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Energy Saving Smart Light System Development: The Approach and Technique

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ABSTRACT

Today's trend, human kind always bring smartphone everywhere. Electricity consumption is increasing every year because of the demand of users. Commonly electricity use is in lighting system, audio system, daily routine and other things. Mostly usage of electricity consumption is lighting system because with light people can do a job or task easily when at day night or dark area. Since the lighting system is important, the details process and technique must be clear in developing the smart lighting system. Therefore, the objective of this paper is to investigate the approach and technique for the development of energy saving smart light system. This system might control light brightness with LDR (Light Dependent Resistor) sensor and occupancy sensor such as PIR (Passive Infrared) sensor. Development will consider smart phone as one of the devices to control the system in order to dimmable LED brightness or anything else. It is begin by literature reading in ensuring the best approach, method or technique for the development. Then, the flows of algorithm on methods and technique used is also illustrated to shows the process of the development. The hardware and software used are also presented in this paper. With this, other developer will more easier in the way to do the same sort of development to be as their guidance.

Key words : LED, LDR, system control, Arduino, prototype

1. INTRODUCTION TO BUE FORMATION

In recent decades, saving energy has become a vital issue in many countries. The energy awareness and energy conservation has started to open up new avenue in saving energy area [1]. Lighting is one of the major uses of electricity and accounts for major portion of national electricity usage for instance building lighting system consumes about half of total energy usage of building [2]. It means that diminishing the consumed energy by lighting system is sufficient to decrease the expenses and CO2 emission. In Malaysia, total building consumption is 48% of the electricity that generated in the country. For the commercial building they consume almost to 38,645 Giga watts (GWH) and for the residential buildings use 24,709 GWH. Demanded the electricity in Malaysia is increasing from 91,539 GWH in the year 2010 to 108,732 GWH in 2016 [3]. Basically, the lighting system used manual switch that is on-off switch. Sometimes people forget to switch off light and waste the electricity because they busy of working and daily task. On/off switch lighting system will make people cannot focus on their work because they need to stand and walk to switch on the light to continue they work. Sometimes they are lazy to switch on the light until they feel hard to continue do work.

Thus, the aim for this project is to reveal the details process on their approach, method and technique use in order to develop the smart light control system. Next project, the design on smart light that the brightness of light is controlled by light intensity in the area will be developed. After that this project also develops personal control that is mobile application to control and monitor the light. Furthermore, the prototype has dual mode is that are automatic and manual mode to ease their user.

2. THE LIGHT CONTROL SYSTEM

Light is an electromagnetic waveform that can been see through eyes. This wave of electromagnetic has been demonstrate by experiment that is called diffraction and interface. By experiments on polarization, when see the light through the experiment. By expanding every point on its surface equidistant from its center of light were a new source of radiation with same phase and frequency [4].

2.1 Light Concepts

The light has two way of method to produce. First with incandesce and second is luminescence .The letter c is to represent the measurement the speed of light. Figure 1 show

the reflection of light and refraction of light. The light waves can reflection or bounce back from obstacle object. The light spectrum will absorbs all other colors and the object with color can reflect. The wavelength of light can measure by color on the object that been reflect. Also known as the bending of light. It can passes and through one transparent to another transparent. This refraction has made good chance for us to create a lens, rainbow and other thing that use refraction. Human eyes can bend the light because without this refraction, human can't be able to focus the light with retina inside the eye.

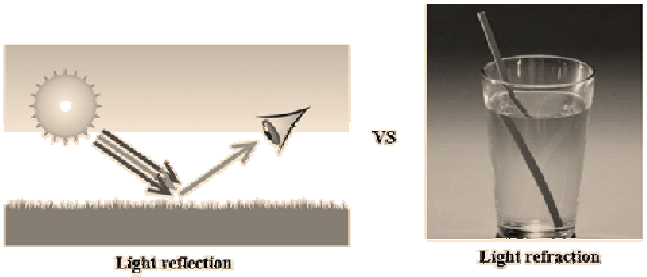

Figure 1: The explanation of light

2.2 The Control System

A control system is an interconnection of components forming a system configuration that will provide a desired system response [5]. The traditional method is no longer suitable in this era in terms of energy consumption. By designing a lighting control system has a lot advantage such as reduce electricity consumption, reduce carbon emissions, reduce stress, easy to use and reduce time.

Also, these systems make a design to home appliance to control all together. For example, touch one button can control all light in the house, it also can raise and dim automatic that been setup by the users. Occupancy Sensor, light sensor and timer is having a great potential to lighting control system. Example of occupancy sensor use in lighting system is PIR sensor. It is to sense movement of human in the area. When human pass by the area the sense will trigger and sent signal to the system. Figure 2 shows the diagram to illustrate the lighting system. By using the sensor and timer, it can reduce energy usage by turn off or dim the light automatic such as when Day the LDR sensor resistance will decrease because of daylight and when night the light illuminated on LDR will decrease and the resistance on LDR will increase high.

Technology becomes more modern, many investors create new technology to make human easy to use in their daily life. All technology has embedded system and also has come with remote control such as air Cond, television, computer and including shop equipment. However, the trend becomes more advanced with more features that have been built in and get the interface harder to use [6]. Today, carry a smart phone become common for people that have better features that has a good high performance, a high resolution screen, and speech function and text-entry capabilities. Phone mostly like to maintain this advantage to control appliance, because improve the hardware is main objective to make a different between phone and became a market as a reason to buy a new brand smart phone.

