

# Development of IoT at hydroponic system using raspberry Pi

Rony Baskoro Lukito\*<sup>1</sup>, Cahya Lukito<sup>2</sup>

Computer Science Department, School of Computer Science, Bina Nusantara University,  
Jakarta, Indonesia

\*Corresponding author, e-mail: rbaskoro@binus.edu<sup>1</sup>, cahya.lukito@gmail.com<sup>2</sup>

## Abstract

*Hydroponics is one of the farming technologies using water media to meet the needs of plant nutrition. Water use in hydroponics systems more efficient compared with the cultivation system using soil media. Water that has been mixed with mineral nutrients needed by plants streamed continuously to the plant roots. Another advantage of this method is very suitable to be applied in a limited area such as urban home environments, the use of the existing space in the house. In the everyday activities of urban residents spending more time outside the home to work, school, shopping and other activities. Thus the observation of hydroponic systems remotely be important to be done from anywhere. Availability, temperature, and pH of the water are some of the factors in hydroponic systems that need to be observed periodically to determine the appropriate action. This problem can be solved by developing the Internet of Things technology in the hydroponic system that observations can be done remotely and reported directly through the Internet.*

**Keywords:** internet of things, paper hydroponic system, raspberry Pi, vertical garden

**Copyright © 2019 Universitas Ahmad Dahlan. All rights reserved.**

## 1. Introduction

Most of the activities of urban residents in the use of their time is spent outside the home to work in the office, school, shopping and other activities. With the limited time you have, the application of Internet of Things technology can provide enormous benefits. System control and monitoring can be done from a long distance and can be accessed at any time. One way to improve the quality of human life in the food self-sufficiency is to adopt a hydroponic system, which is one of the technologies of farming using water media to meet the needs of plant nutrition. Water that has been mixed with mineral nutrients needed by plants streamed continuously to the plant roots. Temperature, pH and conductivity of water need to always be observed to determine the necessary actions.

In this study used the Raspberry Pi, a credit card-sized minicomputer and Arduino-based IOT devices are equipped with multiple sensor modules. The scope of this study will be limited to the development of hardware and software to monitor the main parameters of all hydroponic systems using Internet of Thing technology, consisting of:

- a. The temperature sensor, pH and conductivity of water
- b. An Arduino Internet of Thing module
- c. Database and Web Server is built on Raspberry Pi Pocket PC

By developing a support device hydroponics system that can be applied in a residential neighborhood, this is expected to help increase food security of every family. The next step of this research is to build a Smart Hydroponic System that is integrated with the Internet network.

## 2. Research Method

### 2.1. Internet of Things Technology

Based on one of the existing literature on the [www.internetsociety.org](http://www.internetsociety.org) [1], the term of the Internet of Things (IOT) was first used in 1999 by Kevin Ashton to explain a system that can connect objects who physically looks into an internet network by using sensors. The rapid growth of technology and the support of technology Automation Systems, Information Systems

and Telecommunication System to create a Smart System that can improve human welfare [2]. IoT consist of Instrument, Interconnect, Intelligently process [3].

According to [4], when the sensor operates, the sensor converts a form of energy into another energy called transducer. Sensors that operate indirectly will change their properties, such as resistance, capacitance or inductance, which occurs proportionately. Here are 6 points of the application of IOT which is a combination of two large groups of Information and Analysis and Automation and Control according to an analysis from McKinsey and Company [5]. Tracking behavior, enhanced situational awareness and sensor-driven decision analytics are in group of Information and Analysis. Process optimization, optimized resource consumption and complex autonomous systems are in group of Automation and Control.

This research will focus on sensor-driven decision analytics for a hydroponics system that is in a residential setting. This is the first step to fulfill some parts of the above criteria. The Internet of Things also has been identified as one of the technologies that will emerge in IT technologies as reported in the IT Gartner Hype Cycle [6]. Buckey said, The Internet of Things may react autonomously to the real world. This is known as proactive computing [7].

## 2.2. Raspberry Pi Overview

Raspberry Pi is a minicomputer the size of a credit card which was developed by the Raspberry Pi Foundation in the United Kingdom. The device was created by a hardware architect of Broadcom named Eben Upton. The device is made with the initial goal to assist the introduction of the Fundamentals of Computers in schools and developing countries [8].

Despite having small dimensions, Raspberry Pi can be used to do many things like a personal computer, such as to send and read e-mail, making spreadsheets and electronic documents, browse the internet, play multi-media with quality High-Definition Video. In this study the Raspberry Pi will be used as WEB and Database Server, by connecting the sensor temperature, pH and conductivity of water in the system hydroponics through the intranet. With the development of WEB-based application programs that run on the Raspberry Pi, then the information can be accessed on the Internet via the Ethernet port.

