METHOD OF DETECTING UNLIGHTED UTILITY STREET LIGHTING SYSTEM

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DISSERTATION

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
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CERTIFICATION OF APPROVAL

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Approved:

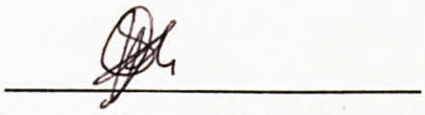
Ir. Mohd Faris bin Abdullah
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

June 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



Nur Afifah binti Mohd Ramli

ABSTRACT

Street lighting is part of the distribution system. These facilities were owned, installed, operated and maintained by the utility supplying electricity or municipal in particular area. The purpose of this report is to discuss about the project and the method of detecting unlighted street lighting system. The report starts with the objectives and scope of study. The relevancy and feasibility of the project being discussed and the problem statements that lead to the idea of the project have been identified. This report highlights about the street lighting circuit and the theory of how the street lighting circuit function. Light failure theory for unlighted street lighting system also included in the report. Method of detecting unlighted street lighting system has been discussed in the literature review part. In methodology part, project planning has been roughed out and flow chart of the methodology has been drawn. Experiments and data gathering have been conducted. The best method for the prototype has been analyzed. Through this project, a prototype for method of detecting unlighted utility street lighting system has been developed and tested.

ACKNOWLEDGEMENTS

First and foremost, I would like to praise God the Almighty, Allah S.W.T for His guidance. Though difficulties occurred, His guidance gave me the chance to still complete this challenging project successfully. Here, I would like to use this special opportunity to express my heartfelt gratitude to everyone that has contributed to the task directly or indirectly.

My deepest appreciation goes to my supervisor; Ir. Mohd Faris bin Abdullah, who has given me endless guidance and moral support throughout the project. I am touched by his dedication and the moments working with him will remain as valuable experience for my future undertakings.

I also truly appreciate the help given by the laboratory technicians of UTP, for assisting me out by throwing out support and endless effort for helping me succeed in this project. Not to forget, my endless gratitude to all the lecturers of UTP, my beloved parents for support in helping me keep focus and finish this project, and to fellow friends that have given feedbacks and helped a lot through their useful ideas and advice.

On the whole, I really appreciate all the help that had been given. Completing this project was such an enjoyment and a very valuable experience for me. I hope that the outcome and results would be beneficial for other students.

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LIST OF ABBREVIATIONS

Tenaga Nasional Berhad	TNB
Programmable Logic Controller	PLC
Alternate Current	AC
Direct Current	DC
Peripheral Integrated Controller	PIC
Analog / Digital	A/D
A/D Result High Register	ADRESH
A/D Result Low Register	ADRESL
A/D Control Register 0	ADCON0
A/D Control Register 1	ADRESH
Analog Digital Converter	ADC
Kirchoff's Current Law	KCL
Light Emitting Diode	LED
Input / Output	I / O

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Street lighting can be defined as the artificial illumination of streets and pathways when available natural light (sunlight) drops below a pre-determined level [1]. The very first electric street lamp was based on electric arc lamps [1]. The first instance of permanent Public Street lighting (electrical) anywhere in the world was in the Public Square of Cleveland, a little park of about 10 acres [1].Street lighting is an essential public service that provides a safer environment to its users. Proper use of roadway lighting as an operative tool provides economic and social benefits to the public [1]. Street lighting plays an important role to reduce the risks of accidents at night, help to assist the protection of property as well as crime and vandalism, making residents feel secure and enhancing the appearance of area after dark [2].

Street lighting control panel usually can control about 20 to 40 street lights. Somehow, the control panel does not indicate the street lighting failure among the lights. The project aim is to propose a method of detecting unlighted street lighting system at the control panel. By implementing Kirchhoff's Current Law in this project, methods are identified and compared so the best method that suitable with the prototype will be use for the project. While constructing the prototype, knowledge of wiring the lamps is essential. After prototype has been constructed, understanding and knowledge regarding PIC is required in order to efficiently use programming software to produce the desired programming code.

1.2 Problem Statement

The method that Street Lighting Maintenance Department of Tenaga National Berhad (TNB) use to monitor whether all street lights are lighten up is by manpower patrolling at all streets. Team of workers will be needed to do a routine by patrolling at all streets during the night. Their responsibility is to keep the street lights functioning and will provide maintenance service whenever there is any failure in street light.

The other way of monitoring is through complaints received from customers. Tenaga National Berhad (TNB) has provided customer service with a website and included contact numbers in the website that allows customers to request their service online and call the right phone number to request service and report any street light problem.

Somehow, these monitoring methods have been a time consuming effort and incur substantial amount of operational cost due to large coverage area. Its effectiveness is questionable since not all the lights could be visited every night.

1.3 Objectives

The objective of this project is to develop a method of detecting unlighted utility street lighting system at the control panel. The method can detect a drop in current at the main junction before it flows to each lamp and indicate any street lighting failure just by looking at the control panel. This is cost effective method rather than using manpower to patrol at all streets and through complains received from the customers.

1.4 Scopes of Study

The scopes of this project are:

- Understand the function and characteristics of each component in street lighting system.
- Understand the street lighting system practiced by TNB.
- Identify method to detect any drop of current at the main junction and indicate it at the control panel.
- Study and understand the wiring of lamps.
- Study and construct suitable electronic circuit design to be implemented for the system.
- Study and use of software to program the PIC to perform the desired output.
- Understand about Analog to Digital Converter in microcontroller.

1.5 Relevancy and Feasibility of the Project

There are so many street lights that are almost impossible to count how many street lights are there in every city, and every state. The number will change constantly as new residential and commercial communities develop in suburban areas and there are hundreds of thousands of new developing communities in the country.

With this proposed method, it will increase the safety of area. Rather wasting time, energy and cost to patrol all street lights, lamp failure can easily known just by looking at the control panel. It is cost effective and can help to ease TNB and local council's work from patrolling at every road and even at the rural area.

CHAPTER 2
LITERATURE REVIEW

2.1 Existing Street Lighting System

Out of the three phase supply, only one phase is taken for the street lighting supply system. The supply will flows to the control panel first before going to the other street lights. Control panel controls about 20 to 40 street lights in a street. In control panel, the components are fuse, meter, contactor and photocell, where in the street lights, the components are ballast, igniter, capacitor, connector and lamp.

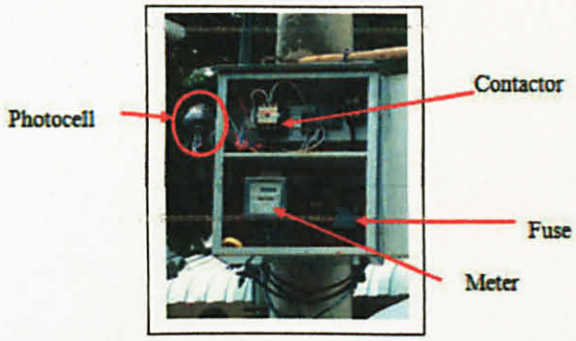


Figure 1 Components in control panel

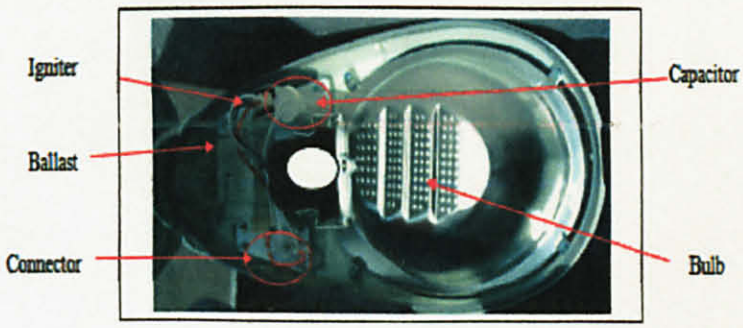


Figure 2 Components in the street light

2.2 Street Lighting Process Flow

Figure 3 below shows the connection of street lighting components:

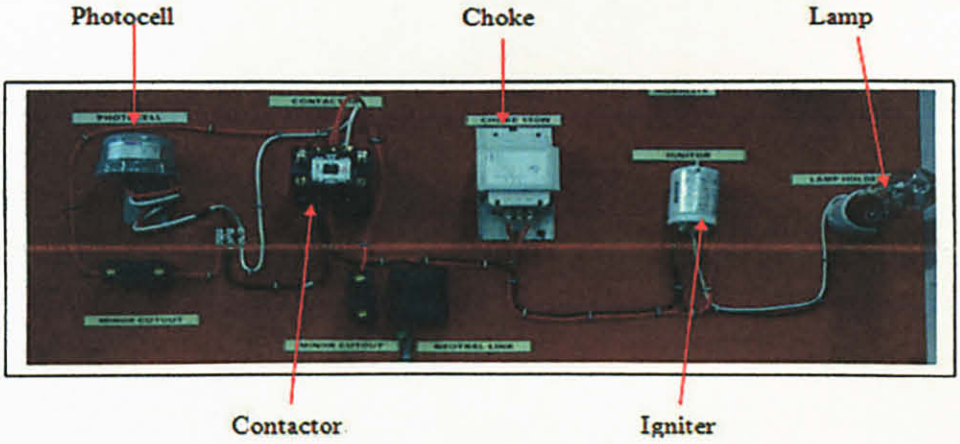


Figure 3 TNB street light panel

Once there are low or no light intensity at all, the photocell activates. This will gives connection to the contactor. Contactor will act as a relay switch that connects electrically to the choke. Choke will limit the current and current flows to the igniter. Igniter act as a starter to provide high voltage during ignition and thus the lamp will be turned on.

