Development Monitoring And Control System For Greenhouse Using Microcontroller Arduino

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ABSTRACT

Greenhouse is a building construction that serves to avoid and manipulating environmental conditions for the cultivation of plants for optimum growth. The conditions essentially kept in the greenhouse of which environmental conditions influence on plant growth processes such as temperature, air humidity, soil humidity, light intensity and others. But the condition is still not can be controlled and monitored properly, then do research on a greenhouse to design a system and application to automatically control and monitoring of the condition.

This system uses a microcontroller as a control center and sensors for measuring temperature, humidity, soil moisture levels, and light intensity. The value of the sensor readings are compared with the value of the set point for the mengerakan output as control automatically via a relay and sent to be stored and processed by the system so that the condition of the greenhouse can be monitored remotely through mobile applications.

This system is capable of automatically controlling set point monitoring based on the readings of the sensors as a tool in the process of maintenance and plant growth.

Keyword : Greenhouse, Humidity, Light, Microcontroller, Temperature

1. INTRODUCTION

Agriculture is an activity of utilizing biological resources made by human to produce food, industrial raw material, or energy source, and to manage its environment. Activity of utilization of biological resources by way of crop cultivation or cultivation which is agriculture activity at upstream include planting process followed by maintenance activities, and finally produce yield.

Natural conditions greatly affect the process of growth and production of crops, with unconfirmed changes in seasons and unstable natural conditions are now making agricultural activities to be threatened. In the world of agriculture, there is enough technology that can be applied to overcome various problems in agriculture. Application of agricultural technology in the form of greenhouse began to be adopted by farmers and agribusiness actors as an effort to conserve agricultural activities because it is considered to have several advantages, ie plants are relatively protected from pests and diseases, and environmental conditions are more awake.

Some environmental factors that affect the growth and production of plants such as temperature, humidity, and light. Low temperatures can cause damage to stems, young leaves, buds, flowers and fruit. The temperature is too high will damage the plant by disturbing the water respiration currents and water absorption that impacts the plants to wither. Plants obtain water supply from roots, excess moisture in the soil can increase harmful compounds for plant roots. Not only humidity soil moisture also affects the rate of evaporation or transpiration, if the humidity is high, then the transpiration rate is low and the absorption of nutrients is also low [14].

Light plays an important role in the process of plant photosynthesis to produce food as a source of energy, the lack of light interferes with the process of photosynthesis [14]. These factors need to be considered and maintained in accordance with the needs of plant growth, so it needs an integrated system and devices that can control and monitor the environmental conditions above so that the process of growth and production of plants can take place optimally and environmental conditions of the plant is always awake.

1.1 Identification

Based on the description on the background of the proposed problem, then the issues reviewed in this final report are as follows:

a. Lack of monitoring process of temperature and humidity in the process of plant growth and production.

b. The absence of monitoring tool moisture content in soil / humidity as planting medium.

c. Limited light intensity in the process of plant growth and production.

1.2 Objectives

The purpose of preparation of this final task to make applications control and monitoring on greenhouse automatically, is as follows:

a. Controlling and monitoring the ideal temperature for plants to grow with good results and maintained.

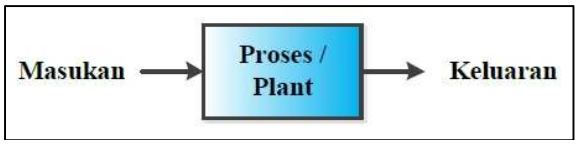
b. Carry out automatic monitoring and watering based on soil moisture to regulate moisture content in soil.

c. Measuring the intensity of light and providing additional light to support the process of plant growth and development.

2 LITERATURE REVIEW

2.1 Control System

Control system is an interconnection system of a system that will provide the desired system response. A linear-based system, which assumes a cause-and-effect relationship for system components. Therefore the controlled component or process can be represented by a block, as in Figure 2.1. The input-output relationship is the cause-effect relationship of the process, which is on an input component to provide an output signal variable [18].