All phones have an ability to communicate over cellular network, and most of the build have a built in many capability features. Such as wireless, Bluetooth and others. The Bluetooth is to allow the users to communicate to others and also control device at surrounding area. Phone also can be personal universal controller that could allow the users to get interfaces that are personalized. For example , a phone could be connected with home appliance and provide interfaces that are users can control the appliance , or it also can combine multiple appliance interface in single interface to make users easy to use. From combining interface also will help a familiar problem that need a full of controller for home appliance.

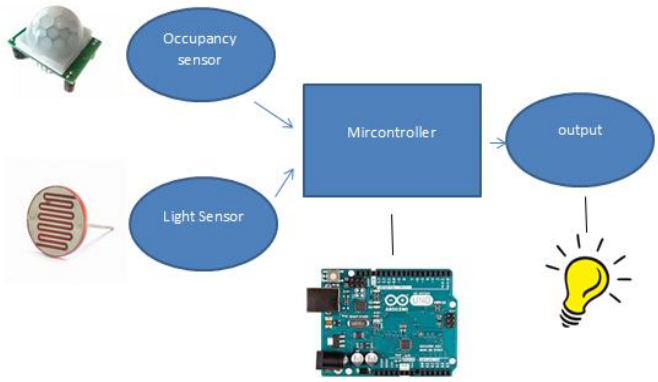

Figure 2: The lighting system control concepts

2.2.1 Personal Universal Controller

Personal universal controller (PUC) system, that are develop to allow the users to control smart lamp in the building by using the remote as interface as shown in Figure 3. When a user decides to control the light appliance, the device will download the data description from the appliance through the Bluetooth and automatically connected the phone and generate the interface for control the light. In the channel has a two way of communication that is the controller and the interface that allow the users to control and command the device and feedback for provide the user. We have reviewed the feedback of the graphical interface on PDAs and speech interface in the past [6]. PUC system has four main part:

- a language,
- communication protocol,
- interface and also
- appliance adapter.

The specification language will enable the system user interface, which can control the appliance in an abstract way. The objective of the designing the language to a create the complete information to generate a great interface for user. Furthermore in this language design included are variable and commands to show the function of the appliance. One of the objectives of this system is to control the real life appliances.

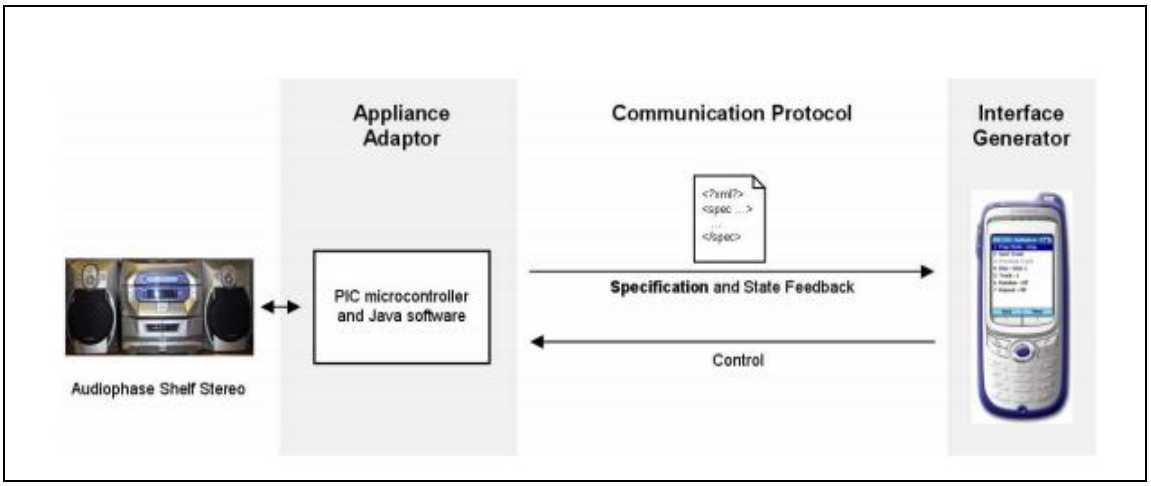

Figure 3: The PUC system

2.2.2 Passive Infra-Red

Passive Infra-red (PIR) is a Passive Infra-Red. The motion sensing is a passive system to sense infrared energy in surrounding. These sensors are known as PIR detector or Pyro electric sensors. The emitting a beam light or microwave energy will sense by the interrupted by a passing person in the area as in Figure 4.

