# Design of Room Lighting Electric Power Savings Using PIR Sensor

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**Abstract**

The current lighting system is one of the big electricity usage. With the lights, human activities can last 24 hours non-stop. The higher the intensity of activities that require lighting, the energy used is also getting higher and higher. For that we need to try to save energy in lighting system. In general, lighting arrangements only use the principle on or off regardless of activity in the room. This leads to inefficient use of electrical energy. From that thought then designed to build room power saving lamps by using PIR sensor is more efficient because the igniter lights the room is controlled automatically. The existence of the subject will be detected using a Passive Infra Red sensor (PIR) applied by the microcontroller. The MOSFET driver is used as a switch. So the lights will light up brightly as long as there are subjects in the room, and the lights will dim back when the subject leaves the room. The subject is focused on humans. With the creation of this system is expected to save electrical energy.

**Keywords**: ATMega 16 Microcontroller, MOSFET, PIR Sensor (Passive Infra Red).

## 1. Introduction

The need for electrical energy in Indonesia continues to increase as the population growth and development of the industrial world. The increase in demand is even more than twice that of economic growth. The use of electrical energy in Indonesia is still not well managed. Indonesia is the most wasteful country in electricity usage in ASEAN. Waste in electricity usage generally occurs in offices or public buildings.

Waste is one of them from energy in the lighting sector on the lights. Lighting in our region consumes enormous energy and costs but not all of the lighting in the region can work efficiently. Using energy efficiently does not mean the use of energy should sacrifice comfort such as reading a book in a dark room does not use lights just to save on lights or turn off all air conditioners in the building to save electricity costs. Examples of actions that use energy efficiently are using compact fluorescent lamp type lamps instead of incandescent lamps that can save energy usage by up to 40 percent to produce the same light intensity, or multiply the windows in the skylights, so as to avoid using lights in daytime. The successful use of energy efficiently is strongly influenced by behavior, habits, and awareness of energy saving. Along with the rapid economic growth and increasing building in Indonesia, the implementation of energy efficiency in buildings in accordance with the Indonesian National Standard becomes very important. According to some sources, in general, buildings in tropical countries such as Indonesia use the most energy for the air system (45-70 percent), lighting systems (10-20 percent), elevators and escalators (2-7 percent) Office equipment and electronics (2-10 percent). Energy-intensive buildings and homes are not only costly but also produce greenhouse gas emissions that damage the environment.

Therefore it is necessary to rebuild to utilize such energy, especially on the use of electrical energy. Electrical energy in lighting lights in buildings or on public roads is sometimes very inefficient in its use in because when the lights are brightly lit but the lack of running activity is done by humans causing waste in the sector of the use of light and electrical energy.

So the design of the automatically controls system is dim light automatically in the room by detecting the presence of the person in the room with the PIR (Passive Infra-Red) detector module so that the data generated by this sensor is sent to the microcontroller ATMega 16, and the microcontroller then sends the processed data to the MOSFET To switch the voltage on the lamp. The intensity of light emitted from the lights will light up dim and bright depending on whether or not people who move in the room. Light if there are people, and otherwise dim if there is no people with a vertical distance of 5 meters and horizontally 4 meters with each to the left 2 meters and to the right 2 meters. With this equipment can be used as a means to reduce excessive energy wastage in this country.

## 2. Research Method

In the design of room saving lamps power using this PIR sensor, where all the performance of the system is controlled by the microcontroller ATmega16 as a manager of programmed data with software (programming) microcontroller based Bascom AVR language and hardware so that in completion of the equipment obtained a result that is as expected. The hardware used consists of:

1. Power Supply Adapter
2. Minimum system of ATMega 16
3. PIR sensor
4. MOSFET driver
5. LED
6. LCD

### 2.1 Adapter Power Supply

Power supply adapter is an electronic device that serves to reduce and change the voltage AC (Alternating Current) into DC voltage (Dirrect Current) which can be used as a source of electronic equipment. Power supply as power source can come from: battery, batteries, solar cell and adapter. This component will supply voltage according to the voltage required by the electronic circuit. The Adapter Power Supply image is shown in Figure 2.1.