## 2.3. Raspberry-Pi Architecture

Until 2015, the Raspberry Pi has had 6 versions, namely: Raspberry Pi 1 Model A and Model A +, Raspberry Pi 1 Model B and Model B +, Raspberry Pi Model B 2, and the Raspberry Pi 2 Zero [9]. Raspberry-Pi using ARM Central Processing Unit Broadcom BCM2835 and a GPU that features some of the following connectors as shown in Figure 2 [10]:

1. General Purpose Input and Output (GPIO)
2. Display Serial Interface (DSI) 15 pin flat ribbon cable that can be connected to communicate with the LCD or OLED display.
3. Camera Serial Interface (CSI) Port for camera connection.
4. This is a Broadcom proprietary header which is useful for Broadcom chip JTAG testing header and Ethernet-out LAN9512 Networking Chip.

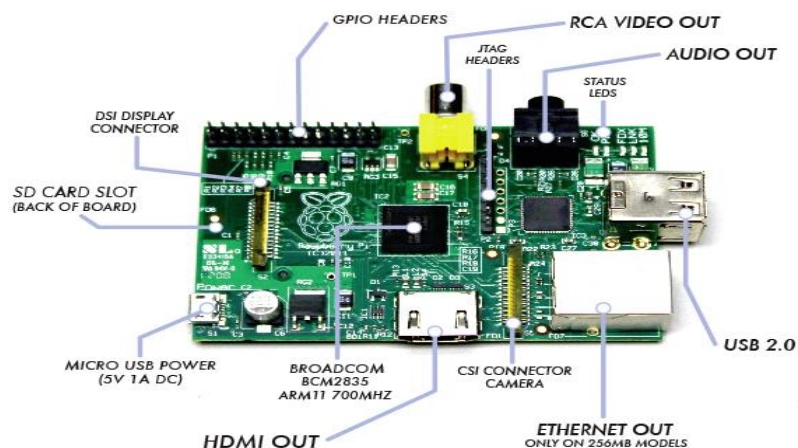


Figure 2. Raspberry-Pi Model-B

Comparison between the Raspberry Pi Model A and Model B can be seen in Table 1. Both have the same CPU speed is 700MHz, with a larger memory 2x for Model B. The price difference is not too far away, Model B already include the number of USB ports available are more and RJ-45 port for networking-based TCP / IP. On the side of the power requirements of Model B requires a current of 700mA at 5VDC voltage compared to Model A, which only requires a current of 300mA at the same voltage of 5VDC [11].

Table 1. Comparison Model of Raspberry Pi

Raspberry Pi	Model A	Model B
Release Date	Q1 2013	Q4 2012
CPU	ARM11 700 MHz	ARM11 700 MHz
GPU	Broadcom VideoCore IV	Broadcom VideoCore IV
RAM	256 MB	512 MB
SoC	Broadcom BCM2835	Broadcom BCM2835
Power Rating	300 mA at 5V	700 mA at 5V
USB	1x USB 2.0	1x USB 2.0
Video Output	Composite RCA; HDMI 1.3/1.4	Composite RCA; HDMI 1.3/1.4
Audio Output	3.5 mm analogue; HDMI	3.5 mm analogue; HDMI
Networking	None	None

Open Source Linux Operating System is the most widely used. By making adjustments to the Raspberry Pi Hardware Architecture, Raspbian is a Free Operating System is based on Debian suitable for general use. Raspbian currently has 35000 software packages that are easy to install, and the support of an active community to improve the stability and performance of each package [12].

2.4. Arduino Minimum System

In accordance with the general explanation, Arduino system is defined as a minimum that is Open Source for easy-to-use Hardware or Software [13]. Arduino Board has the ability to read input from the sensors installed, keystrokes until a short message via a computer network which is then processed into an output that is supported by the microprocessor on board. Arduino also provides supporting software to allow users to create Application Software by providing the Arduino programming language and Arduino IDE Software. In this study, using Wido is an Arduino Compatible Board designed for the purposes of Internet of Thing. Here are the specifications of the module Wido v1.0 as can be seen in Figure 3 [14]. Reach resources or 7-12v (VIN)/5v (Micro USB), Leonardo Arduino Compatible, Integrated with WG1300 WIFI module Chip for 2.4GHz IEEE 802.11 b/g, On board PCB Antenna 2.4G, Microcontroller ATMEL ATmega32U4.