Gambar 1. General Control System Diagram [18]

Control system is a system that aims to control a process for the resulting output can be controlled so that no error occurs against the reference specified. In this case the controlled output is stability, precision and dynamism [18].

2.2 Greenhouse

Greenhouse is a building construction that serves to avoid and manipulate environmental conditions in order to create the desired environmental conditions in plant maintenance. Greenhouse is also called "Greenhouse", as most greenhouses are made of translucent materials such as glass, acrylic, plastic and the like.

Building greenhouses is very useful for keeping plants from unfavorable environmental conditions, either to sunlight, humidity, temperature, wind, or to pests, so that better plant yields can be obtained [15].

2.3 Microcontroller

Microcontroller (micro controller) in an electronic circuit serves as a controller that regulates the working process of the electronic circuit. Inside a microcontroller IC there are CPU, memory, timer, seral and parallel communication channels, input / output ports, ADCs, etc. Microcontroller used in modern electronic system, such as: Car management system, computer keyboard, electronic measurement instrument, television, radio, printer, scanner, PLC (Programmable Logic Controller), robot, automation system, EDC (Electronic Data Capture) [1].

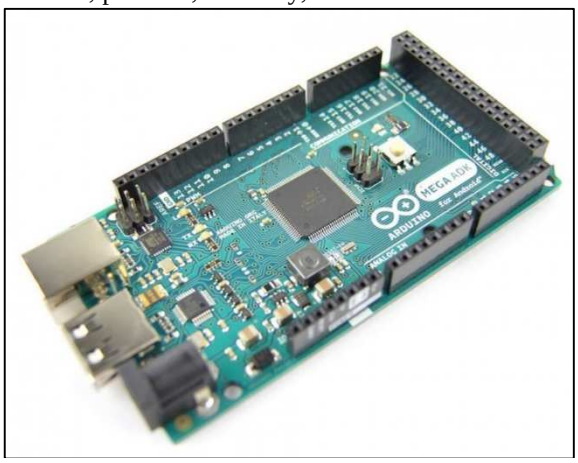
2.4 Arduino

Arduino is a microcontroller board that is open source, so we can use it and make modifications. Board Arduino using Chip / Atmel AVR microcontroller IC. Software used to create, compile and upload programs ie Arduino IDE.

Arduino IDE generates a hex file from a line of program instruction code that uses C language called sketch after it is compiled with Verify / Compile command. Bootloader Chip / IC on Board Arduino has been loaded by Arduino Bootloader program, which allows us to upload program code without using additional hardware.

The bootloader will be active for a few seconds when the board is reset, the compilation of the Arduino IDE can be used and run not only on the Arduino board but can also run on the appropriate AVR microcontroller system even without the bootloader.

This device is intended to utilize microcontroller as control, controlling in making prototype or implementation. Arduino can be used to detect the environment by receiving input from several sensors such as light, temperature, infrared, ultrasonic, distance, pressure, humidity, etc.



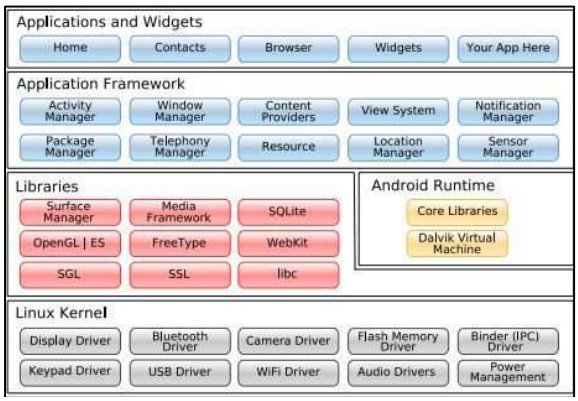
Gambar 2. Board Arduino Mega ADK [1]

2.5 Adnroid

Adnroid is a mobile operating system that grows in the middle of other operating systems that are developing today. Other operating systems such as Windows Mobile, i-Phone OS, Symbian and many more also offer a wealth of content and optimization running on existing hardware devices. However, this existing operating system runs by prioritizing the built-in core application without seeing any substantial potential of third-party applications. Therefore, there is limited distribution of third-party applications for their platforms.