**Figure 2.1.** Adapter Power Supply

## 2.2. ATMega Microcontroller 16

In a simple microcontroller is an IC which contains CPU, ROM, RAM and Port I / O which is the completeness as a minimum microcomputer system so that a microcontroller can be said as a microcomputer in single chip (single chip microcomputer) that can stand alone. So the function of the microcontroller is to run commands that have been programmed using the Basic programming language. The microcontroller leg of ATMega 16 consists of 40 pins, shown in Figure 2.2.

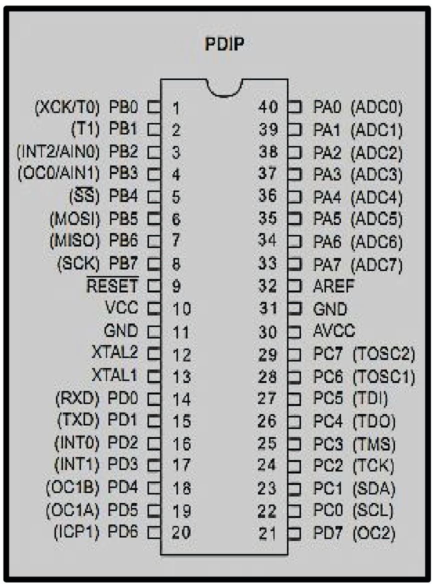


**Figure 2.2.** ATMega Pin Configuration 16

Figure 2.2 shows the functional configuration of ATMega 16 pins as follows:

1. VCC is the input power supply pin, connected to +5 Vdc voltage
2. GND is a ground pin

3. Port A (PA0..PA7) is a two way I / O pin and ADC input pin
4. Port B (PB0..PB7) is a two-way I / O pin and special function pin, ie timer, analog comparator, and SPI
5. Port C (PC0..PC7) is a two-way I / O pin and special function pin, namely TWI, analog comparator, and timer oscillator
6. Port D (PD0..PD7) is a two-way I / O pin and special function pin, that is analog comparator, external interrupt and serial communication
7. RESET is a pin that is used to reset the microcontroller
8. XTAL1 is an external clock input pin, connected to XTAL2
9. XTAL2 is an external clock input pin, connected to XTAL1
10. AVCC is a pin enter voltage for ADC
11. AREF is the pin enter the ADC reference voltage

### 2.3. PIR (Passive Infra Red)

PIR is an infrared-based sensor. However, unlike most infrared sensors that consist of an IR LED. In accordance with its name 'Passive', this sensor only responds to the energy of the passive infrared beam that each object has. Objects that can be detected by these sensors are usually the human body. Motion sensor with PIR module is very simple and easy to apply because PIR module requires 5V DC input voltage effective enough to detect movement up to 5 meter and angle $60^0$. The PIR sensor image is shown in Figure 2.5.

**Figure 2.3.** PIR Sensor

How PIR sensor readings work is incoming infrared through the Fresnel lens and pyroelectric sensor, because infrared rays contain heat energy pyroelectric sensor will produce an electric current. The pyroelectric sensor is made of gallium nitride (GaN), cesium nitrate (CsNo3) and lithium tantalate (LiTaO3). This electric current will cause voltage and read by analog sensor.

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Then this signal will be amplified by the amplifier and compared by a comparator with a certain reference voltage (output is a 1-bit signal). So the PIR sensor only outputs logic 0 (Low) and 1 (High), 0 when the sensor does not detect infrared and 1 when the sensor detects infrared.

In general, PIR sensors are designed to detect humans caused by an IR filter that filters the wavelength of passive infrared light. The IR filter module PIR sensor is capable of filtering the wavelength of passive infrared light between 8 to 14 micrometers. Outside the wavelength the sensor will not detect it. Wavelengths generated from the human body ranging from 9 to 10 micrometers are only detectable by the sensor. So, as one walks past the sensor, the sensor will capture the emission of a passive infrared beam emitted by the human body that has a different temperature than the environment. This infrared ray is then captured by Pyroelectric sensor which is the core of this PIR sensor that causes Pyroelectic sensors consisting of gallium nitride, cesium nitrate and litium tantalate to generate electric current. Then an amplifier circuit that amplifies the current which is then compared by the comparator to produce the output.