2.3 Light Failure Theory

According to Kirchhoff's Current Law (KCL), at any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node [3].

This applies to the street lighting system where the current at the main junction which is at the control panel before current flows into each bulb, is the sum of current use by each bulb. Any drop of current at the control panel will indicate that there is a street lighting failure. Graphical representations of the situation are shown in Figure 4 and Figure 5 below:

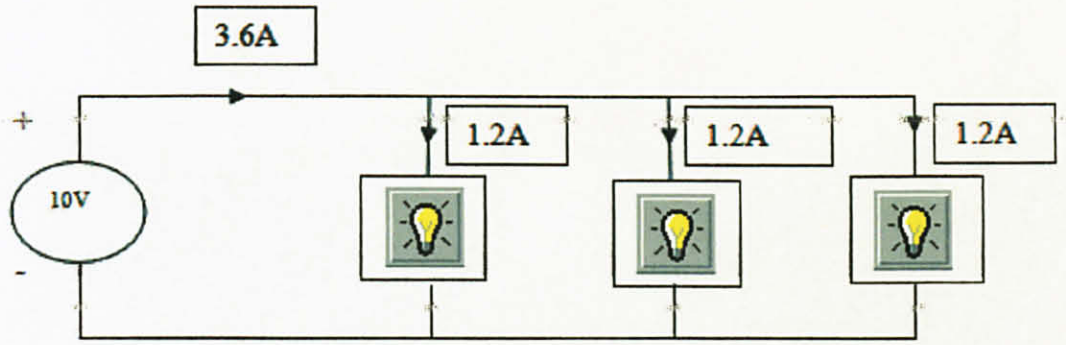


Figure 4 All bulbs are functioning

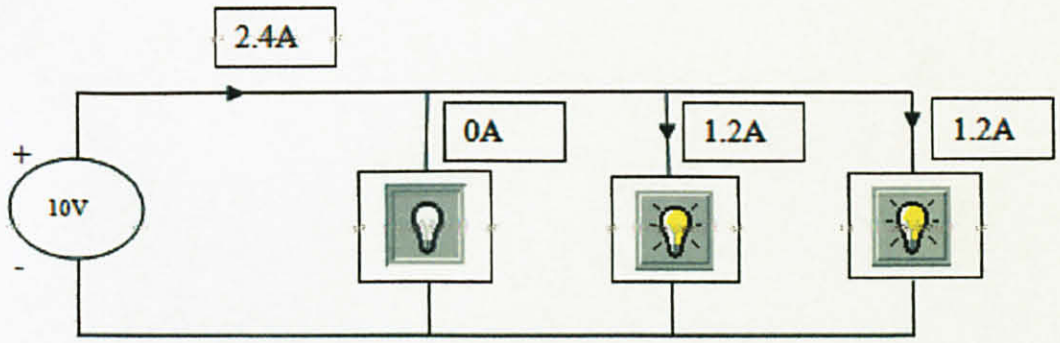


Figure 5 Not all bulbs are functioning

2.4 Method Consideration

There are few methods of detecting unlighted utility street lighting system considered. Each method is analyzed in order to get the best method that suitable with the prototype.

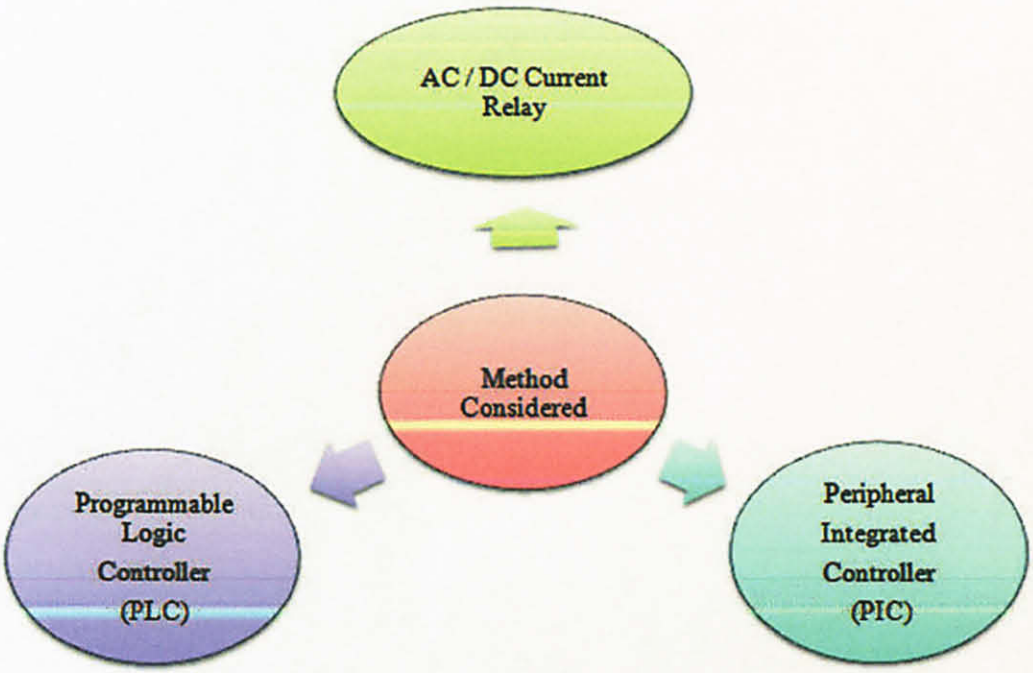


Figure 6 Method Considered

2.4.1 *AC/DC Current Relay*

Measuring and monitoring relay can be used to monitor single phase power monitoring, three phase power monitoring and temperature monitoring. For this application, one of product available at the market is AC/DC Current Relay.

AC/DC Current Relay can detect burned out light bulbs by detecting undercurrent levels. The advantage of using this relay is the relay sensitivity can be adjusted to detect burned out light bulbs even in application where multiple light bulbs are used [11]. Somehow, the limitation of using AC/DC Current Relay is, it only can indicate when all bulbs are not lighted, which means that the number of unlighted street light cannot be known.

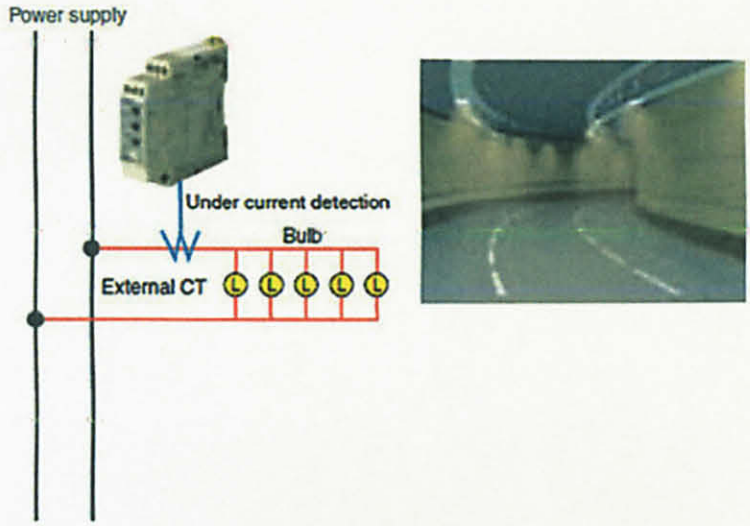


Figure 7 Under Current Detection

2.4.2 *Programmable Logic Control (PLC)*

A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or lighting fixtures. PLCs are used in many industries and machines [5].

