"I hereby acknowledge that the scope and quality of this thesis is qualify for the award of the Bachelor Degree of Electrical Engineering
(Power System)"

Signature : _____

Name of Supervisor : DR HAMDAN BIN DANIYAL

Date : 21 JUNE 2012

SMART METER-TNB DUAL TARIFF FOR DOMESTIC APPLICATION

NASYRAH BT ABDUL RAHIM

This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering (Power Systems)

Faculty of Electrical & Electronics Engineering
UniversitiMalaysia Pahang

JUNE, 2012

Signature : _____

Author : NASYRAH BT ABDUL RAHIM

Date : 21 JUNE 2012

ACKNOWLEDGEMENT

I wish to express my eternal gratitude and sincere appreciation to my supervisor, Dr Hamdan Bin Daniyal for his invaluable guidance, empowering support and profound advice throught the final year project ; Smart Meter-TNB Dual Tariff for Domestic Application.

My heartfelt gratitude also goes to Mr Kamarul Azam from TNB and all my classmate for their guidance and advice.

Finally, above all, to Almighty God for giving me good health, strength and perseverance to complete this final year project.

ABSTRACT

Presently, the usage of electricity is not balanced between day and night. High demand from industrial, commercial and even residential at day time contributed to extra power generation by Tenaga Nasional Berhad (TNB). Some of these generations' resources, such as coal need all-time non-stop burning process. Due to this, there will be some wastage of energy at night time. This study proposes dual tariff electricity for domestic usage. Tariff will be divided into two which is peak time and off-peak time. Off-peak time will have lower tariff compare to peak time. Today, domestic area is using the typical energy meter, which only applicable for single tariff. To apply dual tariff, a new meter should be used; Smart Meter for Dual Tariff. This meter work as same as TNB energy meter, but it displays the energy usage for peak time and off-peak time. There are two LED to indicate peak time and off-peak time. The meter has select button to display important information, either energy usage, bill or tariff. The development of the meter consists of the reverse-engineering of typical energy meter, the separate energy accumulation for peak and off-peak and the display as interface.

ABSTRAK

Pada masa ini, penggunaan elektrik adalah tidak seimbang antara siang dan malam. Permintaan yang tinggi daripada industri, komersil dan kediaman pada siang hari menyumbang kepada penjanaan kuasa tambahan oleh Tenaga Nasional Berhad (TNB). Beberapa sumber penjanaan elektrik, seperti arang batu memerlukan masa proses pembakaran tanpa henti. Oleh yang demikian, terdapat pembaziran tenaga pada waktu malam. Kajian ini mencadangkan dua tarif elektrik untuk kegunaan rumah sahaja. Tarif akan dibahagikan kepada dua yang merupakan masa puncak dan masa luar puncak. Masa luar puncak akan mempunyai tarif yang rendah berbanding dengan masa puncak. Hari ini, kawasan perumahan yang menggunakan meter tenaga tipikal yang hanya berfungsi bagi tarif tunggal. Untuk mengaplikasikan dua tarif, meter baru harus digunakan; *Smart Meter for Dual Tariff*. Meter ini berfungsi sama seperti meter tenaga TNB yang biasa, tetapi ia memaparkan penggunaan tenaga untuk masa puncak dan masa luar puncak. Meter ini mempunyai butang pilih untuk memaparkan maklumat penting, sama ada penggunaan tenaga, bil atau tarif. Proses pembuatan meter ini terdiri daripada proses kejuruteraan terbalik dari meter tenaga tipikal, pengumpulan tenaga yang berasingan bagi puncak dan luar puncak dan paparan sebagai penghubung.

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CHAPTER 1

INTRODUCTION

1.1 Current Issue

Electricity in Malaysia was managed by TenagaNasionalBerhad(TNB) alone. Electricity in Malaysia can be divided into five which is industry, domestic, commercial, public lighting and mining and agricultural[1].

Figure 1.1:Single phase electronic kWh energy meter

For domestic application, TNB implement typical electricity meter or energy meter to all houses. Energy meter or electricity meter as in Figure 1.1is a basic meter that will calculate,display and record electrical energy consumed by user per month in terms of kWh unit [2].

Table 1.1 : Domestic Tariff in Malaysia

Domestic Tariff		
	Unit	Rates
For the first 200 kWh (1-200 kWh) per month	sen/kWh	21.8
For the next 100 kWh (201-300 kWh) per month	sen/kWh	33.4
For the next 100 kWh (301-400 kWh) per month	sen/kWh	40.0
For the next 100 kWh (401-500 kWh) per month	sen/kWh	40.2
For the next 100 kWh (501-600 kWh) per month	sen/kWh	41.6
For the next 100 kWh (601-700 kWh) per month	sen/kWh	42.6
For the next 100 kWh (701-800 kWh) per month	sen/kWh	43.7
For the next 100 kWh (801-900 kWh) per month	sen/kWh	45.3
For the next 100 kWh (901 kWh onwards) per month *The minimum monthly charge is RM3.00*	sen/kWh	45.4

Table 1.1 show domestic tariff implement by TNB. This tariff is called block tariff.Every month, TNB worker will come to every house to calculate the bill using block tariff[1]. This tariff will cost the customer due to their consumption rates. If their consumption is higher, so the bill will increase and vice versa. This block tariff has no relationship with the time of use of energy. Related to this, consumer can use the electrical energy whenever they want, day or night.

1.2 Problem Statement

Normally, office or commercial customer will start their operation on 8 am until 5 pm. Industries also have same operation hours. Only some industry operates 24 hours.Electrical energy consumption for housing area is higher starting from 6 am until 10 pm. This is due to house cleaning using vacuum and laundry that is usually done during the day. This show that energy consumption during the day is higher than night and this create an imbalanced energy consumption between night, which is off-peak time and day, which is peak time.Due to this, there will be some waste of energy produced by TNB at night.

The way to overcome this problem, dual-tariff system should be implemented to housing area. Dual-tariff is totally different from block tariff that is used by TNB for domestic nowadays. Dual-tariff is a tariff with two rates which is differs by time which is peak time and off-peak time [3]. A rate for peak time is higher than off-peak time rates. Higher rates for peak time will teach domestic customer to reduce the electrical energy consumption during the day and plan to use the electricity during the night.

Dual-tariff system cannot be implemented if domestic area still using energy meter. Smart meter which is compatible for dual-tariff must be design. A meter for dual-tariff already in market, but to be more innovative, this meter will be improved to become smart meter. Basically, of course this meter can calculate, display and record electrical energy consumption over specified period of time for peak time and off-peak time. It is called smart meter because it also can display bill and dual-tariff other than energy consumption.

1.3 Background Study

Actually, TNB already offers dual-tariff rates, but only for industry and commercial customer which operates 24 hours. TNB does not have any short-term planning to convert block tariff to dual tariff system for domestic area.

TNB dual tariff rates that already been used by industries and commercial customer as shown in Table 1.2 will be used for this project.

Table 1.2:Dual tariff rates for Industries

Special Industrial Tariff (for consumers who qualify only)		
	Unit	Rates
For each kilowatt of maximum demand per month during the peak period	RM/kW	27.70
For all kWh during the peak period	sen/kWh	28.3
For all kWh during the off-peak period *The minimum month charge is RM600.00*	sen/kWh	16.1

1.4 Objective

Objective of this project is to :

i. Develop a smart meter that is compatible for dual tariff system.
ii. Propose the usage of dual tariff system for home/domestic application.
iii. Re-balanced the energy usage between day and night.

1.5 Scope of Project

This project will cover :

i. Single Phase Application

ii. Sinusoidal Current

This smart meter only applicable for single phase application. TNB already implement dual tariff for industries which is using three phase meter.

CHAPTER 2

LITERATURE REVIEW

There are many country that already implement dual tariff system or commonly known as time of use tariff (ToU). Time for time-of-use tariff is different from each country, depends on the seasons time.Time-of-use tariff also can become a business strategy for certain country. No matter what reasons time-of-use tariff had been choose, the main cause is time-of-use give benefits to the country and users. Australia, United Kingdom, Canada, South Africa, USA, Spain and Switzerland is a country that already implement time-of-usetariff[3,4,5].

Australia already use time-of-use tariff for housing area[6].In Australia, the user can choose whether time-of-use tariff or single rate tariff depends on the way of energy consumption. If the user think that time-of-use is not suitable with the way of their life, they can choose single rate tariff. It is same for UK, which the system and meter known as Economy 7[7].

Before some changes can be made, a study and survey on acceptance of customer should be made by electrical energy supplier, which is TNB in Malaysia.

This is what Victorian Government do. They still study the impact of time-of-use tariff. Until 2012, time-of-use tariff will not be used in Victoria[6].

Ontario, Canada also implement time-of-use tariff for domestic application, but with three different times, which is off-peak, mid-peak and peak time as shown in Figure 2.1. Other than that, the rates also differ between summer and winter.Special things about Ontario time-of-use tariff is weekends and holidays will be off-peak time[8]. Customer must check the rate of tariff frequently to reduce the bill. It is more easier if the user can read the tariff from the meter because the tariff is always change by time in this situation.

