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SMART LECTURE HALL CONTROL SYSTEM USING MICROCONTROLLER

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ABSTRACT

This paper proposes a smart system for controlling the air-conditioners and lighting system in a lecture hall. The idea is to read the information of person who is entering the lecture hall by using a Radio Frequency Identification (RFID) reader and activate the Air-Conditioning and Mechanical Ventilating System (ACMV) and lighting system. The system consists of a Radio Frequency Identification (RFID) reader, microcontroller and a Graphical User Interface (GUI) that will be used as a secondary control panel substituting the RFID reader. By applying this system, the energy consumption is reduced compared to the conventional method. As a preliminary result, a 35% reduction in the energy consumption of the air-conditioning and lighting system in UMP lecture room has been achieved.

Keywords: RFID reader, energy saving control system, graphical user interface, microcontroller.

INTRODUCTION

Nowadays the electricity is one of the most important elements in our life. People used electricity everyday but they do not realize that they must pay for the electricity. Most people also do not know that sometimes they are wasting the electricity and must pay extra money for their own ignorance. People do not realize that by do not turn OFF the electrical appliance for a minute it cost them extra money.

Especially in academic building, the teaching and learning activities are running most of the time. The lighting and air-conditioning in the lecture halls provide much convenience to users, students and lecturers. However, there will be sometimes when no lectures nor students activities conducted, but the Air conditioning and Mechanical Ventilating (ACMV) and lighting system still run. This will result in wasted energy and high electricity bills.

The monthly average of electricity cost in UMP from 2005 to 2008 is increasing every year. In 2005, the average was about RM 160,000 and became RM 302,000 in 2008 (Saad, Abas, Jadin, Yusof, Rahman and Hanafi, 2008).

This high cost is mainly caused by the operating procedure for the air conditioning system. The system will be turn ON from 8 am until 5 pm. Another problem that arise from this procedure is when the total number of students who attend the class is less than 30 students, the students will feel cold and this will affect the students performance in the learning process. This is proven by a survey that was conducted by Faculty of Electrical and Electronics Engineering, FKEE, UMP [1].

Some of the questions were:

1) Do you feel comfortable with the air flow inside the lecture hall ?

2) Do you feel that the class room temperature affects your performace?

80% of the respondences were answering NO to the question No.1. While, 90% of the respondence were answering YES to the question No.2

In order to solve the problem, we propose a smart system for monitoring the ACMV and lighting system in a lecture hall. This smart system is divided into two parts, which are using GUI-based energy saving and RFID smart card. For GUI-based, PIC Compiler and Visual Basic 6.0 (VB) are used to develop the coding and the design of GUI. For RFID smart card, it will be used to monitor the appropriate temperature for lecture hall during the class, lighting as well as for recording the attendance of the students.

RFID smart card was chosen since it is available inside the students and lecturers ID card. Radio Frequency Identification (RFID) tag technology is used in applications that identify or track objects.

The information about what kind of subjects that students take during the semester is all stored in the university database. The venue and lecture time of every subject during the semester also registered inside the database. By touching the student ID at a certain classroom, the system will match the student information and the data of subject taken, venue and class time. When the student ID is found taking the subject in the chosen place at the correct time, then the ACMV and lighting system will be activated. The duration of the normal lecture in UMP is two hours. Therefore, by using a timer inside the smart system, after the class finishes, the system will be automatically turn OFF.

The application of RFID based smart lecture hall system to control the entire system of the all will eliminate much of the problems and manual work associated with paper based and human activated system.

This system will be develop with extended GUI by using Borland C++, Proteus 7 ISIS and PCW PIC C Compiler which will integrate with the RFID proximity reader.

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SMART SYSTEM

This smart system consists of four sub-systems. First is the data acquisition. The students or lectures information will be obtained by touching the ID card that contains RF circuit to an RFID reader.

Second is the data base. This data base contains information about students detail information, what subjects taken during the semester, the venue of the subjects and the class time of the subjects. This information will be matched with the information obtained from RFID reader.

Third is control system circuit. This circuit is designed for controlling the appropriate room temperature, turn ON or OFF the air conditioning system and lighting system.

Fourth is the Graphical User Interface (GUI) of the system. The purpose of the GUI development is to make the control and monitoring easier and can be interrupted when abnormal condition happened.

