# WIRELESS UNIVERSITY ACCESSIBILITY SYSTEM

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## ABSTRACT

For century, most of office and institution used traditional method to check the access authorization of individuals to buildings. This method is proved successful in order to prevent any unwanted intruder but it sometime waste time especially during peak time. Besides it used many man powers to do it. Lately, a very valuable technology called Radio Frequency Identification (RFID) is introduced. RFID is a new technology that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal, or person. The basic idea behind of this technology is to unravel the problem of traditional method by using a card which contains data of user. This card can be easily read by a reader then gives access to enter the building. In this project, a RFID reader will be integrated with Microcontroller 68HC11 where the microcontroller will control the whole system. The project is applied to entrance of university gate which require access before the gate will automatically open. If there any card is attached, the RFID reader will send data to microcontroller and the microcontroller will indentify if the user is staff, student or outsider. This system can prevent any unwanted intruder from entering the building.

# CHAPTER 1

# INTRODUCTION

## 1.1 BACKGROUND

RFID (radio frequency identification) is a new technology that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal, or person. RFID tags are not an "improved bar code" as the proponents of the technology would like you to believe. An RFID system consists of three components: an antenna and transceiver (often combined into one reader) and a transponder (the tag). The antenna uses radio frequency waves to transmit a signal that activates the transponder. When activated, the tag transmits data back to the antenna. RFID technology differs from bar codes. RFID can read the tag using RF, meaning that the RFID reader can be read from a distance, right through your clothes, wallet, backpack or purse. Besides the RFID tag consist of unique ID for each tag. The technology used in RFID has been around since the early 1920s. In our country, this technology already been used for several years in certain place such as in Highway using card ‘Touch N Go’. Some places, they prefer to used Barcode which is cheaper than RFID. Technology spread very fast. In few years later, there is not impossible if RFID will replace the barcode system in today’s life.

Nowadays, there are lots of universities around the world and each of the university consists of student up to 20 thousand. To handle a large amount of student may be problem especially when entering campus. Normally there will be manual checking at entrance of university in order to prevent outsiders. This kind of system sometimes causes some problem such as long queue especially during peak time.

Regarding of this problem, a right solution might be used to overcome this problem. In this project, an automatic checking system will be develop using a RFID reader and applied it directly at entrance gate.  The basic concept is just like 'Touch N Go' that we use at highway. When a card is touched at the reader, then the gate will automatically open if the user has access to enter to the area.

Besides avoiding long queue at entrance, this system offers strategic advantages for security because the data stored in the RFID tag can be protected against undesired read access and any manipulation. RFID tag consists of unique ID for each user. Meaning that, if this system applied at university gate, all of student has their own ID inside the tag and RFID reader will identify it as a student card. This is really important especially avoid strangers from gain access in the area.

Generally, the system will consist of several electronic elements which are RFID tag, RFID reader, a micro controller, the gate itself and sensor.  All of these components will be embedded in the system called "Wireless University Accessibility System". At the end of this project, this system can be applied directly to main gate as it designs for.

All of these elements have their own function and need to be merged in this system. Firstly is about RFID reader. RFID reader is an integrated circuit for storing and processing information, modulating and demodulating a (RF) signal and can also be used for other specialized functions.

The second is an antenna for receiving and transmitting the signal. A technology called chipless RFID allows for discrete identification of tags without an integrated circuit, thereby allowing tags to be printed directly onto assets at lower cost than traditional tags.The transmitter will contain an oscillator, amplifier, and antenna.

RFID reader then will be attached to a micro controller as the brain of this system. RFID reader is design to read data from tag then transmitted the data to the microcontroller. All the flow of the system will be completely control by microcontroller. An excellent programming is needed to be programmed into the microcontroller in order to indentify each ID of tag before access is given to enter the area.

This final project is divided into 3 main sections:-

(1) Electronic design consists of Microcontroller design integrated with sensors
(2) Develop Software to identify the user of the tag
(3) Mechanical design consists of gate model and motor to control the open and closed gate.