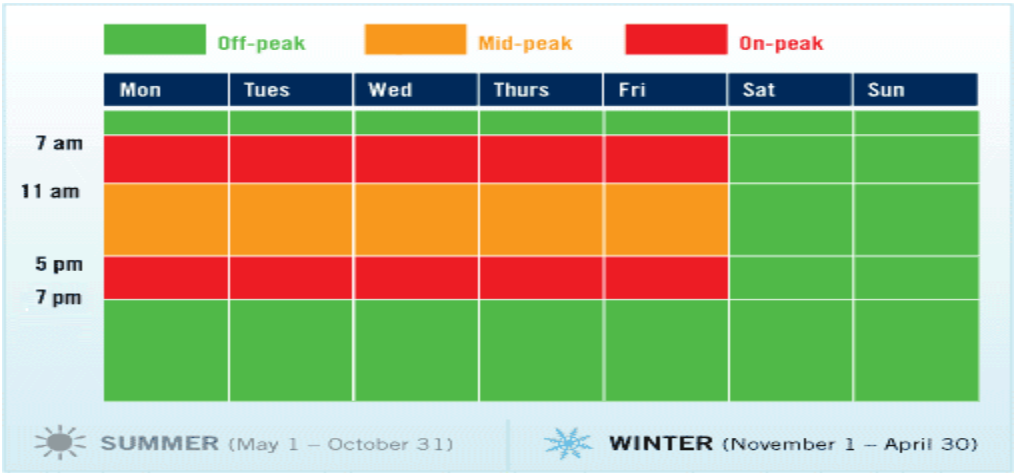


Figure 2.1:Time-of-use tariff in Ontario

Eskom western region, South Africa already carried out a case study on time-of-use tariff to re-balance the usage of energy[9]. The case study shows that electrical energy consumption can be re-balanced using time-of-use tariff.Same situation goes for Spain, which time-of-use tariff was carried out to decrease overcapacity during peak time[10].

In USA, there is an electrical energy supplier known as Baltimore Gas and Electric (BGE) Company used time-of-use tariff as business strategy[11].Only customer that buy electrical energy from BGE company can enjoy the benefit of time-of-use tariff. In Malaysia, TNB is the only electrical energy supplier, so that TNB have no worries about the strategy.

CHAPTER 3

METHODOLOGY

3.1 TNB Meter

TNB have their own requirement for the meter. There are four company build a meter for TNB. One of it is Malaysian intelligent Meters (MiM).All the design purely from TNB. All the meters itself have a sensitivity which no one can open the meter or else the meter will be broken. This action was taken to make sure no one can modify or copy the meter. To make sure this smart meter can fulfill all the requirement from TNB, a real TNB meter is used as illustrate by Figure 3.1. The meter chosen is digital meter for domestic application from MiM as Figure 3.2. This meter will read the current and voltage to calculate power consumption by user. For every 1Wh use, a pulse is produce. People can detect the pulse using the LED indicator. For this project, this pulse will be use as an input for processor to calculate power consumption by user.

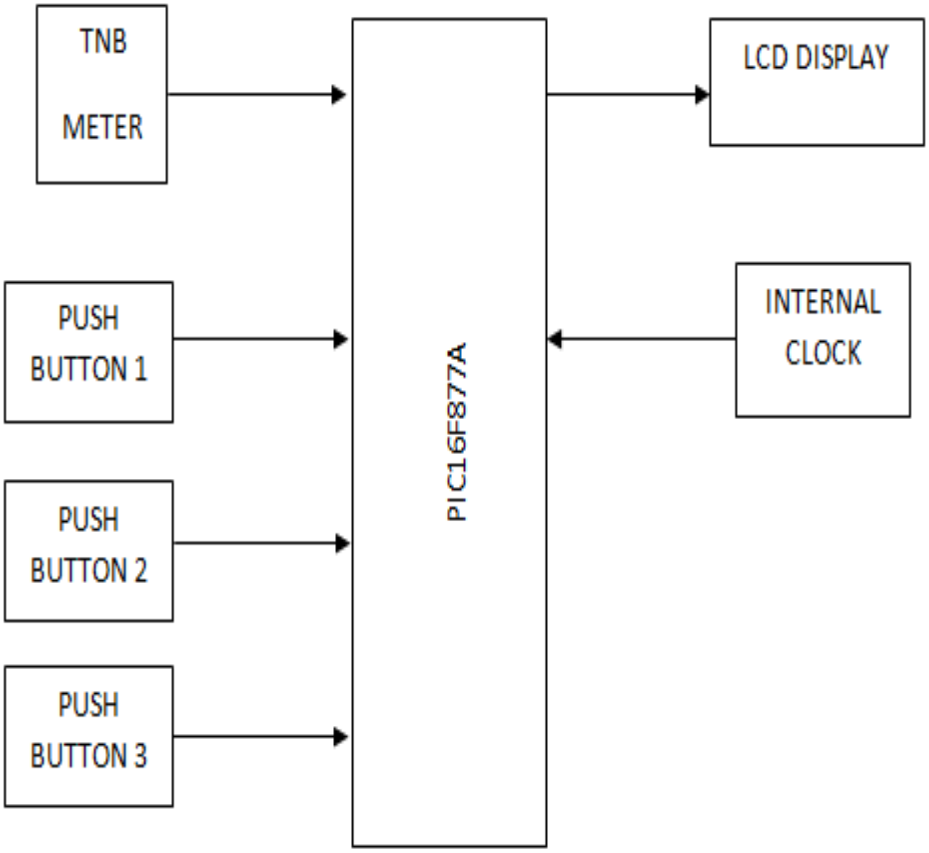


Figure 3.1:Block Diagram for Smart Meter

Figure 3.2:Metronix meter by MiM

As shown by Figure 3.3, A and C is for live wire in and out. B and D is for neutral wire in and out. Output pulse will be connected to PIC16F877A pin 2 as an input.

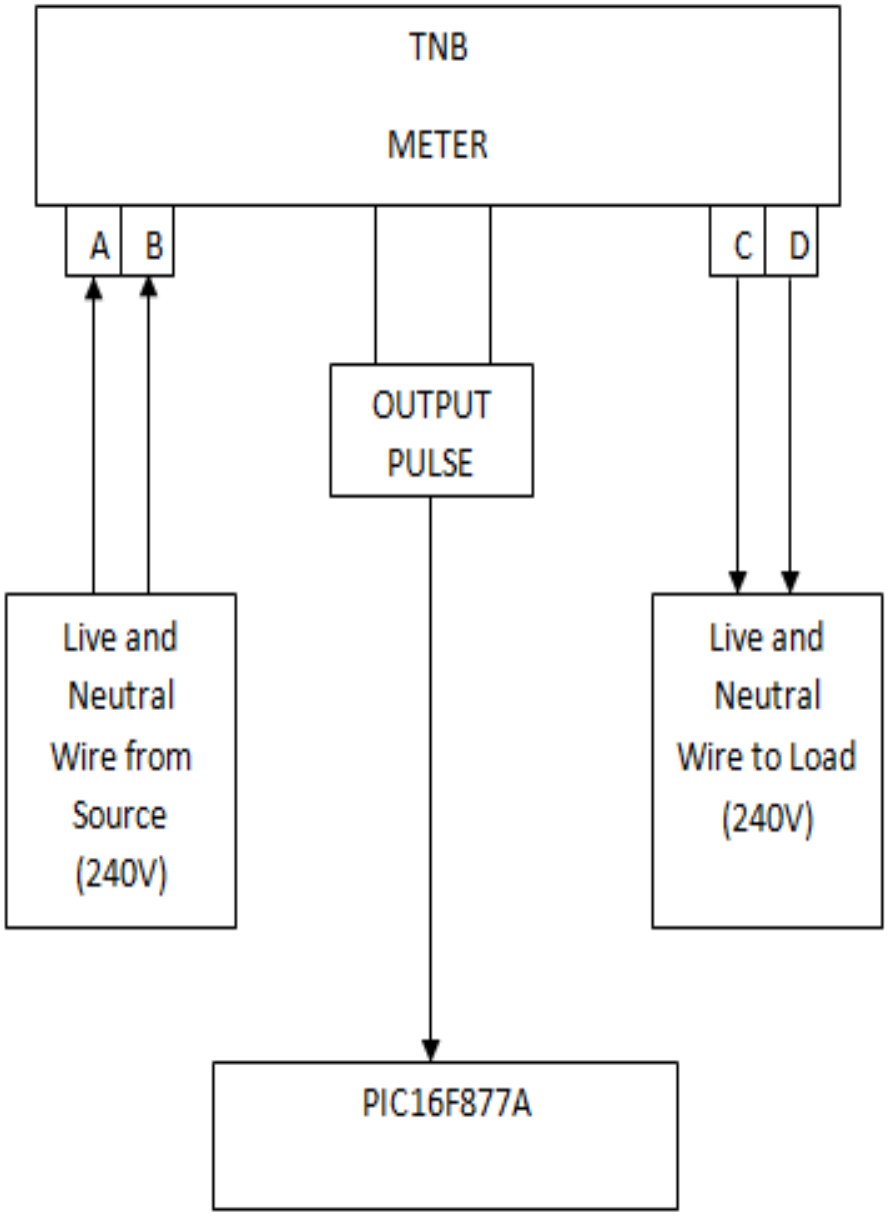


Figure 3.3:Block Diagram for TNB Meter Connection

3.2 LCD Display

Figure 3.4:16x2 LCD display

This smart meter is use 16x2 LCD display as Figure 3.4. Using this LCD, both peak time and off-peak time important information can be display together. Clock also will be display using this LCD display. First line is for peak time and second line is for off-peak time.There are three pushbutton to select either energy usage, bill or tariff to be display at LCD.

3.3 PIC16F877A

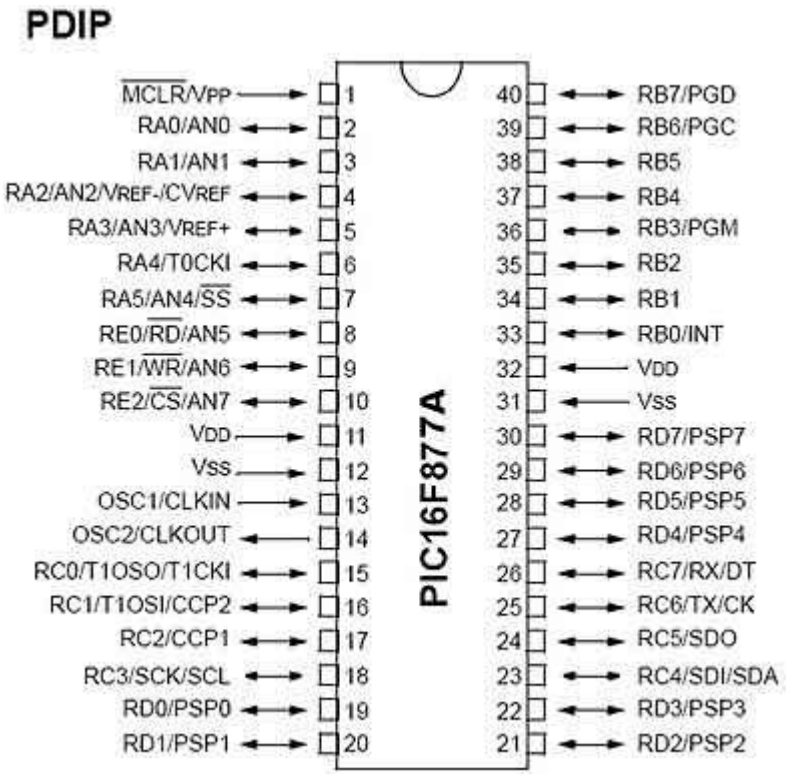


Figure 3.5:PIC16F877A Pin Configuration

Figure 3.5 shows PIC16F877A that work as a processor. Input source for PIC16F877A only 5V.Due to this, voltage regulator LM7805 is used. The input supply is 240V-230V. It will step-down to 6V. Using voltage regulator LM7805, output voltage is 5V and become input voltage for PIC16F877A.