The overall system block diagram is shown in Figure-1.

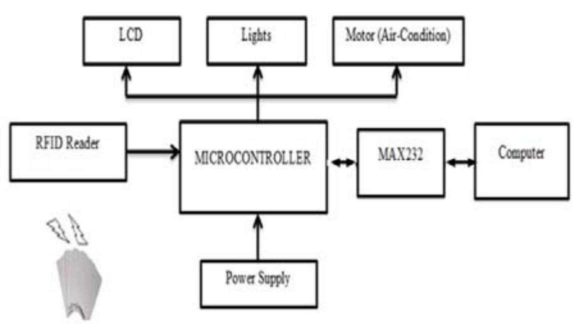

Figure-1. Overall system block diagram.

The working process of the system is shown in Figure-2. When the RFID tag gets into the magnetic field of RFID reader, the RFID tag will receive the RF signal emitted by the microcontroller in RFID reader. By the energy of induced current, the RFID tag will send out information stored in the tag chip. RFID Reader will receive the signal, read and decode the information sent to the central information system for the data processing and also trigger the outputs.

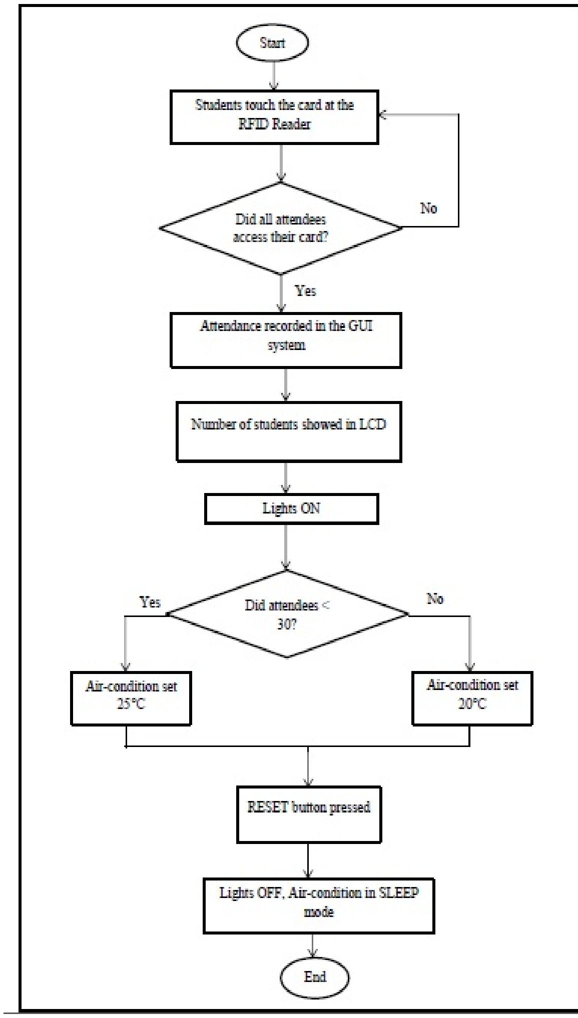

Figure-2. Flow chart for smart system.

The LCD will be ON to display the number of students who had tagged their card to the RFID proximity sensor. Additionally, the lights in the lecture hall will be turned ON as well as the air-condition. The data will be sent to a personal computer through a serial port. The computer will record the identities of the card holder and record the student's attendance in the local server. This enables the lecturers to check and print out the attendance list.

The main part of the smart system is the microcontroller. The LCD which located beside the RFID proximity reader will show the number of students if there is any inputs. At the same time, the attendance will be auto saved in the personal computer which is connected to the microcontroller.

The temperature of air-condition in the lecture hall will change according to the numbers of students in the lecture hall. If the number of students is less than 30, the temperature in the lecture hall will be warmer which is 25°C. If the number of students in the lecture hall is more than 30, the temperature will be cooler which is 20°C.

The lights in the lecture hall will be turned ON once the RFID proximity reader had received any input.

The system will be reset once the reset button had pressed or the lecture time is already two hours. The air-condition will change into sleep mode, the lights will turn OFF and the LCD display will clear the number of students. The reset button is used at the end of every lecture as the personal computer systems need to record a new subject for new sessions.

