Computer Engineering and Applications Vol. 5, No. 2, June 2016

Smart Home: Controlling and Monitoring Households Appliances Using Gsm Network

Budi Rahmadya, Fahrul Ghazi, Derisma

Department of Computer Engineering, Faculty of Information Technology, Andalas University, Indonesia
email: budi-r@fti.unand.ac.id

ABSTRACT

This study discussed about using the smart home automation systems for household appliances such as lights and fans, by utilizing the GSM network as a communication medium to control and monitor the household appliances. In this study, the simulations were performed by the two following modes 1). Self-automated and 2). Manually-automated. In controlling the lamp, the light intensity that values less than 280 lux will give response of turned ON the lamp, while if the value of light intensity is more than 280 lux, it will give a response of turned OFF the lamp. To control the fan, a room temperature value of more than or equal to 30 ° C will turn ON the fan, while the room temperature value which is less than 30 ° C will turn OFF the fan. Simulations were performed by placing the devices in the room and operating it for three days. The test and simulation results were recorded in the form of log files or history files. The self-automated operations mode controlled the system using a sensor (Light Dependent Resistor and LM35 Sensor) unit to detect the environmental condition and take actions according to detected environmental condition. In the manually-automated operation mode, user could control the household appliances according to the user's intention. The light intensity values obtained in the morning were equal to 280 lux, so it will turn off the lights. The room temperature obtained was in the range of 28oC - 33oC; the fan will turn on if the temperature value is equal to or more than 30oC.

Keywords: Automation System, GSM Network, Household Appliances, Light Dependant Resistor Sensor and LM35 Sensor.

1. INTRODUCTION

The concept of smart home has attracted the attention of the information technology experts, and using more advanced technology, smart homes were developed into more sophisticated technology. The smart home which used an automation system makes an ordinary house into an intelligent house. With the automation system, manual task such as closing and opening the door are done automatically because they are performed by the previous automation system. Then, to be able to interact, users and automation systems can use wireless communication to makes the communication easier. Darianian. M, and Martin. P. M [1] has conducted research about smart home using the concept of IOT. The research focuses on discussing the use of energy utilized to reduce the higher cost using mobile RFID. Simulations were done for household appliances.

With the smart home that uses wireless network, an SMS (Short Message Service) would be the medium for the communication. In its implementation the SMS commands can be used as a command interface in the form of a short message, which will then be executed by the appliances in the smart home, such as for turning off or turning on the lights through the SMS. In order for the SMS commands to be executed by the appliances, a microcontroller will serve as an interpreter which interpretss the short message into a line of command. Han, D. M., and Lim. J. H [2] introduced a research discussing the smart home to save energy that is used in electrical household appliances. They used Zigbee communication media for communication control device. In the simulation conducted by the researcher, a working concept of Kruskal's algorithm was used. Results of this study prove that the method used have the ability to save the use of electrical energy.

This paper discussed the smart home automation system, the household appliances monitoring and control by means of SMS could become more sophisticated with the use of microcontrollers like the Arduino. With the use Arduino as the microcontroller, several sensors could be added as the main components in automated system. With a light sensor, a lamp can be turned off when the light is bright, and when it is dark the lamp can be switched on automatically. To find out the status of the lamp, SMS is used as a medium of communication, so the users could retrieve information about the controlled lamp. Other examples of the use microcontroller were its implementation on household appliances. It can be used as an alternative option to improve the comfort, safety and management of household appliances such as fans, lamps, televisions, and others. One of the benefits of using automation systems with microcontroller in household appliances is the ability to conduct electric power efficiency.

2. THE THEORY

2.1 AUTOMATION SYSTEM

Automation system could be stated as a series of several devices, each of which individually has different functions but interrelated, forming an integrated system that continuously check the predisposed input conditions then execute the task as its function automatically or intelligently [3]. Several small systems could be integrated into larger and more complex systems.