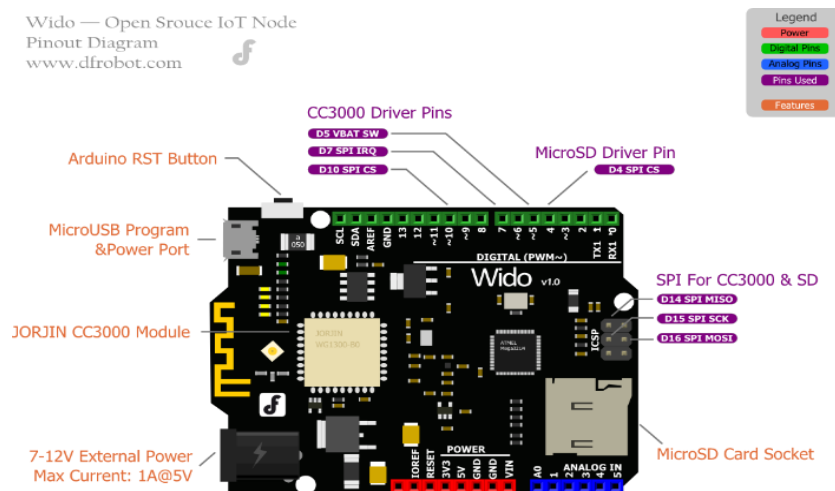


Figure 3. WiDo v1.0 Pin Out [7]

**2.5. Research Methods**

The research methodology is the stages of research must be defined before carrying out the research, so that research can be done with focused, clear, efficient and effective. As shown in Figure 4, it starts with identifying problems how to use the internet of things for hydroponic systems. Then proceed with research on system architecture and algorithms, this relates to the current technology. Next is the development of hardware and software, which includes architectural design, creating of hardware modules and software module design. Followed by testing and evaluation. If it is not as intended, it will repeat the design of hardware and software. If appropriate, a pilot project, testing and report will be made.