Passive RFID proximity card

A passive RFID card is used to activate the system. The passive RFID card uses backscatter which the waves are deflected from their original direction. The passive RFID cards usually do not emit their own RF carrier. It modulates the existing carrier by using Amplitude Shift Keying (ASK). ASK is detected with an envelope detector. The sudden change in the amplitude will be detected and a digital output waveform will be produced. The practical envelope detectors had implemented noise filtering to filter out the noise. The signal produced is usually below 60dB from the carrier.

Passive RFID devices have no power supply built in, meaning that electrical current transmitted by the RFID reader inductively powers the device, which allows it to transmit its information back. Because the tag has a limited supply of power, its transmission is much more limited than an active tag, typically not more than simply an ID number.

An RFID tag consists of an RFID chip, an antenna, and tag packaging as in Figure-3. The RFID circuitry itself consists of an RF front end, some additional basic signal processing circuits, logic circuitry to implement the algorithms required, and EEPROM for storage. The RFID chip is an integrated circuit implemented in silicon.

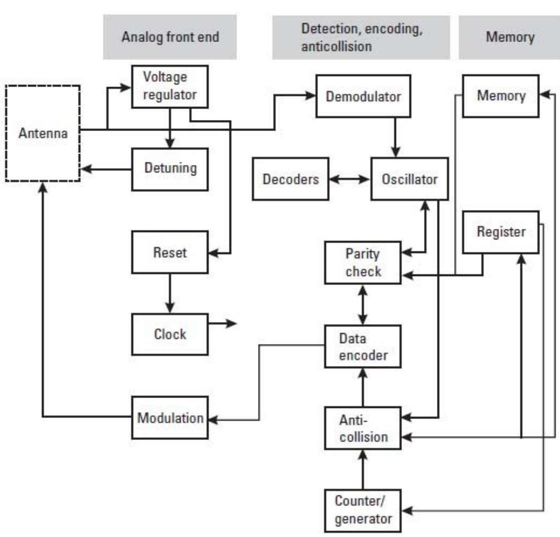

Figure-3. RFID circuit block diagram.

Database

For the database, the controlling system is integrated with the university and faculty database. The data base contains the students detail information, subjects taken, venue of the subjects and the class time of the taken subjects.

Control circuit system

The control system is designed to automatically switched ON the power supply of the air-conditioner or lighting system and also to automatically or manually switch OFF the supply.

The Control System Circuit are divided into four part which are power supply circuit, PIC18F4620 main circuit, lighting system circuit and air-conditioning circuit. For interfacing between software and hardware, three ports of USB to serial converter (RX, TX and GND) are used. These ports are connected to PIC18F4620. Before installing the driver circuit to the wiring bay, the driver circuit must be tested first to avoid fault (short circuit, tripping and etc.) occured. Figure-4 shows the complete circuit for hardware (control system circuit).

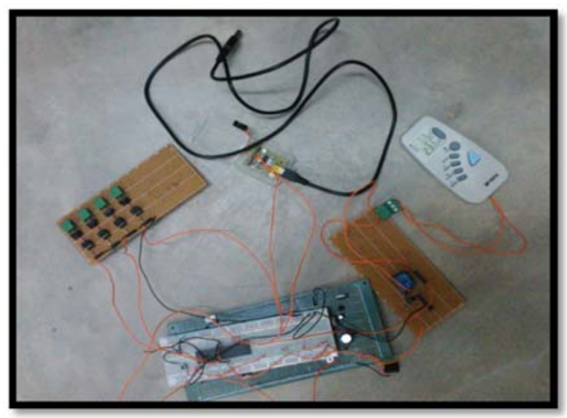

Figure-4. Complete circuit for hardware (control system circuit).

The power supply circuit is to give the voltage supply to the circuit and the Regulator IC in this circuit. This is to make sure that the output voltage have been stepped down form voltage dc input. This circuit is very important because if it does not work, no voltage can be supplied to the hardware circuit and no current can flow. As the result, the hardware circuit cannot be functioned.

The PIC main circuit is needed in order to control the air conditioning system and lighting system. The circuit must be pre-programmed before being used.

The driver circuit for lighting system is for low voltage and for high voltage. Power for the component used in this circuit must be suitable for high voltage to avoid the component from burning. This lighting driver circuit has been designed only for four lighting. However, the connection with PIC can be changed depends on which port that will be used.