In this project, PLC has been identified as one of the method that can be use to display the number of unlighted utility street lighting system on LED correspondingly depending on the AC Current Sensor output. PLC has been identified as one of the method due to [6]:

- **Flexibility:** One single Programmable Logic Controller can easily run many machines

- **Testing:** Programmable Logic Control program can be tested, validated, corrected and evaluated in a lab. The program can be tested saving very valuable time.

- **Visual observation:** When running a PLC program a visual operation can be seen on the screen. Hence troubleshooting a circuit is really quick, easy and simple.

Figure 8 Programmable Logic Controller [13]

2.4.3 Programmable Integrated Circuit (PIC)

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640, originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "**Programmable Interface Controller**" [14]. PIC is the name for the Microchip microcontroller (MCU) family, consisting of a microprocessor, I/O ports, timer(s) and other internal, integrated hardware [10].

PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability [9].

In this project, PIC Microcontroller has been identified as another method that can be use to display the number of unlighted utility street lighting system on LED correspondingly depending on the AC Current Sensor output. Figure 9 below shows the pin diagram of the PIC.

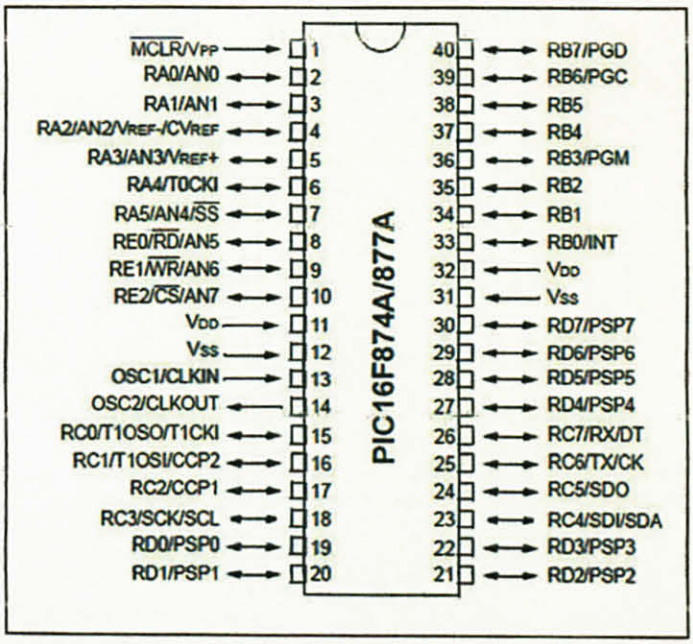


Figure 9 PIC Pin Diagram [7]

2.5 Method Comparison

Each method is compared in terms of its advantage and disadvantage so the most suitable method for the prototype can be identified.

Table 1 Method Comparison

Method	Advantage	Disadvantage
AC / DC Current Relay	▪ Relay sensitivity can be adjusted to detect burned out light bulbs. ▪ Relay can be use with AC or DC.	▪ Bulky in size. ▪ Not applicable to show how many unlighted street lights as each relay can only be set for certain value. ▪ Expensive.
Programmable Logic Controller (PLC)	▪ Desired virtual output can be programmed.	▪ Bulky in size. ▪ Expensive compared to PIC.
Peripheral Integrated Controller (PIC)	▪ Smallest compared to the other method. ▪ Cheapest compared to the other method.	▪ Need extra circuit in order to function.

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

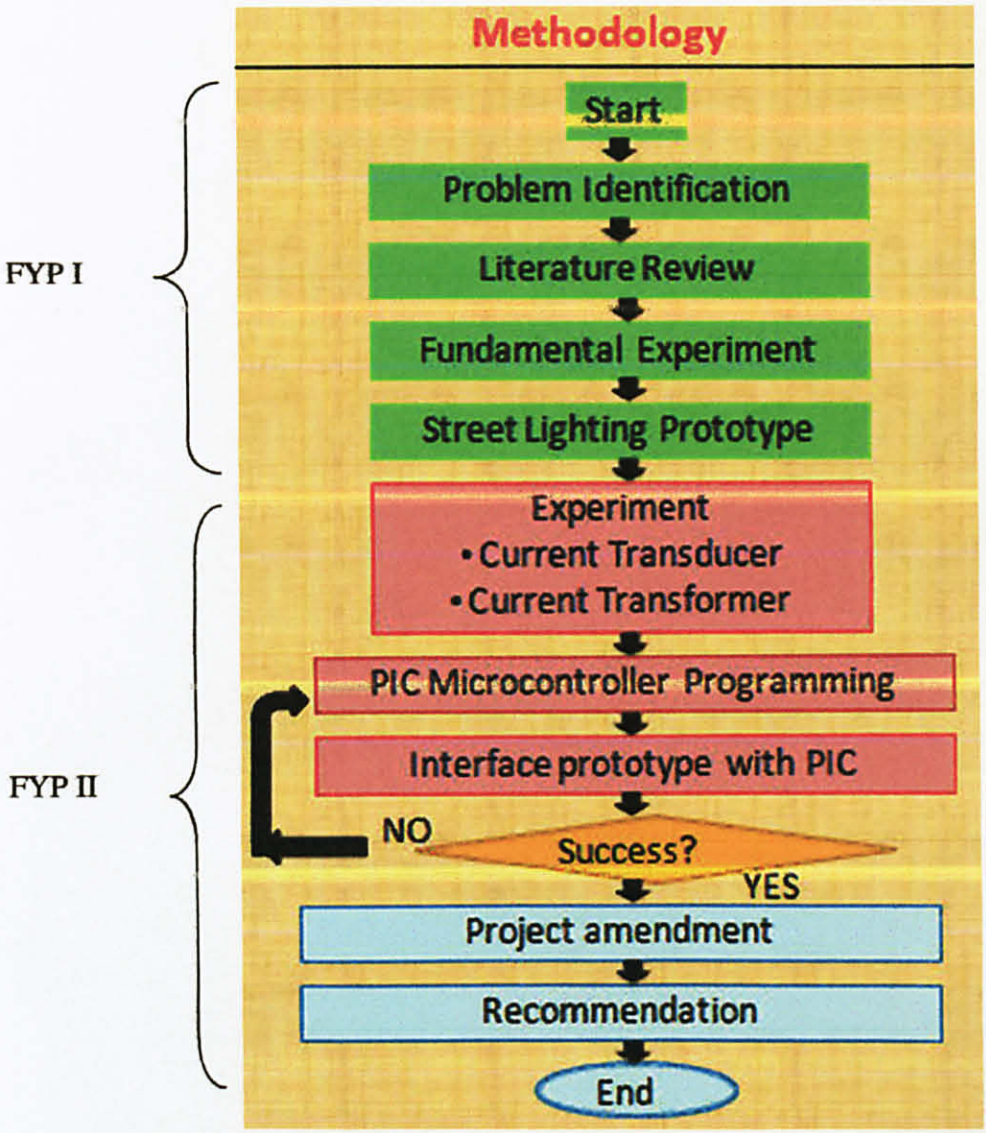


Figure 10 Project Methodology

3.2 Tools Required

Table 2 Selection of Hardware and Software

SUBJECT	HARDWARE	SOFTWARE
Electronic Circuit Design	▪ Laptop/Personal Computer	▪ Pspice
Peripheral Integrated Controller (PIC)	▪ PIC16F877A ▪ Laptop/Personal Computer	▪ MPLAB IDE v8.30 ▪ PIC simulator IDE
Prototype Construction	▪ AC Current Sensor ▪ Project Board ▪ 3 fluorescent lamps ▪ Current Transformer ▪ Switch box ▪ Screws ▪ Crocodile Clip ▪ Plywood ▪ PIC USB Programmer ▪ LEDs ▪ Resistors ▪ Crystal Oscillator ▪ Voltage Regulator ▪ Diode ▪ Multimeter ▪ Wire connector ▪ Wire holder	▪ PIC kit 2 v2.40

