ALARM SYSTEM USING BODY DETECTOR

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ABSTRACT

Nowadays, portable automatic intruder system has become very popular among security systems. Body detector is a valuable technology tool that can be used to perform Alarm System Using Body Detector. Alarm system by using a body detector is an application for the smart alarm system because it relies only with the existence of electrical field that surrounds the human body. This alarm system adopts advanced RF oscillators matched with reliable software technology and advanced hardware circuitry. It integrates capacitance detection, network search, and automatic voice alarm. This system mainly uses capacitance detector, body intruding detection to transmit alarming signal to main unit. When signal is received, it processes it immediately, and then main unit will automatically give an alarm by the designed code. The idea behind this project is to solve the problem of traditional security method by using a non-portable alarm system due to excessive data transfer and complex hardware circuitry. Body detector security system makes all services that relate to information simpler, safer, cheaper and portable. In this project, a Microcontroller PIC16F877 will be used as an actuator of the system that will control the output system through a programming system. The system will be developed to control the system flow such as register data, delete data, and creating program flow to produce the output depends on the activation of body detector hardware circuitry. The PIC16F877 microcontroller will analyze and process the data and if the data has been registered in the system, the security application will work such as triggering the buzzer and LED.
CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Alarm system implies an emergency procedure that should be carried out while body detector is a device that can detect the existence of human body for a certain wide range of area. Alarm system by using a body detector is an application for the smart alarm system because it relies only with the existence of electrical field that surrounds the human body. Safety alarms are used widely nowadays in order to gain safety and precautions for communities and individuals. In new construction, wireless systems may be more economical but it is still on high cost and need experts to develop due to its complexity. This alarm system adopts advanced RF oscillators matched with reliable software technology and advanced hardware circuitry. It integrates capacitance detection, network search, and automatic voice alarm. The reliable components combination from resistance, capacitance, and digital coding technology are also used. This system mainly uses capacitance detector, body intruding detection to transmit alarming signal to main unit. When signal is received, it processes it immediately, and then main unit will automatically give an alarm by the designed code.

Every living human body is surrounded by an electric field, which may potentially be detected at a few meters’ distance. Even if this can only be detected at a distance of a few centimeters (as opposed to millimeters), the applications are legion. The phenomenon of capacitance is entirely dependent on the existence of electric fields. If, therefore, a human body should approach the positive plate of a
capacitor, the body’s electric field will cause the value of the capacitor to rise. In the Body Detector circuit, this is detected by means of an RC (resistance-capacitance) oscillator. As the value of $C$ rises, so the frequency of the oscillator drops. All that remains is to detect this drop in frequency to obtain some interesting results. While in theory its operation is dependent on the electric field which surrounds the human body, in effect it would seem that an invisible field surrounds the sensor – somewhat like the “invisible” defense shields. It would appear, therefore, that as a human hand (for instance) enters this invisible field, an alarm is triggered.

In this final project, the main objective is to create a system that would detect human body existence using body detector. Body detector using alarm system is a very valuable technology tool since there is no use of any giant padlock, heavy chain or security guard service anymore in the system. The other objective is to develop portable alarm system application by enhancing the designation of hardware and software. Alarm system using Body Detector offers strategic advantages for security dependence because the input stored in the capacitance detection circuit through the microcontroller can be protected against undesired accessed trigger and any manipulation.

This is really important to make sure the area is safe and to avoid strangers from gain access in the area. In this project Alarm System Using Body Detector provide an effective security system by having a sensor that is completely vandal-proof and tamper-proof. One could not come near it with a pair of clippers or a similar instrument because it is immune to alternating current (ac) fields and it will also detect body presence on the other side of variety of materials including the insulators.

Generally, the system will consist of a body detector as an input sensor, a PIC16F877 microcontroller that performs as a serial interface to accomplish effective surveillance application and a circuitry of the alarm system applications. The body detector contains an astable oscillator (IC1a) and a non-retrigerable monostable (IC1b). The PIC16F877 circuitry consists of power supply, frequency gain, and programmer function as drivers for communication interface. While the alarm system
made from only passive elements such as capacitors, inductors, resistors, LEDs and buzzer that will performed when access is denied.

