Monitoring of Electrical Output Power-Based Internet of Things for Micro-Hydro Power Plant

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4 authors:

Setiawan Ginting

Joni Welman Simatupang
President University

Iksan Bukhori
President University

Emil R Kaburuan
Universitas Mercu Buana

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Setiawan Ginting
Electrical Engineering Dept.
President University
Cikarang, Indonesia -17550
wawanginting@gmail.com

Joni Welman Simatupang
Electrical Engineering Dept.
President University
Cikarang, Indonesia -17550
joniwsmtp@president.ac.id

Iksan Bukhori
Electrical Engineering Dept.
President University
Cikarang, Indonesia -17550
iksan.bukhori@president.ac.id

Emil Robert Kaburuan
Information System Management Department,
BINUS Graduate Program – Master of Information Systems Management, Bina Nusantara University,
Jakarta, Indonesia 11480
emil.kaburuan@binus.edu

***Abstract*— This research paper describes the output power monitoring process through the Internet of Things (IoTs) system in terms of voltage, current, and water volume using microcontroller for micro-hydro power plant. Electricity consumption caused by an uncontrolled load is different depending on the number of usage. This monitoring system employs the usage of voltage, current, and water volume sensors. These sensors read the data of output power from micro-hydro power plant, then Wi-Fi router is used to send the data to the Thingspeak database. From the experimental results, micro-hydro monitoring system can record the voltage, current, and water volume in real-time to the thingspeak database for every 30 seconds. It is believed that this system will be useful as one of solutions for data monitoring of micro-hydro output power-based IoTs in the future.**

Keywords— electricity consumption, micro-hydro power plant, Internet of Things (IoTs), sensors, Thingspeak database.

I. Introduction

DEVELOPMENT of renewable energy for power plant to produce the electricity is quite challenges due to a lot of consideration such as impact from the natural caused. Especially in Indonesia, there are advantages and disadvantages for renewable energy power plant. This final project concern to micro-hydro power plant as a media for learning session to enhance the capability of understanding of the student for future grid. This smart electricity grid of power plant aims to increase energy efficiency [1].

Existing power plant on the site is monitor led by the worker manually [2]. This condition consumes the energy of the worker to monitor directly the power plant by scheduling intensively. Future generation is being developed through smart plant. Smart plant is connected to internet throughout things applied surrounding the power plant. Our necessity for activities is never out of electricity sources. Smart plant eases our work in monitoring a production progress of electricity day to day. Smart plant eases worker to monitoring the daily production progress and maintaining the failure occur directly from internet database by reducing a time-motion of worker.

Once the micro hydro power plant is digitized further apps can be deployed as internet of things [3]. These efficiency gains come about through a clever blend of internet of thing (IoT) technology and active monitoring. Optimizing in small number of reducing the downtime due to the equipment failures all have an impact. Improvement of internet of thing to monitor the micro hydro power plant highlighted the importance of smarter processes across the industry. Main goal for this project to access the precise, real time information of the power output, enabling a business to reduce workforce costs, increase employee safety, provide significant environmental benefits by reducing emissions and fossil fuel waste, and enabling continuous improvement based on best practice from top performing power plant sites.

Our experimental work assists the micro-hydro power plant to monitor the power output through internet of things that the system is integrated to the micro-hydro power plant. The main purpose is to monitor the power output and to prevent the failure or decreased performance of micro-hydro power plant. In order succeed of applying this system, functional components are necessary to monitor and send a data notification through cloud server.

Therefore, this paper presenting the way how to monitor of power output for micro-hydro power plant system using Arduino microcontroller combined with voltage, current, volume water sensors, Wi-Fi router where later concerned citizens can monitor micro-hydro power plant in real-time by open the website using their own device. since, this should need internet access with mostly named Internet of Things (IoTs) network and people can access directly to the database of Thingspeak [4]. The rest of the paper is organized as follows. Section II describes the basic concepts of Internet of Things related to communication model and brief discussion about the categories of micro-hydro power plant. Section III describes the design specification and implementation of the system. Section IV is dedicated to analyse and discuss the results of the system based on experiments. Section V is conclusion and recommendation.