Adnroid offers a different environment for developers. Each app has the same level. Adnroid does not distinguish between core applications and third-party applications. The Application

Programming Interface (API) provided offers access to hardware, or even mobile data, or system data. Even users can remove the core application and replace it with a third-party app. Serves as an operating system for mobile devices Adnroid has an architecture, the outline of the Adnroid operating system architecture can be explained as follows [7]:



Gambar 3. Android Architecture [7]

2.6 Java

Java is a high level programming language (high level), meaning that this language is easily understood by humans in general, because it uses human everyday language. Java was originally created by the Sun Microsystems company, by James Ghosling, Patrick Naughton, and Mike Sheridan in 1991, and it took approximately 18 months to develop the first version of Java that used to be called Oak, which Java is now acquired by Oracle. Java is usually used for development of Desktop Applications (computers), Web Applications, Mobile Applications, Embedded Systems, Robots, Games, etc.

Java language is similar to C ++ language, but developed to be easy to understand and use. Java uses the concept of OOP (Object Oriented Programming), meaning that all the core program from Java is referring to an Object. Java includes an independent platform, which means you can run with a variety of OS (Operating System) and computer architecture. Like on Adnroid devices from Google, and Some Desktop Applications, such as AntiVirus programs, media player programs, Enterprise Applications etc. [11].

2.7 Java Script Object Notation

Based on its official website www.json.org, JSON is part of the Java Script programming language (Standard ECMA-262 3rd Edition - December 1999). JSON is a fully independent text format but uses conventions that are familiar with C-family programming languages, including C, C ++, C #, Java, Java Script, Perl, Python, and so on. It is this advantage that makes JSON an ideal data-interchange language. JSON is built in two structures [10]:

A. Multiple pairs of names / values. In some programming languages commonly referred to by the term object, record, struct, hash table, key list or associative array.

B. The values are an ordered list. Commonly referred to as arrays, vectors, lists or lists in programming languages.

JSON is a universal data structure, in the sense that it can be used in various programming languages. Almost all programming languages fully support JSON in various formats. This allows data formats that can be exchanged using a programming language also using the basis of the JSON structure [10].

2.8 Web server apache

Apache merupakan server web yang dapat di jalankan di berbagai sistem operasi yang berbesa seperti Unix, BSD, Linux, Windows dan Novell Netware yang bertugas untuk melayani fasilitas web dengan menggunakan protocol http. Apache sendiri bersifat open source, yang artinya dapat digunakan secara bebas oleh semua pengguna. Apache di kenal memiliki fitur-fitur canggih seperti penanganan pesan kesalahan yang dapat di konfigurasi serta otentikasi berbasis basis data, dan memiliki tampilan GUI yang memungkinkan penanganan server menjadi mudah.

Web server apache akan bekerja saat pengguna mengetikkan request melalui protocol http:// untuk membuka suatu halaman. Apache akan menjawab request yang di ketikkan user dan kemudian menampilkan halaman yang di minta. Secara sederhana dalam pembuatan web akan menggunakan PHP sebagai bahasa pemrograman untuk memberikan intruksi-intruksi tertentu kepada computer[13].