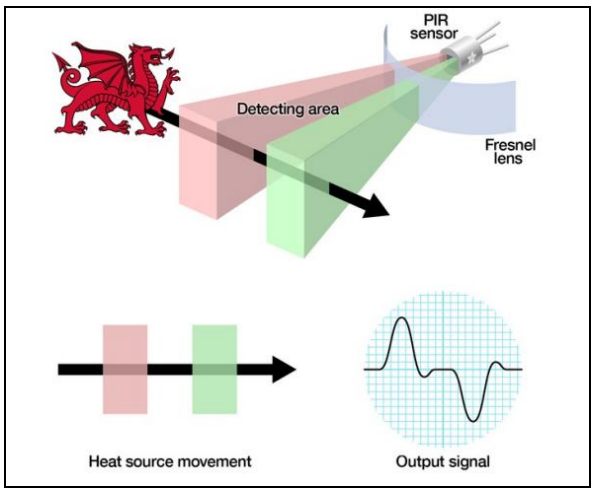

Figure 4: Explanation of PIR Sensor

The PIR is easy to sensitive with the infrared energy emitted in every living move at the surrounding area .Example , when a person walk into the Sensor area field, the sensor will a sense the infrared energy through the body. Inside the PIR sensor has a light is a designed to light up when sense a movement of living thing, but will not react to person that a standing and not move, that is the function of the light. A moving living thing effect a sudden change in infrared energy, but motionless body it will make infrared energy slower.

Slower changes will cause by fluctuation in the temperature in surrounding. No motion sensor system if perfect, but the PIR sensor is the most sensitive and good option [7]. There is many types of light sensor that build and inventor and each type has a different function such as photodiode, photovoltaic cells, photomultiplier, phototransistors, charge couple device and photo resistor.

2.2.3 LDR

Light Dependent Resistance (LDR) sensor is use in this prototype. The value resistance in LDR can increase or decrease with change in daylight intensity in the area. Furthermore, the LDR sensor is durable with change of weather in the area .Example, raining, dry season, rough and dirty place [8]. LDR is a variable resistor that control by light intensity. LDR are made from high resistance semiconductor material, such as cadmium supplied. As in Figure 5 when a night time come the light illuminated on LDR will decrease and the resistance on LDR will increase high because lack of daylight. Besides that, when a day time, the light illuminated increase and the resistance on LDR decrease. Hence the resistance of LDR is varying by light intensity in the area.

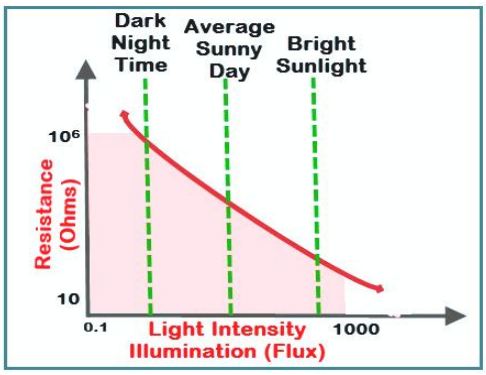

Figure 5: Intensity vs. Resistance

2.3 Comparison Between LED, ILB and CFLs

Past few years, only one type of light bulb that people use, the incandescent. The new type of bulb have been create , the CFL(compact Fluorescent Light) with more cheaper cost and more option .Compared to CFL and incandescent light bulb (ILB), light emitting diode (LED) are new type and they brightness are dim and expensive. In past five years, manufacture of LED light bulb try more harder to improve the performs same like the good old fashioned while still maintain the ability of LED light such as low energy usage , low effect on the environment went use and low heat emission . So now have come with new build LED light bulb with capability 10w only but same brightness with 75w of incandescent light.

From Table 1, the best saving bulb is LED because it is cheaper. Besides that, lifespan of LED is much better compare than other bulb. The people no need to waste money buy bulb every year to keep their house safe. Besides that, the LED bulb is low Carbon dioxide emissions. It can reduce the carbon dioxide in this earth and reduce pollution.

Table 1: Comparison LED, Incandescent bulbs and CFLs

	CFL	LED	ILB
WATTS	13-15watts	6-8 watts	60 watts
LIFESPAN	8000 hours	25,000 hours	1200 hours
CARBON DIOXIDE EMISSIONS	Medium Co2 emissions	LOW Co2 Emissions	High Co2 emissions
EFFECT TO LOW TEMPERATURE	Yes – Because not work under negative 10 degrees Fahrenheit.	None	Sometimes
HUMIDITY	Yes	No	Sometime
STRENGTH	Not very strong – glass can break easily	Very strong – LED can handle bumping	Not very strong –glass and filament can break easily
FAILURE	Yes	No typical	sometime

2.4 Demand of Electricity in Malaysia

In Malaysia, energy consumption increase every year. The percent of electricity increase between five to six per cent every year because of increased usage of electricity and rapid industrial in Malaysia [9,10]. Malaysia has developed new healthy generating capacity and adds increase 4780 megawatt. Figure 6 shows the electricity consumption is increase every year. In 1971, the electricity consumption was 3,464 GWH and in 2008 the electricity increasing to 94,728 GWH. Besides that, in year 2020 demand in Malaysia electricity consumption will increase around 30%, which mean it is 124,677 GWH [11].

