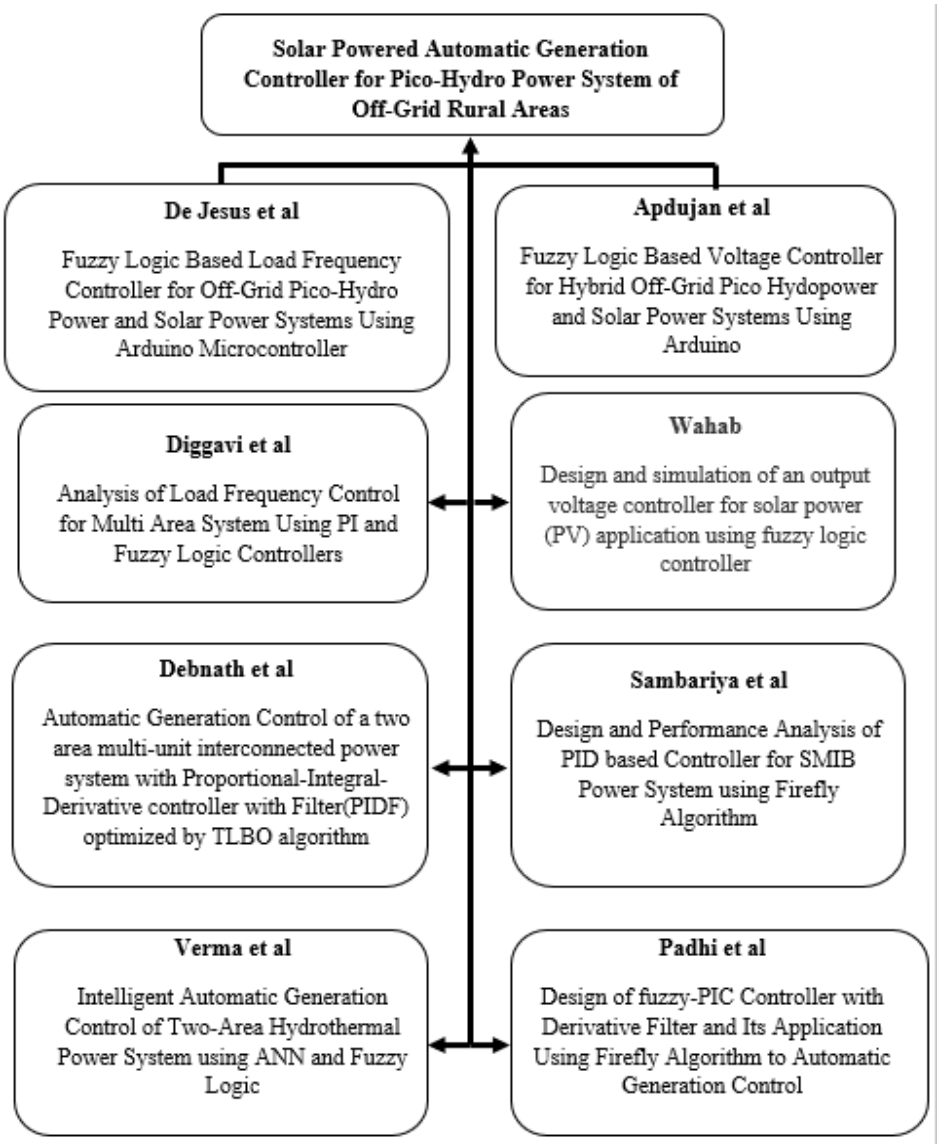
water to turbines of these systems may change as per the season so the speed can't be looked after consistently. Thus, a frequency controller can be joined for these systems to keep up steady frequency even with change in prime mover control. The Battery Energy Storage (BES) is a feasible answer for load leveling the voltage and frequency control. The BES charges, when the associated load is lesser than the generator power and releases when the load control request is higher than the generation (Chandran , Murshid, & Singh, 2018).

Chapter 3

METHODOLOGY

This chapter discusses and illustrates how the researchers will gather the essential information that will be utilized in the entire conduction of the study. This also demonstrates how the data will be gathered.

3.1 Theoretical Framework



3.2 Conceptual Framework of the Study

Table 3.1 illustrates the input, process, and output of the study. Voltage and frequency are the sole input in the system which will be detected by the voltage and frequency sensors circuit and undergo recognition by the Arduino. The output of the system shall be a torque that will control the opening of the gate valve which will control the water flow in the turbine.

INPUT	PROCESS	OUTPUT
SOFTWARE REQUIREMENTS: -Arduino Software IDE -MATLAB **HARDWARE REQUIREMENTS:** -Speed Governor (includes servo motor, gate valve, and chain) **KNOWLEDGE REQUIREMENTS:** -Utilization of MATLAB, and Arduino -Mechanics on Speed Governor	**SOFTWARE DEVELOPMENTS** -Simulation and Programming **HARDWARE DEVELOPMENT:** -Creating an Automatic Generation Controller -Implement the AGC into the speed governor **TESTING:** -Functionality and Usability Testing -Accuracy Testing -Reliability Testing -Expert Verification -Project Immersion	Solar Powered Automatic Generation Controller for hybrid solar and Pico - hydropower system

Table 3.1 Conceptual Framework

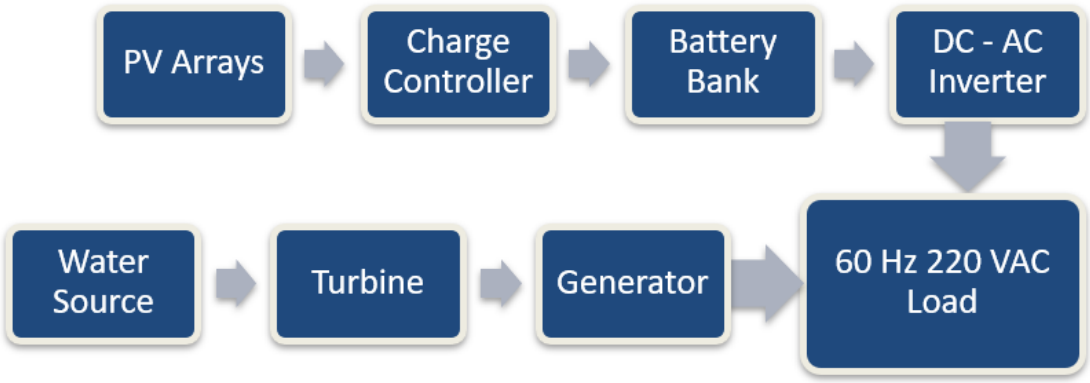


Figure 3.1 Hybrid Solar and Pico-Hydropower System

The hybrid solar and pico-hydropower system is illustrated in Figure 3.1. This includes the solar power system together with the pico-hydropower system. The solar power system has the PV arrays, charge controller, battery bank, and DC - AC inverter. The pico-hydropower system on the other hand has a turbine and a generator.

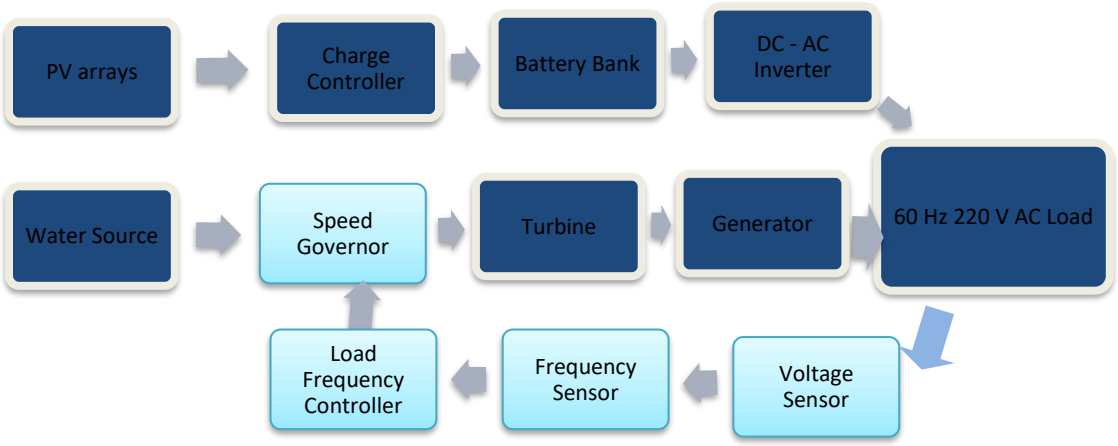


Figure 3.2 Implementation

Implementation of Figure 3.2 will be needed to attain a 213.4 V to 226.6 V and 59.7 Hz to 60.3 Hz range of outputs. As above figure shown, an AGC together with a speed governor will be implemented with the hybrid power system. The AGC is composed of frequency sensor circuit, voltage sensor circuit and Arduino. Frequency and voltage sensor circuits interconnected with the generator will be responsible for obtaining its output frequency and voltage. The data gathered by the sensors will then be recognized by the Arduino as inputs. Upon having difference from the set output voltage and frequency, the Arduino will then control the speed governor.

Moreover, the speed governor is composed of a DC motor and gate valve. The rotation of the DC motor will be controlled by the Arduino. Interconnected with a chain, the DC motor will control the opening of the gate valve which controls the water flow that hits the blades of the turbine. In short, AGC will recognize inconsistencies with the set output standard of the generator and will give command to the speed governor to adjust the water flow to be able to immediately attain the balance in the load requirement, and voltage and frequency generated.

3.3 Overall Research Flow

The research flow will be done in conformity with the Figure 3.3 illustrated below. Through brainstorming, the researchers shall conduct a survey in the chosen off-grid area and address the foregoing problems. Upon identifying the solution, the researchers must identify first the materials to be used for the construction of the device. Building of

circuitries, several programming, and a conduct of testing and validation are necessary for the study to be proven and certified.

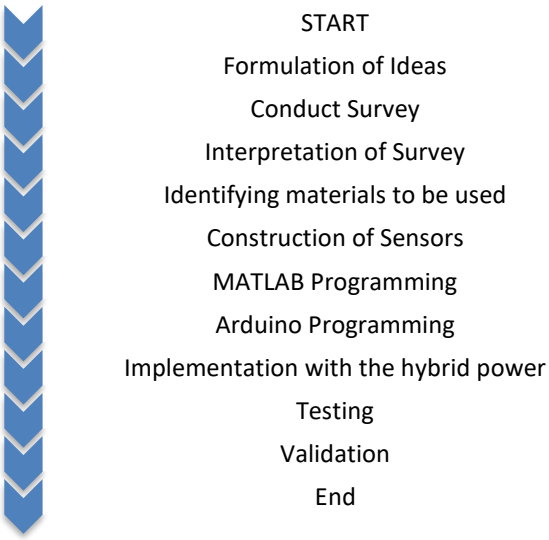


Figure 3.3 Overall Research Process Flow

3.4 Project Development

3.4.1 Software Development

The program will be done by using Matrix Laboratory (MATLAB) and an Arduino IDE. The MATLAB will be used to conduct the comparative study between algorithms of the Automatic Generation Controller. The Simulink function of MATLAB will be mainly used to simulate the above-mentioned algorithms.

The Arduino IDE will be used for the programming of Arduino Uno and for the control process of the rotation of the servo motor that will control the gate valve which is responsible for the water flow management. 0

3.4.2 Hardware Development

The construction of the AGC will require voltage sensor circuit, frequency sensor circuit, DC motor, and gate valve. The voltage sensor circuit will measure the variation in the voltage output of the generator. This voltage sensor circuit will be connected to the Arduino Uno and be connected to a voltage meter to physically examine the variation in the voltage output of the generator.

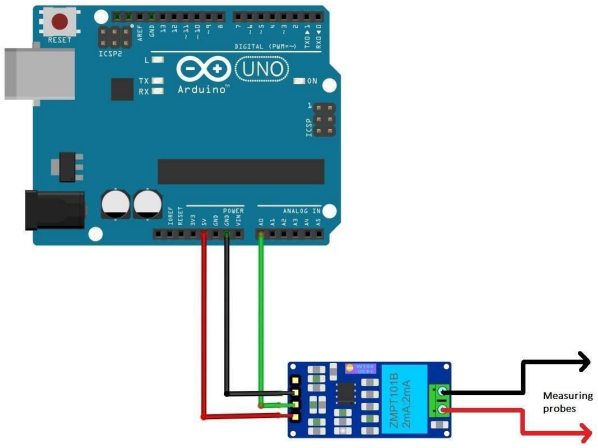


Figure 3.4 Voltage Sensor Circuit Connected to Arduino UNO

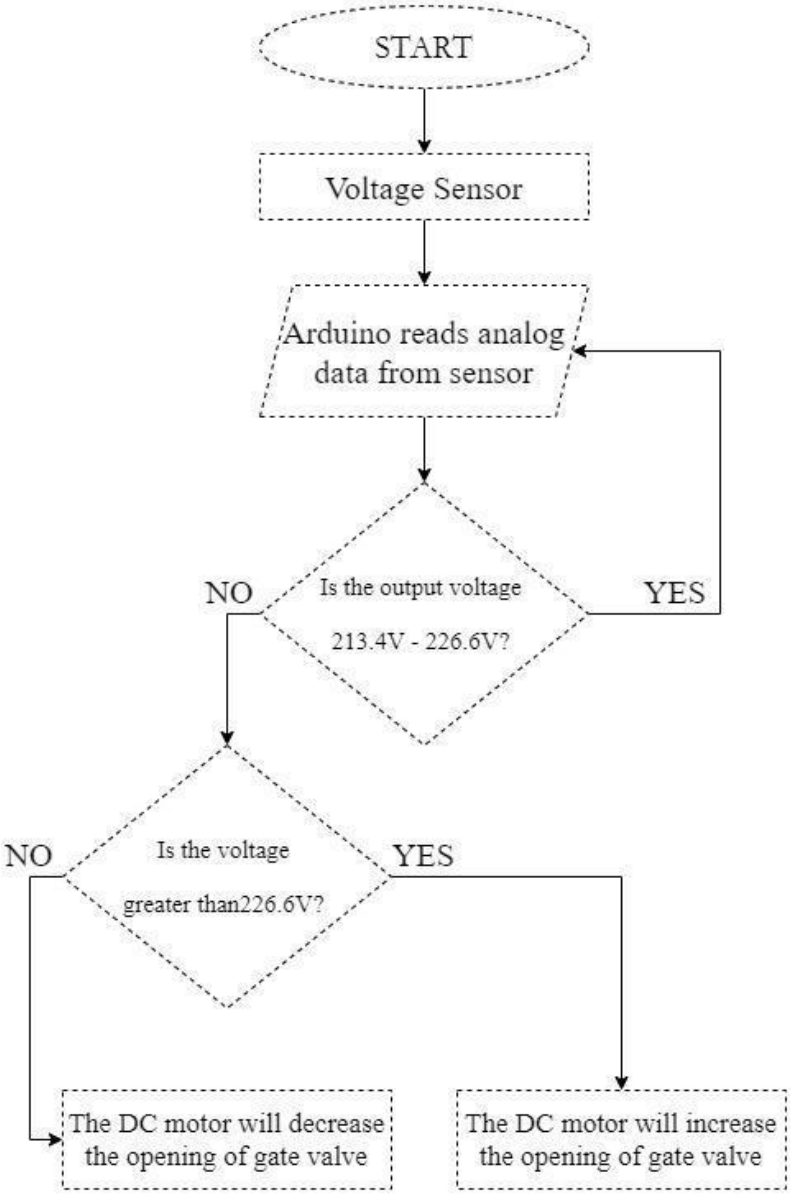


Figure 3.5 Voltage Sensor Circuit Flow Chart

The frequency sensor circuit composed of diodes, capacitors, resistors, transistor, and IC will measure the frequency output of the generator as the voltage varies from time to time. This frequency sensor circuit will be connected to the Arduino Uno together with the Voltage Sensor Circuit to monitor the variations in the frequency.

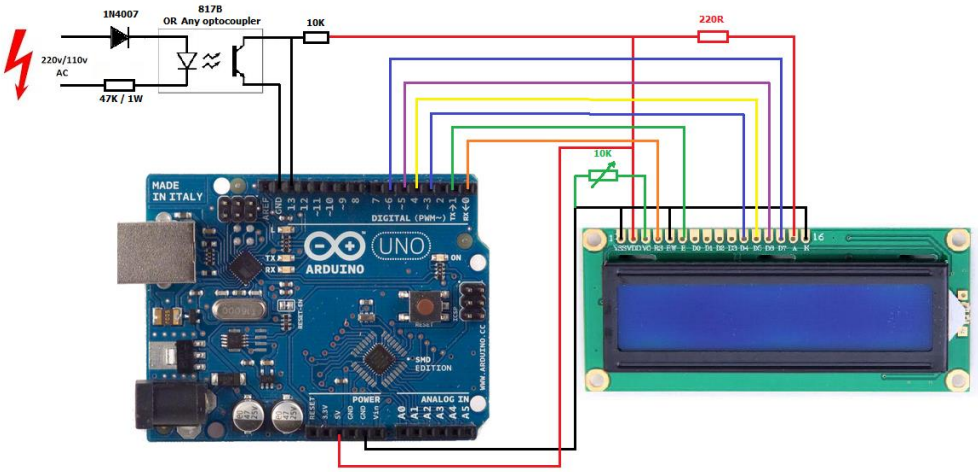


Figure 3.6 Frequency Sensor Circuit Connected to Arduino UNO

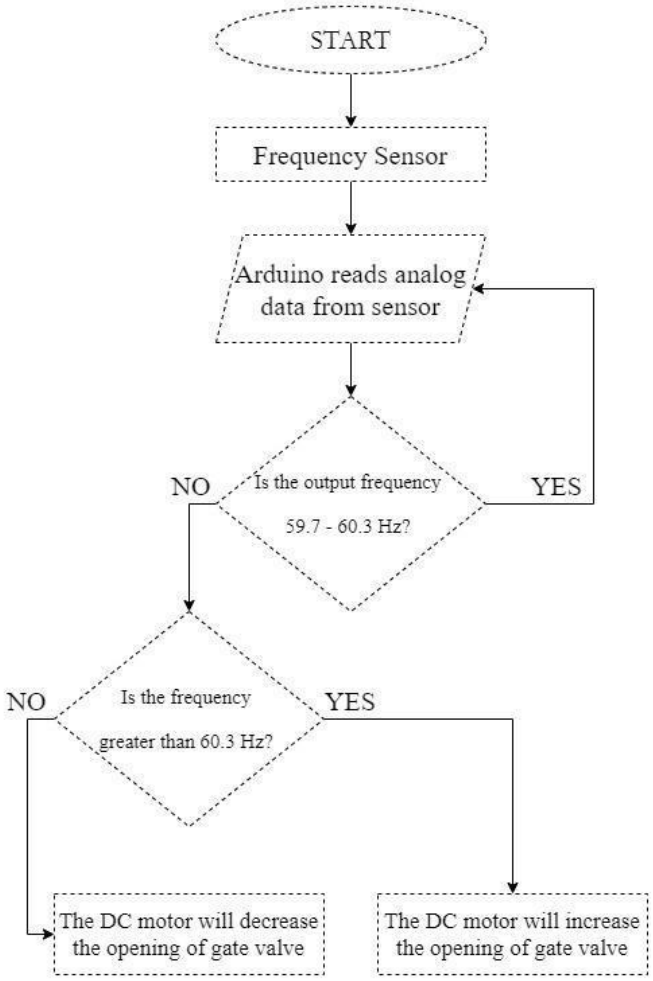


Figure 3.7 Frequency Sensor Circuit Flow Chart

The DC motor will be used to control the gate valve. With 360-degree rotation, the researchers will have to connect it to the gate valve using a chain. In case the chain is unavailable, minimal degree rotation may be used and directly connect the gate valve with the DC motor.

The gate valve will be the receiving end of the output torque of the AGC. In coordination with the DC motor, the opening of the gate valve will be controlled. As it opens wide or narrows down, water flow will be maximized or minimized with accordance to the command of the program.

3.4.3 System Flow

The voltage and frequency output of the generator will be measured by the frequency and voltage sensor circuit, respectively. The measured parameters will then be interpreted by the program (Arduino Uno). The program will give command to the DC motor which will then be converted as a torque. The torque will be responsible in controlling the opening of the gate valve having control in water flow. Depending on the intensity of the water flow, the voltage and frequency output will be regulated to the standard range value of 213.4 V – 226.6 V and 59.7 Hz – 60.3 Hz.

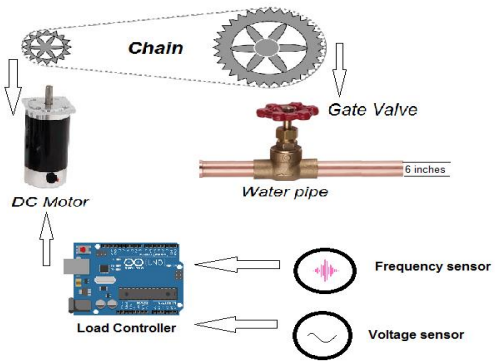


Figure 3.8 System Flow

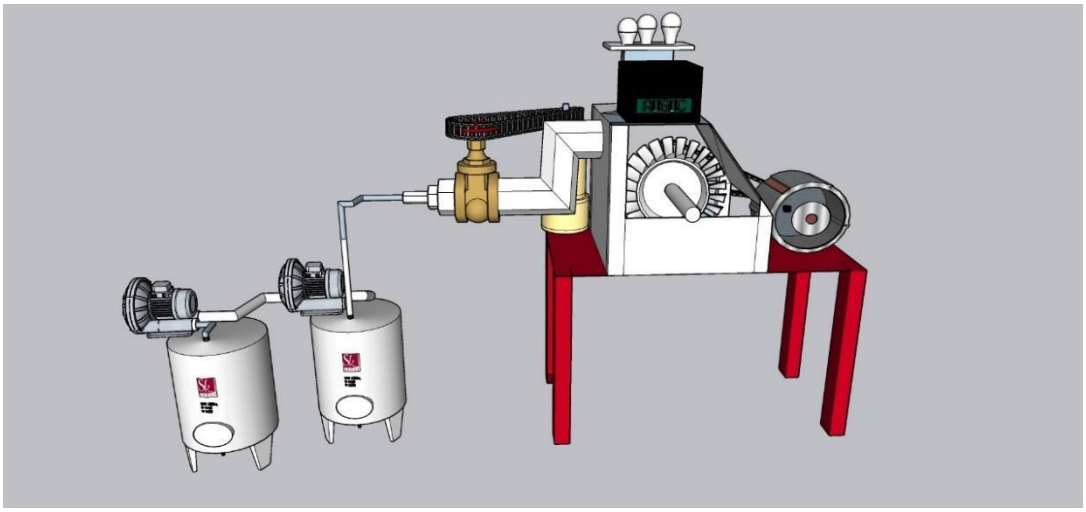


Figure 3.9 Front view of Miniature System of Automatic Generation Controller

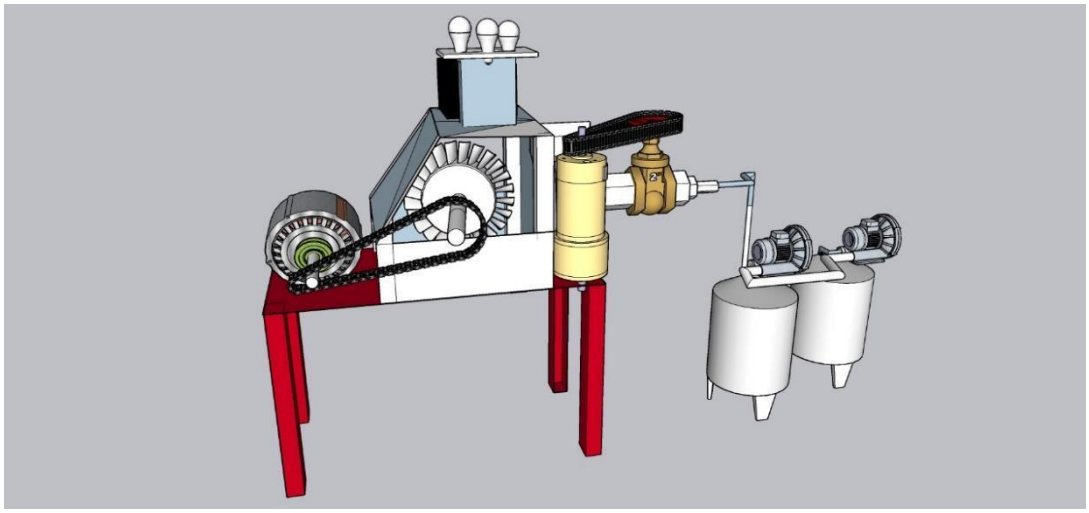


Figure 3.10 Rear view of Miniature System of Automatic Generation Controller

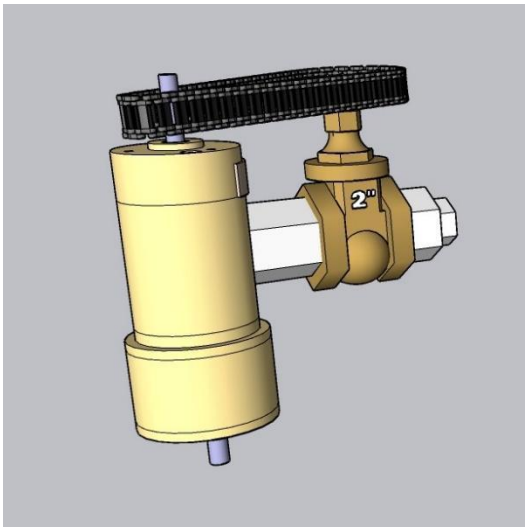


Figure 3.11 Chain System

Figure 3.12 Actual Set-up at the site

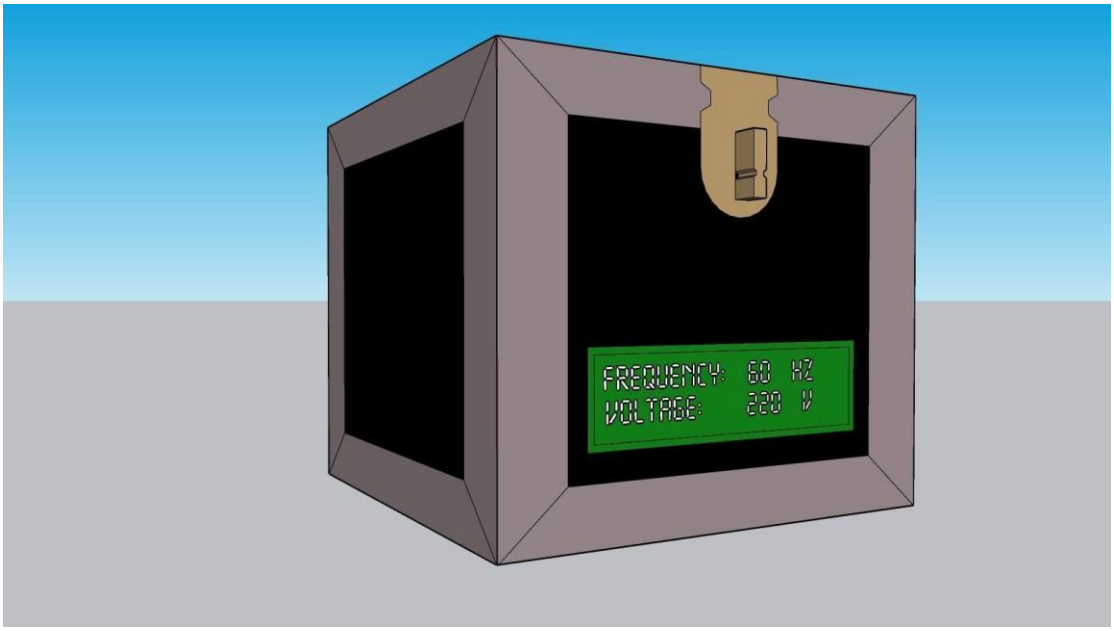


Figure 3.13 Front view of Design Consideration for AGC Device

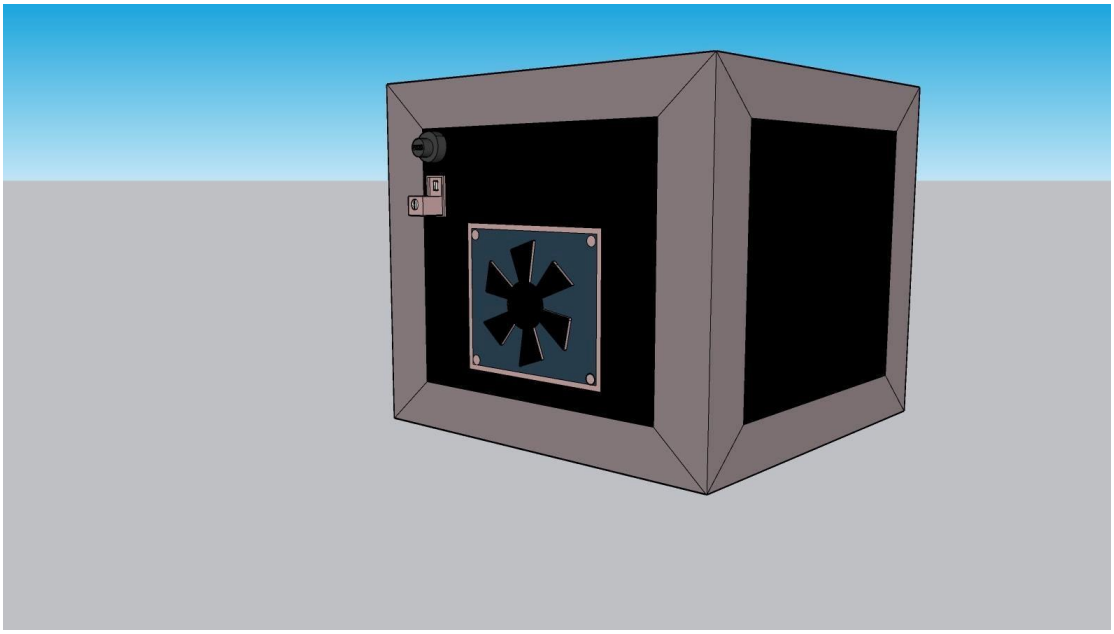


Figure 3.14 Rear view of Design Consideration for AGC Device

3.5 Testing Procedure

The implementation of Automatic Generation Controller in the hybrid solar and pico-hydro-power system will be done simultaneously with twenty light bulbs as sample load requirements. Turning on and off several light bulbs, frequency and voltage output will vary which will test the effectiveness of the device. This will be done for the month of December to February during the project deployment period.

3.6 Evaluation Procedure

The device will be evaluated by the research experts. The researchers together with the research experts shall be present in conducting the evaluation of the project. The researchers must present the comparative study of algorithms used and the application and function of the project.

3.7 Gantt Chart

The table below illustrates the timetable of the overall project study. This includes the formulation of ideas, construction of the device itself, making the research paper, testing, and evaluation of the device.

ACTIVITY	2019												2020						
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun	Jul	Aug
Brainstorming of ideas																			
Interview																			
Topic Defense																			
Research about the topic																			
Chapter 1																			
Chapter 2																			
Planning and Designing																			
Chapter 3																			
Title Defense																			
Buying of Materials																			
Progress Presentation																			
Programming																			
Hardware																			
Comparative Study																			
Developing Voltage and Frequency Sensor Circuit																			
Site Visit																			
Devised Chain System																			
Testing and Evaluation																			
Pre-Final Defense																			
Establishing Solar Energy System for additional backup supply																			
Chapter 4																			
Chapter 5																			
Finalization of Document																			
Final Defense																			

Chapter 4

RESULTS AND DISCUSSION

This chapter presents the project technical description, structural description, project capabilities and limitations and tabulation of results and interpretation.

