Power Management Control System for Computer Laboratories

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***Abstract*—A power management control system is designed and proposed in this research that aims to monitor and control the power energy distribution on computer laboratories and classrooms based on the time of the day and the number of students inside the room. A cheap CPLD board is used as a control mechanism which minimizes power energy wastage that results in minimizing the electrical consumption of computer laboratories and classrooms. Two adjacent computer laboratories were used to as testbed in controlling the electrical power distribution on each room and the air-conditioning system based on the time of the day and the number of people inside the laboratories. Initial results show that a 7.70% reduction in the power consumption is achieved by the proposed system. Finally, a database system for class schedules is used to control power energy distribution on computer laboratories.**

***Index Terms*—Control System; Power Management.**

I. Introduction

With the improvements in the electrical and electronics industry, the high demand in electrical power results in a relatively high cost on power consumption. Most of the schools and universities in the Philippines suffer from very high overhead cost that is primarily due to high electrical power consumption most from computer laboratories and classrooms. There are several researches [1][2] that focus on how to effectively conserve electrical power consumptions mostly at home or in the offices by using simple microcontrollers to control power switches and plugs. A study [3] shows that a portion of the high-power consumption is due to standby power consumed by electrical appliances. The focus of this research is how to effectively monitor [4] the correct usage of power not just at homes and offices but also in school laboratories and classrooms. Several literatures on Smart energy management systems [6][7][8][9][10][11] show some level of improvements in terms of power conservation using smart plugs, smart appliances and smart meters. In this research, a simple CPLD based embedded system is used effectively monitor and control power consumptions for computer laboratories and classrooms. The proposed control system can significantly reduce power consumption by 7.70% or more.

II. Statement of the Problem

The high cost of overhead due to electrical power consumption is one of the dilemmas each university is facing every month. Millions and millions of pesos are being used to pay-up high cost of electrical bills. But most of the time, the electrical power consumption is not being optimized. A significant percentage of the power is being wasted due to the inability of school authorities to monitor correct power usage of each and every classroom in the university.

A power management system is proposed in this research that is able to control the supply of electrical power to certain computer laboratories and classrooms. This power management system is able to block electrical power supply to classrooms beyond class hours and weekend. During class hours, the power management system is able to control the power distributed on each room and the state of the air conditioning system used inside the classroom or laboratory. This power management control system is based primarily on two important parameters: the number of people inside the room and the time of the day. Two conditions are set with respect to the time of the day. First, the power control system will deliver power during weekdays and Saturdays from 6am to 5pm. Second, a database of the class schedules is programmed using a lookup table. The control system only delivers power during official class schedules. And lastly, a manual override is also devised in the controller in order to bypass rules set in the central control mechanism.

Actual computer laboratories are used in this research to demonstrate the capabilities and design of the power management system. This central controller of the power management system can use any ordinary microcontrollers such as Arduino, Atmel, Motorola or Zilog for interfacing and decision handling. Due to availability of the resources, a cheap Altera MAX 2 CPLD board is used to maximum the device utilization in the research laboratory.

III. Methodology

This research uses a cheap CPLD Board, the Altera Max II Board as a control device that is able to monitor the power consumptions and control the power distribution in computer laboratories or classrooms in universities depending on the time of the day or class schedules and the number of people inside the laboratory. The diagram below shows the major aspects that are covered by the CPLD based central control mechanism.

The clock system or the timer is embedded in the program inside the Max II board.

Figure 1 shows the overall block diagram of a CPLD based power management control system used in computer laboratories and classrooms to minimize power wastage to conserve power and save money from high costs of electrical power bills. The system basically covers four important tasks as shown in Figure 1.

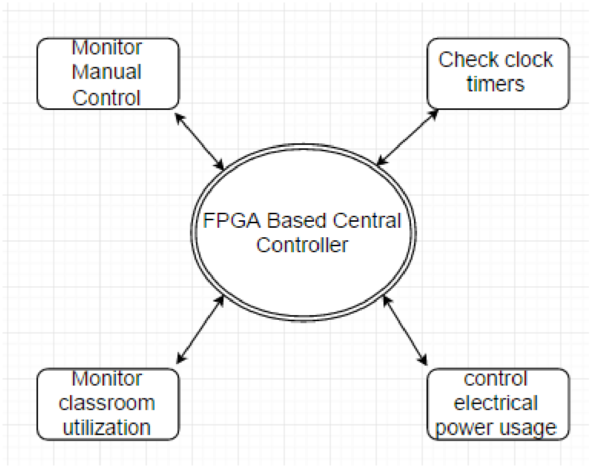

Figure 1: System block diagram of the power management system

A main or central controller is needed for the interfacing of sensors and control of electrical switches and will also serve as the decision maker of the system. Any microcontroller or embedded system can be used in this purpose. This research uses a cheap Altera CPLD board, the Altera Max II. This central controller is the heart of the power management control system.