### 2.4. LED (Light Emitting Diode)

The LED lamp is an indicator light in an electronic device that usually has a function to indicate the status of the electronic device. For example on a computer, there are LED power lights and LED indicators for the processor, or in the monitor there is also a power saving lamp. Led as a model of future light is considered to suppress global warming because of its efficiency. LED as a lightbulb and fluorescent competitors, the current application began to expand. LED lights are now used for lighting for homes, street lighting, traffic and interior / exterior buildings. LED lamps are made of mica plastic and semi-conductor diode that can be lit when powered by low voltage (about 1.5 volts DC or equivalent to the flow of the battery on the flashlight). The LED image can be seen in Figure 2.4

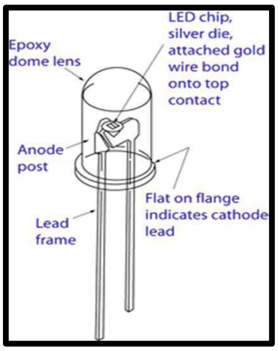


**Figure 2.4**. LED

### 2.5. Liquid Crystal Display (LCD)

Is a liquid crystal form that will emulsify when given voltage. The LCD used is a 16 X 2 LCD with each character formed by 8 pixel rows and 5 pixel columns. The shape of the 16 X 2 LCD can be seen in Figure 2.5

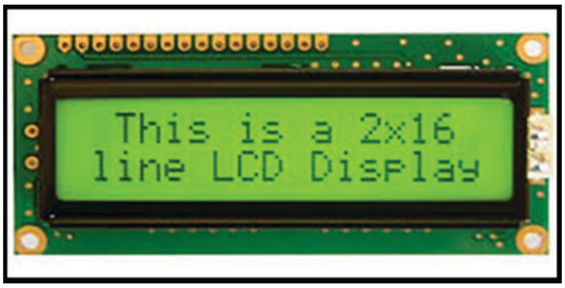


**Figure 2.5.** LCD (Liquid Crystal Display)

### 2.6. MOSFET Driver

MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is one type of transistor that has a very high input impedance (gate) so by using MOSFET as an electronic switch, it is possible to connect it with all types of logic gates. By making the MOSFET as a switch, it can be used to control loads with high currents and lower cost than using bipolar transistors. To make a MOSFET as a switch then only use MOSFET in saturation condition (ON) and cut-off condition (OFF) [12]. The type of MOSFET used in this project is IRFZ44N. The MOSFET driver form is shown in Figure 2.6.

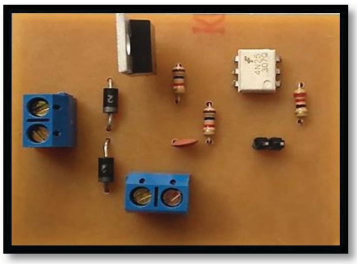

**Figure 2.6.** MOSFET Driver

## 3. Result and discussion

In the design and making equipment there are several variables that are tested and measured for data retrieval as well as know the working system of equipment made. These variables include:

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### 3.1.1 Power

Electrical power is the level of energy consumption in a circuit or electrical circuit. Energy sources such as power supply will generate electrical power while the loads connected to it such as the lamp will absorb the electrical power. The higher the wattage the lamp used will be the higher the power consumed. Therefore, the ignition of the lights automatically according to the presence of people using the PIR sensor as a detector is very helpful in electric power saving.

Based on these definitions, the formulation of electric power is as below:

$P = V. I.$

Where :

P = Electricity with unit Watt (W)

V = Voltage with Unit Volt (V)

I = Electric current with Ampere unit (A)

### 3.1.2. PIR Sensor Detection Distance

Research on the distance of this sensor is aimed to know the distance of detection of PIR sensor to object, either vertically or horizontally.

### 3.2 Block Diagram

To facilitate the design of equipment in need of the block diagram, the control system bright dim lights in the room automatically based on the subject has the block diagram shown in Figure 3.1.