2.9 My Structure Query Languag

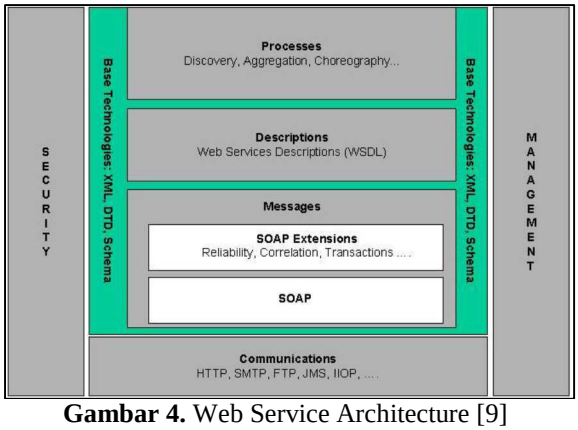
My Structure Query Language (MySQL) is a software SQL database management system (Data Management System) or the DBMS of the many DBMS, such as Oracle, MS SQL, Postgre SQL, etc. MySQL is a multithread, multi-user, open source DBMS under the GNU General Public License (GPL). The reliability of a DBMS can be known from the way its optimizer performs the SQL commands it creates. In addition to MySQL is flexible with various programming, MySQL also has an interface to various applications and programming languages by using the API function (Application Programming Interface).

2.10 Web Service

Web service is a computing entity that can be accessed through internet or intranet network with certain protocol standard in platform and interface of independent programming language. The purpose of the development is to bridge communication between programs, so that applications that one and

other applications contained on a same network or on different networks can communicate with each other as long as using the standard protocol set by the web service. This can happen, because the protocol standard is not tied to a platform or programming language. The protocol itself is built by Extensible Markup Language (XML) which in fact has been supported by many platforms, programming languages, and by developers around the world.

The web service architecture is built by multiple layers and interconnected technologies. Many ways to visualize the service, as much as how to build and use the following image web services are just one way to describe the architecture [9].



Gambar 4. Web Service Architecture [9]

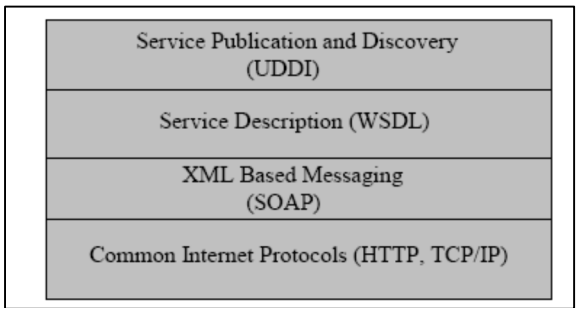
Web Service is structured by three standard components:

a. Simple Object Access Protocol (SOAP)

b. Web Service Definition Language (WDSL)

c. Universal Description, Discovery and Inttegration (UDDI)

The existence of such standards makes the web service easy to access through multiple interfaces and also allows for possible systems built on different platforms and different languages to collaborate on in a job [9].



Gambar 5. Web Service Components [9]

Web Service as a whole has four layers of components as shown above:

a. Layer 1: Standard Internet protocols such as HTTP, TCP / IP

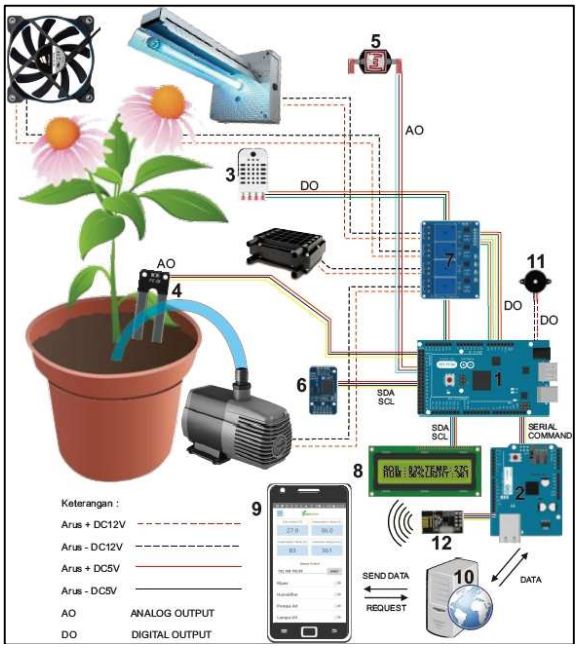
b. Layer 2: Simple Object Access Protocol (SOAP), an XML-based object access protocol used for data / information exchange between services.

c. Layer 3: Web Service Definition Language (WSDL), is a standard language in XML format that serves to describe all available services.