Body Detector works based on a system that relies on capacitance value surrounding human body and PIC16F877 microcontroller acts as an activator of the body detector input and PicBasic programming creates the flows of the whole operation of alarm application. In security field, Alarm System Using Body Detector will be more secured than the other personal alarm system. It offers varieties of convenience such as it can be a portable alarm system, can demand varies of distance of body detector could function and does not require any maintenance.

This final project is divided into 3 main sections:-

(1) Electronic design consists of Body Detector circuitry, PIC16F877 microcontroller design and alarm security system application.
(2) Develop Software to verify the input and activate the flows of alarm applications.
(3) Mechanical design consists of body detector casing model.

1.2 OBJECTIVES

1.2.1 To create a system that would detect human body existence using body detector.

Current security application requires human for manual surveillance either using CCTV or depend on security guards. Body detector has the potential to eliminate human intervention. The advantages of develop a body detector alarm system is reduce labor costs, reduced costs, fewer errors and increased the building simplicity security.
1.2.2 To develop portable alarm system application by enhancing the designation of hardware and software.

Modern alarm system does not have the ability to perform in a state of portable. With body detector, the application can be portable and we able to have it functioned everywhere we desired. This is because body detector can be operates in many modes.

1.2.3 To develop a system that can verify and activate the flows of alarm system application using PIC16F877 microcontroller.

The PIC16F877 CPU is optimized for low power consumption and high performance operation at bus frequencies up to 4 MHz. In many applications, the PIC16F877 provides a single chip solution with mask programmed ROM or user-programmable EPROM. By implementing PIC16F877, body detector act as an input to microcontroller while the microcontroller act as an activator for the sequence and flows of the alarm system applications.

1.3 SCOPE OF PROJECT

The scopes that need to be proposed for this project are:

1.3.1 To develop a system that could detect the existence of human the range between 1 < cm² < 30.

1.3.2 To create the application of alarm system body detector and integrate the system by using PIC16F877 microcontroller.
1.4 PROBLEM STATEMENT

This project is focusing on the detection of human body existence and the creation in the application of alarm system. Yet, there are lots of problems with the previous alarm system.

1. Technologies produced alarm system that would probably be intelligent, but the capital to undergo the constructions is still on high cost and need experts to develop. But for alarm system using body detector, the only capital for undergo the construction is fully depends on the electrical fields around human body. By this means, body detector will functioned only with the existence of human body. Body detector circuitry is simple (consists of resistance capacitance elements) and low cost.

2. RFID, Bluetooth and wireless alarm system are not able enough to be portable kit and could not bring the alarm everywhere. By using body detector, sensor (example, metal sensor sheet of tin foil), this element could be a portable sensor and the sensitivity to trigger the body detection is high. By this means, elements in body detector can be adopted to be portable alarm system applications. It could be an alarm everywhere we desired.

3. The previous body detector circuitry have very high sensitivity for temperature rising. It is satisfactorily functioned in the temperature between 10°C - 25°C. But for this new development of body detector, it will function satisfactorily in the temperature between 20°C to 35°C.
1.5 **THESIS OVERVIEW**

This Alarm System Using Body Detector final thesis is a combination of 6 chapters that contains and elaborates specific topics such as the Introduction, Literature Review, Methodology, Hardware Design, Software Design, Result, Discussion, Conclusion and Further Development that can be applied in this project.

Chapter 1 basically is an introduction of the project. In this chapter, the main idea about the background and objectives of the project will be discussed. The full design and basic concept of the project will be focused in this chapter. The overview of the entire project also will be discussed in this chapter to show proper development of the project.

Chapter 2 will be discussed about the literature reviews of this project based on journals and other references.

Chapter 3 will be focused on methodologies for the development of alarm system body detector. This includes the future project development that can be added in this project.

Chapter 4 will be focused on hardware design of the Alarm System using Body Detector. This chapter included three main sections. The first section will be focused on the circuitry on body detector, while the second section will be stressed on the microcontroller design which is about the PIC16F877 design. The other section is about the implementation of applications design. In electronics design, we will discuss about fabricating the body detector and microcontroller board.
Chapter 5 will be discussed about the software development of the PIC16F877 microcontroller board. In this section, software development such as software compiler, software design will be discussed further. The difference between ordinary Microcontroller and PIC family microcontroller also will be described in this chapter.

