DIGITAL KWH METER

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

Signature : ____________________________

Name : MOHD SHAWAL BIN JADIN

Date : 12 MEI 2009

DEDICATION

Special dedicated to my family, my friends, and to all faculty members

For all your care, support, and believe in me.

Sincerely;

Lily Suraiya binti Ramely

ACKNOWLEDGEMENT

I would like to forward my very appreciation to my supervisor, Mr Mohd Shawal bin Jadin for the guidance and support. I also would like to express my gratitude to my academic advisor, for his support and believe in me during my studies.

I am very thankful to Universiti Malaysia Pahang and FKEE for providing good facilities in campus and laboratory specifically. A very big thank you dedicated to all the staff of Faculty of Electrical and Elecronic. Also not forgeting my family and colleagues.

ABSTRACT

The purpose of this project is to develop a digital KWh meter and display the instantaneous values of current (I), voltage (V), and power (P), and total energy (KWh) consumed by load on liquid crystal display (LCD). The scopes include developing hardware to measure instantaneous current, voltage and power consumed by load and also interfacing the hardware with PIC microcontroller so that energy can be calculated. This research was about the alternative for electromechanical induction meter which is widely used to measure energy consumed by load. First, both current and voltage that is used by load will be measured. Then, both values will be fed to ADE7753. The total energy will be calculated and the output will be in form of pulse. Finally the output from the ADE7753 will send to the PIC microcontroller and will be displayed on LCD. Furthermore, users can choose the desired readings to be displayed using the selection buttons.

ABSTRAK

Tujuan utama projek ini adalah untuk membina kilowatt jam meter digital dan memaparkan nilai bacan arus (I), voltan (V), kuasa (P) dan jumlah keseluruhan tenaga (KWh) yang digunakan oleh beban (perkakas elektrik) di rumah. Skop-skop dalam kajian ini termasuklah membina litar yang mampu menentukan nilai arus dan voltan dan kuasa yang digunakan oleh beban. Selain itu, dengan menggunakan *PIC microcontroller*, jumlah tenaga yang digunakan akan dikira dan kesemua nilai bacaan ini akan dipaparkan di *LCD*. Kajian ini dijalankan adalah untuk mencari alternatif lain kepada konvensional Kilowatt jam meter bagi menentukan jumlah tenaga yang digunakan oleh pengguna. Kedua-dua nilai arus dan voltan yang digunakan akan ditentukan sebelum nilai-nilai tersebut menjadi masukkan kepada ADE7753. keluaran daripada ADE7753 ialah jumlah kuasa yang digunakan. Tenaga dikira berdasarkan nilai arus dan voltan yang diukur oleh litar. Akhir sekali nilai bacaan ini akan dipaparkan pada *LCD* dengan menggunakan *PIC microcontroller*. bukan itu sahaja, pengguna juga boleh memilih nilai bacaan yang dikehendaki dengan menekan butang pilihan.

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LIST OF SYMBOLS/ABBREVIATIONS

AC	-	Alternating Current
DC	-	Direct Current
E	-	Energy
EEC	-	Electric Energy Computation
I	-	Current
KWh	-	Kilowatt-hour
LCD	-	Liquid Crystal Display
P	-	Active power
PIC	-	Programmable Integrated Circuit
Q	-	Reactive power
R	-	Resistance
S	-	Apparent power
TIDA	-	Timing-Interruption Data Acquisition

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CHAPTER 1

INTRODUCTION

1.1 Introduction

1.1.1 Electrical Power and Energy

Electrical power is defined as the rate at which electrical energy is transferred by electrical circuit. In direct current, instantaneous electrical power is calculated using Joule's Law. Joule's Law is

$$\mathbf{P = V \cdot I}$$

Where,

P is the electric power,

V the potential difference,

I is the electric current.

If Joule's law is combined with Ohm's law ($V = RI$) two more equations, two more equations are produced:

$$\mathbf{P = I^2R}$$

and

$$\mathbf{P = V^2/R}$$

Where,

R is the electric resistance.

In alternating current circuits may result in there are periodic reversals of the direction of energy flow due to energy storage elements such as inductance and capacitance. Figure 1.1 below shows the components of AC power.

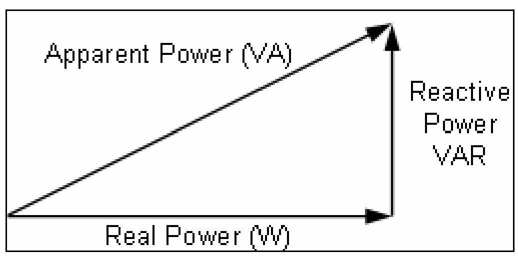

Figure 1.1: Power triangle-The components of AC power

The relationship among real, reactive and apparent power is:

$$\mathbf{S^2 = P^2 + Q^2}$$

Real and reactive powers can also be calculated directly from the apparent power, when the current and voltage are both sinusoids with a known phase angle between them:

$$\mathbf{P = S * \cos\theta}$$

$$\mathbf{Q = S * \textit{sin}\theta}$$

Energy in kilowatt-hour is the product of power in the unit of kilowatts multiplied by the times (hour). So, as a result, the SI unit is Kilowatt-hour. As example, there are a water heater with 100W power rating that has been used for 10 hour, the total energy the heater consumed is:

$$\mathbf{E = P.h}$$

$$E = 100WX10$$

$$E = 1kWh$$

KWh is measured using a meter that is located at every household so that users can easily pay for the energy they used every month. There are a few type of meter are used for this purpose, but the most common one which is still in used is electromechanical induction meter.

1.1.2 Electromechanical Induction Meter

KWh meter is the most common meter that can be found at every household. The function of this meter is to determine the amount of energy consumed by the users of the household, so that the cost of the energy can be calculated. The most popular type of meter that is still used by many is electromechanical induction meter, which is illustrated by figure 1.2 below.

Electromechanical induction meter operates by counting the revolution of the aluminum disc that rotates at the speed proportional to the power consumed by load. The aluminum disc acted upon to coils that are voltage coil and current coil. Voltage coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and current coil produces a magnetic flux proportion to the current. Next, eddy current produced in the aluminum disc and a force is exerted on the disc proportional to the product of instantaneous current and voltage.