II. BASIC CONCEPTS AND MECHANISM

Internet of thing is a wonderful development in Electrical Engineering, Information Technology and Communication industry. Whole industry sectors are focusing in the Internet, which is a global network of connected computer network use the standard Internet protocol suite to serve billions of users worldwide. This includes everything from cell phones to wearable devices and to almost anything else that can think of. From an operational perspective, it is useful to think about how IoT devices connect and communicate in terms of their technical communications models.

Internet of Things devices connect directly to an internet cloud service like an application service provider to exchange data or control message traffic. Example: Nest Learning Thermostat, the device transmits the data to a cloud database where the data can be used to analyze, etc. The IoT device connects through an application layer gateway model service as a conduit to reach a cloud service. Example: Smartphone running an application to communicate with a device and relay data to a cloud service.

A decade from now, everything could be connected to the internet of things. The internet of things is becoming an increasingly growing topic of conversation both in the workplace and outside of it. It is a concept that not only has the potential to impact how nowadays life but also how we work. Simply we define, this basically connecting any device with an on and off switch to the internet. Sensors will be one of the key drivers of IoT expansion. Sensors measure physical inputs and transform them into raw data, which is then digitally storable for access and analysis. In today's context, sensors can measure anything from temperature, pressure, flow and position, to light intensity. And they are being embedded into everything, from electricity networks, roads and other infrastructure, to mobile, wearable, home automation and security devices. Hence, IT industry pioneers are executing new ideas of connecting things and people to deliver new services to the market. Thus, internet of thing benefits to long term period such as safety and security, efficient process, business operation, costs saving, assets utilization, and productivity.

In the following paragraph, we would like to show about the categories of micro-hydro power plant as seen in TABLE I and to discuss some systems that have been built by other researchers so that we can make a comparison regarding the strength and weakness of their systems and what makes our system different as shown in TABLE II**.** Micro-hydro is part of a renewable energy resource which comes from the motion of water through micro-hydro device in order to generate electricity. When the water is flowing, its potential energy converts into kinetic energy. This kinetic energy of the flowing water turns blades or vanes in micro-hydro turbines, and then energy is changed to mechanical energy. The turbine turns the generator rotor which converts this mechanical energy into electrical energy. Micro-hydro power is the small-scale harnessing of energy from falling water.

TABLE I. CLASSIFICATION OF HYDROPOWER BY SIZE

No	Size	Description
1	Large-hydro	More than 100 MW
2	Medium-hydro	15 – 100 MW
3	Small-hydro	1 – 15 MW
4	Mini-hydro	100 kW – 1 MW
5	Micro-hydro	5 – 10 kW
6	Pico-hydro	100 watts – 5 kW

TABLE II. COMPARISON PARAMETERS BETWEEN DIFFERENT WORKS

Refs/Parameters	[3]	[4]	This Work
Access to monitor the power output	SIM800L	Ethernet Shield	Ethernet Shield and TP-Link MR3020
Sensors	ZMPT101B and CT 60/5	ZMPT101B and ACS712	ZMPT101B, ACS712, and YF-S201
Time Interval to Update	Program Request	40 seconds	30 seconds
Value Shown in Monitor	Value	Value	Value, Graph, Date
Output Result	Power	Power	Voltage, Current, Power, and Flowrate

Starting with a very conventional technology that uses SIM800L as its monitoring media through message. However, there is no data transmit of voltage and current to the message in this system. Meanwhile the interval time from the sensor to send the data through the message took around twenty seconds. This system uses an Arduino Mega as the main microcontroller of the system, a voltage sensor of ZMPT101B and current sensor CT 60/5 are used as the drive of the power monitoring so that it can send the data sensor in power only through message. Voltage and current sensor will detect the data of the object and an LCD which displays the response data received by the sensor. These output sensors will send a value of the metering the power to Arduino Mega to send the data in power data only.