The central controller has an embedded clock sequence timer and calendar that can monitor the time of the day and the correct day of the week. This clock segment is needed by the central controller to decide whether it will block or open the supply of electrical power to the power outlets located at the computer laboratories. Piezo electric sensors are used as triggers for the up and down counters located at separate entrance and exit doors of the rooms. The number of people inside the room can be monitored from a built-in counter in the central controller. A separate control mechanism is also used to control the settings of the air conditioning units inside the room. Finally, a manual override is provided to manually block or allow the supply of electrical power from the main power source. The flow chart of the control program is shown in Figure 2.

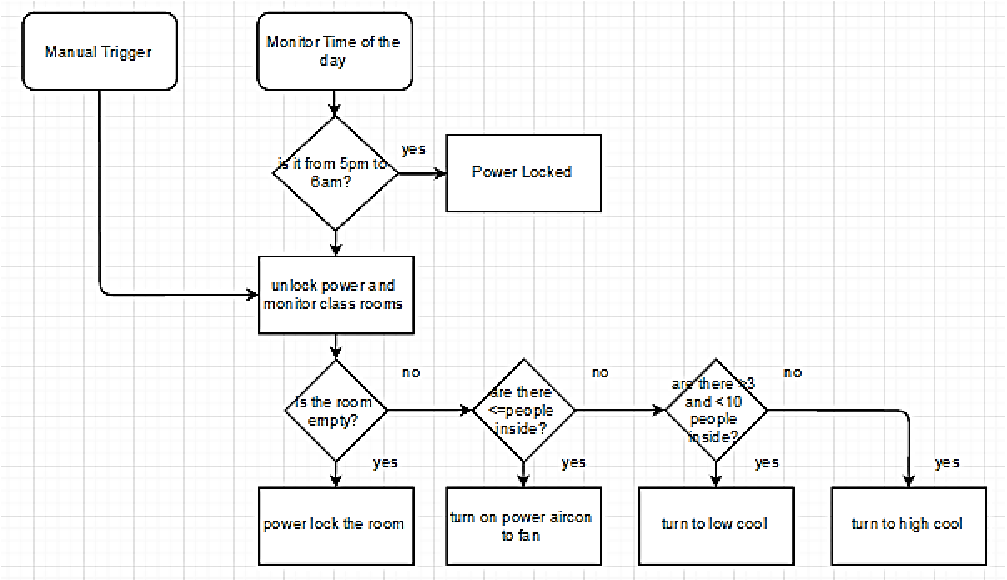

Figure 2: System flowchart

Figure 2 shows the system flow chart showing how the system will respond to the time of the day, number of people inside class rooms and manual trigger in the control panel. A manual trigger is programmed to bypass the controller and to manually control the electrical power distribution in the room. The program monitors the time of the day, From 5pm to 6am, the central controller locks the power distribution on the room. This means that the electrical power source is blocked and no supply of electricity will flow to the electrical outlets of the room. During the period between 6am and 5pm, the central controller monitors the class schedules and the number of people inside the room through the counter triggered by the sensors in the entrance and exit of the room. If the count is zero, the central controller again blocks the supply of electrical power to the room. If the room is not empty, the central controller provides electrical power to the lights and outlets of the room and starts controlling the state of the air conditioning unit. The air conditioning unit can be set to fan, low cool or high cool depending on the number of students inside the laboratory. The incoming sections will show and discuss the design and layout of two adjacent computer laboratories used and the electrical wiring design used in actual electrical wiring inside the rooms.

A. Laboratory Classroom Prototype

Two class computer classrooms are used as test bed in this research to simulate the real time performance of the power management control system. Each computer laboratory has its own entrance and exit doors that contain pressure sensors used to trigger the up-down counters in the central controller. These sensors are used to monitor the actual number of people inside each laboratory rooms.

Figure 3 below shows the electrical wiring design for the two adjacent computer laboratories used in this research.