The aluminum disc is supported by a spindle which has a worm gear that drives the register. The dials may be of the cyclometer type, an odometer-like display that is easy to read where for each dial a single digit is shown through a window in the face of the meter, or of the pointer type where a pointer indicates each digit. It should be noted that with the dial pointer type, adjacent pointers generally rotate in opposite directions due to the gearing mechanism.

The amount of energy presented by one revolution of the disc denoted by the symbol KWh which is given in units of watt-hours per revolution. The value 7.2 is commonly seen. Using the value of KWh, one can determine their power consumption at any given time by timing the disc with a stopwatch. If the time in seconds taken by the disc to complete one revolution is t, then the power in watts is P = 3600xKWh/t.

For example, if KWh = 7.2, and one revolution took place in 14.4 seconds,

KWh = 7.2

t = 14.4s

P = 3600X7.2/14.4

P = 1800W

This method can be used to determine the power consumption of household devices by switching them one by one. Most domestic electricity meters must be read manually. [1]

Figure 1.2: Electromechanical Induction Meter

1.2 Problems statement

Due to all the rotations, electromechanical induction meter consumes a small amount of power, typically around 2 watts.[4] So, the customers have to pay not only the energy used to operate all the house appliances, but they also have to pay for energy used in calculating the energy used. Moreover, the accuracy of the electromechanical induction meter also can be questioned. This is because the accuracy of this particular type of meter is depends on the quality of the material used in designing the meter.

Thus, because of these two main problems that arise when the electromechanical induction meter is used, digital KWh meter is introduced. Digital KWh meter consumes relatively smaller power than electromechanical induction meter. Not only that, the accuracy of digital KWh meter also reliable because the calculation will be done by microcontroller.

1.3 Objective

The objective of this project is to develop a digital KWh meter and display the instantaneous values of current, voltage, power and total energy consumed by load on liquid crystal display (LCD).

1.4 Scopes

There are two scopes of this project:

i. To develop hardware to measure instantaneous current and voltage consumed by load.
ii. To interface the hardware with PIC microcontroller so that the total power and energy can be calculated.

CHAPTER 2

LITERATURE REVIEW

2.1 Increasing the capability of the KWh meter

For monitoring electrical energy, the instrument for measuring electrical the energy are moving coil meters which could be seen in every home in the type of KWh meter. When considering on accuracy of these meters which will depend on the quality of material such as the saturated properties of magnetic field on moving plate and coil axis. In order to increase the capability of the meter, the meter inform of solid state will be developed for accuracy in measurement without material fatigue in mechanism. [4]

2.2 Solid State Meter

2.2.1 Introduction

There is a new type of meter instead of the common electromechanical induction meter. It calls the solid state meter where the energy is displayed on LCD. This is means that the energy can be read automatically without the need of manual calculation from users. In addition to that, the meter can also records other parameters such as reactive power used and power factor of the load. The values can easily been view just by pressing the selection button.[4]

2.2.2 Technology

Solid state meters use current transformer to measure current. So, current carrying conductor does not need to pass through the meter itself. Thus, the meter can be located remotely from the main current carrying conductor.[4]

2.2.3 Communication Technology

Currently, high end electronic meters are design with quite a wide range of communication technologies. Some of the technologies are Low Power Radio, Bluetooth, apart from the now conventional RS-232 and RS-485 wired link. Often, meters are design to be able to read serial interface bus so that the entire usage profiles with time stamps are available at a click of a button.[4]

2.2.4 Advantages

There are a few advantages of this solid state meter. First of all, this type of meter is user friendly. That is because users can read the value of consumed energy automatically, while when using the electromehanical induction meter users need to calculate the total energy using the formula P = 3600xKWh/t. Furthermore, the energy calculation is more accurate since it is done by microcontroller and not done manually by human. In addition to that, solid state meter not just provides the values of total energy but it also can be design to provide other parameters of the supply and load which can be access only using a selection button. Lastly, the solid state meters are built up without material fatigue in mechanism like the electromechanical induction meter that depends on the rotation of aluminum disc.[4]

2.3 Current and Voltage Measuring

The main part that a KWh meter needs to do is measuring current and voltage consumed by load. For current measurement, transducers are needed. The transducer chosen usually is current transformer and for sampling it the current transformer is then connected to amplifier and filter circuit so the voltage that represents current used is not more than 5V. Next, for measuring voltage, a simple stepped down centre-tapped transformer is needed. Like current, the value of voltage can be sample by connecting the transformer to an amplifier and filter circuit. [6]

2.4 Energy Measuring Circuit

There are an alternative for measuring the total energy. Analog device ADE7753 can be used. The ADE7753 provides a serial interface to read data, and a pulse output frequency, which is proportional to the active power. Both voltage and current inputs require a 0 to 0.5V analog input. The analog inputs are sampled by ADCs within the ADE7753, and their magnitudes and phases are used to digitally calculate real, reactive, and complex power in the line. [9]

2.5 Electrical energy computation

Equation (1) is the basis for the computation of the energy consumption (E) of any given load during a time interval Δt (= t2 - tl):

$$E = \int_{t1}^{t2} v(t)i(t)dt \quad (1)$$

Where v(t) is the supply voltage and i(t) is the load current. In actuality, a discrete version of Equation (1) is used, where the voltage and current signals, after proper conditioning, are sampled and converted to digital form by an 8 bits A/D converter, operating at a sampling frequency of 1,082 kHz. The voltage and current sampled values are transferred serially to the microcontroller. The microcontroller processes and stores the energy consumption. The energy is compared to a reference value (Eref) set during the calibration process, where, for a 1kW load, the consumed energy is calculated and accumulated (integrated) for 100 periods of 924ps (a program cycle). [8]

2.6 Software structure description

The new meter comprises monitor/control programme, TIDA programme and EEC programme, Main programe is the main body of the software used for performing the functions of KWh meter, and comprise several subroutines.