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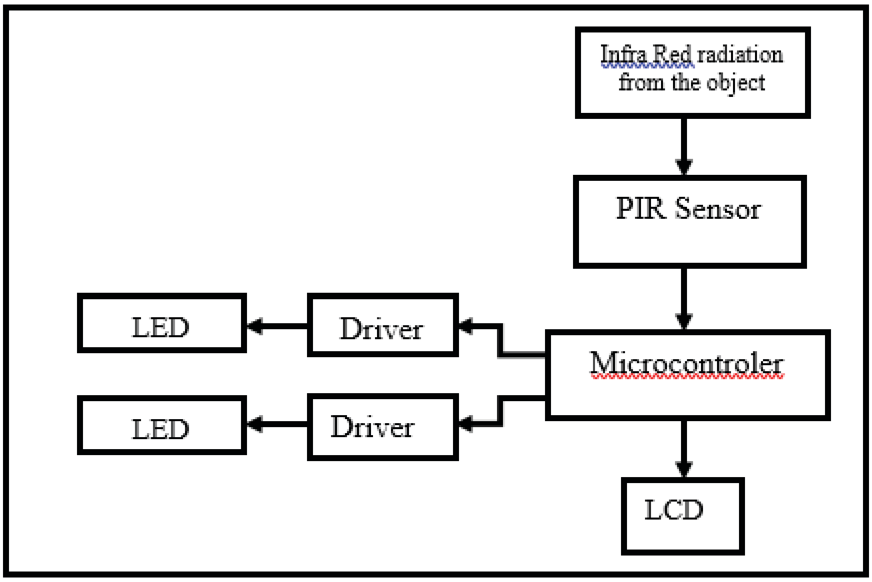


**Figure 3.2** Block Diagram

### 3.2.1 The Working Principle of the equipment

The bright dim system in the room light automatically based on the presence or absence of human activity in the room serves to save the power of lights in order to reduce the waste of electrical energy. equipment work based on a system as a whole and integrated from each circuit where the working principle of the equipment circuit as follows:

1. The adapter power supply reduces and changes the AC (Alternating Current) voltage to DC voltage (Dirrect Current) which can be used as a power source of electronic equipment.
2. The function of the PIR sensor as a detector of the human body as a human being moves, the human body will generate a passive infrared beam with varying wavelengths to produce different heat which causes the sensor to respond, so that the output coming out of the PIR sensor is data transmitted to the microcontroller.
3. The MOSFET driver function is as a switch to connect and disconnect the voltage on the lamp when the ATMega 16 microcontroller receives data from the PIR sensor as a detector of human presence in the area.
4. The main function of the LCD is to display the messages or data that we have program through the microcontroller, so it can facilitate humans in operating the equipment that can be used.
5. The main function of ATMega 16 microcontroller is to store programmed program and as controller or controller of all components and circuit

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connected with ATMega 16 microcontroller such as PIR sensor, MOSFET driver, LCD.

### 3.3 Software Planning

Software design is needed to support hardware that has been made, to facilitate the preparation of software, it is necessary to create a flowchart as in Figure 3.3