Chapter 6 discusses all the results obtained and the limitation of the project. All discussions are concentrating on the result and performance of Alarm System Using Body Detector. This chapter also discusses the problem and the recommendation for this project.

Chapter 7 discusses the conclusion and further development of the project. This chapter also discusses about complexity of integrating new technology to develop a complete working system and overall alarm system using body detector for the future development.
CHAPTER 2

LITERATURE REVIEW

2.1 An Overview

A human body detector comprising: a capacitance-type sensor that a human body contacts or approaches, the capacitance-type sensor including a sensor resonance circuit and a wave detector circuit; detection means for receiving an output of the capacitance-type sensor, and distinguishing between the human body from a raindrop and detecting only the human body based on a change in the output within a predetermined time, the detection means including a band-pass filter, the band-pass filter including a differentiator, a high-pass filter and a comparator; and wherein the sensor resonance circuit has a sensor electrode supplied with a constant frequency voltage and outputs a resonance voltage integrated the constant frequency voltage with respect to a capacitance of an object that contacts to the sensor electrode, the wave detector circuit outputs a wave detection voltage obtained through wave detection and conversion of the resonance voltage, and the differentiator differentiates the wave detection voltage with respect to time to acquire the changing rate.

In a human body detector, a wave-detection circuit for detecting waves of a resonance voltage is connected to a sensor resonance circuit that varies a constant frequency voltage in accordance with a change in the capacitance of a sensor electrode. The wave-detection circuit is connected to a differentiator that acquires a changing rate by differentiating the wave-detection voltage with respect to time, and allows a voltage to pass if the changing rate of the voltage is greater than or equal to
a predetermined value. The differentiator is connected to a high-pass filter that allows passage of a voltage whose changing rate is greater than or equal to a second predetermined value. The high-pass filter is connected to a comparator whose non-inversion input terminal is connected to a power source that applies there to a reference voltage.

While **alarm system** (Figure 2.1) is a sound or visual signal which indicates an error condition. The terms alarm and alert are often used synonymously. It is a sudden fear caused by the realization of danger and usually gives warning of existing or approaching danger. For an electrical, electronic, or mechanical device that serves to warn of danger by means of a sound or signal, the sounding mechanism of an alarm clock is applied. In alarm system using body detector, it seems that this will be the best and possible applications. This could include safety switch (which would render an entire area a safety zone, this could shut down dangerous machinery, or child-proof certain areas), a touch sensor (trigger the alarm when items is touched), and also a tamper alarm.

![Figure 2.1: Alarm system applications](image)
A microcontroller (μC) is a computer-on-a-chip. It is a type of microprocessor emphasizing high integration, low power consumption, self-sufficiency and cost-effectiveness. It is a highly integrated chip that contains all the components comprising a controller. Typically this includes a CPU, RAM, some form of ROM, I/O ports, and timers. Unlike a general-purpose computer, which also includes all of these components, a microcontroller is designed for a very specific task -- to control a particular system. As a result, the parts can be simplified and reduced, which cuts down on production costs. Microcontrollers are sometimes called embedded microcontrollers, which just mean that they are part of an embedded system -- that is, one part of a larger device or system. Microcontroller will be the output from body detector and will be programmed with specific assembly language. Thus the operation of application is fully depending with the instruction programming.

2.2 Body Detector

Body Detector is a device that functioned by detecting human body existence which is in the area of body detector located. Body detector is detected by means of RC oscillator. Body detector relies on the fact that the human body itself possessed a fairly large order of capacitance to the ground (earth) and that if such a body approaches the positive plate of a given capacitor, its value will rise. Then, one could find a means to detect such an increase in capacitance, one means of detecting the presence of a human body. Electronic oscillators are often designed around an LC tank circuit, a tuned circuit formed with an inductor and a capacitor. But use of an inductor is not a requirement. Instead, the tuned circuit can be built using just resistors and capacitors. Such an oscillator is referred to as an RC oscillator. In the body detector circuit described here, this is detected by means of an RC (resistance-capacitance) oscillator. As the value of C rises, so the frequency of the oscillator drops. All that remains is to detect this drop in frequency to obtain some very interesting results.
Due to its high sensitivity and good stability, the body detector may be attached to a wide variety of metal objects (in the process sensitizing the entire object concerned. Although body detector is dependant on the electric field which surrounds the human body, in effect it acts as though an invisible field were created around the object concerned. From practical point of view, the sensor may include any object from size of a pin to 30kg in weight. However, the greater the weight metal sensor, the less the sensitivity of the circuit, the more critical the tuning and the more it becomes susceptible to temperature variations especially. If attached to lighter metal objects (sheet of tin foils), the body detector may be tuned to detect a person presence up to 50 cm away. At several centimeters’ distance, the circuit is sufficiently stable to avoid spurious triggering over a wide temperature range. Modern proximity sensor will seldom detect a human body at more than a few millimeters’ distance. Besides, the fact that some applications do not need a greater range because it is difficult to achieve greater range sensitivity with any reliability. In order to achieve greater range, Alarm System Using Body Detector need to overcome these challenges:

i) Environmental variations which affect the stability of the circuit. The bodies electrical is describe as extremely weak, and the body’s capacitance at a small distance from a sensor is typically measured in fractions of a pico Farad. Therefore, the circuit need exceedingly sensitive.

ii) To find a means of reliably picking up small shifts in frequency as a body approaches, and to incorporate these in the circuit in a user-friendly way.

One of the advantages of the body detector is that the sensor is potentially completely vandal-proof and temper-proof. This means we could not come near it with a pair of clippers or similar instruments, let alone fingers. It is immune a.c. fields and it will also detect body presence on the other side of a variety of materials including insulators.
The body detector will work satisfactorily over a wide range of conditions. But my project which is Alarm System Using Body Detector is designed to perform to its best potential under the following circumstances:

iii) Over a modest temperature range (20°C to 35°C)
iv) Using relatively lightweight sensor – up to a kilogram (ideal)
v) Over longer periods (days at a time rather than minutes or hour)
vi) Multiple applications which require the unit or sensor to be moved

2.3 PIC 16F877 microcontroller

2.3.1 An Overview

The PIC (Programmable Interface Controller) line of microcontrollers was originally developed by the semiconductor division of General Instruments Inc (Figure 2.2). The first PIC’s were a major improvement over existing microcontroller because they were a programmable, high output current, input/output controller built around a RISC (Reduced Instruction Set Code) architecture. The first PICs ran efficiently at one instruction per internal clock cycle, and the clock cycle was derived from the oscillator divided by 4. Early PICs could run with a high oscillator frequency of 20 MHz. This made them relatively fast for an 8-bit microcontroller, but their main feature was 20 mA of source and sink current capability on each I/O (Input/Output) pin. Typical micros of the time were advertising high I/O currents of only 1 milliampere (mA) source and 1.6 mA sink.
Figure 2.2: PIC microcontrollers

PIC16F8X provides the EEPROM and flash. They have all the features of the base 14-bit core group which are interrupts, 13 I/O, one 8-bit timer, 0.5k or 1k of code space as EEPROM or flash and 36 or 68 bytes of RAM. Unique to these devices is the 64 bytes of EEPROM data memory. This data will stay even when power is removed so it’s great for storing calibration or variable data to be used when the program starts again. They are very handy for development because they can be programmed over and over again without ever leaving the circuit while 16F87X have flash program memory so they can be reprogrammed over and over again. They are built to be identical to the 16C7X family with some data memory and program memory updates. They offer 22 to 33 I/O, three timers and up to 8k of program memory. They have all the special functions the 16C6X and 16C7X parts have as mentioned earlier. All the projects in this book will be built around the 16F876 because it is flash reprogrammable, has A/D, and has all the other PIC features. It also offers the option to build a bootloader inside. A bootloader allows you to program the part from a serial port without any special programmer circuitry.
2.3.2 PIC16F877 microcontroller implementation

Regarding this project, several reviews were made. One of the researches made is about the brain of the Alarm System using Body Detector which is PIC 16F877 microcontroller. PIC 16F877 is general purpose microprocessor which has additional parts that allow them to control external devices. Basically, a microcontroller executes a user program which is loaded in its program memory.

The reason for using PIC 16F877 (Figure 2.3) is because of the general purpose microprocessor which has additional parts that allow them to control external devices. Basically, a microcontroller executes a user program which is loaded in its program memory.