2.2 LM35 TEMPERATURE SENSOR

LM35 is a temperature sensor manufactured by National Semiconductor that has a high accuracy [4]. The output is in form of an analog voltage and has a measurement range from -55ºC to + 150ºC with an accuracy value ± 0.5ºC. The output voltage is 10mV / ºC. Output ports could be connected directly to a microcontroller that has ADC or to Arduino, since Arduino has a port for the ADC (analog input) as 6 pieces. The circuit module temperature sensor as Figure 1 below:

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

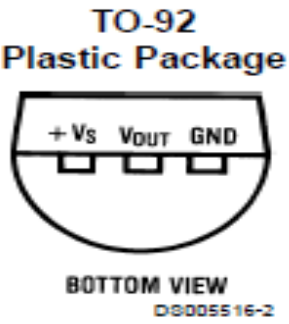

FIGURE 1. LM35 Temperature Sensor [4]

As shown on Figure 2.1, the LM35 temperature sensor has three legs, namely: the first legs (+ Vs)is connected to the (Vcc) with value +5V voltage. The Arduino Uno board and the feet GND is connected to ground, while at the foot (VOut) which is the output of the processed analog data from LM35 sensor connected to the analog inputs on the Arduino Uno board.

2.3 LDR Sensor

The output of the LDR sensor is in the form of resistance, but we still can calculate the light intensity in lux, but this data reading is inaccurate. There is a formula related to the resistance of a LDR towards light intensity in lux, as shown below:

I. $$\boldsymbol{R_{ldr}} = \frac{\mathbf{500}}{\mathbf{lux}} \quad (1)$$

Rldr value depends on the counted voltage that passes LDR, by reading the voltage, it can be used separately to calculate Rldr and to calculate the light intensity in lux. If the sensor LDR given input voltage is 5 volts, and 10 KΩ resistor, the output voltage will be:

$$V_{out} = \left(\frac{5}{10+R_{ldr}}\right) * R_{ldr} \quad (2)$$

$$V_{out} = \frac{5*R_{ldr}}{10+R_{ldr}} \quad (3)$$

II.

Since it does not count the voltage, but a value between 0 and 1024, each section of the voltage can be counted by dividing 5 by 1024 which is equal to 0.0048828125. Thus the last formula can be made as follows:

$$V_{out} = AnalogReading * 0.0048828125 \quad (4)$$

Then

$$R_{ldr} = \frac{10V_{out}}{5-V_{out}} \quad (5)$$

As mentioned above, Rldr is read in kilo ohms. Thus, the formula can be written as follows [5]:

$$\text{Lux} = \frac{500 * (5 - V_{out})}{10 * V_{out}} \quad (6)$$

The above formula is ready be written in the form of lines of program, and to be used in measuring the intensity of light in lux units.

3. SYSTEM DESIGN

3.1 Block Diagram System

At this stage, the block diagram system was designed as shown in Figure 2 as follows:

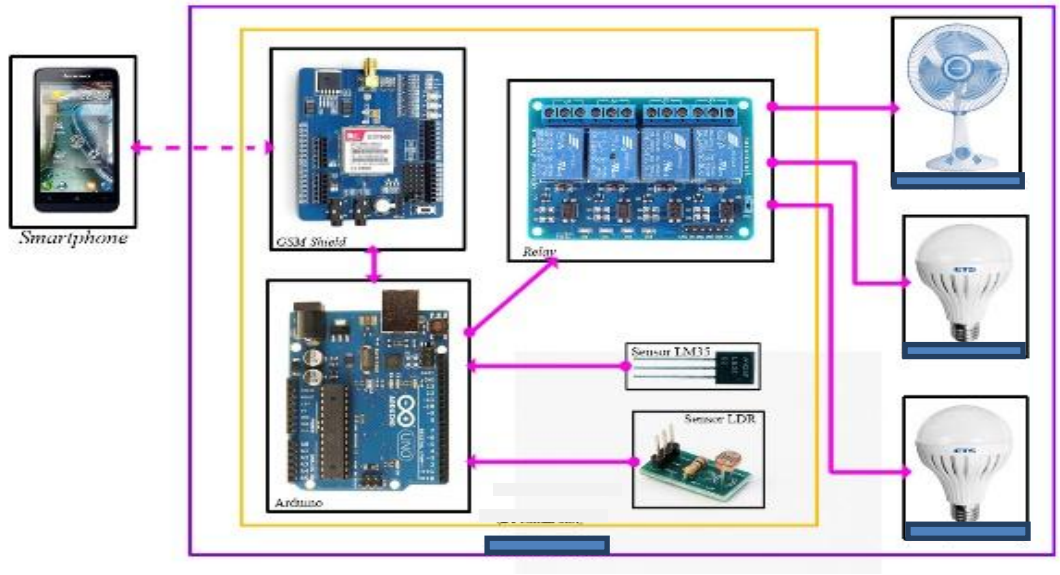

FIGURE 2. Block Diagram System

Information:

1. Smartphones will always communicate with the automation systems through GSM Shield. These communications are established by sending and receiving SMS, sent back by the automation system.
2. In operating mode in which the user controls the home appliances (manually-automated), the smartphone will send the commands to the Arduino via GSM Shield, then the commands will be executed by Arduino through the relay. Relay serves as a switch that will turn on or turn off home appliances based on the contents of the SMS received by the Arduino.
3. In operating mode in which the sensor controls the home-appliances (self-automated), 2 pieces of lamp will be controlled by the Arduino based on the light intensity which is read using a LDR sensor. The cooling fan will be controlled by the Arduino based on the environmental temperature that sensed by the LM35 sensor.
4. Smartphone will receive the status of any changes in the lamp and fan through the SMS

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

3.1.1 GSM SHIELD ARDUINO DESIGN

The control and monitoring function of automation systems are built through sending and receiving Short Message Service (SMS), which use the Arduino GSM Shield composed as seen in Figure 3.

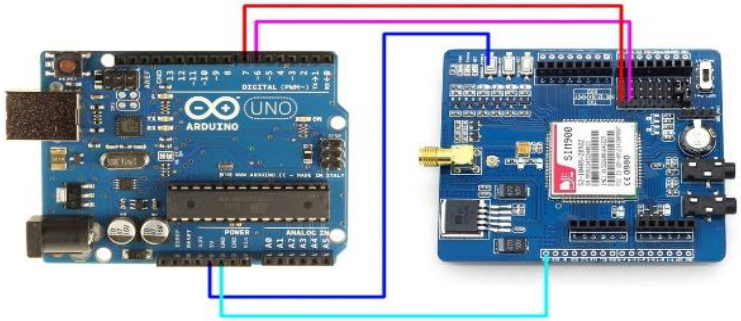

FIGURE 3. Arduino Circuit with GSM Shield

3.1.2 FAN CONTROL DESIGN

This research used cooling fan to cool the hot air in a room. The hot temperature was read by the sensor LM35. Figure 4. below illustrate the circuit controlling the fan in a room:

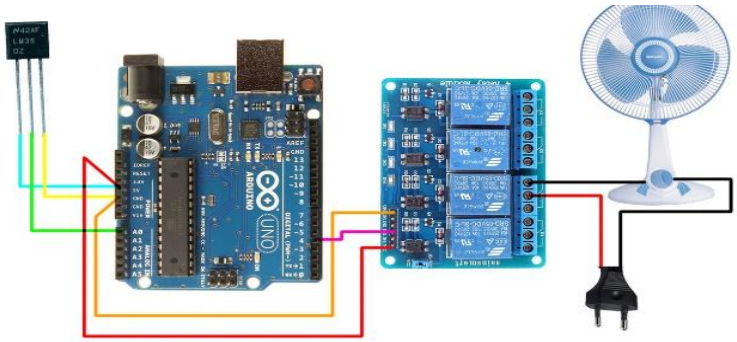

FIGURE 4. Fan Control Circuit

3.1.3 LIGHTING CONTROL DESIGN

In order to turn on and turn off (on/ off) the lamp automatically adapting the light intensity conditions, the lamp would be connected to the relay, the sensor LDR serves as a detector of light intensity (lux) which provides input to the Arduino and runs commands on the lamp based on the input of previous light condition. Illustrated in Figure 3.4 is lamps control circuit with a LDR sensor:

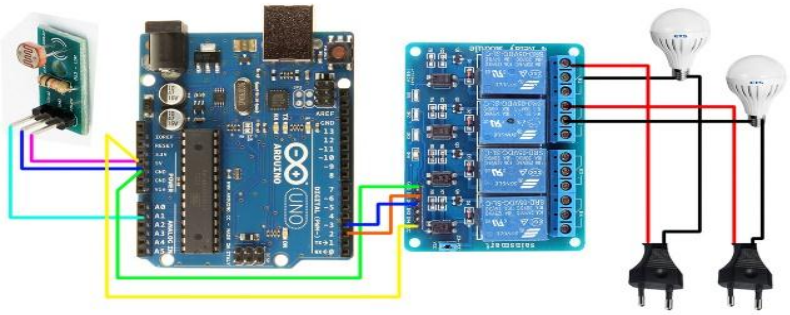

FIGURE 5. LDR sensor circuit with Lamps

4. TESTING AND ANALYSIS

Data used to analyze the working process of the hardware is acquired from this test. The device of automation system for monitoring and home appliances control made for this research is shown on figure 6.

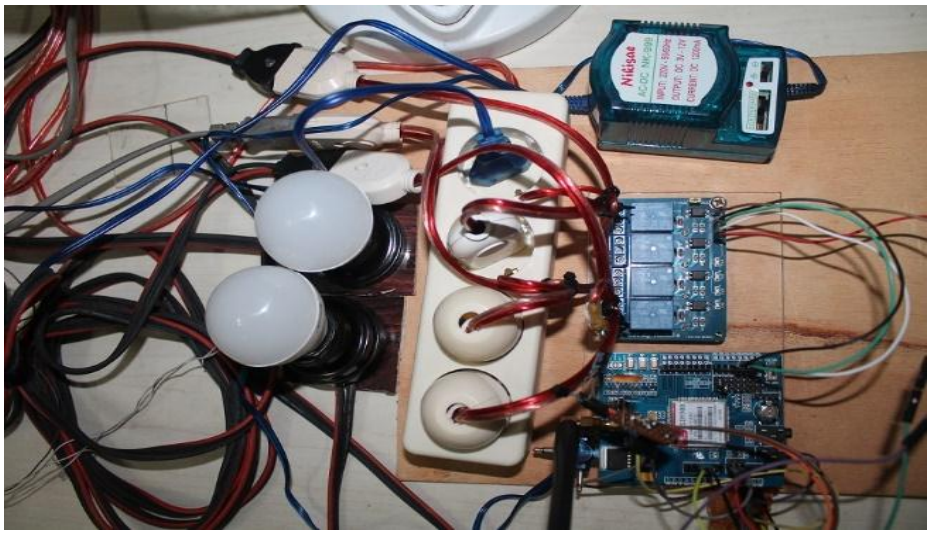

FIGURE 6. The devices of automation system for monitoring and home appliances control via sms

4.1 HARDWARE TESTING DAN ANALYSIS

A. THE LM35 TESTING

This test is done to measure the reading accuracy of LM35 sensor by calibrating the LM35 sensor. The calibration is done by connecting the legs of 2 LM35 sensors (output) with the multimeter legs to read the output voltage of the sensor. After that, both sensor and thermometer are exposed to heat source. Temperature readout is done every five seconds during two minutes. Table 1 shows the result of tempeature calibration of LM35sensor.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

TABLE 1.
LM35 Calibration Result

No	Time (s)	LM35 (volt)	Thermometer temperature (^oC)
1	5	0,3217	30
2	10	0,3215	30
3	15	0,3197	30
4	20	0,3197	30
5	25	0,3198	30
6	30	0,320	30
7	35	0,3197	30
8	40	0,3196	30
9	45	0,3195	30
10	50	0,3192	30
11	55	0,3197	30
12	60	0,3197	30
13	65	0,3203	30
14	70	0,3208	30
15	75	0,3218	30
16	80	0,3228	30
17	85	0,3240	30
18	90	0,3250	30
19	95	0,3260	30
20	100	0,3273	30

B. LDR SENSOR TESTING

LDR testing is done outside the room by putting both LDR and lux meter in the same place. In order to achieve lux values in shaded, sunlit, and dark conditions, the test is done in the morning, at noon, and at night. The data result of the comparison of light measurement between LDR and Lux meter is presented in Table 2 below :