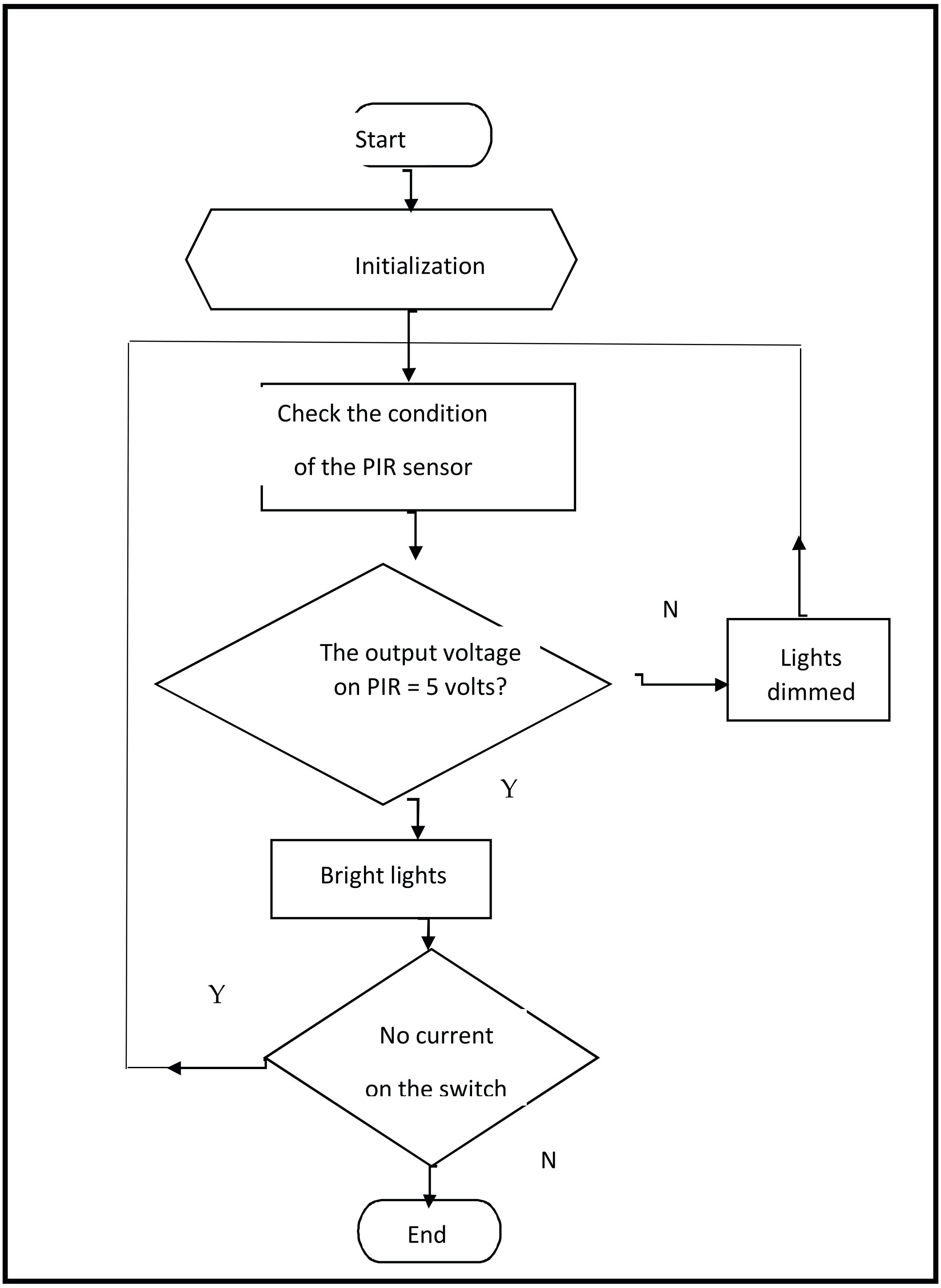


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**Figure 3.3.** Flowchart Control System

### 3.4. Minimum Test Result of ATmega 16 System As Output

After testing, it can be seen that the microcontroller can function as Output. The test results are shown in Figure 3.4

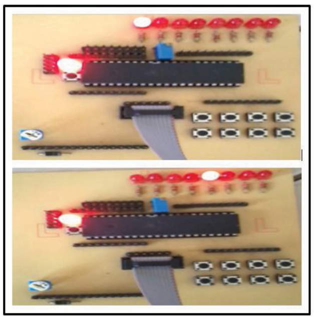

**Figure 3.4.** Output Test Results Minimum ATmega System 16

To more clearly know the results of microcontroller testing as Output in show in Table 3.1.

**Table 3.4** Table Testing Microcontroller As Output

| No. | Logic at B port | *LED* at *Port* 0 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | L7 | L6 | L5 | L4 | L3 | L2 | L1 | L0 |
| 1 | 11111110 | H | H | H | H | H | H | H | **L** |
| 2 | 11111101 | H | H | H | H | H | H | **L** | H |
| 3 | 11111011 | H | H | H | H | H | **L** | H | H |
| 4 | 11110111 | H | H | H | H | **L** | H | H | H |
| 5 | 11101111 | H | H | H | **L** | H | H | H | H |
| 6 | 11011111 | H | H | **L** | H | H | H | H | H |
| 7 | 10111111 | H | **L** | H | H | H | H | H | H |
| 8 | 01111111 | **L** | H | H | H | H | H | H | H |

**Description: L = Low (On)**

**H = High (Off)**

At the minimum test the ATmega 16 system as the output where for logic 1 (high) states the light goes out while the logic 0 (low) states the light is on.

