SMART LIGHTING & AIR CONDITIONING SWITCHING DEVICE

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MARCH 2005

"I declare that I have read through this report and conclude that this report achieves the scope and quality requirement for the purpose to award the Degree of Bachelor In Electrical Engineering (Industrial Power)"

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Date : **9th March 2005**

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This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree of Bachelor In Electrical Engineering (Industrial Power)

Fakulti Kejuruteraan Elektrik
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March 2005

"I declare that the report/work submitted is my own, except for the excerpts and texts where every one of its sources is explained and stated."

Signature : _____

Name : **MAY FRANNY SEPIKIT**

Date : **5th March 2005**

I dedicate this to my beloved parents,
my whole family, and to all my friends
who have stood by me throughout these 4 years,

ACKNWOLEDGEMENT

I would like to acknowledge the following people, who have assisted and supported me in the completion of this thesis.

I would like to express my sincere gratitude to my supervisor DR. Alita Dewi for her constant guidance, encouragement and for her patience throughout the completion of this thesis.

I would like to express my sincere gratitude to the staff of FKE for their generous cooperation without even a dose of hesitation

I would like to express my sincere thanks to my friends, particularly Hafizul Mahadi Effendi and Izimikel Linggin for being very generous in sharing their time and knowledge.

I would also like to express my deepest gratitude to my family who have endured with me, supported and encouraged me with their continuous love since the beginning, now and hopefully until the days to come.

Last but but least, my never ending gratitude to God Almighty for everything HE has provided me.

ABSTRACT

In a world where energy is an essential and costly part of our daily lives, efficiency is a benchmark that was, is and will always be a challenge to achieve. The SMART LIGHTING & AIR CONDITIONING SWITCHING DEVICE is one such system that fully takes on this energy efficiency challenge. An unoccupied room with all the lights and air conditioning left on even only for a few minutes is a common and disturbing example of waste of precious energy. Neglect and absent-mindedness is mainly the cause of this waste of energy. This system will help to ensure that waste of energy from an unoccupied room with the lights and air conditioning on will cease to be a case. With the existing technologies of motion sensor, thermal sensor, and switching, the smart lighting and air conditioning switching device could improve the specification of the present occupancy switch.

ABSTRAK

Dalam dunia yang mana tenaga merupakan suatu keperluan harian yang penting dan tak ternilai, kecekepan tenaga merupakan tanda-bendul yang akan senantiasa menjadi cabaran untuk dihadapi dan dicapai. Sistem Pensuisan Pencahayaan dan Penyaman Udara Pintar (SMART LIGHTING & AIR CONDITIONING SWITCHING DEVICE), merupakan suatu sistem yang akan menyahut cabaran pencapaian kecekapan tenaga yang berkesan. Situasi dimana sesebuah ruangan atau bilik tidak berpenghuni dengan lampu dan penyaman udaranya dibiarkan beroperasi walau hanya beberapa minit merupakan suatu contoh pembaziran tenaga yang membimbangkan kerana is berlaku hampir di semua tempat, pada setiap masa. Kecuaian dan sikap tidak kisah merupakan antara penyebab utama pembaziran tenaga ini berlaku. Sistem ini akan membantu untuk memastikan pembaziran tenaga yang telah diterangkan tadi tidak akan berlaku. Berbekalkan teknologi yang sudah sedia ada seperti pengesan pergerakan (motion sensor), pengesan haba (thermal sensor) dan juga pensuisan, sisteme pensuisan pencahayaan dan penyaman udara pintar ini mampu memperbaiki lagi spesifikasi "suis penempatan" (occupancy switch).

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CHAPTER 1

INTRODUCTION

1.1 Project Objective

The objective of this project is to design and build a switching device that can automatically switch off and on lights & air conditioning units in an unoccupied room, relying upon the detection of installed sensors. When sensors detect the state of occupancy of a room, it will then relay the required data to a control circuit which in turn will switch off the lights and air conditioning units.

1.2 Problem Statement

The problems in this project are:

1. To determine on the most appropriate type of sensors that should be used based on what should be sensored in order to efficiently & effectively trigger the switch.