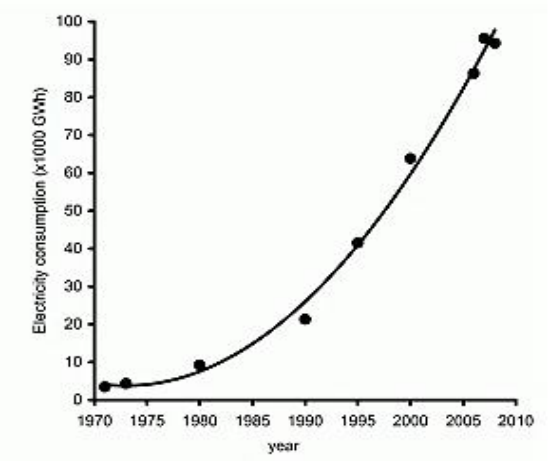

Figure 6: Malaysia electricity consumption

3. THE METHODOLOGY

3.1 Light control System via Arduino

The main circuit using a LDR for sensing element, which the process of system by Arduino that take the LDR sensor as an input element. For output from Arduino is LED. Other component such as relay, transistors used for high voltage supply [12]. The LDR sensor will sense the light and send the data to Arduino. Then Arduino will analyze the data and sent the respond through LED as shown in Figure 7. The Arduino coding is programmed using Arduino IDE for control the brightness of LED follow by intensity.

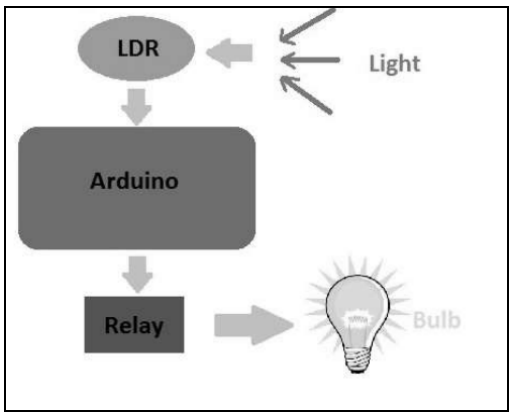

Figure 7: The lighting system using Arduino

3.2 Smart Lighting System using Raspberry PI

In this project, the lighting system using Raspberry Pi variable system that can reduce cost electricity bills and Carbon Emission [13]. Raspberry PI can generated conserved energy in electrical grid .The system hardware and software can modify for the addition of new module. This system suitable to implement in industrial, residential, Shop and university to save energy and reduce cost of consumables as shown in Figure 8. The objective of this system is need no manual system to switch off light and fan when no person stay in the room. A Micro SD card is acts as hard drive for the Raspberry PI and use for powered by USB and video output. The Raspberry also has a low power usage around 2 watt [14]. The system is use version Linux that cause the low powered device. Python language is use for program the circuit board. This system also use a web camera to capture image of the room and compare the image with human pattern that have save in openCV software. When the image fails match it will turn off the power supply .Furthermore, this system no use occupancy sensor for operation raspberry PI.

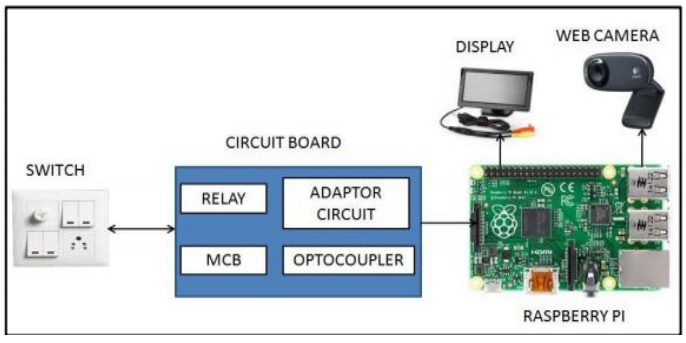

Figure 8: Raspberry PI Lighting System

3.3 ZigBee Remote Control Automatic Street Light

In this method, using Arduino as microcontroller and Zigbee module as based remote control. The sensor is to control and secure the area of system [15]. Furthermore, the sensor is the input and collects the data the transfer to the controller of the software to analyze the data to the system. For the Adruino is to collecting data from all streetlight in parallel processing and convert the data into serial communication. Then, the data will direct transfer to Zigbee transmitter and receiver modules. When data sent through zigbee module, it will control terminal to check the condition of the street light. If the condition of street light is fail, the receiver will transmit information state of street light to a terminal.

This prototype is powered by using solar panel and battery. The solar panel will give a system power with solar energy, in the same time it will charge the battery during day. At receiver side, base system will monitor the progress the entire of lighting system. The UART use to receive the data about condition of street light that transmit by zigbee module. The result required graphical display of the terminal. The interface in base station will monitor state and condition of street light system. This summary of each method. Every project has different way of process system. From the Table 2, result shows the suitable method is using adruino based smart light control system and it is suitable to depict for this project. Easy to write code and cheaper. Besides that, easy to conduct this project with Arduino.

4. APPROACH AND TECHNQUE FOR THE DEVELOPMENT

Every automatic system has a method to produce and generate the result. The method is show how the system processes. Example smartphone, every brand of smartphone use different method to produce such as iPhone 6s use processor Apple A9 and the Samsung use processor snapdragon 820.
In this research, the microcontroller will be adruino to control the system as shown in Figure 9. This project implement an auto-intensity LED light using LDR sensor with interface an Arduino board. The objective is to reduce energy and saving by using automatic lighting system by measure by outside light condition.