3 DESIGN

3.1 System Design Analysis

Analysis of system architecture is a process to describe the physical system to be built and also its supporting components. Here is a picture of the system architecture that will be built as in the picture below.

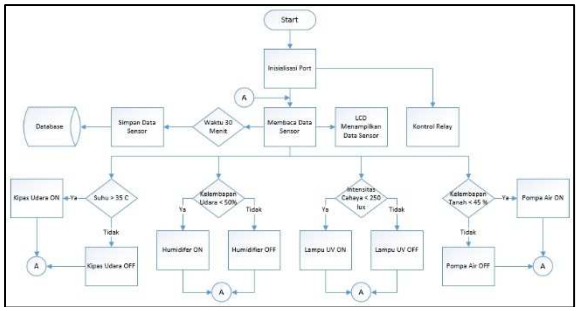


Gambar 6. System Design Architecture

Here is an explanation of the architecture picture of controlling and monitoring system of greenhouse using arduino microcontroller:

1. Board Arduino Mega ADK, serves as the core of the system to perform reading, organizing, processing to display data from all devices and components connected in the system.
2. Ethernet Shield, serves as the sender of data from the Arduino board to the web server and as a receiver of commands from system apps already installed on Android-based smartphone devices.
3. DHT11 sensor, used to measure the value of air temperature and humidity value in greenhouse environment. The value of the sensor is sent to the Arduino board for processing, display and storage.
4. Soil mousture sensor, used as a measure of the level of soil moisture in the greenhouse environment. The humidity level values are sent to the Arduino board for processing, display and storage.
5. Light Dependent Resistor (LDR), serves as a measure of light intensity values. The value of the

LDR sensor is processed by the Arduino board to obtain the LUX light quantity.
6. Real Time Clock (RTC) module, functions to display time data in real time, as system counter in running a case in system.
7. Relay 4 Channel Module, functions as a circuit breaker and connecting electrical current. These relays are connected with water pumps, air fans, humidifiers and lamps. The relay will set ON or OFF any connected device based on the value sent from the Arduino board.
8. LCD Display, serves to display data and system status in real time on Arduino devices.
9. Android Smartphone, used as the interface between the user with the system to perform control and monitoring system that can later see the stored data, bypass control of the water pump, lights, fan and humidifier.
10. Web Server, serves to perform or will transfer user request files via HTTP communication protocol, SQL query processing on database, php command execution.
11. Buzzer Alarm, serves as a system notification. The alarm will be active when the system detects triggers based on parameters already specified in the system.
12. Wifi Module ESP8266, serves as a communication medium between Arduino board with mobile devices / smartphone to control the relay module.



Gambar 7. Flowchart Process System

3.2 Hardware Requirements

The hardware that will be used based on the minimum requirement that must be fulfilled are:

A smartphone device with an Android operating system. Used as an interface between users with control systems and monitoring greenhouse, through mobile devices / smartphone berrbasis Android users can view and perform direct control of the system. The minimum requirement of adnroid smartphone device can be seen in the following table.

Tabel 1. Mobile / Smartphone Hardware

No	Perangkat Keras	Spesifikasi
1	Sistem Operasi	Android 4.0 Ice Cream Sandwich
2	Processor	800Mhz
3	RAM	512Mb
4	Memory Internal	1Gb

Relays are electrically operated switches and are Electromechanical components consisting of 2 main parts namely Electromagnet (Coil) and Mechanical (a set of Switch Contacts / Switches are used as controller connectors as well as electric circuit breakers connected to water pumps, UV lamps, Fan and humidifier.