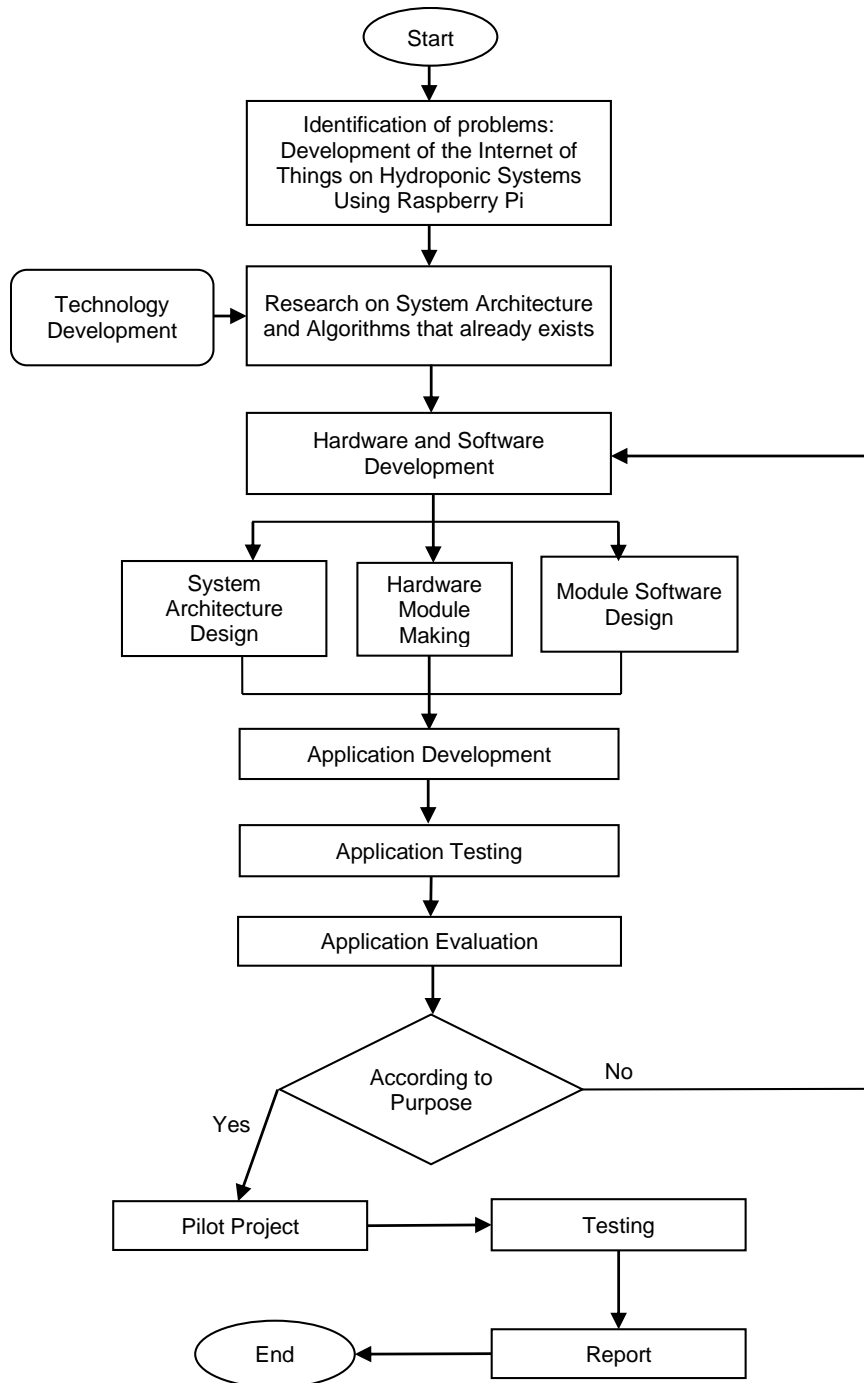


Figure 4. Methodology

### 3. Results and Analysis

#### 3.1. Hardware specifications

In the designing of Home Lighting System Automation project will use Raspberry Pi Model B 1 as shown in Figure 5 that has a user interface Mini Power, SD Card, USB, HDMI, LAN, RCA Composite Video Output, Analog Audio output Stereo Mini jack and GPIO header. With a complete interface which is owned and embed application program in the Raspberry Pi, the making of an electronic project to become more efficient and effective.

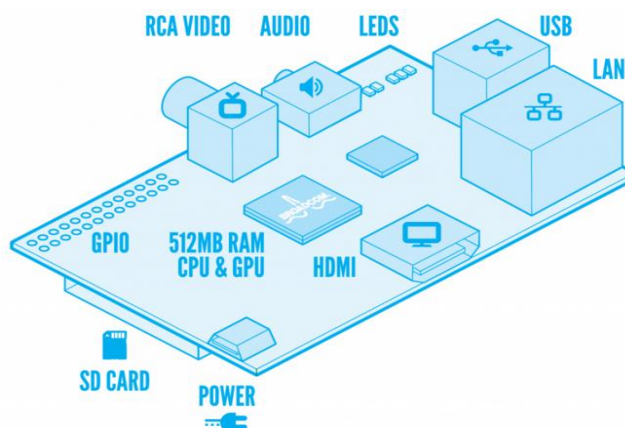


Figure 5. Raspberry Pi 1 Model B

Here are some of the enhancements needed to install the Operating System on a Raspberry Pi to be used optimally: Casing, Minimum 4GB Class-4 SD Card, Monitor with HDMI input, HDMI cable, Keyboard and Mouse with USB interface, 5VDC 700mA Power Supply with Micro USB interface, Access the Internet to do the Software Update. Necessary also a 5VDC power supply with 700mA minimum and at least 4GB SD Card Class 4 [15]. If you want to connect to the Monitor, it is necessary to HDMI Cable. Keyboard and mouse can be connected via the USB port. Connection to the network can use the RJ-45 Ethernet or Wireless LAN using the Wi-Fi Dongle USB port. And a casing for Raspberry-Pi, because the module is not equipped with Casing.

### 3.2. Architectural Design Internet of Things on Hydroponics Systems

#### 3.2.1. Hydroponic IOT Hardware System Architecture

Here is a Hardware Architecture of the application of Internet of Things Hydroponic System using the Raspberry Pi as a Web Server and Wido Arduino base module as the main controller for the sensor module temperature, pH and conductivity of water that can be grouped into the following sections:

##### 1. Input

The measurement results from the sensors connected to the module Wido be input data that will be sent to the Raspberry Pi to be stored in the database. The lighting system has three sensors, namely: temperature, pH and conductivity.

##### 2. Output

The output of this system in the form of a statistical report WEB base that displays the value of the temperature measurement, pH and conductivity of water from Hydroponics System.

##### 3. Module Raspberry Pi

Application development on Raspberry Pi module using the programming language PHP, Java Script and HTML Script. All measurement data is stored using MySQL. Wido lines of communication with the module is connected via Wireless LAN.

##### 4. Wireless LAN Router

UTP CAT-5 cable is used to connect the Raspberry Pi into a Wireless router that has an RJ-45 port, while the interface is used as a Wireless LAN Access Point.

## 5. Computer and Smart Phone

Computer and Smart phone connected via Wireless LAN Router can serve as a monitoring tool of the hydroponic system as shown in Figure 6.

