

SMART AUTOMATED HOME

MEGAT IZZUDDIN BIN MEGAT AB MANAP

MAY 2008

“I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation & Automation)”

Signature :

Supervisor's Name : Jurifa Bt Mat Lazi

Date : 6 May 2008

SMART AUTOMATED HOME

MEGAT IZZUDDIN BIN MEGAT AB MANAP

**This Report Is Submitted In Partial Fulfillment of Requirements for the Degree of
Bachelor in Electrical Engineering (Control, Instrumentation & Automation)**

**Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka**

May 2008

DECLARATION

I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references.”

Signature :

Name : MEGAT IZZUDDIN BIN MEGAT AB MANAP

Date : 6 MAY 2008

DEDICATION

For my beloved father, Megat Abd Manap Bin Megat Husain and mother,
Arbaah Bte Mat Said, my brother and sister

ACKNOWLEDGEMENTS

First of all, I would like to express my thankfulness to Allah S.W. T who has given me the strength, knowledge and capability to implement and complete my Projek Sarjana Muda and also to complete this report.

I would like to express my highest and foremost gratitude to my project supervisor, Puan Jurifa Bt Mat Lazi for her guidance, help and advices to complete this project. Next, I would like to thank Malaysian Coal Integrated Engineering Services (MCIE), the company which I had my industrial training attachment with for their sponsorship of equipments and devices which I used for my project. I would also like to thank the Faculty of Electrical Engineering (FKE), Universiti Teknikal Malaysia Melaka (UTeM) for giving me the opportunity to implement and complete my project.

Next, I would like to thank my parents for their financial and support and also to my fellow friends in 4BEKC. Last but not least, I would like to thank everyone who is directly and indirectly involved in this project. Their support and encouragement has given me the strength and effort to complete this project. Thank you.

ABSTRACT

This project is about the construction of an automated control system for a smart home to control critical house parameters, which includes the indoor and outdoor lightings, indoor ventilation, garbage management, garden watering, garage/parking and events alert. The outdoor lightings are automatically activated when the day gets dark by using a dark detection circuit. The indoor lightings are equipped with dimmers and the switches are relocated to more strategic locations. The indoor ventilation is connected to a temperature sensing circuit which controls a pair of ventilation fans to lower the indoor temperature. The garbage management automatically takes care of the garbage according to the collection schedule. The garden watering will be automatically activated according the time. The garage/parking system are designed to be safer and more convenient for the occupants while the event alert warns its occupant of possible danger. The operation for each parameters are represented on a scale model. The system utilizes the use of Programmable Logic Controller (PLC) and Integrated Circuit (IC) to create an interconnected control system. Each system are connected with other common input and output devices such as motors, switches, sensors, lights, relays etc.

ABSTRAK

Projek ini adalah berkenaan tentang pembinaan suatu sistem kawalan automatik utk rumah pintar untuk mengawal bahagian-bahagian penting rumah termasuklah lampu dalaman dan lampu luaran, ventilasi dalam rumah, pengurusan sampah, pengairan taman, tempat letak kereta dan juga amaran awal. Lampu luar boleh dihidupkan secara automatik menggunakan litar mengesan kepekaan cahaya. Lampu dalaman pula telah dilengkapi dengan pemalap dan suis akan ditempatkan semula di tempat yang lebih strategik. Ventilasi dalam rumah akan disambungkan dengan litar pengesan kepekaan haba yang mengawal sepasang kipas ventilasi utk menurunkan suhu di dalam rumah. Pengurusan sampah pula menguruskan sampah mengikut waktu kutipan sampah. Pengairan taman juga akan dihidupkan secara automatik mengikut waktu. Tempat letak kereta akan direka untuk menjadi lebih selamat dan lebih mudah untuk penghuni manakala amaran awal memberi amaran tentang bahaya yang bakal menimpa. Operasi untuk setiap bahagian diwakilkan pada model skala. Sistem ini akan mengaplikasikan penggunaan Pengawal Logik Aturcara (PLC) dan Litar terbina dalam (IC) untuk mencipta suatu sistem kawalan. Setiap sistem disambungkan dengan input dan output seperti motor, suis, sensor, lampu, geganti dan lain-lain.