TIDA and EEC programme deal with interruption due to a timer, i.e., sampling period. Operation will enter TIDA and EEC once after main programme has been put into service and initialized, at the end of an interruption, Operation will in turn return to main programme, as shown in Figure 2.1.[7]

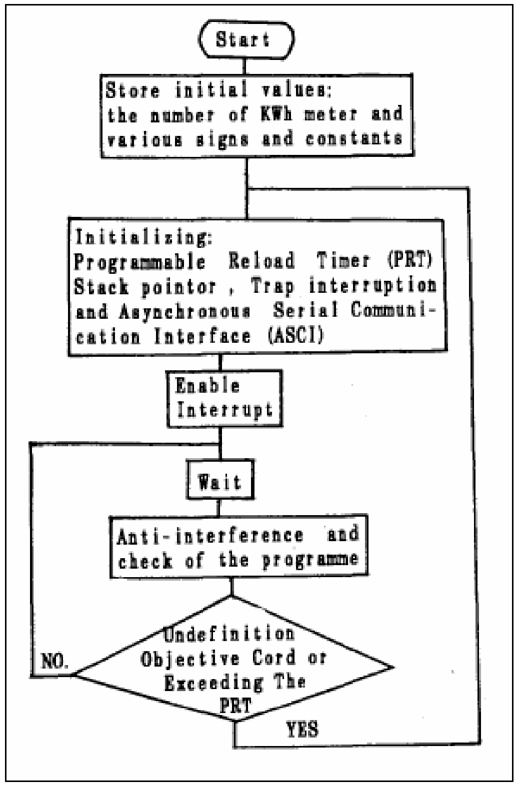

Figure 2.1: Flow chart of the system

CHAPTER 3

METHODOLOGY

3.1 Hardware development

Referring to figure 3.1, the development of the hardware for this project is divided into three main parts. The first part is current and voltage sensing circuit. This circuit is used to sample the voltage and current that is consumed by load. The output voltage of this circuit is supposed to be 0.3V as the allowable voltage to be received by ADE7753 is about 0V to 0.5V. Next is energy measurement circuit to produces pulse that is proportional to the active power of the load. The most important part of the circuit is ADE7753. ADE7753 will generate the pulse represent the active power and others parameters also can be access from its serial bus. Finally, the last part is microcontroller circuit. There are two modules involved in the microcontroller circuit that are the display module and selection module. These two modules are developed for the users convenient. Selection module enable the users to select and view he desired values of current, voltage, active power and total energy of a particular load. The displays of the parameters are made possible by the display module.

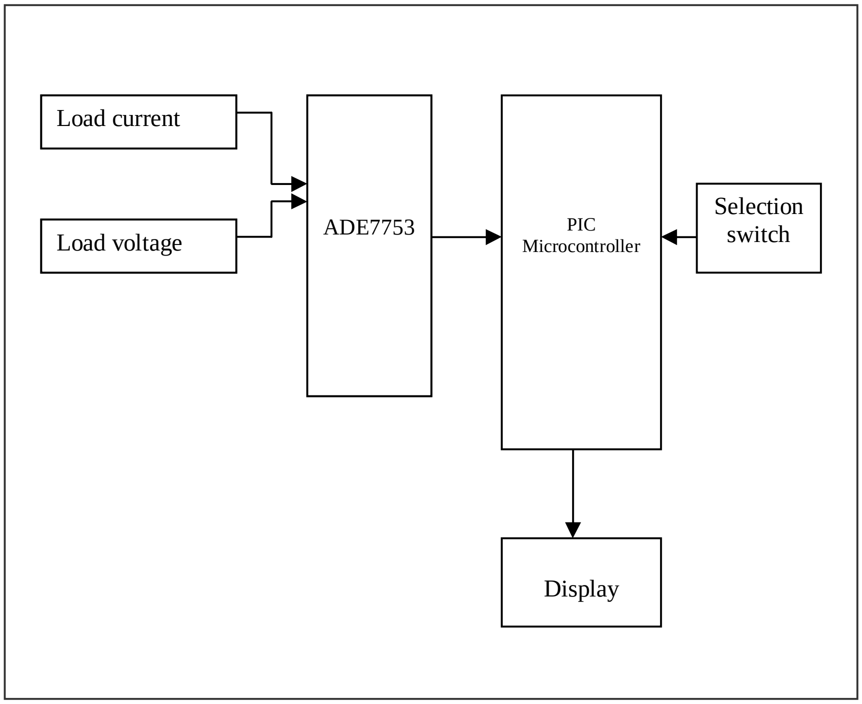

Figure 3.1: Basic Block Diagram of System

3.1.1 Power Supply

The purpose of this circuit is to power some 5V logic from a 240VAC source. A stepped down (240V/9V) is connected from the 240V. This is how 240VAC is reduced to 9VAC. Next, the reduced voltage is sent to a bridge rectifier. Bridge rectifier is used to rectify AC to DC. The output voltage of this bridge rectifier is 9VDC. Then, to regulate the 9VDC to 5VDC, the bridge rectifier is connected to the LM7805 voltage regulator. LM7805 will reduce the 9VDC to 5VDC.Finally; the output from the regulator can be used to power up the PIC16F877A and ADE7753. Figure 3.2 shows the circuit of the power supply circuit.

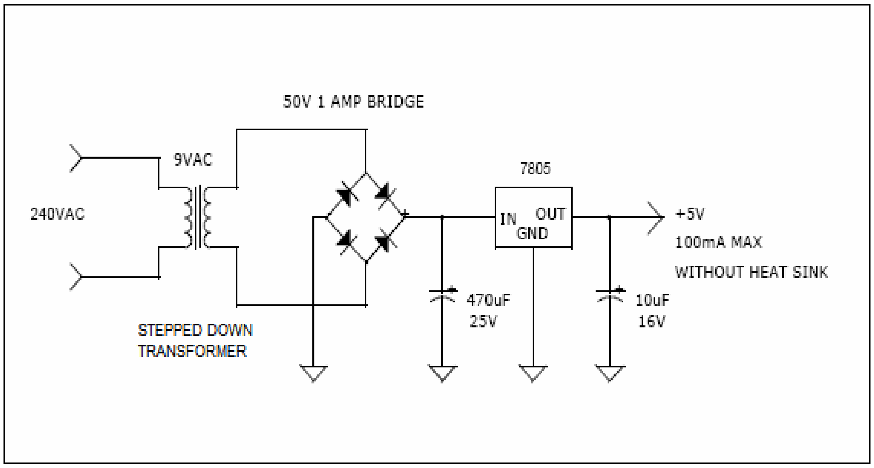

Figure 3.2: Power Supply Circuit

3.1.2 Current and Voltage sensing circuit

Figure 3.3 illustrates the circuit connection of current and voltage circuit. The current sensing circuit is consisting of only one component, which is 20mΩ and 5W single shunt resistor. The resistor is located at the neutral wire. The load side is connected to pin V1P of ADE7753, and the source side is connected to pin V1N of ADE7753. Maximum current that will be drawn through the line is 15A. So, voltage across the shunt resistor,

$$\mathbf{V = IR}$$
$$= 15 \times 20\text{m}$$
$$V = 0.3\text{V}$$

When the maximum current of 15A is being drawn, the Maximum power dissipation in the resistor,

$$\mathbf{P = I^2R}$$
$$= 15^2 \times 20\text{m}$$
$$= 4.5\text{W}$$

Since the 5W resistor is chosen, the power is still within the resistor rated value.