The driver circuit for air-conditioning system is connected to the supply +5V, ground and air-conditioner

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remote controller and PIC Port C/Port D. This air-conditioning driver circuit has been designed only for one air-conditioner. However, it can be changed by changing the connection with PIC depends on which Port that we want to use. A simple test can be tried to check whether this circuit is working or not by connecting the output of the circuit to the +5V. If the relay is detected, this means that there is no problem with the connection of the circuit.

Graphical user interface (GUI)

As the preliminary step of the project, a GUI in Visual Basic 6.0 was designed to manually control the ACMV and lighting system in lecture hall. Serial port (Comm1) is used to interface the GUI with the hardware. Coding for interface between hardware and software are made by using this serial port.

At the same time, another GUI was designed to record the attendance of the students. The database in the local server can be read out through the RFID cards as to identify the card holder. By using this system, attendance details, students detail can be checked by the lecturers. However, the system can only be accessed by authorized person such as lecturer or management department as it requires the username and password.

GUI-based energy saving (manually system)

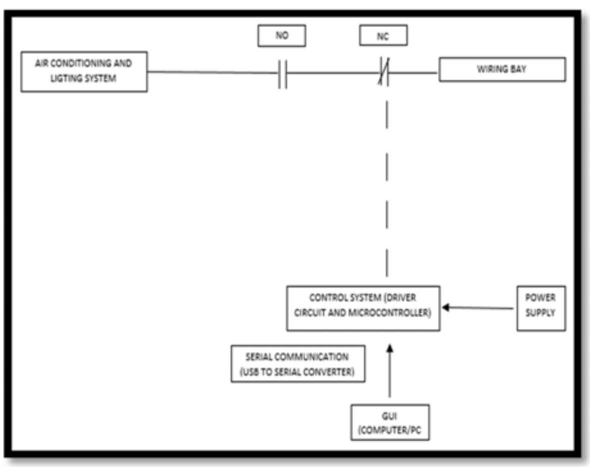

Figure-5. Block diagram for GUI-based system.

The block diagram of the GUI-based is shown in Figure-5. It consists of 9Vdc power supply, the voltage regulator will decrease the dc voltage supplied by dc power supply into 5V. Then the 5V voltage will be supplied to PIC microcontroller and the driver circuit of lighting and air-conditioning system. The hardware is connected to computer/PC by using serial communication which is USB to Serial (UART) Converter. Then, hardware can be controlled by GUI after the interfacing of software and hardware.

Figure-6 shows that both hardware and software can be done concurrently. However, they must be tested separately. If they are no error or problem occurred during the testing, hardware and software can be integrated and interfaced by using USB. The hardware will be installed at wiring bay and the control system are ready to be used.

This GUI has four pages that includes page START (to start enter the program), page for main form of the GUI, page for the Control System (lighting and air-conditioning) and for page END (user exit the program) which is go back to main form of the GUI.

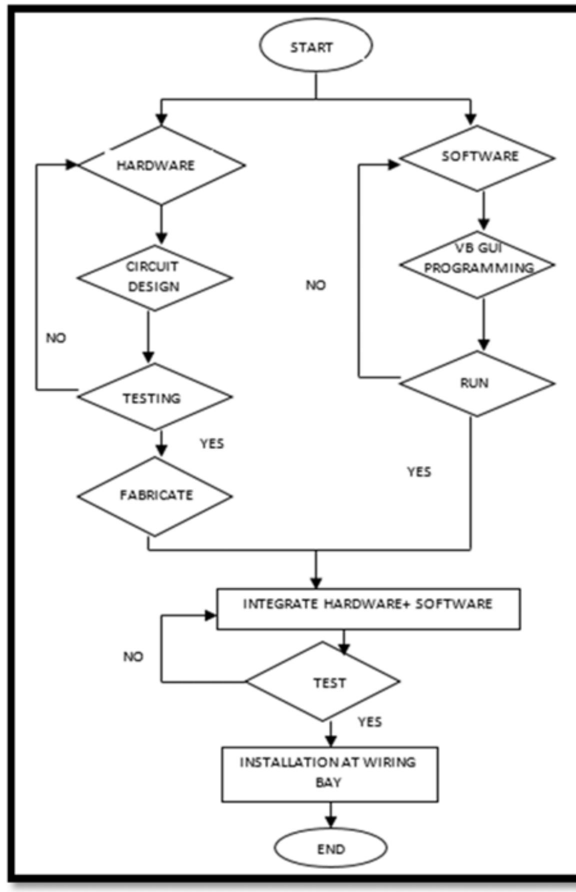

Figure-6. Flow chart for GUI-based system.