Afterwards, a power monitoring equipment is consisting of microcontroller and Local Hosting. The sensors involved AC current and voltage sensor that used to sense the data from the object to the Local Hosting. Arduino Mega is used as the data processing circuit and as the microcontroller, and the outputs are data from the sensor by real time motor. The use of local hosting as the database is an application that used for internal memory in monitoring the power that the power monitoring equipment of microcontroller should be connected to the PC to send the data. If the prototype is using the local hosting and the microcontroller should have connected to the monitoring PC than it makes the user could only monitor the object in certain range which has to connect directly.

As conclusion, there are still much things need to be done in order to make the system looks perfect. From our point of view, the advantages of our work compare to others include such as the system can be connected and input the sensor data into a website where everyone can access it using their own devices (IoT Network System) and microcontroller can directly send the data from sensors to the system to get the power output from power plant. Therefore, it can be divided into five parameters that we can compare from their work with our work. For access the monitoring, they did not use Internet of thing in their system. For sensors, they did not use a water volume sensor to sense the amount of water through. For time interval, sensors are highly taking around 30 second to update from sensors to database of Thingspeak. For value shown on monitor, they only show clearly about value from sensors to monitor and this project has shown value, graph, and date. The last, for output result, this project shows the value from sensors of voltage, current, power, and volume of water.

III. Design Specification and Implementation

The design of the project is categorized into two classes: hardware design and software design. There are three important of hardware devices that can be introduced. First is Arduino Mega 2560R3 [5-6], which is applied as the microcontroller of the whole system that receives input signals from voltage sensor ZMPT101B [8], ACS712 current sensor [9], YF-S201 water volume sensor [10], process it, and then send the output data to database of Thingspeak through Ethernet shield with Wi-Fi router [7]. The complete schematic diagram of the proposed system is shown in Figure 1 below.