TABLE OF CONTENTS

CHAPTER	CONTENTS	PAGE
	TITLE PAGE	i
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF FIGURES	xiii
	LIST OF TABLES	xv
	LIST OF APPENDICES	xvi
	LIST OF ABBREVIATIONS	xvii
1	INTRODUCTION	
1.1	Project Background	1
1.2	Problem Statement	3
1.2.1	General Problem Statement	3
1.2.2	Detailed Problem Statement	4
1.3	Project Objective	4
1.4	Project Scope	5
1.5	Project Advantages & Benefits	6

2 LITERATURE REVIEW

2.1	Case study	7
2.1.1	The Home Depot Smart Home	7
2.1.2	The purpose of building the Home Depot Smart Home at Duke	8
2.1.3	The Duke Smart Home Program	9
2.1.4	Benefits of the Duke Smart Home Program	10
2.1.5	Accessibility in The Home Depot Smart Home	12
2.1.6	Cooling Systems for The Home Depot Smart Home	12
2.1.7	Daylighting	12
2.1.8	Fire Safety	13
2.1.9	Geothermal Pump	13
2.1.10	Indoor Air Quality Monitoring	13
2.1.11	Leadership in Energy and Environmental Design (LEED)	13
2.1.12	Media-on-Demand	14
2.1.13	Photovoltaic System Design	14
2.1.14	Protecting Public Health – UV Disinfection of Drinking Water	14
2.1.15	Recycling	15
2.1.16	Retractable Roof	15
2.1.17	RFID Technology	15
2.1.18	Security	16
2.1.19	Soundproofing and Acoustic Suggestions	16
2.1.20	Water Catchment, Purification/ Rainwater Harvesting	16
2.1.21	Adaptive Digital Signal Processing – Active	16

	Noise Filtering	
2.1.22	Facial Recognition	17
2.1.23	Advanced HVAC Control and Artificial Intelligence Controllers	17
2.1.24	LED Lighting	17
2.1.25	Residential Piezoelectric Energy Sources	17
2.1.26	Sensor Platform	18
2.1.27	Shower Heat Recovery	18
2.1.28	Sleep Monitoring	18
2.1.29	Home Automation	19
2.2	Conclusion	19

3 METHODOLOGY

3.1	Overview	20
3.1.1	Literature review	20
3.1.2	Design the modules and circuits	20
3.1.3	Simulate circuits	20
3.1.4	Redesign circuits	21
3.1.5	Purchase components	21
3.1.6	Assemble circuits	21
3.1.7	Test operation	21
3.1.8	Troubleshoot	21
3.1.9	Assemble the modules	22
3.1.10	Test operation	22
3.1.11	Improvements, modifications and additions	22
3.1.12	Analysis	22
3.1.13	Connect the assembled modules	22
3.1.14	Test operation	23
3.1.15	Finalize	23

3.2	Flowchart	24
3.3	Gantt chart	26
4	PROJECT BACKGROUND	
4.1	Introduction	27
4.1.1	Smart Home	27
4.1.1.1	Functions of smart home system	28
4.1.1.2	Benefits of smart home system	29
4.2	Project Background	30
4.2.1	Indoor Lighting	30
4.2.1.1	Overview	30
4.2.1.2	Design	30
4.2.1.3	Circuit	32
4.2.1.4	Hardware and software	33
4.2.2	Outdoor Lighting	34
4.2.2.1	Overview	34
4.2.2.2	Design	34
4.2.2.3	Circuit	35
4.2.2.4	Hardware and software	38
4.2.3	Indoor Ventilation	39
4.2.3.1	Overview	39
4.2.3.2	Design	39
4.2.3.3	Circuit	41
4.2.3.4	Hardware and software	42
4.2.4	Garbage disposal	44
4.2.4.1	Overview	44
4.2.4.2	Design	45
4.2.4.3	Circuit	46