Tabel 2. Hardware Relay 4 Channel Module

Relay	4 Channel
Signal Control	TTL Level
Max Switch Voltage	250 VAC 30 VDC
Indikator	LED
Operating Voltage	5V
Contact Action	10ms / 5ms

DHT11 is a digital sensor that can measure the temperature and humidity of the surrounding air.

Tabel 3. DHT11 Hardware

Operating Voltage	5V
Temperature Range	0-50 C error 2 C
Humidity Range	20-90% RH error 5% RH
Interface	Digital
Interchangebility	Fully Interchangeable
Long Term Stability	< 0.5% RH / year

Soil mousture sensor is a sensor that can detect the humidity of surrounding soil. This sensor consists of two probes to pass an electric current in the ground as shown in the figure below. Then read the resistance to get the value of humidity level.

Tabel 4. Hardware Soil moisture sensor

Operating Voltage	5V
Output Voltage	0-4.2V
Current	35mA
Pin	VCC, GND, DO, AO
Size	60x20x5cm

Light Dependent Resistor (LDR) is a type of Resistor whose resistance value or resistance value depends on the intensity of the light it receives. LDR resistance values will decrease during bright light and the barrier value will be high if in dark conditions.

Tabel 5. Hardware Light Dependent Resistors

Operating Voltage	5V
Sensitivity Control	Potensiometer
Pin	VCC, GND, AO, DO
Signal Output	Digital / Analog
Indikator	LED

Real Time Clock (RTC) is an electronic clock in the form of a chip to calculate the time (from seconds to years) accurately and keep / keep the time data in real time.

Tabel 6. Hardware Real Time Clock Module

Operating Voltage	5V
Clock Chip IC	DS3231
Clock Accuracy	0-40 range 2ppm
Memory Chip	AT24C32 (storage 32K)
Battery	CR2032

Ethernet Shield is a module to facilitate the interface between ethernet communication with microcontroller. This module works with TTL voltage level. Applications of this module are embedded web servers, embedded DHCP servers, and other applications related to ethernet communication. Ethernet Shield module is used as a medium / communication interface through TCP / IP protocol to send the process data from the sensor on the system to be stored in the database.

Tabel 7. Hardware Ethernet Shield Module

Input Voltage	36V-57V
High efficiency DC/DC converter	typ 85% @ 80% load
Chip	Wiznet W5100
Speed	10/100Mb
TCP/IP Protocols	TCP, UDP, ICMP, IPv4, ARP, IGMP, PPPoE
Internal Memory	32Kbytes RX/TX Buffer
Indikator	LED
SD Library	Micro SD on board
Compliant	IEEE802.3af
Connector	RJ45 (HR911102A)
Size	7cm x 5.25cm x 2.25cm

Wifi Module ESP8266 is a wifi module that lately more popular with hardware developers. Another plus, ESP8266 can run the role as an adhoc access point or client at once. Wifi Module ESP8266 is used as a medium of communication between mobile devices / smartphones that users use as a direct control of the system.

Tabel 8. Hardware Wifi ESP8266 Module

Protocols	802.11 b/g/n/e/i
Frequency Range	2.4G ～ 2.5G (2400M ～ 2483.5M)
Antena	PCB Trace, External, IPEX Connector, Ceramic Chip
Operating Voltage	2.5V ~ 3.6V
Current	80mA
Security	WPA/WPA2
Encryption	WEP/TKIP/AES
Network Protocols	IPv4, TCP/UDP/HTTP/FTP
Peripheral	UART/SDIO/SPI/I2C/I2S/IR
Interface	GPIO/ADC/PWM/LED
User Configuration	AT Instruction Set, Cloud Server, Android/iOS App

3.3 Software Requirements

The software used in the construction of this system is as a medium to connect the use of commands with hardware that works in a system as for the software used can be seen in the table below.