4.1 Project Technical Description

"A Solar Powered Adaptive Neuro Fuzzy Inference System (ANFIS) – based Automatic Generation Controller for Pico-Hydro Power System for Off-Grid Rural Areas" aimed to construct a power system that will automatically sense and control the voltage and frequency output of the Pico-Hydro Generator together with the development of a program using Adaptive Neuro Fuzzy Inference System (ANFIS) that will give instructions in a way of commands that will regulate and standardize the opening and closing of the gate valve using DC motor into a stable range of voltage and frequency of 213.4 V to 226.6 V and 59.7 Hz to 60.3 Hz.

The solar panel served as the source of energy for the operation of the device. The generator produces electrical power that will supply the load. The Arduino is a powerful tool that controls and monitors the frequency and voltage as well as responsible for the regulation of DC motors working together with H-Bridge.

4.2 Project Structural Organization

The length of the chassis of the device is 25.4 cm, width is 20.4 cm and lastly the height of the chassis is 15.1 cm. The actual appearance of the chassis of the device is depicted in the following figures

The front view as shown in Figure 4.1 is made up of LCD that shows the readings of voltage and frequency at the same time. The LCD will show Freq which means Frequency and Volt that stands for voltage. It also has a lock that will provide security and safety of the components inside the device.

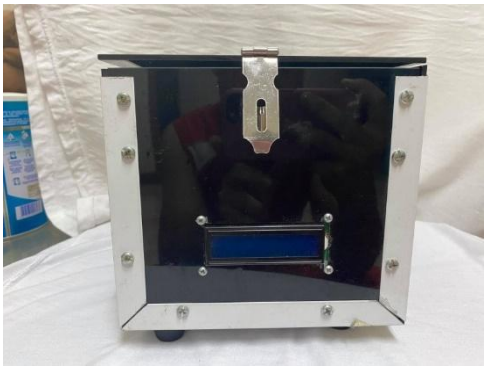


Figure 4.1 Front View of AGC Device

Figure 4.2 Rear view of AGC Device

Moreover, the side view seen on the Figure 4.2 has a fan that is operated in 12 V that is used to expel the hot air inside and maintain it to room temperature. It is essential to have an exhaust system to prevent malfunctioning of the sensors and prevent overheating of the device. Figure 4.2 also includes a fuse and a plug that is connected to generator output and wires that are connected in the generator. The wires also have labels that are designated for voltage sensor and frequency sensor for easy distinction

Figure 4.3 shows the interior of the device which consists of frequency sensor circuit, voltage sensor circuit, Arduino Uno, LCD and cooling fan,

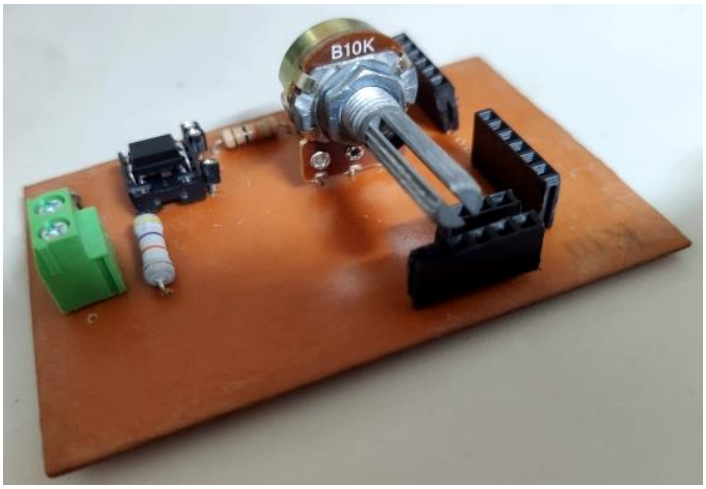
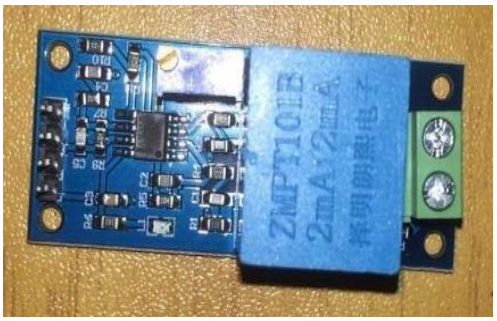


Figure 4.4 Frequency Sensor Circuit

The figure 4.4 displays frequency sensor circuit that is considered to be one of the most important parts of the study that is attached to Arduino. The role of the frequency sensor is to measure the frequency from the output of the generator. It consists of a potentiometer, integrated circuit, resistors and header pins.



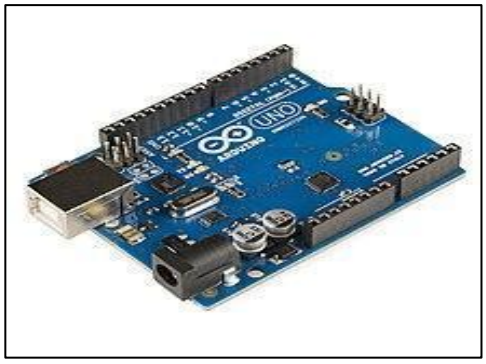


Figure 4.5 Voltage Sensor Circuit ***Figure 4.6 Arduino Uno***

AC Voltage Sensor Module ZMPT101B that is seen on Figure 4.5 acts as the voltage sensor of the device. It is used primarily for the detection and measurement of voltage.

Arduino Uno is shown in Figure 4.6. Arduino Uno is selected to control the inputs of the frequency and voltage sensor circuit together with the chosen algorithm and manage the chain system that is responsible for the closing and opening of the gate valve. Voltage Sensor Circuit and Arduino Uno are located inside of the device

4.3 Project Limitation and Capabilities

Based on the testing conducted, the researchers have proven that the system is efficient at lower cost. Compared to the combined traditional voltage controller and frequency controller, the group was able to minimize the size of the device and make it more convenient to carry and use. This project can be used to control the fluctuating frequency and voltage of a power system. It can be used in an off-grid power system particularly the Pico-hydro. It adjusts the gate valve depending on the produced frequency and voltage of the power system to attain a desirable and tolerable amount of voltage and frequency for residential consumption.

4.4 Project Evaluation

The researchers installed the Automatic Generation Controller at Dingalan, Aurora. The data gathering conducted to further determine the performance and efficiency of the device.

4.4.1 Data and Results

The device of the study was deployed at Dingalan together with the collection of the necessary data used in the research.

A. Proportional Integral Derivative (PID) Controller

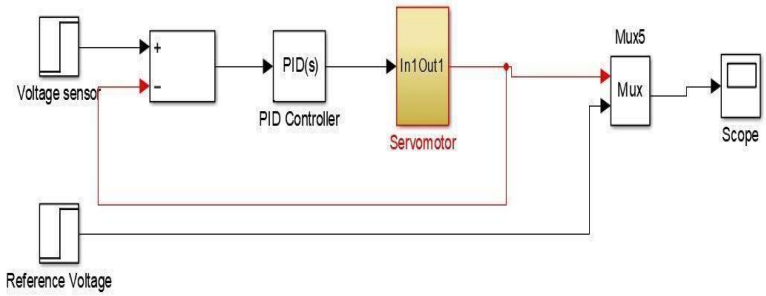


Figure 4.7 Proportional Integral Derivative Controller

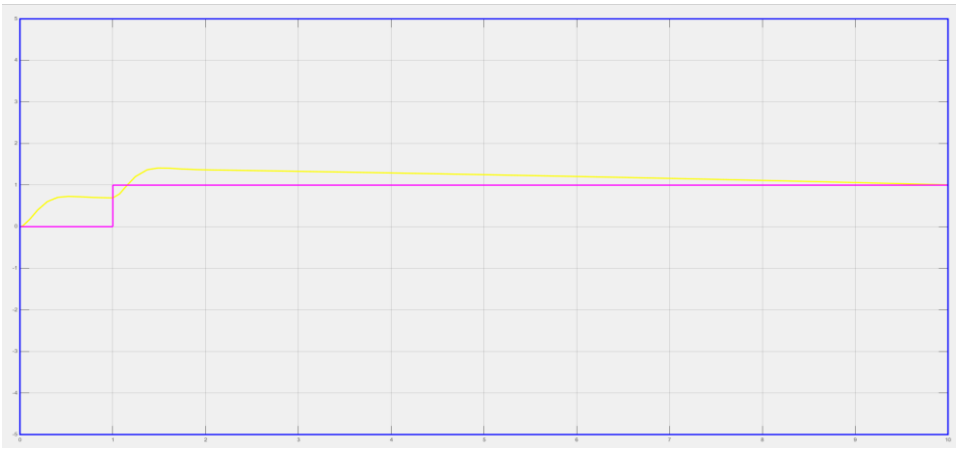


Figure 4.8 Proportional Integral Derivative Graph

B. Fuzzy Logic

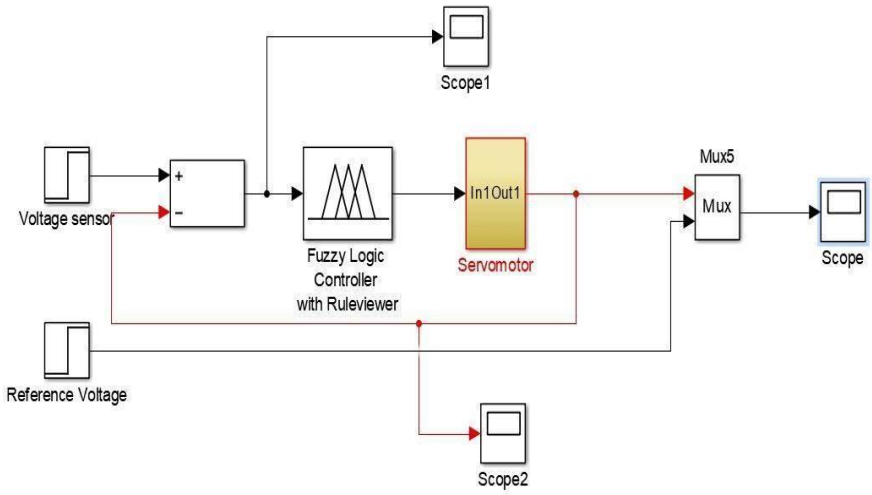


Figure 4.9 Fuzzy Logic Controller

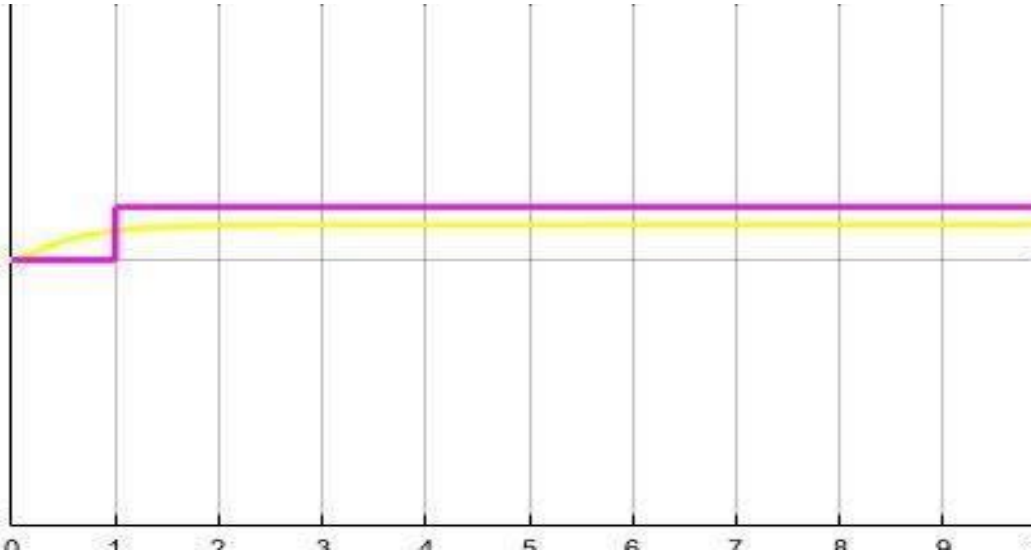


Figure 4.10 Fuzzy Logic Graph

C. Artificial Neural Network (ANN) Controller

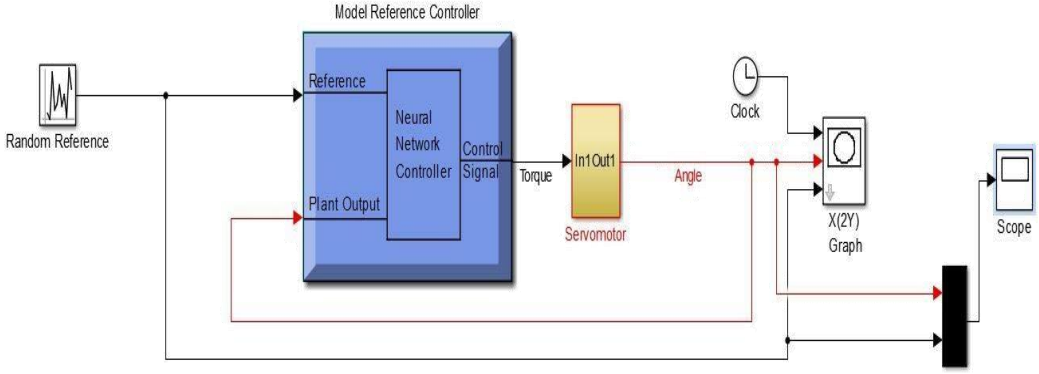


Figure 4.11 Artificial Neural Network (ANN) Controller

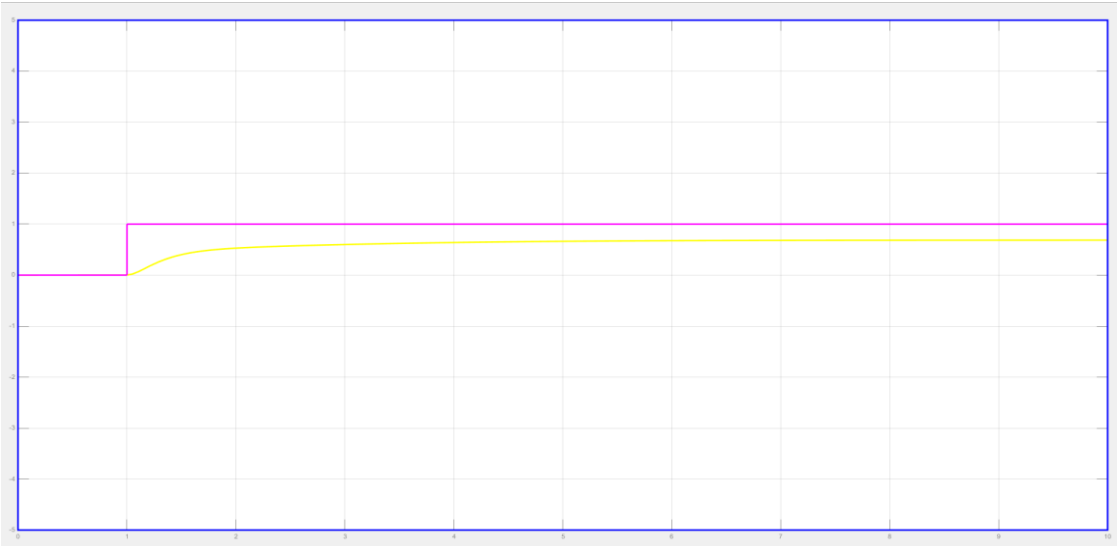


Figure 4.12 Artificial Neural Network Graph

D. Adaptive Neuro Fuzzy Inference (ANFIS) Controller

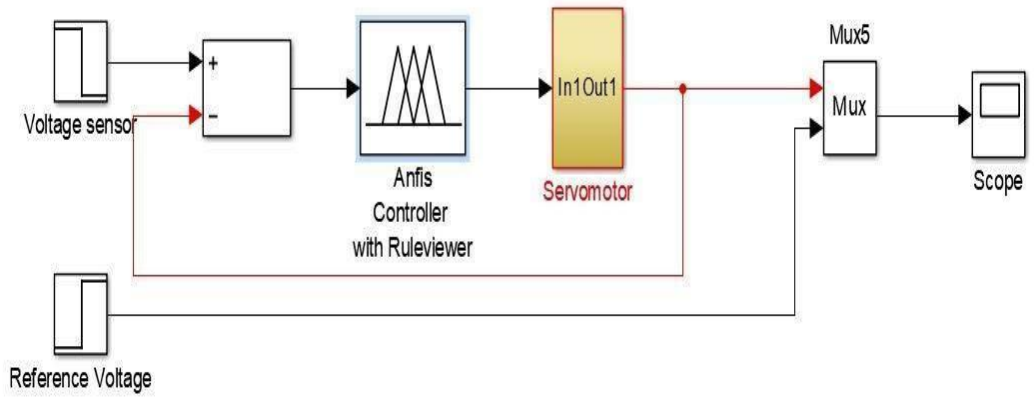


Figure 4.13 Adaptive Neuro Fuzzy Inference (ANFIS) Controller

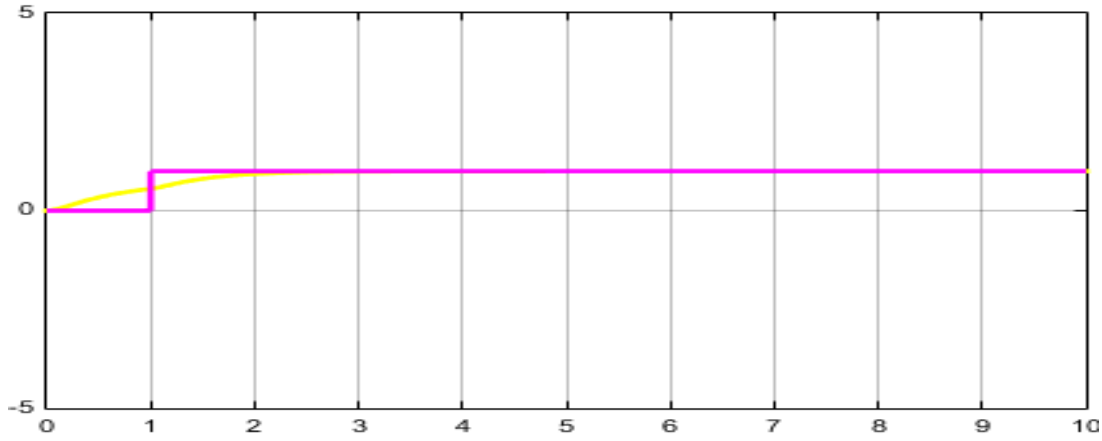


Figure 4.14 Adaptive Neuro Fuzzy Inference (ANFIS) Graph

E. FREQUENCY SENSOR AND VOLTAGE SENSOR

Table 4.1 shows the difference from the value displayed in the frequency generator and from the value measured by the frequency sensor. Ave percent error is 0.568% making the frequency sensor 99.432 % reliable.

Table 4.1 Reliability of Frequency Sensor

TRIAL	FREQUENCY IN THE FUNCTION GENERATOR (Hz)	MEASURED VALUE (Hz)	ERROR %
1	31.443	31.62	0.562923385
2	35.038	35.14	0.291112506
3	40.233	40.47	0.589068675
4	45.310	45.56	0.55175458
5	48.050	48.34	0.603537981
6	50.339	50.68	0.677407179
7	52.183	52.47	0.549987544
8	53.009	53.29	0.530098662
9	55.035	55.33	0.536022531
10	58.139	58.49	0.603725554
11	65.00	65.46	0.707692308
12	75.093	75.55	0.608578696
		Ave % Error:	0.568 %

Table 4.1 shows the difference from the value measured in the variac and from the value measured by the voltage sensor. Ave percent error is 0.80% making the voltage sensor 99.20% reliable.

Table 4.2 Reliability of Voltage Sensor

TRIAL	VOLTAGE IN THE VARIAC (V)	MEASURED VALUE (V)	ERROR %
1	20.51	21.227	3.498
2	40.13	40.544	1.0316
3	60.24	61.023	1.299
4	80.56	80.128	0.536
5	100.20	101.854	1.651
6	120.97	122.106	0.939
7	141.05	143.191	0.025
8	160.34	160.773	0.270
9	180.55	180.964	0.229
10	200.78	200.257	0.260
11	220.71	221.642	0.422
12	240.33	241.433	0.459

13	260.26	260.355	0.037
14	280.47	281.461	0.353
15	300.40	302.474`	0.690
		Average % Error:	0.80%

DATA FROM MINI SYSTEM IN FIRST 120 SECONDS (WITHOUT LOAD AND AGC)

Table 4.3 Measured voltage and frequency output from the system without load and AGC

NTH 10 SECOND	Frequency	Voltage
1	57.630	211.312
2	59.650	218.719
3	59.670	218.792
4	59.820	219.342
5	60.140	220.515
6	60.050	220.185
7	61.280	224.695
8	65.550	240.352
9	63.180	231.662
10	62.640	229.682
11	60.284	221.564

12	60.144	220.735

DATA FROM MINI SYSTEM IN FIRST 240 SECONDS (WITH AGC AND 1 LOAD AT 60TH SECOND)

Table 4.4 Measured voltage and frequency output from the system with 1 load and AGC

NTH 20 SECOND	Frequency	Voltage
1	59.653	218.841
2	60.146	220.784
3	58.227	215.015
4	57.249	212.031
5	58.121	214.916
6	58.968	216.115
7	60.248	220.867
8	61.483	225.348
9	60.151	221.014
10	59.948	219.004
11	60.179	220.563
12	60.437	220.409

DATA FROM MINI SYSTEM IN FIRST 240 SECONDS (WITH AGC AND 1 LOAD AT 40TH SECOND and 2 LOAD AT 180TH SECOND)

Table 4.5 Measured voltage and frequency output from the system with 2 loads and AGC

NTH 20 SECOND	Frequency	Voltage
1	59.873	219.745
2	58.597	215.674
3	57.896	212.341
4	58.941	214.648
5	58.031	216.706
6	60.614	220.760
7	61.761	225.080
8	60.543	221.794
9	59.094	219.017
10	59.949	219.274
11	60.068	221.321
12	60.208	220.998

F. STABILIZATION TIME OF THE VOLTAGE AND FREQUENCY CONTROLLER

Acquired from Table 4.3, 4.4 and 4.5, loading a 3 watts bulb causes the system to produce lesser voltage and frequency output. With the help of AGC illustrated in Table 4.6, the system was able to stabilize in producing frequency and voltage in standard range in a certain amount of time. Average stabilization time is 48.425 sec.

Table 4.6 Stabilization Time of the AGC

TRIAL	FREQUENCY (Hz)	VOLTAGE (V)	TIME (sec)
1	58.597 - 59.784	215.674 - 219.476	69.2
2	59.094 - 59.949	219.017-219.274	20
3	59.094 - 60.068	219.017 - 221.321	39.8
4	58.227	215.015	64.7
		Ave time:	**48.425**

4.4.2 Evaluation

Table 4.7 shows the evaluation of the system conducted with a survey of 30 respondents. Each criterion shows the result of the project's Reliability, Functionality, Safety, Aesthetics, and its Overall rating.

Table 4.7 Evaluation Ratings

CRITERIA	RESULTS
Reliability	4.68
Functionality	4.51
Safety	4.45
Aesthetics	4.69
Over-all rating	**4.58**

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter contains the research summary, conclusions and recommendations of the entire study. It seeks to summarize the end result of the research.

5.1 Summary of Findings

The project study entitled "A Solar Powered Adaptive Neuro Fuzzy Inference System (ANFIS) – based Automatic Generation Controller for Pico-Hydro Power System for Off-Grid Rural Areas" aimed to develop a solar powered system that automatically detects and measures voltage and frequency simultaneously from the Pico-Hydro generator with the use of algorithm referred as Adaptive Neuro Fuzzy Inference System (ANFIS) that imposes accurate rules that will be received by the Arduino that serves as a microcontroller. The Arduino will interpret the commands and regulate the opening and closing of the gate valve by the use of a DC motor together with the chain system.

5.2 Conclusions

The following conclusions were drawn based on the data and results obtained:

1. The designed Automatic Generation Controller that uses Arduino was able to control the gate valve to stabilize the voltage and frequency to 213.4 V – 226.6 V and 59.7 Hz – 60.3 Hz, respectively.
2. The chain system was able to control the gate valve with 23 clockwise/counterclockwise rotations that control the water entering the turbine that powers up the generator.

3. The Adaptive Neuro Fuzzy Inference System algorithm is properly implemented and more suitable and efficient for the automation of controlling the frequency and voltage output of the system in standard range compared to PID, ANN and Fuzzy Logic.
4. The Automatic generation controller stabilizes the voltage and frequency output of the power system in the average time of 48.425 seconds. The over-all performance evaluated to be reliable, functional, and safe.

5.3 Recommendations

To further improve the research and advancement of this study, the following suggestions were drawn:

1. Make automatic generation controllers for other types of power systems.
2. Inspect the deployment site and choose one that is within reach and will not require valuable amount as fare
3. Find ways to make a more continuous and sustained water flow to meet desirable outputs of the hydropower system.
4. Minimize the cost and physical sizes of materials which will result in a more efficient device.
5. Integrate IoT with the project.

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APPENDIX A

Literature Matrix

LITERATURE MATRIX

Title & Author	Summary	Discussions	Limitations
Title: Comparative study of different controllers for automatic generation control of an interconnected hydro-thermal system with generation rate constraints. **Authors:** Swasti R. Khuntia, Berhampur, Orissa, Sidhartha Panda	This paper compares the conventional integral, fuzzy and hybrid neuro-fuzzy (HNF) controllers for the automatic generation control (AGC) of an interconnected hydro-thermal system. The design objective is to improve the transient performance of the interconnected system following a disturbance.	This paper has investigated the performance of conventional integral controller, fuzzy controller and HNF controller on a two-area hydro-thermal system with GRC. These controllers are designed to improve the transient performance of the interconnected system following a disturbance in either area. Appropriate generation rate constraints in each area have been considered in the analysis.	The limitations of conventional integral controllers are their slow response, lack of efficiency and poor handling of system nonlinearities. A fuzzy system can explain the knowledge it encodes but can't learn or adapt knowledge from training examples, while a neural network can learn from training examples but cannot explain what it has learned.
Title: Comparative study of different controllers for automatic generation control of an interconnected hydro-thermal system with generation rate constraints. **Authors:** Swasti R. Khuntia, Berhampur,	This paper compares the conventional integral, fuzzy and hybrid neuro-fuzzy (HNF) controllers for the automatic generation control (AGC) of an interconnected hydro-thermal system. The design objective is to improve the transient performance of the interconnected system	This paper has investigated the performance of conventional integral controller, fuzzy controller and HNF controller on a two-area hydro-thermal system with GRC. These controllers are designed to improve the	The limitations of conventional integral controllers are their slow response, lack of efficiency and poor handling of system nonlinearities. A fuzzy system can explain the knowledge it encodes but can't

Orissa, Sidhartha Panda	following a disturbance.	transient performance of the interconnected system following a disturbance in either area. Appropriate generation rate constraints in each area have been considered in the analysis.	learn or adapt knowledge from training examples, while a neural network can learn from training examples but cannot explain what it has learned.
Title: Application of hybrid DEPSO algorithm to study the performance of different PID controller structures for automatic generation control of a two-area multi-units interconnected power system. **Authors:** Tridipta Kumar Pati S 'O' A University, Bhubaneswar, Odisha, India Binod Kumar Sahu S 'O' A University, Bhubaneswar, Odisha, India	This paper manages structure and examination of programmed age control of a two territory four unit interconnected warm power framework. Three unique structures of corresponding fundamental subordinate controllers are utilized to consider the transient reaction of the proposed framework. Areal comprises two warm creating units with warm turbines and area2 has two warm producing units with non-warm turbines. The increases of PID controllers are enhanced by utilizing a novel half and half Differential Evolution-Particle Swarm Optimization procedure. Step stack brother of 1 % is connected in a real to	In this study, a novel half breed DEPSO transformative calculation is utilized for the productive tuning of three unique structures of PID controller for two unequal zone four units interconnected warm control framework. A stage stack irritation of 1% is connected in area1 to examine the transient reaction of the framework as far as pinnacle undershoot, crest overshoot and settling time. Results for all PID controller structures utilized for programmed age	Lack of memory that may make the solution to get stuck with local optima. The loss of diversity in swarms in the PSO algorithm normally shows instability in few solutions and may get trapped in local optima.

	contemplate the execution of various structures of PID controllers. At last it is seen that the third PID controller setup performs superior to the next two.	control of the proposed power framework are looked at and it is seen that the third PID controller structure yields better execution coming about with less undershoot, overshoot and settling time.	
Title: Fuzzy-PID controller optimized TLBO algorithm on automatic generation control of a two-area interconnected power system **Authors:** Jyoti Ranjan Nayak, Tridipta Kumar Pati, Binod Kumar Sahu, Sanjeeb Kumar Kar,Siksha 'O' Anusandhan University, Odisha, India	Structure and execution examination of load stream recurrence of a two zone four unit interconnected non warm power framework is portrayed in this paper. Two distinct controllers that are fluffy corresponding to a vital subsidiary (FPID) controller and relative vital subordinate (PID) are utilized to think about the transient reaction of the proposed framework. Area1 comprises two warm creating units with non-warm turbines just as area2 too. The increases of FPID and PID controllers are enhanced by utilizing a novel Teaching Learning Based Optimization (TLBO) system. Step heap of 10 % is connected to area1	In this study a novel TLBO algorithm is used for the efficient tuning of two different controllers i.e. FPID & PID for a two area four units interconnected non-reheat thermal power system. SLP of 10% is applied in area1 to analyze the transient response of the system in terms of peak undershoot, peak overshoot and settling time. Results obtained for all controller structures used for automatic generation control of the proposed power system are	Teaching Learning Based Optimization was used to analyze the results in the two controllers namely FPID and PID controller. It is said that the FPID controller produces good results when compared to the other. Since this is about controllers, we can enhance these ideas by using the internet as a transmission medium and also we must consider the efficiency of simpler codes.

	to ponder dynamic execution of various proposed controllers. At long last it is seen that the FPID controller of single information setup performs superior to the next.	compared and it is seen that the single input FPID controller structure yields better performance resulting in less undershoot, overshoot and settling time. Objective function for the optimizing technique is the ITAE. Number of populations and maximum number of iterations are taken as 100 for both the controllers A step load disturbance of 10% is applied to area no.1 to study the transient behavior of the proposed two-area non-reheat thermal system.	
Title: Automatic generation control of a two area multi-unit interconnected power system with Proportional-Integral-Derivative controller with Filter (PIDF) optimized by TLBO algorithm	This article portrays the programmed age control of a two territory multi-unit interconnected power framework with Proportional-Integral-Derivative controller with Filter (PIDF) tuned by showing learning-based enhancement (TLBO) calculation. Every	In this research study a novel attempt is made to implement adaptive PIDF controller in multiarea and multi-unit interconnected power system for automatic generation control. A recent	The performance of the PID controller is not satisfactory when the input signal contains noise and unwanted harmonics.

Authors: Manoj Kumar Debnath, Siksha 'O', Nimai Charan Patel, Keonjhar, Odisha Ranjan Kumar Mallick	region is furnished with three warm units with water powered speakers. The increases of the PIDF controllers are at the same time enhanced by applying a stage stack bother of 0.01 in zone 1 thinking about basic time total blunder (ITAE) as the wellness work. The improvement of the control conduct of the proposed streamlined PIDF controller is demonstrated in examination with the traditional PID controller. The dynamic reactions of the framework are thought about as far as settling time, top overshoots and undershoots. Further the affectability and vigor of framework is checked by applying unsettling influences in both the region all the while.	optimization technique known as TLBO algorithm is used to optimize the controller parameters for both the PIDF and PID controllers. Comparison of dynamic performances of PIDF and PID controller reveal that PIDF controller exhibit better performances in terms of settling time, peak overshoots and undershoots. Further the robustness of the proposed controller is also verified by applying the SLP in both the areas simultaneously	
Title: The stability of solar panel-diesel generator system **Authors:** Valery Zhuikov, Kateryna Osypenko	The steadiness states of the power supply framework with sunlight-based board and diesel generator are contemplated. It is demonstrated that the proportion between sun-based board and load flows influences the dependability of frameworks with circulated age. The expansion of steadiness	In the study the stability workspaces of power supply systems with distributed generation are limited both in high and in low frequencies due to dependence on the gain value and ratio between solar	The system stability conclusions at low frequencies, at high frequencies, the stability condition is violated, hence the storage battery should be dual used.

	workspaces is accomplished by utilizing the capacity battery as a gadget that expands the framework solidness.	panel and load currents. The extension of stability workspaces is achieved by using the storage battery as a device that increases the system stability.	
Title: Modeling of the solar panel diesel-generator system stability. **Authors:** Julia Yamnenko, Kateryna Osypenko, Bohdan Hnatyuk	The topic of concentrating the disseminated age frameworks steadiness is significant because of a few elements. These are: the consistent load level and condition change and, likewise, the difference in generators parameters that make up this framework. In the article, the dependability of appropriate age framework consisting of the two generators, one of which works a present source mode is considered. First generator is the sunlight-based board with MPPT gadget and the second generator is the diesel-generator with yield voltage direction by means of fuel supply and field winding current control channels. Logical articulations and C++ application for the steadiness	To verify the results obtained analytically, consider a mathematical model of solar panel – diesel generator system in Matlab Simulink. With this the transition of system supply from diesel generator to joint supply from diesel generator and solar panel is made. The system has three feedback loops: on output solar panel output power; on field winding voltage; on load power. The model operates as follows: the diesel generator power reduces by corresponding 3 kW power, and the system is	The problem of stability research of the solar panel – diesel generator system, containing three feedback loops, when changing the load and the environment parameters as well as the development of software for the operative system control is urgent. The stability of the system in the low frequency range.

	computation, just as the scientific models of the framework in Matlab Simulink with load size change are given.	stable. This is due to the fact that feedback loops gains are chosen from previously given formulas (1) – (5). The obtained stability conditions of solar panel – diesel generator system for the low and high frequency ranges and application for their visualization can be used for operating control of the system when parameters of the load and environment are changing.	
Title: New approach of a conceptual solar thermal steam generator and its design &optimization **Authors:** Arnab Dey, Bipul Nath, Biplab Mondai, Rajarshi Chakraborty	In this research study, a new design approach of a solar steam generator/boiler. We have used a design tool here for optimization of system efficiency considering different subsystem efficiency. This concept comes from the conventional thermal power plants boiler, with the difference that the heat comes from mirrors that concentrate the solar radiation on its external absorbing side	A new approach of a solar boiler is shown in this paper. This concept comes from the conventional thermal power plants boiler, with the difference that the heat comes from mirrors that concentrate the solar radiation on its external absorbing side at open air, instead	Steam generator required when using other heat transfer fluids.

	at open air, instead of fuel flames heating its internal tube grid. The results of our conceptual design show how much plant performance is achievable, comparable with the most advanced solar concepts. From analysis of this innovative solar boiler applied to electricity production, it is found that overall efficiency of the conversion from direct solar irradiation energy to electricity is above 20%, which is comparable to the value of parabolic trough and central tower technologies. With best of our knowledge, no one has reported this kind of work.	of fuel flames heating its internal tube grid. The results of our conceptual design is showing the results of our conceptual design show that plant performance of 20% is achievable, comparable with foreseen figures in the most advanced solar concepts, comparable with the most advanced solar concepts, The main point in our work is related to a better use of the concentrated radiation in order to reduce exergy losses and to maximize total power. For the moment, our analysis points out that the overall efficiency with this concept, for a given radiation field, is higher than the calculated values of other types of solar power plants.	

Title: Smart solar AC generator without inverter **Authors:** Muhammad Aziz Ul Haq,Hifsa Iram	Renewable energy resources are the major demand of the day. As fossil fuels are limited so they just can't rely on them especially in this new age where the demand for energy has increased drastically. Solar energy can be one of the effective renewable energy sources. This is a new way of looking at a solar panel that we can generate alternating current directly from photovoltaic cells. They can use an array of photovoltaic cell pairs that are connected in antiparallel form to create an AC waveform. Solar panels today produce DC power which has to be firstly converted into AC to be mostly used in business and home appliances. Solar panels become very expensive when we add a solar panel's price joint with the price of inverters and phase synchronizers. In addition to that the power losses of different components that are used in the DC to AC converters, so it becomes even more unappealing. They show a new technique for the generation of AC power from Solar	Solar energy is the need of the day as the demand for energy is increasing day by day and we need clean and free energy. As fossil fuels are limited and most of them are not environmentally -friendly, solar is the best solution to our energy crises. There are many techniques to use solar energy but the best and most easily implemented at any place is to generate electricity using solar cells. But the problem with solar cells is that they produce DC electricity, so we have to first convert it into AC using an inverter. Inverter makes that setup more expensive and decreases its efficiency. To counter this problem a mechanical setup is used which directly generates AC from the solar	Limitations are the size of the solar cells should be small and a proper sheet should be used as base and spinning disk. Weight and frictional losses. Efficiency is quite low.

	panels devoid of inverters. By adopting this technique, we can remove power losses due to an inverter. There is no need for batteries in our technique so overall cost is also reduced. Another very good aspect of this technique is that we get a very pure sine wave of better efficiency than that of an AC inverter. They can generate the sine wave of any frequency by just controlling the speed of the motor used in this technique.	cells cell array which is less expensive and can have almost the same efficiency as an inverter. It is a new technique and after some more modifications we can make it better so that it could come in domestic use.	
Title: Advanced Solar Energy Systems with Thermoelectric Generators **Authors:** Mikel Larrañaga Aizpurua,Zbigniew Leonowicz	Thermoelectric power generation is a promising alternative technology for the electricity production in the future because of no moving or mechanical elements, low O&M costs or their long lifespan. This research study paves a good pathway for reaching more efficient and competitive renewable energy sources. In the paper are presented the newest developments in technology, economics and operation. The combined applications of thermoelectric generators with heat storage and	STEG/CSTEG systems seem to be an attractive alternative technology for electricity production in the future because of no moving or mechanical elements, low O&M costs and their long lifespan. The recent research paves a good pathway for reaching more efficient and competitive thermoelectric devices, with the expectation of becoming another	Several thermoelectric technologies were discovered and examined its efficiency and reliability on producing power sources. To further improve this, we can test discoveries in different environment locations and situations like in the river, falls, mountains and other ideal places where energy can be obtained.

	photovoltaics show today an economically viable solution to low efficiency of thermoelectric technology. The aim of this paper is to review and show possible solutions to arrive at a solar thermoelectric system that is competitive with other solar energy technologies. The study is focused on technical and economic aspects, to conclude the viability of the implementation of solar thermoelectric systems in the electric power industry.	renewable electricity generation system in the electric power industry in upcoming years or decades.	
Title: Analysis of Water Source Availability Estimation for Pico-Hydro Electric Generator **Author:** R. Ismu Tribowo and Aidil Haryanto	The analysis of water source availability estimation is needed for Pico Hydro Electric Generator. Water balance estimation is an important tool to assess the current in water resource availability in an area over a specific period of time. Water inflow is equal to the water outflow. Except that if there is any change of storage within an area that we are interested.	To analyze the availability of water estimation, the researchers used the Curve Number method. Curve number method has two calculation phases. The first one is the volume estimation from runoff precipitation and the second one is the determination of distribution of time runoff including the highest-runoff flow. If there is a	To get drainage data from the rain's runoff more accurately. It can be conducted directly in activity location, especially at the peak rainy season and the peak dry season.

		lack of heavy rain distribution for a 6 hours period of time, the researchers then used a storm curve method that is assumed to represent the situation in any location.	
Title: Compatibility Analysis of Grid-connected Pico-hydro Systems using Conventional Photovoltaic Inverters **Authors:** Vicente Leite, Ângela Ferreira, José Couto, and José Batista1	Hydropower is one of the common types of hydroelectric power plant. It increases the energy demand. The water released from the reservoir flows through the turbine that will spin it and will activate the generator that is responsible to produce electricity.	Pico-hydro power plants are very small-scale infrastructures designed to generate electric power, usually under 5 kW by converting the power available in flowing waters in rivers, canals and streams and they are quite different from classical hydroelectric power plants. They are considered as the most appropriate solution for electrification of rural and isolated communities in hilly and mountainous regions where it is very expensive to implement conventional	However, such dedicated inverters for grid connection would become an expensive solution and are far way to be an off-the-shelf technology available on the market.

		transmission and distribution power systems.	
Title: Design and Control of Solar PV-Pico Hydro Based Microgrid **Author:** Rohini Sharma, Seema and Bhim Singh	This study deals with a solar photovoltaic (PV) and pico hydro based micro-grid that has a battery energy storage that is responsible to transfer uninterruptible power across the voltage source converter (VSC) and to the common coupling point. The battery energy storage manages the flow even if the loading and variable power generation changes. The researchers also used pico hydro because of its reliability and cost-effectiveness.	In steady-state operation, a hybrid micro grid has two techniques of operation that is grid-connected mode or island mode. The power equilibrium between the main grid and photovoltaic (PV) array is comparatively easy in grid connected mode. However, in grid-connected mode, the grid acts as an infinite source, which can supply or absorb the power. As and when the grid is not existing, in autonomous mode with pico-hydro at PCC (Point of Common Coupling) subsequently then island control has to balance supply and demand.	There were specific points for maximum turbine power and speed with the variation of the site water flow rate.

Title: Design of axial coreless permanent magnet generator for small hydro power plant **Author:** Rostislav Huzlik and Cestmir Ondrusek	This research deals with the development of axial, coreless permanent magnet generators that are supposed to be used in small hydroelectric power plants with a small slope and strong water flow.	There are two possibilities how to increase the ratio of energy produced by the hydroelectric power: (1) to install a new hydroelectric power plant or (2) increase the efficiency of the installed hydroelectric power plant by innovating the hydraulic and electric parts of it.	The turbine speed is not controlled. There is a risk of cavitation generation if the level of sucking height is under the level of real runner position.
Title: Flapping Foil Power Generation: Review and Potential in Pico-Hydro Application **Author:** Young, J., Lai, J. C. S., and Platzer, M. F.	Flapping foils are introduced as an alternative to rotary turbines in small-scale water-flow power generation applications. It maintains high efficiency at low flow speeds and small sizes, making them the interest for pico-hydro installation. The highest levels of power and efficiency are with very large foil pitch and attack angles that are massively separated for much of the cycle of the flapping.	Performance is measured as for rotary turbines that are as the percentage of energy extracted from the fluid stream passing through the frontal area of the turbine. Flapping foil designs promise similar performance levels while specifically benefiting from and exploiting the low speed environment, potentially expanding the commercially exploitable wind and tidal current resource base.	There has been some investigation of the effect of foil section on power generation performance and the low flow speeds under consideration for flapping foil systems.

Title: Hydro-Based, Renewable Hybrid Energy System for Rural/ Remote Electrification in Nigeria **Author:** Kamilu Oluwafemi Lawal and Abubakar Tafawa	This paper presents the concept of using more than one renewable energy source and technologies that will help the researchers to solve the energy problem of rural or remote centers, especially in a region with renewable energy potential. Nigeria is abundantly blessed with all major sources of energy; solar power, wind, geothermal and bio-energy. But the country lacks the expertise to control and utilize these sources of power.	Electricity interacts with human development at different levels. It helps to facilitate economic development and poverty reduction by underpinning industrial growth and enhancing productivity. It contributes to social development by helping to fulfill the basic human needs of nutrition, warmth and lighting, in addition to education and public health. Installation of small mini-grids for rural or remote areas is one way to increase the power generation in Nigeria. Renewable Electrical Energy is one alternative source to generate electrical energy.	This is not economically viable due to the lack of critical mass, the low potential electricity demands, the long distances between the existing grid and the rural area and the costs of electrifying small communities through grid extension.

Title: Pico-Hydel Hybrid Power Generation System with an Open Well Energy Storage **Author:** Anilkumar T T1, Sishaj P Simon , P Srinivasa Rao Nayak, K Sundareswaran, and N P Padhy	This paper proposes an approach for off-grid micro-hybrid system models to represent the locally available sustainable and renewable energy sources. The performance of the proposed model is proven using solar irradiance and wind speed data during winter and rainy seasons. The ratio of expected input energy and load demand on the succeeding day is used to control the water discharge on the current day. This model taps the unused potential of the open well as an energy storage system. But then, it limits the usage of batteries in satisfying the basic load demand of domestic consumers who do not have access to grid electricity.	As the time goes by, the demand for energy increases in both households and in industries but the existing power generation technologies are facing a huge problem because the energy production is not compatible with international environmental requirements and is not sustainable and the energy security endangers. One of the most promising applications is the use of renewable energy sources. The most effective and economic alternative energy that we can use is the wind and solar energy.	The current solar and wind based energy technologies that will help the rural electrification needs to have batteries which is one of the reasons that can pollute the air, needs maintenance and timely replacement. These limitations necessitate an energy system suitable for remote and isolated areas in developing countries.
Title: Pico-Hydro Power Generation Using Dual Pelton Turbines and Single Generator **Author:** Ahmad Khusairee Yahya, Wan Noraishah	This paper describes the design and development of pico-hydro generation systems using consuming water distributed to houses. Water flow in the domestic pipes has	The water flow inside the pipelines has the potential of kinetic energy to spin small scale generator turbines for electricity	The main problem is about 30% losses of the total hydro power coming out of the nozzle that usually occur when the power in the

Wan Abdul Munim and Zulkifli Othman	kinetic energy that potential to generate electricity for energy storage purposes in addition to the routine activities such as laundry, cooking and bathing. The inherent water pressure and flow inside the pipe from the utility's main tank that is used for those usual activities is also used to rotate a small scale hydro turbine to drive a generator for electrical power generation. Hence, this project is conducted to develop a small scale hydro generation system using consuming water distributed to houses as an alternative electrical energy source for residential use.	generation. Therefore, this project has been done to show the additional use of consuming water distributed to houses for electrical power generation instead of routine activities such as bathe, laundry and dish washing. The electricity can be generated at the same time those usual activities are done without extra charge on the water bill consumption. The main function of the system is to store the generated power by means of battery charging for future use particularly during electricity blackouts.	water is converted into rotating mechanical power by hitting the turbine blades. Then, another 20% to 30% will be lost in the generator when the power is converted to mechanical energy
Title: Theoretical Analysis of a Pico-Hydro Power System for Energy Generation in Rural or Isolated Area **Author**: Alpesh Desai, Indrajit	Many people live in India in rural or isolated communities without access to grid-based electric power because the urban areas primarily need large-scale production and there is a transmission and distribution cost.	Water Flow Rate is also the main and very important parameter in the Pico-hydro power system. The water flow rate, measured in liter per second	Gross head can be used to estimate power availability and determine general feasibility, but net head is used to calculate the

Mukhopadhyay, and Abhijit Ray	Pico-hydro power is a system with promises to generate electrical power from free Hydro energy. Hydro power is considered a natural resource in those countries which have mountainous landscapes and adequate levels of rain and/ or snow. These theoretical analysis shows that the head and water flow rate are the most important parameters for the pico-hydro power system design. The study proposes the most suitable very Small plant, affordable by local government standards to respond to the electricity demand of a typical village in a rural area. The study proposes the most suitable very Small plant, affordable by local government standards to respond to the electricity demand of a typical village in a rural area.	(liter per second), is the amount of water which flows past you in one second when you stand by the stream. The flow measurement techniques described are the bucket method and the float method. The simplest flow measurement for small streams is the bucket method. This method has been used, as the capacity of the proposed hydro power system is significantly small. The flow rate of the water diverted into a buck takes for the container to fill is recorded.	actual power available.
Title: Design of 5kw Pico Hydro Power Plant Using Turgo Turbine **Author:** Vipin Uniyal, Nikhil Kanojia, Kshitij Pandey	The hydro power plant is widely used for electricity generation all around the world. But the size of hydro power plants is big. .This Paper will provide us a basic understanding of pico hydroelectric power generation. The pico	The turgo turbine is the same as the pelton turbine but the runner is split in half. Turgo turbines are used for medium and high heads. The turgo turbine	Site specific power output needs to pre-feasibility check, and the specific site installation.

	hydro power plant is below the 5kw power generation plant. Pico hydro plants are basically used in rural raeas and off grid power generation.	works between the head 15 m to 300 m. The Turgo turbine is an impulse turbine; water does not change the pressure as it moves through the turbine blades. The water energy is converted into kinetic energy with help of a nozzle. The high speed of the water jet then directed on to the turbine blades and after striking the water to the turbine blades the turbine is rotated at high speed. Then the shaft is rotated, and the electricity is generated in the generator. Water exits with a small energy. Turgo Turbine runner is the same as Pelton runner but it is split in half.	
Title: Active Control for Power Quality Improvement in Hybrid Power Systems	The utilization of renewable energy in the world has made an impact on the society. In some countries, for example in Lebanon, to deal with the ongoing	The enhancement of renewable energy leads to problems such as stability, reliability and	This study limits on the examination of STATCOM hysteresis control technique for

Author: Walid Frangieh and Maged B. Najjar	need for energy, they have an ongoing renewable energy project namely Hawa Akkar and Beirut River Solar Snake (BRSS). With these projects they try to lessen the use of hydrocarbons. It created system stability problems and power quality issues when the enhancement of the systems started. Nowadays active filters such as Static Synchronous Compensator (STATCOM) and Dynamic Voltage Restorer (DVR) were employed to the task. It replaced the use of passive filters due to its advantages such as voltage stability and enlargement of critical clearing time. MATLAB/SIMULINK is used as a simulation medium and exhibits the function of STATCOM and DVR.	power quality. The power quality has a great importance to wind turbines. Solutions must be made to problems by using different technologies such as smart meters, monitoring systems, controllers and remote ability. Power quality can be solved by some techniques such as IEC, Voltage Variation, Harmonics and Consequences of the issues. The International ElectroTechnical Commission Guidelines hands over the procedures to establish power quality characteristics. Voltage Variation is caused by wind speed and induction generator torque. Harmonics formed due to power electronic switching devices present in the system	harmonic cancellation. It used a separate control for the STATCOM and DVR. By enhancing this, we can examine from a nonlinear load to linear load type

		and it can be reduced with the use of filtering by rapid switching. STATCOM can be implemented to regulate the voltage as a shunt compensator for the WTIG. It is a Battery Energy Storage System (BESS) connected to a DC link capacitor which itself is connected to a Voltage Source Converter (VSC). The DVR is used to protect critical or sensitive loads by mitigating the effects of voltage sags or swells on the distribution feeder due to faults in the system by maintaining constant voltage magnitude.	
Title: Automatic Generation Control of Three Area Hydro Thermal Power Systems with Electric and Mechanical Governor	The thermal and hydro power plants were implemented with reheat turbines and either mechanical governor. For the load frequency control, the conventional Proportional Integral	Thermal and hydro plants are prepared with single reheat turbines the same with mechanical or electrical governor. A	The performance for mechanical and electric governors is achieved with or without considering the effect of Generation Rate

Author: K.Jagatheesan and Dr.B.Anand	(PI) was used. For the design of conventional controller gain, Integral Time Absolute Error (ITAE) was utilized. With or without considering generation rate constraint effects, the performance of mechanical and electric was compared together with Integral (I) and Proportional Integral (PI) controllers. The result of the simulation exhibits that electric governor is more efficient than mechanical governor	controller is an important device used in devices to modify the error signal and produce a control signal. There are two types of controller namely Integral Controller and Proportional Plus Integral Controller. Each type has a unique function. In Integral Controller to eradicate or lessen the steady state error however it cannot control the minimum or maximum overshoot while Proportional Plus Integral Controller amplifies the loop gain.	Constraint. For enhancements, mechanical and electric governors must be examined with considering the effect of Generation Rate Constraint.
Title: Calculation and Modeling of Hybrid Power Generation System Using Solar Energy **Author:** Rajdeep Raval and Sourav Choubey	Nowadays, renewable resources replaced the usage of non renewable resources since its supply is decreasing. In line with that, electricity becomes a necessity in the society. People find ways to enhance and increase its production. Solar energy and generators	People find alternative safe and reliable ways to generate electricity that is by non-renewable energy resources or by renewable energy resources. There are several	This study aims to find ways to attain electricity through renewable resources like solar and wind energy. One way to enhance our supply is by using the Hybrid Energy Scheme.

	are created to be the solution to the problem. A Hybrid Energy System was created to achieve uninterrupted power.	substitute sources of renewable resources like solar and wind energy. Solar energy is obtained through the radiation from the sun. It can be a good source but it has disadvantages since it depends on the weather or season. We can solve this dilemma by using or combining two energy sources. Hybrid Energy Scheme is an energy system where two energy sources are combined to gain power. We can achieve Hybrid Energy Scheme by constructing the model of the system. System must include a model for Solar-Photovoltaic Generator, Diesel Generator, Converter, Charge controller and Battery Bank but we must take into	It can be improved by mixing two energies. The energy that can be used must not depend on a weather condition.

		consideration the budget needed for the system.	
Title: Design of Fuzzy-PID Controller with Derivative Filter and Its Application Using Firefly Algorithm to Automatic Generation Control **Author:** Manoj Kumar Debnath, Jyoti Ranjan Padhi, Priyambada Satapathy and Ranjan Kumar Mallick	Firefly algorithm is a method employed to tune coefficients of Fuzzy-PID controllers in accordance with the derivative filter (FPIDF). It is said to be a powerful optimization technique to regulate frequency on a unified power system with thermal non-reheat type turbines. Step Load Perturbation (SLP) was compiled to take note of the response of the system. The results were examined through Bacteria Foraging Optimization (BFO) tuned PI controller and Hybrid BFO-PSO tuned PI controller.	Problems arise when there is unexpected mismatch with load demand and total production of energy. Automatic Generation Control was established to help with power systems. Integral, PI and PID controllers are some of the standard controllers of an Automatic Generation Control. There are two approaches recommended to achieve a reliable and efficient power system namely Controller Formation and Firefly algorithm. PID controllers were commonly utilized in the industry because of its simplicity and robustness. Xin She Yang proposed the Firefly	FPIDF controller using firefly algorithm was utilized to meet good quality standards of a system. To enhance this idea, controller can be tested in various weather conditions to further determine its durability and effectiveness.

		algorithm. It is inspired by how a firefly works in the environment. With proper selection of controllers, everyone can achieve a faster response and system stability.	
Title: Floating Solar Collector For Hybrid Hydro-Solar Power Plant **Author:** Rajesh Giri, Ajay kumar, Sujeet Mishra, Neha Shah	Technology is vastly improving nowadays. There are several innovations in the field of science that made the life of people better. We can generate electricity from solar energy. Changing the conventional way to non conventional. There are restrictions on how solar energy can be utilized as well as advantages with the use of it.	For a greater and reliable productivity of sources, we can use Hybrid renewable energy or Hybrid Power. Solar energy is free from cost as well as other renewable resources but the problem is how we can utilize and maximize its potential and capability. We must create a hydro system where it suffices for the need of the villagers or community. Through simulations of different block diagrams, experiments and customizing past systems.	Issues regarding where the fund can be obtained were experienced. It cannot handle the peak loads well without energy storage. For further reinforcement, find other ways that complement each other like reliable sources where it can work in all weather conditions.

Title: Hybrid solar-wind power monitoring and control system **Author**: Gutierrez-Villalobos Jose M, Mora-Vazquez Julio C. and Martínez-Hernández Moises. A	As time passes, population arises leading to several problems that the world is now experiencing. One of the problems is the use of clean and renewable power sources. The advancement of technology becomes a great help. Solar plants and wind turbines illustrate massive improvement in power generation and cogeneration. Alternative ways have disadvantages since there are several factors affecting them. Hybrid system becomes an answer with these problems .Mixing two electricity systems that both maintain constant energy production and keep longer battery life	Many countries initiated steps on how to lessen the use of fossil fuels. The governments promoted green technology. Its cost reduced swiftly leading to attain the usage of two main types of renewable energies. Solar Energy exhibits photovoltaic panels which need a direct current (DC) to be transformed into alternating current (AC) hence an inverter is required. To be able to establish wind power generation, industries and manufacturers need to find ways to minimize the cost. Monitoring and controlling systems must be considered in systems making.	The data obtained exhibits that the load must be kept energized at all times. Conventional power systems were used. Hence for improvement of this, the internet can be used to provide assistance in monitoring the performance of the system. Artificial intelligence can also be utilized for further determining system behavior and to also consider weather conditions.
Title: Hybrid Wind Solar System for Efficient Power Generation	Hybrid Power System is one of the most widely used renewable energy. It is composed of wind and solar energy. A proposal for a new solution for	Different algorithms can be employed in controlling power generation. One of which	Hybrid control model based voltage control of HES was introduced. Different measuring

Author: Ravikumar S and Dr. H Vennila	enhanced voltage stability with quality power output. To extract voltage from wind and solar, wind energy conversion systems (WECS) and Photovoltaic panels must be implemented. Through Honey Bee Optimization (HBO), voltage stability can be attained. We can use computer simulation to analyze how efficient a system would be with or without a controller.	algorithms is Honey Bee optimization algorithm which has the capability to adapt complex optimization problems. This method has been put into use to solve the daily voltage control, which not only has a better response but also converges more quickly than ordinary evolutionary methods like genetic algorithms. In order to attain a reliable power generator, there are proposed models that can be employed such as HES. It has a permanent magnet synchronous generator, uncontrolled full bridge rectifier and buck converter. HES has phase full bridge inverter, Sinusoidal Pulse Width Modulation (SPWM), and many more. Each part plays	devices were utilized such as the proposed control model, PI controller and ABC algorithm. In addition, we can improve this by implementing the utilization of the internet for faster interpreting of data.

		an important role in converting, integrating and enhancing the generation. Algorithms corresponding to its function support the entire system. Simulations were made to examine the results.	
Title Impact of Grid Connected Solar Power on Load Frequency Control In Restructured Power System **Author:** Yogesh R Prajapati, Vithal N Kamat, Jatinkumar J Patel and Bhupendra Parekh	Gujarat power system is divided into two areas and each area has two Generating Companies (GENCOs) and two Distribution Companies (DISCOMs). Each area has been examined in different parameters like the effect of grid connected solar power on frequency and the blinking nature from solar. MATLAB/Simulink was used to simulate the power systems. The capacity to store power is also considered.	GENCOs, TRANSCOs, DISCOs and ISO take part in the services which bring tasks to accomplish in vertically integrated utility (VIU). With unexpected results, the power is supplied by the sources. The sources were examined through different formulas to meet the standard and desired outcome. Photovoltaic modeling is also considered to enhance solar power and measure the effect of grid in solar plants. Through various simulations of	Restructuring power systems is considered to answer the increasing demand for power sources. Battery energy storage (BES) was used to meet the necessity of storage for local load and solar power fluctuation. Weather conditions and locations must be considered since some system or equipment delicately affected by these then failed to meet the desired output.

		cases, we determine the errors and good quality possessed by each. First case is a Pocolo based contract wherein the load has been changed. Second case is Bilateral contract wherein DISCOs contract is considered.	
Title: Load Frequency Control of a Renewable Energy Sources based Hybrid System **Author:** Asim Datta, Krishanu Bhattacharjee, Sanjoy Debbarma, and Biswajit Kar	We can improve the hybrid generating system by mixing diversified types of renewable energy sources which makes renewable resources more accessible. Load Frequency Control (LFC) has issues like it avoids partial or complete collapse of the system however with Automatic Generation Control (AGC), LFC can be obtained.	Improvement of renewable energy sources using technology is one of the main issues today. Up until today, we cannot fully maximize its potential. It is because renewable energy sources are varying through time. Industries opt to find ways to integrate the technical and economical parameters. Hybrid systems are one of the many solutions mankind has created. SPV, WG and MH generation are some of proposed hybrid	The study covers usage of different renewable energy such as solar, wind, and many more. Hence, we can use the internet to fasten the track of analysis since the availability of it becomes easier.

		systems. The average power in SPV can be obtained using its formula. Secondly, wind turbines transform wind energy to mechanical energy and power output can also be calculated through formula. Thirdly, Micro-Hydro Model inverts energy from water flow to electrical energy and is composed of penstock and turbine generator. Lastly, we can obtain one source from another.	
Title: Induction generator for Pico-hydro generation as a renewable energy source **Author**: Shrikant S. Katre	The vast exhaustion of fossil fuels and its undesirable effect to the environment had led to numerous researches. Solar, wind, and biomass are some of the renewable energy sources that were abused in the past years. Hydro power was discovered through innovation. 5KW is the capacity of a small hydro power plant. The effect of the excitation capacitor on	Power plants are economy friendly, easy to install and require minimum resistance. Induction generators are easily available and powerful. It exhibits self-protection to overload and short circuit. These generators have unique	Induction motor was tested in motor delta and capacitor delta configuration. It is assessed as a self-excited generator. To improve the data obtained, pico-hydro units can be tested in different areas like in falls and rivers.

	the generator was also discussed.	characteristics. They stop when they experience overload and resume when the overload is removed. Excitation capacitors are needed to create an induction generator. There are five important modes in which the motor and capacitors can be interconnected. We need to perform testing so that the motor will perform true to its desired function. Several tests were done. One of the tests is to find out the effects of the speed and diameter of the water wheel in determining the maximum power. Diameter of the water wheel is inversely related to the speed. Water wheels with large diameters run very slowly so the length of the water wheel affects the torque and the	

		power developed by the wheel.	
Title: Pico-hydro power generation using dual Pelton Turbines and Single Generator **Authors:** Ahmad Khusairee Yahya, Wan Noraishah Wan Abdul Munim, IEEE, Zulkifli Othman, IEEE.	Pico-hydro age framework is the viable approach to help the remote networks by creating power utilizing water as a principle source. The principal target of this task is to present the green innovation for the general public to diminish the expense of fuel utilization. Green innovation is an elective vitality while it is shoddy, powerful and dependable. It can diminish wellsprings of fuel, capital expenses also, contamination. Moreover, the possibility of this venture is to create power by building up a model of pico-hydro framework that creates low ability to Be utilized in country networks. By and Large, this undertaking concentrated on planning and delivering a pico-hydro framework that can be utilized for little limit types of gear, for example, engine and globule.	As this study goes for applications in country zones, the objective is to construct a framework that changes over mechanical energy into electrical energy to give control enough to produce little hardware, for example, engines and globules. By having PVC pipe in a running or streaming water with high weight, the pipe can possibly drive the turbine where it identifies with a generator to change mechanical energy into electrical energy.	With the assistance of high-pressure water originating from running or streaming water, pico-hydro framework can work getting it done execution, yet when the water loses weight, the framework may not be effective as it previously was. This examination restrains on the application where the water pressure isn't steady. In any case, as an upgrade, they can put some controllers for water pressure so that the water pressure will be steady regardless of what the climate is.

Title Smart Controller Design for Solar-Grid Hybrid System **Authors:** Krishna Neupane, Tore Marvin Undeland, Amit Rouniyar.	The mix of little estimated independent sun-based frameworks to the matrix is muddled coming about into costly activity which isn't reasonable to all. All things considered, this paper introduces a brilliant controller-based plan utilizing advanced flag handling for savvy activity of solar powered framework tied framework. The crossover framework can measure the associated framework. what's more, send the task procedure in order to get the compelling use of sun-oriented yield. The synchronization isn't vital as this strategy can be adequately modified by the utilization of load discretization. This gives a shabby, effective, solid and cost viable task. The system has been tried for the 120-Watt sun powered board with the battery reinforcement stockpiling and its viability is watched. The battery reinforcement is made to work amid the cut-off of Grid or Grid and Solar supply. The execution of the framework over the	Solar hybrid power systems are crossover control frameworks that combine sun-based power from a photo-voltaic structure with another power creating essentialness source. This investigation means to have a financial plan benevolent framework that can be managed by anybody since the combination of little estimated independent sun-oriented frameworks to the lattice is in fact convoluted coming about into a costly task which isn't moderate to all. The vitality originated from the sun through sun-oriented boards which is associated with a battery that stores sun powered vitality and after that can be utilized later as electrical vitality., the reason for this	This study is set to control one vitality source, considering that, it will be costlier if the said network who are utilizing the said brilliant controller starts to utilize another vitality source to use the regular assets, they can use to diminish the utilization of ordinary vitality. Besides, this investigation confines on the application where the vitality sources are multiple. As an option, they can make a controller that is appropriate or competent to control more than one vitality source.

	wide scope of activity and transient states are guaranteed by reasonable perception and adjustment.	investigation is to make a keen controller utilizing advanced flag handling for financially savvy activity of sunlight-based matrix tied framework. The half breed framework is additionally fit for giving errands on a far-off place to get the powerful use of sun-oriented yield. This framework is intended to fill the requirements of one network where sun-based power is utilized just as reinforcement to charge the battery and effectively used to diminish the utilization of customary vitality.	
Title: Solar-wind hybrid energy system using MPPT **Authors:** Ligade Gitanjali Vasant, Prof. Dr. Pawar V. R.	Vitality requests are regularly expanding on the planet, scanning for petroleum products is done on need premise. These powers are not reasonable, they contaminate the earth. Lack of petroleum products assets and antagonistic condition	As this study plans to maintain a strategic distance from and keep the use of non-renewable energy sources, for example, coal, oil, and oil, a framework	Having normal sources, for example, wind and sun powered vitality. Utilizing MPPT as controller for the yield of both normal sources is turned out to be simpler, however

	influences made utilization of Renewable Energy Sources (RES) as Solar vitality and Wind vitality basic. Sun based, and Wind vitality are regular assets which are not exhausted by use and are increasingly prominent. Accessibility and straightforwardness to get electric power made Solar and Wind control as elective vitality sources. Sun based, and Wind vitality joined to frame Solar-Wind Hybrid Power System (SWHPS), which will improve the characteristics of one another and another. To decrease the power request on the ordinary power age area, the streamlined usage of these common assets is fundamental to deliver control. Different strategies are by and by for age of intensity utilizing Solar-Wind Hybrid System with Maximum Power Point Tracking (MPPT). Consistent voltage strategy is utilized for greatest power exchange. This technique ought to have some key features	which utilizes sun based and wind vitality as essential source is intended to be an elective method for getting vitality. MPPT or Maximum Power Point Tracking is a calculation that is incorporated into charge controllers utilized for extricating most extreme accessible power from PV modules under specific conditions. MPPT is a microchip that is utilized to control the yield of both sun-based and wind vitality sources.	some factor is should be examined like having temperamental supply of wind and sun powered, for instance, when the climate is bright, supply originating from the sun is excessively, and when it's sprinkling, a lot of wind can be gotten while low supply of sun is experienced. As an answer for that issue, a controller could be embedded before the MPPT microchip controller, with the goal that just appropriate measure of wind and sunlight-based energy enters the MPPT that will be changed over into electrical energy.

	to build strength and effectiveness.		
Title: Controller for 1kw – 5kw wind solar hybrid generation systems **Authors**: Mao Meiqin, Su Jianhui, Liuchen Chang, Zhang Guorong, Zhou Yuzhu	In the areas where sunlight-based vitality and wind vitality are normally reciprocal, the use of wind-sun oriented cross breed age frameworks (WSHGS) can lessen the capacity limit of batteries and the all-out expense of the framework contrasts and remains solitary PV or wind age framework. This paper exhibits a cost-impact controller framework for 1kW to 5kW WSHGS with low DC voltage input (24V DC or 48V DC) and high yield AC sine wave voltage (220V AC). This controller framework includes as pursues: 1) PWM hacking innovation in charging control of batteries, which can make wind turbine and sun-oriented cluster work at the greatest control point with the goal that the general framework effectiveness can be enhanced significantly. 2) Constant voltage and constrained current two-circles control of battery charge, which	As this study goes for applications in the regions where sun and wind vitality sources are huge, planning a framework which utilizes the said sources can be an approach to limit the utilization of ordinary energies. This controller is intended to drive the yield of wind and sun powered cross breed vitality and changes over it into electrical vitality that can be utilized as an option for ordinary energies.	As this study is intended to control low power vitality, this study constrains on the applications where the power is higher than 5kW, that just implies that, when the power created is more than 5kw the framework isn't much helpful in light of the fact that it isn't proficient to deal with high power vitality and it could prompt annihilation of the framework, as an improvement, we can put a caution when a surprising high power vitality is ingested to keep the breaking of the framework.

	can make batteries in buoy charging state, improve the cycle rate and drag out the life of the batteries. 3) SPWM transformation with front-end high recurrence DC-DC modules in parallel and uncommon microchip control IC with elite expense, which can achieve sine wave yield voltage with high dependability and high load effectiveness.		
Title: Agent-based energy management and control of a grid-connected wind/solar hybrid power systems	Steadiness of wind/sun-based half and half power framework plays an imperative job intensity framework. In this paper, a framework associated with the wind/sunlight-based mixture control framework is proposed. It contains four subsystems: wind turbine age, sunlight based photovoltaic (PV), stockpiling batteries and burdens. Every one of them is associated with the AC transport or DC transport. The vitality of the executives and control framework are executed by a programmable rationale controller (PLC). Four activity modes, i.e., prepared, remain by, run, stop, are characterized. It	A matrix associated photo-voltaic power framework, or lattice associated PV control framework is a power creating sun-based PV control framework that is associated with the utility network. While, an independent power framework (SAPS or SPS), otherwise called remote region control supply (RAPS), is an off-the-matrix power framework for areas that are not fitted with a power dissemination	As this study is intended to have the capacity to take a shot at either framework associated mode or remain solitary mode, few elements are waiting be concerned., first is the cost, making a framework that can take a shot at the two modes is very expensive, one is on the grounds that you require greater gear and materials to be utilized. Two is the support, having this confused framework needs more directing than another framework.

	utilizes specialist based helpful control procedures to accomplish the most extreme power point following (MPPT) of wind turbines, what's more, photovoltaic, and the framework keeps running under ideal activity conditions. Analyses demonstrate that this framework can keep running under either lattice associated mode or remain solitary mode. It has a compassionate graphical UI (GUI) and elite.	framework. As this study goes for application where the power or any customary vitality is either accessible or not, the framework is intended to be good for the two situations, the said structure is proficient to chip away at either condition to guarantee that the execution won't change., both breeze and sun based energy source are associated with an AC or DC transport which is likewise associated with a battery that stores the vitality gathered that can be utilized later as substitute for power., this investigation additionally means to ration vitality that can obliterate the planet.	Second is the assets, we require assets to achieve such investigation. What's more, founded on the item yield, the min framework is tremendous. In this way, an enormous and very much ventilated place is additionally a need.
Title: Voltage and frequency control of isolated pico-hydro system	Pico-hydro control plants are normally an independent hydropower system that works to give power to rustic	Isolated Pico-Hydro structures are frameworks that are normally an independent framework used	Because of environmental change, sudden difference in season is unavoidable. It

Authors: B.A Mhlambi, K. Kusakana, J. Raath.	networks and are embraced as a major sustainable power source as a result of their favorable circumstances over the extensive hydropower plants. Be that as it may, they require an overseeing framework to restrain the variety of water turbine speed because of season change and variety of shopper stack. These varieties bring about fluctuating yield voltage and recurrence from the generator. To take care of this issue, consistent voltage and recurrence is accomplished by controlling the electrical power yield and water control contribution by methods for electronic load controller, dump loads, control converters and mechanical direction of turbine water stream. This paper surveys the diverse advances of controlling voltage and recurrence in Pico-hydro framework. Besides, the utilization of a PV inverter in Pico-hydro and the most extreme power direct following innovation toward concentrate control	to give power to remote territories and are acknowledged as one of the major sustainable power sources due to their favorable circumstances over the expansive hydropower plants. Be that as it may, because of season change, the gathered vitality isn't steady making it destructive for the gadgets or machines that are associated in the frameworks. As this investigation intends to keep away from vacillations of vitality, a controlled electrical vitality yield and water weight input must be watched.	could prompt a sudden burst of vitality to the framework than can hurt the machines associated with it. To tackle this issue, a consistent recurrence and voltage must be accomplished by methods for dump loads, electronic load controller, control converters, and so forth., with the goal that the electrical power yield and water control info can be controlled.

	from PV clusters will likewise be evaluated.		
Title: Smart energy management and control of stand-alone pico-hydro systems **Authors:** Vipina Valsan, P. Kanakasabapathy	Independent frameworks are the main suitable choice for zap of rustic and remote areas. This paper presents a plan and advancement of a practical, productive, brilliant vitality the board framework for the control of three-stage self-energized acceptance generators (SEIG) reasonable for remain solitary pico-hydro control age with consistent information control. The goal is to enhance the usage productivity of the pico-hydro framework in genuine while keeping up voltage control and load the executives of the small-scale matrix framework.	Having a Stand-alone pico-hydro framework is a pragmatic decision for rustic network in light of the fact that, of its cost, support, materials, and so on as this examination plans to have a further developed independent framework, they have planned a pico-hydro framework that can effectively control oneself stimulated acknowledgment generator (SEIG) to get steady information control.	Most independent pico-hydro frameworks are just ready to control or get a steady water control input, this investigation confines the applications where the electrical yield is watched. Since a few nations are tropical nations, it will be an issue to the framework when the measure of information control abruptly bursts. It could prompt vacillation of electrical power output. To take care of this issue, the framework must not just observe, or check the water control input yet in addition screen the electrical power yield to counteract sudden changes that could

			prompt harming of the system.
Title: Voltage and frequency regulation with load leveling of PMSG based pico-hydro system using SLMS control algorithm **Authors:** Vineet P. Chandran, Shadab Murshid, Bhim Singh	This work manages voltage and recurrence control (VFC) of lasting magnet synchronous generator (PMSG) based pico-hydro framework with the heap leveling. In this proposed framework, a bi-directional DC-DC converter (BDC) with a battery vitality stockpiling (BES) is coupled to voltage source converter (VSC). A bi-directional converter, whose input is BES, is utilized to control the DC-interface voltage of the VSC. Alongside the DC-interface voltage, it additionally keeps up dynamic power balance in the framework. The BDC empowers to utilize a BES with diminished rating of 250V, while the DC-connect voltage is constantly kept up at 380 V. The battery gives stack leveling by charging amid delicately stacked conditions. At the point when the associated load surpasses more than PMSG based pico-hydro age, at that	As this study goes for a Pico-hydro framework that is very much controlled, the voltage and recurrence is directed by methods for load leveling. The framework utilizes a DC-DC converter coupled to a battery that is utilized to store vitality originating from the water control input.	This study confines the framework being utilized for long without keeping up its productivity, this proposed examination is made of a different framework that needs intensive support, yet since it is introduced in a provincial spot, it will be hard for the upkeep laborer to visit the system.

	point the overabundance control is conveyed by the BES. The power quality enhancement of the framework alongside VFC is acknowledged utilizing a VSC. The VSC alongside VFC likewise deals with other power quality issues like sounds and load unbalancing. A meager least mean square (SLMS) based control calculation is utilized to gauge key parts of load flows and to produce reference source flows for VSC control.		
Title: Simulated performance evaluation of SEIG with electronic load controller used in renewable energy conversion system. **Authors**: Umesh C. Rathore, Samjeev Singh	Computational programming innovation in demonstrating and reproduction has altered the approach of research in designing. This paper shows the utilization of MATLAB programming devices for demonstrating and reenactment in the field of intensity gadgets and its applications in sustainable power source transformation frameworks. In this paper the recreation utilizing MATLAB/Simulink condition has been done to assess the execution of 3-stage	This study is tied in with using the computational programming software, the MATLAB, as this study plans to assess the execution of SEIG or self-energized selection generator with electronic load controller that is utilized in sustainable power source framework, MATLAB is presented as a valuable programming software that can	As this study includes PC works, this investigation restricts the client when the place of test is in provincial places that have no methods for power or web organization, additionally MATLAB Software instruments are not totally furnished with devices you will require later on.

	self-excited enlistment generator (SEIG) with electronic load controller utilized in small scale/Pico hydro control age framework. The primary point of the control techniques for 3-stage self-energized acceptance generators is to manage or keep up the ideal voltage and recurrence of the created yield. This is accomplished utilizing electronic load controllers. The principle capacity of the electronic load controller is to keep up the yield stack steady as observed by the enlistment generator under various customer stack conditions and furthermore to keep up the required power quality norms. In this paper, recreated aftereffects of execution of 3-stage SEIG with electronic load controller sustaining confined load under various working conditions has been exhibited. The reenactment programming with solid graphical programming devices gives the freedom to persistent redesign the framework until upgraded results are accomplished which	be utilized to reproduce the framework simple. Equipment usage of any hypothetical idea in designing utilizing experimentation gives the better comprehension of the subject under investigation. With the headway in innovation and huge utilization of minimal effort computational software alongside modern programming instruments, new strategies in experimentation work have been advanced for better comprehension of the frameworks. The primary favorable position of utilizing PCs and programming instruments in any field is their capacity to configuration, play out the investigations and dissect the	

	can be utilized progressively equipment execution of the planned framework.	framework without physically utilizing it.	
Title: Design and development of a pico-hydro turbine system for the use in developing countries **Authors:** J. Hofmeister, S. Krebs, G. Schickhuber, G. Schrfenberg	In Sub-Saharan Africa under 10% of the provincial populace approaches power. Independent power frameworks (SPS) can be an answer for the issue of the absence of power, which features difficulties, for example, module establishment costs just as the adequate learning required for introducing, keeping up and working such frameworks. In view of this reality, a 250 W Low Head turbine framework was produced and enhanced to have the upside of the effortlessness of establishment and a development from promptly accessible materials. This plan scores the electrical proficiency of 60%, decreases producing unit drift to 130 € and considers the need of giving an unmistakable and straightforward manual depicting the assembling and establishment. A superior variant of the heap controller, utilizing a microcomputer is	Not all nations are having a similar season in the meantime, in some country network or zone in Africa, the pico-hydro framework is the most appropriate, productive, powerful sustainable source they can have. This examination intends to be improved and build up a pico-hydro turbine. Turbines is a machine for creating persistent power in which a wheel or rotor, ordinarily fitted with vanes, is made to rotate by a quick moving stream of water, steam, gas, air, or other liquid. In each nation there is an opportunity to produce nearby power out of sustainable assets to	As this study is proposed to build up a pico-hydro turbine framework for the utilization in creating nations, few elements should be considered. One is the atmosphere, not all nations are having similar nations, a few nations have an ordinary stream of water occasionally, yet there are a few nations that are constantly influenced by storms causing the stream of water turns out to be substantial, and there are some with constrained running waterway. To stop it, this investigation restrains the application where the stream of water is precarious, to take care of this issue, the turbine

	under current improvement. Mounting of the framework has been improved to lessen the measure of development material required to give continuous 230 V at 50 Hz AC or discretionary 12 V DC control supply.	substitute fossil vitality use. Notwithstanding that the advantage of little sustainable power source SPS turned out to be outstanding yet in a large portion of the nations there is only a little market for them and significantly progressively imperative, there is an absence of information about introducing, working and keeping up such frameworks appropriately.	together with a controller must be sufficiently improved to control a steady water control contribution to acquire a progressively consistent yield electrical power.
Title: A Hybrid Model of Vertical Axis Wind Turbine - Solar Power Generation for Highway and Domestic Application **Author**: Avinash P. Bavchakar, Ketan N. Chougale, Sushant P. Rane, Nitin B. Sawant, Sloni S. Belanekar	The use of renewable energy is very rampant nowadays. In recent years, wind and solar energy are being used as renewable energy. But these, standing alone are not reliable as it is dependent on the weather. In this study, wind and solar energy is used together to collect energy to charge batteries that will energize some domestic and highway applications. Such devices will be placed near highways to collect strong winds coming from passing	As this study aims for applications in highways, our goal is to power up highway lights which require 100watts each. Having the photovoltaic material of a solar panel which generates electricity during daytime, and the DC Generator which converts the mechanical energy from the	This study limits the application for highway lights. But as an enhancement, we can modify the blades of the turbine to be coupled with larger generators to produce more power.

	vehicles and simultaneously, solar power from the sun.	kinetic energy of the wind turbine which then generates electricity, we will be able to charge the battery unit. We also have here the Charge Controller which selects which source is more applicable to charge the battery unit. Then the battery unit will then supply power to the DC load.	
Title: A New Design of Banki's Water Turbine Model for Pico Hydro in Tabanan Bali **Author**: Lie Jasa and I Putu Ardana	The reliability of a water turbine greatly depends on the curvature angle of its blades. In this study, it is found that the 15 degree curvature angle of the blade of Banki's water turbine model is much more efficient than 16 degree, which was commonly used in industrial and commercial productions.	Pico-hydro consists of a water turbine and a generator. The water turbine made up of steel will then rotate. The rotation will be transferred to the generator by a connection of fan belt pulley. A cover of turbine runner is attached to receive the water falling vertically which will aggravate rotation of the turbine.	The location where the pico hydro was placed is cemented. For enhancements, we can construct a new one with the flexibility of being placed in a rocky or soil location such as falls and rivers.

Title: A Reliable Single Stage Single Phase Hybrid Solar Inverter with Anti-islanding Protection **Author:** Jalaj Arya, Lalit Mohan Saini	Solar inverter is needed for smart grid implementation. In order to protect the solar inverter, we used anti-islanding protection obtained through a high speed AC breaker. The study also considered the IEEE-519, guideline of German VDE0126-1-1Standard.	PV cell is what made up a PV system. By connecting parallel PC cells, we can make a solar panel. According to German VDE0126-1-1 Standard inverter should be off within 0.2 sec. at the time of islanding occurs. This is important for the safety of the solar inverter. During the process, we connected 11 modules in a panel which produced an output of 660 W which is distributed to the inverter. We used seven components in total including the LC Filter.	The study limits itself on relying on photovoltaic materials as the source of the renewable source. In the future for enhancement, we could incorporate the use of blades of wind turbines as a back-up source during the night time as the solar panels were only active during daytime.
Title: Design and tests of generators for micro hydro plants **Author:** dr hab. inż. Zbigniew Goryca prof. PŚk, dr hab. inż. Konrad Dąbała, dr inż. Sebastian Różowicz and dr	This study compares the output of two generators designed to be incorporated in small water turbines. Both of the generators have used the same stator. However, they have distinct characteristics in terms of number of slots, pole windings and number of segments which will	In the first generator, the researchers used three magnets twisted with respect to one another to minimize the cogging torque. In the second generator, the magnets in the outer segments	This study limits hydro power plants. For enhancement, we could explore incorporating solar panels together with micro-hydro to produce renewable energy.

inż. Zdzisław Krzemień	vary the output of the generator in terms of voltage, current and cogging torque.	are pushed outside and used screws to hold them as the magnets strongly repel each other. As they conduct laboratory tests, several things were measured such as cogging torque, voltage output, resistances of windings and the shape of the output waveform. After several examinations, it is found that generators with permanent magnets have higher efficiency to power plants compared with asynchronous machines.	
Title: Fuzzy based Optimal Load Management in Standalone Hybrid Solar PV /Wind/Fuel Cell Generation System **Author:** Sayantani Dey, Ritesh Dash and S.c. Swain	This study will focus on making a hybrid photovoltaic-wind-fuel that generated electricity for remote residential loads. With the use of fuzz based as a controller, a constant voltage DC supply will be generated and then distributed to the load.	Basically, we used three energy sources in this study: The solar, wind and fuel. The solar panel and turbine will supply DC voltage on the DC bus but for the times that these two will not suffice the power necessity of the load, the	The study has focused on using fuzzy based controllers which in fact, we can try another algorithm for constructing the controller. We have seen that the fuzzy based controller brings out the maximum power the source can give. However,

		hydrogen tank will do its responsibility. It will supply energy to the DC bus. As the solar and wind energy reaches its peak having surplus energy, an electrolyzer connected at the DC Bus will be activated and create more hydrogen to refill the hydrogen tank.	we have to know if other algorithms are much more effective than the fuzzy.
Title: Hybrid Control of A Solar Tracking System Using SUI-PID Controller **Author:** Yasser M. Safan, Sameh Shaaban and Mohamed I. Abu El-Sebah	Solar tracking is a way of collecting solar energy by reducing the angle of incidence of the sun ray to the solar panel. With this study, the researchers aim to bring out the maximum power of the panels during daytime using hybrid control energy. The use of Multi-Degree of Freedom-Simplified Universal Intelligent PID Controller (MDOF-SUI PID) to track the sun rays is implemented.	The system uses a solar tracking system which will bring out maximum power of the panels. The researchers have encountered a problem with the supply power of the tracking system as it requires greater power. By constructing the tracking control system, we mainly use three subsystems, the mechanical system, the electrical system and control system. These subsystems will ensure optimum tracking of solar	This study focuses on the utilization of solar energy. For enhancement, we could incorporate hydro energy to supply the driving power of the tracking system for optimum usage of renewable energy.

		radiation with the least error.	
Title: Hydroelectric Backup System for Off-Grid Households **Author:** Viorel MIRON ALEXE, Iulian BĂNCUȚĂ and Nicolae VASILE	This article tackles a smart system that will monitor the power consumption of large industrial consumers who depend on renewable energies like photovoltaic and water. The researchers aim to improve the energy efficiency and sustainability using photovoltaic materials and hydro energy as a back-up source.	We have here a battery bank system which will supply the load. To be able to charge up the battery, a solar panel is then connected which also consists of a water tower with a water pump and hydroelectric generator. During the day, the solar panel will supply the source to the load and simultaneously, the water tower will collect water with its nearby water body and vice versa during the night. With this, sustainability of renewable energy will be assured.	We used residential consumers as a recipient of renewable energy in this study. For enhancement, we could have commercial buildings as the recipient of the energy that we generated.
Title: Parabolic Trough Solar-Thermal-Wind-Diesel Isolated Hybrid Power System: Active Power/Frequency Control Analysis	The system comprises solar thermal power system, wind generator, diesel engine generator and battery energy storage system. With these, we are able to investigate the system's frequency	The researchers proposed a solar thermal power system with the capacity of 7.5 hours, a wind turbine that generates 1.5 MW DG-800kW	We may explore a real time prototype model of HPS under a non-conventional energy lab for enhancement. This may give a

Author: Sudhanshu Ranjan, Dulal Chandra Das, Soumyashree Behera, N. Sinha	control. Different algorithms were used to damp out unwanted oscillations to ensure maximum dynamic performance of the system.	and BESS-200kWh. The system requires 2.2MW. After thorough investigations, using various algorithms to control the frequency of the system, MBS based PID and PI controllers have given the most significant improvement in the frequency profile of the system.	better frequency profile in the system in this study.
Title: Simulation of Operation Modes of Inverter Hydro-generator **Author:** B.V. Lukutin, E.B. Shandarova and I.O. Muravlev, D.L. Matukhin, A.F. Makarova	The study focuses on a hydro generator which comprises an unregulated propeller hydro turbine and a synchronous generator through reversible frequency converter. The simulink in MATLAB was used to analyze the load operation of the said hydro turbine.	In the model, we used a control circuit voltage of the stator winding of the synchronous machine, voltage generator, 4 oscilloscopes and inverter power switches. Through the simulation process, simulation results match the actual physical processes. MATLAB with its simulink has successfully created a generic tool for electric power conversion processes in	The whole study transpires through just a simulation process. For enhancement, we could perform a real time investigation with the results and determine which operation mode is the most efficient.

		hydro generators.	
Title: The Study of the Energy Management System Based-On Fuzzy Control for Distributed Hybrid Wind-Solar Power System **Author:** J. M. Yang, K. W. E. Cheng, J. Wu*, P. Dong, and B. Wang	Having the wind turbine and solar panel for renewable energy sources will always result with random variation in the output. With this study, we used a fuzzy energy management system to have a constant output for a safe and reliable performance of the loads.	We designed a hierarchical fuzzy control EMS for a HGS comprising wind, PV and storage batteries. We use five different outputs to test the fuzzy control system. The results have shown that the algorithm used has no complexity at all. EMS can switch the mode of power source from solar radiation and wind turbine. With this, the EMS met the system requirements.	The study focuses on incorporating wind turbines in solar panels which in fact, we could incorporate hydro generators instead of the wind turbine stated above. Hydro generators have less variation in the output than the wind turbine.

APPENDIX B

User Manual

AUOMATC GENERATION CONTROLLER MANUAL

SAFETY INSTRUCTIONS

The following safety guidelines are intended to prevent unforeseen risks of damage from unsafe or incorrect operation of the device.

- To reduce the risk of explosion, fire, death, electric shock, injury or scalding to persons when using this device, follow basic precautions, including the following:
- This device is not intended for use by persons (including children) with reduced physical, sensory, or mental capabilities, or lack of experience and knowledge.

➢ OPERATION

- Be sure to use only those parts listed in the service parts list.
- Never attempt to modify the equipment.
- Never touch, operate, or repair the device with wet hands.
- Do not place any objects on the power cable.

➢ MAINTENANCE

- Before cleaning or performing maintenance, disconnect the power supply.

➢ TECHNICAL SAFETY

- Installation or repairs made by unauthorized persons can pose hazards to you and others.
- Servicing shall only be performed as recommended by the equipment manufacturer.
- Maintenance and repair requiring the assistance of other skilled personnel shall be carried out under the supervision of the person competent in the use of the device.

- The information contained in the manual is intended for use by a qualified service technician who is familiar with the safety procedures and equipped with the proper tools and test instruments.
- Failure to read and follow all instructions in this manual can result in equipment malfunction, properly damage, personal injury and/or death.
- This appliance shall be installed in accordance with national wiring regulations.
- When the power cord is to be replaced, the replacement work shall be performed by authorized personnel using only genuine replacements parts.
- This appliance must be properly grounded to minimize the risk of electric shock.
- If you have any doubt whether the device is properly grounded, have the power outlet and circuit checked by a qualified electrician.
- The appliance shall be stored in a well-ventilated area where the room size corresponds to the room area as specified for operation.
- The appliance shall be stored so as to prevent mechanical damage from occurring.

CAUTION

To reduce the risk of minor injury to persons, malfunction, or damage to the device when using it, follow basic precautions, including the following:

- **INSTALLATION**
    - Do not install the device in an area where it is directly exposed to sea wind.
    - Do not install the device in an area where it can be reached by the water rain.
    - Install the device such that it is protected from direct sunlight. Do not place the device in a place where it is directly exposed to sunlight.
    - Make sure that all components are properly installed before operating the device.

- Be sure to check if there is a wrong connection or misfit wire.
- Do not place any object on the device.
-

➢ **MAINTENANCE**

- Never touch the metal parts of the device.
- Use necessary equipment when cleaning, maintaining or repairing the device. • Never use strong cleaning agents or solvents when cleaning the device or spray water. Use a smooth cloth.

PARTS

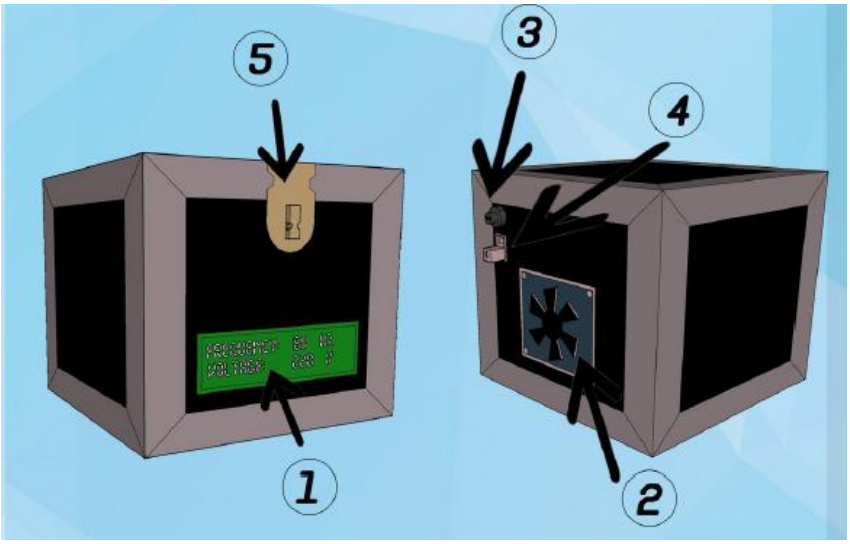


Figure N.

Device parts:

1. LCD display
2. Exhaust fan
3. Fuse
4. Switch
5. Lock

INTRODUCTION

Automatic Generation Controller (AGC) is a device developed by the proponents to automatically control the output voltage and frequency of a generator that is connected to a pico-hydropower system. It is connected to the output of the generator and automatically measures the output voltage and frequency and does its tasks depending on the measurement accordingly if the measured voltage and frequency is below the standard range, it instructs the speed governor to tighten the opening to limit the water entering the valve and vice versa.

TECHNICAL SPECIFICATIONS:

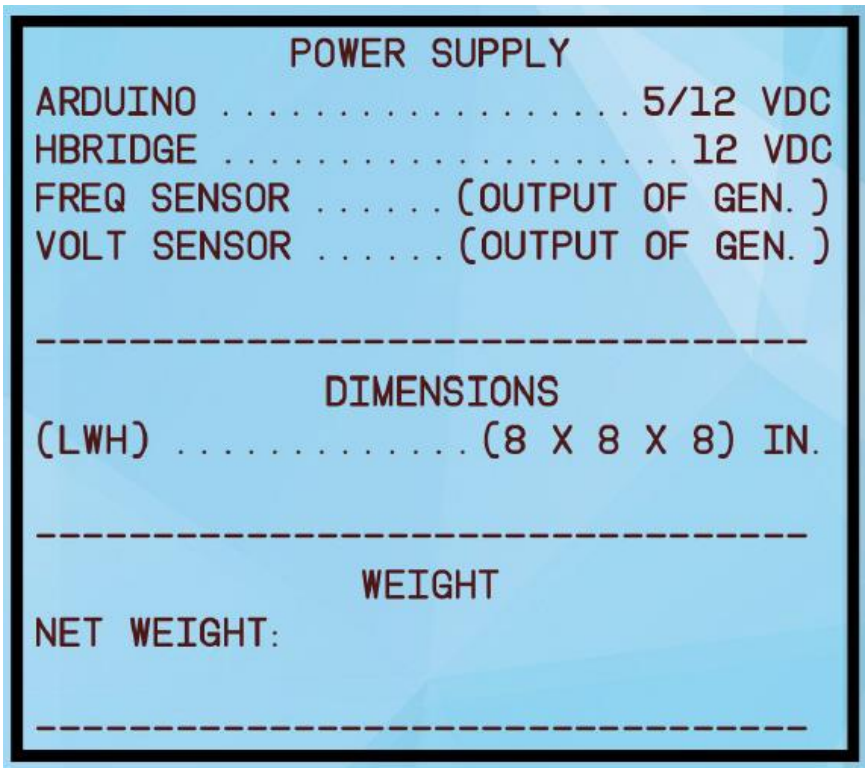


Figure M.

HOW TO USE:

1. Turn off the Pico hydro system before connecting any parts.

2. Make sure that all f is insulated.

3. Check the fuse!

4. Connect the probes respective terminals.

5. Open the gate valve halfway

6. Turn on the switch of the device.

7. Check if the system is working well.

8. Leave the device on a well ventilated and far from water

APPENDIX C

Source codes

CODES

//READINGS

```
#include <Filters.h>  //Easy library to do the calculations

#include <LiquidCrystal.h>

int input = 13;



int high_time;

int low_time;

float time_period;

float freq;

LiquidCrystal lcd(0 ,1 ,3, 4, 5, 6);




float testFrequency = 60;                     // test signal frequency (Hz)

float windowLength = 40.0 / testFrequency;   // how long to average the signal, for
statistist
```

```
int Sensor = 0; //Sensor analog input, here it's A0


float intercept = -0.1; // to be adjusted based on calibration testing

float slope = 0.0955; // to be adjusted based on calibration testing

float current_Volts; // Voltage


const unsigned long event_1 = 3000;

const unsigned long event_2 = 23000;

unsigned long previousTime = 0;


unsigned long printPeriod = 1000; //Refresh rate

unsigned long previousMillis = 0;

//READINGS


//ANFIS

float divider;

float frequency;
```

```
float anfis;
int PH_PIN = 9; // Direction pin
int PWH_PIN = 10; // Speed control/PWM pin
//beefy motor
/*
  GND   ===> GND
  RESET ===> RESET
  +5V   ===> SR
  D3   ===> PH
  +5V  ===> PWL
  PH = 9
  PWH = 10
 */
void setup() {
  pinMode(PH_PIN, OUTPUT);
  pinMode(PWH_PIN, OUTPUT);
 pinMode(input, INPUT);
```

```
  lcd.begin(16, 2);
}

void loop() {


  RunningStatistics inputStats;               //Easy life lines, actual calculation of the RMS
requires a load of coding
  inputStats.setWindowSecs( windowLength );


  while ( true ) {
    Sensor = analogRead(A0);  // read the analog in value:
    inputStats.input(Sensor);  // log to Stats function


    if ((unsigned long)(millis() - previousMillis) >= printPeriod) {
      previousMillis = millis();   // update time every second
```

```
    current_Volts = intercept + slope * inputStats.sigma(); //Calibartions for offset and
amplitude
    current_Volts = current_Volts * (40.3231);            //Further calibrations for the
amplitude


    high_time = pulseIn(input, HIGH);
    low_time = pulseIn(input, LOW);
    time_period = high_time + low_time;
    time_period = time_period / 1000;
    frequency = 1000 / time_period;


  }
  // For Voltage


  lcd.setCursor(0, 1);
  lcd.print("volt:");
  lcd.setCursor(5, 1);
  lcd.print(current_Volts);
```

```
lcd.setCursor(12, 1);

lcd.print(" V");

// For Frequency

lcd.setCursor(0, 0);

lcd.print("Freq:");

lcd.setCursor(5, 0);

lcd.print(frequency);

lcd.setCursor(12, 0);

lcd.print("Hz");




if (current_Volts >= 226.6 && frequency >= 66) {

  anfis = .33;

  //need pa bagalin si generator

  // Serial.println("Closing the Gate Valve");

}
```

```
if (current_Volts <= 213.4 && frequency <= 54) {
  anfis = .99;
  //need pa bilisan si generator
  // Serial.println("Opening the Gate Valve");
}

if (current_Volts > 213.4 &&  current_Volts < 226.4) {
  if (frequency > 54 && frequency < 66) {
    anfis = .66;
    //Serial.println("Steady State");
  }
}

if (frequency > 54 && frequency < 66) {
  if (current_Volts <= 213.4) {
    anfis = .44;
    // open ng konti gate valve
```

```
  }
}

if (frequency > 54 && frequency < 66) {
  if (current_Volts >= 226.4) {
    anfis = .55;
    // close konti gate valve
  }
}

if (current_Volts > 213.4 &&  current_Volts < 226.4) {
  if (frequency <= 54) {
    anfis = .77;
    //open ng konti gate valve
  }
}
```

```
if (current_Volts > 213.4 &&  current_Volts < 226.4) {
  if (frequency >= 66) {
    anfis = .88;
    //close ng konti gate valve
  }
}
```

```
if (anfis == .33) {
  unsigned long currentTime = millis();
  if(currentTime - event_2 < event_1) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 225);
  }

  else if(currentTime - previousTime <= event_1) {
```

```
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 225);
  }
  else if(currentTime - previousTime > event_1 && currentTime < 23000) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 0);
  }
}

if (anfis == .99) {

  unsigned long currentTime = millis();
  if(currentTime - event_2 < event_1) {
   digitalWrite(PH_PIN, HIGH);
   analogWrite(PWH_PIN, 225);
  }
```

```
  else if(currentTime - previousTime <= event_1) {
   digitalWrite(PH_PIN, HIGH);
   analogWrite(PWH_PIN, 225);
  }
  else if(currentTime - previousTime > event_1 && currentTime < 23000) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 0);
  }
}

if (anfis == .66) {

  digitalWrite(PH_PIN, LOW);
  analogWrite(PWH_PIN, 0);
  delay(1);
}
```

```
if (anfis == .44) {


  unsigned long currentTime = millis();
  if(currentTime - event_2 < event_1) {
   digitalWrite(PH_PIN, HIGH);
   analogWrite(PWH_PIN, 180);
  }


  else if(currentTime - previousTime <= event_1) {
   digitalWrite(PH_PIN, HIGH);
   analogWrite(PWH_PIN, 180);
  }
  else if(currentTime - previousTime > event_1 && currentTime < 23000) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 0);
  }
}
```

```
if (anfis == .55) {


  unsigned long currentTime = millis();
  if(currentTime - event_2 < event_1) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 180);
  }


  else if(currentTime - previousTime <= event_1) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 180);
  }
  else if(currentTime - previousTime > event_1 && currentTime < 23000) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 0);
  }
```

```
}


if (anfis == .77) {


  unsigned long currentTime = millis();
  if(currentTime - event_2 < event_1) {
   digitalWrite(PH_PIN, HIGH);
   analogWrite(PWH_PIN, 180);
  }


  else if(currentTime - previousTime <= event_1) {
   digitalWrite(PH_PIN, HIGH);
   analogWrite(PWH_PIN, 180);
  }
  else if(currentTime - previousTime > event_1 && currentTime < 23000) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 0);
```

```
  }
}

if (anfis == .88) {

  unsigned long currentTime = millis();
  if(currentTime - event_2 < event_1) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 180);
  }

  else if(currentTime - previousTime <= event_1) {
   digitalWrite(PH_PIN, LOW);
   analogWrite(PWH_PIN, 180);
  }
  else if(currentTime - previousTime > event_1 && currentTime < 23000) {
   digitalWrite(PH_PIN, LOW);
```

```
        analogWrite(PWH_PIN, 0);

      }

    }

  }

}
```

APPENDIX D

Device Specifications

ENHANCE XP

PHOTOVOLTAICS

250W - 275W Polycrystalline Module

Made in Taiwan - Independent OST Factory Audit Completed

Enhance Photovoltaic Modules surpass all international recognised quality standards and are produced by one of the world's leading fully vertical integrated photovoltaic module producers on the worlds most advanced European produced fully automated robotic production lines, this process ensures exceptionally high quality, reliability and performance, even in low light conditions.

High Module Efficiency

Module efficiency up to 16.9% achieved through advanced cell technology and manufacturing capabilities.

Extended wind & snow load tests

Pass ASTM E330; Maximum wind speed: 197 km/h (safety factor 3)
(short-side installation ≥ 2400 Pa guaranteed)

Positive Power tolerance

Positive tolerance of up to +4.99 watts delivers higher outputs.

Excellent weak light performance

3.5% relative efficiency reduction at low irradiance (200W/m²)

Anti-PID

Potential Induced Degradation Test Certified according to IEC 62804.

Prolonged aging test

2000 hour damp heat test; 400 Thermal cycles

Corrosive Resistant

Robust design & materials ensures reliability whilst operating under the most extreme conditions such as marine or farming environments.

Superior Protection

Tyco IP 67 rated junction box protects against extreme weather conditions and dust

Comprehensive Warranty

Market leading 12.5 year product warranty

Linear Warranty

Guaranteed 25 year linear performance. Min 97% after the first year, afterwards Max 0.6% reduction p.a up to 25 years.

www.enhance-photovoltaics.com

Specifications are subject to change without notice

ENHANCE XP
PHOTOVOLTAICS

250W - 275W Polycrystalline Module

Electrical Data

		XP-250	XP-255	XP-260	XP-265	XP-270	XP-275
Nominal Power Watt P_{max}	W_p	250	255	260	265	270	275
Power Output Tolerance P_{max}	W	0~+4.99	0~+4.99	0~+4.99	0~+4.99	0~+4.99	0~+4.99
Maximum Power Voltage V_{mp}	V	30.34	30.64	30.93	30.79	30.92	31.10
Maximum Power Current I_{mp}	A	8.25	8.33	8.43	8.61	8.74	8.85
Open Circuit Voltage V_{oc}	V	37.33	37.50	37.67	38.42	38.53	38.63
Short Circuit Current I_{sc}	A	8.69	8.76	8.83	9.11	9.17	9.23
Module Efficiency η_m	%	15.4	15.7	16.0	16.3	16.6	16.9

*Electrical data under Standard Test Conditions (STC): Cell Temperature of 25°C, Irradiance 1000 W/m², AM 1.5
*Values w/o tolerance are typical numbers
*Specifications subject to change

Mechanical Data

Item	Specification
Dimensions	1640mm (l) x 992mm (w) x 40mm (d)
Weight	18.5 kg
Solar Cell	60 polycrystalline 6" silicon cells (156mm x 156mm)
Front Glass	Anti-reflective tempered solar glass, 3.2mm thickness
Cell Encapsulation	EVA (Ethylene-Vinyl-Acetate)
Back Cover	Composite film
Junction Box	Tyco IP 67 rated
Frame	Anodized aluminium frame

Operating Conditions

Item	Specification
Mechanical Load	5400pa (Certified by TUV Rheinland)
Maximum System Voltage	DC 1000 V
Series Fuse Rating	15 A
Operating Temperature	-40 to 85 °C

Temperature Characteristics

Item	Specification
Nominal Operating Cell Temperature	44.1°C ± 2°C
Temperature Coefficient of I_{sc}	0.046 % / °C
Temperature Coefficient of V_{oc}	-0.313 % / °C
Temperature Coefficient of P_{max}	-0.420 % / °C

*Nominal Operating Cell Temperature (NOCT): Irradiance 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s
*Please refer to Enhance Photovoltaics standard module installation guide before using this product
*Reduction in efficiency from 1000 W/m² to 200 W/m² at 25°C: 3.5% ± 2%

Loading Volume

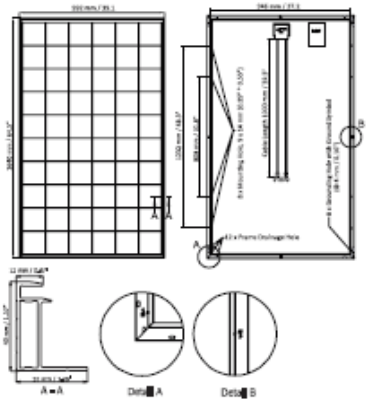
Item	Specification
Container	728 pcs
Pallet	26 pcs

Contact Details

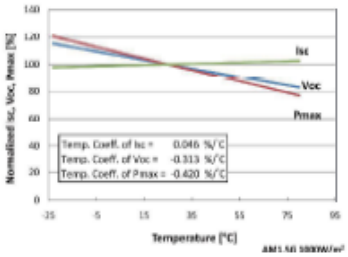
SOLFEX energy systems
Units 3-5
Charnley Fold Industrial Estate
Bamber Bridge, Preston
Lancashire, PR5 6PS

T - 00 44 1772 312847
F - 00 44 1772 335277
E - photovoltaicssales@solfex.co.uk
W - www.solfex.co.uk

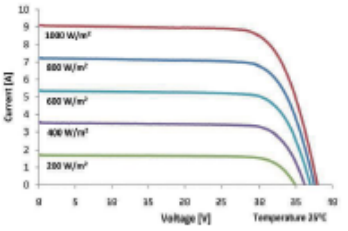
Front & Back View



Dependence on Temperature



Dependence on Irradiance



Specifications are subject to change without notice

Sealed Lead-Acid Battery
Deep Cycle

727-0427(12V100Ah)

Specification

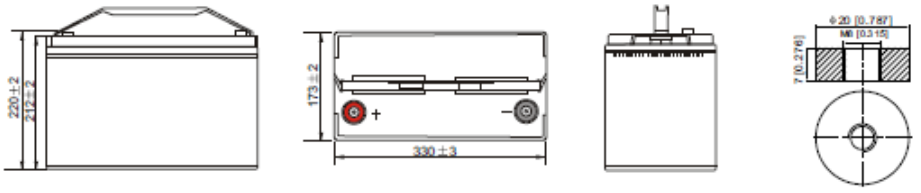
Cells Per Unit	6
Voltage Per Unit	12
Capacity	100.0Ah@10 hr-rate to 1.80V per cell @25°C
Weight	Approx 30.4kg
Max. Discharge Current	1200A (5 sec)
Internal Resistance	Approx 4.9mΩ
Operating Temp.Range	Discharge : -15~50°C (5~122°F) Charge : 0~40°C (32~104°F) Storage : -15~40°C (5~104°F)
Nominal Operating Temp. Range	25±3°C (77±5°F)
Float charging Voltage	13.5 to 13.8 VDC/unit Average at 25°C
Recommended Maximum Charging Current Limit	30.0A
Equalization and Cycle Service	14.4 to 15.0 VDC/unit Average at 25°C
Self Discharge	The batteries can be stored for more than 6 months at 25°C. Self-discharge ratio less than 3% per month at 25°C. Please charge batteries before using.
Terminal	T11
Container Material	A.B.S. (UL94-HB) , Flammability resistance of UL94-V0 can be available upon request.

Applications

- *Electric tools*
- *Mobility*
- *Lawn mowers*
- *Golf trolleys and golfcart*
- *Portable apparatus, lights and instruments;*
- *Electric toys*
- *Emergency lighting*
- *Fire and security alarms*
- *Portable power*
- *Wheelchairs*
- *Medical equipments.*
- *Solar energy*

Dimensions

Unit: mm Dimension: 330(L)×173(W)×212(H)×220(TH)



Constant Current Discharge Characteristics : A (25°C)

Amps

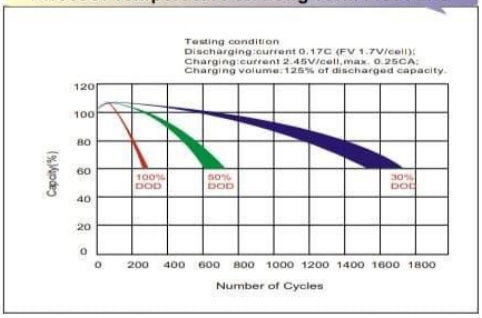
F.V/Time	10min	15min	20min	30min	45min	1h	2h	3h	4h	5h	6h	8h	10h	20h
1.85V/cell	146.4	123.2	107.7	77.5	61.5	49.9	31.0	24.2	19.6	15.9	13.9	11.3	9.4	5.31
1.80V/cell	187.1	148.9	127.3	91.4	71.6	55.9	33.9	26.0	20.9	17.1	14.9	12.0	10.0	5.36
1.75V/cell	205.6	162.6	136.9	94.9	74.3	58.5	35.1	26.5	21.4	17.5	15.3	12.2	10.1	5.41
1.70V/cell	224.1	173.6	143.9	98.8	77.2	60.4	36.5	27.2	22.0	18.0	15.6	12.4	10.2	5.51
1.65V/cell	241.8	184.6	152.8	104.2	79.2	62.4	37.5	28.4	22.7	18.5	16.0	12.6	10.4	5.58
1.60V/cell	262.5	197.4	162.8	110.0	82.5	64.6	38.8	29.3	23.4	19.1	16.3	12.7	10.5	5.61

Constant Power Discharge Characteristics : W (25°C)

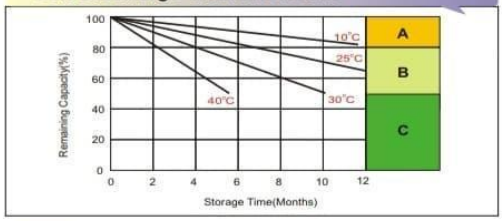
Watts

F.V/Time	10min	15min	20min	30min	45min	1h	2h	3h	4h	5h	6h	8h	10h	20h
1.85V/cell	273.2	232.3	205.2	148.8	119.0	96.9	60.4	47.2	38.4	31.3	27.4	22.4	18.7	10.6
1.80V/cell	344.4	276.5	238.8	173.5	137.3	107.9	65.6	50.6	40.8	33.5	29.3	23.7	19.8	10.7
1.75V/cell	373.8	299.1	254.8	179.3	141.8	112.5	67.8	51.4	41.6	34.3	30.1	24.1	20.0	10.8
1.70V/cell	401.7	316.9	266.3	185.8	147.0	115.7	70.3	52.7	42.6	35.1	30.7	24.5	20.2	11.0
1.65V/cell	430.4	334.8	281.5	195.2	150.2	119.2	72.1	54.8	44.0	36.0	31.3	24.8	20.6	11.1
1.60V/cell	459.4	353.8	296.8	204.0	155.1	122.5	74.1	56.2	45.1	37.0	31.9	25.0	20.8	11.2

Effect of Temperature on Long Term Float Life



Self Discharge Characteristics

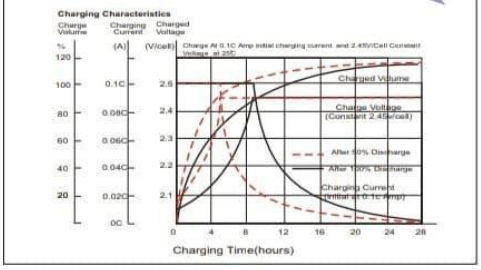


A No supplementary charge required
(Carry out supplementary charge before use if 100% capacity is required.)

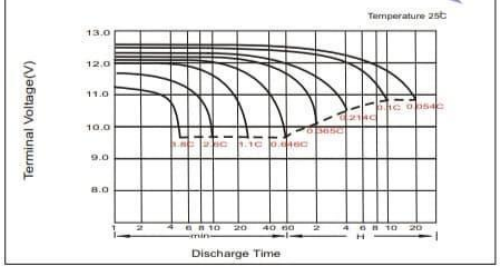
B Supplementary charge required before use.Optional charging way as below:
1.Charged for above 3 days at limted current 0.25CA and constant volatge 2.25V/cell.
2.Charged for above 20hours at limted current 0.25CA and constant volatge 2.45V/cell.
3.Charged for 8~10hours at limted current 0.05CA .

C Avoid this storage period unless regular Top charge.
Supplementary charge may often fail to recover the full capacity

Cycle Charging Characteristics



Discharge Characteristics



Available Capacity Subject to Temperature

Battery Type		-20℃	-10℃	0℃	5℃	10℃	20℃	25℃	30℃	40℃	45℃
AGM Battery	6V&12V	46%	66%	76%	83%	90%	98%	100%	103%	107%	109%

Discharge Current VS. Discharge Voltage

Final Discharge Voltage V/cell	1.80V	1.75V	1.60V
Discharge Current (A)	（A）≤0.2C	0.2C＜（A）＜1.0C	（A）≥1.0C

Charge the batteries at least once every six months, if they are stored at 25°C.

Charging Method:

Constant Voltage	-0.2Cx2h+2.4~2.45V/Cellx24h,Max. Current 0.3CA
Constant Current	-0.2Cx2h+0.1CAx 12h
Fast	-0.2Cx2h+0.3CAx4.0h

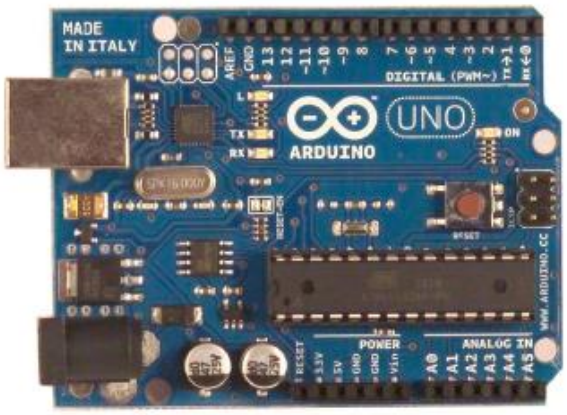
Pb

Maintenance & Cautions

Float Service:
◆It is recommended to check battery/Float voltage each month.
Equalisation charge:
◆Equalisation charging is recommended once every 3 to 6 months using.
◆Discharge 100% rated capacity.
◆Charge 2.35v/cell constant voltage, maximum 0.3CA 24hrs.
Cyclic Service:
◆Temperature compensation for varying temperatures:
-Charge voltage -5mV/Cell/degC from 25degC norm.
◆The service life of your battery will be affected by:
-The number of discharge cycles, depth of discharge, ambient
temperature and charging voltage.

Issue date: Sep. 2014

Arduino UNO



Product Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

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

Index

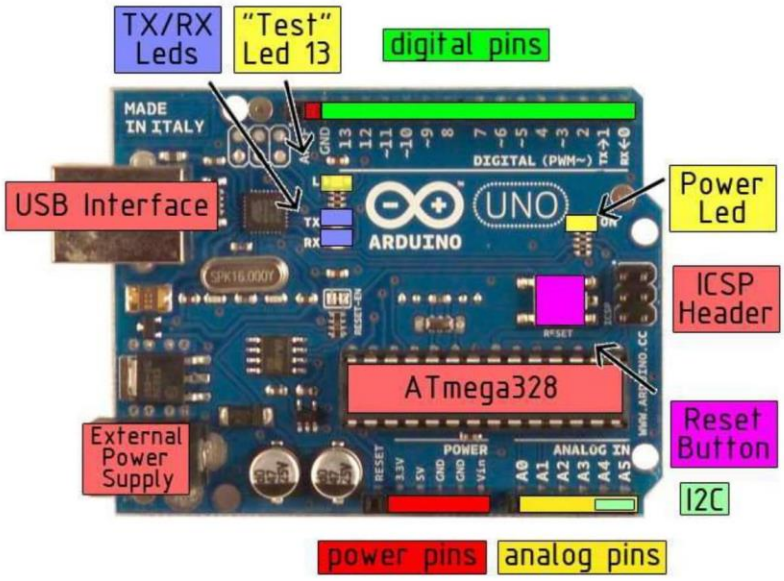
Technical Specification

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

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

the board



Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

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

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. TThese pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

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

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

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

There are a couple of other pins on the board:

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

See also the mapping between Arduino pins and Atmega328 ports.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an *.inf file is required..

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

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

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

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno w/ ATmega328" from the **Tools > Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega8U2 firmware source code is available . The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader).

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

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

Physical Characteristics

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

How to use Arduino

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

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

Linux Install Windows Install Mac Install

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

Blink led

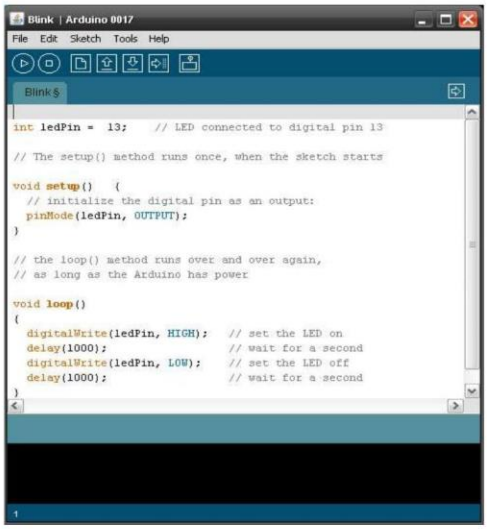
Now you're actually ready to "burn" your first program on the arduino board. To select "blink led", the physical translation of the well known programming "hello world", select

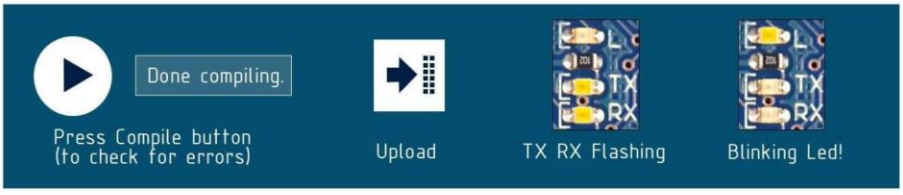
File>Sketchbook>
Arduino-0017>Examples>
Digital>Blink

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

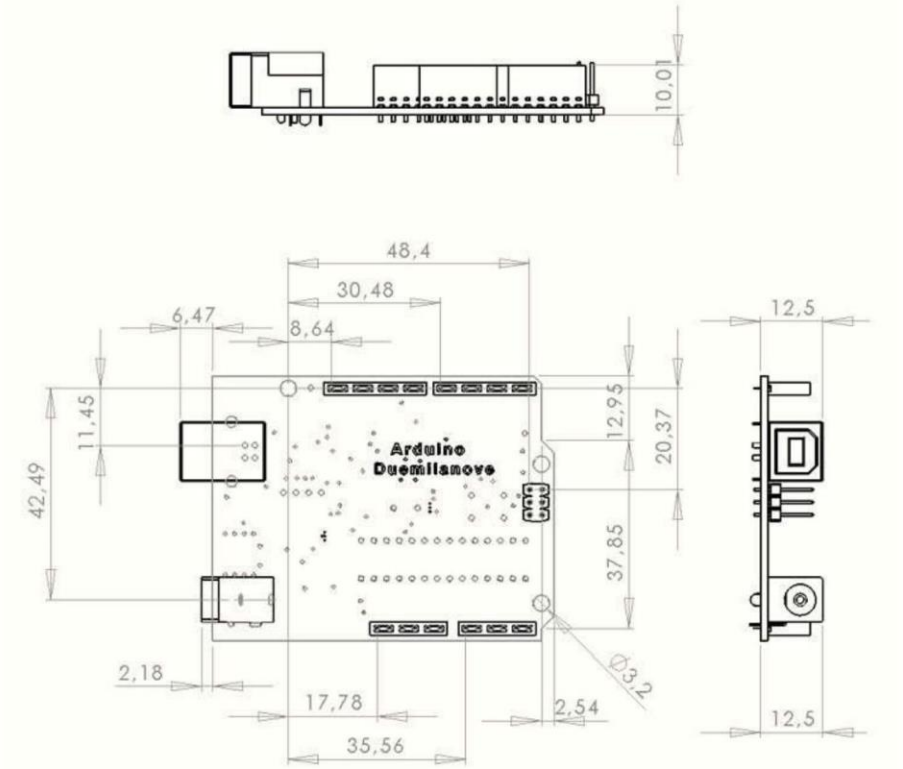
In **Tools>Board** select

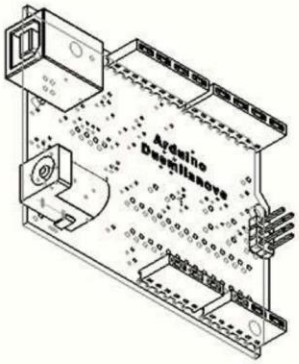
Now you have to go to
Tools>SerialPort
and select the right serial port, the one arduino is attached to.





Dimensioned Drawing





Terms & Conditions

1. Warranties

1.1 The producer warrants that its products will conform to the Specifications. This warranty lasts for one (1) years from the date of the sale. The producer shall not be liable for any defects that are caused by neglect, misuse or mistreatment by the Customer, including improper installation or testing, or for any products that have been altered or modified in any way by a Customer. Moreover, The producer shall not be liable for any defects that result from Customer's design, specifications or instructions for such products. Testing and other quality control techniques are used to the extent the producer deems necessary.

1.2 If any products fail to conform to the warranty set forth above, the producer's sole liability shall be to replace such products. The producer's liability shall be limited to products that are determined by the producer not to conform to such warranty. If the producer elects to replace such products, the producer shall have a reasonable time to replacements. Replaced products shall be warranted for a new full warranty period.

1.3 EXCEPT AS SET FORTH ABOVE, PRODUCTS ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." THE PRODUCER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING PRODUCTS, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE

1.4 Customer agrees that prior to using any systems that include the producer products, Customer will test such systems and the functionality of the products as used in such systems. The producer may provide technical, applications or design advice, quality characterization, reliability data or other services. Customer acknowledges and agrees that providing these services shall not expand or otherwise alter the producer's warranties, as set forth above, and no additional obligations or liabilities shall arise from the producer providing such services.

1.5 The Arduino™ products are not authorized for use in safety-critical applications where a failure of the product would reasonably be expected to cause severe personal injury or death. Safety-Critical Applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Arduino™ products are neither designed nor intended for use in military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Arduino™ products which is solely at the Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

1.6 Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products and any use of Arduino™ products in Customer's applications, notwithstanding any applications-related information or support that may be provided by the producer.

2. Indemnification

The Customer acknowledges and agrees to defend, indemnify and hold harmless the producer from and against any and all third-party losses, damages, liabilities and expenses it incurs to the extent directly caused by: (i) an actual breach by a Customer of the representation and warranties made under this terms and conditions or (ii) the gross negligence or willful misconduct by the Customer.

3. Consequential Damages Waiver

In no event the producer shall be liable to the Customer or any third parties for any special, collateral, indirect, punitive, incidental, consequential or exemplary damages in connection with or arising out of the products provided hereunder, regardless of whether the producer has been advised of the possibility of such damages. This section will survive the termination of the warranty period.

4. Changes to specifications

The producer may make changes to specifications and product descriptions at any time, without notice. The Customer must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." The producer reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The product information on the Web Site or Materials is subject to change without notice. Do not finalize a design with this information.

Enviromental Policies

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

Specification

for

LCD Module

1602A-1
(V1.2)

1. 0 FEATURES

- Display Mode: STN, BLUB
- Display Formate: 16 Character x 2 Line
- Viewing Direction: 6 O'Clock
- Input Data: 4-Bits or 8-Bits interface available
- Display Font : 5 x 8 Dots
- Power Supply : Single Power Supply (5V±10%)
- Driving Scheme : 1/16Duty,1/5Bias
- BACKLIGHT（SIDE）：LED（WHITE）

2.0 ABSOLUTE MAXIMUM

Item	Symbol	Min.	Max.	Unit
Power Supply for logic	Vdd	-0.3	+7.0	V
Power supply for LCD Drive	Vlcd	Vdd-10.0	Vdd+0.3	V
Input Voltage	Vi	-0.3	Vdd+0.3	V
Operating Temperature	Ta	0	+50	℃
Storage Temperature	Tstg	-10	+60	℃

3.0ELECTRICAL CHARACTERISTICS

(Ta=25℃;Vdd=3.0V±10%,otherwise specified)

Item	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Power Supply for Logic	Vdd	--	4.7	5.0	5.5	V
Operating Voltage for LCD	Vdd-Vo	--	--	5.0	--	V
Input High voltage	Vih	--	2.2	--	Vdd	V
Input Low voltage	Vil	--	-0.3	--	0.6	V
Output High voltage	Voh	-Ioh=0.2mA	2.4	--	--	V
Output Low voltage	Vol	Iol=1.2mA	--	--	0.4	V
Power supply current	Idd	Vdd=3.0v	--	1.1	--	mA

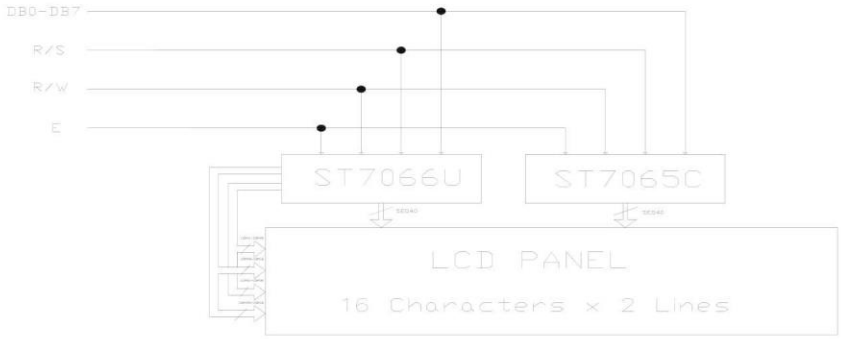
4.0 MECHANICAL PARAMETERS

Item	Description	Unit
PCB Dimension	80.0*36.0*1.6	mm
View Dimension	69.5*14.5	mm

5.0 PIN ASSIGNMENT

No.	Symbol	Level	Function	
1	Vss	--	0V	Power Supply
2	Vdd	--	+5V	
3	V0	--	for LCD	
4	RS	H/L	Register Select: H:Data Input L:Instruction Input	
5	R/W	H/L	H--Read L--Write	
6	E	H,H-L	Enable Signal	
7	DB0	H/L	Data bus used in 8 bit transfer	
8	DB1	H/L		
9	DB2	H/L		
10	DB3	H/L		
11	DB4	H/L	Data bus for both 4 and 8 bit transfer	
12	DB5	H/L		
13	DB6	H/L		
14	DB7	H/L		
15	BLA	--	BLACKLIGHT +5V	
16	BLK	--	BLACKLIGHT 0V-	

6.0 BLOCK DIAGRAM



7.0 POWER SUPPLY BLOCK DIAGRAM

- **DL : Interface data length control bit**
  When DL = "High", it means 8-bit bus mode with MPU.
  When DL = "Low", it means 4-bit bus mode with MPU. So to speak, DL is a signal to select 8-bit or 4-bit bus mode.
  When 4-bit bus mode, it needs to transfer 4-bit data by two times.
- **N : Display line number control bit**
  When N = "Low", it means 1-line display mode.
  When N = "High", 2-line display mode is set.
- **F : Display font type control bit**
  When F = "Low", it means 5 x 8 dots format display mode
  When F = "High", 5 x11 dots format display mode.

N	F	No. of Display Lines	Character Font	Duty Factor
L	L	1	5x8	1/8
L	H	1	5x11	1/11
H	x	2	5x8	1/16

- **Set CGRAM Address**

	RS	RW	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0

Set CGRAM address to AC.
This instruction makes CGRAM data available from MPU.

- **Set DDRAM Address**

	RS	RW	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0

Set DDRAM address to AC.
This instruction makes DDRAM data available from MPU.
When 1-line display mode (N = 0), DDRAM address is from "00H" to "4FH".
In 2-line display mode (N = 1), DDRAM address in the 1st line is from "00H" to "27H", and DDRAM address in the 2nd line is from "40H" to "67H".

- **Read Busy Flag and Address**

	RS	RW	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0

When BF = "High", indicates that the internal operation is being processed.So during this time the next instruction cannot be accepted.

The address Counter (AC) stores DDRAM/CGRAM addresses, transferred from IR.

After writing into (reading from) DDRAM/CGRAM, AC is automatically increased (decreased) by 1.

- **Write Data to CGRAM or DDRAM**

	RS	RW	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	1	0	D7	D6	D5	D4	D3	D2	D1	D0

Write binary 8-bit data to DDRAM/CGRAM.

The selection of RAM from DDRAM, CGRAM, is set by the previous address set instruction : DDRAM address set, CGRAM address set. RAM set instruction can also determine the AC direction to RAM.

After write operation, the address is automatically increased/decreased by 1, according to the entry mode.

- **Read Data from CGRAM or DDRAM**

	RS	RW	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	1	1	D7	D6	D5	D4	D3	D2	D1	D0

Read binary 8-bit data from DDRAM/CGRAM.

The selection of RAM is set by the previous address set instruction. If address set instruction of RAM is not performed before this instruction, the data that read first is invalid, because the direction of AC is not determined. If you read RAM data several times without RAM address set instruction before read operation, you can get correct RAM data from the second, but the first data would be incorrect, because there is no time margin to transfer RAM data.

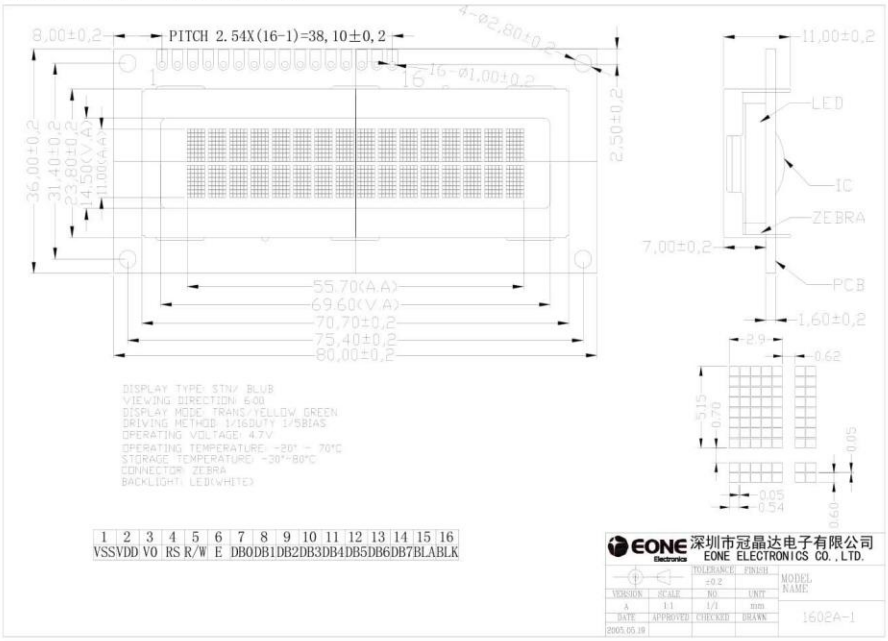
In case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address set instruction : it also transfer RAM data to output data register. After read operation address counter is automatically increased/decreased by 1 according to the entry mode. After CGRAM read operation, display shift may not be executed correctly.

* In case of RAM write operation, after this AC is increased/decreased by 1 like read operation. In this time, AC indicates the next address position, but you can read only the previous data by read instruction.

NO.7066-0A


b7-b4
b3-b0
0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111
0000 CG RAM (1)
0001 (2)
0010 (3)
0011 (4)
0100 (5)
0101 (6)
0110 (7)
0111 (8)
1000 (1)
1001 (2)
1010 (3)
1011 (4)
1100 (5)
1101 (6)
1110 (7)
1111 (8)

9. EXTERNAL DIMENSIONS



DME33

MODEL CODE	VOLTAGE	OUTPUT	CURRENT
SA	12V	0.7W	0.12A
SB	24V	0.7W	0.06A
BA	12V	3.0W	0.42A
BB	24V	3.0W	0.22A

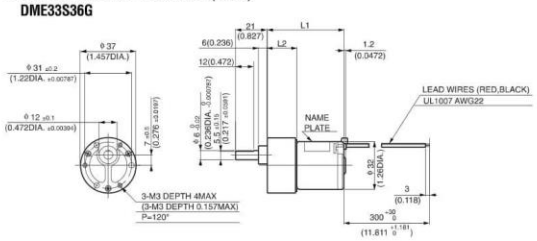
WITH GEARBOX 36G

Gear heads for intermittent drive

36G

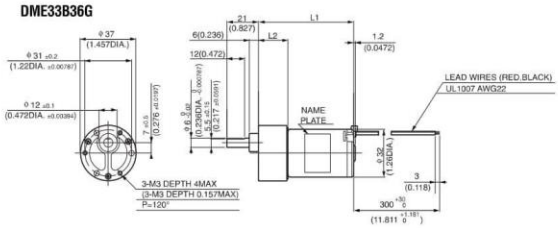
●DIMENSIONS Unit mm(inch)

DME33S36G



GEAR RATIO	L1		L2		WEIGHT	
	(mm)	(inch)	(mm)	(inch)	g	lb
10	51.0	2.008	19.8	0.78	170	0.37
18~30	53.5	2.106	22.3	0.878		
50~100	56.0	2.204	24.8	0.976		
120~300	58.5	2.303	27.3	1.075	190	0.42
400~600	61.0	2.402	29.8	1.173		

DME33B36G



GEAR RATIO	L1		L2		WEIGHT	
	(mm)	(inch)	(mm)	(inch)	g	lb
10	63.5	2.5	19.8	0.78	200	0.44
18~30	66.0	2.598	22.3	0.878		
50~100	68.5	2.697	24.8	0.976		
120~300	71.0	2.795	27.3	1.075	220	0.49
400~600	73.5	2.894	29.8	1.173		

●with 36G TYPE GEARBOX

Model	Gear ratio		10	*18	*20	*30	50	60	75	100	*120	*150	*180
	Rated speed	r/min	450	250	225	150	90	75	60	45	37.5	30	25
DME33S36G□☆	Rated torque	N·m	0.011	0.018	0.021	0.032	0.048	0.058	0.072	0.096	0.098	0.12	0.15
		oz·in	1.67	2.64	3.06	4.58	6.80	8.19	10.28	13.61	13.89	18.05	22.22
DME33B36G□☆	Rated speed	r/min	370	205	185	123	74	61.6	49.3	40	34	28.4	24.4
	Rated torque	N·m	0.063	0.1	0.11	0.16	0.25	0.3	0.38	0.39	0.39	0.39	0.39
		oz·in	9.03	13.89	15.28	23.61	36.11	43.05	54.16	55.55	55.55	55.55	55.55

Model	Gear ratio		*200	*250	*300	400	500	600
	Rated speed	r/min	22.5	18	15	11.2	9	7.7
DME33S36G□☆	Rated torque	N·m	0.16	0.21	0.25	0.31	0.39	0.39
		oz·in	23.61	30.55	36.11	44.44	55.55	55.55
DME33B36G□☆	Rated speed	r/min	22.2	18.2	15.4	11.7	9.5	8
	Rated torque	N·m	0.39	0.39	0.39	0.39	0.39	0.39
		oz·in	55.55	55.55	55.55	55.55	55.55	55.55

NOTE 1: Enter the required reduction ratio in the □.
2: *Rotation of gearbox shaft is in reverse of rotation of motor.
3: Enter the required voltage A or B in the ☆.

WITH GEARBOX

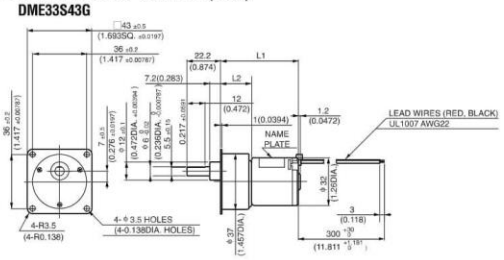
43G

Gear heads for intermittent drive

43G

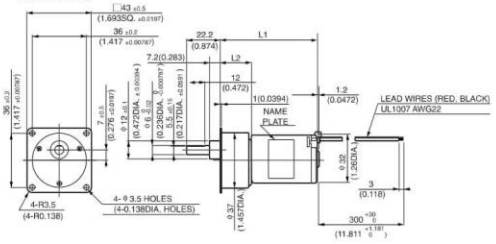
●DIMENSIONS Unit mm(inch)

DME33S43G



GEAR RATIO	L1		L2		WEIGHT	
	(mm)	(inch)	(mm)	(inch)	g	lb
10	49.5	1.949	18.3	0.720	200	0.44
18~30	52	2.047	20.8	0.819		
50~100	54.5	2.146	23.3	0.917		
120~300	57	2.244	25.8	1.016		
400~600	59.5	2.343	28.3	1.114		

DME33B43G



GEAR RATIO	L1		L2		WEIGHT	
	(mm)	(inch)	(mm)	(inch)	g	lb
10	62	2.441	18.3	0.720	220	0.49
18~30	64.5	2.539	20.8	0.819		
50~100	67	2.638	23.3	0.917		
120~300	69.5	2.736	25.8	1.016		
400~600	72	2.835	28.3	1.114		

●with 43G TYPE GEARBOX

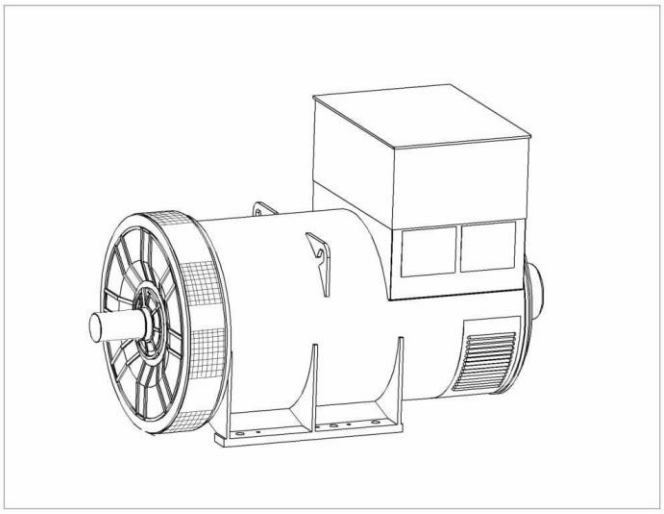
Model	Gear ratio		10	*18	*20	*30	50	60	75	100	*120	*150
	Rated speed	r/min	450	250	225	150	90	75	60	45	37.5	30
DME33S43G□☆	Rated torque	N·m	0.011	0.018	0.021	0.032	0.048	0.058	0.072	0.096	0.098	0.12
		oz·in	1.67	2.64	3.06	4.58	6.80	8.19	10.28	13.61	13.89	18.05
DME33B43G□☆	Rated speed	r/min	370	205	185	123	74	61.6	49.3	40	34	28.4
	Rated torque	N·m	0.064	0.1	0.11	0.16	0.25	0.3	0.38	0.39	0.39	0.39
		oz·in	9.03	13.89	15.28	23.61	36.11	43.05	54.16	55.55	55.55	55.55

Model	Gear ratio		*180	*200	*250	*300	400	500	600
	Rated speed	r/min	25	22.5	18	15	11.2	9	7.7
DME33S43G□☆	Rated torque	N·m	0.15	0.16	0.21	0.25	0.31	0.39	0.39
		oz·in	22.22	23.61	30.55	36.11	44.44	55.55	55.55
DME33B43G□☆	Rated speed	r/min	24.4	22.2	18.2	15.4	11.7	9.5	8
	Rated torque	N·m	0.39	0.39	0.39	0.39	0.39	0.39	0.39
		oz·in	55.55	55.55	55.55	55.55	55.55	55.55	55.55

NOTE 1: Enter the required reduction ratio in the □.
2: *Rotation of gearbox shaft is in reverse of rotation of motor.
3: Enter the required voltage A or B in the ☆.

STAMFORD
power generation

PI734B - Technical Data Sheet



PI734B

SPECIFICATIONS & OPTIONS

STAMFORD
power generation

STANDARDS

Newage Stamford industrial generators meet the requirements of BS EN 60034 and the relevant sections of other national and international standards such as BS5000, VDE 0530, NEMA MG1-32, IEC60034, CSA C22.2-100, AS1359.
Other standards and certifications can be considered on request.

DESCRIPTION

The STAMFORD PI range of synchronous ac generators are brushless with a rotating field. They are separately excited by the STAMFORD Permanent Magnet Generator (PMG). This is a shaft mounted, high frequency, pilot exciter which provides a constant supply of clean power via the Automatic Voltage Regulator (AVR) to the main exciter. The main exciter output is fed to the main rotor, through a full wave bridge rectifier, protected by surge suppression.

VOLTAGE REGULATORS

The PI range generators, complete with a PMG, are available with one of two AVRs. Each AVR has soft start voltage build up and built in protection against sustained over-excitation, which will de-excite the generator after a minimum of 8 seconds.
Underspeed protection (UFRO) is also provided on both AVRs. The UFRO will reduce the generator output voltage proportional to the speed of the generator below a pre-settable level.

The **MX341 AVR** is two phase sensed with a voltage regulation of ± 1 %. (see the note on regulation).

The **MX321 AVR** is 3 phase rms sensed with a voltage regulation of 0.5% rms (see the note on regulation). The UFRO circuit has adjustable slope and dwell for controlled recovery from step loads. An over voltage protection circuit will shutdown the output device of the AVR, it can also trip an optional excitation circuit breaker if required. As an option, short circuit current limiting is available with the addition of current transformers.

Both the MX341 and the MX321 need a generator mounted current transformer to provide quadrature droop characteristics for load sharing during parallel operation. Provision is also made for the connection of the STAMFORD power factor controller, for embedded applications, and a remote voltage trimmer.

WINDINGS & ELECTRICAL PERFORMANCE

All generator stators are wound to 2/3 pitch. This eliminates triplen (3rd, 9th, 15th …) harmonics on the voltage waveform and is found to be the optimum design for trouble-free supply of non-linear loads. The 2/3 pitch design avoids excessive neutral currents sometimes seen with higher winding pitches. A fully connected damper winding reduces oscillations during paralleling. This winding, with the 2/3 pitch and carefully selected pole and tooth designs, ensures very low levels of voltage waveform distortion.

TERMINALS & TERMINAL BOX

Standard generators feature a main stator with 6 ends brought out to the terminals, which are mounted on the frame at the non-drive end of the generator. A sheet steel terminal box contains the AVR and provides ample space for the customers' wiring and gland arrangements. It has removable panels for easy access.

SHAFT & KEYS

All generator rotors are dynamically balanced to better than BS6861:Part 1 Grade 2.5 for minimum vibration in operation. Two bearing generators are balanced with a half key.

INSULATION/IMPREGNATION

The insulation system is class 'H', and meets the requirements of UL1446.
All wound components are impregnated with materials and processes designed specifically to provide the high build required for static windings and the high mechanical strength required for rotating components.

QUALITY ASSURANCE

Generators are manufactured using production procedures having a quality assurance level to
BS EN ISO 9001.

NOTE ON REGULATION

The stated voltage regulation may not be maintained in the presence of certain radio transmitted signals. Any change in performance will fall within the limits of Criteria 'B' of EN 61000-6-2:2001. At no time will the steady-state voltage regulation exceed 2%.

Note: Continuous development of our products entitles us to change specification details without notice, therefore they must not be regarded as binding.

Front cover drawing is typical of the product range.

STAMFORD
power generation

PI734B

WINDING 312

CONTROL SYSTEM	SEPARATELY EXCITED BY P.M.G.		
A.V.R.	MX341	MX321	
VOLTAGE REGULATION	± 1%	± 0.5 %	With 4% ENGINE GOVERNING
SUSTAINED SHORT CIRCUIT	REFER TO SHORT CIRCUIT DECREMENT CURVES (page 7)		

INSULATION SYSTEM	CLASS H							
PROTECTION	IP23							
RATED POWER FACTOR	0.8							
STATOR WINDING	DOUBLE LAYER LAP							
WINDING PITCH	TWO THIRDS							
WINDING LEADS	6							
MAIN STATOR RESISTANCE	0.0016 Ohms PER PHASE AT 22°C STAR CONNECTED							
MAIN ROTOR RESISTANCE	1.67 Ohms at 22°C							
EXCITER STATOR RESISTANCE	17.5 Ohms at 22°C							
EXCITER ROTOR RESISTANCE	0.048 Ohms PER PHASE AT 22°C							
R.F.I. SUPPRESSION	BS EN 61000-6-2 & BS EN 61000-6-4,VDE 0875G, VDE 0875N. refer to factory for others							
WAVEFORM DISTORTION	NO LOAD < 1.5% NON-DISTORTING BALANCED LINEAR LOAD < 5.0%							
MAXIMUM OVERSPEED	2250 Rev/Min							
BEARING DRIVE END	BALL. 6228 C3							
BEARING NON-DRIVE END	BALL. 6319 C3							
	1 BEARING				2 BEARING			
WEIGHT COMP. GENERATOR	2760 kg				2710 kg			
WEIGHT WOUND STATOR	1306 kg				1306 kg			
WEIGHT WOUND ROTOR	1139 kg				1077 kg			
WR² INERTIA	32.7498 kgm^2				31.7489 kgm^2			
SHIPPING WEIGHTS in a crate	2833kg				2779kg			
PACKING CRATE SIZE	194 x 105 x 154(cm)				194 x 105 x 154(cm)			
	50 Hz				60 Hz			
TELEPHONE INTERFERENCE	THF<2%				TIF<50			
COOLING AIR	2.69 m^3/sec 5700 cfm				3.45 m^3/sec 7300 cfm			
VOLTAGE STAR	380/220	400/231	415/240	440/254	416/240	440/254	460/266	480/277
kVA BASE RATING FOR REACTANCE VALUES	1360	1400	1400	1375	1525	1625	1655	1690
Xd DIR. AXIS SYNCHRONOUS	3.50	3.26	3.02	2.64	4.25	4.04	3.77	3.53
X'd DIR. AXIS TRANSIENT	0.21	0.20	0.18	0.16	0.26	0.25	0.23	0.22
X"d DIR. AXIS SUBTRANSIENT	0.16	0.15	0.14	0.12	0.19	0.18	0.17	0.16
Xq QUAD. AXIS REACTANCE	2.26	2.10	1.95	1.70	2.74	2.61	2.43	2.28
X"q QUAD. AXIS SUBTRANSIENT	0.32	0.29	0.27	0.24	0.38	0.37	0.34	0.32
X_L LEAKAGE REACTANCE	0.04	0.04	0.03	0.03	0.05	0.05	0.04	0.04
X_2 NEGATIVE SEQUENCE	0.22	0.21	0.19	0.17	0.27	0.26	0.24	0.23
X_0 ZERO SEQUENCE	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03
REACTANCES ARE SATURATED	VALUES ARE PER UNIT AT RATING AND VOLTAGE INDICATED							
T'd TRANSIENT TIME CONST.	0.13s							
T"d SUB-TRANSTIME CONST.	0.01s							
T'do O.C. FIELD TIME CONST.	2.14s							
Ta ARMATURE TIME CONST.	0.02s							
SHORT CIRCUIT RATIO	1/Xd							

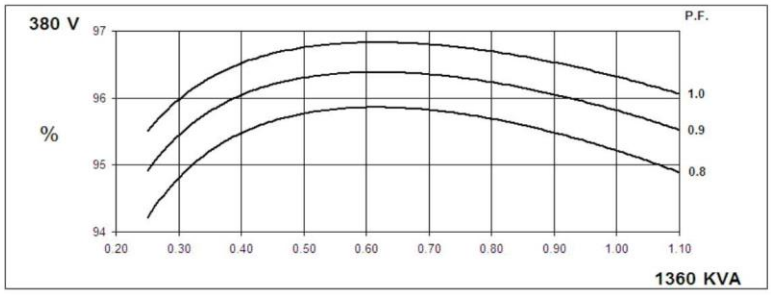
50 Hz

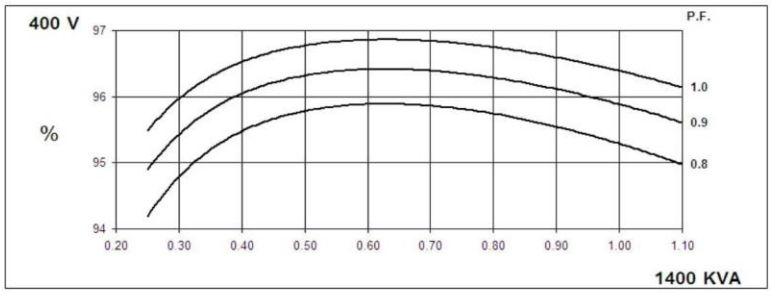
PI734B

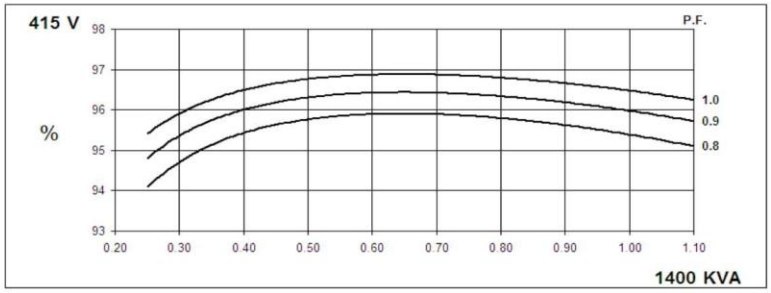
Winding 312

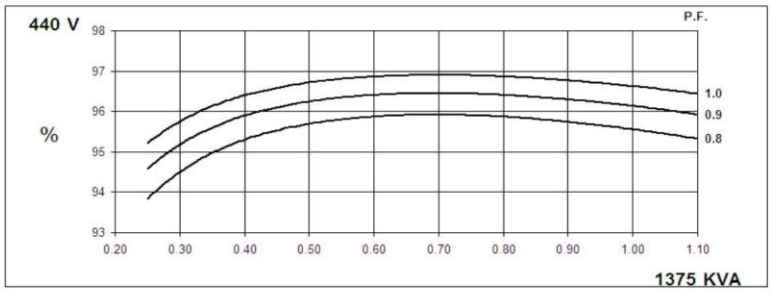
STAMFORD power generation

THREE PHASE EFFICIENCY CURVES









STAMFORD
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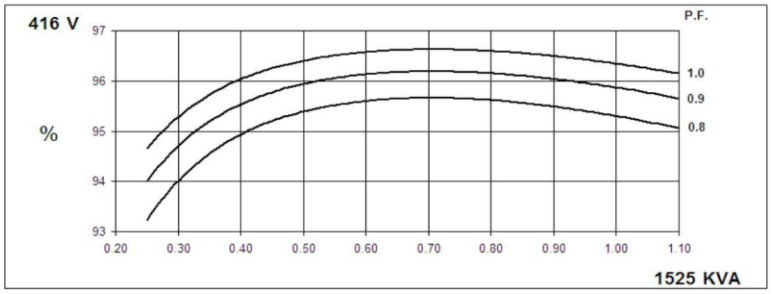
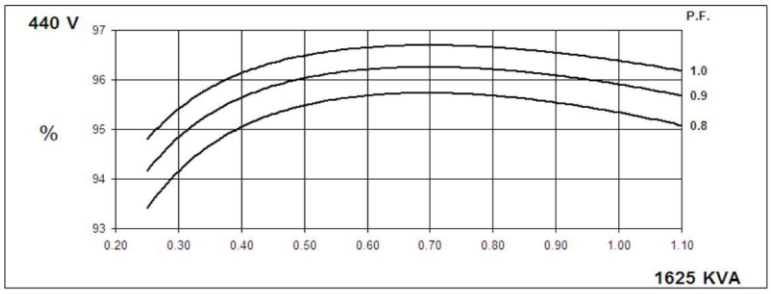
PI734B

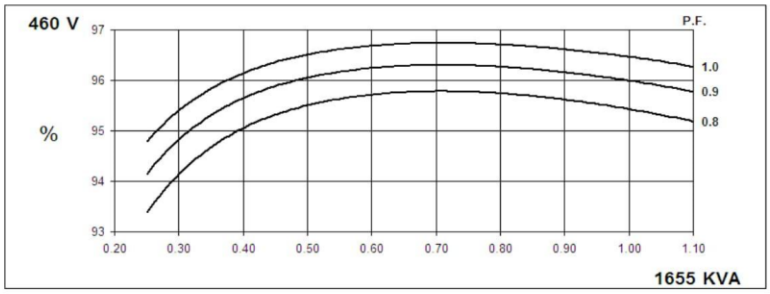
Winding 312

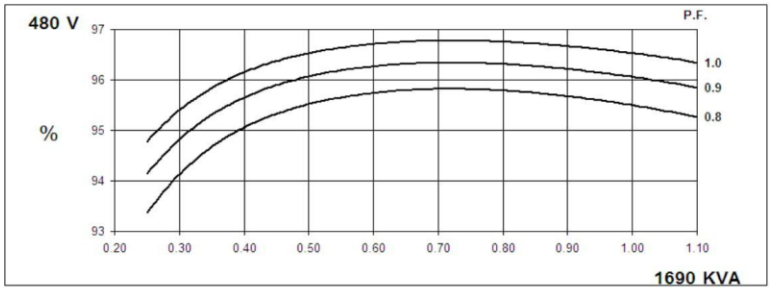
60 Hz

THREE PHASE EFFICIENCY CURVES







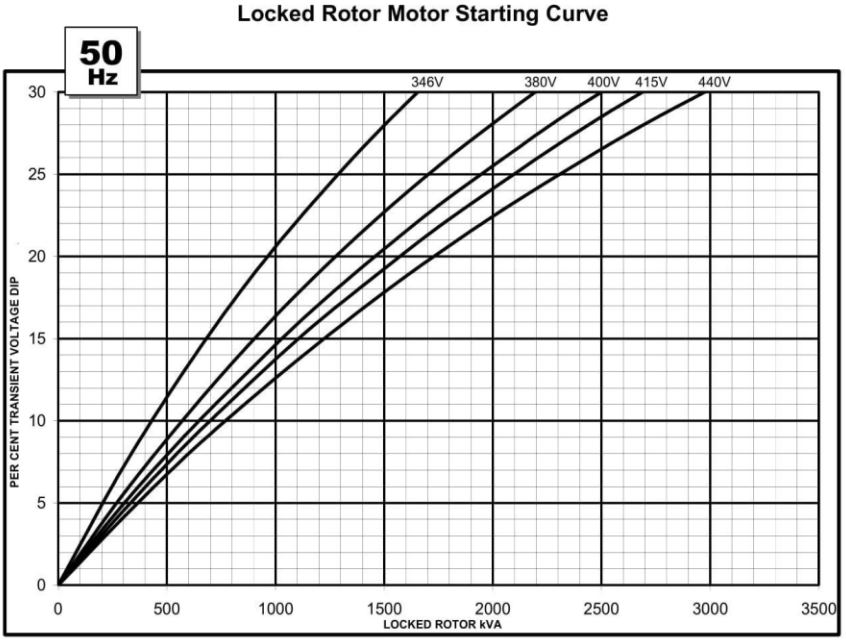


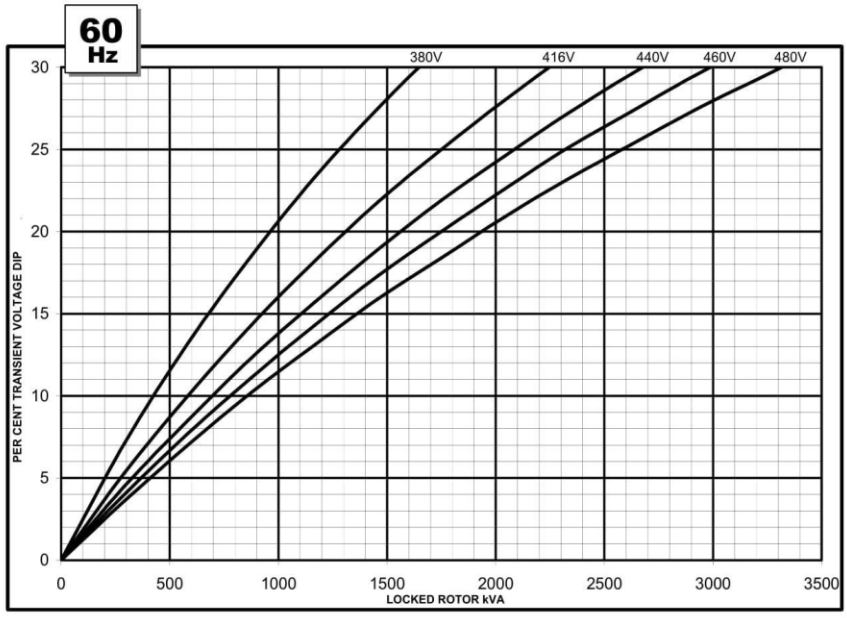
PI734B

Winding 312

STAMFORD power generation

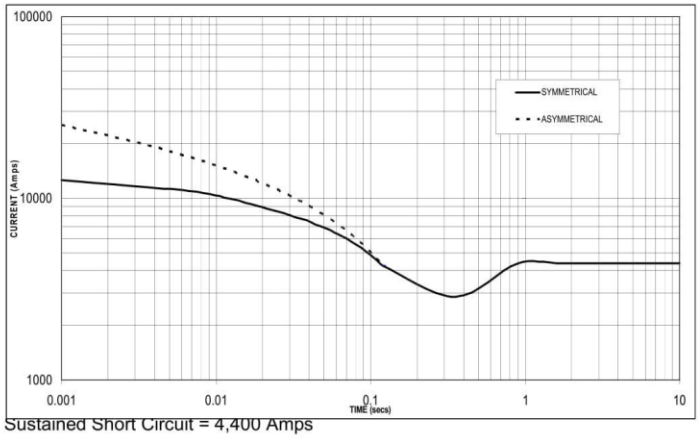
Locked Rotor Motor Starting Curve





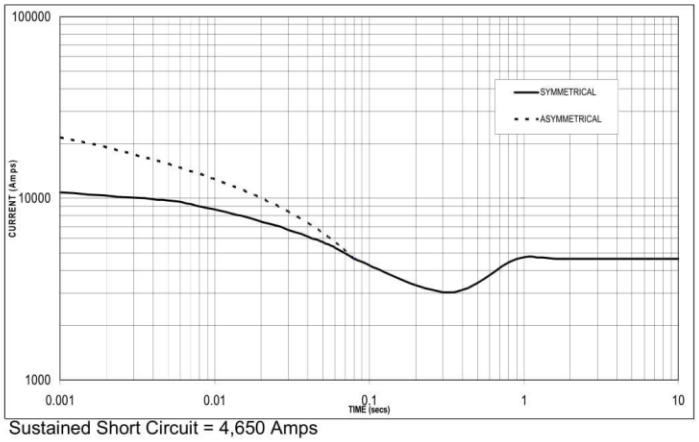
Three-phase Short Circuit Decrement Curve. No-load Excitation at Rated Speed
Based on star (wye) connection.

50 Hz



Sustained Short Circuit = 4,400 Amps

60 Hz



Sustained Short Circuit = 4,650 Amps

Note 1

The following multiplication factors should be used to adjust the values from curve between time 0.001 seconds and the minimum current point in respect of nominal operating voltage :

50Hz		60Hz	
Voltage	Factor	Voltage	Factor
380v	x 1.00	416v	x 1.00
400v	x 1.05	440v	x 1.06
415v	x 1.09	460v	x 1.10
440v	x 1.16	480v	x 1.15

The sustained current value is constant irrespective of voltage level

Note 2

The following multiplication factor should be used to convert the values calculated in accordance with NOTE 1 to those applicable to the various types of short circuit :

	3-phase	2-phase L-L	1-phase L-N
Instantaneous	x 1.00	x 0.87	x 1.30
Minimum	x 1.00	x 1.80	x 3.20
Sustained	x 1.00	x 1.50	x 2.50
Max. sustained duration	10 sec.	5 sec.	2 sec.

All other times are unchanged

Note 3

Curves are drawn for Star (Wye) connected machines.

PI734B

Winding 312 / 0.8 Power Factor

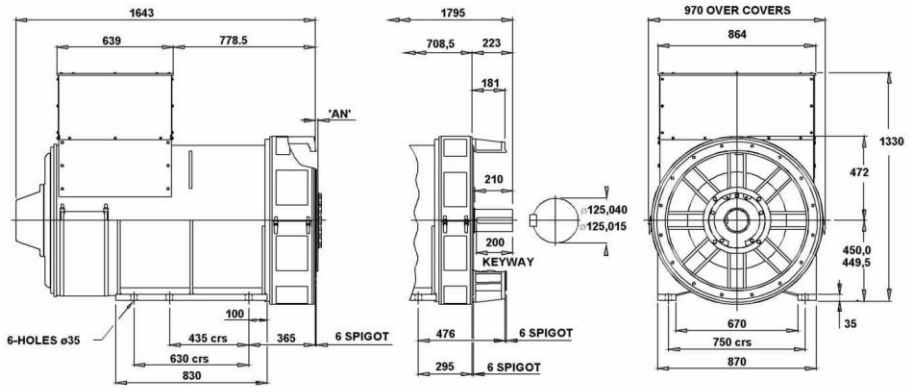
STAMFORD power generation

RATINGS

Class - Temp Rise		Cont. F - 105/40°C				Cont. H - 125/40°C				Standby - 150/40°C				Standby - 163/27°C			
50Hz	Star (V)	380	400	415	440	380	400	415	440	380	400	415	440	380	400	415	440
	kVA	1265	1305	1305	1280	1360	1400	1400	1375	1415	1460	1460	1430	1455	1500	1500	1470
	kW	1012	1044	1044	1024	1088	1120	1120	1100	1132	1168	1168	1144	1164	1200	1200	1176
	Efficiency (%)	95.4	95.5	95.6	95.7	95.2	95.3	95.4	95.6	95.1	95.2	95.3	95.5	95.0	95.1	95.2	95.4
	kW Input	1061	1093	1092	1070	1143	1175	1174	1151	1190	1227	1226	1198	1225	1262	1261	1233

60Hz	Star (V)	416	440	460	480	416	440	460	480	416	440	460	480	416	440	460	480
	kVA	1415	1510	1540	1575	1525	1625	1655	1690	1590	1690	1725	1760	1630	1740	1775	1810
	kW	1132	1208	1232	1260	1220	1300	1324	1352	1272	1352	1380	1408	1304	1392	1420	1448
	Efficiency (%)	95.4	95.5	95.6	95.6	95.3	95.3	95.4	95.5	95.2	95.2	95.3	95.4	95.1	95.2	95.3	95.3
	kW Input	1187	1265	1289	1318	1280	1364	1388	1416	1336	1420	1448	1476	1371	1462	1490	1519

DIMENSIONS



COUPLING DISC	'AN'
S.A.E No 18	15,7
S.A.E No 21	0
S.A.E No 24	0

1-BRG ADAPTORS
S.A.E No 0
S.A.E No 00

2-BRG ADAPTORS
S.A.E No 0
S.A.E No 00

NEWAGE AVK SEG

Barnack Road • Stamford • Lincolnshire • PE9 2NB
Tel: 00 44 (0)1780 484000 • Fax: 00 44 (0)1780 484100
Website: www.newage-avkseg.com

TD_PI734B.GB_05.04_02_GB

OVERVIEW

Overview

Panasonic Valve Regulated (Sealed) lead-acid battery (VRLA battery) have been on the market for more than 30 years. The VRLA battery is a rechargeable battery which requires no watering.
Adopting lead-tin-calcium alloy as the grid alloy, it has outstanding characteristics against severe use conditions such as overcharge, overdischarge, vibration, shock and also for various storage conditions. Our accumulation of technologies has enabled us to respond to market requirements promptly by developing batteries such as trickle/cycle long life type .
The VRLA battery covers a broad range of applications including, electric tools, UPS, and three and four wheel electric wheel chairs for the elderly.

Battery types and model numbers

- For main power source — Cycle long life type .....LC-XC
- For main and standby power source — Expected trickle life 3-5(* 6) years..LC-R
- For standby power source
  - Expected trickle life 3-5 (* 6) years...UP-RW
  - Expected trickle life approx. 6(*10) years
    - Standard case .....LC-X
    - Flame-retardant case ..LC-P

Expected trickle life: Up to 50% of initial capacity under the following conditions:

Temperature: 25˚C
Discharge current: 0.25CA
Discharge ending voltage: 5.25V for 6V battery, 10.5V for 12V battery
Charge voltage: 6.85V for 6V battery, 13.7V for 12V battery
*Life : conform to Eurobat (20˚C / 0.1C)

Construction and Electrolyte

- **Positive plates**

Positive plates are plate electrodes of which a grid frame of lead-tin-calcium alloy holds porous lead dioxide as the active material.

- **Negative plates**

Negative plates are plate electrodes of which a grid frame of lead-tin-calcium alloy holds spongy lead as the active material.

- **Electrolyte**

Diluted sulfuric acid is used as the medium for conducting ions in the electrochemical reaction in the battery.

- **Separators**

Separators, which retain electrolyte and prevent shorting between positive and negative plates, adopt a non-woven fabric of fine glass fibers which is chemically stable in the diluted sulfuric acid electrolyte. Being highly porous, separators retain electrolyte for the reaction of active materials in the plates.

- **Valve (One way valve)**

The valve is comprised of a one-way valve made of material such as neoprene. When gas is generated in the battery under extreme overcharge condition due to erroneous charging, charger malfunctions or other abnormalities, the vent valve opens to release excessive pressure in the battery and maintain the gas pressure within specific range (7.1 to 43.6 kPa). During ordinary use of the battery, the vent valve is closed to shut out outside air and prevent oxygen in the air from reacting with the active material in the negative electrodes.

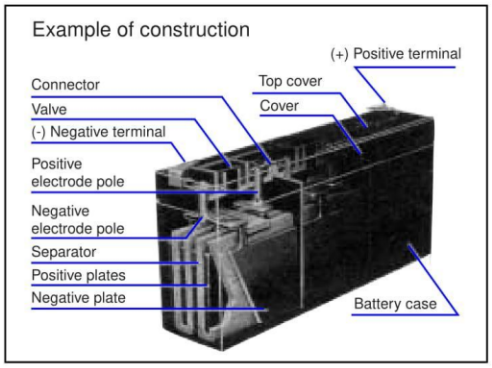
- **Positive and negative electrode terminals**

Positive and negative electrode terminals may be faston tab type, bolt fastening type, threaded post type, or lead wire type, depending on the type of the battery. Sealing of the terminal is achieved by a structure which secures long adhesive-embedded paths and by the adoption of strong epoxy adhesives. For specific dimensions and shapes of terminals, see page 68.

- **Battery case materials**

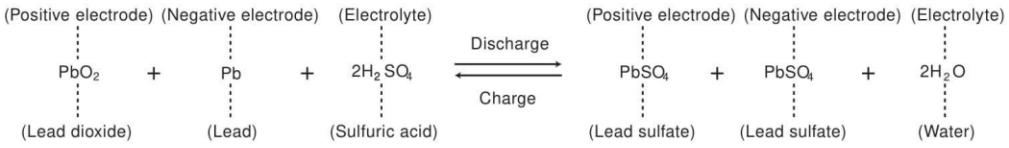
Materials of the body and cover of the battery case are ABS resins, unless otherwise specified.

Example of construction

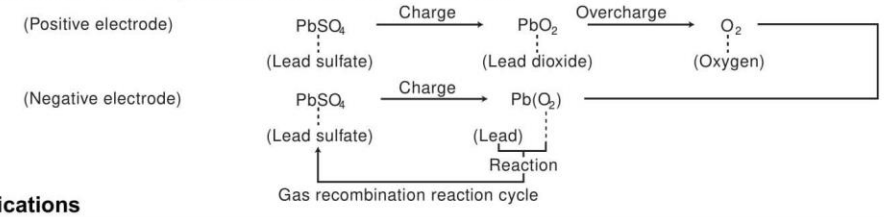


Electrochemical Reactions on Electrodes

The electrochemical reaction processes of the sealed lead-acid battery (negative electrode recombination type) are described below.
Where “charge” is the operation of supplying the rechargeable battery with direct current from an external power source to change the active material in the negative plates chemically, and hence to store in the battery electric energy in the form of chemical energy. “Discharge” is the operation of drawing out electric energy from the battery to operate external equipment.



In the final stage of charging, an oxygen-generating reaction occurs at the positive plates. This oxygen transfers inside the battery, then is absorbed into the surface of the negative plates and consumed. These electrochemical reaction processes are expressed as follows.



Applications

- **Stand-by/Back-up power applications**
  - Communication equipment: base station, PBX, CATV, WLL, ONU, STB, etc.
  - Back-up for power failure: UPS, ECR, computer system back-up, sequencers, etc.
  - Emergency equipment: lights, fire and burglar alarms, radios, fire shutters, stop-position controls (for machines and elevators), etc.

- **Main power applications**
  - Communication and telephone equipment: cellular phones (bag phones), transceivers, etc.
  - Electrically operated vehicles: picking carts, automated transports, electric wheelchairs, cleaning robots, electric automobiles, etc.
  - Tools and engine starters: grass shears, hedge trimmers, cordless drills, screwdrivers, jet-skis, electric saws, etc.
  - Industrial equipment/instruments and non life-critical medical equipment*: measuring equipment, non life-critical medical equipment (electrocardio-graph), etc.
  - Photography: camera strobes, VTR/VCR, movie lights, etc.
  - Toys and hobby: radio-controllers, motor drives, lights, etc.
  - Miscellaneous uses: integrated VTR/VCR, tape recorders, other portable equipment, etc.

*(Note) When any medical equipment incorporating a Panasonic VRLA battery is planned, please contact Panasonic.

Features

- **Leak-resistant structure**

A required-minimum quantity of electrolyte is impregnated into, and retained by, the positive and negative plates and the separators; therefore electrolyte does not flow freely. Also, the terminal has a sealed structure secured by long adhesive-embedded paths and by the adoption of strong epoxy adhesives which makes the battery leak-resistant. (Note) In stand-by/back-up uses, if the battery continues to be used beyond the point where discharge duration has decreased to 50% of the initial (i.e. life judgment criteria), cracking of the battery case may occur, resulting in leakage of the electrolyte.

- **Long service life**

Service life of our long-life series (LC-P, LC-X series is approximately double that of the conventional (LC-R) batteries (Temperature 25°C, discharge rate 0.25 CA/ 1.75V/cell, discharge frequency every 6 months, 2.30V/cell charge).

- **Easy maintenance**

Unlike the conventional batteries in which electrolyte can flow freely, VRLA batteries do not need the specific-gravity check of the electrolyte nor the watering structurally; this makes the battery function fully and makes maintenance easy.

- **No sulfuric acid mist or gases**

Unlike the conventional batteries in which electrolyte can flow freely, VRLA batteries generate no sulfuric acid mist or gases under the use condition we recommend. In uses under conditions other than recommended, however, gas generation may occur, therefore do not design the battery housing with a closed structure.

- **Exceptional deep discharge recovery**

As seen in the figure on the next page, our VRLA battery shows exceptional rechargeablity even after deep discharge, which is often caused by failure to turn off the equipment switch, followed by standing (approx. 1 month at room temperature is assumed).

Transportation

Our VRLA batteries should be handled as common cargo for both air shipment (*1) and boat shipment (*2), as they can withstand electrolyte leakage during the vibration test, the differential atmospheric pressure test and the altitude test in accordance with the special requirements of transportation regulations specified by the international organizations (ICAO: International Commercial Aviation Organization and IMO: International Maritime Organization).
(*1: Special provision A67 *2: Special provision 238)

- **ISO**

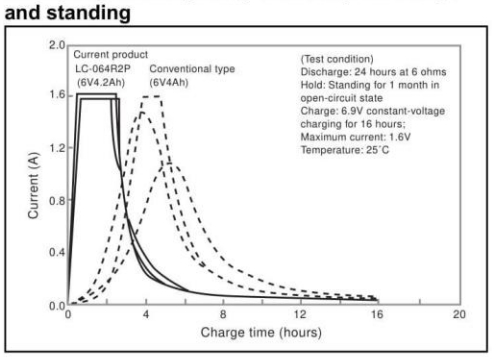
The Quality System and the Environmental Management System at our palants were recognized and registered as conforming to ISO.

	ISO 9001:2000	ISO 9002	ISO 14001
PSB (Japan)	✓		✓
PSBS (China)		✓	✓

- **JIS (Japan Industrial Standards)**

Our small sized VRLA batteries comply with JIS C 8702.

Example of rechargability after deep discharge and standing



- **UL recognition**

Our VRLA batteries fall into UL1989 (Standby Batteries). UL1989 requires that the battery is free from the hazard of bursting, that is, when the battery is overcharged the vent valve opens to release internal pressure. UL-recognized types of VRLA batteries to date are listed in the following table. A number of the recognized battery types are in use for such applications as emergency lights.

- **VdS and other recognition**

The types of VRLA batteries which have acquired VdS (Germany) recognition and the Japanese recognition to date are also listed.

Table of battery types which acquired local/ overseas recognition

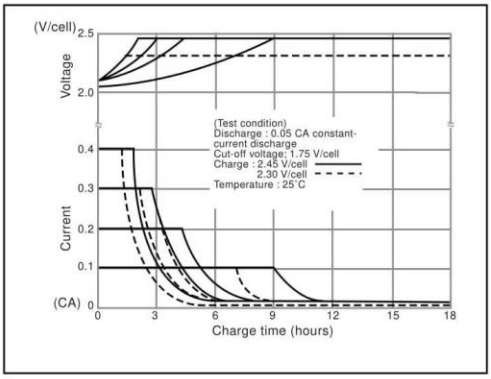
Standard/recognition	Contents	Recognition number	Recognized Models
UL U.S. Safety standard	UL1989 Standby Batteries	MH13723	LC-R061R3(a) LC-P067R2(a) UP-RW1220(a) LC-R063R4(a) LC-P0612(a) UP-RWA1232(a) LC-R064R2(a) LC-P127R2(a) UP-RW1245(a) LC-R067R2(a) LC-PD1217(a) LC-R0612(a) LC-X1220(a) LC-R121R3(a) LC-X1224(a) LC-R122R2(a) LC-X1228(a) LC-R123R4(a) LC-X1238(a) LC-R127R2(a) LC-X1242(a) LC-RA1212(a) LC-X1265(a) LC-RD1217(a) LC-XA12100(a) LC-R1233(a) LC-XC1228(a) LC-V1233(a) LC-XC1238(a)
VdS German Safety Standard		G196049 G188151 G191053 G193046 G100001 G198049 G100002 G199090	LC-R121R3PG LC-R122R2PG LC-R123R4PG LC-R127R2PG/PG1 LC-RA1212PG/PG1 LC-RA1212P/P1 LC-X1224APG/AP LC-X1238APG/AP LC-X1238PG/P LC-X1265PG/P

Additional configuration codes (alphabetic letters or numbers) may appear for (a) in the code numbers of UL recognized types.
(Note) These standards are also valid for old model numbers.

- **Charging**

Charge characteristics (constant voltage-constant current charging) of VRLA batteries are exemplified below.

Example of constant-voltage charge characteristics by current



In order to fully utilize the characteristics of VRLA batteries, constant-voltage charging is recommended. For details of charging see page 19.

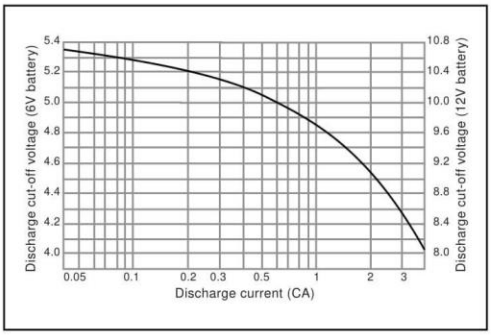
- **Discharging**

a) Discharge current and discharge cut-off voltage

Recommended cut-off voltages for 6V and 12V batteries consistent with discharge rates are given in the figure below. With smaller discharge currents, the active materials in the battery work effectively, therefore discharge cut-off voltages are set to the higher side for controlling overdischarge. For larger discharge currents, on the contrary, cut-off voltages are set to the lower side.

(Note) Discharge cut-off voltages given are recommended values.

Discharge current vs. Cut-off voltage



b) Discharge temperature

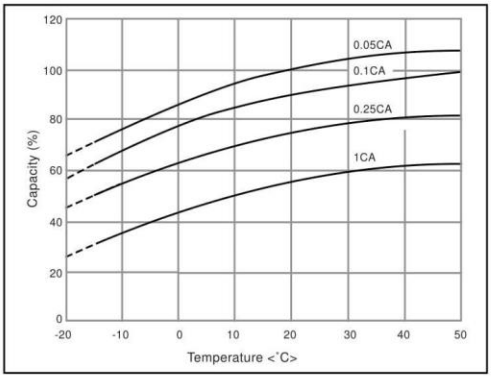
(1) Control the ambient temperature during discharge within the range from -15°C to 50°C for the reason described below.

(2) Batteries operate on electrochemical reaction which converts chemical energy to electric energy. The electrochemical reaction is reduced as the temperature lowers, thus, available discharge capacity is greatly reduced at temperatures as low as -15°C. For the high temperature side, on the other hand, the discharge temperature should not exceed 50°C in order to prevent deformation of resin materials which house the battery or deterioration of service life.

c) Effect of temperature on discharge characteristics

Available discharge capacity of the battery varies with ambient temperature and discharge current as shown in the figure below.

Discharge capacity by temperature and by discharge current



d) Discharge current

Discharge capability of batteries is expressed by the 20 hour rate (rated capacity). Select the battery for specific equipment so that the discharge current during use of the equipment falls within the range between 1/20 of the 20 hour rate value and 3 times that (1/20 CA to 3 CA): discharging beyond this range may result in a marked decrease of discharge capacity or reduction in the number of times of repeatable discharge. When discharging the battery beyond said range, please consult Panasonic in advance.

e) Depth of discharge

Depth of discharge is the state of discharge of batteries expressed by the ratio of amount of capacity discharged to the rated capacity.

- **Storage**

a) Storage condition

Observe the following condition when the battery needs to be stored.

(1) Ambient temperature: -15°C to 40°C (preferably below 30°C)
(2) Relative humidity: 25% to 85%
(3) Storage place free from vibration, dust, direct sunlight, and moisture.

b) Self discharge and refresh charge

During storage, batteries gradually lose their capacity due to self discharge, therefore the capacity after storage is lower than the initial capacity. For the recovery of capacity, repeat charge/discharge several times for the battery in cycle use; for the battery in trickle use, continue charging the battery as loaded in the equipment for 48 to 72 hours.

c) Refresh charge (Auxiliary charge)

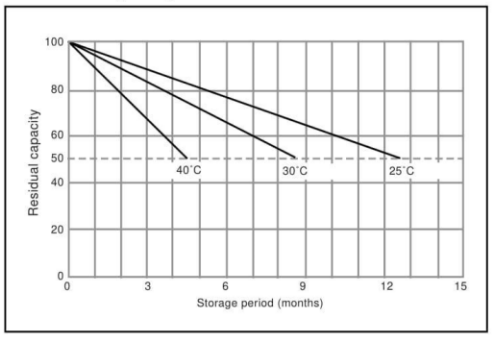
When it is unavoidable to store the battery for 3 months or longer, periodically recharge the battery at the intervals recommended in the table below depending on ambient temperature. Avoid storing the battery for more than 12 months.

Storage temperature	Interval of auxiliary charge (refresh charge)
Below 20°C	9 months
20°C to 30°C	6 months
30°C to 40°C	3 months

d) Residual capacity after storage

The result of testing the residual capacity of the battery which, after fully charged, has been left standing in the open- circuit state for a specific period at a specific ambient temperature is shown in the figure below. The self discharge rate is very much dependent on the ambient temperature of storage. The higher the ambient temperature, the less the residual capacity after storage for a specific period. Self discharge rate almost doubles by each 10°C rise of storage temperature.

Residual capacity test result

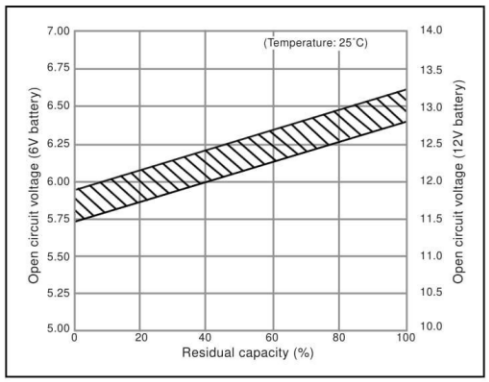


CHARACTERISTICS - CONTINUED

e) Open circuit voltage vs. residual capacity

Residual capacity of the battery can be roughly estimated by measuring the open circuit voltage as shown in the Figure.

Open circuit voltage vs. Residual capacity 25°C



- **Temperature conditions**

Recommended temperature ranges for charging, discharging and storing the battery are tabulated below.

Charge	0°C ~ 40°C
Discharge	-15 °C ~ 50°C
Storage	-15 °C ~ 40°C

- **Battery life**

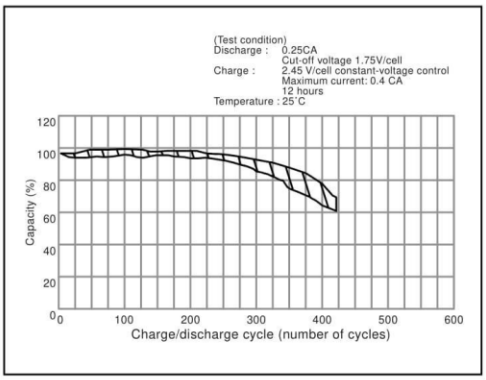
a) Cycle life

The cycle life (number of cycles) of the battery is affected by such factors as battery types, charging methods, ambient temperature, interval between charge and discharge, or depth of discharge. Typical cycle life characteristics of the battery are shown in the above figure. This is typical data obtain from a well-equipped laboratory.

Cycle times depend on each model of batteries and may differ from this data when batteries are actully used in the field.

Expected life is also affected by charge conditions. For life performance, please check actual charge/ discharge pattern in the field. The life is shortened at shallow discharge about less than 30% of rated capacity. For additional inquiries, please contact Panasonic office.

Cycle life characteristics

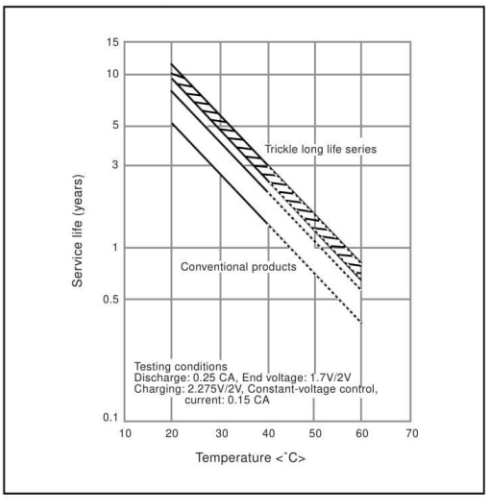


CHARACTERISTICS - CONTINUED

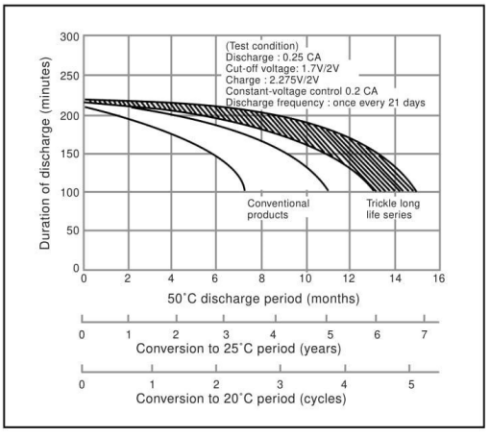
b) Trickle (Float) life

Trickle life of the battery is largely dependent on the temperature condition of the equipment in which the battery is used, and also related to the type of the battery, charge voltage and discharge current. The respective Figures show the influence of temperature on trickle life of the battery, an example of trickle (float) life characteristics of the battery, and the test result of the battery life in an emergency lamp.

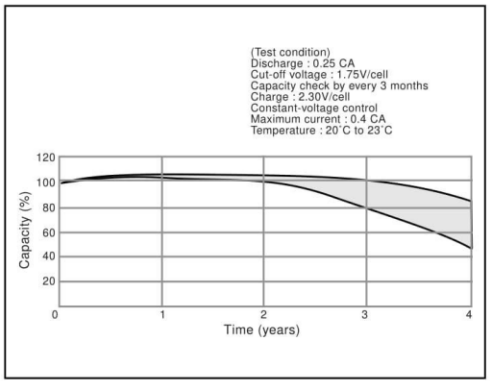
Influence of Temperature on Trickle life



Trickle life characteristics at 50°C



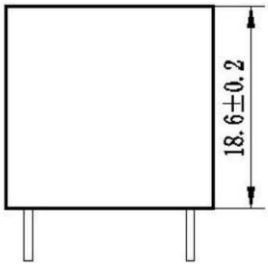
Trickle (Float) life characteristics (LC-R)

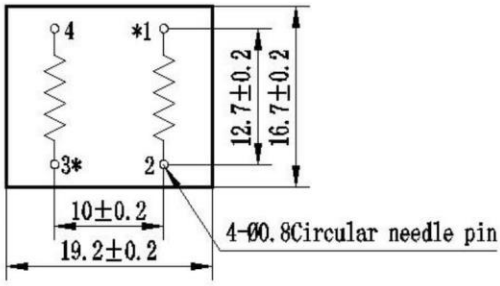


ZMPT101B
Current-type Voltage Transformer

Small size，high accuracy, good consistency, for voltage and power measurement

Structural parameters：





Remarks: primary input: 1、2 pins secondary output: 3、4pins
Or
primary input:: 3、4 pins secondary output::1、2pins
"*" Same polarity

Front view **Bottom view**

The main technical parameters：

Model	ZMPT101B
Rated input current	2mA
Rated output current	2mA
turns ratio	1000:1000
phase angle error	≤20′ （input 2mA，sampling resistor 100Ω）
operating range	**0~1000V** **0~10mA（sampling resistor 100Ω）**
linearity	≤0.2%(20%dot~120%dot)
Permissible error	-0.3%≤ f ≤+0.2%（input 2mA，sampling resistor 100Ω）
isolation voltage	4000V
application	voltage and power measurement
Encapsulation	Epoxy
installation	PCB mounting（Pin Length>3mm）
Operating temperature	-40℃~+60℃
Case Material	**ABS (Note: ABS CASE is NOT available for wave-soldering)**

Direction for use:

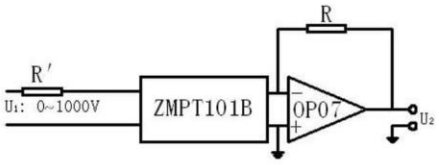


Figure Ⅰ

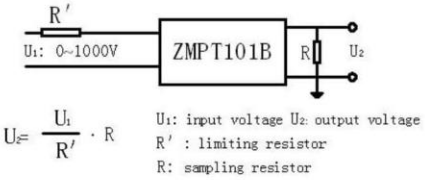


Figure Ⅱ

1. The typical usage of the product is for the active output (Figure Ⅰ). R′ is a limiting resistor, R is a sampling resistor.
2. The product can be directly through the resistance sampling , easy to use (Figure Ⅱ).

Beefy H-Bridge Motor Driver

Application Reference

The Beefy H-Bridge Motor Driver is the latest variants in our high current DC Motor driver series. When used in intermittent low duty applications (e.g. Mobile Robots)

Quick Specifications:

Motor Supply Voltage: 7 to 35VDC
Load Current: >20A surge, 6A continous (Note 1)
Control Input: Logic 5V
Driver Chip: Allegro A3941
Indicators: Two LED Fault Indicators

Wiring Example

An annonated wiring setup using a microcontroller (e.g. Arduino Uno) is shown in the figure below. For example, the arrow symbol labeled "Note 4" denotes more details explained in Note 4.

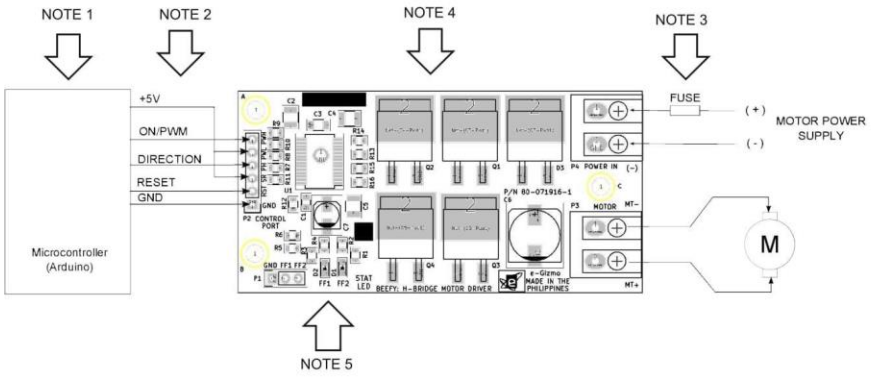


Figure 1. Beefy H-Bridge Motor Driver wiring diagram.

1. Microcontroller

Beefy Motor Driver will work with any microcontroller circuit operating with 5V I/O logic. This includes the gizDuino, Arduino, and Genuino ATMEGA based boards.

2. Control Inputs

The Beefy Motor Driver can be operated in a quite lot of configuration. However, if you are like most users who do not want to be bothered by many details and just want to get things done, the sample wiring as shown should suffice. The equivalent pin functions are described as follows:

2.1 ON/PWM - A 5V input will drive the motor to full power. PWM input will proportionately reduce output power (e.g. for speed control function).

2.2 DIRECTION - A logic low input will make the driver output power at the indicated polarity. Driving this input to logic high will reverse the driver output polarity (i.e. reverse the motor rotation).

2.3 RESET - A logic low at the RESET input will shutdown the Motor Driver. This should be kept at logic high during normal operation.

2.4 SR pin has significance while the ON/PWM pin is driven low. In this wiring example, SR pin is permanently tied to +5V (logic High). This keeps a pair of MOSFET conducting when the ON/PWM pin is in the LOW state. This, in effect, provides some braking action, allowing for tighther control of the motor speed. Wire the SR pin to logic low if you want the motor to coast instead.

Here is a short list of advantages and disadvantages of wiring SR = Logic High (Slow Decay mode).

Advantages:
Better speed control.
Higher torque at low duty PWM input (low motor speed)

Disadvantages:
Draws more power from the motor supply when motor is lightly loaded.
Driver tends to run hotter at light motor load because of the additional energy it dissipates as a consequence of braking.

For a more detailed description of the pin functions, please consult the A3941 datasheet.

3. Motor Power

The Beefy Motor Driver can work with motor supply voltages ranging from 7V up to 35VDC.

3.1 Use a power source with volt-amp rating sufficient to run your motor at the desired output power.

3.2 Use wires of sufficient size and with in-line fuse of suitable amperage to connect with your motor power source.

4. Usage Precautions

The Beefy motor driver must be installed in locations where there is unrestricted air movements. Mounting it with the pcb edge up will be advantageous, especially if you are to operate the driver with hefty currents for an extended period of time.

The Beefy Motor Driver can handle fairly large amount of current. For example, it can conduct currents in excess of 15 ampere when operated intermittently, such as moving and stopping a robot. It can survive

momentary shorts and overload without incurring permanent damage.

Because of the absence of heatsink, however, it should not be operated continously ON with currents in excess of 6A (@100% PWM duty cycle input). Otherwise, permanent damage due to overheating may occur. Installing a cooling fan will allow you to operate it continously with drive currents in excess of 10A.

5. Fault LED

FF1	FF2	STATUS
ON	ON	Normal Operation
ON	OFF	Shorted load
OFF	ON	Chip over temperature
OFF	OFF	V5,VREG,Vboostrap undervoltage

Fault conditions are available at P1 port, and may be connected to the host microcontroller for fault monitoring functions if it is so desired. Note that an ON LED translates to logic low at P1 port.

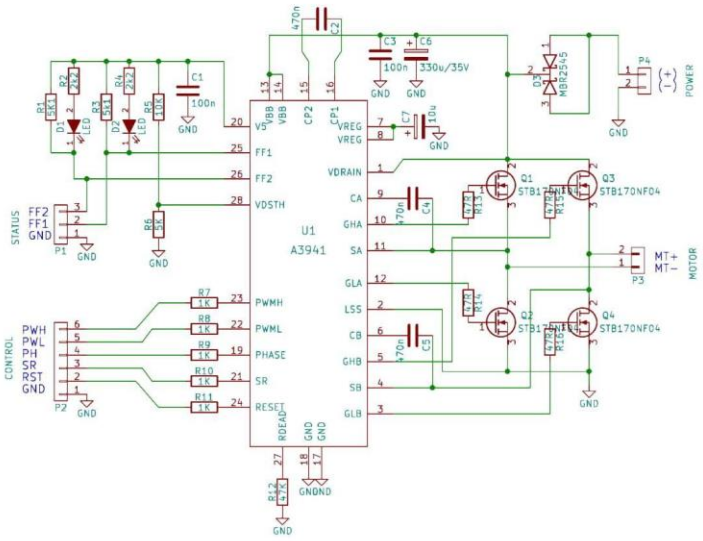


Figure 2. Beefy H-Bridge Motor Driver full schematic diagram.

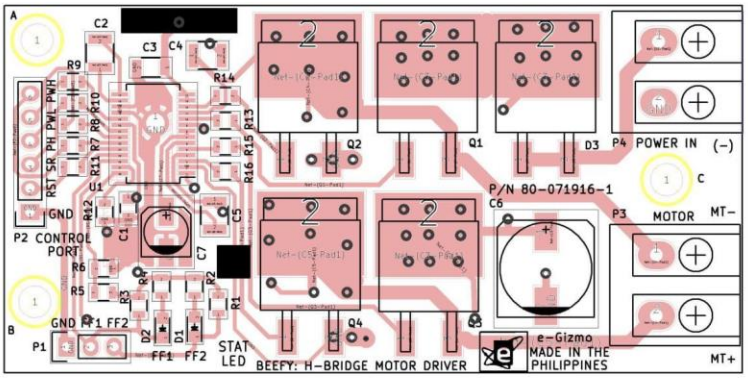


Figure 3. PCB Guide with top layer track pattern.

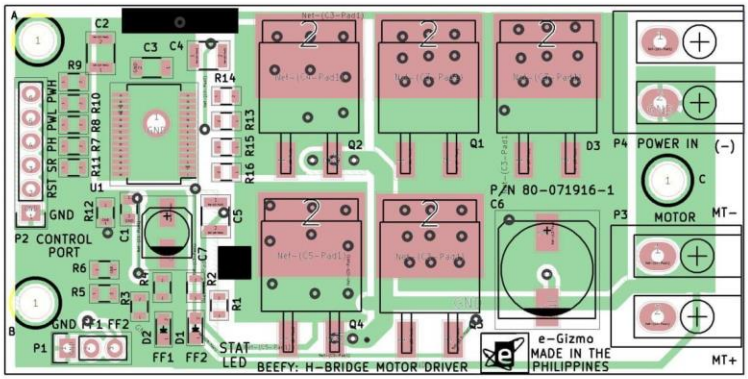


Figure 4. PCB Guide with bottom layer track pattern.

Appendix E
Bill of Materials

ELECTRONICS PART

COMPONENT	DESCRIPTION	QUANTITY	PRICE	TOTAL PRICE
Arduino Uno		1	750.00	750.00
MATLAB License		1	5,043.88	5,043.88
Resistor	• 1k Ω(¼ Watts) • 47k Ω(¼ Watts) • 27k Ω(¼ Watts)	2 2 2	1.00 1.00 1.00	2.00 2.00 2.00
Capacitor	• 1 uF (25V) • 10 uF (25V) • 56 nF • 100 nF	2 2 2 2	2.00 2.00 2.00 2.00	4.00 4.00 4.00 4.00
Rectifier Diode	• 1N4007 • 1N4148	1 2	2.00 2.00	2.00 4.00
Transistor	Bc527	1	3.00	3.00
Integrated Circuit (IC)	• 555 • Max6576	1 1	20.00 50.00	20.00 50.00
Zener Diode	5V	2	5.00	10.00
Resistor	Variable	1	15	15.00
Power Supply	12VDC	1	300	300.00
H-Bridge	Beefy Motor Driver	1	765.00	765.00
ZMPT101B	Voltage Sensor	1	300.00	300.00
			SUB-TOTAL	7, 284.88.00

ELECTRICAL PART

COMPONENT	DESCRIPTION	QUANTITY	PRICE	TOTAL PRICE
DC Motor	High Torque	1	1,500.00	1,500.00
Moving coil	100 uA	1	550.00	550.00
Transformer	Ideal	1	500.00	500.00
Speed Governor		1	500.00	500.00
Solar Panel	275 Watts	1	8,000.00	8,000.00
Panasonic 12VDC Battery		2	8, 500.00	8, 500.00
Charge Controller		1	2,500.00	2,500.00
			SUB-TOTAL	22,050.00

SIMULATION PART

COMPONENT	DESCRIPTION	QUANTITY	PRICE	TOTAL PRICE
AC Synchronous Alternator	220VAC 60 Hz 3 kVA 1 Phase 1800 rpm	1	6,000	6,000
Pulley track bearing		1	1,000	1,000
Light Bulb	1.5W	4	60.00	240.00
Socket		4	20.00	80.00
Switch		4	50	200.00
Stranded wire	#16	5m	16.00	80.00
PVC Pipe	2”	1	300.00	300.00
PVC Pipe	1”	1	80.00	80.00
Gate Valve	2 inches (diameter)	1	1,500.00	1,500.00
Chain and Sprocket	34T, 17T	1	1,100.00	1,100.00
			SUB-TOTAL	10,580.00

MISCELLANEOUS PART

COMPONENT	DESCRIPTION	QUANTITY	PRICE	TOTAL PRICE
Acrylic Chassis	10x8 inches	1	420.00	420.00
Connecting Wires	• Stranded Wires • Male to male	10 (m) 20	100.00 5.00	100.00 100.00
Soldering Lead		2	100.00	200.00
Soldering Iron	50 Watts	1	250.00	250.00
Circuit Board	Presensitized	2	120.00	240.00
Circuit Board	2 x 3	2	15.00	30.00
Power House		1	3,000.00	3,000.00
			SUB-TOTAL	4,340.00

TOTAL EXPENSES

MATERIALS	AMOUNT
ELECTRONICS PART	**7,284.88**
ELECTRICAL PART	**22,050.00**
SIMILATION PART	**10,580.00**
MISCELLANEOUS	**4,340.00**
TOTAL:	**44,254.88**

APPENDIX F

Documentations

Documentations

Image 1: First Site Visit

(Dingalan, Aurora)

Image2: Measuring the site for Power House

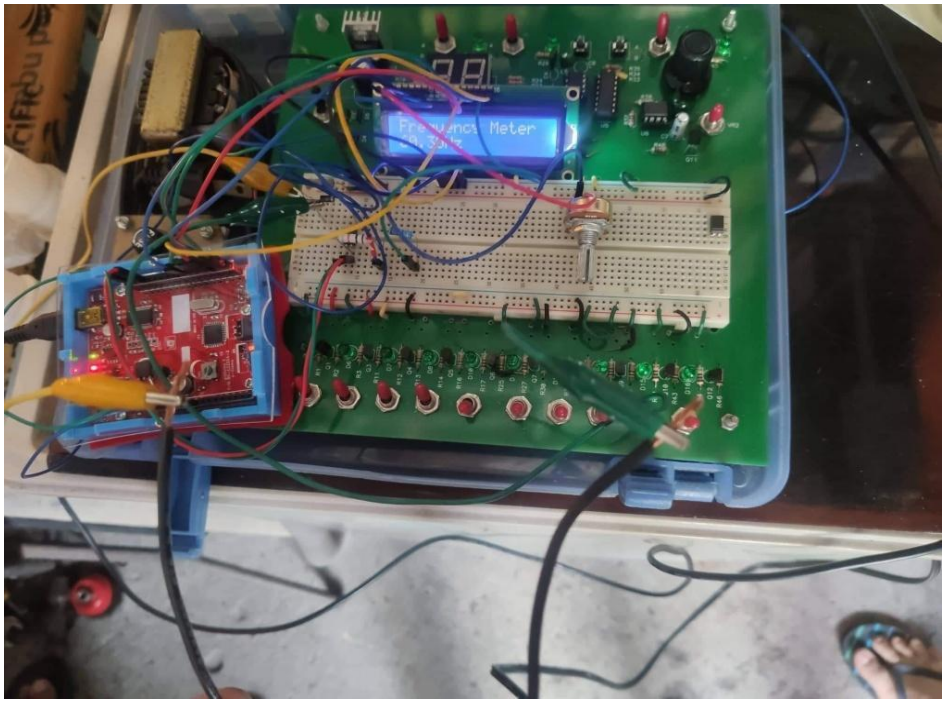


Image 3: Testing of Frequency Sensor Circuit

```
 */
int PH_PIN = 3; // Direction pin
int PWH_PIN = 4; // Speed control/PWM pin

void setup(){
  pinMode(PH_PIN, OUTPUT);
  pinMode(PWH_PIN, OUTPUT);

}
void loop(){
  digitalWrite(PH_PIN, HIGH);
  analogWrite(PWH_PIN, 225);
delay(5000);
  digitalWrite(PH_PIN, LOW );
  analogWrite(PWH_PIN, 225);
  delay(5000);

}
```

Image 4: Program for Controlling DC Motor

(Clockwise and Counterclockwise)

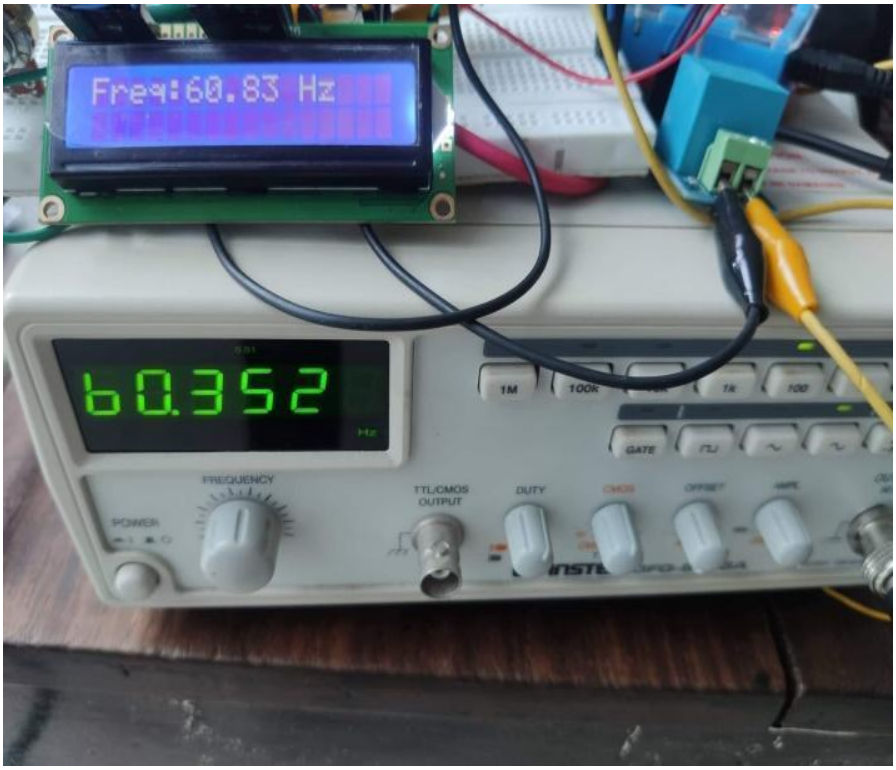


Image 5: Testing of Frequency Sensor Circuit

(Frequency Generator)

Image 6: Chain System

Image 7: Inspection of the Actual Generator in Dingalan, Aurora

Image 8: Measuring Procedures

Image 9: Installation of Solar Panel

Image 10: Installation of LED Light Bulbs

Image 11: Re-designing the Miniature of AGC

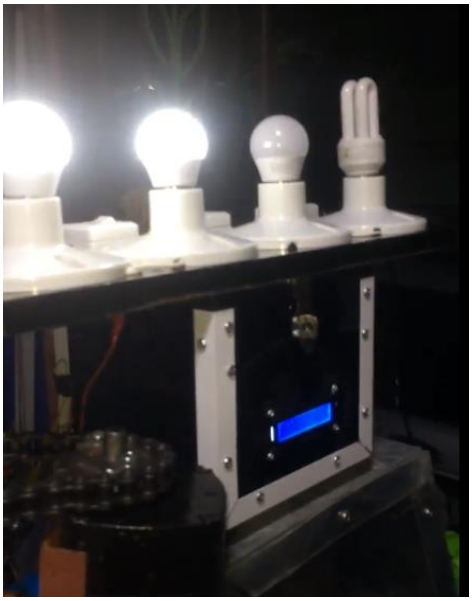


Image 12: Testing

Image 13: Simulation

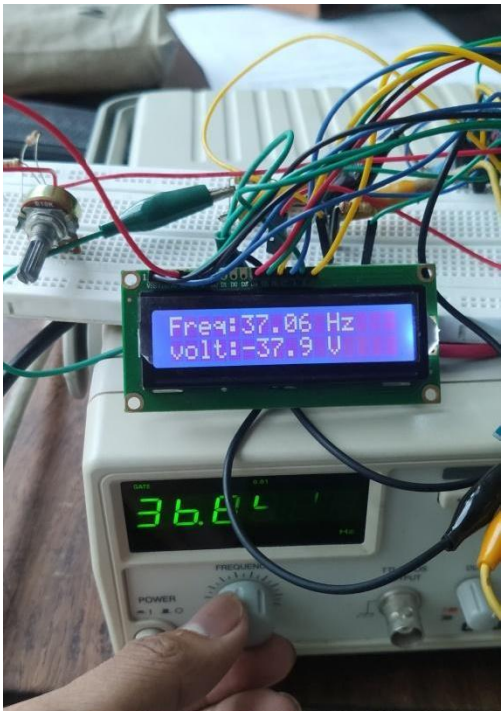


Image 14: Simulation of Voltage and Frequency Sensor Circuit using Oscilloscope

Image 15: Last site visit with our Adviser

Image 16: Proponents together with their thesis adviser

APPENDIX G

Researchers' Profile

objectives

Secure a responsible career opportunity to fully utilize my training and skills while making a significant contribution to the success of the company.

character Profile

Age: 22 years old
Civil Status: Single
Date of Birth: August 5, 1998
Nationality: Filipino
Religion: Roman Catholic

SKILLS

Knowledgeable in computer-related works particularly Microsoft Office Applications (Word, Excel and PowerPoint)

Character Reference

DANICA B. NAYAO
Nutritionist and Dietician
+639198167605

NORIESAN G. CABRERA
Teacher 3, Lakandula High School
+639427424084

KATE C. LIBTAQUE
Team Manager
+639260612131

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

TIMOTHY JOHN F. CAPULONG

TIMOTHY JOHN F. CAPULONG

Blk 49Lot 21 Poinsettia St., Evergreen Executive Village,
Bagumbong, Caloocan City
0928-978-7075
tjcapulong@yahoo.com

EDUCATION

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Bachelor of Science in Electronics Engineering
2015-2020

ST. BENEDICT SCHOOL OF NOVALICHES
2011-2015

OUR LORD'S ANGEL SCHOOL
2005-2011

WORK EXPERIENCE

GOVERNMENT SERVICE INSURANCE SYSTEM
Intern
Financial Center, Pasay City, Metro Manila
April 2019 – June 2019

SEMINARS ATTENDED

APPRECIATE 2018
Technological University of the Philippines

APPRECIATE 2019
Technological University of the Philippines

CAREER PATHWAY: WALK WITH PROMINENCE THROUGH PROFESSION
Justo Alberto Auditorium
February 8, 2020
Pamantasan ng Lungsod ng Maynila

HOW TO WIN JOB INTERVIEW
Justo Alberto Auditorium
February 8, 2020
Pamantasan ng Lungsod ng Maynila

REDEFINING SUCCESS
Justo Alberto Auditorium
February 8, 2020
Pamantasan ng Lungsod ng Maynila

GRADUATE STUDIES: TO PURSUE OR NOT TO PURSUE
Justo Alberto Auditorium
February 8, 2020
Pamantasan ng Lungsod ng Maynila

objectives

Looking for workplace where I can apply my educational qualifications and adapt my theoretical knowledge into practical work through which I hope to achieve professional growth and be of help to the company in reaching its goals.

character Profile

Age: 21 years old
Civil Status: Single
Date of Birth: January 13, 1999
Nationality: Filipino
Religion: Roman Catholic

SKILLS

n Oral and Written Communication Skills
ɜ and can Easily Adjust to any Situations
ɜdgeable in computer-related works (e.g. MS Office 365)
to Render Overtime
and Easy to Learn
ɜe and Hardworking Individual
ɔ basic electronic technical works (e.g. analyzing, designing, troubleshooting)

Character Reference

ERLINDA B. GONZALEZ, RL, MLS
Chief Librarian, Emilio Aguinaldo College
+639296617413

RENATO R. SUPERO JR.
Test System Technician 1, Maxim Integrated Ph., Cavite
+639500532377

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

JOHN ARVIN B. LISING

JOHN ARVIN B. LISING

Blk. 12 Lot 17, Greentown Villas I, Mambog III, Bacoor, Cavite
0927-835-8480
johnarvinlising@gmail.com

EDUCATION

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Bachelor of Science in Electronics Engineering
2017 – 2020

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Bachelor of Technology in Electronics and Communication Engineering Technology
2014 – 2017

WORK EXPERIENCE

GOVERNMENT SERVICE INSURANCE SYSTEM (Intern)
Financial Center, Pasay City, Metro Manila
June 2019 to August 2019

PUBLIC EMPLOYMENT SERVICE OFFICE
Bacoor New City Hall, Bacoor, Cavite
March 2017 to June 2017

COCA-COLA BOTTLERS PHILIPPINES, INC. – IMUS PLANT (Intern)
122 Nia Road, Buhay na Tubig, Imus

SEMINARS ATTENDED

INTELLECTUAL PROPERTY SEMINAR
RM. 419, CIT, Technological University of the Philippines
September 28, 2016

TRACKS ORIENTATION
IRTC Building, Technological University of the Philippines
May 31, 2017

APPRECIATE 2018
IRTC Building, Technological University of the Philippines

APPRECIATE 2019
IRTC Building, Technological University of the Philippines

CAREER PATHWAY: WALK WITH PROMINENCE THROUGH PROFESSION
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REDEFINING SUCCESS
GRADUATE STUDIES: TO PURSUE OR NOT TO PURSUE
Justo Alberto Auditorium
February 8, 2020
Pamantasan ng Lungsod ng Maynila

objectives

To apply my knowledge and skills in the best possible way for achieving the company's goal and to able to enhance my professional skills.

character Profile

Age: 23 years old
Civil Status: Single
Nationality: Filipino
Religion: Jehovah's Witnesses

SKILLS

- Computer skills
- PLC
- Pneumatic and Electro-pneumatic system
- Knowledge in Microsoft Office
- Knowledge in troubleshooting Electronic equipment and circuit boards
- Electrical wiring and equipment
- Design Network system and simulate using packet tracer

Character Reference

DARWIN SIMBAJON
Call Journey – Full dtack Developer
09778136807

ARISTEO CIRUELOS
Converge ICT Field sale executive
09106797048

ARIEL SAN AGUSTINE
Owner of Takoyum-oh Food House.
09985673813

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

BRYCE HART C. LOYOLA

BRYCE HART C. LOYOLA

#292 Dona Amparo St. Panamitan, Kawit, Cavite
0926-418-5292
bryce.hart.loyola@tup.edu.ph

EDUCATION

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Bachelor of Science in Electronics Engineering
2016 – 2020

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Information and Control Engineering Technology
2013 – 2016

KING'S WAY CHRISTIAN ACADEME AND BINAKAYAN NATIONAL HIGHSCHOOL
2009-2013

IBAYO ELEMENTARY SCHOOL
2003-2009

WORK EXPERIENCE

TOTAL POWERBOX SOLUTION, INC. (Technician)
GMA, Cavite
March 2016 – June 2016

PHILIPPINE LONG DISTANCE TELEPHONE (Intern)
Kawit, Cavite
June 2019 – July 2019

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA (Student Assistant)
Ayala Blvd., Ermita, Manila
2018-2020

objectives

Secure a responsible career opportunity to fully utilize my knowledge and skills, while making a significant contribution to the nation building. -I am a driven and ambitious nation scholar with aiming to achieve goals beyond expectation while harmoniously working with people

character Profile

Age: 22 years old
Date of Birth: September 24, 1997
Civil Status: Single
Nationality: Filipino
Religion: Roman Catholic

SKILLS

English Communication, Education, Mathematics, Electronics.

Character Reference

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

ADONIS L. RAMIREZ

ADONIS L. RAMIREZ, ECT

Gen. Solano St., San Miguel, Manila
0956-697-9685
radonis247@gmail.com

EDUCATION

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Bachelor of Science in Electronics Engineering
2015-2020

PALIPARAN NATIONAL HIGH SCHOOL
2011-2015

RIZAL ELEMENTARY SCHOOL
2004 - 2010

WORK EXPERIENCE

BIBO COMPANY
ESL – Teacher
Present

GOVERNMENT SERVICE INSURANCE SYSTEM
Intern
Financial Center, Pasay City, Metro Manila

EVERISE
Customer Care Agent (Non-voice)

SEMINARS ATTENDED

CAREER PATHWAY: WALK WITH PROMINENCE THROUGH PROFESSION
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Justo Alberto Auditorium
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February 8, 2020
Pamantasan ng Lungsod ng Maynila

GRADUATE STUDIES: TO PURSUE OR NOT TO PURSUE
Justo Alberto Auditorium
February 8, 2020
Pamantasan ng Lungsod ng Maynila

objectives

To secure a cooperative education in the field of Electronics Engineering that will enhance and strengthen my skills and achieve professional growth and to be a help in reaching company's goal.

character Profile

Height: 5'3
Age: 22 years old
Civil Status: Single
Date of Birth: April 26, 1998
Nationality: Filipino
Religion: Roman Catholic

SKILLS

Knowledgeable in computer-related works particularly Microsoft Office Applications (Word, Excel and PowerPoint)

Can do basic electronic technical works (analyzing, designing, and troubleshooting)

Knowledgeable in basic programming (Python and Matlab)

Knowledgeable in circuit designing (PCB Express and Circuit Wizard)

CHARACTER REFERENCE

ENGR. GILFRED ALLEN M. MADRIGAL
Professor, Technological University of the Philippines
+639125457788

ENGR. LEAN KARLO S. TOLENTINO
Director, University Extension Services,
Technological University of the Philippines
+639958925845

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

JULIA E.SIMPLICIANO

JULIA E. SIMPLICIANO

#429 3rd Avenue, Barangay Fatima IV, Area E, Sapang Palay Proper, City of San Jose Del Monte, Bulacan
0915-800-2409
juliaespinosimpliciano@gmail.com

EDUCATION

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Bachelor of Science in Electronics Engineering
2017 – 2020

TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES – MANILA
Bachelor of Technology in Electronics and Communication Engineering Technology
2014 – 2017

RAMON MAGSAYSAY HIGH SCHOOL
Espana, Manila
2011-2014

GENESIS CHRISTIAN ACADEMY
Gulod, Sapang Palay Proper
2003-2011

WORK EXPERIENCE

PHILIPPINE GENERAL HOSPITAL
UP-PGH, Taft Avenue, Ermita, Manila
January 3, 2017 - April 10, 2017

GOVERNMENT SERVICE INSURANCE SYSTEM
Financial Center, Pasay City, Metro Manila
July 2, 2019 - August 23,2019

SEMINARS ATTENDED

TRACKS ORIENTATION
IRTC Building, Technological University of the Philippines
May 31, 2017

APPRECIATE 2018
IRTC Building, Technological University of the Philippines

2018 MACHINE DESIGN SUMMIT
Engineering Theater, College of Engineering, UPDiliman, Quezon City
February 3, 2018

PALEETAN 2018
UP NCPAG AVR, UP Diliman Quezon City
September 29, 2018

APPRECIATE 2019
IRTC Building, Technological University of the Philippines

APPENDIX H

Proofread Certificate

C E R T I F I C A T I O N

This is to certify that the research work presented in this thesis, **A SOLAR POWERED ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM (ANFIS)-BASED AUTOMATIC GENERATION CONTROLLER FOR PICO-HYDRO POWER SYSTEMS FOR OFF-GRID RURAL AREA**S by the group of researchers namely Timothy John F. Capulong, John Arvin B. Lising, Bryce Hart C. Loyola, Adonis L. Ramirez, and Julia E. Simpliciano, aligned with the set of structural rules that govern the composition of sentences, phrases, and words in the English language.

Ms. Christine Mae V. Romblon, LPT

Grammarian

Lic. No. 1835129

February 4, 2021

Date Signed