2. To determine on the type of control circuit that should be implemented in this system, regarding to the specification of the Smart Lighting & Air Conditioning Switching Device
3. To determine circuit model, in order to build Lighting and air-conditioning switching device that is smart when it is deciding to either switch OFF or switch ON the light and air conditioning.

These problematic are going to determine the methodology as mentioned in the next sub-chapter (**sub-chapter 1.3**) in carrying out this project.

1.3 Methodology

Achieving the objective of this project and answering the problematics as mentioned in the previous chapter, the following methodology are going to be carried out in this project:

1. Literature studies
2. Studying on control circuit & sensor
3. Development and simulation of switching device circuit
4. Realization of switching device

Literature study is done for the purpose of learning about occupancy sensors/detectors and its system components (Electronic control Unit (controller), Relay & Power Supply). In the literature study, determination will be done on the types of sensors and which type is best to be applied in this project. This requires the sensor to detect and get the closest accurate input to trigger relay switch on whether to "ON" (relay close) or "OFF" (relay open), by which will also lead to the steps of determining the type

of rooms to implement this system in terms of application in the KUTKM. Determining the best type of sensor and the room/space to implement it later on will need a process of learning the detail operation of specified sensor.

The steps mentioned before will then lead to the section where model of scenarios that will trigger the system and what might cause false triggering should be determined. In the process of doing this, information such as type of lamps, operation of air-conditioning (AC) and types of AC, in terms of its voltage, ampere and power requirement need to be recorded to help in the development of the control circuit.

The purpose of studying the control circuit & sensor is to learn, analyze and obtain the model of the most effective and reliable control circuit (which is also complemented by the other main components) to implement in this system. At the end of the development & simulation of switching device circuit, the equivalent circuit of the device will be realized and the connection of each or between the components can be clearly seen and understand. It should be that by this stage a simulation model or design circuit will already be at hand.

At this stage, the proposed device should already be realized. The objective of Smart Lighting & Air Conditioning Switching Device should be fulfilled. Problems or obstacles faced would already be solved. The detailed description about the activities and the planning time of achievement for each phase of the methodology can be seen in the project planning chart as shown in ***Table1-1***.

Table 1-1: Project Planning Chart

PERANCANGAN PROJEK
PROJECT PLANNING

Senaraikan aktiviti-aktiviti utama bagi projek yang dicadangkan. Nyatakan jangka masa yang diperlukan bagi setiap aktiviti.
List major activities involved in the proposed project. Indicate duration of each activity to the related month(s).

	2004							2005					
Aktiviti Projek *Project Activities*	J	J	A	S	O	N	D	J	F	M	A	M	J
Title preparation	→												
Project proposal		→											
Literature study		→	→										
Studying on circuit control & sensor			→	→									
Development & Simulating circuit design			→	→	→	→							
Progress report			→	→									
Present progress report				→	→								
Realization of device						→	→	→					
Draft of project report								→					
Report								→	→	→			
Presentation									→				

CHAPTER 2

PRINCIPAL COMPONENTS OF SMART SWITCHING DEVICE

In this Smart Switching device the principal components consists of the **sensor** to detect movement or motion within the required space and then sending the signal to the **microprocessor** which is another principal component in this device. The microprocessor shall process the signal it receives and will execute the next step accordingly to the written program.

2.1 Sensor

A sensor is a device that gives a useable signal, related to some physical stimulus. The parts of a sensor may include, but are not limited to a transducer, power conditioning, signal conditioning, and output electronics. A simplified representation of the components of a sensor is shown in ***Figure2-1***. The ***Figure2-1*** should be read from left to right where the circles are possible external connections.

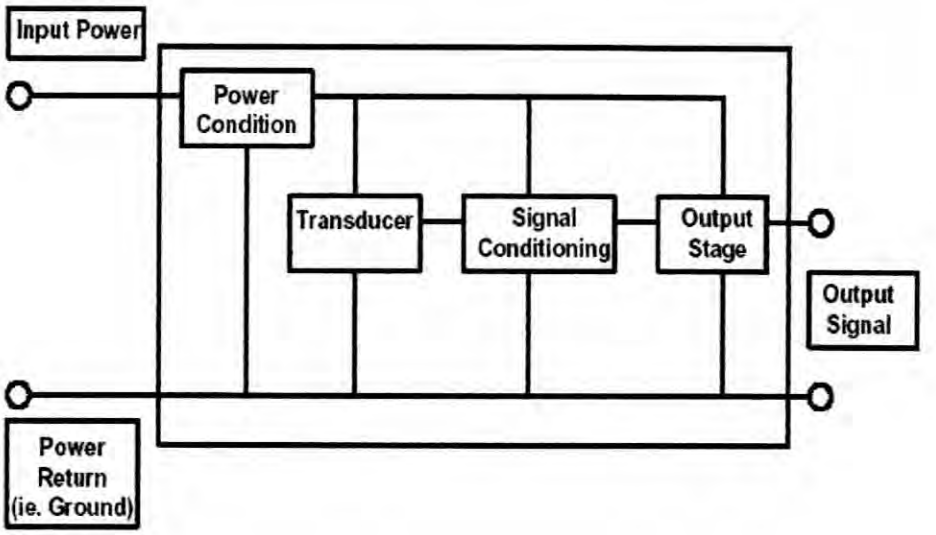

Figure 2-1 Components of a sensor

Listed below are the technologies of sensors that are commonly used in detecting state of occupancy of a room.

1. Infrared or Passive Infrared (PIR)
2. Ultrasonic or Ultrasound (US)
3. Microwave
4. Audio

These occupancy sensors (including passive infrared, ultrasonic, and dual technology or hybrid sensors) serve three basic functions, which are:

1. Automatically turn lights on when a room becomes occupied,
2. Keep the lights on without interruption while the controlled space is occupied, and
3. Turn the lights off within a preset time period after the space has been vacated.

2.1.1 Types of Sensor

Generally speaking, there are three categories of occupancy sensors. These types of sensors are motion detecting sensor, heat-detecting sensor which is commonly known as infrared sensor and sound sensing sensor. Out of these three sensors, another sensor can be developed by combining any two of the sensors mentioned before to become one sensor known as hybrid sensor.

2.1.1.1 Motion-detecting

Based on sensing media, this sensor is able to be divided into two categories of sensor, which are:

a) Ultrasonic or Ultra Sound (US)

These sensors contain both an ultrasound generator and receiver. The ultrasound generator emits sound waves that saturates the space and any motion towards or away from the sensor causes a change in the reflected frequency. Changes in the wave are detected by the sensor which sends a positive signal to the controller. ***Table 2-1*** shows the average sensitivity distances for ultrasonic sensors. While ***Figure 2-2*** shows the motion detection concept for Ultrasonic sensor, where high-frequency sound waves are transmitted from the sensor, reflected from room objects and surfaces and eventually returned to the receiver located in the sensor

Table 2-1: Sensitivity of Ultrasonic Sensors

Sensitivity	Distance from Sensor
Hand motion	Up to 25 feet
Arm and upper torso motion	Up to 30 feet
Full body motion	Up to 40 feet

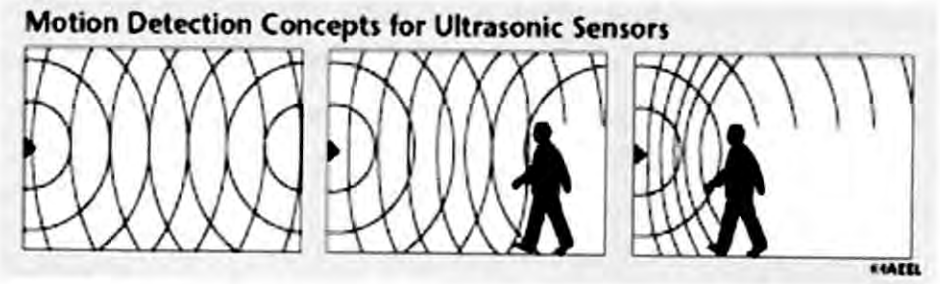

Figure 2-2 A simplified wave patterns in an empty room illustrates the motion detection concepts for ultrasonic sensors.

The advantages of this sensor is, it is sensitive to almost all types of motion, no coverage gaps, and can detect movements that are not in their line-of sight. However these sensors tend to be more expensive than any PIR sensors, and are more prone to false signals, where obstructions can reduce their effectiveness.

Since this technology is able to detect any movement large enough, false readings can occur due to movements of large volumes of air by HVAC systems or fans. Ultrasonic sensors cannot be effectively masked like PIR sensors and are subject to false triggering from outside the control area.

Care must be taken to avoid overlapping sensors. There have been reports that sensors operating in the 25 to 27 kHz range may interfere with hearing aids.

Taking into consideration all the reasons stated above, it is recommended that the ultrasonic sensor technology is well suited to an enclosed space such as a conference room or lunch room, because the waves must be contained within the space. This technology can also be applied to areas with partitions because the waves can saturate the areas behind them. Recent tests showed that the waves can cover areas behind hard partitions well, like in bathrooms.

However, in areas with cloth-covered partitions, such as open office spaces, the sensors did not detect motion in the obstructed areas. An excellent choice for larger areas, open offices, hallways, conference rooms, bathrooms and unusually shaped areas.

b) Microwave

These sensors contain both a microwave generator and receiver. Sensors emit microwaves and detect movements through changes in the reflected frequency (most automatic door openers are microwave-operated).

The advantage of this sensor is that it is quite sensitive and usually has good coverage. However, very little data currently exist on their reliability or operating cost. It is recommended that this type of sensor technology be applied in specialized applications only.

2.1.1.2 Heat-sensing (infrared)

Infrared or Passive Infrared (PIR)

Passive infrared sensors respond to the infrared (IR) heat energy emitted by people. A lens divides its coverage areas into pie-shaped segments and positive detection occurs when the sensor "sees" the motion of infrared radiation from one wedge to the next. They are passive because they do not emit radiation, they only detect it.

The PIR sensor detects motion by sensing temperature change over time. PIR sensors are line of sight devices which means they cannot "see" around corners or through partitions. Infrared radiation is detected by a pyroelectric transducer. The lens

surrounds the sensing transducer and focuses heat energy onto the detector. A lens views an area with an array of narrow and discrete beams or cones. When there is motion in a space across the cones of vision, a positive signal is generated and sent to the controller. Because of the fan-shaped detection pattern of the PIR sensors, coverage gaps occur between the cones of vision of alternate segments of the lens, as shown in ***Figure 2-3*** below.

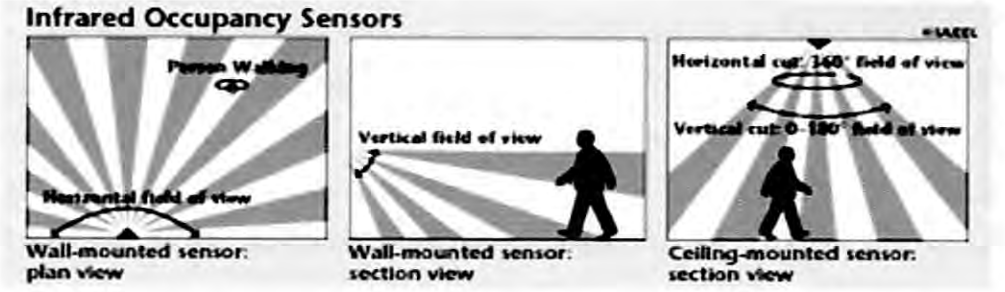

Figure 2-3. Infrared occupancy sensors contain at least one pyroelectric detector located behind an infrared transmitting lens with etchings.

This lens design results in horizontal and vertical "fan-shaped" detection zones, as illustrated in ***Figure 2-3***. The sensor responds to motion across these zones and must detect motion across one or more zones within a specified period to keep the lights on. The gaps widen with *distance*. A coverage gap of 8 feet occurs at a distance of 40 feet from the sensor. The sensitivity of the sensor decreases with distance from the sensor because the sensor is most sensitive on movement between the cones. Average sensitivity ranges are shown in ***Table 2-2***.

The sensitivity of PIR sensors can vary greatly with product quality and electronic circuit design. An essential component of this system is the time delay. The adjustable delay keeps the sensor from turning off the lights during short periods when the space is occupied but there is no motion. Each space will have its own optimum setting which is best determined by observation.