The voltage sensing circuit consists of high-impedance bridge between live and neutral wires. The bridge is actually resistors with values of 470kΩ and 680Ω that is connected in series between the live and neutral wires. Pin V1N and V2N will of ADE7753 are connected across 680Ω resistor. So, voltage across the 680Ω resistor,

$$\mathbf{V_2 = [R_2 / (R_1+R_2)]\ (V_i)}$$

$$= [680 / (680+470k)]$$

$$V_2 = 0.3V$$

At 240VAC line voltage, the current leakage through the voltage sensing bridge is approximately 0.5mA, and therefore power dissipation in the voltage sense resistors is not a concern.

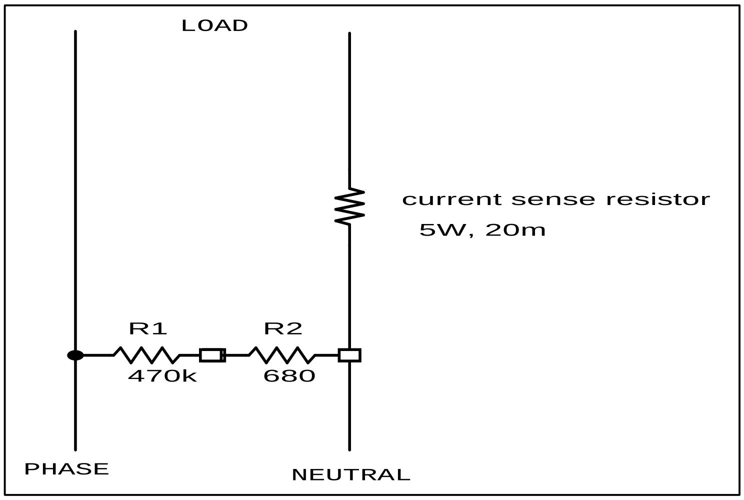

Figure 3.3: Current and Voltage sensing Circuit

3.1.3 Energy measurement circuit

The Energy Measurement circuit is responsible for direct current, voltage, measurements, and from them, determining real power consumption. The Energy Measurement circuit must be capable of relaying these measured and calculated values to the microcontroller via a serial bus. The heart of the Energy Measurement subsystem is Analog Devices Energy Meter ADE7753. The ADE7753 offers analog voltage and current inputs, and an SPI serial interface. Both voltage and current inputs require a 0 to 0.5V analog input.

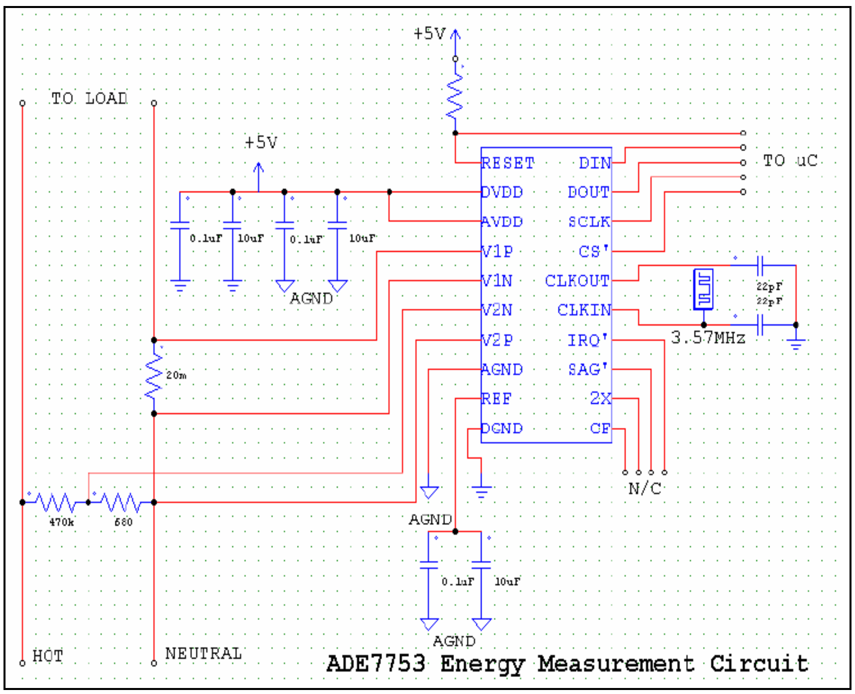

Figure 3.4: Energy Measurement Circuit

Referring the figure 3.4 above, the pin connections are as follow. ADE7753 RESET pin is connected to a 10KΩ resistor that is connected to +5V supply. A logic low on this pin holds the ADCs and digital circuitry (including the serial interface) in the reset condition. DVDD is for digital power supply while AVDD is for analog power supply. Both of these pins need to be decoupled with

DGND/AGND with a 10µF capacitor in parallel with a 0.1µF these two pins will provide the supply voltage for both digital and analog circuitry. V1P and V1N are the analog inputs for channel 1. Analog input for channel 1 is current. Using shunt resistor, the voltage which is proportional to load current is measured and is fed to channel 1 ADE7753. Then of cause V2P and V2N are the analog inputs for channel 2 of the ADE7753. Voltage is the analog inputs for channel 2. The load voltage is measured using voltage divider and then is fed to the channel 2 of the ADE7753. Next pins are analog ground reference (AGND) and digital ground reference (DGND). These two pins provide the ground reference for both digital and analog circuitry. Furthermore, to provide a clock source for ADE7753, a resonant crystal is connected to CLKOUT and CLKIN pins of the ADE7753.the clock frequency for a specified operation is 3.579545MHz.not only that, to allow ADE7753 to communicate with microcontroller, there are four pins of ADE7753 that need to be connected to microcontroller. The first one is chip select pin (CS). This active low logic input allows ADE7753 to share serial bus with microcontroller. The second pin is SCLK pin. SCLK pin is the serial clock input for the synchronous serial interface. All serial data transfer is synchronous to this clock. This pin is connected to the SCK pin of the microcontroller. The next one is data output for serial interface (DOUT) pin. Data is shifted out at this pin on the rising edge of SCLK. DOUT is connected to SDI pin of the microcontroller. The last one is the data input for serial interface pin (DIN). Data is shifted in at this pin on the falling edge of SCLK. This pin is connected to the SDO pin of the microcontroller. The analog inputs are sampled by ADCs within the ADE7753.