The main circuit using a LDR for sensing element, which the process of system by Arduino that take the LDR sensor as an input element .For output from Arduino is LED. Other component such as relay, transistors used for high voltage supply [10]. The LDR sensor will sense the light and send the data to Arduino. Then Arduino will analyze the data and sent the respond through LED. The Arduino coding is programmed using Arduino IDE for control the brightness of LED follow by intensity. The features is improved by in this research. The use of occupancy sensor of PIR sensor, sense movement of human in the area to increase the light brightness from dim to 100% brightness. Furthermore, this project uses personal control such as smartphone, to control the system with long distance.

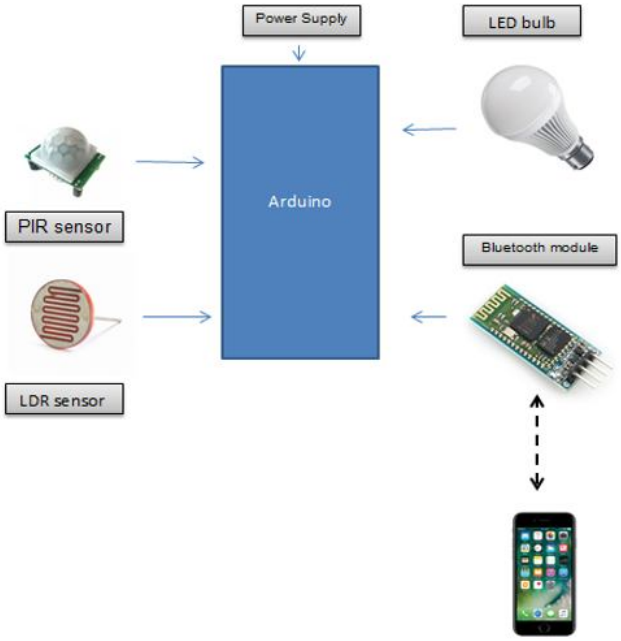

Figure 9: The lighting system control by Arduino + smartphone

Figure 10 shows the workflow of the initial prototype. This section explains the first process until the end of the light system. Firstly system runs, system will calculate the light intensity using LDR sensor. When the intensity reach value for condition night, light will on but the light will turn on dim mood. Next, when PIR sensor sense human by pass the area it will increase the light brightness of light. Lastly, if system reaches condition morning the light will turn off. After finish research hardware and software, will construct a circuit design for the hardware and do wiring for the hardware.

Furthermore, after finish do wiring circuit. It will do coding for the hardware by using software. Then will integrate the hardware and software and will do system testing. If find error when running system testing, it will do the troubleshoot for find the problem in hardware or software.

Moreover, the system is complete running without error and smooth need to collect data and do analysis. When collect data is complete, the data will be generating to the graphs. Lastly, complete the documentation.

Table 2: Comparison method for lighting control system

Author	Area	Problem	Solution	Result
Deepak Kumar Rath, (2016) Arduino Based: Smart Light Control System	Resident	Wastage of electricity	Use LDR to control light power	Reduce the Cost of bill
Ankit Maslekar (2015) Smart Lighting System using Raspberry PI	Resident	Reduce carbon emissions	Using webcam to control the system	Help to reduce consumption bill
Srikanth M (2014)-ZigBee Remote Control Automatic Street Light	Street Light	Waste energy consumption	Use Zigbee module to monitor and control the light at base station.	Provide safe night time environment