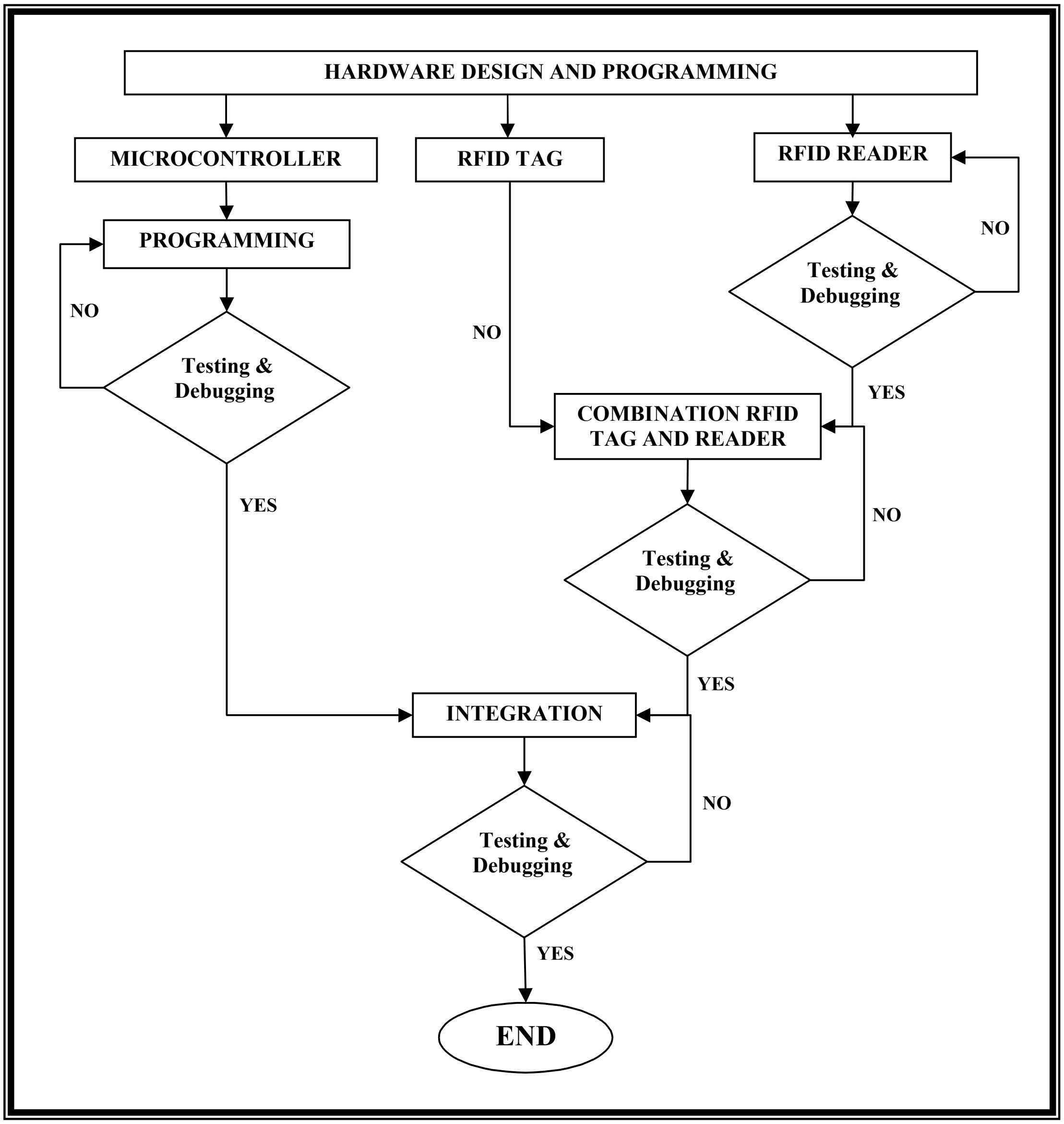



**Figure 1.1:** Product Flow for the whole project

## 1.2 OBJECTIVES

### 1.2.1 To explore the function of RFID

Even though RFID was introduced early 1970's, since this technology doesn't included in syllabus, a deep understanding about RFID is needed before RFID technology can be applied into any system.

### 1.2.2 To develop a prototype of automatic entrance system using RFID technology

The main objective is to developed automatic entrance using RFID. In this project, RFID reader will be attached to a microcontroller. Everything regarding of this system such as flow of system etc is controlled totally by microcontroller. A prototype of automatic entrance will be build integrated with microcontroller and RFID reader.

## 1.3 PROJECT SCOPE

The main goal of this project is develop an automatic entrance system using RFID technology. There is 2 scope will be cover in this project. Firstly is to use appropriate RFID Tag & Reader for this application. Secondly is to design an automatic gate using microcontroller combined with RFID technology.

### 1.3.1 Use appropriate RFID Tag & Reader for this application

There are lots of RFID reader and tag sold at market. Not only brand, but also frequencies of the RFID itself need to be considered. Since this system will be applied to a university, the RFID reader must used same frequencies as university ID card. For better result, the manufacture for both RFID reader and tag should be same.