3.1.4 Microcontroller

The purpose of using microcontroller is to log, manipulate, and display data reported by the Energy measurement circuit. The Microcontroller must connect to the ADE7753 Energy Meter via an SPI serial interface, must share a clock with the ADE7753, must accept inputs from buttons, and must generate outputs to drive an LCD display. The chosen controller is the Microchip PIC16F877A. as shown as figure 3.5, there are three different circuit that involving PIC16F877A. The circuits are basic circuit, display module circuit and selection module circuit. The basic circuit to ensure the PIC16F877A operates is including connecting its pin 1, pin 11 and pin 32 to +5V. Not only that, pin 12 and pin 31 must be connected to ground. Plus, to provide clock source, pin 13 and pin 14 is connected to a 4MHz crystal.

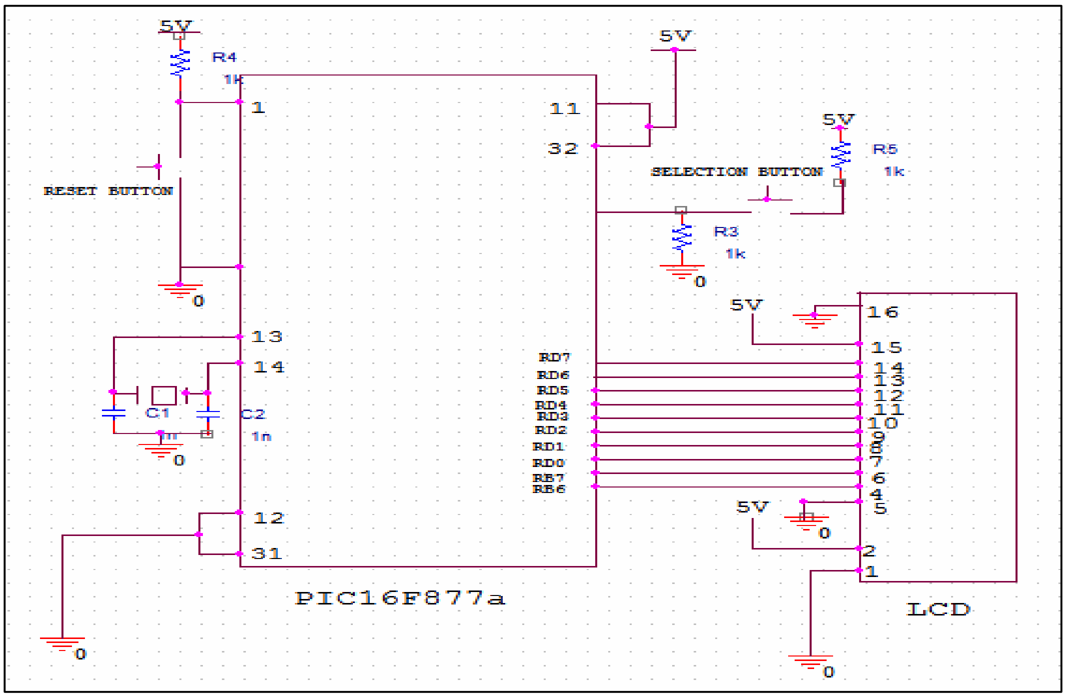

Figure 3.5: Microcontroller Circuit

3.1.4.1 Display Module

The LCD used in this project is LCD-JHD162A. LCD-JHD162A is a 2x16 character LCD. The function of each pin is stated in the table 1 below. VSS is connected to the ground to provide the ground reference to the LCD. VCC is connected to +5V to provide supply voltage for the LCD. Pins RD0 to RD7of microcontroller are used as digital outputs to drive the LCD display. Pins RD0 - RD7 is connected to pin 7 - pin 14 of the LCD simultaneously. While pin RB7 of the microcontroller is connected to RS pin of LCD and pin RB6 of microcontroller is connected to E pin. Pin 15 of the LCD is connected to +5V and pin 16 is connected to ground. Both of these pin will light the LCD's backlight. LCD-JHD162A accepts both 4- and 8-bit data packets, and so the LCD interface is therefore implemented with 8 bits. For further understanding, figure 3.6 give you an idea about the connections of the LCD's pins.

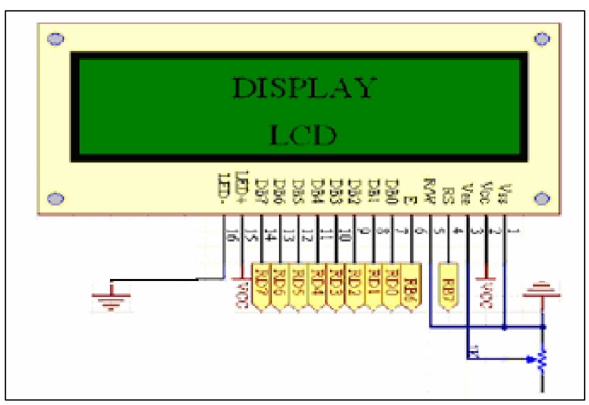

Figure 3.6: LCD Connection

Table 3.1: LCD's pins Function

PIN	NAME	FUNCTION
1	VSS	Ground
2	VCC	Positive supply for LCD
3	VEE	Brightness adjust
4	RS	Select register, select instruction or data register
5	R/W	Select read or write
6	E	Start data read or write
7	DB0	Data bus pin
8	DB1	Data bus pin
9	DB2	Data bus pin
10	DB3	Data bus pin
11	DB4	Data bus pin
12	DB5	Data bus pin
13	DB6	Data bus pin
14	DB7	Data bus pin
15	LED+	Backlight positive input
16	LED-	Backlight negative input

3.1.4.2 Selection Module

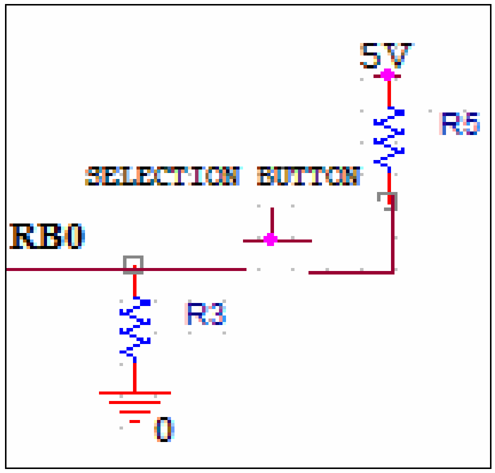

Figure 3.7: Selection Button Connection

The ON/OFF button is used in this project to facilitate the users to select what values to be display on the LCD. The button is providing digital input to the microcontroller through pin BR0 once it being press.