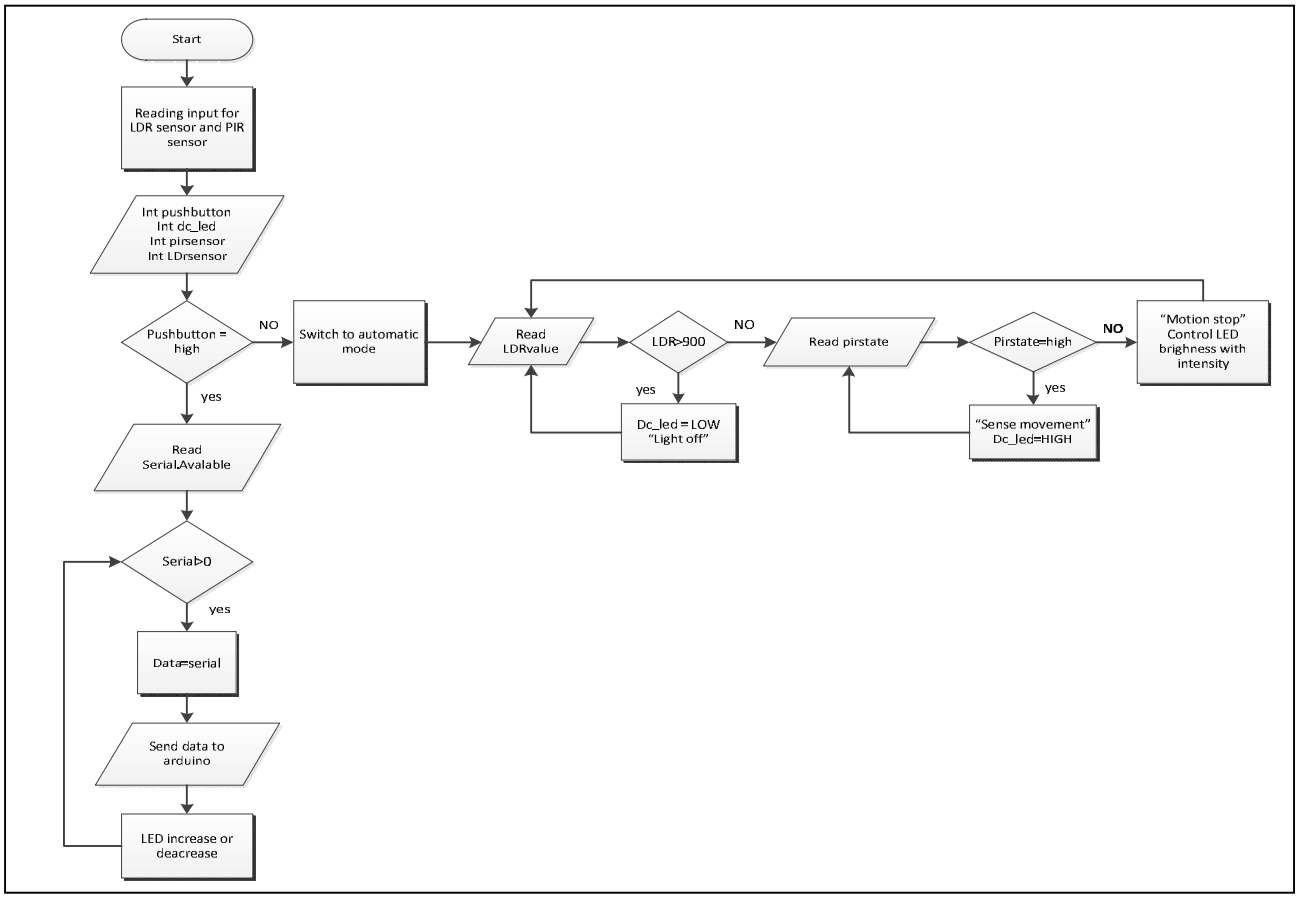

Figure 10: Process Flow of Lighting System

4.1 Hardware development

This prototype is developed from the combination of several electrical components, which are Arduino Uno R3, PIR sensor, LDR sensor, personal control: smartphone and HC – 05 Bluetooth. Arduino Uno is a microcontroller boar that has an ATmega328 chip and it has 14 digital input/output pins [16]. The specification of Adruino as in Table 3, while Table 4 shows the PIR sensor and Table 5 for LDR sensor specification. Follow with that is the personal control: smartphone and HC – 05 Bluetooth specification as shown in Table 6.

This component functioned as main brain for this light system. Converting process of the signal from light sensor into a readable signal for Arduino its need help from a laptop. The resistance of a light sensor decreases with increasing incident light intensity follow the weather surrounding. Motion sensor or PIR sensor to increase the light intensity to maximum when the sensor senses the movement of human in the area.

Table 3: Specification of Arduino

Description	Value
Operating Value	5V
Input Voltage	7-12 V
Digital I/O pins	14
Analog Input	6
DC current for I/O pin	40 mA
DC Current for 3.3V pin	50 mA
Flash memory	32 KB
Clock Speed	16 MHz

Table 4: Specification of PIR Sensor

Description	Value
Current	50uA
Output signal	0-3v
Input voltage	3.3V - 5V
Sensitivity Range	6 meters

Table 5: Specification of LDR sensor

Description	Value
Input voltage	3.3 – 5 v
Current	10mA
Output pin	2 – digital and analog output
Dimension	32 x 14 mm

Table 6: Specification of HC-05 module

Description	Value
Input Voltage	3.6- 6 v
Current	30mA
Size	43mm x 15mm

The motion sensing is a passive system to sense infrared energy in surrounding. These sensors also are known as PIR detector or Pyro electric sensors. The sensor will be acts digital output for arguing. The PIR sensor with will increase the light intensity into maximum when the sense the movement in the range. Powered the PIR with 5v to positive symbol and connect the ground to ground. The output of PIR sensor will connect to digital output on Arduino. The value resistance in LDR can increase or decrease with change in daylight intensity in the area.

Additionally, the LDR sensor is durable with change of weather in the area. In this project, LDR is use to control light brightness by change the value of resistance with outside daylight. Personal control allows for adjustment of the light or electric lighting by the user and can be offered switches or push button , pull cords ,computer or handset control that are easily accessible by the user. In this project, use smartphone control and the interface will be set up in the android and will connect to the Arduino so the user can control manual the system. Furthermore, the design for the interface will do as simple and easy to understand for the user. This module is act to transparent wireless when the connection being paired by user. The module Bluetooth have two work mode its command mode and data mode. When the user connects the Bluetooth on smartphone or other gadget, the user can control the light brightness.

Arduino Uno will be used as the controller to all LED. It will control led brightness according the signal from the light sensor and motion sensor with Arduino board. One leg of the LDR will connect to the Vcc 5v in Arduino board. Another will put in analog pin. For the resistor, one leg will go analog same pin as LDR and grounded as Figure 11. The positive on the sensor will supply with 5v from the board and the ground will be ground in board. For the sensor output will be connect to the digital output on the board.