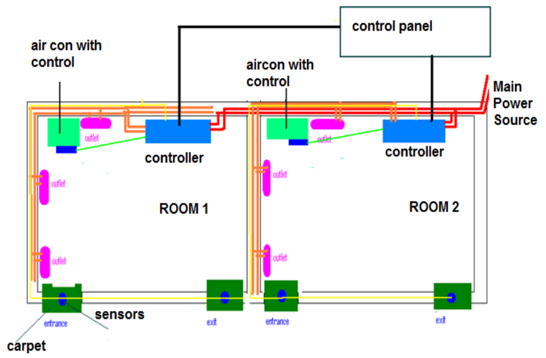

Figure 3: Two adjacent computer laboratory rooms used as testbed in this research

Figure 3 shows the two adjacent classrooms that are used as test beds for this research. The blue boxes on each room are the locations of the controllers used. These controllers are relays or switches that connect or isolate the computer laboratory power outlets to the main power source. These controllers can block or allow the flow of electrical power inside the rooms that deliver power to the loads such as lightings, power from electrical outlets, computers and air conditioning units. Each room has one controller and all these controllers are interfaced and being controlled by the central control system.

Each room has a dedicated entrance and exit doors with pressure sensors below the carpet. These sensors trigger an UP and DOWN counter on each room. These two classrooms and all control mechanisms are tested for six weeks. Two weeks of monitoring the power consumption without the proposed central controller, another two weeks with embedded central controller that monitors the time of the day and the count inside the room; and another two weeks with embedded controller that monitors actual class schedules and people count inside the rooms.

B. Electrical Wiring Installation

The design and installation of electrical wiring for the two computer laboratories or classrooms is shown below. The electrical wiring is directly connected to the central controller. Each controller is capable of supplying electrical power for its load such as for one electric fan, one fluorescent lamp, one computer power line and one air conditioning unit. A computer power line can supply power to a maximum of 25 computers in the laboratory. The wiring shown in Figure 4 is used as a generic electrical wiring for each computer laboratory or classroom.

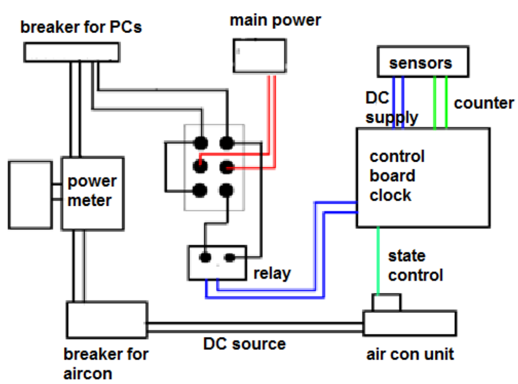

Figure 4: Electrical wiring of proposed power management system

Figure 4 shows the electrical wiring design for the power management system. A power meter is installed in each classroom to monitor the power consumption with the embedded control system. A 30A circuit breaker is used for the electrical outlet for the computers and a 60A circuit breaker for the air conditioning unit. The circuit breaker for the computers is connected through a relay switch controlled by the central controller to the main power source. This enables the user to turn off the supply of power to the computers even if the central controller allows power distribution on it. There are also DC sources that are used to power up sensors and the control mechanism for the air conditioning unit. The central controller communicates with the pressure sensors through programmed counters and the air conditioning unit controller whenever there is a change in the number of people inside the laboratory.

C. Air-Condition Control Mechanism

A control mechanism for the air conditioning unit is also designed in order to change the state of the air conditioning unit. A servo motor is used and constructed to control the rotary switch on the air conditioning unit and change its settings from off, fan, low cool and high cool. These states depend on the number of people present inside the room as counted by the sensors in the entrance and exit doors. Figure 5 shows the state flow diagram in order to determine the needed state of the air conditioning unit.

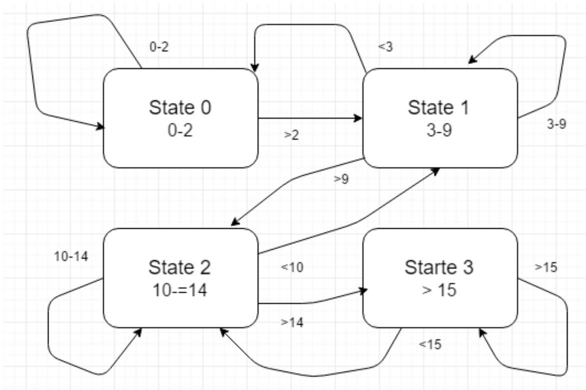

Figure 5: State flow diagram control for the air conditioning unit settings

Figure 5 shows the state flow diagram of the controller mounted in the air conditioning unit. These settings are highly dependent on the counters triggered by the sensors in the entrance and exit doors in the computer laboratory.