TABLE 2.
LDR Test Result

No	**Morning**			**Noon**			**Night**		
	LDR (lux)	**Lux Meter (lux)**	**Error Percentage (%)**	**LDR (lux)**	**Lux Meter (lux)**	**Error Percentage (%)**	**LDR (lux)**	**Lux Meter (lux)**	**Error Percentage (%)**
1	276	258	6.52 %	1390	1293	6.98 %	10	10	0.00 %
2	272	258	5.15 %	1431	1487	3.91 %	10	10	0.00 %
3	280	259	7.50 %	1313	1519	15.69 %	10	11	10.00 %
4	276	260	5.80 %	1476	1487	0.75 %	10	11	10.00 %
5	276	261	5.43 %	1390	1454	4.60 %	12	11	8.33 %
6	274	261	4.74 %	1350	1427	5.70 %	11	11	0.00 %
7	283	262	7.42 %	1390	1313	5.54 %	11	10	9.09 %
8	278	263	5.40 %	1350	1393	3.19 %	9	10	11.11 %
9	276	263	4.71 %	1313	1500	14.24 %	11	11	0.00 %

10	274	264	3.65 %	1313	1430	8.91 %	11	11	0.00 %
	Average Error Percentage		**5.63** %	**Average Error Percentage**		**6.95** %	**Average Error Percentage**		**4.85**%

IV. C. GSM SHIELD TESTING

V.

This GSM Shield data communication test is selected to measure the speed of data communication of the GSM Shield. For this reason, Putty software is utilized. Putty is put in connection with the GSM shield by adjusting the serial port on a computer that has been connected to Arduino and installed with GSM Shield.

On the Arduino that has been connected to a computer, a similar line serial, COM6, is used. However, the speed is adjusted based on the baudrate of GSM communication in general. The data of the GSM Shield communication speed test is presented in Table 3 below :

TABLE 3.
The Result of GSM Shield Data Communication Speed Testing

No	*Baudrate* (bps)	Terminal Putty Readout (text)	Status
1	1200	~æ	failed
2	2400	ÿ	failed
3	9600	status=READY	succeed
4	19200	~~fæøff``f	failed
5	38400	øxøxxøxxxxøxxxxxxxx	failed
6	57600	àààààààààààààààààààààààààà	failed
7	115200	tidak ada	failed

The test is followed by a GSM Shield time response test in 9200 bps baudrate. The test was done three times to find the result for the fastest time response, since if the test is done only once then the time response would not be valid due to the changeable SMS time response during a busy GSM network time. Therefore, the test was conduted three times to obtain the fastest time response that would then be used as a comparative data measurement. The result is presented in Table 4 below:

TABLE 4.
The Result of GSM Time Response Testing using SMS

No	Numb. of Characters	Data size (bit)	Time Response Testing (s)			Fastest Time (s)
			1	2	3	
1	10	80	3	5	6	3
2	20	160	4	4	3	3
3	30	240	6	3	9	3
4	40	320	6	4	10	4
5	50	400	21	5	6	4
6	60	480	9	5	8	4
7	70	560	8	10	7	4
8	80	640	8	10	12	4
9	90	720	8	11	11	4
10	100	800	9	9	8	4
11	110	880	10	5	8	5
12	120	960	13	5	7	5

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

13	130	1040	9	5	8	5
14	140	1120	8	9	5	5
15	150	1200	7	9	8	5
16	160	1280	7	9	8	6
17	170	1360	9	20	11	9
18	180	1440	10	21	15	10
19	190	1520	12	15	14	12
20	200	1600	20	12	13	12

4.3 COMPLETE SYSTEM TESTING AND ANALYSIS

4.3.1 FIRST SIMULATION OF AUTOMATION SYSTEM TESTING

The first simulation was done by turning on the device for 24 hours. The result of the first simulation is presented in the history of automation system on Table 5 below:

TABLE 5.
First Simulation History

No	Date/Time	Lamp 1	Lamp 2	Cooling Fan	Auto	Temp-erature	Lux
1	12/1/2016 6:00 AM	ON	ON	OFF	ON_AUTO	25.98	30
2	12/1/2016 6:07 AM	ON	ON	OFF	ON_AUTO	27.21	33
3	12/1/2016 7:09 AM	OFF	OFF	OFF	ON_AUTO	28.65	800
4	12/1/2016 8:14 AM	OFF	OFF	ON	ON_AUTO	30.91	1200
5	12/1/2016 9:18 AM	OFF	OFF	OFF	OFF_AUTO	31.37	1097
6	12/1/2016 11:00 AM	OFF	OFF	OFF	OFF_AUTO	31.78	1281
7	12/1/2016 11:28 AM	OFF	OFF	ON	OFF_AUTO	31.2	1244
8	12/1/2016 12:00 AM	OFF	OFF	ON	OFF_AUTO	29.56	1459
9	12/1/2016 14:05:23 PM	OFF	OFF	ON	OFF_AUTO	31.21	1247
10	12/1/2016 14:08:04 PM	OFF	OFF	ON	OFF_AUTO	33.13	1026
11	12/1/2016 15:05:18 PM	OFF	OFF	ON	ON_AUTO	31.58	1000
12	12/1/2016 16:00:44 PM	OFF	OFF	ON	ON_AUTO	31.31	1417
13	12/1/2016 17:30:08 PM	OFF	OFF	ON	ON_AUTO	32.28	1370
14	12/1/2016 18:00:58 PM	OFF	OFF	ON	ON_AUTO	33.17	987
15	12/1/2016 18:29:60 PM	OFF	OFF	ON	ON_AUTO	30.36	399
16	12/1/2016 18:45:21 PM	ON	ON	OFF	ON_AUTO	29.33	99

17	12/1/2016 19:00:48 PM	ON	ON	OFF	OFF_AUTO	29.33	58
18	12/1/2016 20:00:27 PM	ON	ON	OFF	OFF_AUTO	28.8	64
19	12/1/2016 21:00:47 PM	ON	ON	OFF	OFF_AUTO	29.06	40
20	12/1/2016 22:00:48 PM	ON	ON	OFF	OFF_AUTO	29.56	33

Table 4.6 above shows that automation system can operate manually or self-automated at a certain time: in the morning at 6 AM the appliances were self-automated and at 7 AM when the lux value is above 280, the lamp was automatically turned off.

After that, the self-automated mode was switched into manually-automated mode; during this mode, the automation system was controlled by the user. At noon when the temperature is high, user turned on the fan to cool the air. At 6 PM in the afternoon, the appliances were automatically activated, and the lamps stayed on if the lux value is below 280.

4.3.2 SECOND SIMULATION OF AUTOMATION SYSTEM TESTING

The second simulation was done by turning on the device for 24 hours. The result of the second simulation is presented in the history of automation system on Table 6

TABLE 6.
Second Simulation History

No	Date/Time	Lamp 1	Lamp 2	Cooling Fan	Auto	Temp-erature	Lux
1	13/1/2016 6:00:59 AM	ON	ON	OFF	ON_AUTO	26.79	40
2	13/1/2016 6:20:41 AM	ON	ON	OFF	ON_AUTO	28.91	260
3	13/1/2016 6:30:50 AM	OFF	OFF	OFF	ON_AUTO	28.88	433
4	13/1/2016 6:50:58 AM	OFF	OFF	OFF	ON_AUTO	29.43	862
5	13/1/2016 7:00:07 AM	OFF	OFF	OFF	ON_AUTO	29.1	1172
6	13/1/2016 11:00:47 AM	OFF	OFF	ON	ON_AUTO	32.98	1221
7	13/1/2016 11:30:31 AM	OFF	OFF	ON	ON_AUTO	32.43	1226
8	13/1/2016 12.00:31 PM	OFF	OFF	ON	ON_AUTO	32.21	1282
9	13/1/2016 14:30:14 PM	OFF	OFF	ON	ON_AUTO	32.84	1355
10	13/1/2016 15:50:22 PM	OFF	OFF	ON	ON_AUTO	32.87	1392
11	13/1/2016 16:00:36 PM	OFF	OFF	ON	OFF_AUTO	31.47	1260
12	13/1/2016 16:00:07 PM	OFF	OFF	ON	OFF_AUTO	31.43	1202

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)

On the second simulation, half of the data was acquired through self-automated mode for the first twelve hours and the rest was through manual automation. During this simulation, the appliances run smoothly based on its automation system design. User was also able to operate the appliances well.

4.3.3 THIRD SIMULATION OF AUTOMATION SYSTEM TESTING

The third simulation was done by turning on the device for 24 hours. The result of the third simulation is presented in the history of automation system on Table 7.