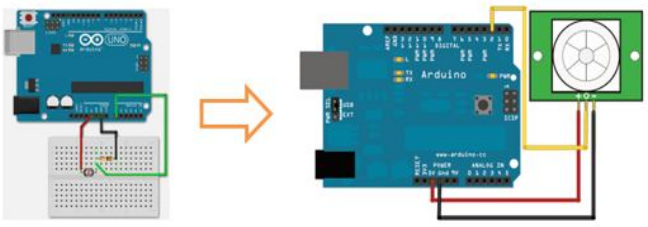

Figure 11: The circuit for PIR sensor

Figure 12 shows the VCC on the HC-05 will supply with 3.3 v from the board and GND will be ground in Arduino. RX pin will connect to TX in Arduino and the TX pin will connect to Rx in Arduino. Figure 13 MOSFET is a transistor, just a special kind. They are 3 lead components that have 2 simple functions, to switch or amplify (in this example it is setup as a switch). Basically have an ins called the source, an out called the drain, and a control called the gate. When Arduino send a HIGH signal to the gate (control pin), the transistor switches and allows current to flow from the source (in) to the drain (out).

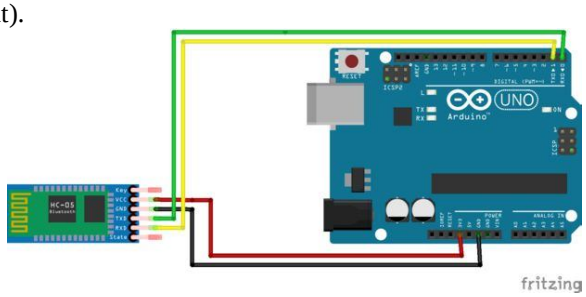

Figure 12: The connection for HC-05 Module

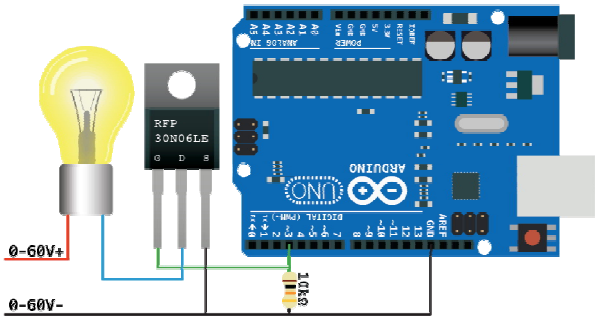

Figure 13: N-channel MOFSET with 12v dc LED

4.1 Software Development

Arduino IDE use to do a program code for run the system. The Program code will upload and run to the board. The LDR will be as an input in Arduino board. when the resistance decrease or increase effect of daylight ,the Arduino has be programmed to control the light brightness by follow condition has been wrote in the software. For PIR sensor is use to sense movement. When person come to the area, the sensor will sense and sent the signal to the Arduino that been program. For application software, will be design on the website MIT App invertor for interface in the smartphone. The user can control the smart light when smart phone when the smartphone has been connected to the Bluetooth.

4.1.1 Arduino Integrated Development Environment

The Arduino IDE is software to compiler and writing the programing code. The code will upload into the Atmega chip. Any Arduino device is compatible for using this Arduino IDE. Before using to the prototype need to do software firmware that to translate the machine signal into actual movement. To run the prototype need to upload a firmware. Next, is to choose the correct electronics board from the tools menu .Beside that need to find the serial port for the Arduino

device for connect with computer. After connected the Arduino to serial port, click upload in the Arduino IDE interface to upload the code into the board. The software will compile the code, if error the Arduino software will stop upload to the board as illustrated in Figure 14.

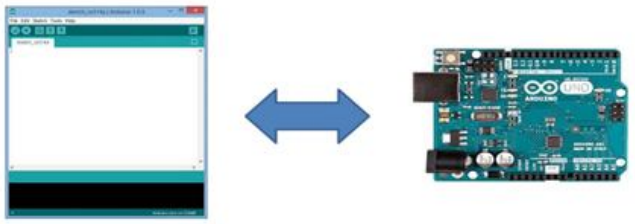

Figure 14: Arduino IDE

4.1.2 MIT App Inventor

MIT App inventor is a website that to create an application. For write a program and create an application that transform the complex language into visual. In this website have to part, first part is App inventor Designer where component can be select to the application. Second part is App Inventor Blocks Editor, where u can construct block of program to component to make how the component works. Besides that, it also can assemble visual which like a puzzle block. Every step of the block can been test in the phone to make sure every step is working properly as shown in Figure 15. Also, after finish construct the application code. It can download into android to test the application.