RESULT AND DISCUSSIONS

As the preliminary result, we have finished in conducting the development and test on part three and four of the system. Part three is the control circuit system, while part four is the GUI development.

Analysis on control system circuit

This part is to analyse the output voltage for each part of the hardware circuit. Each part of hardware circuit are given input of +5V which is connected to power supply circuit. Power supply circuit is connected directly with +9V AC to DC Converter Adapter (Rectifier). It is reduced to +5V because of DC voltage regulator in the power supply circuit that has function to step-down the voltage supply. Every hardware circuit are connected with digital oscilloscope in order to measure the value of voltage output and peak to peak voltage.

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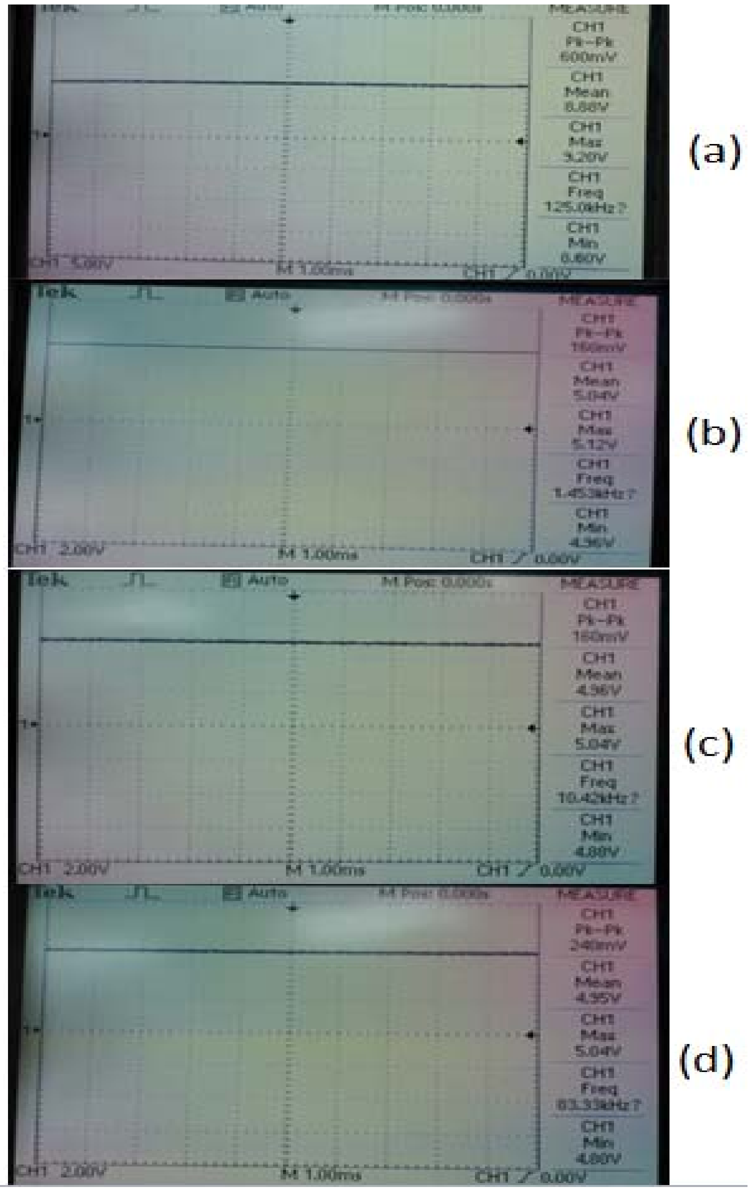

Figure-7. Measurement of (a) Input voltage AC-DC converter adapter; (b) Power supply circuit of control system; (c) Lighting system driver circuit and (d) Air-conditioning system driver circuit.