### 3.5 Atmega 16 Minimum System Test Results As Input

After doing the testing, it can be seen that the microcontroller can function as Input. The test results are shown in Figure 3.5.

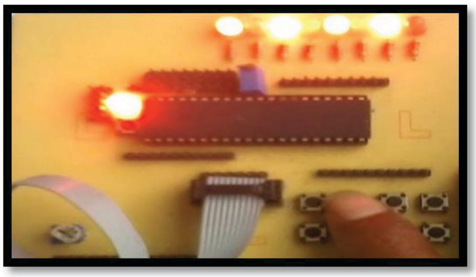

**Figure 3.5**. Minimum Input Test Result of AT Mega System 16

To more clearly know the results of microcontroller testing as Input in show in Table 3.5

**Table 3.5.** Table Testing Microcontroller As intput

| CONDITION *SWITCH* (SW) | LED | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Pc.7 | Pc.6 | Pc.5 | Pc.4 | Pc.3 | Pc.2 | Pc.1 | Pc.0 |
| *Port*d.0 pushed | 1 | 1 | 1 | 1 | 0 | 0 | 0 | **0** |
| *Port*d .1 pushed | 0 | 0 | 0 | 0 | 1 | 1 | **1** | 1 |
| *Port*d .2 pushed | 0 | 1 | 0 | 1 | 0 | **1** | 0 | 1 |
| *Port*d .3 pushed | 1 | 0 | 1 | 0 | **1** | 0 | 1 | 0 |
| *Port*d .4 pushed | 0 | 0 | 1 | **1** | 0 | 0 | 1 | 1 |
| *Port*d .5 pushed | 0 | 0 | **0** | 1 | 1 | 1 | 0 | 0 |
| *Port*d .6 pushed | 1 | **1** | 1 | 0 | 0 | 1 | 1 | 1 |
| *Port*d .7 pushed | **0** | 0 | 0 | 1 | 1 | 1 | 0 | 0 |

**Description: Logic 1 LED Lights Off**

**Logic 0 The LED light is on**

AT Mega 16 minimum system testing as input where for logic 1 (high) states lights out while logic 0 (low) states the light is on.

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### 3.6 LCD Test Results

After doing the testing, it can be seen that LCD can function to display the command. The test results are shown in Figure 3.6.


**Figure 3.6.** LCD Test Results

### 3.7 MOSFET Driver Test Results

After performing the test, it can be seen that the MOSFET can act as a switch. The test results are shown in Figure 3.7.

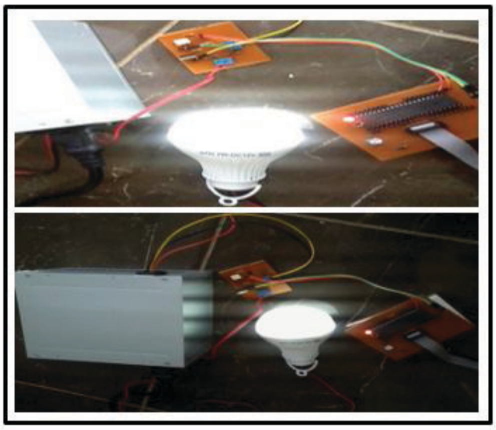

**Figure 3.7** MOSFET Test Results

**Table 3.7** MOSFET Test Results as a switch

| Port. | Logika | Kondisi Lampu |
|---|---|---|
| Portc.0 | 1 | On |
| | 0 | Off |
| Portc.1 | 1 | On |
| | 0 | Off |
| Portc.2 | 1 | On |
| | 0 | Off |
| Portc.3 | 1 | On |
| | 0 | Off |
| Portc.4 | 1 | On |
| | 0 | Off |
| Portc.5 | 1 | On |
| | 0 | Off |

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| | | |
|---|---|---|
| Portc.6 | 1 | On |
| | 0 | Off |
| Portc.7 | 1 | On |
| | 0 | Off |

### 3.8 Sensor and LCD Test Results

After performing the test, the sensor can work as a detector of the subject and its data in the LCD mirror. The test results are shown in Figure 3.8.