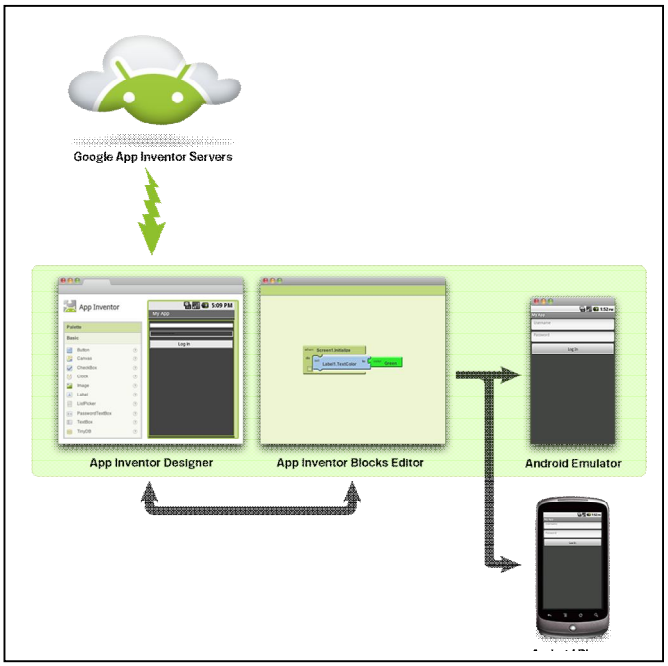

Figure 15: MIT App Inventor

4.1.3 LIFA (LabVIEW Interface for Arduino)

LIFA that allows developers to acquire data from the Arduino microcontroller and process it in the LabVIEW Graphical Programming environment.

First step need to do is download the labVIEW in internet and the install the lab VIEW into the computer as in Figure 16.

Figure 16: Setup NI-VISA driver

Second install NI-VISA is The Virtual Instrument Software Architecture (VISA) is a standard for configuring, programming, and troubleshooting instrumentation systems comprising GPIB, VXI, PXI, Serial, Ethernet, and/or USB interfaces. VISA provides the programming interface between the hardware and development environments such as LabVIEW, Third Step installs the VI package Manager. VI package manger is used to Install/remove add-ons to the NI LabVIEW a VI package is a single file that is handled automatically by VIPM as in Figure 17. This makes sharing LabVIEW code easy.

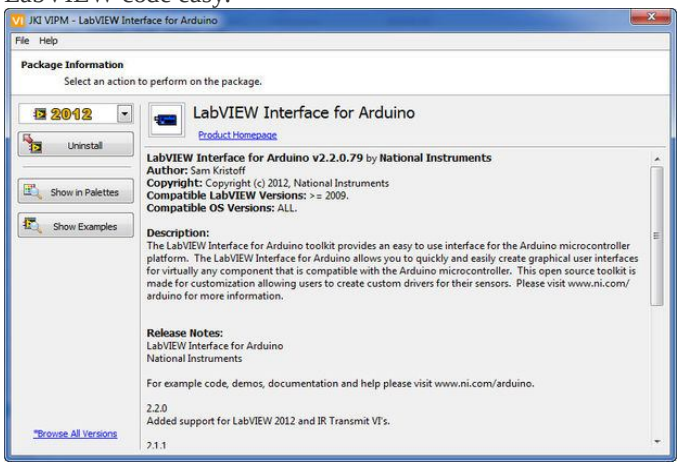

Figure 17: Download LIFA into LabVIEW

Next, Download labVIEW interface with Arduino file in VI package Manager. After that, have access to the Arduino palette in LabVIEW and can be use the palette to interface with the LabVIEW Interface for Arduino Firmware once it has been loaded onto your Arduino. Lastly , upload the LIFA base program in Arduino. This program must be upload to communicate LabVIEW and Arduino. After that, Connect Arduino to computer and choose the com port for Arduino by click tools then go to serial port.

Next, choose what type Arduino that uses for example choose Arduino UNO for board Arduino UNO. Then open LIFA program that have been save and upload to the board.

5. CONCLUSION

A usage of energy consumption increases every year because of demand and usage by human. Electricity usage is very important for human kind to do work or daily routine, such as run machine, wash cloth in washing machine, do coffee with coffee maker and other daily routine. So the usages of electricity increase every year. The objective of this paper is to investigate and reveal the details process on their approach, method and technique use in order to develop the energy saving smart light control system.

This research also valuable as it contribute to the green environment according to energy saving philosophies [17-18]. There are several concepts of light control system, such as LED, LDR, ILB, PUC, PIR and CFL. As the demand of electricity usage in Malaysia is arise, it is suitable to proceed with this project. By implementing energy saving concept it will reduce the usage of electricity consumption.

The method of constructed smart light system also investigated and reveal in details. With three method of lighting system using Raspberry Pi, Adruino or Zigbee module, the approach and technique used for the development is also demonstrated. The lighting system control using Arduino and smartphone is selected as the best method to be used for the next research project. The hardware and software used in the development also presented in this paper to assist others researchers to develop their own.

The development of energy saving smart light system that control light brightness with LDR (Light Dependent Resistor) sensor and occupancy sensor such as PIR (Passive Infrared) sensor will be developed for further research work. By this research project, lighting system will perform and improve their functioning and ability. The key of this prototype is a light sensor can control light brightness for the system. Therefore, this prototype also using motion sensor to sense movement to increase the light brightness.

There are many advantages for this prototype. One of them is the LDR sensor that will control the power of light brightness by intensity. The other advantage is that, the prototype is using LED bulb since it has more life span than other light bulbs and LED uses less power (watts) per unit of light generated (lumens). LED also helps to reduce CO2 (carbon dioxide) emission and reduce electric bills. The LED is ideal for operation under cold and low outdoor temperature settings. Since mobile phone is an important device/gadget to human kind this project is develop a personal control, which user can connect to Wi-Fi or Bluetooth and control the light using mobile application.

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