3.2 Software Development

PBASIC compiler is used to compile and program the PIC16F677A. the flow chart in figure 3.8 shows how the system is programme.When the voltage is supply to the system, system will initializes. This includes the LCD and Timer01 of the PIC16F877A is elapsed. If there a load that is connected to this meter, the analog signal will be sampled and it will be send to channel 1 and channel 2 ADE7753. Based on that particular signal, ADE7753 will produces pulse that is proportional to the active power of the load. Next PIC16F877A will read the serial bus for value of power to use it to calculate total energy. Then the value will be displayed on LCD. If the selection button is pressed, PIC16F877A will read the serial bus from ADE7753 to display the value o voltage, current and power of the load. But, if that condition is not true which means the button is not pressed, the LCD will continuously displays the value of energy that has been calculated this process will continue until no voltage is supplied to the meter.

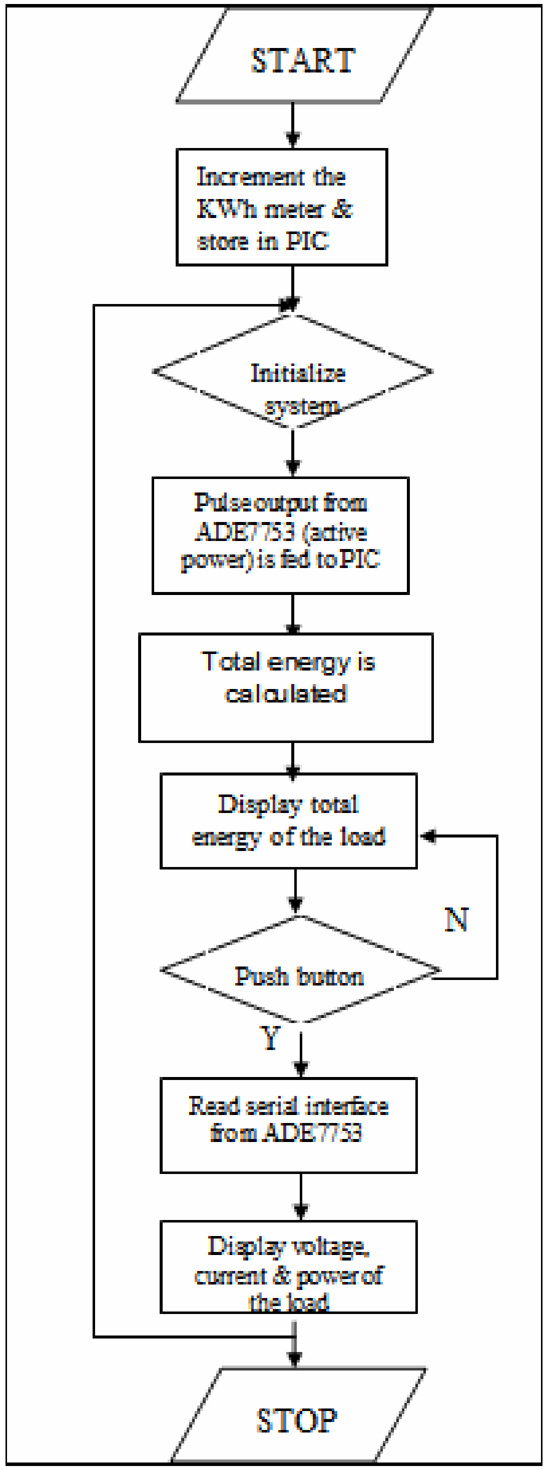

Figure 3.8: Flow Chart of the programme

CHAPTER 4

RESULT AND DISCUSSION

4.1 Results

4.1.1 Power Supply

For gaining +5V to provide supply voltage to ADE7753 and PIC16F877A, AC adaptor is used. The ready to use adaptor consists the basic circuit of power supply that involving stepped down transformer, bridge rectifier, capacitors and lastly, voltage regulator. AC adaptor is used because its reliability. Plus, there was a time constraint that disables the development of power supply. So, to save time, it is better to use an AC adaptor. The 5V supply voltage from the adaptor is directly fed to the PIC16F877A and ADE7753. Figure 11 below shows the AC adaptor which is used for +5V power supply.

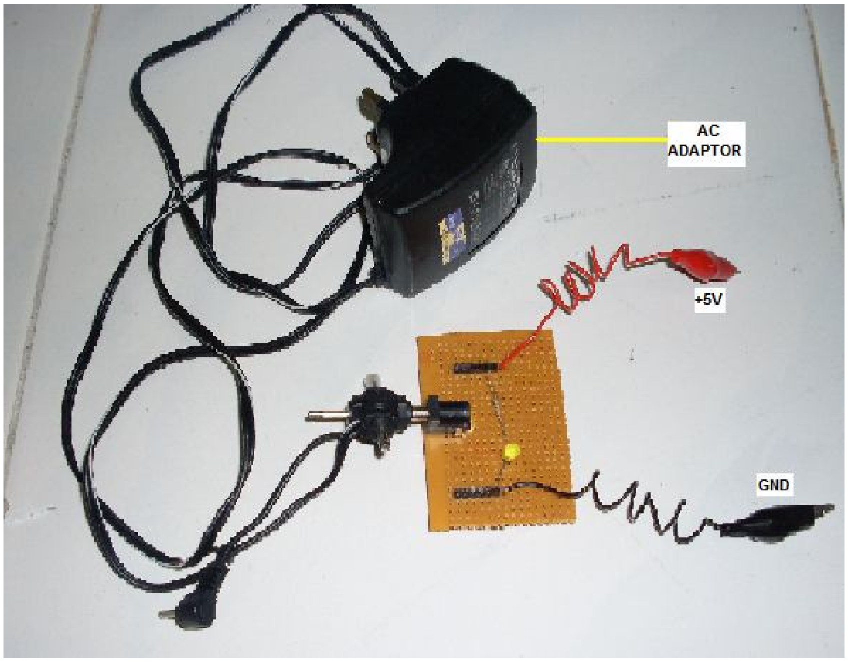

Figure 4.1: +5V Power Supply

4.1.2 Current and Voltage Sensing Circuit

Figure 12 shows the connection that made up current and voltage sensing circuit. The shunt resistor which is connected in series with natural wire is used to detect current. But practically, the resistor sense the voltage that is representing the current used and sent it to channel 1 ADE7753. Three ½W resistors are connected to construct a bridge between hot and natural wires. Both current and voltage sensor must send input voltage in a range between 0V to 5V. From the measurement, the values of voltage produced are as follows:

Table 4.1: Measured voltage of current and voltage sensor

Circuit	Measured Voltage
Current Sensor	0.2V
Voltage Sensor	0.2V

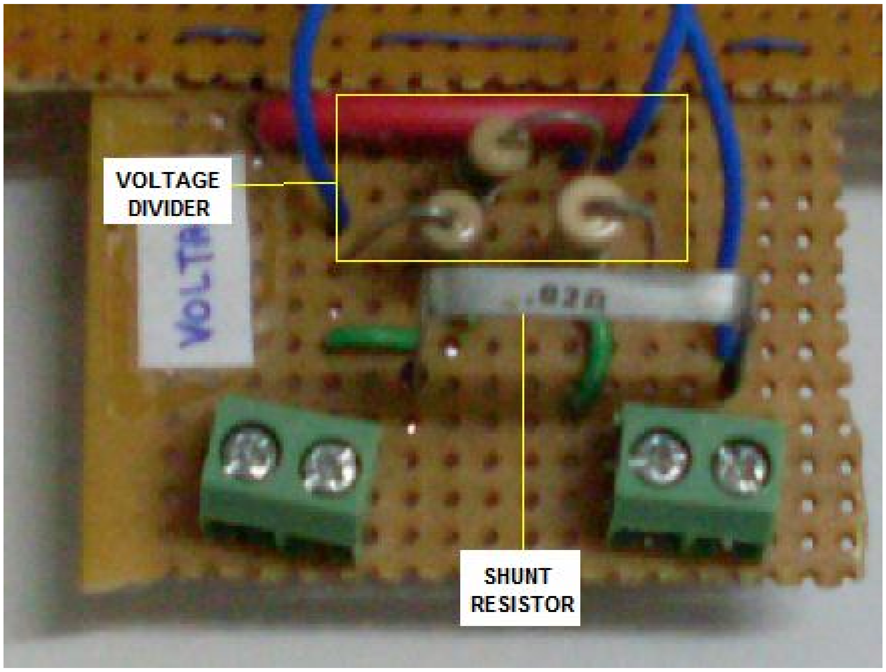

Figure 4.2: Current and voltage sensor

4.1.3 Energy Measurement Circuit

To build up a energy measurement circuit, the most important part is ADE7753. So, as can be seen in figure 13, ADE is connected to its basic circuit and also current and voltage sensing circuit to be able to generate pulse that is proportional to load's active power. The values that are displayed on LCD when 9W desk lamp is connected to the circuit are as follows:

Table 4.2: Values displayed on LCD

	Value displayed
1	252252
2	306694
3	107869

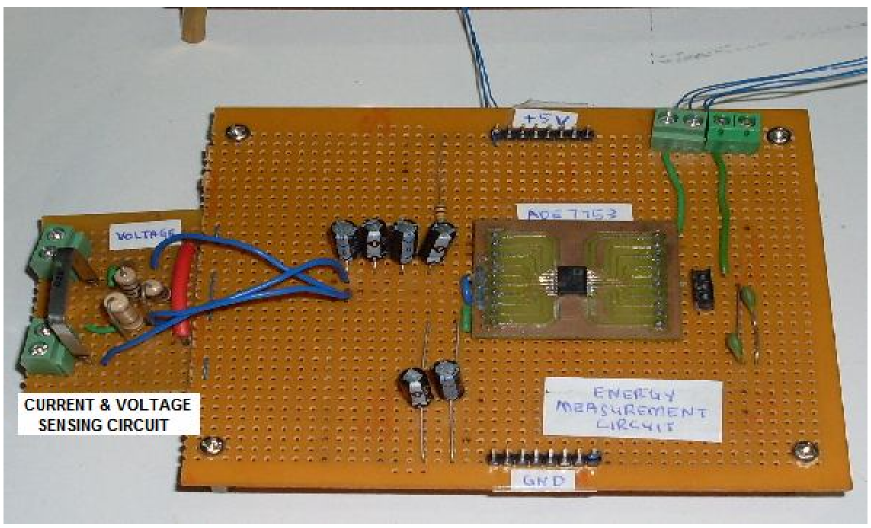

Figure 4.3: Energy Measurement

4.1.4 Microcontroller

For microcontroller circuit, PIC16F877A is connected to its basic circuit and two other modules. With 5VDC power supply PIC16F877A will run and calculated the total energy of the load. Not only that the PIC16F877A will also display the values of the parameters on LCD

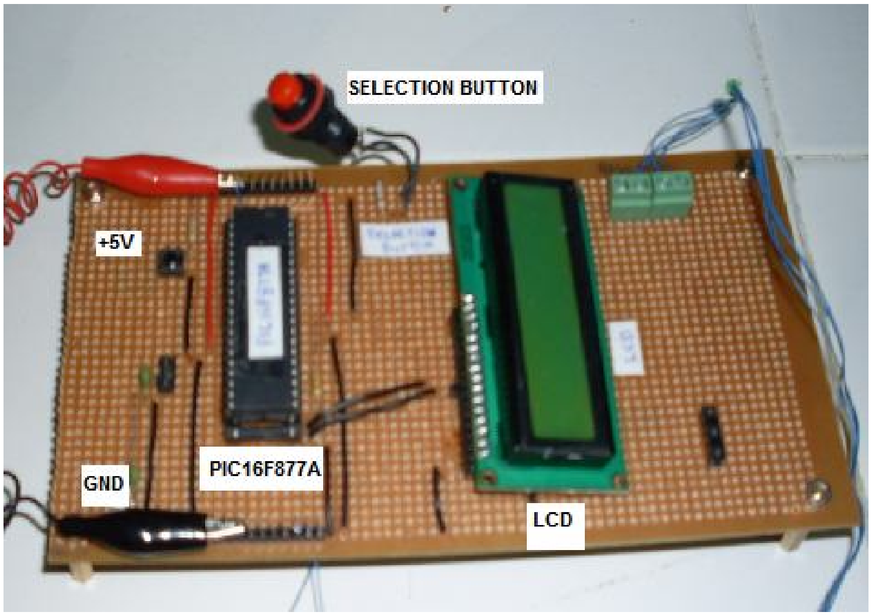

Figure 4.4: Microcontroller

4.1.5 Full system

Although the hardware is well developed, the values of all parameters that are total energy, power, current and voltage cannot be displayed on the LCD. When load is connected to the meter, only decimal values of the parameter are displayed. So, the meter failed to determine the total value of the energy consumed by load and also failed to show the values of other parameters.