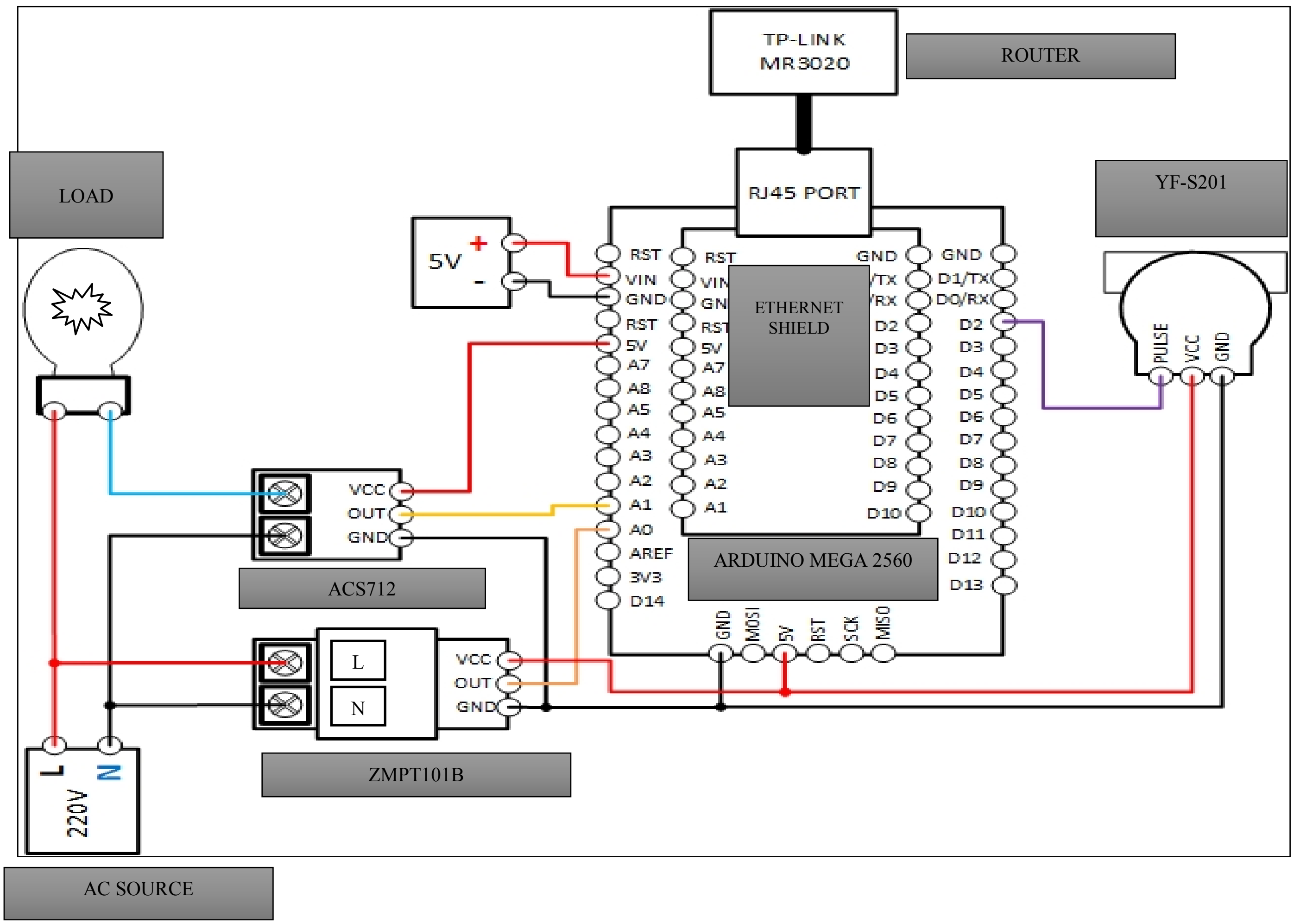

Fig. 1. Schematic diagram of the proposed micro-hydro power plant for monitoring the electrical output power through Internet of Things (IoTs) system.

In this prototype, voltage and current sensors are used to measure the voltage and current produced from micro-hydro power plant. And water volume sensor is used to measure the amount of water that is flowing through the micro-hydro power plant itself. By employing the concept of device to cloud communication which has a meaning that IOT device connects directly to an internet cloud service such as website or webserver to exchange and control the data using their own device with internet access turn on. In this case, Ethernet shield and Wi-Fi router as IoT devices will get the data from Arduino and sensors, send the data into a webserver which have been prepared and it will send the message for the latest data of voltage, current, and water volume to certain number that have been programmed before. The other feature is people can know the condition of power output for every 30 seconds in graph to monitor the change of value produces detail.

Arduino Mega 2560

The reason of choosing Arduino MEGA 2560 as the microcontroller is because Arduino MEGA 2560 has enough pins for this project. Besides, finding Arduino MEGA 2560 in market is easier than any other Arduino products, since Arduino MEGA 2560 is the most well-known product of Arduino manufacturer. The module of Arduino MEGA 2560 is shown in Fig. 2.

Voltage sensor ZMPT101B

ZMPT101B voltage sensor module is a voltage sensor made from the ZMPT101B voltage transformer. It has high accuracy, good consistency for voltage and power measurement and it can measure up to 250V AC. It is simple to use and comes with a multi turn trim potentiometer for adjusting the ADC output. The analysis in this paper tends to find more accurate relationship between the input voltage and the ADC output by regression analysis. The ADC output is adjusted using the trimpot to an appropriate value against a reference input.

ZMPT101B is used as the voltage sensor for AC voltage. All of its wires are connected into Arduino Mega 2560 R3. There are 4 pins of the ZMPT101B which consist of VCC, GND, and Out. A0 as the analog input from the Arduino Mega that connect the ZMPT101B to read the data of process. ZMPT101B usually working at rated current 1~2 mA when rated input voltage $\leq$ 100V. It usually chooses the operated current 2 mA when rated input voltage $\geq$ 220V. the wiring diagram of voltage sensor ZMPT101B is shown in Fig. 3.

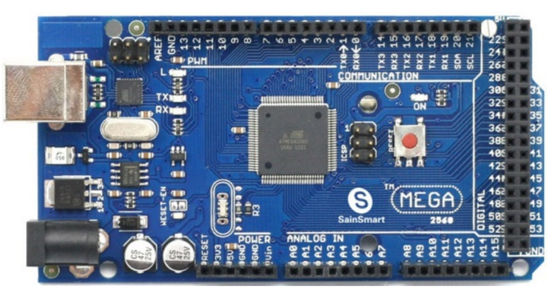

Fig. 2. Module of Arduino MEGA 2560.