Figure-7 shows waveform of output signal that comes from the oscilloscope. The output signal is in the form of straight line because the output is DC voltage. The values in the right side of the graph are the result of the measurement. It can be summarized in Table-1.

From Table-1, it is clearly seen that the measured voltage is close to the value of the given actual voltage. This result indicates that the circuit is working properly and can be used for controlling the air conditioning and lighting system.

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Table-1. Summary of measurement of control circuit system.

Circuit	Actual voltage (V)	Measured voltage (V)	Peak to peak (mV)
AC-DC Converter adapter	9.0	8.8	600
Power Supply circuit	5.0	5.04	160
Lighting system driver circuit	5.0	4.96	160
Air-conditioning system driver circuit	5.0	4.95	240

Each part of the hardware circuit is accepted because the measurement value of output voltage is approximate to the actual value. The value of peak to peak voltage for each part of the hardware circuit is very small which is in unit mV. Peak to peak voltage is the value of ripple voltage in steady dc circuit. The value of ripple voltage is very small because the circuit is already smoothen by filter circuit in the AC-DC Converter Adapter.

GUI development

Figure-8. Page 1 of GUI.

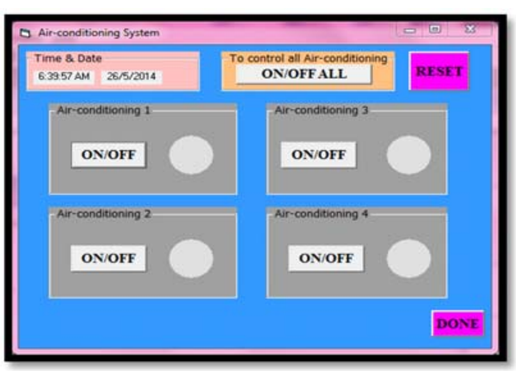

Figure-9. GUI for air-conditioning system window.

Figure-8 shows a GUI page for the control system. When “Air-conditioning System” button has been clicked, the page of “air-conditioning system” will show the 4 buttons of ‘ON/OFF’ as shown in Figure-9. Serial port (comm1) will send ASCII code to the hardware through USB to serial converter and the indicator colour will change to green when the button “ON/OFF” is pressed as in Figure-10.

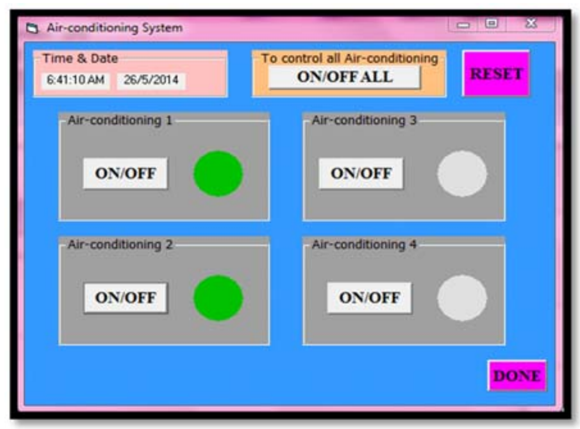

Figure-10. “ON/OFF” button was pressed.

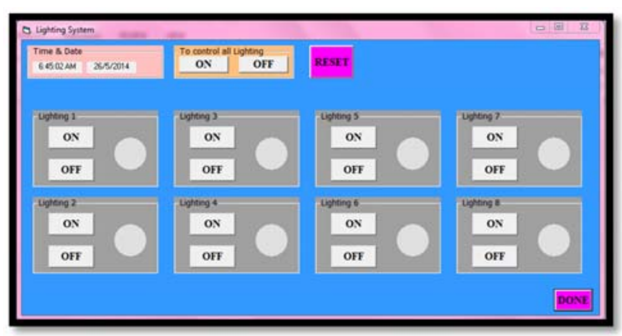

Figure-11. Lighting system window.

When “Lighting System” button has been clicked, the page of “lighting system” will show the eight buttons of ‘ON” and six buttons of “OFF” as shown in Figure-11. Serial port (comm1) will send ASCII code to the hardware through USB to serial converter and the indicator colour will change to green if button “ON” been click or red if button “OFF” been click.

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When the "ON" button was pressed, the green light will appear. It shown in Figure-12. And if the upper "ON" button (to control all lighting) was pressed, all the green light will appear and it shows to ON all the lighting in control system, as shown in Figure-13.