4.2.4.4	Hardware and software	46
4.2.5	Garage and car park	50
4.2.5.1	Overview	50
4.2.5.2	Design	50
4.2.5.3	Circuit	53
4.2.5.4	Hardware and software	53
4.2.6	Events alert	58
4.2.6.1	Overview	58
4.2.6.2	Design	58
4.2.6.3	Circuit	59
4.2.6.3.1	Water Level Sensor	59
4.2.6.3.2	Heat Sensing	61
4.2.6.3.3	Smoke Sensor	62
4.2.6.3.4	Buzzer Interval	64
4.2.6.4	Hardware and software	65
4.2.7	Garden Management	68
4.2.7.1	Overview	68
4.2.7.2	Design	68
4.2.7.3	Circuit	69
4.2.7.4	Hardware and software	70
4.3	Components	71
4.3.1	Programmable Logic Controller (PLC)	71
4.3.1.1	Introduction to PLC	71
4.3.1.2	Features of PLC	72
4.3.1.3	Comparing PLC with other control systems	73
4.3.1.4	Programming	75
4.3.2	Omron ZEN	76
4.3.2.1	Features	76

4.3.2.2	Programming	76
4.3.2.3	Functions	77
4.3.2.4	Expansion	77
4.3.2.5	Support software	78
4.3.3	Integrated circuit (IC)	79
4.3.3.1	Introduction	79
4.3.3.2	History of ICs	79
4.3.3.3	Advantages of ICs	80
4.3.3.4	Popularity of ICs	80
4.3.3.5	Classifications of ICs	80
4.3.4	555 Timer IC	81
4.3.4.1	Introduction	81
4.3.4.2	Inputs of 555	83
4.3.4.3	Outputs of 555	84
4.3.4.4	555 Astable	84
4.3.5	741 Op-Amp IC	85
4.3.5.1	Introduction	85
4.3.5.2	Definition of 741 pin functions	86
4.4	Project Costs & Expenses	87

5 RESULT & DISCUSSION

5.1	Result	89
5.2	Discussion	90
5.2.1	Problems & Challenges	90

6 CONCLUSION & RECOMMENDATIONS

6.1	Recommendations	92
6.2	Conclusion	93

REFERENCES	94
APPENDICES	95

LIST OF FIGURES

FIGURE	TITLE	PAGE
1.1	Block Diagram of control system using PLC and IC	1
2.1(a)	The Home Depot Smart Home	7
3.2	Project flow chart	24
3.3	Gantt chart	26
4.1(a)	A smart home system	28
4.2.1(a)	Block diagram for Indoor Lighting	30
4.2.1(b)	Assembled circuit for the Indoor Lighting	32
4.2.1(c)	Light dimmer circuit using PWM control method	32
4.2.2(a)	Block diagram for Outdoor Lighting	34
4.2.2(b)	Assembled circuit for the Outdoor Lighting	35
4.2.2(c)	IC 555 Timer pin allocations	35
4.2.2(d)	Internal circuit for IC 555 Timer	36
4.2.2(e)	Light/dark sensing circuit for Outdoor Lighting	36
4.2.3(a)	Block diagram for Indoor Ventilation	39
4.2.3(b)	Wheatstone Bridge	40
4.2.3(c)	Assembled circuit for Indoor Ventilation	41
4.2.3(d)	Temperature sensing circuit for Indoor Ventilation	41