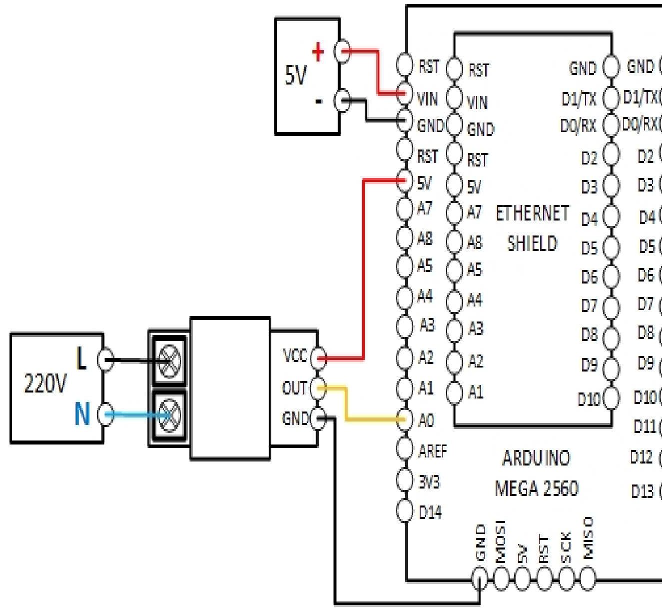

Fig. 3. Wiring diagram of voltage sensor ZMPT101B.

Current sensor ACS712

ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device protection allows for easy implementation. Typical applications include motor monitor, load detection and management, switchmode power supplies, and overcurrent fault protection. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging. The internal resistance of this conductive path is 1.2 mΩ typical, providing low powerloss. The thickness of the copper conductor allows survival of the device at up to 5 times overcurrent conditions. The terminals of the conductive path are electrically isolated from the signal leads. This allows the ACS712 to be used in applications requiring electrical isolation. Its wiring diagram can be seen in Fig. 4.

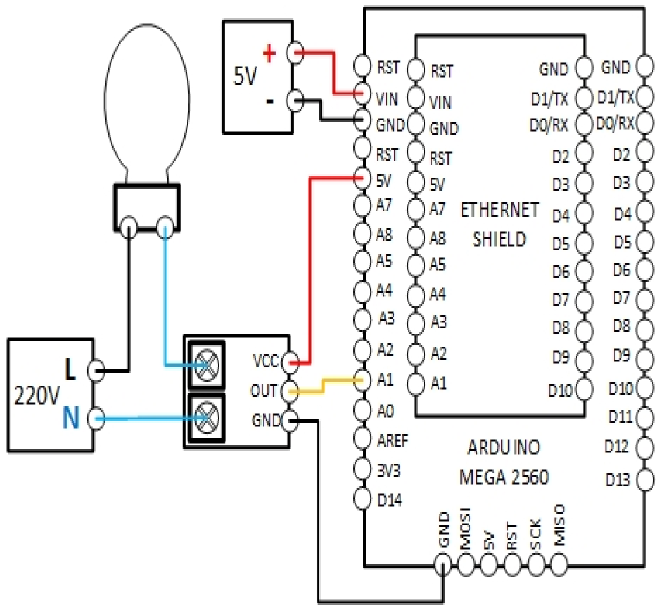

Fig. 4. Wiring diagram of current sensor ACS712.

Water volume sensor YF-S201

This sensor can be used to measure water flow for solar, water conservation systems, storage tanks, water recycling home applications, irrigation systems and much more. The sensors are solidly constructed and provide a digital pulse each time an amount of water passes through the pipe. The output can easily be connected to a microcontroller for monitoring water usage and calculating the amount of water remaining in a tank. This sensor sits in line with water line and contains a pinwheel sensor to measure how much liquid has moved through it.

This water flow sensor has only three wires and it can be easily interfaced between any microcontroller and Arduino board. It requires only +5V VCC and gives pulse output, the sensor needs to be tightly fitted between water pipeline. Connect the +5V wire to Arduino power pin 5V and GND pin to GND then connect Signal pin to Digital pin D2, this sensor has monitor circuit hence there is no need for pull up resistor, some sensor requires pull up resistors refer datasheet of water flow sensor before concluding data calculation.