**Figure 3.8.** Sensor And LCD Test Results When Detected


**Figure 3.9**. Sensor And LCD Test Results When Not Detected

To more clearly know the results of detection testing PIR sensors are shown in Table 3.8

**Table 3.8.** Sensor And LCD Test Results

| Port D.<br>PIR Sensor | Room condition | PIR Sensor *Output* Respon |
|---|---|---|
| Port D.0. | human present | 1 |
| | No human | 0 |
| Port D.1. | human present | 1 |
| | No human | 0 |
| Port D.2. | human present | 1 |
| | No human | 0 |
| Port D.3. | human present | 1 |
| | No human | 0 |
| Port D.4. | human present | 1 |
| | No human | 0 |

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| | | |
|---|---|---|
| Port D.5. | human present | 1 |
| | No human | 0 |
| Port D.6. | human present | 1 |
| | No human | 0 |
| Port D.7. | human present | 1 |
| | No human | 0 |

### 3.9 Sensor Detection Distance Detection Results

Results of this equipment research prove that this pear sensor is able to detect people with a vertical distance of 5 meters and a horizontal distance of 4 meters. The test is shown in Figure 3.9.

**Figure 3.9.** Vertical Distance Measurement Results


**Figure 3.10.** Results of Horizontal Distance Measurement

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**Table 3.9.** Results of PIR Sensor Distance Detection Test

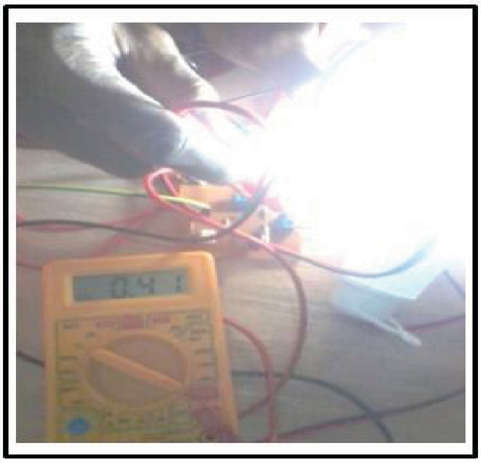
| Vertikal | Respon Sensor | Horizontal | Respon Sensor |
|---|---|---|---|
| 6 meter | Not detected | 6 meter | Not detected |
| 5 meter | detected | 5 meter | Not detected |
| 4 meter | detected | 4 meter | detected |
| 3 meter | detected | 3 meter | detected |
| 2 meter | detected | 2 meter | detected |
| 1 meter | detected | 1 meter | detected |

## 3.10 Electrical Power Measurements

In testing, this test aims to determine the power consumed by the lights when illuminated bright and when dimmed dim. This test is done in stages as follows:

### 3.10.1 Power Measurement Results On Each Lamp

Testing is done to know that the intensity of light emitted from the lamp used with a voltage of 12 volts when the light conditions are 0.41 Ampere and at the time dim conditions are 0.04 amperes. This condition is measured using AVO meter. For more clearly shown in Figures 4.9 and 4.10.



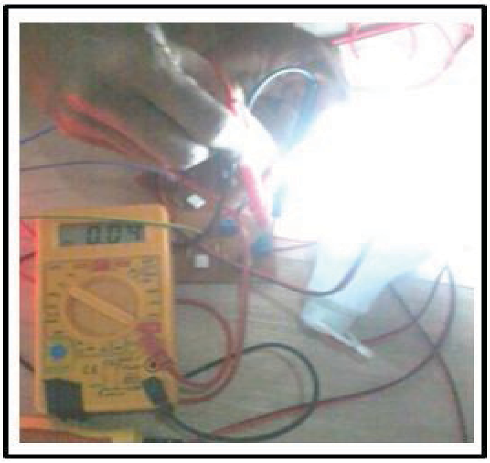


**Figure 3.11**. Measurement Results **Figure 3.12.** Measurement results

Light condition light The light conditions are dim

The higher value of this Watt higher power consumed. Based on these definitions, the formulation of electric power during light and dim is as below:

**Bright Condition: P = V. I.**

P = 12 x 0.41

P = 4.92 Watts

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Converted to rupiah, Light = 4.92 x 12 hours / 1000 x Rp 1.300

Rp = 59.04 / 1000 x Rp 1.300

Rp = 0.05904 x Rp 1.300

**Rp = 76.752**

**Dim Condition: P = V. I**

P = 12 x ( 0,04 x 11 )
P = 12 x 0,44
P = 5,28 Watts

Converted to rupiah, Dimmed = 5.28 x 12 hours / 1000 x Rp 1.300

Rp = 63.36 / 1000 x Rp 1.300

Rp = 0,06336 x Rp 1,300

Rp = 82,368

**3.10.2 Power Measurement Results On Control System**

Testing is done to know that the use of power consumption in the control system on this equipment. This condition is measured using AVO meter. For more clearly shown in Figure 4.11.

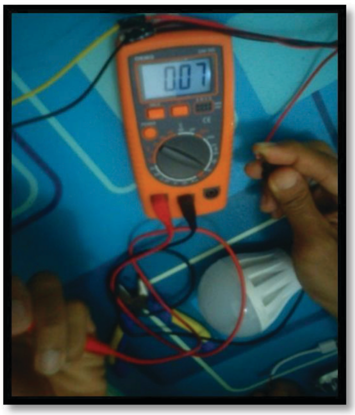

**Figure 3.12.** Power Measurement Results On Control System

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Based on these definitions, the formulation of electric power as below:

**P = V . I**
P = 5 x 0,07
P = 0,35 Watts

### 3.10.3. Total Power Measurement Results

Testing in doing this aims to determine the use of total power in consumption in this equipment. This condition is measured using the AVO meter when the light is on. For more clearly the measurement results are shown in Figure 3.13.


**Figure 3.13.** Total Power Measurement Results

Based on these definitions, the formulation of electric power as below:

**P = V . I**
P = 220 x 0,26
P = 57,2 Watts

Converted to rupiah = 57,2 x 12 hours / 1000 x Rp 1.300

Rp = 686,4 / 1000 x Rp 1.300

Rp = 0,6864 x Rp 1.300

Rp = 892.32

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### 3.10.4. Power Comparison With Conventional Lamp

The test is done to know the percentage of saving lamp usage in this equipment with conventional lamp.

Known light power on this equipment 57.2 Watt and conventional lamp 18 x 11 = 198 Watt. Percentage savings as follows:

57,2 / 198 x 100 %
= 0,28 x 100 %
= 28 %

## 4 Conclusion

Based on the design, testing, analysis and objectives of the research, it can be concluded as follows:

1. Power consumption on each lamp in bright condition = 4.92 Watt and if converted to rupiah = 76.752 rupiah.

2. Power consumption on each lamp when dim condition = 0.48 Watt and if converted to rupiah = 7,488 rupiah.

3. Power consumption on overall lamp when bright condition = 54,12 Watt and if converted to rupiah = 844.272 rupiah.

4. Power consumption on overall lamp when dim condition = 5.28 Watt and if converted to rupiah = 82.368 rupiah.

5. Power consumption on control system = 0.35 Watt

6. Total power consumption = 57.2 Watt and if rupiah = 892.32

7. Save 28% savings from conventional lamps

8. The PIR sensor is capable of detecting people in the area with a horizontal distance of 4 meters, each left 2 meters and a 2 meter and 5 meter vertical with an angle of $\mathbf{60^0}$.

9. PIR sensors can only detect the presence of people when the person is doing the activity (move). When the person is not doing the activity (immovable) even though it is within the detection range of the sensor then the PIR sensor can not detect because in that condition the PIR sensor will regard it as the ambient temperature.

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