Figure 2.3: PIC16F877 microcontroller development board
Instead of using the MC68HC11 or Intel 8051 microcontroller, PIC 16F877 type of microcontroller architecture is distinctively minimalist. PIC microcontroller is the name for the microchip microcontroller (MCU) family, consisting of a microprocessor, I/O ports, timer (s) and other internal, integrated hardware. It is characterized by the following features:

(i) Separate code and data spaces.
(ii) A small number of fixed length instructions.
(iii) Most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips.
(iv) All RAM locations function as registers as both source and/or destination of math and other functions.
(v) A hardware stack for storing return addresses.
(vi) Data space mapped CPU, port, and peripheral registers.
(vii) The program counter is also mapped into the data space and writable (this is used to synthesize indirect jumps).

Unlike most other CPUs, there is no distinction between "memory" and "register" space because the ram serves the job of both memory and registers, and the ram is usually just referred to as the register file or simply as the registers. PIC microcontrollers have a very small set of instructions (only 35 instruction), leading some to consider them as RISC devices, however many salient features of RISC CPU's are not reflected in the PIC architecture. For examples:

(i) It does not have load-store architecture, as memory is directly referenced in arithmetic and logic operations.
(ii) It has a singleton working register, whereas most modern architectures have significantly more.
2.3.3 PIC 16F877 Bootloaders

Bootloader is a utility which reads a program from a communication channel writes it to program/data memory and executes it. It therefore allows the possibility for programs to be updated or changed at a later date without requiring special programming hardware. The implementation of a bootloader for a Microchip PIC processor (16F877), however, the same procedure could be applied to many other type of processors. Before any coding starts, we should first think about how things are going to be positioned in program memory. Since the bootloader needs control after reset, it will mean that it will need to use the reset vector. Since we want to make it easy to build bootloader compatible programs, it is best if the bootloader is positioned entirely at the start of memory, or, all at the end of memory. On mid-range PIC's, the regular interrupt vector is located at address 0x4. If the bootloader was going to be positioned entirely at the start of memory, it would then have to redirect the interrupt vector to the downloaded program. Since this would add complexity to the code and latency to the vector, we have decided to position the bootloader at the end of memory. We will still need the reset vector, however, so this will mean shifting the downloaded program's reset vector elsewhere.

As shown in Figure A 2.4, typically the reset vector contains instructions to jump into the main program. Because the bootloader needs the reset vector, we therefore must move the downloaded program's reset vector elsewhere. Figure B 2.4 shows how the reset vector now points to the bootloader code and the downloaded program's reset vector will be positioned to an address just before the bootloader.

How it works:

i) On reset the bootloader will take control and prompt the user to send a hex file. It will wait here (with count down) for a configurable number of seconds.
ii) If no hex file is sent, the bootloader will assume that no update is required and it will jump to the redirected reset vector which in turn will run the previously downloaded program. If no program has ever been downloaded, the redirected reset vector will simply contain a jump to the beginning of the bootloader and the whole process will start again.

iii) If a HEX file is sent to the bootloader within the count down period, it will start interpreting the data and writing it to program memory. The bootloader will look for addresses less than 0x4 (reset vector) and will instead write this elsewhere. It will also ignore addresses conflicting with those used by the bootloader, thus protecting it from being overwritten.

Figure 2.4: PIC 16F877 Bootloaders
2.3.4 Memory Organization

There are three memory blocks in each of the PIC16F87X MCUs. The Program Memory and Data Memory (Figure 2.5) have separate buses so that concurrent access can occur. The PIC16F87X devices have a 13-bit program counter capable of addressing an 8K x 14 program memory space. The PIC16F877/876 devices have 8K x 14 words of FLASH program memory, and the PIC16F873/874 devices have 4K x 14. Accessing a location above the physically implemented address will cause a wraparound. The RESET vector is at 0000h and the interrupt vector is at 0004h.

![Figure 2.5: PIC 16F877 Memory Maps](image)

Figure 2.5: PIC 16F877 Memory Maps
The data memory is partitioned into multiple banks which contain the General Purpose Registers and the Special Function Registers (Figure 2.6). Bits RP1 (STATUS<6>) and RP0 (STATUS<5>) are the bank select bits. Each bank extends up to 7Fh (128 bytes). The lower locations of each bank are reserved for the Special Function Registers. Above the Special Function Registers are General Purpose Registers, implemented as static RAM. All implemented banks contain Special Function Registers. Some frequently used Special Function Registers from one bank may be mirrored in another bank for code reduction and quicker access. The register file can be accessed either directly or indirectly through the File Select Register (FSR).