IV. Experimental Results and Discussion

All those sensors and microcontroller which have been mentioned are main components/devices to build the device prototype which can be seen in Fig. 3.

The micro-hydro power plant frame box was done succesfully. Figure 5 and 6 show the top view of the proposed device prototype and electrical power output, respectively.

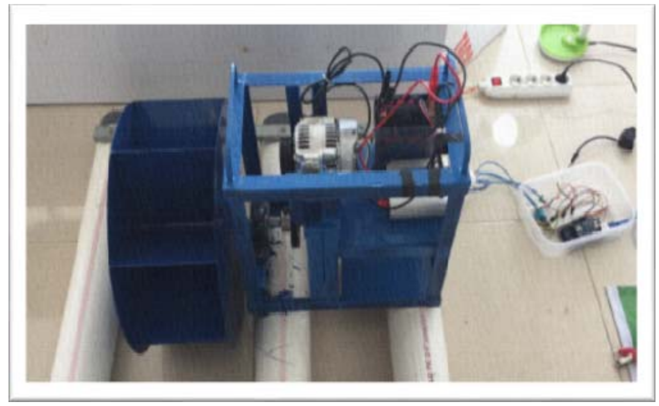

Fig. 5. Top view of the proposed micro-hydro prototype.

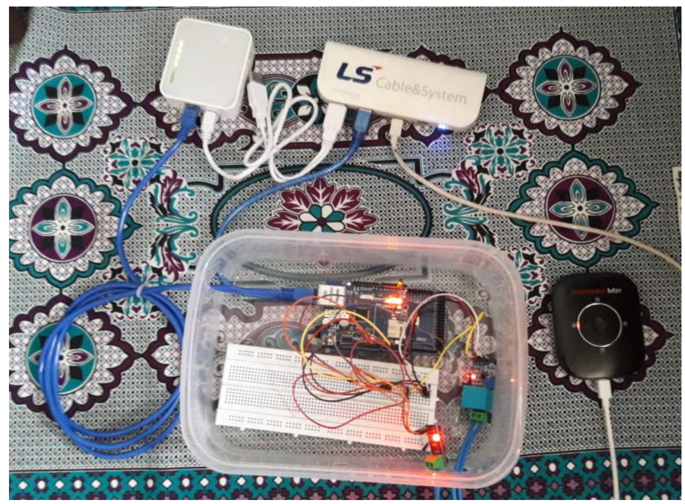

Fig. 6. Top view of electrical output power system monitoring.

Microcontroller, ZMPT101B and ACS712 are located inside the box frame of the micro hydro power plant. Meanwhile, YF-S201 flowrate located above the turbine of micro hydro power plant which covered with pipe to connect with microcontroller and isolated with funnel above the flowrate as port of water flow in. Once the microcontroller is paired with the internet connection, the system can monitor the value of power output from micro hydro power plant.

In addition, this research work has also completed the monitoring of electrical power output-based internet of thing for micro-hydro power plant prototype cloud server which can be accessed easily from the webserver. The author has done some tests in order to find out the optimum energy from micro hydro power plant in producing electricity. Results is stored in Thingspeak as shown in Fig. 7.

Potential energy of water flow in motion turns the turbine of the micro hydro power plant than this mechanical energy turns the generator rotor which converts from its mechanical energy to electrical energy. Form of electricity will be stored in the rechargeable battery 12VDC which can be used to connect with power inverter to 220VAC. This condition made user to use the load such as lamp needs.