When the "OFF" button was pressed, the red light will appear as shown in Figure-14. And if the upper "OFF" button (to control all lighting) was pressed, all the red light will appear and it shows to "OFF" all the lighting in control system, as shown in Figure-15.

When "RESET" button is pressed, the GUI of air-conditioning and lighting system will remained as initial condition as shown in Figure-9 and Figure-11.

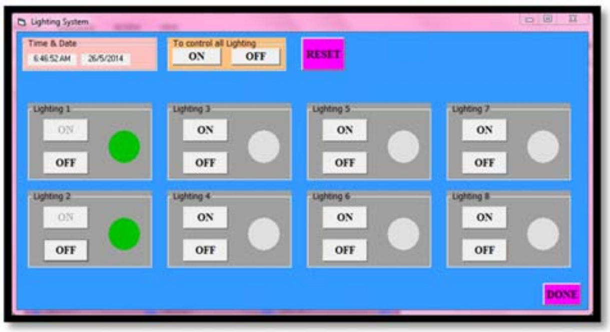

Figure-12. "ON" button was pressed.

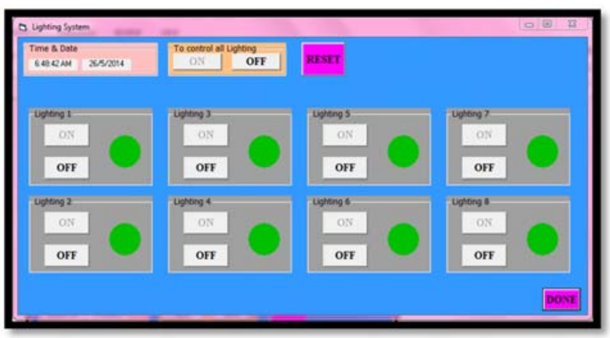

Figure-13. All "ON" button was pressed.

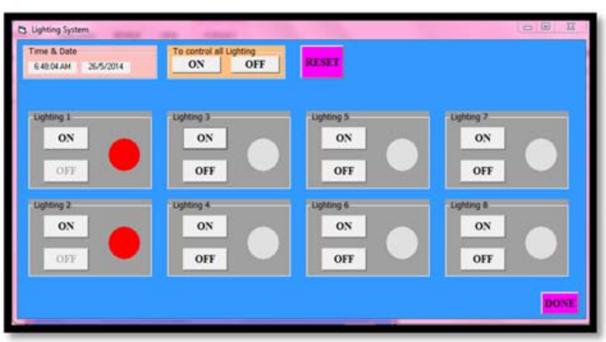

Figure-14. "OFF" button was pressed.

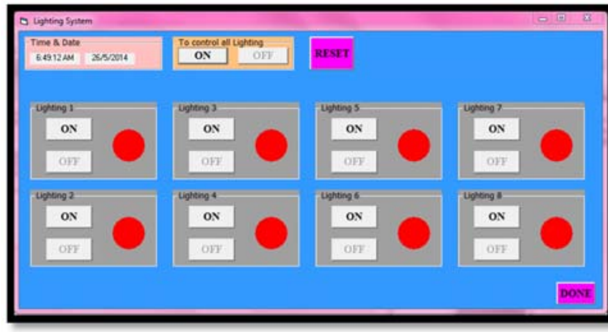

Figure-15. All "OFF" button was pressed.

CONCLUSIONS

This project is a preliminary work on a smart lecture hall. Graphical User Interface (GUI) for ACMV and lighting control system to reduce the energy concumption in a lecture hall is developed. A working prototype of lighting and air-conditioning control system using GUI is built.

Software development for controlling system and GUI using Visual Basic (VB) was successfully done. The hardware for the complete control lighting and air conditioning system circuit is designed.

Graphical User Interface development for application in a smart lecture hall is successfully developed. This GUI can be used for controlling the lighting and air-conditioning system by using software to reduce electricity cost. As a result, this application can lead to the decreasing of power consumption in a lecture hall.

User can turn on or turn off the air-conditioning system by clicking one button from computer/PC or using conventional switch manually. User can reduce their electricity bill by reduce the usage.

The application has beed tested in one of our class room. It is found that the power consumption is reducing up to 35%.

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