TABLE 7.
Third Simulation History

No	Date/Time	Lamp 1	Lamp 2	Cooling Fan	Auto	Temp-erature	Lux
1	14/1/2016 6:00:32 AM	ON	ON	OFF	ON_AUTO	28.62	75
2	14/1/2016 6:30:38 AM	OFF	OFF	OFF	ON_AUTO	28.07	300
3	14/1/2016 7:00:15 AM	OFF	OFF	ON	ON_AUTO	31.77	606
4	14/1/2016 8:00:01 AM	OFF	OFF	ON	OFF_AUTO	31.17	685
5	14/1/2016 09:00:45 AM	OFF	OFF	ON	OFF_AUTO	31.21	500
6	14/1/2016 10:00:01 AM	OFF	OFF	OFF	OFF_AUTO	31.62	644
7	14/1/2016 11:00:11 AM	OFF	OFF	OFF	OFF_AUTO	31.29	566
8	14/1/2016 12:00:50 PM	OFF	OFF	OFF	OFF_AUTO	29.52	607
9	14/1/2016 14:00:31 PM	OFF	OFF	OFF	OFF_AUTO	29.99	480
10	14/1/2016 14:30:38 PM	ON	ON	OFF	OFF_AUTO	30.48	459
11	14/1/2016 15:00:50 PM	ON	ON	OFF	OFF_AUTO	29.77	499
12	14/1/2016 16:30:08 PM	OFF	OFF	OFF	OFF_AUTO	30.88	538

Table 7 above shows that automation system works manually and self-automated at a certain time in the third simulation; in the morning at 6.30 AM the appliances run in self-automated mode while the sensor read the environmetal condition, and if the readout showed that the lux value of the sensor is above 280, then both lamps were turned, and if the temperature was below 30°C, the fan was turned off. After that, the self-automated mode was deactivated and switched into manually-automated mode. During this mode, the automation operation system was controlled by the user.

5. CONCLUSION AND FUTURE RESEARCH

In this research, we conducted simulation tool which used applications on smartphones, as the means for monitoring and control as well as of using communication networks Global System for Mobile Communications (GSM). The result was that the lamp is still switched off when the intensity of sunlight coming into the room is more than 280 lux. In the daytime, lights are still switched off because the intensity of light inside the room reaches 280 lux. At night, the light intensity is less than 280 lux and the light will give response to a switched ON light. The fans will be switched ON at the temperature equal to 30oC or higher, and the fan will be switched OFF if the temperature is less than 30oC. In sending SMS, the number of characters will affect the size of data the SMS sent. One character equals to 8 bits of data. If the data is more than 160 characters, the SMS will be sent in two parts.

In the future research, we will compare the performance of the LM35 temperature sensor with another temperature sensor such as DHT11 and to implement a wider communication network methods based on IOT.

REFERENCES

[1]. Daraninan, M, and Martin. P. M, "Smart Home Mobile RFID-based Internet-Of-Things Systems and Services, "International Conference on Advanced Computer Theory and Engineering," 2008.
[2]. Han, D. M, and Lim, J. H, "Smart Home Energy Management System using IEEE
[3]. 802.15.4 and ZigBee," IEEE Transactions on Consumer Electronics, Vol. 56, No. 3, August 2010.
[4]. Achyat, M. B. P, and Priandana, K, "Rumah Pintar Berbasis Pesan Singkat dengan Menggunakan Mikrokontroler Arduino," Departemen Ilmu Komputer, Fakultas Matematika dan Ilmu Pengetahuan Alam, Institut Pertanian Bogor, 2004.
[5]. Wicaksono, H, "Programmable Logic Controller Teori, Pemrograman Dan
[6]. Aplikasinya Dalam Otomasi Sistem," Yogyakarta: Graha Ilmu, 2009.
[7]. Rangari, V. V., Bhat, A. P., Joshin, V. A, and Dhoble, S. J, "Low Cost Microcontroller Based Decay Measurement System for Display Phosphors," American Journal of Electrical and Electronic Engineering Vol. 2, No. 6, 180-184, 2014.

ISSN: 2252-4274 (Print)
ISSN: 2252-5459 (Online)