At first, PIC16F877A will take the data from TNB meter. For every pulse it receives, it is equal to 1Wh. It will count up every time it get the pulse. The data will be stored depends on time. If the pulse trigger between 6am until 6pm, data will be store in peak time memory. If the pulse trigger between 6pm until 6am, the data will be store in off-peak time memory.PIC16F877A have 256 bytes EEPROM data

memory. Due to this, no external memory is needed for this smart meter. Other than that, PIC16F877A also already have internal clock. But, whenever the power supply is switch off, then all the data and clock will be reset.

3.4 Circuit Digram

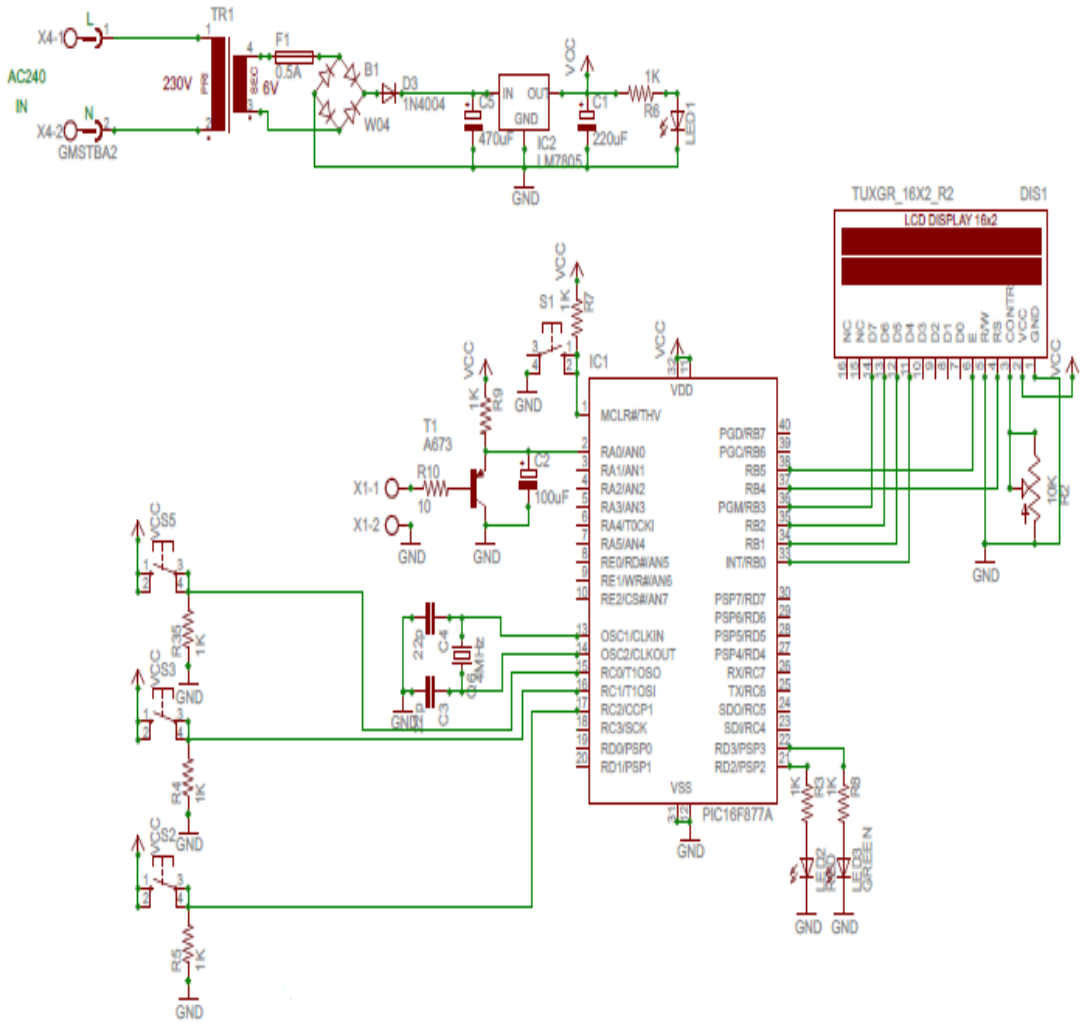


Figure 3.6:Circuit Diagram of smart meter

Figure 3.6 shows the circuit diagram for smart meter illustrated using Eagle Software. We can see that the pulse from TNB meter will cross the PNP transistor. PIC16F877A will count up the data whenever it get low input.

3.5 Programming

All the programming is done using microC PRO for PIC.

```
//define pin used
#define ip  PORTA.F0
#define sw1 PORTC.F0
#define sw2 PORTC.F1
#define sw3 PORTC.F2
#define led_red PORTD.F2
#define led_green PORTD.F3
#define sec_flag flag.F0
#define sw_flag    flag.F0 //mode position for display

//declare variables
charmsec,sec,minutes,hour;
char flag;

char val1;
```

```
char peak;

charnon_peak;

char temp;

char txt[20];

char t;

char x;

char mode;

double price;

char j;


//function prototype

voiddisplay_meter(void);

voiddisplay_num(void);

voidshow_clock();

voidset_timer();

voiddisplay_bill();

voiddisplay_tariff();

void display(char,char,float);


//*******************************

//timer intterupt

//intterupt every 1msec

//increase sec,minutes and hour
```

```
void interrupt(){


if  (INTCON.T0IF){
asm{clrwdt}
msec++;
if (msec>60){
msec = 0;
sec++;
sec_flag=1;
if (sec >=60){
sec = 0;
minutes++;
if(minutes>=60){
minutes=0;
hour++;
if(hour>=24)
                {
hour=0;
                }


            }


          }
```

```
      }
  }
}

//**********************************
//main program

void main(void)
{
 ADCON1=0x06;          //initialize off analogue
 TRISA=0xFF;           //set input or output for porta-portb  1=input,0=output
 TRISB=0x00;           //portb as output lcd
 TRISC=0x0F;           //portc for switch input
 TRISD=0x00;           //else all output
 TRISE=0x00;
 PORTA=PORTB=PORTC=PORTD=PORTE=0x00;      //clear ports
 INTCON=0xA0;                        //on timer interrupt
 OPTION_REG=0b10000101;
LCD_Config(&PORTB,4,5,6,3,2,1,0);       //set lcd define to portb
Lcd_Init(&PORTB);                    // Lcd_Init_EP4, see Autocomplete
LCD_Cmd(LCD_CURSOR_OFF);              // send command to LCD (cursor off)
LCD_Cmd(LCD_CLEAR);                  // send command  to LCD (clear LCD)
peak=non_peak=0;
```

```
sec=minutes=hour=0x00;                  //clear all time

mode = 0;                               //start mode =0


//endless loop

do

 {


if(hour>=6 && hour<=18)                 //when hour from 06-18 then led red on

   {

led_red=1;

led_green=0;

   }

else                                    //else non peak hour led green on

   {

led_red=0;

led_green=1;

   }




if(mode==0)                             //when mode =1??

  {

if(sec_flag)                            //every 1sec will display clock

   {
```

```
show_clock();                    //call display clock on lcd
sec_flag=0;
  }
set_timer();
display_meter();                 //call display peak and non peak units in lcd
 }
else if (mode==1)                //when mode = 1
 {
display_bill();                  //calculate and display bill at lcd
 }
else if (mode==2)                //when mode = 2
 {
display_tariff();                //display tariff at lcd
 }



if(sw1 && !sw3)                  //increase mode when sw1=1 and sw3=0
 {
if(mode>=2)                      //then increase mode value
mode=2;
else
mode++;
```

```
LCD_Cmd(LCD_CLEAR);
while(sw1 && !sw3);              //wait until button released
 }

if(sw2 && !sw3)                  //decrease mode when sw2=1 and sw3=0
 {
if(mode<=0)
mode=0;
else
mode--;
LCD_Cmd(LCD_CLEAR);
while(sw2 && !sw3);              //wait until button released
 }

if(!ip)                          //when input detect low
 {
if(hour>=6 && hour<=18)          //check timer = peak??
peak++;                          //then peak value+1
else
non_peak++;                      //else non peak value ++
while(!ip)
  {
```

```
   }
delay_ms(100);                //delay msec
  }

}while(1);                    //keep looping
}

//************************************

voidshow_clock(void)          //display time on lcd
{
lcd_out(1,1,"Time:");
bytetostr(hour,txt);
display_num();
lcd_chr_cp(':');
bytetostr(minutes,txt);
display_num();
lcd_chr_cp(':');
bytetostr(sec,txt);
display_num();
}

//************************************
```

```
voiddisplay_num(void)          //display number of peak and non peak on lcd
{
if(txt[1]!=' ')
lcd_chr_cp(txt[1]);
else
lcd_chr_cp('0');
if(txt[2]!=' ')
lcd_chr_cp(txt[2]);
else
lcd_chr_cp('0');
}
```

```
//*****************************************************************
**********
```

```
voiddisplay_meter(void)         //call function to display Peak and non Peak values
{
lcd_out(2,1,"P:");
bytetostr(peak,txt);
lcd_chr_cp(txt[0]);
```

```
lcd_chr_cp(txt[1]);

lcd_chr_cp(txt[2]);


lcd_out(2,9,"NP:");

bytetostr(non_peak,txt);

lcd_chr_cp(txt[0]);

lcd_chr_cp(txt[1]);

lcd_chr_cp(txt[2]);

}


//*****************************************************************************
********


voidset_timer(void)          //function to set timer

{

if(sw3 && sw1)               //press button1 and button3 then increase hour

 {

if(hour>=23)

hour=0;

hour++;

show_clock();

while(sw3 && sw1);

 }
```

```
elseif(sw3 && sw2)          //press button2 and button3 then increase minutes
 {
if(minutes>=59)
minutes=0;
minutes++;
show_clock();
while(sw3 && sw2);
 }
}

//*****************************************************************************
********

voiddisplay_bill(void)          //calculate to display bill
{
lcd_out(1,1,"RM-P:");           //count peak
price = peak * 0.0283;
display(1,6,price);
lcd_out(2,1,"RM-NP:");          //count non peak
price = non_peak * 0.0161;
display(2,7,price);
}
```

```
voiddisplay_tariff(void)
{
lcd_out(1,1,"P:28.3 KW/H");
lcd_out(2,1,"NP:16.1 KW/H");
}

//*****************************************************************************
*******
//display calculation value at lcd
voidloop_display(void)
{
for(j=0;j<=3;j++)
 {
if(isdigit(txt[j]))
lcd_chr_cp(txt[j]);
 }
}

void display(char x, char y, float value)
{
lcd_chr(x,y,'=');
for(j=0;j<=12;j++)
txt[j]=0;
```

```
floattostr(value,txt);
if(value<=0.001)            //when current <0.001
 {
lcd_out(x,y+1,"0.00");      //then display 0.00
 }
else if(value<=0.01)        //when < 0.01
 {
lcd_out(x,y+1,"0.00");      //display 0.00
loop_display();             //display float conversion
 }
else if(value<=0.1)         //when <0.1
 {
lcd_out(x,y+1,"0.0");       //display 0.0
loop_display();             //display conversion
 }
else if(value<=1)           //when < 1
 {
lcd_out(x,y+1,"0.");
loop_display();
 }
else if(value>1)            //when > 1
 {
for(j=0;j<=2;j++)
```

```
  {
if(isdigit(txt[j]))
lcd_chr_cp(txt[j]);
if(txt[j+1]=='.')
   {
lcd_chr_cp(txt[j+1]);
lcd_chr_cp(txt[j+2]);
break;
   }
  }
 }
}
```

CHAPTER 4

RESULT ANALYSIS AND DISCUSSION

In this prototype meter, pulse from actual TNB meter is used.A good quality meter will give 1000 pulses for 1kWh energy usage. So, one pulse equal to 1Wh usage. This meter must be test to make sure the pulse send to PIC16F877A is accurate.

A resistive load of 2400W is connected to TNB meter. The output pulse from TNB meter is observe using oscilloscope. Figure 4.1 show that complete one cycle is 20ms and frequency is 50Hz.

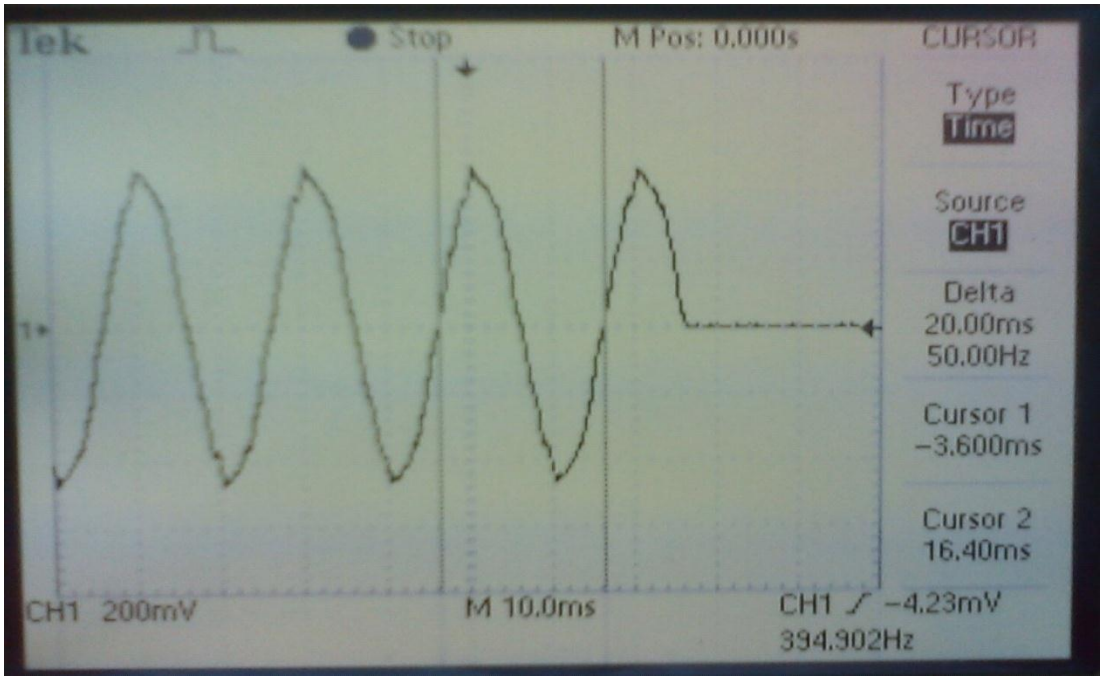


Figure 4.1:Complete Output Pulse

Figure 4.2 shows that output pulse is 0V.Vp for the signal is 464mV.

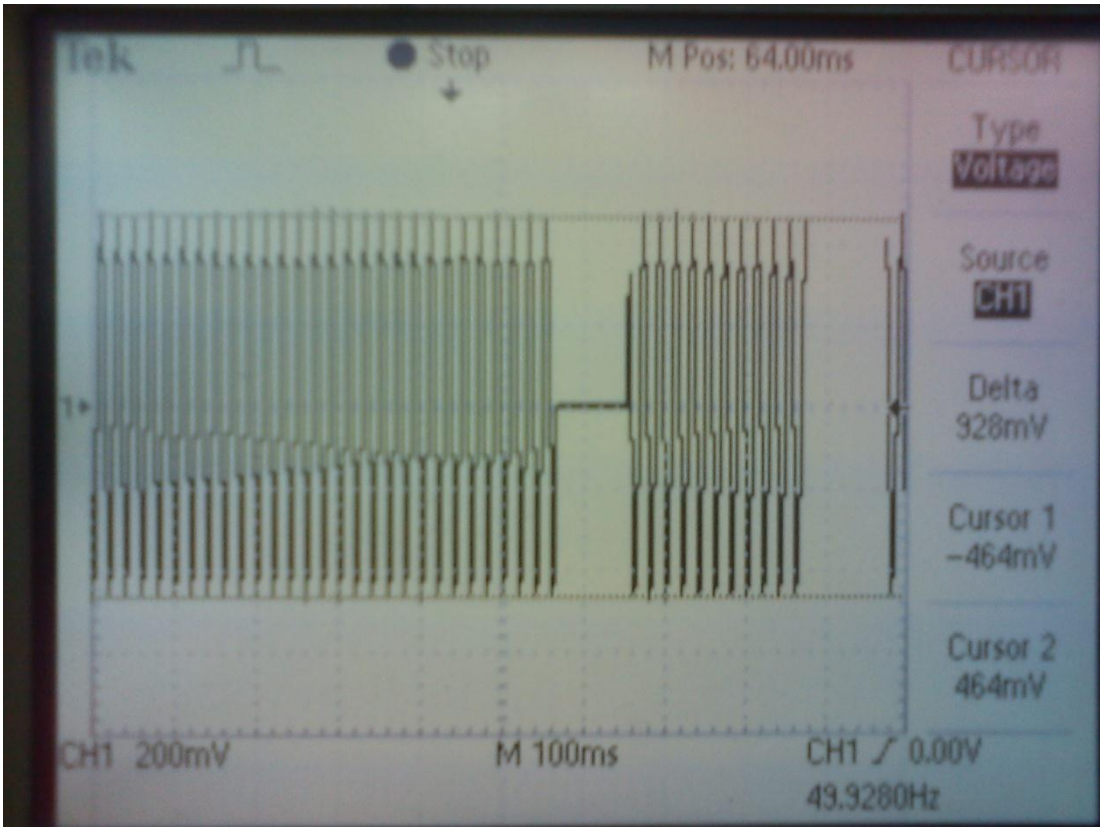


Figure 4.2:Output pulse from TNB meter

A period for one cycle pulse is shown by Figure 4.3, which is 88ms.

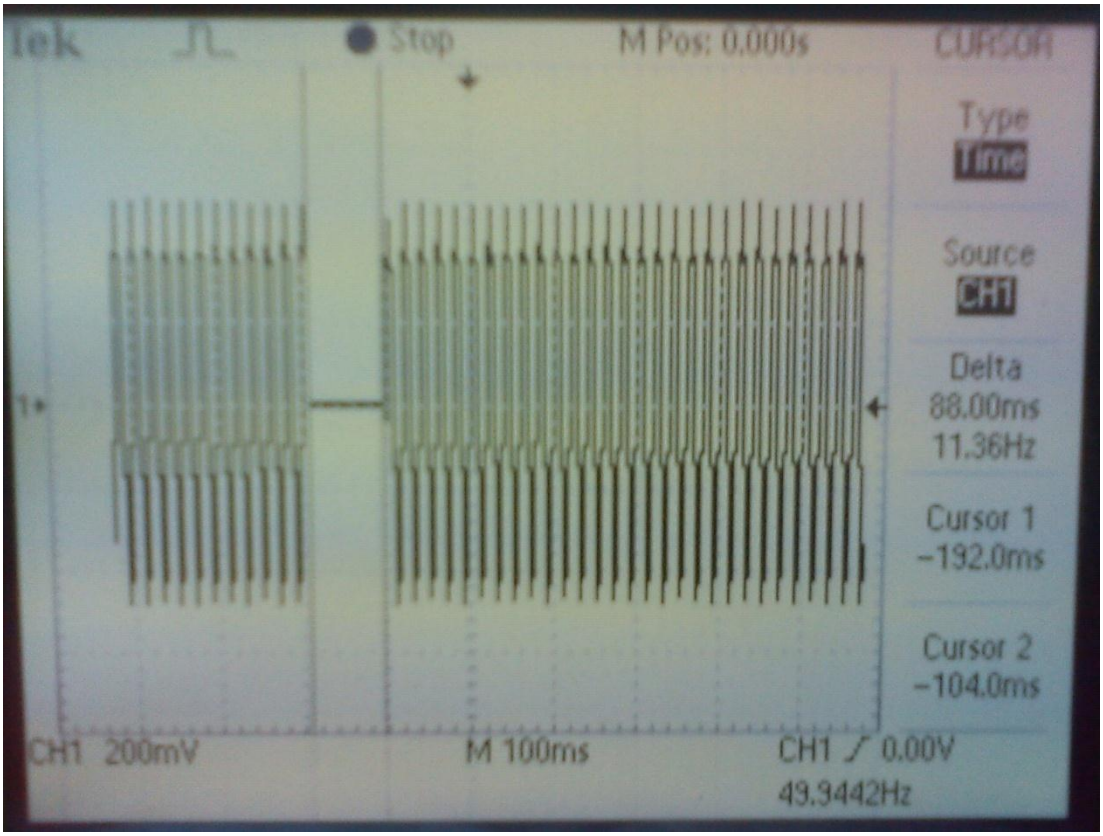


Figure 4.3:One Cycle Pulse

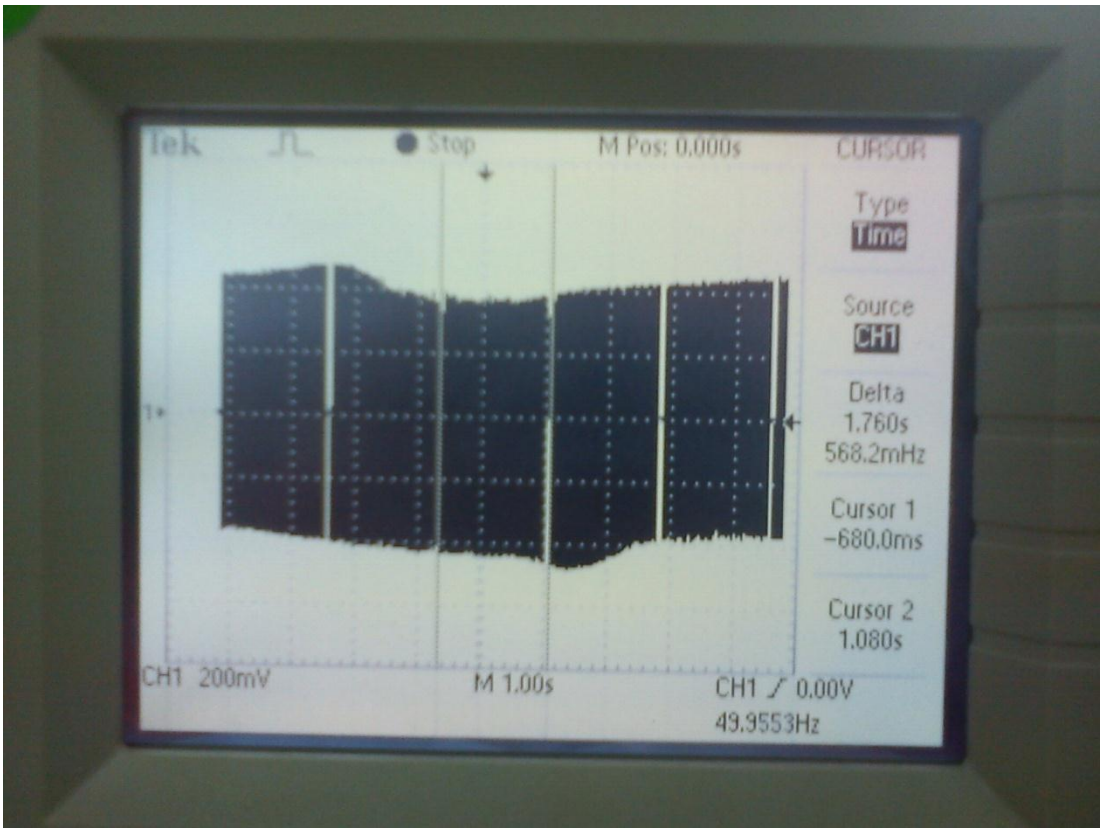


Figure 4.4:Time between two pulses

Figure 4.4 shows that period for the pulses to trigger is every 1.76s.

Using a theory ;

E (1 hour) = 2400Wh

So in 1 hour, there will be 2400 pulses.

$T = \frac{1\,hour}{2400}$;

$T = \frac{60x60}{2400} = \frac{3600}{2400}$

T = 1.5s

This show that the meter work properly but maybe the input voltage at that time is not 240V, but reduce to 130V and give a reading for 1.76s.

An experiment also had been done at TNB Asia Jaya Laboratory. The experiment is to compare the reading of current for load that have above 0.5 power factor and below 0.5 power factor. It shows that when power factor is low, then the current draw will be decrease and meter reading for power consumption will be

reduce. That is why if the industries have power factor below 0.85 will be penalize.The industries with low power factor will use high power consumption but pay less.

For domestic area, power factor is not the concern subject. So, energy meter for domestic application does not calculate power factor. But, the user still will pay less than what they use if their load having low power factor.

Figure 4.5 shows the prototype meter, which have 3 functioning button, an LCD display and PIC16F877A as a main component.

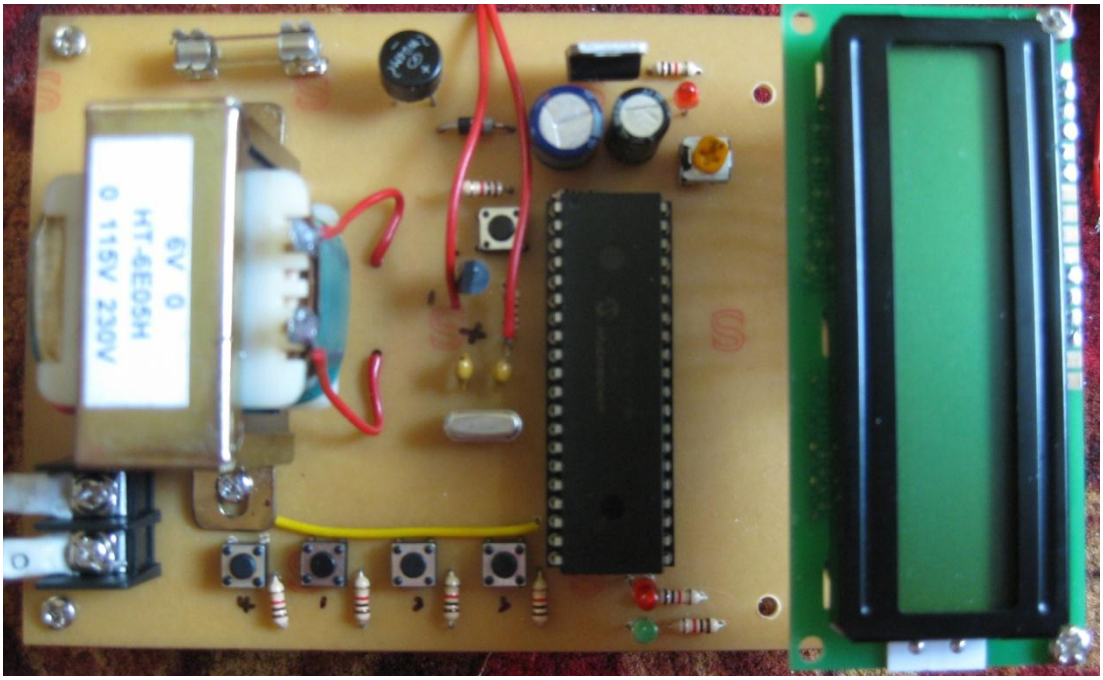


Figure 4.5:Prototype Meter

CHAPTER 5

CONCLUSSION AND FUTURE RECOMMENDATION

5.1 Conclusion

Dual-tariff system for domestic application is the best way to re-balance the electrical energy consumption between day and night in Malaysia [6][7]. Dual-tariff system will teach the domestic customer to use the electrical energy more during the off-peak time. Related to this, a compatible meter with dual tariff system must be developing.

5.2 Future Recommendation

The internal clock for this meter should have an external power to ensure the clock is still running even during electricity black out. This is important to make sure the indicator switch on at the right time and data was store in the right place.

REFERENCE

[1] TNB Announcement. Available: www.tnbbuzz.com retrieved on 5.10.2011

[2] "Energy Meter," *Energy Meter*, 2002.

[3] I. G. Paterson,"Designing time of use tariffs for local authorities", IEEE, South Africa, 2009.

[4] K. Campbell "Implementation time of use tariffs",IEEE, Republic of South Africa, 2009.

[5] D.P.theron, "A PC-BASED METER-TO-BILL INTERFACE FOR A TIME-OF-USE TARIFF", IEEE, Eskom, 2009.

[6] Smart meter guide and cost. Available: www.switchwise.com.au retrieved on 15.10.2011

[7] Economy 7. Available: www.uswitch.com retrieved on 23.10.2011

[8] time-of-use prices Available: www.ieso.ca retireved on 15.10.2011

[9] D. Ramsbottom, "time-of-use tariffs in eskom western region," November 2009.

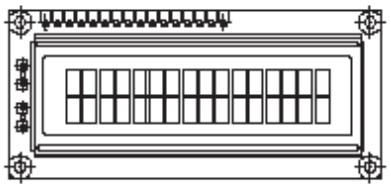
[10] M. Filippini, "short and long-run time-of-use price elasticities in Swiss residential electricity demand," 2010.

[11] (2011, time-of-use pricing. Available: www.bge.com retrieved on 24.10.2011

APPENDICES

APPENDIX A

16 x 2 Character LCD



FEATURES

- 5 x 8 dots with cursor
- Built-in controller (KS 0066 or Equivalent)
- + 5V power supply (Also available for + 3V)
- 1/16 duty cycle
- B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A,K (LED)
- N.V. optional for + 3V power supply

MECHANICAL DATA

ITEM	STANDARD VALUE	UNIT
Module Dimension	80.0 x 36.0	mm
Viewing Area	66.0 x 16.0	mm
Dot Size	0.56 x 0.66	mm
Character Size	2.96 x 5.56	mm

ABSOLUTE MAXIMUM RATING

ITEM	SYMBOL	STANDARD VALUE			UNIT
		MIN.	TYP.	MAX.	
Power Supply	VDD-VSS	- 0.3	–	7.0	V
Input Voltage	VI	- 0.3	–	VDD	V

NOTE: VSS = 0 Volt, VDD = 5.0 Volt

ELECTRICAL SPECIFICATIONS

ITEM	SYMBOL	CONDITION		STANDARD VALUE			UNIT
				MIN.	TYP.	MAX.	
Input Voltage	VDD	VDD = + 5V		4.7	5.0	5.3	V
		VDD = + 3V		2.7	3.0	5.3	V
Supply Current	IDD	VDD = 5V		–	1.2	3.0	mA
Recommended LC Driving Voltage for Normal Temp. Version Module	VDD - V0	- 20 °C		–	–	–	V
		0°C		4.2	4.8	5.1	
		25°C		3.8	4.2	4.6	
		50°C		3.6	4.0	4.4	
		70°C		–	–	–	
LED Forward Voltage	VF	25°C		–	4.2	4.6	V
LED Forward Current	IF	25°C	Array	–	130	260	mA
			Edge	–	20	40	
EL Power Supply Current	IEL	Vel = 110VAC:400Hz		–	–	5.0	mA

DISPLAY CHARACTER ADDRESS CODE:

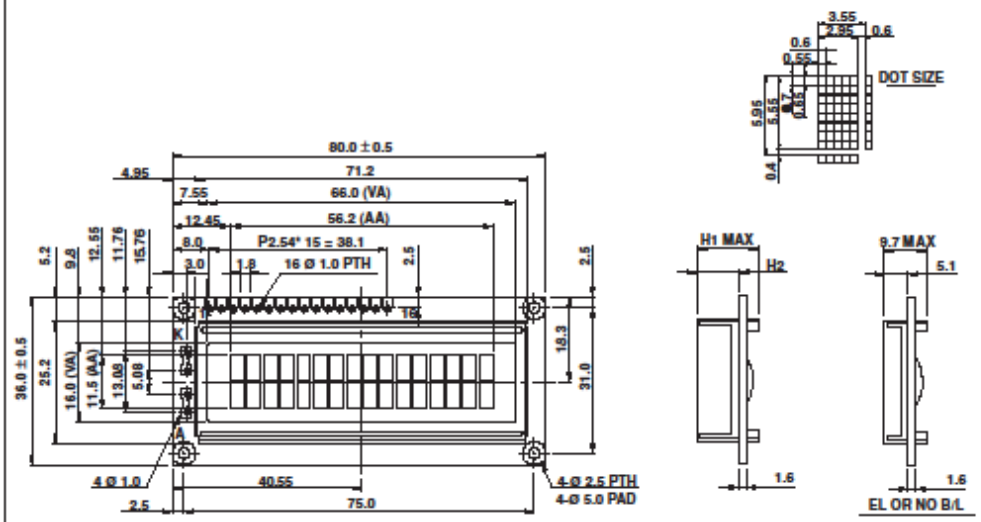
Display Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DD RAM Address	00	01														0F
DD RAM Address	40	41														4F

LCD-016M002B

Vishay 16 x 2 Character LCD

PIN NUMBER	SYMBOL	FUNCTION
1	Vss	GND
2	Vdd	+ 3V or + 5V
3	Vo	Contrast Adjustment
4	RS	H/L Register Select Signal
5	R/$\overline{W}$	H/L Read/Write Signal
6	E	H →L Enable Signal
7	DB0	H/L Data Bus Line
8	DB1	H/L Data Bus Line
9	DB2	H/L Data Bus Line
10	DB3	H/L Data Bus Line
11	DB4	H/L Data Bus Line
12	DB5	H/L Data Bus Line
13	DB6	H/L Data Bus Line
14	DB7	H/L Data Bus Line
15	A/Vee	+ 4.2V for LED/Negative Voltage Output
16	K	Power Supply for B/L (0V)

DIMENSIONS in millimeters



LED - H/L B/L

	HIGH	LOW
H1	13.2	12.1
H2	8.6	7.5

APPENDIX B

Malaysian Intelligence Meters Sdn. Bhd. (503540-V)
No.3, Jalan Pemberita U1/49
Selayan III, Temasya Industrial Park
Glenmarie, 40150 Shah Alam,
Selangor Darul Ehsan, Malaysia
Tel : +(603) 55695481 E-Mail : info@mim.net.my
Fax : +(603) 55695488 Website : www.mim.net.my

Towards a Comprehensive Solution For Revenue Collection

G3

Single Phase Electronic kWh Energy Meter with Normal LCD Display

SPECIFICATION

Connection	1 phase, 2 Wire
Accuracy Class	Class 1 & Class 2
Operating Temperature	-20 C to +70 C
Humidity	95% RH
Dimension	225mm x 151mm x 57mm
Enclosure Material	Poly Carbonate V-O
Metering Technology	Shunt
Flame Retardation	UL94-V
Lifetime	10 Years (min)
Weight	0.72 kg
Degree of Protection	IP54 of IEC 62059
Input Voltage Range	240V ± 20%
Current Range	10(100) A
Variation of Power Factor	0.5 Lag to 0.8 Lead
Meter Constant	1000imp/kWh
Frequency	50Hz ± 5%
Impulse Voltage Rating	12 kV
Dynamic Range	1000:1
Energy Verification	LED Pulse, Output Pulse Terminal

CHARACTERISTIC

- Color for domestic and commercial use
- Anti-Tampering / Magnetic Immunity up to 500m Tesla
- Low power Rate
- Display on LCD with backlight

STANDARD METHODOLOGY

IEC 62052-11:2003
IEC 62053-21:2003
BS 5685

APPENDIX C

PIC16F87XA
Data Sheet

28/40/44-Pin Enhanced Flash Microcontrollers

MICROCHIP

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

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 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^2C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel 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

Special Microcontroller Features:

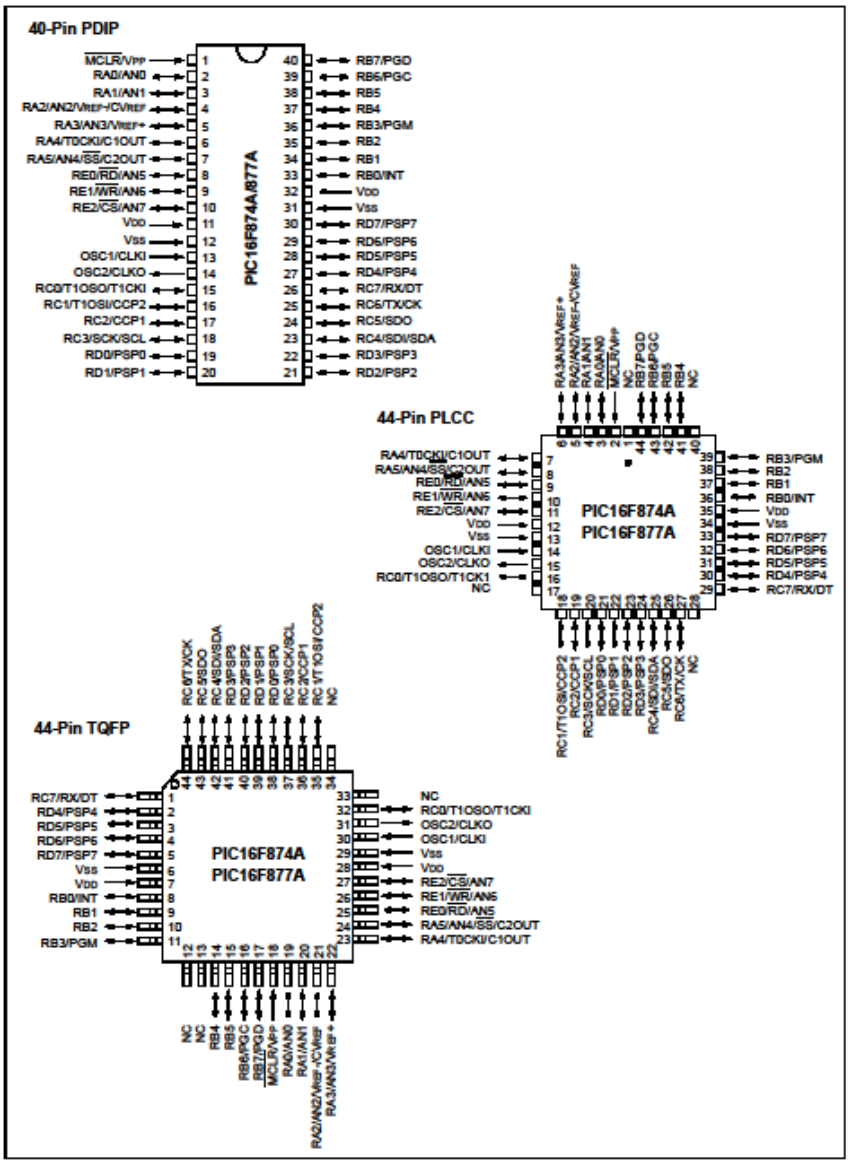
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- 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

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

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			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

Pin Diagrams (Continued)



1.0 DEVICE OVERVIEW

This document contains device specific information about the following devices:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

PIC16F873A/876A devices are available only in 28-pin packages, while PIC16F874A/877A devices are available in 40-pin and 44-pin packages. All devices in the PIC16F87XA family share common architecture with the following differences:

- The PIC16F873A and PIC16F874A have one-half of the total on-chip memory of the PIC16F876A and PIC16F877A
- The 28-pin devices have three I/O ports, while the 40/44-pin devices have five
- The 28-pin devices have fourteen interrupts, while the 40/44-pin devices have fifteen
- The 28-pin devices have five A/D input channels, while the 40/44-pin devices have eight
- The Parallel Slave Port is implemented only on the 40/44-pin devices

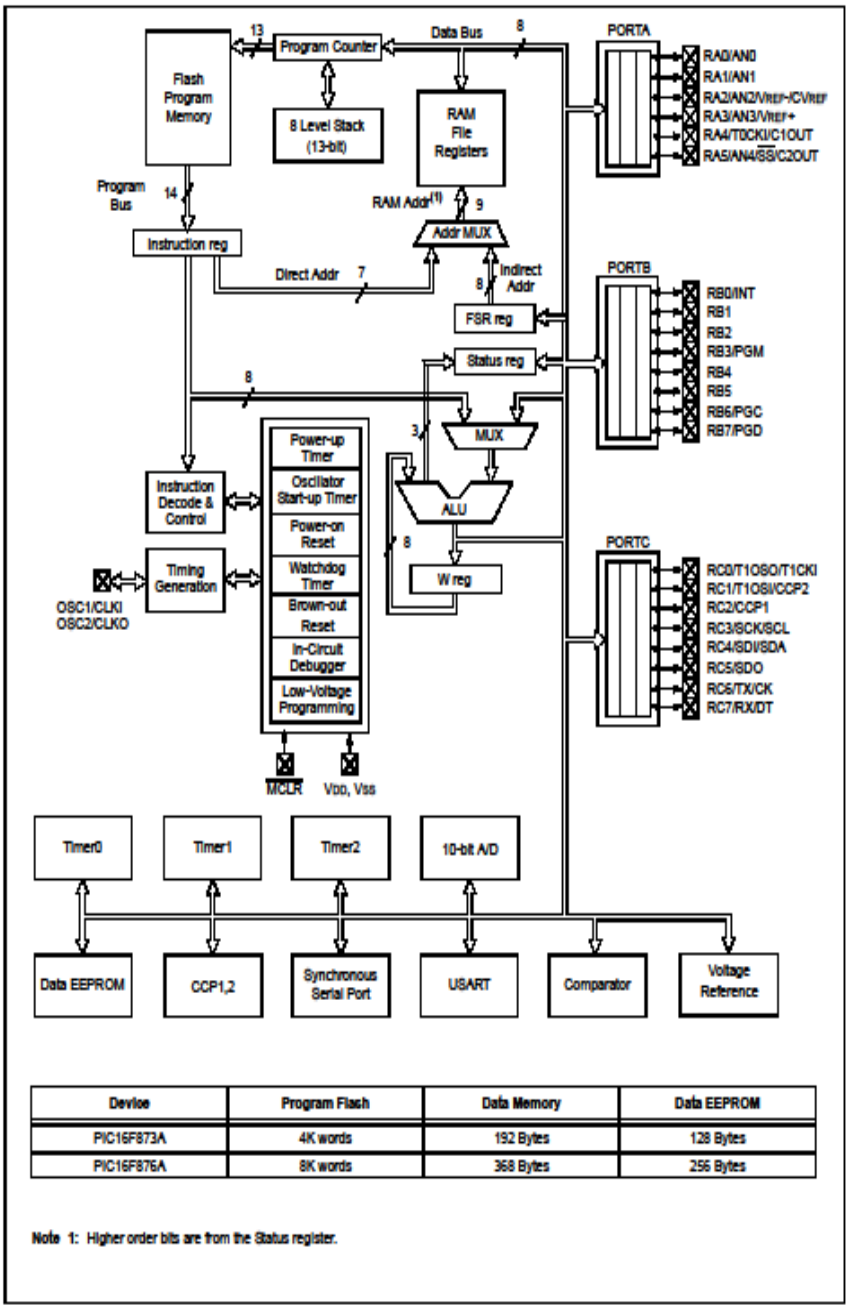
The available features are summarized in Table 1-1. Block diagrams of the PIC16F873A/876A and PIC16F874A/877A devices are provided in Figure 1-1 and Figure 1-2, respectively. The pinouts for these device families are listed in Table 1-2 and Table 1-3.

Additional information may be found in the PICmicro® Mid-Range Reference Manual (DS33023), which may be obtained from your local Microchip Sales Representative or downloaded from the Microchip web site. The Reference Manual should be considered a complementary document to this data sheet and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

TABLE 1-1: PIC16F87XA DEVICE FEATURES

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz	DC – 20 MHz
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory (14-bit words)	4K	4K	8K	8K
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	—	PSP	—	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

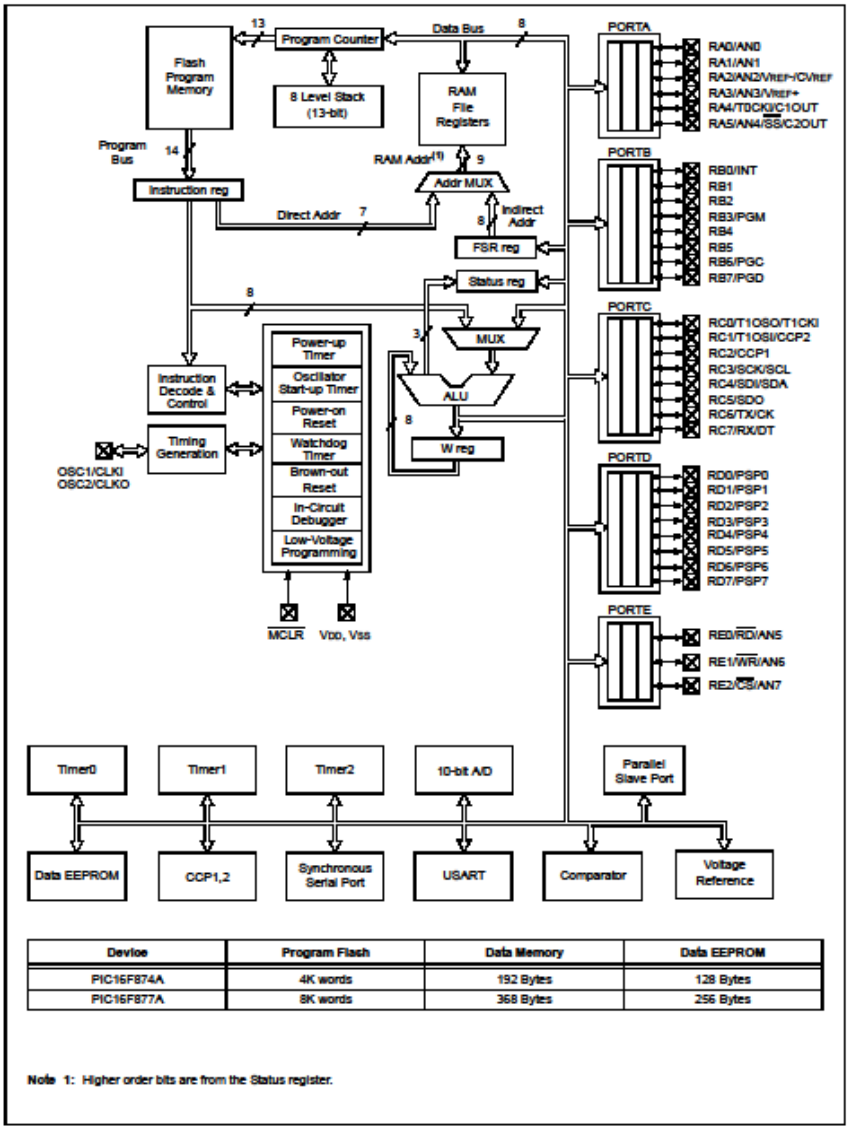
FIGURE 1-1: PIC16F873A/876A BLOCK DIAGRAM



Device	Program Flash	Data Memory	Data EEPROM
PIC16F873A	4K words	192 Bytes	128 Bytes
PIC16F876A	8K words	368 Bytes	256 Bytes

Note 1: Higher order bits are from the Status register.

FIGURE 1-2: PIC16F874A/877A BLOCK DIAGRAM



Device	Program Flash	Data Memory	Data EEPROM
PIC16F874A	4K words	192 Bytes	128 Bytes
PIC16F877A	8K words	368 Bytes	256 Bytes

Note 1: Higher order bits are from the Status register.

TABLE 1-2: PIC16F873A/876A PINOUT DESCRIPTION

Pin Name	PDIP, SOIC, SSOP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKI	9	6		ST/CMOS(3)	Oscillator crystal or external clock input.
OSC1			I		Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; otherwise CMOS.
CLKI			I		External clock source input. Always associated with pin function OSC1 (see OSC1/CLKI, OSC2/CLKO pins).
OSC2/CLKO	10	7		—	Oscillator crystal or clock output.
OSC2			O		Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO			O		In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}$/VPP	1	26		ST	Master Clear (input) or programming voltage (output).
$\overline{MCLR}$			I		Master Clear (Reset) input. This pin is an active low Reset to the device.
VPP			P		Programming voltage input.
					PORTA is a bidirectional I/O port.
RA0/AN0	2	27		TTL	
RA0			I/O		Digital I/O.
AN0			I		Analog input 0.
RA1/AN1	3	28		TTL	
RA1			I/O		Digital I/O.
AN1			I		Analog input 1.
RA2/AN2/VREF-/CVREF	4	1		TTL	
RA2			I/O		Digital I/O.
AN2			I		Analog input 2.
VREF-			I		A/D reference voltage (Low) input.
CVREF			O		Comparator VREF output.
RA3/AN3/VREF+	5	2		TTL	
RA3			I/O		Digital I/O.
AN3			I		Analog input 3.
VREF+			I		A/D reference voltage (High) input.
RA4/T0CKI/C1OUT	6	3		ST	
RA4			I/O		Digital I/O – Open-drain when configured as output.
T0CKI			I		Timer0 external clock input.
C1OUT			O		Comparator 1 output.
RA5/AN4/$\overline{SS}$/C2OUT	7	4		TTL	
RA5			I/O		Digital I/O.
AN4			I		Analog input 4.
$\overline{SS}$			I		SPI slave select input.
C2OUT			O		Comparator 2 output.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-2: PIC16F873A/876A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP, SOIC, SSOP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
					PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/INT	21	18		TTL/ST(1)	
RB0			I/O		Digital I/O.
INT			I		External interrupt.
RB1	22	19	I/O	TTL	Digital I/O.
RB2	23	20	I/O	TTL	Digital I/O.
RB3/PGM	24	21		TTL	
RB3			I/O		Digital I/O.
PGM			I		Low-voltage (single-supply) ICSP programming enable pin.
RB4	25	22	I/O	TTL	Digital I/O.
RB5	26	23	I/O	TTL	Digital I/O.
RB6/PGC	27	24		TTL/ST(2)	
RB6			I/O		Digital I/O.
PGC			I		In-circuit debugger and ICSP programming clock.
RB7/PGD	28	25		TTL/ST(2)	
RB7			I/O		Digital I/O.
PGD			I/O		In-circuit debugger and ICSP programming data.
					PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	11	8		ST	
RC0			I/O		Digital I/O.
T1OSO			O		Timer1 oscillator output.
T1CKI			I		Timer1 external clock input.
RC1/T1OSI/CCP2	12	9		ST	
RC1			I/O		Digital I/O.
T1OSI			I		Timer1 oscillator input.
CCP2			I/O		Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	13	10		ST	
RC2			I/O		Digital I/O.
CCP1			I/O		Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL	14	11		ST	
RC3			I/O		Digital I/O.
SCK			I/O		Synchronous serial clock input/output for SPI mode.
SCL			I/O		Synchronous serial clock input/output for I^2C mode.
RC4/SDI/SDA	15	12		ST	
RC4			I/O		Digital I/O.
SDI			I		SPI data in.
SDA			I/O		I^2C data I/O.
RC5/SDO	16	13		ST	
RC5			I/O		Digital I/O.
SDO			O		SPI data out.
RC6/TX/CK	17	14		ST	
RC6			I/O		Digital I/O.
TX			O		USART asynchronous transmit.
CK			I/O		USART1 synchronous clock.
RC7/RX/DT	18	15		ST	
RC7			I/O		Digital I/O.
RX			I		USART asynchronous receive.
DT			I/O		USART synchronous data.
VSS	8, 19	5, 6	P	—	Ground reference for logic and I/O pins.
VDD	20	17	P	—	Positive supply for logic and I/O pins.

Legend: I = Input O = output I/O = Input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKI	13	14	30	32		ST/CMOS(4)	Oscillator crystal or external clock input.
OSC1					I		Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; otherwise CMOS.
CLKI					I		External clock source input. Always associated with pin function OSC1 (see OSC1/CLKI, OSC2/CLKO pins).
OSC2/CLKO	14	15	31	33		—	Oscillator crystal or clock output.
OSC2					O		Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO					O		In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}$/VPP	1	2	18	18		ST	Master Clear (input) or programming voltage (output).
$\overline{MCLR}$					I		Master Clear (Reset) input. This pin is an active low Reset to the device.
VPP					P		Programming voltage input.
							PORTA is a bidirectional I/O port.
RA0/AN0	2	3	19	19		TTL	
RA0					I/O		Digital I/O.
AN0					I		Analog input 0.
RA1/AN1	3	4	20	20		TTL	
RA1					I/O		Digital I/O.
AN1					I		Analog input 1.
RA2/AN2/VREF-/CVREF	4	5	21	21		TTL	
RA2					I/O		Digital I/O.
AN2					I		Analog input 2.
VREF-					I		A/D reference voltage (Low) input.
CVREF					O		Comparator VREF output.
RA3/AN3/VREF+	5	6	22	22		TTL	
RA3					I/O		Digital I/O.
AN3					I		Analog input 3.
VREF+					I		A/D reference voltage (High) input.
RA4/T0CKI/C1OUT	6	7	23	23		ST	
RA4					I/O		Digital I/O – Open-drain when configured as output.
T0CKI					I		Timer0 external clock input.
C1OUT					O		Comparator 1 output.
RA5/AN4/$\overline{SS}$/C2OUT	7	8	24	24		TTL	
RA5					I/O		Digital I/O.
AN4					I		Analog input 4.
$\overline{SS}$					I		SPI slave select input.
C2OUT					O		Comparator 2 output.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	9		TTL/ST(1)	
RB0					I/O		Digital I/O.
INT					I		External interrupt.
RB1	34	37	9	10	I/O	TTL	Digital I/O.
RB2	35	38	10	11	I/O	TTL	Digital I/O.
RB3/PGM	36	39	11	12		TTL	
RB3					I/O		Digital I/O.
PGM					I		Low-voltage ICSP programming enable pin.
RB4	37	41	14	14	I/O	TTL	Digital I/O.
RB5	38	42	15	15	I/O	TTL	Digital I/O.
RB6/PGC	39	43	16	16		TTL/ST(2)	
RB6					I/O		Digital I/O.
PGC					I		In-circuit debugger and ICSP programming clock.
RB7/PGD	40	44	17	17		TTL/ST(2)	
RB7					I/O		Digital I/O.
PGD					I/O		In-circuit debugger and ICSP programming data.

Legend: I = Input O = output I/O = Input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	15	16	32	34		ST	
RC0					I/O		Digital I/O.
T1OSO					O		Timer1 oscillator output.
T1CKI					I		Timer1 external clock input.
RC1/T1OSI/CCP2	16	18	35	35		ST	
RC1					I/O		Digital I/O.
T1OSI					I		Timer1 oscillator input.
CCP2					I/O		Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	17	19	36	36		ST	
RC2					I/O		Digital I/O.
CCP1					I/O		Capture1 input, Compare1 output, PWM1 output.
RC3/SCK/SCL	18	20	37	37		ST	
RC3					I/O		Digital I/O.
SCK					I/O		Synchronous serial clock input/output for SPI mode.
SCL					I/O		Synchronous serial clock input/output for I^2C mode.
RC4/SDI/SDA	23	25	42	42		ST	
RC4					I/O		Digital I/O.
SDI					I		SPI data in.
SDA					I/O		I^2C data I/O.
RC5/SDO	24	26	43	43		ST	
RC5					I/O		Digital I/O.
SDO					O		SPI data out.
RC6/TX/CK	25	27	44	44		ST	
RC6					I/O		Digital I/O.
TX					O		USART asynchronous transmit.
CK					I/O		USART1 synchronous clock.
RC7/RX/DT	26	29	1	1		ST	
RC7					I/O		Digital I/O.
RX					I		USART asynchronous receive.
DT					I/O		USART synchronous data.

Legend: I = Input O = output I/O = Input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

TABLE 1-3: PIC16F874A/877A PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin#	PLCC Pin#	TQFP Pin#	QFN Pin#	I/O/P Type	Buffer Type	Description
							PORTD is a bidirectional I/O port or Parallel Slave Port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	38		ST/TTL(3)	
RD0					I/O		Digital I/O.
PSP0					I/O		Parallel Slave Port data.
RD1/PSP1	20	22	39	39		ST/TTL(3)	
RD1					I/O		Digital I/O.
PSP1					I/O		Parallel Slave Port data.
RD2/PSP2	21	23	40	40		ST/TTL(3)	
RD2					I/O		Digital I/O.
PSP2					I/O		Parallel Slave Port data.
RD3/PSP3	22	24	41	41		ST/TTL(3)	
RD3					I/O		Digital I/O.
PSP3					I/O		Parallel Slave Port data.
RD4/PSP4	27	30	2	2		ST/TTL(3)	
RD4					I/O		Digital I/O.
PSP4					I/O		Parallel Slave Port data.
RD5/PSP5	28	31	3	3		ST/TTL(3)	
RD5					I/O		Digital I/O.
PSP5					I/O		Parallel Slave Port data.
RD6/PSP6	29	32	4	4		ST/TTL(3)	
RD6					I/O		Digital I/O.
PSP6					I/O		Parallel Slave Port data.
RD7/PSP7	30	33	5	5		ST/TTL(3)	
RD7					I/O		Digital I/O.
PSP7					I/O		Parallel Slave Port data.
							PORTE is a bidirectional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	25		ST/TTL(3)	
RE0					I/O		Digital I/O.
$\overline{RD}$					I		Read control for Parallel Slave Port.
AN5					I		Analog input 5.
RE1/$\overline{WR}$/AN6	9	10	26	26		ST/TTL(3)	
RE1					I/O		Digital I/O.
$\overline{WR}$					I		Write control for Parallel Slave Port.
AN6					I		Analog input 6.
RE2/$\overline{CS}$/AN7	10	11	27	27		ST/TTL(3)	
RE2					I/O		Digital I/O.
$\overline{CS}$					I		Chip select control for Parallel Slave Port.
AN7					I		Analog input 7.
VSS	12, 31	13, 34	6, 29	6, 30, 31	P	—	Ground reference for logic and I/O pins.
VDD	11, 32	12, 35	7, 28	7, 8, 28, 29	P	—	Positive supply for logic and I/O pins.
NC	—	1, 17, 28, 40	12,13, 33, 34	13	—	—	These pins are not internally connected. These pins should be left unconnected.

Legend: I = input O = output I/O = input/output P = power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.