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Results

4.1.1 Prototype Design

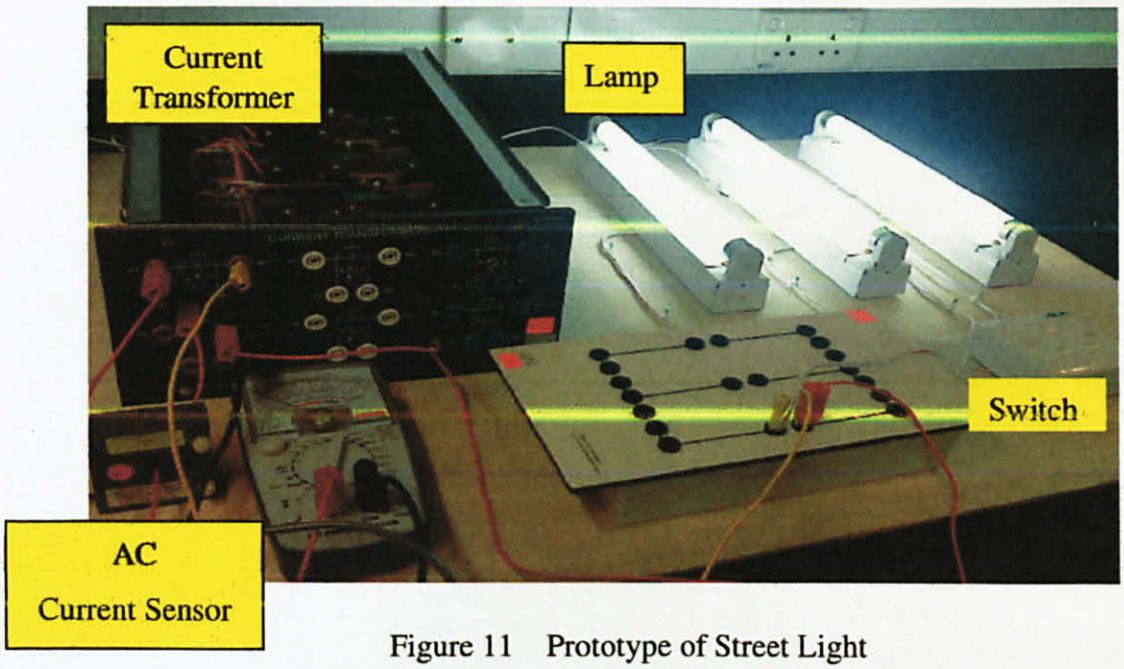


Figure 11 Prototype of Street Light

Fluorescent lamp has been chosen to represent street light. Each lamp is connected to a switch in order to represent the situation whether the lamp is lighted or unlighted. Current at the main junction is stepped up using Current Transformer 1:5 ratios. The purpose of stepping up the current is to make sure there is sufficiently large current as an input to the AC Current Sensor. Figure 12 shows the electrical diagram of prototype above.

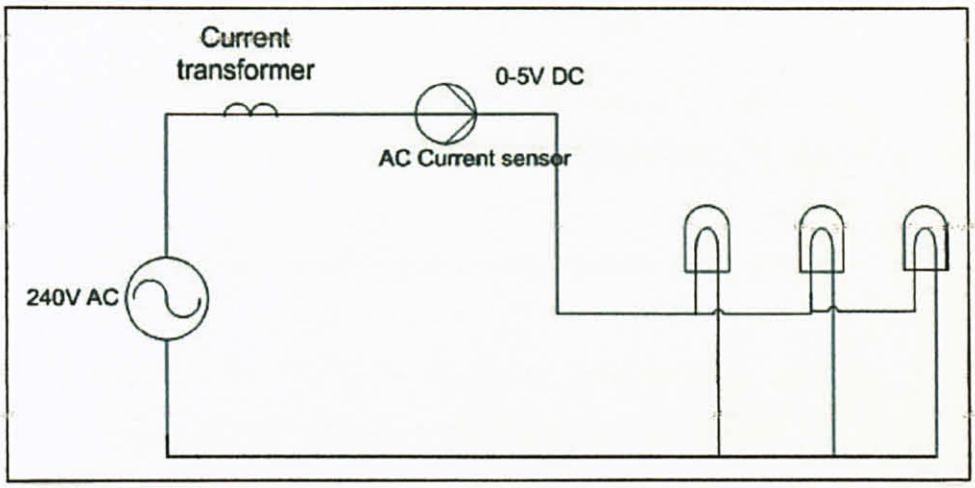


Figure 12 Prototype electrical diagram

Current sensor or current transducer is needed for this project in order to change the corresponding current at the main junction in the street lighting system from AC current to DC output. AC Current Sensor chosen for the prototype is SC100A. This Current Sensor input range is from 0-100A AC and the output of this current sensor is 0-5V DC. The sensor has been chosen because it [8]:

- Require no external power
- Split core design
- Self powered
- Output signal is accurate even at a very low input current levels

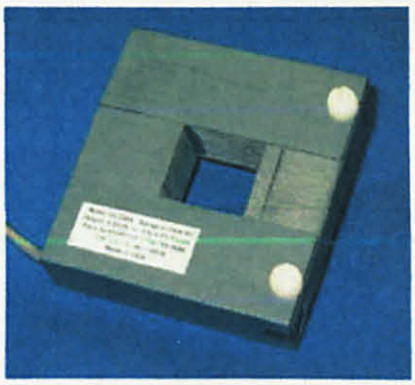


Figure 13 AC Current Sensor SC100A

4.1.2 Circuit Development

PIC16F877A microcontroller circuitry is designed based on the project requirement, functionality, and availability of its features especially on the I/O pins.

- AN0 has been chosen as an analog input for this project.

- Port D (RD7, RD6, and RD5) has been chosen as an output to show using LED the corresponding output from the lamps.

- There are two parts of the circuit. One part is to show the number of unlighted street light while another part is to show the number of lighted street light. Figure 14 below is the circuit constructed for the project.

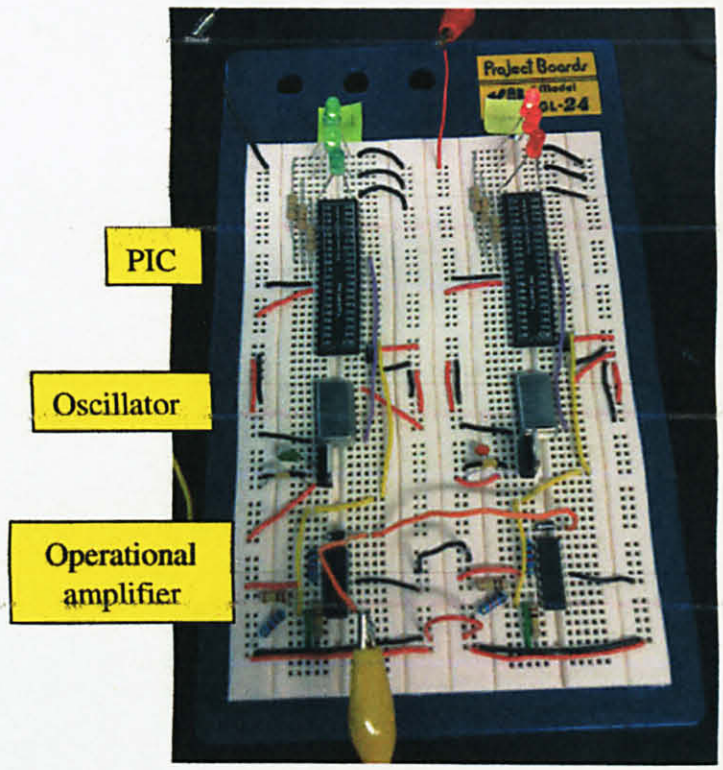


Figure 14 Circuit constructed

Figure 15 below is the schematic diagram of the circuit that connects voltage regulator, the clock and operational amplifier to the PIC.