Tabel 9. Software Requirements

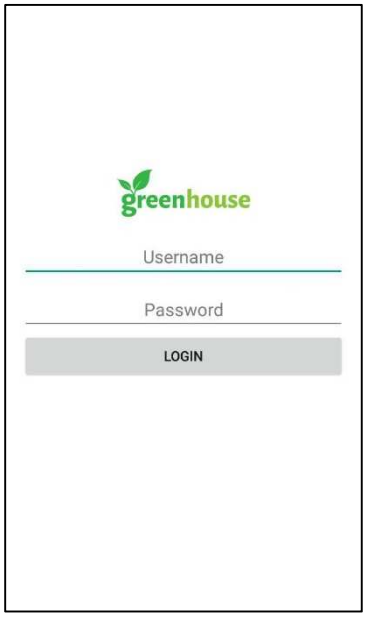
Perangkat Lunak	Fungsi
Arduino IDE	Perancangan sketch program dan upload sketch program Arduino
Text Editor	Perancangan script php dan JSON
Android Studio	Pembangunan aplikasi mobile berbasis Android
MySQL	Media penyimpanan data dan sistem manajemen basis data
File Transfer Protocol	Transfer file via protokol FTP

4 IMPLEMENTATION

The following interface implementation is the result of designing the already created interface. Here is a view for the results of the implementation of research on the previous design.

4.1 Login Interface

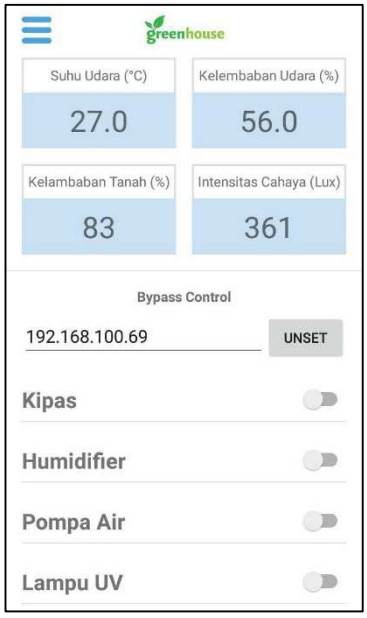
On the login page the user must enter a username and password to be able to use the application system control and greenhouse monitoring.



Gambar 8. Login Interface

4.2 Main Page Interface

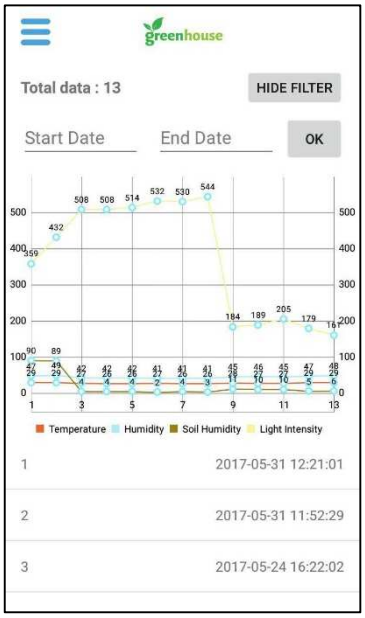
On this page users can view the greenhouse status in realtime, the user can also control the water pump, light, humidifier and fan by entering the control system's IP Address and shifting the ON / OFF control button of each tool.



Gambar 9. Main Page Interface

4.3 Graphical Data Interface

On this page all data stored in the database is displayed in the form of data garfik, user can do filter / data selection to be displayed based on time to be displayed.



Gambar 9. Graphical Data Interface

4.4 Log Data Interface

On this page all data stored in the database is displayed in the form of log data, the user can do filter / selection of data to be displayed based on the time to be displayed.