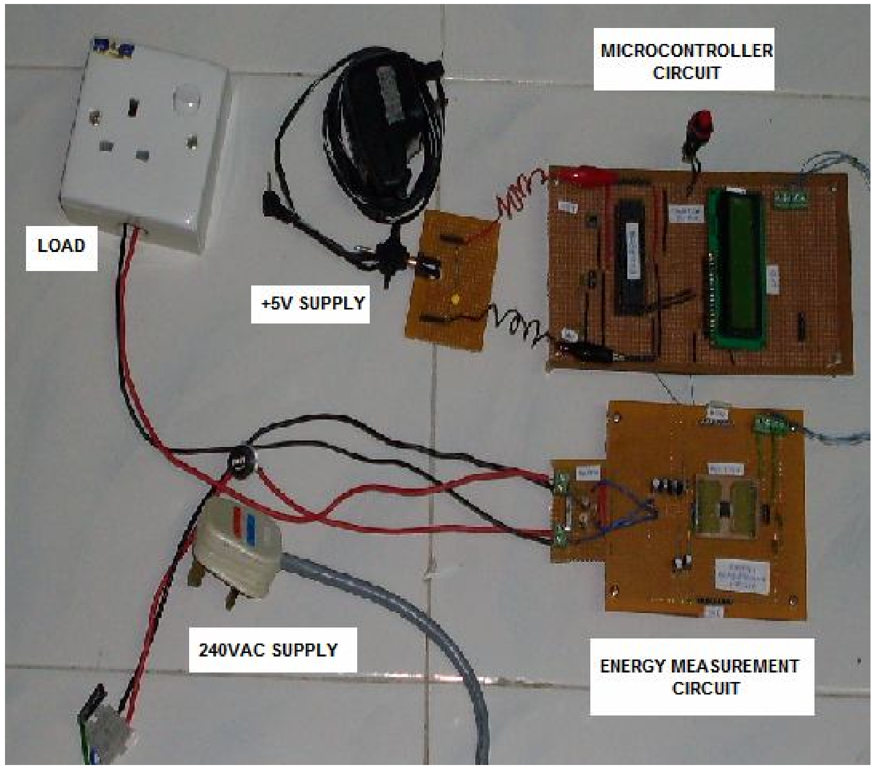

Figure 4.5: KWh Meter

4.2 Discussion

4.2.1 Comparison between Theoretical and measured values of Current and voltage sensor

Table 4.3: Comparison of voltage values

Circuit	Theory	Measured
Current sensor	0.3V	0.2V
Voltage sensor	0.3V	0.2V

There is a difference between the Theoretical and measured values because the resistors used are not the exact value they suppose to be. Power loses also occur when the power flows through the resistors and cables.

4.2.2 Failure to calculate the coefficient value

Although the PIC16F877A is communicating with the ADE7753 by SPI, the LCD after reading from a particular serial bus, ADE7753 will send a decimal value of the desired parameter depends on the system. For a system with 5V reference voltage, the decimal value that will be displayed is more than 300000. So, due to the failure to calculate the coefficient value, there is no real values of any parameters can be calculated or displayed.

4.3 Problems encountered and solutions

The most critical problem that happened in this project is how to measure and sample the current and voltage that is consumed by load. But, through many references and helps the transducers for both current and voltage measurement is decided. For current measuring, an open air current sense shunt resistor with a value of 20mΩ is chosen. The resistor is connected in series with the natural wire. Then, for measuring voltage, a simple voltage divider is chosen. 470k and 680 resistors are connected between the life and natural wire. For gaining the desired value of 0.3V, the 680 resistor is tapped.

Not only that, there is also a problem in measuring the power that is consumed by load. So, in order to solve this problem, an analog device ADE7753 is chosen. The ADE7753 provides a serial interface to read data, and a pulse output frequency, which is proportional to the active power. Furthermore, the chip is a mounted surface type ic that makes it impossible to be soldered on the board. In the end a PCB board for ADE7753 is designed so that it can be soldered.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Costing and commercialization

5.1.1 Costing

All the cost for the components needed in this project is displayed in table 5 below. Other than all the components listed such as LCD, ADE7753, there are also other components that is included in 'other components' list. For example; capacitors, resonant crystal, header and many more. There is no price for PIC16F877A because the PIC is provided by Laboratory

Table 5.1: Project costing

NO	ITEM	PRICE (RM)
1	ADE7753	32.70
2	PIC16FF877A	-
3	Open air current sense shunt resistor	6.90
4	AC adapter	19.50
5	LCD display 2x16	51.00
6	Other components	76.30
	TOTAL	RM 186.40

5.1.2 Commercialization

This project can be commercialize and use as an alternative for electromechanical. Since the components needed for this project is easy to find, the meter can be produce in large number. The digital KWh meter can be very helpful for users in order to calculate and view the total energy consumed every month.

5.2 Conclusion

As for the conclusion, only the hardware for measuring the total energy is developed. However, the values of the calculated values cannot be displayed because of there are problem occurred in interfacing between the ADE7753 and PIC16F877A. as stated in the discussion section, this is due to the failure of interfacing he PIC16F877A and ADE7753.Not only that the coefficient that is needed to be calculated to gain the real parameters values is not calculated.

5.2 Recommendation

For the future recommendation, this project needs to be continued and upgraded. The digital KWh meter should be developed to be used by industry where three phase loads and supplies are utilized. This is because ADE7753 not only useful for calculating active power as well as reactive power, but ADE7753 has serial bus for many other parameters such as apparent power and many more.

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