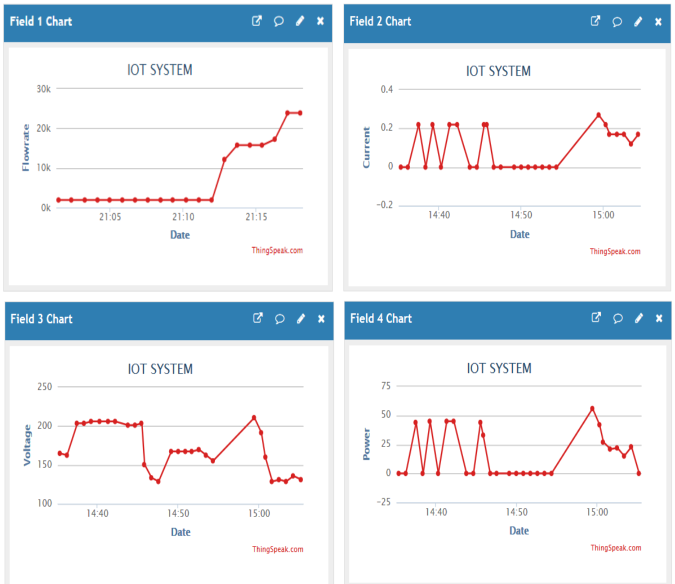

Fig. 7. Results that shown in windows of Thingspeak.

Microcontroller of electronic power output should be connected to the internet connection through Wi-Fi router. Initiating of internet connection between Ethernet shield and Wi-Fi router took around 5 seconds until entire LED of Wi-Fi router turn on. This moment recognizes connection for Arduino microcontroller. Voltage, current, and water volume sensors are reading the data of power output from micro-hydro power plant of power inverter.

Data from voltage, current, and water volume sensors directly sent to Thingspeak and update automatically for every 30 seconds. In functional testing, it can be found that the system is working properly according to the initial plan and design in Section III and the experimental testing for monitoring of electrical output power-based internet of things for micro-hydro power plant in Section IV.

A range – status explanation that determined in the system can be seen in TABLE III and Fig. 8.

TABLE III. PROPORTIONALITY OF WATER VOLUME W/ VOLTAGE

No	**Water Volume (mL)**	**Voltage (V)**
1	6030	164,89
2	6989	162,47
3	8566	203,63
4	9587	203,63
5	10215	206,5
6	11478	201,21
7	12423	203,63
8	13898	210,9

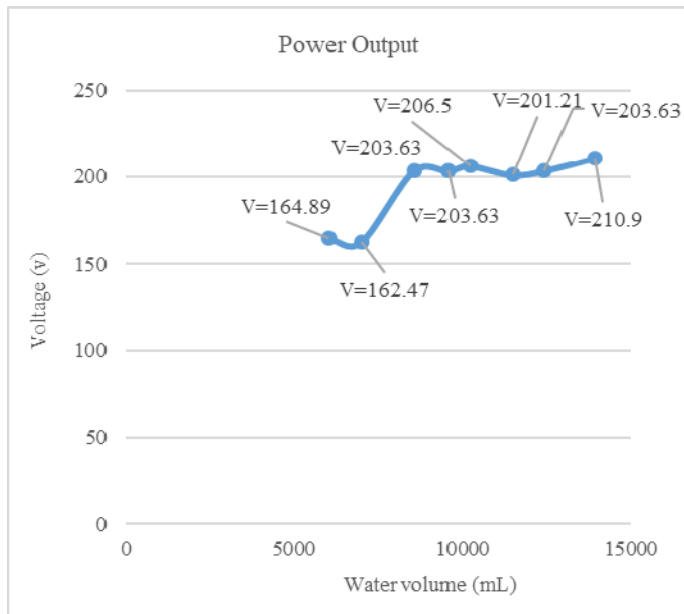

Fig. 8. Graph of water volume which proportional to the voltage.

V. CONCLUSION AND RECOMMENDATION

In this paper, an implementation of Internet of Things (IoTs) network for monitoring electrical power output has been described. This device achieves the objectives of this project by having the following abilities, such as: first, the system is able to record the data frequently and post it into a website by received the sensing data from voltage, current, and water volume sensor and delivered by Ethernet shield Wi-Fi router. Second, the system is able to access as free in webserver and free to share this publicly. From our experimental results, it is predicted that this system will be useful as one of solutions to reduce energy of worker directly to power plant.

Some developments can be made to improve the system in the near future, such as by enhancing the reliability of the signal by adding some module to the system which can make the system more stable and secure and also by using the more accurate voltage, current, and water volume sensor, respectively.

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