Gambar 10. 4.4 Log Data Interface

4.5 Light Intensity Testing

Light Dependent Resistor (LDR) sensor testing on the measurement of light intensity is done by comparing the measurement results from DHT11 with luxmeter HS1010 directed directly to sunlight. The sampling of DHT11 sensor test data is done for 3 hours with recording interval once 15 minutes.

Tabel 10. Measurement of Light Intensity

Time	LDR (Lux)	HS1010 (Lux)	Difference (Lux)
13/8/17 11:00	210	209	1
13/8/17 11:15	208	201	7
13/8/17 11:30	213	217	4
13/8/17 11:45	215	220	5
13/8/17 12:00	219	213	6
13/8/17 12:15	221	224	3
13/8/17 12:30	218	211	7
13/8/17 12:45	223	231	8
13/8/17 13:00	227	229	2
13/8/17 13:15	228	232	4
13/8/17 13:30	231	233	2
13/8/17	226	227	1

13:45			

From the results of LDR sensor testing with measuring instrument HS1010 comparison in the above table can be concluded that the results of light intensity measurement of LDR sensor approaching the measurement results using the measuring instrument HS1010, with an average error of ± 4.1.

4.6 Testing Temperature and Humidity

DHT11 sensor testing of temperature and humidity measurements was done by comparing the measurement results of DHT11 with HTC-2 digital humidity thermometer. The test was carried out with an initial temperature value of 30 ° C and 57% moisture on the DHT11 sensor, by bringing the sensor and comparator close to a wax with a distance of ± 5 cm in a room. Sampling of DHT11 sensor testing data is done for 30 minutes with 3 minute recording interval.

Tabel 11. Measurement of Temperature Humidity

DHT11		HTC-2		(˚C)	(%)
(˚C)	(%)	(˚C)	(%)		
30.67	50	30.87	52	0.2	2
31.36	51	32.06	55	0.7	4
32.84	51	34.14	55	1.3	4
33.45	54	33.85	62	0.4	8
33.89	55	35.59	61	1.7	6
35.12	54	37.22	59	2.1	5
35.69	56	37.29	62	1.6	6
36.31	57	37.41	60	1.1	3
36.82	57	37.32	64	0.5	7
37.41	57	38.41	65	1	9

4.7 Soil Humidity Testing

Testing Soil mousture sensor is done by measuring the humidity level of soil in the plot area of ± 10m2 as a sample value from the measurement of soil moisture level with position placement of different measurement sensors.

Tabel 10. Measurement of Soil Humidity

Condition	Soil 1 (%)	Soil 2 (%)	Soil 3 (%)	Soil 4 (%)	Difference (%)
Before Watering	43	40	41	39	4
	45	39	43	41	6
	42	41	42	43	2
	41	43	46	42	5
After Watering	72	68	69	70	4
	68	67	71	71	4
	71	70	73	74	4
	73	73	70	72	3

From the results of Soil moisture sensor testing on a field of planting produced the difference in measurement with an average difference of ± 3.5.

4.8 Analysis of Test Results

Of the overall test results that have been done, the system of control and monitoring of this greenhouse can function in accordance with the previous design. This tool can run its function based on set point or manually through the mobile application, data measurement results can be stored on the web server and displayed through the application. The data already stored can be viewed in the form of graphs or log data.

5 CONCLUSION

5.1 Conclusion

Based on the results of analysis, design, implementation, testing software and hardware on the system that has been done, can be drawn the following conclusions:

a. Control and monitoring systems can help shop owners in the process of growing and growing plants.

b. Systems and applications are able to help control and monitor the temperature, humidity, moisture and light intensity well and in accordance with the design, both hardware design and software design based on the results of implementation and testing.

5.2 Suggestion

As for some suggestions that writers can convey to the further development of the system designed among them as follows:

a. Using solar panels as a resource that harnesses energy from sunlight.

b. Can add visual mode by using the camera so that it can be viewed directly.

c. Develop the process of data transmission and connection between software and tools to be more stable.

d. Added a feature to make set point changes via app

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