Figure 2.6: PIC 16F877 Register File Map

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**Note:**

1. These registers are not implemented on the PIC16F876.
2. These registers are reserved, maintain these registers clear.
CHAPTER 3

METHODOLOGY

3.1 BLOCK DIAGRAM

3.1.1 BLOCK DIAGRAM OF BODY DETECTOR

Figure 3.1 shows the block diagram of body detector system for this project. At the heart of the Body Detector is a versatile mixer which will detect frequency variations within a small fraction of one percent. While the mixer is deceptively simple, it has a high degree of accuracy as well as flexibility. It starts with sensor detection by the capacitance around human body, thus activate the body detector. This version of body detector only used two detection sections and also requires no special optimization for the sensor and may be easily adjusted to almost any sensor of one’s choosing. The block diagram is based on astable oscillator (IC1a) and a non-retrigerable monostable (IC1b) that operates in tendem. Nearly all of the components surrounding IC1 have the same temperature coefficients. Both astable oscillator and the non-retrigerable monostable are housed in the same package (IC1), which means that any warming or cooling of the devices affects both sub-circuits more or less equally. Thus, environmental variations are largely cancelled out.
3.1.1.1 Sensor

At the block diagram of the system, sensor will be the input to the main system. The sensor which put at the body detector will detect any existence of capacitance human body around the body detector in certain distance. Any metal sensor will do and the sensitivity will be different to each metals. When we set the sensor to be a sheet of tin foil (light sensor), the sensitivity to trigger the body detection is high.

Figure 3.1: Block Diagram of the Body Detector System
3.1.1.2 Body Detector Circuit

After received the signals from sensor that capacitance is detected, it will trigger the binary mixer and monostable timer. If then a body comes near, the frequency of CMOS dual timer will drop, and therefore monostable timer will go “high” for duration fractionally shorter than the period of astable. The output of CMOS dual timer is fed to the trigger input of another CMOS dual timer. Therefore astable triggers monostable CMOS dual timer.

3.1.2 BLOCK DIAGRAM OF PIC 16F877 MICROCONTROLLER

All the system in this project is controlled by PIC 16F877. This project is using two modules of microcontroller board, one for the receiving part of the input from body detector and the other one for transmitting output and displaying part. There are five main parts remaining in microcontroller. There are power circuit, reset circuit, clock circuit and programmer module.

3.1.2.1 PIC 17F877 PIN ASSIGNMENT

In Alarm System Using Body Detector, the pin used in PIC 16F877 (Figure 3.2) are mainly at PORTB which include pb0, pb1, pb2, and pb3. While for the voltage supply I used pin11 and pin32 and for ground I used pin12 and pin31. For clock input, I used OSC11 and OSC2 (pin13 and pin14).
In PIC 16F877, there are two types of features which are the core features and the peripheral features. The core features of PIC 16F877 can be seen at Figure 3.3 (upper part). For core features of PIC16F877, it includes only 35 single word instructions to learn, could operate speed at DC - 20 MHz clock input DC - 200 ns instruction cycle. It also has up to 8K x 14 words of FLASH Program Memory, 368 x 8 bytes of Data Memory (RAM) and 256 x 8 bytes of EEPROM Data Memory and the interrupt capability (up to 14 sources). Same with other processors, PIC16F877 also have direct, indirect and relative addressing modes. Programmable code protection and Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation is available on this microcontroller. It is able to select the oscillator options and have low power, high speed CMOS FLASH/EEPROM technology. With wide operating voltage range: 2.0V to 5.5V the processor could read/write access to program memory. While for the peripheral features of PIC 16F877 can be seen at
Figure 3.3 (lower part). This includes the timer which is 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 and Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler. It also have two Capture (16-bit, max. resolution is 12.5 ns), Compare (16-bit, max. resolution is 200 ns), and PWM modules (max. resolution is 10-bit). Lastly, it includes 10-bit multi-channel Analog-to-Digital converter.

Figure 3.3: PIC 16F877 Block Diagram