### 1.3.2 Design an automatic gate using microcontroller combined with RFID technology

Because this system will be applied at entrance of building or area, a prototype of automatic entrance gate will be build. In general, when a card is touch, RFID reader will send the data inside the card to microcontroller then the data will be processes either access will be given or not to the owner of the card. If yes, the gate will automatically open and if not, the gate will remain closed.

## 1.4 THESIS OVERVIEW

This “Wireless University Accessibility System” final thesis is a combination of 6 chapters that contains and elaborates specific topics such as the Introduction, Literature Review, Hardware Design, Software Development, 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 discussion is all about the background and objectives of the project. The overall overview of the entire project also will be discussed in this chapter.

Chapter 2 will be discussed about the literature review for the development of the Wireless University Accessibility System. Everything related to the project will be describe generally in this chapter

Chapter 3 will be focused on hardware design of the Wireless University Accessibility System. This chapter included seven subtopics. The entire hardware used in this project will be discussed briefly including wired connection for each part.

Chapter 4 will be discussed about the software development of the microcontroller. In this section, all basic programming will be explained through flow chart with a sample programming.

Chapter 5 discusses all the results obtained and discussion of the project. The main flow chart for this project will be explained briefly under this topic.

Chapter 6 discusses the conclusion and further development of the project. This chapter also discusses about total costing involved and potential of this project for commercialization.

# CHAPTER 2

# LITERATURE REVIEW

## INTRODUCTION

Wireless University Accessibility System is an automatic entrance system develops especially for university. This system consists of two modules which are **RFID module**, **Electronic module and Software module.** All the modules will be combining together and build this system full functioning. Each module carries own functioning and special features which will be discussed in detail in this chapter. Figure 2.0 show overall of the system.

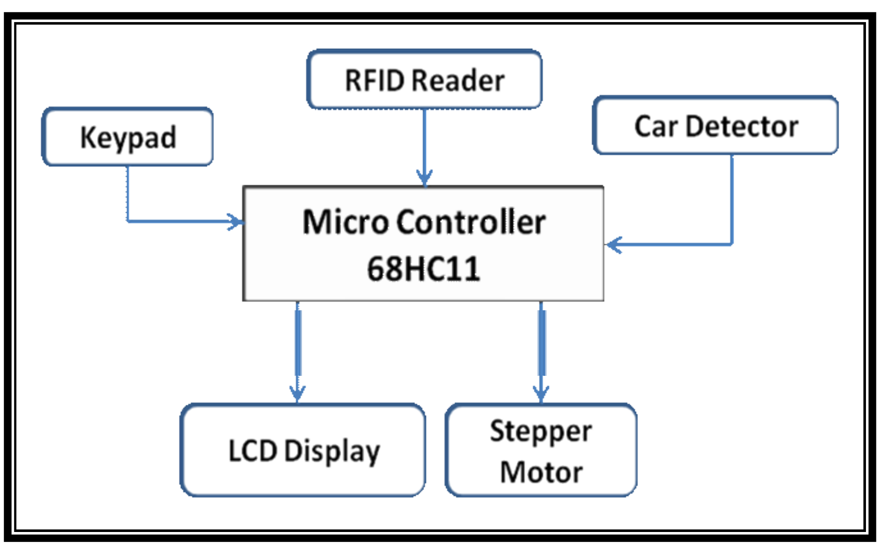



**Figure 2.0:** Overall System of Wireless University Accessibility System

## 2.1 RFID MODULE

### 2.1.1 History of RFID

It's generally said that the roots of radio frequency identification technology can be traced back to World War II. The Germans, Japanese, Americans and British were all using radar which had been discovered in 1935 by Scottish physicist Sir Robert Alexander Watson-Watt to warn of approaching planes while they were still miles away. The problem was there was no way to identify which planes belonged to the enemy and which were a country's own pilots returning from a mission.

Radio Frequency Identification (RFID) research and discovery began in earnest in the 1970s. RFID is commonly used to transmit and receive information without wires. RFID readers and tags communicate through a distance using radio waves. There are a lot of advantages in RFID system, included their price, size, memory capacity and their capability. The pure memory-based RFID chip without a co-processor is cheap, and its footprint is small and usually use in car immobilizer applications where the IC has to fit in a tiny glass tube buried in the key. RFID fast processing speed is also essential.

Advances in radar and RF communications systems continued through the 1950s and 1960s. Scientists and academics in the United States, Europe and Japan did research and presented papers explaining how RF energy could be used to identify objects remotely. Companies began commercializing anti-theft systems that used radio waves to determine whether an item had been paid for or not. