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Mohamad Syafiq Azwan Mohd Nor

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Control System Development for Hybrid Generator Project

MOHAMAD SYAFIQ AZWAN BIN MOHD NOR

**mohdsyafiq1995@gmail.com:*

Abstract

Hybrid generator is one of the renewable energy project that have been developed to solve the problem of accessibility the electricity and its cost. The project can be classified as one of the green technology project as the main resource of this project in producing the electricity comes from the magnetic induction from the solenoid. The force from the magnetic induction of the solenoid will converts into the mechanical energy and then will be converts once again into electrical energy through the generator. Parallel to the development of this hybrid generator projects, it need the controller system to control their input-output power supply and operate as a monitoring system to display all the activities and data in the system. The controller in this project involved with certain parameter which are current, temperature, humidity, speed and capacity of the voltage storage in the system. ACS 712 current sensor is used in measuring the current flow, DHT22 temperature and humidity sensor is used as to identify the temperature of possible heat point in the system, IR module sensor as the revolution per minute rpm counter and Arduino Atmega 2560 is used as a microcontroller of the system. Every details of the parameter will be display on the monitor from the output of each sensor through the platform of an open source which is Node Red. This controller system comprises with the Raspberry Pi as computing device in programming the system. Through this controller system, the hybrid generator will be easier to be access and user-friendly, thus provide high efficiency and will be a good source of electricity to the society and environment. For the future study, this controller system can be developed with more functioning units and easier to be access corresponding to the development of industry revolution 4.0.

Keywords: *renewable energy, hybrid generator, control system, data monitoring system*

1. Introduction

Control system is one of the most important element in managing the activity or data in certain process or machine mechanism. Controlling the system means that the users have accessibility to handle and supervised the machine under their control. The main objective of the control system is to ease the system process as a control system can manages the commands, give directions or regulates the behavior of other devices or systems using control loops [1]. The controller system was relevant to all application from the home based application such as the application of split unit air Cond that using a remote as controlling devices to a domestic used in industrial such as the boiler system which are used for controlling processes or machines [2].

In this case study, the hybrid generator project has certain problem in controlling the hybrid generator system involved with certain parameters which are current, temperature, humidity, and speed. If the power supply cannot be controlled, it will be a waste of energy and could be insufficient power to the certain products or usage. The systems need a controller system that can control the input-output of the system, regulate the system and monitoring system. Moreover, there is also a problem in cut off the voltage to the battery storage when it's full as the overcharge could lead to the wastage of energy and also could be a potential hazard to the users. [3] In this scope of study, the hybrid generator project need a good monitoring system that can display all of the status of the system and could detect the disturbances occur. This is to enhance the efficiency and the easy to used ability of the system. Objective of this study is to develop a monitoring system that can display the status of each activity in the system.

The control system basically can be divided into two categories which are the closed loop and open loop system [4]. Both of these systems have their own functionality and can be used for certain process. In an open loop control system, the control action from the controller is independent of the process variable [5]. Conversely, in a closed-loop control system, the control action from the controller is dependent on the desired and actual process variable as the output data can be control from the main control board that receive the input data from the user. The main element of a closed loop controller system is the feedback loop which ensures the controller exerts a control action to control a process variable at the same value as the set point. Closed-loop controllers are also called as a feedback controller. For continuously modulated control, a feedback controller is used to automatically control a process or operation. [6] The control system compares the value or status of the process variable (PV) being controlled with the desired value or set point (SP), and applies the difference as a control signal to bring the process variable output of the plant to the same value as the set point. [7]

The success of hybrid generator project will give a good impact to the world and especially in generating electricity with more efficient and safe. The project of hybrid generator project has a huge potential in solving the problems of the dependent weather renewable energy resources as the system mechanism in this hybrid generator is basically refer to the solenoid system and Faradays Law. [8] When a small voltage is applied at the system, the current will flow through the winding wire copper and will create a magnetic field and energy toward the magnet shaft that will repel and rotate the crankshaft and the gear system. The gear system is used as transmission energy from the solenoid system to the generator and the current produce by the generator will be store at the UPS battery system. Then all the process in the hybrid generator project will be control by each functioning unit that will perform certain task.