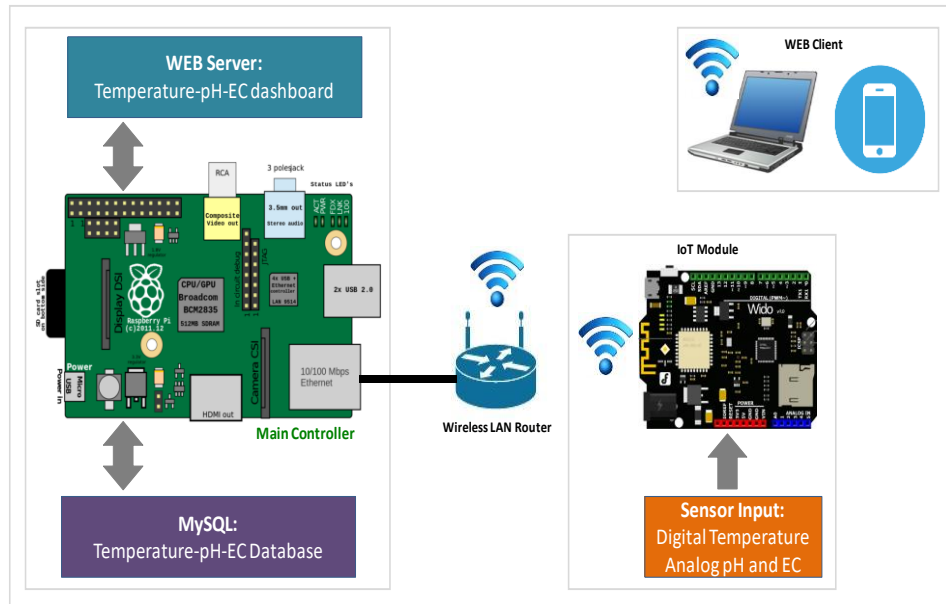


Figure 6. Hydroponic IoT Hardware System Architecture

Hardware System Architecture with the above is possible for us to reach easily from anywhere in the home environment as long as the range of your wireless LAN. Monitoring can be done by accessing the Web address of the Raspberry Pi using a Web browser application.

### 3.2.2. Hydroponic IOT Software System Architecture

Here is a Software Architecture of the application of Internet of Things on Hydroponic System using the Raspberry Pi as shown in Figure 7:

#### 1. Rasbian Raspberry Pi Operating System

Rasbian Operating System is a software system that is responsible for managing and aligning work of Raspberry Pi hardware in order to work properly to support system monitoring applications Hydroponics are working on it.

#### 2. Web Server

Raspberry Pi serves as Web servers that store, process and transmit Web pages to the Web client. Communication between Server and Client is to use the Hypertext Transfer Protocol (HTTP). GUI created using HTML script in which there is some JavaScript to interact with the applications used to read data from a database created using PHP.

#### 3. Web Client

Application Software that is used on the client side is a standard Web browser application that always exist on a computer or Smart Phone. Communication between the Web server and Web Client via Wireless LAN network will be formed at the time of the Web address Hydroponics system incorporated into the Web browser.

#### 4. Hydroponics Database

MySQL is a database used to store data obtained from the sensor module. The writing and reading of data to MySQL Database using applications built using PHP

#### 5. Application Sensor

Applications created using Arduino as a programming language. Digital Temperature Sensor is connected to the input pin, while the pH and conductivity sensors connected to analog pin of the module Wido. Applications that are embedded in the module Wido serves to capture data generated by sensors and sends it to the Raspberry Pi.