4.2.3(e)	12VDC CPU fan rated at 0.13A	43
4.2.3(f)	Temperature display unit	43
4.2.4(a)	Block diagram for garbage disposal	45
4.2.4(b)	Concept diagram for garbage disposal	45
4.2.4(c)	Ladder diagram for overall Garbage Disposal module	48
4.2.4(d)	Inductive proximity sensor used for platform position	48
4.2.4(e)	AC Synchronous motor used for platform rotation	49
4.2.5(a)	Concept diagram for garage and car park	50
4.2.5(b)	Block diagram for garage and car park	51
4.2.5(c)	Limit switch and triangular marker	52
4.2.5(d)	Rotating platform	52
4.2.5(e)	Optical distance sensor	54
4.2.5(f)	Ladder diagram for garage door	56
4.2.5(g)	Ladder diagram for rotating platform	57
4.2.6(a)	Block diagram for Events Alert	58
4.2.6(b)	Assembled circuit for Water Level Sensor	59
4.2.6(c)	Water Level Sensor circuit for Events Alert	60
4.2.6(d)	Assembled circuit for Heat Sensing	61
4.2.6(e)	Heat Sensing circuit for Events Alert	61
4.2.6(f)	Assembled circuit for Smoke Sensor	62
4.2.6(g)	Smoke Sensor circuit for Events Alert	63
4.2.6(h)	Assembled circuit for Buzzer Interval	64
4.2.6(i)	Buzzer Interval circuit for Events Alert	64
4.2.7(a)	Block diagram for Garden Management	68
4.2.7(b)	Ultrasonic pest repellent circuit for Garden Management	69
4.3.1(a)	PLC and input/output arrangements	71
4.3.1(b)	Control Panel with PLC	72
4.3.2(a)	Multi function and space saving features	76
4.3.2(b)	Programming the Omron ZEN	76
4.3.2(c)	Expansion units	77
4.3.2(d)	Support software	78

4.3.3	Integrated circuit	79
4.3.4(a)	Actual pin arrangements	81
4.3.4(b)	Example circuit symbol	83
4.3.4(c)	555 Astable output, a square wave	84
4.3.4(d)	555 Astable circuit	85
4.3.5	741 Op Amp pin functions	86
5.1	Completed project	89

LIST OF TABLES

TABLE	TITLE	PAGE
4.3(a)	Purchased hardware total cost	87
4.3(b)	Sponsored hardware total cost	88
4.3(c)	Total cost for purchased and sponsored hardware	88

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	UTeMEX poster	96
	LM555 Single Timer datasheet	97
	LM741 Operational Amplifier datasheet	109
	Optical distance sensor datasheet	116
	Omron ZEN features catalog	118

LIST OF ABBREVIATIONS

ABBREVIATIONS

MEANING

CCTV	Closed circuit television
DC	Direct current
AC	Alternating current
IC	Integrated circuit
LCD	Liquid crystal display
LDR	Light dependant resistor
LED	Light emitting diode
PLC	Programmable logic controller
PIC	Programmable interface controller
PWM	Pulse Width Modulation
NO	Normally open
NC	Normally close

CHAPTER 1

INTRODUCTION

1.1 Project Background

This chapter provides the necessary background for this project, which explains the basic principle of PLC and IC control system.

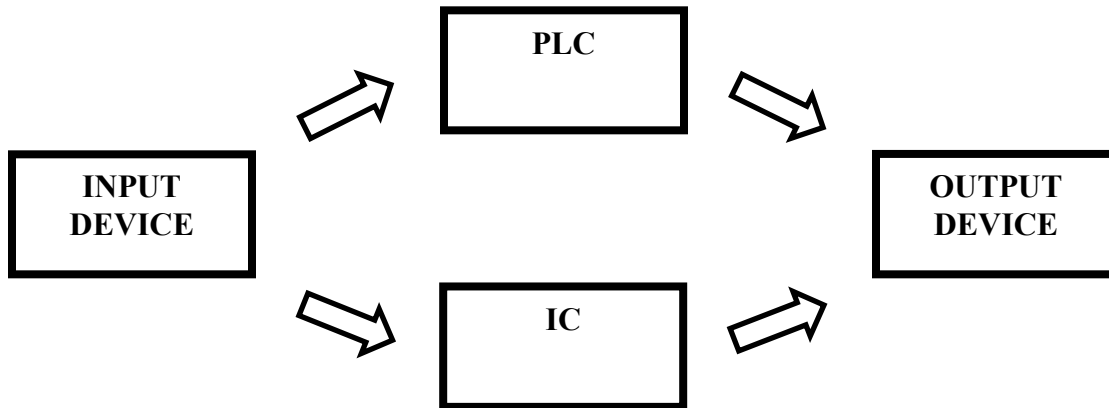


Figure 1.1: Block Diagram of control system using PLC and IC

To create a control system, it must have 3 basic components which are input, process and output. The process consists of the PLC and IC which acts as input signal processing device to control the output. A brief introduction to the concept of application is given to provide basic understanding of this project.