2. Methodology

2.1. Define the parameters involved and components selection

From the point of the literature review and the data gathering process, concepts have been generated to design a controller system for the hybrid generator project. There is certain type of control system that can be applied to the hybrid generator project to optimize and monitor the input and output of the system. Basically the concept of the controller system is a closed loop system. This is because of the monitoring system involved with feedback that will show the status of the system which is the power input and output, the percentage of the UPS battery, and the temperature at the certain point. Parameter that involved in this control system are current, temperature, humidity, and speed. Each parameter is designated with suitable devices and components to perform the task proficiently.

Table 1: Component and device specifications

No	Main Components	
1	 Figure 1: Arduino Atmega 2560	Description • Operating Voltage: 5V • Input voltage: 7-12 V • Digital I/O Pins: 54 (15 provide PWM output) • Analog Input Pins: 16 • DC Current per I/O Pin: 20 mA • DC Current for 3.3V Pin: 50 mA Function • As a microcontroller in the system. • All the data will be process and obtain through the command of the microcontroller.
2	 Figure 2: ACS 712 Sensor	Description • Single supply operation: 5.0 V • Internal conductor resistance: 1.2 mΩ • Minimum isolation voltage from pins 1-4 to pins 5-8: 2.1 kV RMS • Output sensitivity: 66 to 185 mV/A • Output voltage proportional to AC or DC currents Function • As a sensing element unit for current • Detect the value of current flow in the system
3	 Figure 3: DHT22 Sensor	Description • Power supply: 3.3-6V • DC Output signal digital signal via single-bus • Sensing element: Polymer capacitor • Operating range: (humidity 0-100% RH), (temperature -40~80Celsius) • Accuracy humidity: +-2%RH (Max +-5%RH); temperature <+- 0.5Celsius Function • As a thermal sensing unit in the system • Measure the temperature and humidity at certain point in the system
4	 Figure 4: IR Sensor Module	Description • Input Power: 3.3V or 5VDC. • Obstacle detection range: 2cm to 10cm • Adjustable sensitivity with on board potentiometer • Detection angle: 35 degree Function • As a speed sensor unit in the system (rpm counter) • Measure the revolution per unit of the gear

2.2. Sketch flow and schematic diagram of the system

The flow of the controller system is determined and sketched based on the position of existence components of hybrid generator. The controller system components are placed in the point of which the parameter need to be measured. For the current sensor, ACS712 sensor is placed at two different point which are the input and output of the hybrid generator system. This is to determine and monitor the current flow into the system. The arrangement of the thermal sensing unit is basically placed on the possible heat point in the system which are at the solenoid and voltage storage. For the speed detector, the IR sensor module is placed at the gearing system to indicate the revolution per minute of the gear.

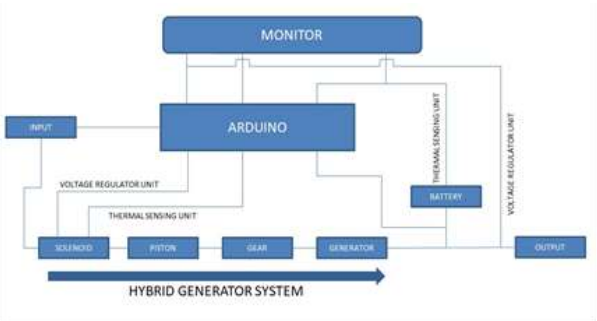

Figure 5: Flow chart of the system

The components of the controller system are sketched in schematic diagram in Fritzing software to determine the connection between the microcontroller and the other devices.

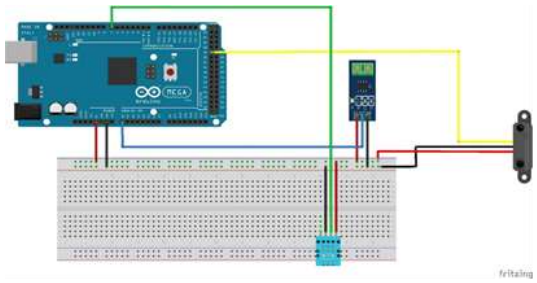

Figure 1: Connection and wiring diagram

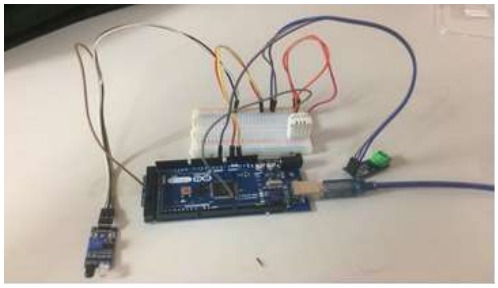

Figure 2: Actual wiring

All components are assembled together and coding for the system is sketched. For the primary test, the coding is sketched on the Arduino Ide Software and has been run to ensure all the device is connected properly and display a probable value for each parameters involved. The output value is shown on the serial port which display output value based on the arrangement display from the coding script.