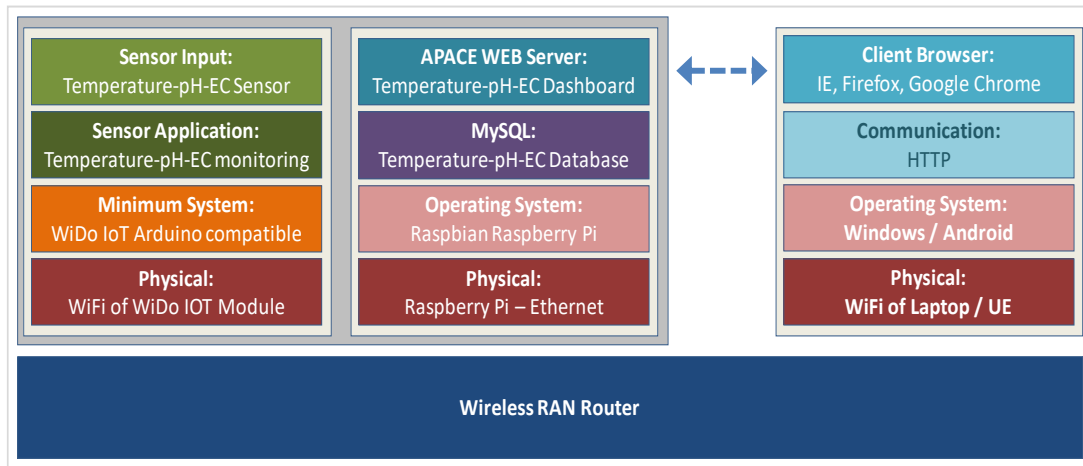


Figure 7. Hydroponic IoT Software System Architecture

By using the Client Server Architecture Model, then most of the process will be performed by the Raspberry Pi as a server so that the resources required on client devices is small. Another thing is the advantage of this model is the Client can easily fit into any monitoring system for Hydroponics from Client devices connected to wireless LANs are equipped with WEP or WPA Wireless Security.

### 3.3. Hardware Implementation

Raspberry Pi is placed on a box next to the wireless router, while IOT sensor box is placed close to a hydroponic plant cultivation. Connection to the Wireless Router using a Cat-5 Ethernet cable with bandwidth of 100Mbps. As shown in the Figure 9 below, there are three sensors connected to Wido IOT module through each interface. The temperature sensor is connected to a digital pin while the pH and conductivity sensor is connected to the analog pin of Wido. Wireless Ethernet module is already available on Wido IOT module, so that the measurement results of the sensors can be sent over the network to the Raspberry Pi Wireless LAN.

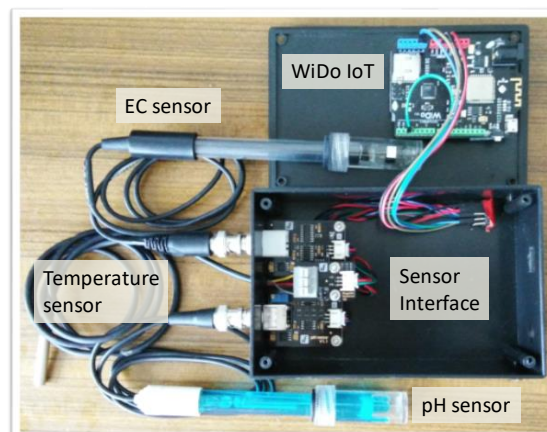


Figure 9. Sensors

### 3.4. Software Implementation

As in the plans for the IOT Hydroponic System Software Architecture, there are two major applications that run on the Raspberry Pi is: MySQL as the database server and Apache

Web Server. To display the data stored in MySQL database used Java Script and HTML Script. The process of data reading and writing of data to the MySQL database used two simple applications created using PHP programming language. Applications on the sensor module Adafruit\_CC3000 Wido use programming library for Wireless LAN communication and OneWire library for programming temperature sensor. As for debugging purposes SPI library used for serial communication.

### 3.5. Test Results

Tests performed on a hydroponic system that serves as a real model of the application of the Internet of Things. Here is the view of the sensor measurement results stored in a MySQL database on the Raspberry Pi which serves as WEB Server. The following Figure 10 is a temperature measurement experiment. Seen in this image when the temperature sensor is brought close to the heat source, the graph will rise. When kept away from the heat source, the temperature graph returns to room temperature.

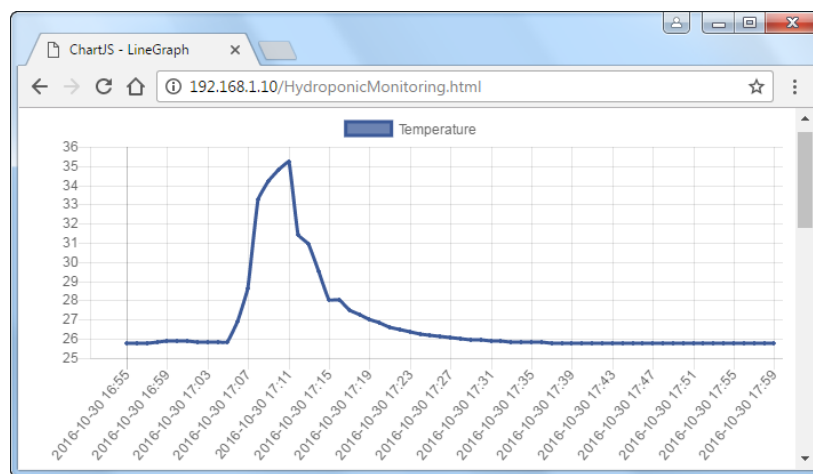


Figure 10. Temperature measurement results with Wido IoT Sensor Module

The following Figure 11 is an experiment for measuring pH. When the pH sensor is inserted into the ground, the graph shows an approximate value of 7. It proves that the pH sensor works. The third sensor used is measurement of conductivity. Experiments on these sensors also show that the conductivity sensor works well as shown in Figure 12.