The input device comes in the form of ordinary on/off limit switches, push buttons, variable resistors, photo-electric sensors, proximity sensor, light dependent resistors (LDR) and thermistors. These devices provide the activation signal in the form of analog or digital signal to the control unit.

The controller part which is the PLC and the IC acts as the primary control unit for this project. In this system, the PLC controller used is the Omron ZEN micro PLC unit. The input signals are transmitted digitally into the PLC and an appropriate

–decision” will be made by the PLC according to the programmed ladder logic diagram. The PLC will then produce a digital signal in the form of relay output. The PLC is chosen over PIC to provide control for this project due to its multiple inputs and output arrangements and also its easy and user friendly programming using ladder logic diagram. The key feature for the PLC that is used is the built in daily, weekly and monthly timer capability which provides useful control for time controlled operation.

The IC is used for analog signal processing which involves decision making through logic gates combination and comparing two or more sets of input signals. There are two main advantages of ICs over discrete circuits which is the cost and performance. Cost is low because the chips, with all their components, are printed as a unit by photolithography and not constructed a transistor at a time. Performance is high since the components switch quickly and consume little power, because the components are small and close together.

For this project, the control is divided into two control devices which are the PLC and the IC. The purpose for this design is to fully utilize the advantages of both devices. The PLC has the advantage of easy programming, multiple relay outputs and enables systematic & organized wiring to be implemented. The IC on the other hand has the advantage of miniature size, low costs and provides tons of function according to the circuit it is connected. By combining two forms of these widely used devices, a good and reliable control system can be created to cater the project’s needs.

The output device will be in the form of relays, buzzer, DC motors, tweeter, lights, LEDs and fans. These devices receive activation signal from the PLC, IC or directly from the input device and perform various functions including illumination, cooling and etc.

1.2 Problem Statement

This project like all others is created to solve problems that we humans encounter everyday. Upon completion of this project, the problems that we face will hopefully be solved or at least reduced. To make it easier to explain regarding the problem statements, they are divided into two parts, which is general aspect and detailed according to the system arrangements

1.2.1 General Problem Statement

- There is no training kit that emphasizes the combination between PLC and electronics based circuits.
- Most training kit available focuses on industrial system but not home automation system.
- Available home automation has limited control over devices/system and costly.
- Normal homes are inconvenience, not safe and not economical.

1.2.2 Detailed Problem Statement

- For the indoor lightings, the lights switches are located far away, not easily to access locations and the lights cannot be dimmed.
- The outdoor lights needs to be turned on and off manually at day & night and sometimes the occupant forgot to turn them off. This causes wastage in electricity bills.
- The temperature inside (indoor) are hot and unpleasant. The hot/warm air is trapped inside house due to poor ventilation
- The occupant missed the weekly garbage collection time and the garbage spilled when bringing it outside the house. Furthermore, the odor from the garbage attracts flies & disease.
- Plants at the garden die due to lack of watering and the gardens are infected by pests.
- Accidentally hit the garage wall/children while reversing the vehicle and sometimes the occupant forgets to close the garage door
- House does not have fire and flood warning system.

1.3 Project Objective

The objective of this project is to design & construct a control system which consists of home automation and lighting control that can be used for various purpose especially teaching & learning and home application.

The lighting control is used to control the illumination and brightness for the indoor and outdoor lightings while the home automation is used to control the indoor ventilation, garbage disposal, garden management, garage/car park and events alert.

1.4 Project Scope

Scope and limitations for this project:

- Design and construction of a control system consist of home automation and lighting control.
- Constructed using PLC, Electronic circuits, DC motors, sensors, switches, relays etc.
- The model design & construction consists of small scale model that represents the connection and function of the system.
- System powered by DC source through switching power supply and voltage regulators.
- Lighting
 - i. Indoor
 - ii. Outdoor
- Home automation
 - i. Ventilation (Indoor)
 - ii. Garbage disposal
 - iii. Garden management
 - iv. Garage/car park
 - v. Events alert