2.3. Node Red platform

Then the data is transferred to the Node Red platform via the universal serial bus (USB) link. The data is split into four data classification using the node function unit. This is to classified and divide the data display into their desired output value.

Figure 3: Node Red startup

Then, all the data is managed on the dashboard menu based on the type of display module consists of gauge type, charts and text. After that, all the node function involved with the output display is deployed on the user interface server or local host server at http://localhost:1880/. If there are disturbances or error in displaying the output data, the troubleshoot action is done comprises by checking the coding script and or node function and inspect the connection and wiring of all components.

3. Result and Discussion

Overview the result is basically to indicate that the monitoring system is well function as the sensor of each parameter display the decent data. The result obtained can be view on the Node Red localhost server which is at http://localhost:1880/ui/#!/0.

Figure 9: Monitoring system

Table 2:Reference table for the data monitoring system

No	Name	Description
1	Gauge type display	Gauge level indicate the value of data through its needle point
2	Real time data graph	The data value sampling with time
3	Gauge reading 1	Show the value from the gauge reading
4	Gauge reading 2	Show the value from the gauge reading

Table 3: Data classification

Data classification / Ui Groups	
1	Temperature
2	Humidity
3	Current
4	Speed

Data from each sensor will be display at each ui group on the dashboards. From the figure above, the temperature and humidity reading from the DHT22 sensor indicate the actual room temperature (classroom) which is 31°C and 71 percent of humidity. The data is compared to the actual reading from the thermometer to indicate the systems accuracy in interpolate the data. The current reading from the ACS712 sensor show the value of the current flow into the system and the current measurements are reported with a voltage output. The values out of the ACS712 are constantly changing when measuring AC Current as the main power is at high frequency range within 50 to 60 Hertz. [9] There will be interruption and disturbances during the measurement of current as to find the voltage peaks, it need to sampling fast and long enough to takes consecutive samples data. [10] The speed reading is to indicate the revolution per minute of gear at the hybrid generator project. An IR sensor is used as the rpm counter as the device can detect the presence of an object in front it and can calculate and converts into the revolution terms.

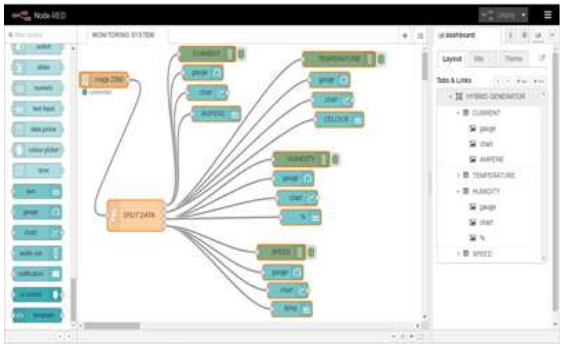

Figure 4: Data flowchart

The flow of the data display is managed at the localhost server [11]. Data from the serial port input is split into four output display using the node function. The data is classified into each user interface group that will be displayed on the Node Red dashboard. The data can be displays into many forms as it can be selected from the dashboards menu. [12] In this case study for hybrid generator project, each data is display through the forms of gauge level, line graph and text. The significance of this data display is to ensure the system operate efficiently and easy to user to interface the data obtain from the monitoring system [13].

Conclusions and Recommendations

In this study, the data monitoring system of hybrid generator project were fabricated and tested via the various type of data. The successfulness of data monitoring system proves that the objectives of this study was successfully achieved which are to develop a monitoring system that can display the status of each activity in the system. From the results, the data obtained is valid and verified as the data value is accurate according to the actual reading. This study is significant as the controller system of this hybrid generator project can give a positive impact to the user which easier in monitoring the system data. In mean time, the data monitoring system can be upgraded to be more efficient by applying the internet of things(IoT) aspect [14]. The effectiveness of the project also could give a lot of good impact to the world as the hybrid generator project produced the electricity using a renewable sources and clean energy [15]. The input power to run the system is low but the output power that produced is high, thus gives a positive effect to the electricity cost and could help to improve the cost of living among Malaysians. Moreover, this project could be applied to the certain area that is difficult to get the electricity as the hybrid generator is the portable type and easy to access to the user.

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