The controller is at State 0 if there are between 0 and two persons inside the room, the electrical power will still be locked. At this point, the lights and electrical outlets have power but the air conditioning unit will remain in the OFF state.

If the number of people inside the room is increased to 3 up to 9 persons, then the controller will set the air conditioning unit to FAN. This is State 1 of the controller. If the count goes down to below 3, then the controller will go back to State 0.

If the number of people inside the room is increased to 10 up to 14 persons, then the controller will set the air conditioning unit to LOW COOL. This is State 2 of the controller. If the count goes down to below 10, then the controller will go back to State 1.

If the number of people inside the room is increased to 15 persons and up, then the controller will set the air conditioning unit to HIGH COOL. This is State 3 of the controller. If the count goes down to below 15, then the controller will go back to State 2.

The states and the counts for each state can easily be changed by just changing the necessary parameters in the program from the CPLD board.

D. Piezo Electric Sensor

Four piezoelectric switches are used and installed in each of the four doors in the test bed. They are installed at the bottom of the carpets located at the entry and exit points of the class rooms. The switches at the entrance doors trigger the UP counts while the switches on the exit doors trigger the DOWN counts. Figure 6 below shows the actual piezo electric switch used in this research.

Figure 7: Piezo electri switch used for the UP-DOWN counters

The signals from the piezo electric sensors are too weak. A conditioning unit is constructed to improve the signal and minimize the noises from it. A conditioning circuit is shown in Figure 8 below. Aside from the conditioning circuit, a de-bouncer program is also done in the central controller. This ensures a correct count from the sensors.

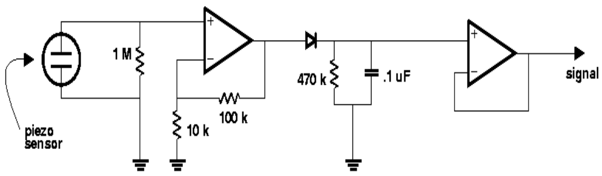

Figure 8: Conditioning circuit for the piezo electric sensors

E. Control Board

Any controller can be used as central controller implemented in this research. Because of availability, The Altera Max II was used. Figure 9 shows the connectivity and program dependency of the central controller.

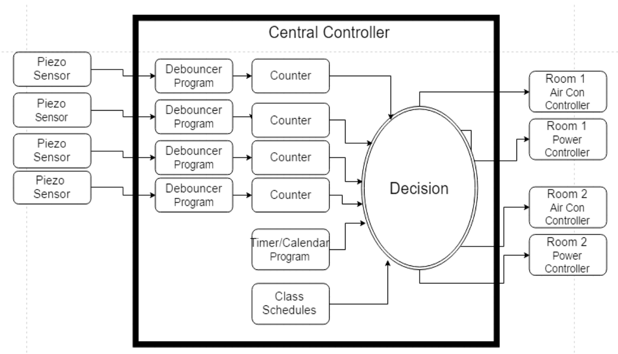

Figure 9: Central controller programs and interface

The central controller has direct connections with the sensors and actuators. The internal programs include the counters, de-bouncers, timer and calendars, class schedule using lookup tables and the rules for decision making.

IV. Discussion of Results

The two adjacent computer laboratories were used as test bed in this research. The electrical wirings in the rooms are re-installed in order to simulate the effectiveness of the proposed power management system. Six weeks of data are initially gathered in order to determine whether there is a corresponding improvement in power conservation due to the installation of the proposed system.

The computer laboratories power consumptions are monitored without the power management controller. The monitoring period was done in the first two weeks. Another two weeks of data gathering is done to monitor the power consumptions of the rooms with the power management system installed. The control is based on the time of the day and the count of people inside the room. The last two weeks are used to gather data for the power consumption of the classrooms with the power management system. This time, the control is based on the actual class schedules and the count of people inside the room. Table 1 shows the class schedules for the two computer laboratories.