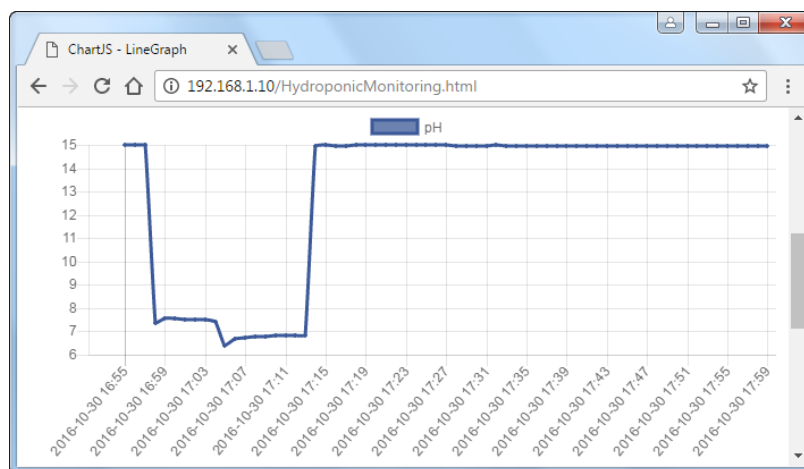


Figure 11. pH measurement results with Wido IoT Sensor Module



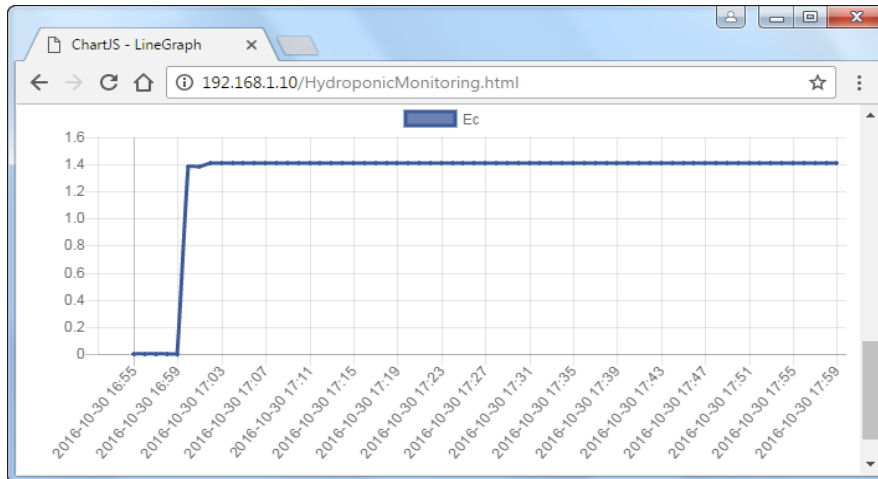


Figure 12. Conductivity measurement results with Wido IoT Sensor Module

The process of developing, testing and evaluation of the design of the hardware for the sensor module and the application program still needs to be refined. As shown in Figure 13 that the pH value be interrupted at any time when the conductivity sensor is activated.