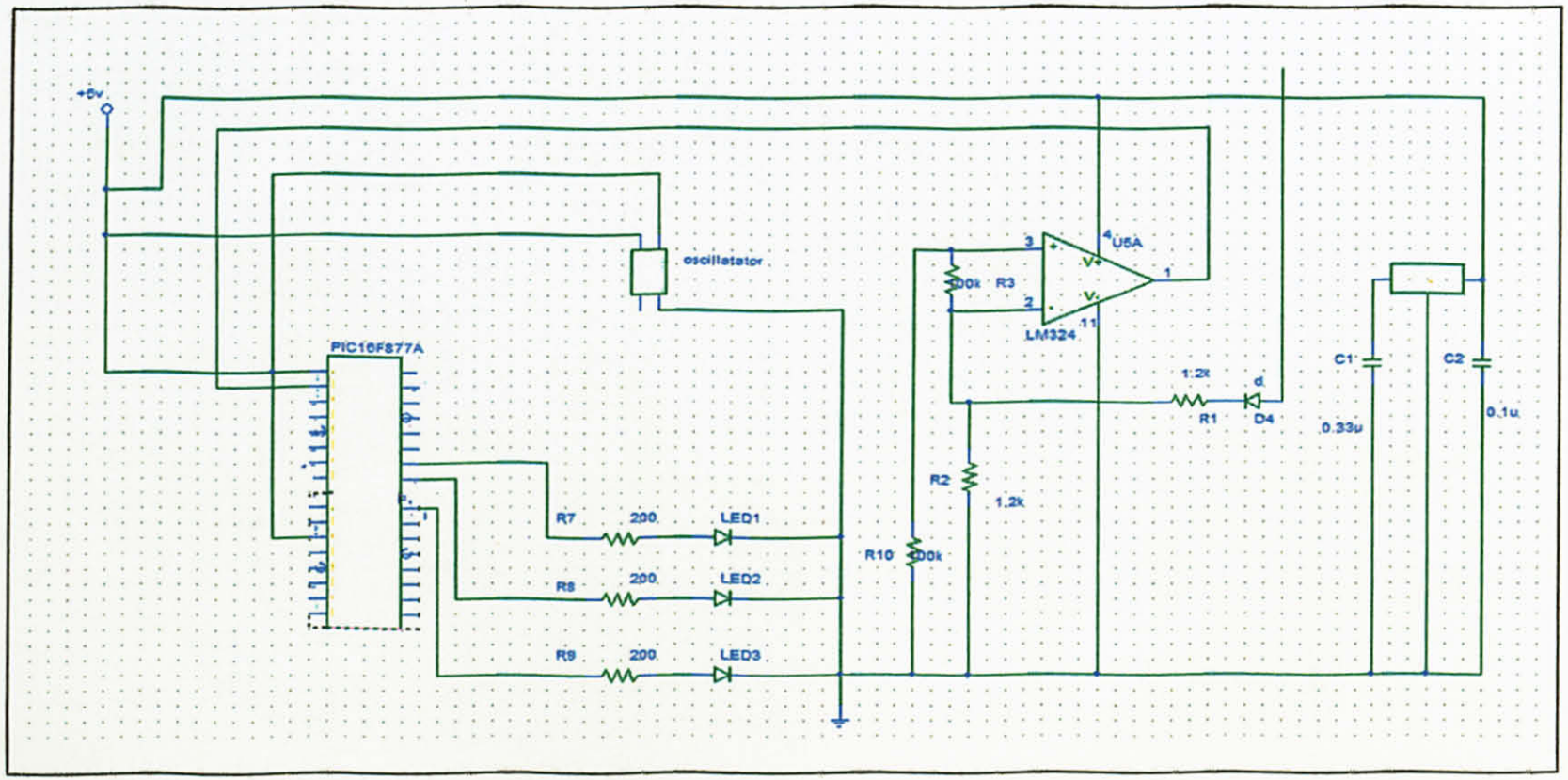


Figure 15 Schematic diagram

4.1.3 Programming & Simulation

The Peripheral Integrated Controller (PIC) is programmed using MPLAB software and simulated using PIC Simulator IDE. The programming used is C programming language for the purpose of microcontroller. PIC has been chosen among other method because it is cheap, smaller in size and its simplicity to construct and troubleshoot.

Conversion of voltage to digital output is as follow [15]:

$$\frac{V}{V\ fullscale} = \frac{Digital\ Value}{1023}$$

$V_{fullscale}$ = 5V, the equation then becomes:

$$Digital\ Value = v \times \frac{1023}{5}$$

Table 3 below shows the digital value that will be use to program the PIC. Voltages are taken from the output of the operational amplifier and converted to digital values using equation above.

Table 3 Digital Values

Number of Lighted Lamps	Voltage (V)	Digital Values (x)
0	0.138	$x \leq 39$
1	0.221	$40 \leq x \leq 100$
2	0.58	$101 \leq x \leq 250$
3	1.58	$x \geq 251$

Figure 16 below shows an example coding using MPLAB to program the PIC according to the digital values in Table 3.

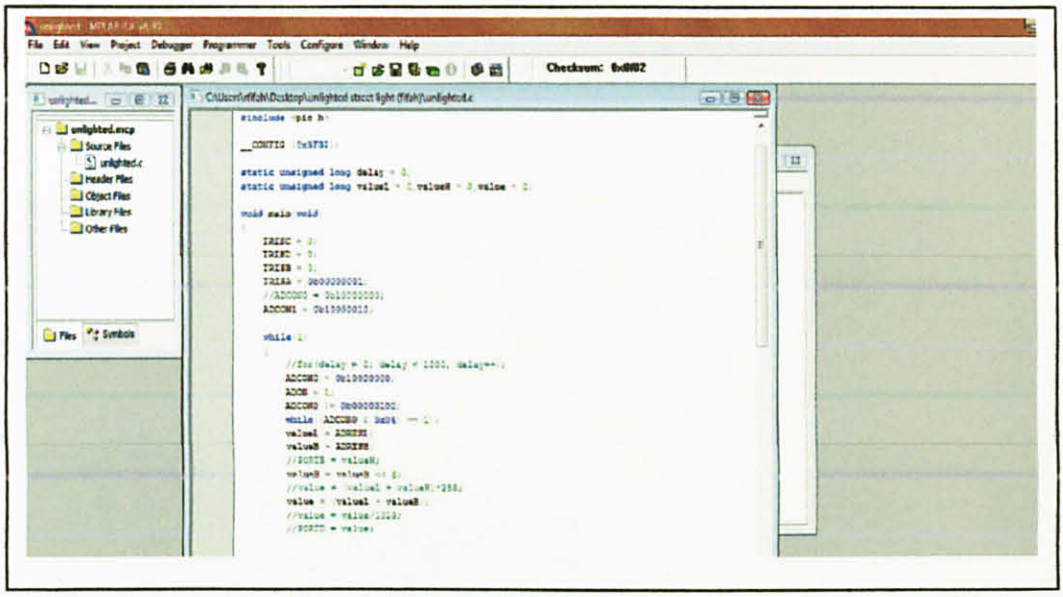


Figure 16 An example of coding using MPLAB

The success build for the programming is shown in Figure 17 below:

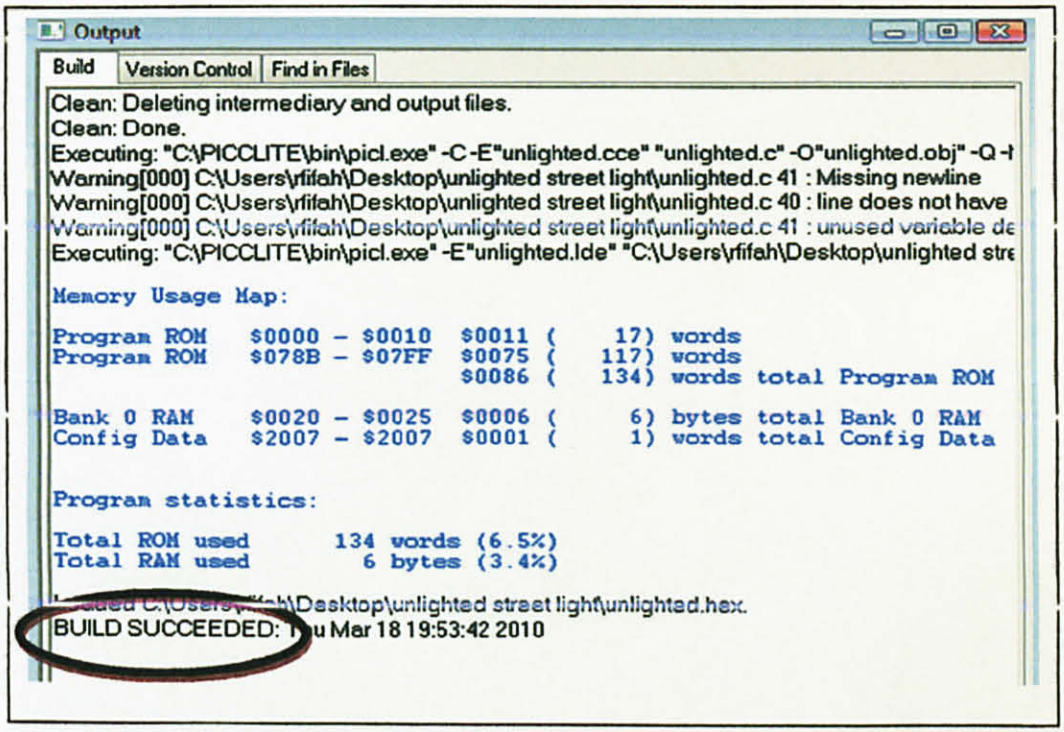
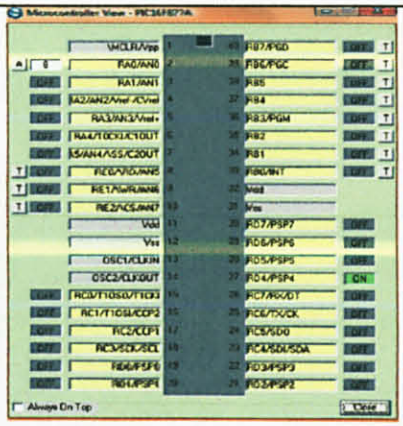
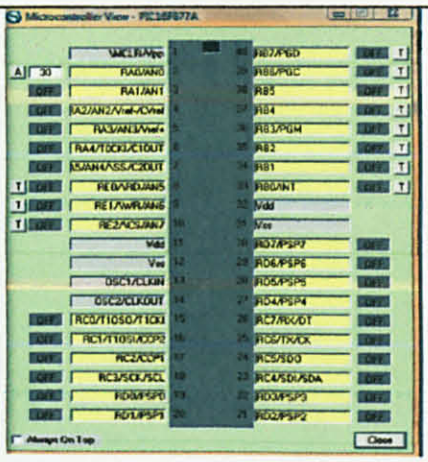


Figure 17 Success build

The success program is then loaded using PIC Simulator IDE and the microcontroller view option has been choose to see the simulation results.