Table 1
Actual Class Schedules. XX means Occupied

Laboratory 1							
	Mon	Tue	Wed	Thurs	Fri	Sat	Sun
8-11	XX	XX	XX	XX	XX	XX	
11-2		XX					
2-5	XX		XX		XX		
Laboratory 2							
	Mon	Tue	Wed	Thurs	Fri	Sat	Sun
8-11	XX	XX		XX	XX	XX	
11-2	XX	XX	XX	XX	XX	XX	
2-5			XX				

Tables 2, 3 and 4 show the power consumptions of the two computer laboratories.

Table 2
Power Consumptions without Power Management Controller

Day	Room 1	Room 2
Mon	55.2	60.2
Tue	49.9	55.1
Wed	50.2	59.2
Thurs	51.3	58.9
Fri	49.2	54.2
Sat	47.8	47.1
Sun	3.5	4.8
Mon	52.3	59.3
Tue	51.2	55.9
Wed	49.7	58.3
Thurs	50.5	59.1
Fri	52.7	57.2
Sat	43.2	55.1
Sun	2.4	3.3

Table 2 shows the power consumption of the two computer laboratory rooms without the power management system. There are no classes during Sundays but as shown, there are still power consumed by the two computer laboratories.

Table 3 shows the power consumption of the two computer laboratory rooms with installed power management system. The control is based on the time of the day and the count inside the room. The power is available from 6am to 5pm.

Table 3
Power Consumptions with Installed Power Management Controller

Day	Room1	Room 2
Mon	49.4	58.1
Tue	48.2	52.7
Wed	46.9	56.3
Thurs	48.2	55.9
Fri	47.8	51.6
Sat	40.9	43.1
Sun	0	0
Mon	50.1	52.9
Tue	48.2	50.6
Wed	47.1	52.6
Thurs	49.3	52.1
Fri	47.1	51.8
Sat	45.8	50.2
Sun	0	0

Table 3 shows the electrical power consumptions of the two computer laboratory rooms using the power management system to control the electrical power distribution in the rooms. A significant decrease in the power consumption can be seen. Also, During Sundays when no classes are conducted, there is zero (0W) power consumptions for the two rooms. This is a proof of the effectiveness of the proposed power management system. Table 4 shows a more complex power management control system that monitors the actual class schedules of the two rooms. The power is cut on the times that there are no classes scheduled in the rooms. This prevents unauthorized usage of the room and high power wastage due to standby power of the computer's AVR and other electrical appliance that may be connected to the power outlets.

Table 4
Power Consumptions with Installed Power Management Controller
Monitoring actual class schedules

Day	Room 1	Room 2
Mon	44.4	51.1
Tue	43.2	46.7
Wed	42.9	50.3
Thurs	44.2	51.9
Fri	42.8	47.6
Sat	37.9	39.1
Sun	0	0
Mon	45.1	46.9
Tue	42.2	46.6
Wed	43.1	45.6
Thurs	42.3	46.1
Fri	43.1	47.8
Sat	41.8	45.2
Sun	0	0

Table 4 shows the power consumptions of the two laboratory rooms during the two weeks data with installed power management control system that monitors actual class schedules and people count inside the room.

Table 5 below shows the power consumptions gathered during the three phases of the experiment.

Table 5
Summary of Power Consumptions

	Power Consumed	Percentage Power Savings
Two weeks data without power management system	1.2968kW	0%
Two weeks data with power management system monitoring time of the day and people count	1.1969kW	7.70%
Two weeks data with power management system monitoring actual class schedules and people count	1.0779kW	16.88%

V. CONCLUSION

The system is very effective in conserving power and can save significant amount of money in long terms. The AVRs of computers in the computer laboratories are most often neglected to be turned off and consumes electrical power overnight even if the computer is off. The proposed system cuts the electrical power whenever the room is empty or there is no class schedule on the rooms, thus, minimizing a significant standby power and saves lots of money from high electricity overhead cost!

The system is also effective in cutting the electrical power during nighttime and Sundays. The possibility of people using the room beyond daytime and during weekends is eliminated. The actual effectiveness of the system can be seen in the long duration of usage and if implemented in a large scale system.

VI. RECOMMENDATIONS

The system is more effective if implemented in several computer laboratories and classrooms. The system can be further improved by choosing a good sensor that may be able to detect the entry and exit activities in the room without exposing the sensors to the students.

For future work, the system can also be connected to a data logger or Internet of Things, in a large scale implementation, data logging of the date and the amount of power consumed per day will be very useful in monitoring the power usage of each room or laboratory.

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