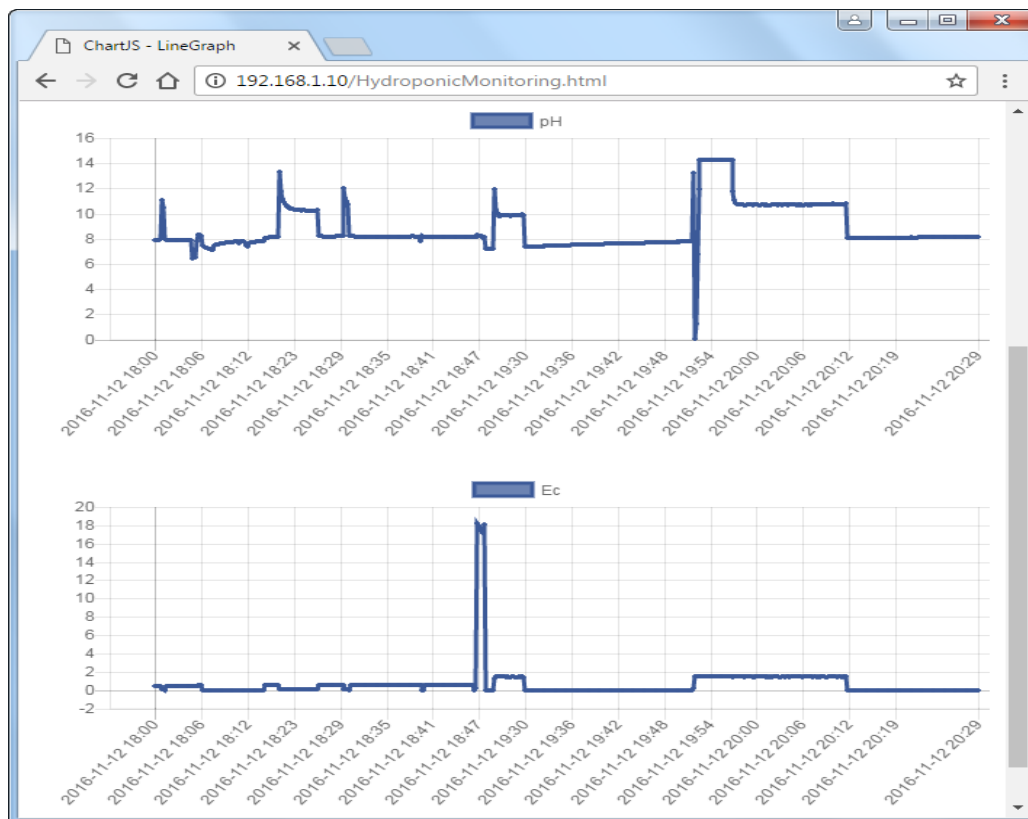


Figure 13. pH Sensor problems running concurrently with conductivity sensor

#### 4. Conclusion

Conclusions derived from the development of the Internet of Things in the hydroponic system using the Raspberry Pi is as follows:

At the time of the conductivity sensor is activated, the water pH measurement results become inaccurate because the electrical current coming out of one of the electrodes of the sensor module conductivity. Placement WiDo as IOT module should be ensured to have the level of the Wi-Fi signal strength is strong enough so that the data from measurements by sensors can be sent to the Raspberry Pi (Database Server) as well. Raspberry Pi can work well as a Web Server and Database Server.

The suggestions and inputs for the development of this system are: Need a control circuit to make pH sensor and conductivity can work simultaneously. Development of monitoring connected to the internet, so that monitoring can be accessed from anywhere and anytime. Development of the system towards the Smart Hydroponics System

## References

- [1] K Rose, S Eldridge, L Chapin. The Internet of Things (IoT): An Overview. The Internet Society (ISOC). Reston. Virginia. 2015.
- [2] M Chui, M Löffler, R Roberts. The Internet of Things. McKinsey Quarterly. 2010: 5.
- [3] R Jain. Introduction to Introduction to Internet of Things Internet of Things. Washington University, Saint Louis. 2015.
- [4] EMF d Jesus, MCM Neto. LibsensorPy: A Library to Improve the Development of Ubiquitous Applications on Raspberry Pi. in WebMedia '15 Proceedings of the 21st Brazilian Symposium on Multimedia and the Web, Manaus, Brazil. 2015.
- [5] A McEwen, H Cassimally, Designing the internet of things, Chichester: Wiley. 2014.
- [6] S Madakam, R Ramaswamy, S Tripathi. Internet of Things (IoT): A Literature. *Journal of Computer and Communications*. 2015; 3: 164-173.
- [7] J Buckley. From Rfid to the Internet of Things-Pervasive networked systems. Auerbach Publications, New York. 2006.
- [8] JPN Vicuña, FFR Castillo FLE, Urgilés, JRM Ríos. Raspberry Analysis in the Teaching of Computer Sciences. *International Journal of Applied Engineering Research*. 2017; 12(7): 1182-1189,
- [9] D Briere, P Hurley. Wireless Home Networking for Dummies, 4th Edition, John Wiley & Sons. 2010.
- [10] M Richardson, S Wallace. Getting Started with Raspberry Pi, Sebastopol: O'Reilly Media, Inc. 2012.
- [11] P Sachdeva, S Katchi. A Review Paper on Raspberry Pi. *International Journal of Current Engineering and Technology*. 2014; 04(06): 3818-3819.
- [12] WW Gay, Experimenting with Raspberry Pi, Apress, 2014.
- [13] N Urkude, M Gaur, B Gujar. A Study on Arduino Microcontroller & Its Applications. *International Journal of Research in Science & Engineering*. 2016; 2(6): 197-202.
- [14] A Mulyana, Y Wiradinata, R. Sutriadi. Internet of Things (IoT) for Urban Detailed Spatial Plan with Zoning Map in IOP Conference Series: Materials Science and Engineering, 2018.
- [15] A M Haris, S Shaikh. Raspberry PI. *International Journal of Research in Engineering Research & Technology (IRPERT)*. 2016; 1(1): 1-4.