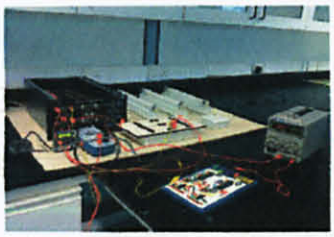
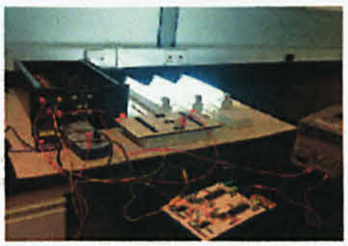
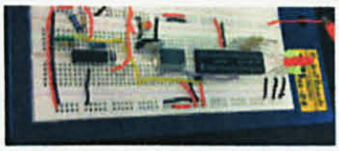
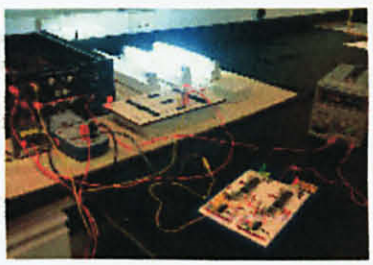
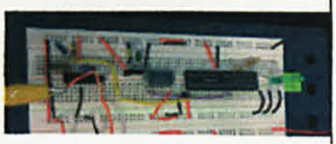
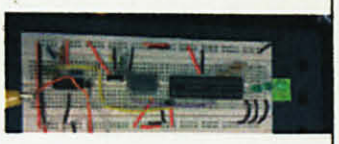
Table 4 Microcontroller view for simulation results

Digital Values (x)	Microcontroller View	Results
$40 \leq x \leq 100$		Pin 27 turns ON
$101 \leq x \leq 250$		Pin 27 and 28 turns ON
$x \geq 251$		Pin 27, 28 and 29 NOT turns ON

4.1.4 PIC and Prototype Interface Results

The coding is then downloaded to the PIC16F877A using PIC Kit Programmer and PIC Kit2. The results are shown in the Table 5:

Table 5 Prototype and PIC interface result

Prototype	Unlighted part	Lighted part
3 bulbs off 	3 LEDs on 	3 LEDs off 
3 bulbs on 	3 LEDs off 	3 LEDs on 
2 bulbs on 	1 LED on 	2 LEDs on 
1 bulbs on 	2 LEDs on 	1 LED on 

4.2 Discussion

4.2.1 Electronic Circuitries

- There are 8 pins (AN0 - AN7) that can be used as an analog input to the PIC.
- Effect of ADC circuit is can be minimized by decoupling the voltage regulator as in Figure 18 below [14]:

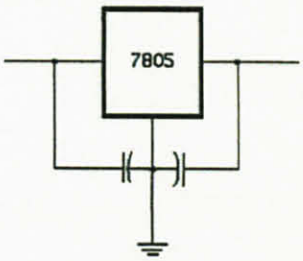


Figure 18 Voltage Regulator

- Operational amplifier is needed in order to increase the values of voltage from the AC Current Sensor. Figure 19 represent an ideal non-inverting amplifier:

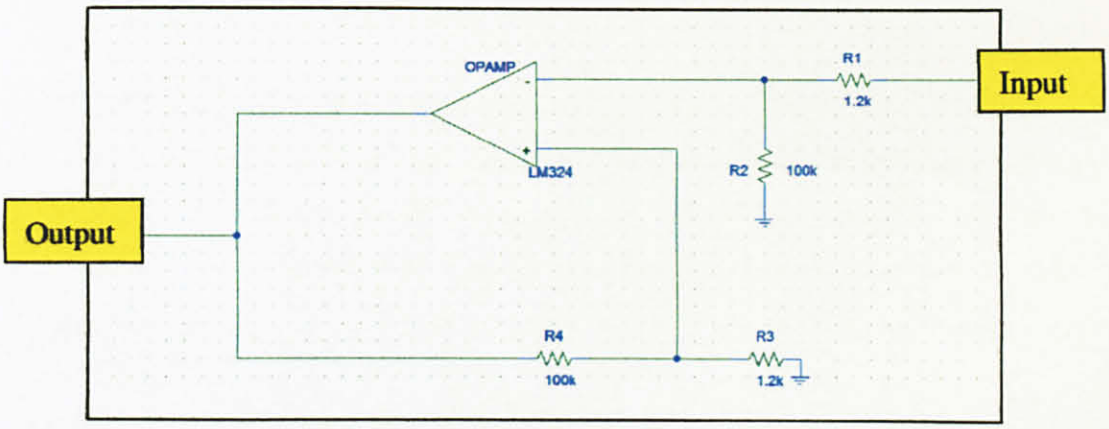


Figure 19 Operational Amplifier

- Values for resistors are calculated based on the formula:

$$R = \frac{V_{in} \times R_f}{V_{out}}$$

V_{out} = 5V, R = R1 = R3 and R_f = R2 = R4

- As there are two parts of the circuit, the advantage and disadvantage of the circuit is discussed in Table 6:

Table 6 Advantage and Disadvantage of Different Monitoring Circuit

LED representation	Advantage	Disadvantage
Unlighted part	LED represents the number of unlighted street light.	Only can know the number of unlighted street light just by counting the numbers of lighted LED.
Lighted part	LED represents the number of lighted street light.	Need to count the number of unlighted LED if want to know the number of unlighted street light.

4.2.2 PIC Programming & Simulation

- PIC16F877A is capable of performing Analog to Digital Conversion. Digital computers use binary (discrete) values, but in physical world everything use analog (continuous). Transducers are also referred as sensors. Sensors produced output that is voltage. Thus, there is need for analog-to-digital converter (ADC) to translate the analog signals to digital numbers so that the microcontroller can read and process them [12].

- ADC has *n*-bit resolution, where *n* can be 8, 10, 12, 16, or even 24 bits depending on the PIC use. The higher-resolution ADC provides a smaller step size, where step size is the smallest change that can be discerned by ADC [12]. PIC16F877A has 10-bit ADC resolution. 10-bit will provide outputs from 0 to 2^{10}-1, 1023 to represent the analog input.

- Conversion time in ADC is defined as the time it takes the ADC to convert the analog input to digital numbers. The conversion time is dictated by the clock source connected to the ADC [12].

- ADC for PIC16F877A has four registers. These registers are [4]:

  - ADRESH : A/D Result High Register
  - ADRESL : A/D Result Low Register
  - ADCON0 : A/D Control Register 0
  - ADCON1 : A/D Control Register 1

- ADCON0 register is used to set the conversion time and select the analog input channel among other things. In order to reduce the power consumption of PIC, the ADC feature is turned off when the microcontroller is powered up [12]. Figure 20 below shows the ADCON0 Register:

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit 7							bit 0

bit 7-6 **ADCS1:ADCS0:** A/D Conversion Clock Select bits
00 = Fosc/2
01 = Fosc/8
10 = Fosc/32
11 = FRC (clock derived from the internal A/D module RC oscillator)

bit 5-3 **CHS2:CHS0:** Analog Channel Select bits
000 = channel 0, (RA0/AN0)
001 = channel 1, (RA1/AN1)
010 = channel 2, (RA2/AN2)
011 = channel 3, (RA3/AN3)
100 = channel 4, (RA5/AN4)
101 = channel 5, (RE0/AN5)(1)
110 = channel 6, (RE1/AN6)(1)
111 = channel 7, (RE2/AN7)(1)

bit 2 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
If ADON = 1:
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (this bit is automatically cleared by hardware when the A/D conversion is complete)

bit 1 **Unimplemented:** Read as '0'

bit 0 **ADON:** A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shut-off and consumes no operating current

Figure 20 ADCON0 Register [4]

- ADCON1 Register is used to select the Vref voltage. After A/D conversion is complete, the result sits in registers ADRESL and ADRESH. The ADFM bit of the ADCON1 is used for making it right justified or left justified because only 10 bits needed [12]. Figure 21 below shows the ADCON1 Register.

U-0	U-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	—	—	—	PCFG3	PCFG2	PCFG1	PCFG0
bit 7							bit 0

bit 7 **ADFM:** A/D Result Format Select bit
1 = Right justified. 6 Most Significant bits of ADRESH are read as '0'.
0 = Left justified. 6 Least Significant bits of ADRESL are read as '0'.

bit 6-4 **Unimplemented:** Read as '0'

bit 3-0 **PCFG3:PCFG0:** A/D Port Configuration Control bits:

PCFG3: PCFG0	AN7[1] RE2	AN6[1] RE1	AN5[1] RE0	AN4 RA5	AN3 RA3	AN2 RA2	AN1 RA1	AN0 RA0	VREF+	VREF-	CHAN/ Refs[2]
0000	A	A	A	A	A	A	A	A	VDD	Vss	8/0
0001	A	A	A	A	VREF+	A	A	A	RA3	Vss	7/1
0010	D	D	D	A	A	A	A	A	VDD	Vss	5/0
0011	D	D	D	A	VREF+	A	A	A	RA3	Vss	4/1
0100	D	D	D	D	A	D	A	A	VDD	Vss	3/0
0101	D	D	D	D	VREF+	D	A	A	RA3	Vss	2/1
011x	D	D	D	D	D	D	D	D	VDD	Vss	0/0
1000	A	A	A	A	VREF+	VREF-	A	A	RA3	RA2	6/2
1001	D	D	A	A	A	A	A	A	VDD	Vss	6/0
1010	D	D	A	A	VREF+	A	A	A	RA3	Vss	5/1
1011	D	D	A	A	VREF+	VREF-	A	A	RA3	RA2	4/2
1100	D	D	D	A	VREF+	VREF-	A	A	RA3	RA2	3/2
1101	D	D	D	D	VREF+	VREF-	A	A	RA3	RA2	2/2
1110	D	D	D	D	D	D	D	A	VDD	Vss	1/0
1111	D	D	D	D	VREF+	VREF-	D	A	RA3	RA2	1/2

A = Analog input D = Digital I/O

Figure 21 ADCON1 Register [4]

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Street lighting plays an important role in our life. The objective of this project is to develop a method of detecting unlighted utility street lighting system at the control panel. The method will detect a drop of current and indicate it at the control panel of street light. This is cost effective method rather than using manpower to patrol at all streets.

A good understanding on street lighting system will help to get the idea in real life situations are needed in this project. There are many method can be considered for this project, but each method has its own advantages and disadvantages. AC Current Transducer is needed in order to change the corresponding current at the junction from AC to DC. The output value of sensor in voltage is the value needed to program the PIC.

Overall, this project has successfully completed. This project has been developed thoroughly within the time and able to meet the objectives. This project covers most of aspects in electrical and electronics engineering, because it applies electrical in wiring the lamp, electronics in building the circuits and computers in designing the programming.

5.2 Recommendations

- Further study on cable loss calculation should be done so the exact location of the unlighted street light can be known.
- C language of the program can be revised to minimize the complexity of the programming.

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[15] Lecture notes 11, Chapter 4, ADC

APPENDICES

APPENDIX A

PROJECT GANTT CHART

FYP I Gantt chart

Action	Work Week (Timeline)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Project Topic Selection														
Method identification														
Preliminary Research Work														
Submission Preliminary Report														
Project work and research														
Experiment														
Progress Report Submission														
Planning on prototype														
Research on tools and components availability for prototype														
Seminar														
Interim report														

FYP II Gantt chart

Action	Work Week (Timeline)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Experiment on Method														
Progress report I														
Current transducer searching														
Testing on transducer														
Interface transducer with prototype														
Study on microcontroller														
Develop PIC programming														
Interface prototype with PIC														
Progress report II														
Testing on system														
Amendment of the project														
Poster exhibition (pre EDX)														
Draft report														
Submission of final report (soft bound)														

APPENDIX B

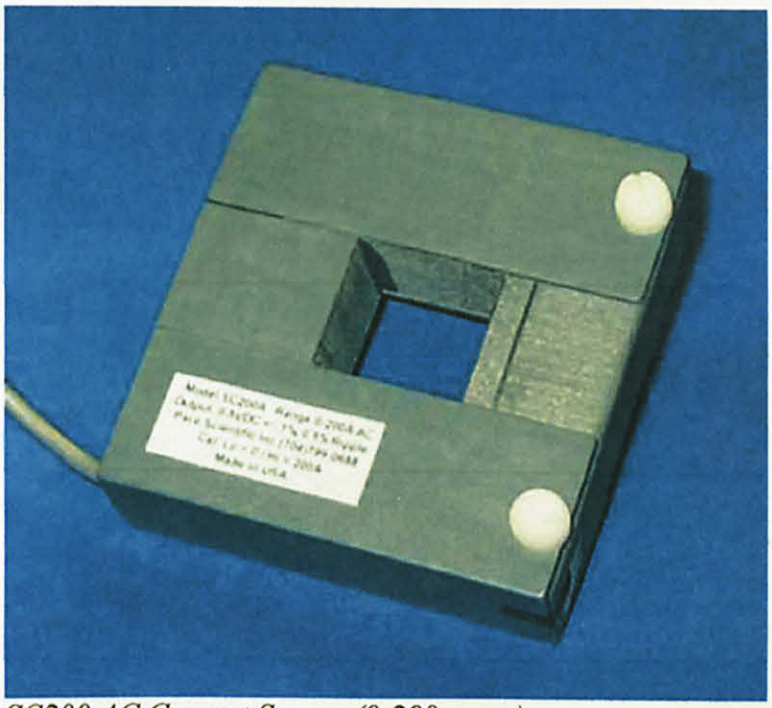
AC CURRENT SENSOR DATA SHEET

AC Current Sensors

Connect directly to any our Data Logger input channel. Also connects directly to any recorder or data acquisition system that has a 0-5vdc input. No external power required.

- Split core design
- Self powered
- Rugged plastic housing
- Output signal is accurate even at very low input current levels (below 1% of full scale).

Split core construction simplifies installation on existing conductor. Nylon thumb screws, no exposed metal parts; Monitor motors, pumps, or any AC load.



SC200 AC Current Sensor (0-200 amps)

Specifications - AC Current Sensors	
Input Current	AC Current, single phase, 50 - 400 Hz, load power factor 0.5 to 1.0 lead or lag.
Accuracy	±2.0% of reading from 2.5 % to 100% of full scale. ±4% of reading at 1% of full scale.
Bandwidth	10-1000Hz (within ±3db)
Temperature effect	±0.05% (-20 to 85°C)
Response time	250 milliseconds (input from 10% to 90% of full scale).
Ripple	0.5%
Voltage rating	600 Vac. Tested with full wave 10KV impulse for 60 seconds.
Overload	1.6x full scale (continuous).
Surge	3x full scale.

Lead wires	8 ft (2.4 meter) signal cable.
Output signal	Linear 0 - 5vdc
Low range usability	To below 0.1% of full scale.
Overall size	Add 2" to Window size in table below for overall length and height dimension (Add 2.5" for SC1500A). Overall width 1.25" (includes nylon thumbscrews)

Part No.	**Range**	**Window Size**	**Price $RM**
SC100A	0-100 amps ac	0.5" square	**595.00**
SC200A	0-200 amps ac	1" square	**695.00**
SC500A	0-500 amps ac	2" square	**1,350.00**
SC1500A	0-1500 amps ac	2.5" square	**1,550.00**

APPENDIX C

PIC16F877A DATA SHEET

PIC16F874A/877A

40-Pin Enhanced FLASH Microcontroller Product Brief

High Performance RISC CPU:

- Only 35 single word instructions to learn
- All single cycle instructions except for program branches, which are two cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM data memory
- Pinout compatible to other 40-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

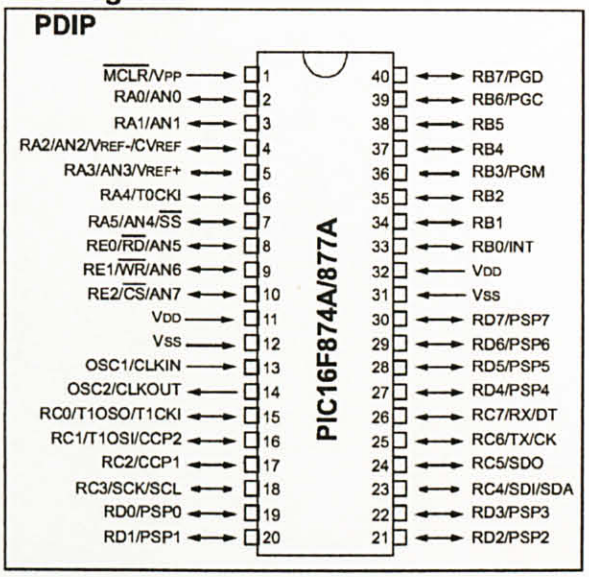
- Timer0 module: 8-bit timer/counter with 8-bit prescaler
- Timer1 module: 16-bit timer/counter with prescaler, can be incremented during SLEEP via external crystal/clock
- Timer2 module: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
- Master Synchronous Serial Port (MSSP) module. Two modes of operation:
  - 3-wire SPI™ (supports all 4 SPI modes)
  - I^2C™ Master and Slave mode
- Addressable USART module:
  - Supports interrupt on Address bit
- Parallel Slave Port (PSP) module 8-bits wide, external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls
- High Sink/Source Current: 25 mA

Analog Features:

- 10-bit 8-ch Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (V_{REF}) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Pin Diagram:

PDIP



CMOS Technology:

- Low power, high speed FLASH/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low power consumption

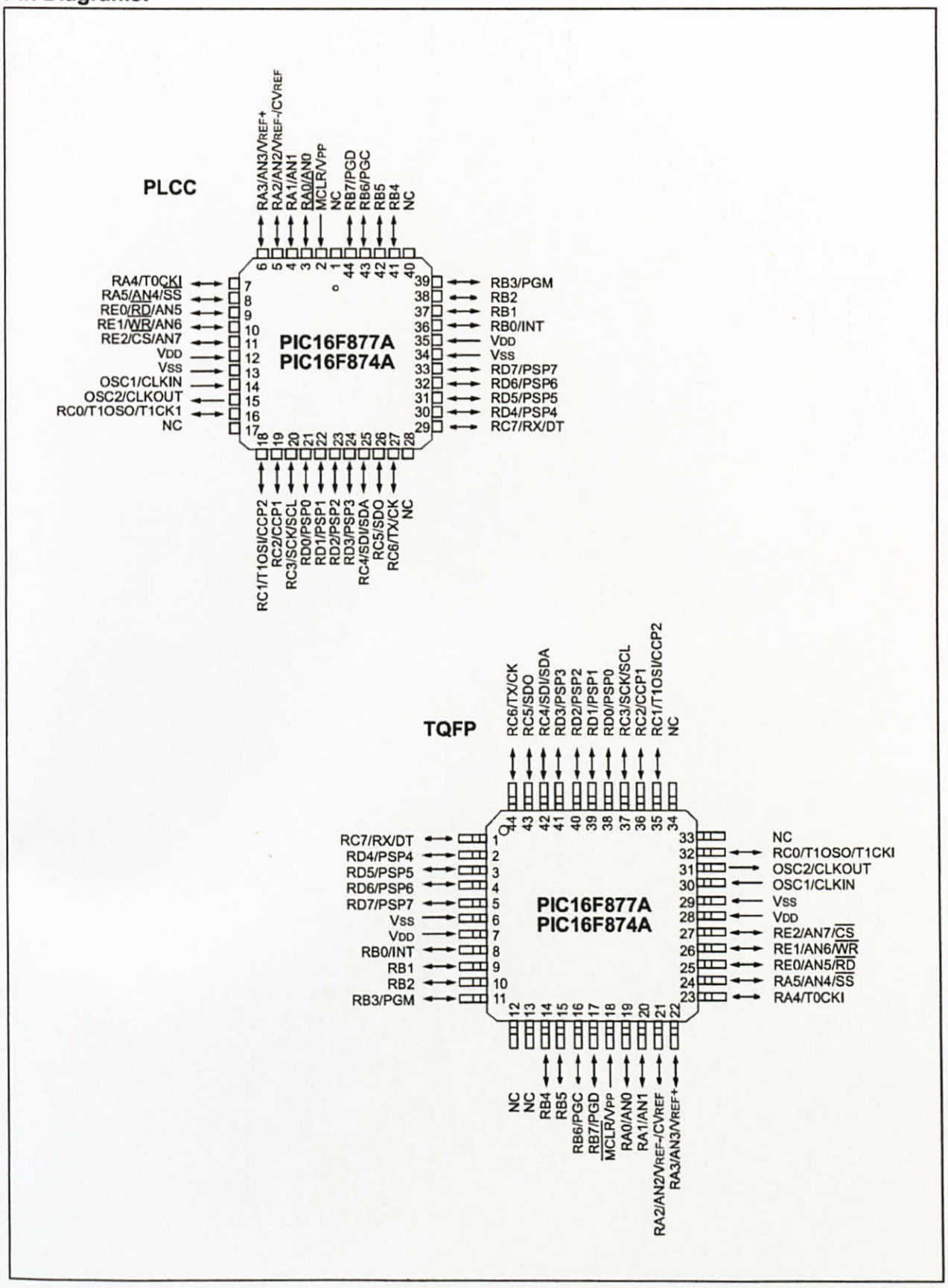
Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced FLASH program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^2C			
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2 / 1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2 / 1	2

Advance Information

Pin Diagrams:



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Advance Information

APPENDIX D

C CODE FOR UNLIGHTED STREET LIGHT

```
//this program represent the number of unlighted street light at LED port D.

#include <pic.h>

__CONFIG (0x3F32);

static unsigned long delay = 0;
static unsigned long valueL = 0,valueH = 0,value = 0;

void main(void)
{
    TRISC = 0;
    TRISD = 0;
    TRISB = 0;
    TRISA = 0b00000001;
    //ADCON0 = 0b10000000;
    ADCON1 = 0b10000010;

    while(1)
    {
        for(delay = 0; delay < 100; delay++);
        ADCON0 = 0b10000000;
        ADON = 1;
        ADCON0 |= 0b00000100;
        while((ADCON0 & 0x04) == 1)
        valueL = ADRESL;
        valueH = ADRESH;
        //PORTB = valueH;
        valueH = valueH << 8;
        //value = (valueL + valueH)*255;
        value = (valueL + valueH);
        //value = value/1023;
        //PORTD = value;


        if(value <= 39)
        {
            PORTD = 0b11100000; //0 lamp on, 3 led on
        }
        else if(value >= 40 && value <= 100)
        {
            PORTD = 0b01100000; //1 lamp on, 2 led on
        }
        else if(value >= 101 && value <= 250)
        {
            PORTD = 0b00100000;//2 lamp on, 1 led on
        }
        else if(value >= 251)
        {
            PORTD = 0b0000000; //3 lamp on,  0 led on
        }


    }
}
```

APPENDIX E

C CODE FOR LIGHTED STREET LIGHT

```
//this program represent the number of lighted street light at LED port D.


#include <pic.h>

__CONFIG (0x3F32);

static unsigned long delay = 0;
static unsigned long valueL = 0,valueH = 0,value = 0;

void main(void)
{
    TRISC = 0;
    TRISD = 0;
    TRISB = 0;
    TRISA = 0b00000001;
    //ADCON0 = 0b10000000;
    ADCON1 = 0b10000010;

    while(1)
    {
        for(delay = 0; delay < 100; delay++);
        ADCON0 = 0b10000000;
        ADON = 1;
        ADCON0 |= 0b00000100;
        while((ADCON0 & 0x04) == 1)
        valueL = ADRESL;
        valueH = ADRESH;
        //PORTB = valueH;
        valueH = valueH << 8;
        //value = (valueL + valueH)*255;
        value = (valueL + valueH);
        //value = value/1023;
        //PORTD = value;


        if(value <= 39)
        {
            PORTD = (value/value);
        }
        if(value >= 40 && value <= 100)
        {
            PORTD = ((value/value)*32);
        }
        if(value >= 101 && value <= 250)
        {
            PORTD = ((value/value)*96);
        }
        if(value >= 251)
        {
            PORTD = ((value/value)*224);
        }


    }
}
```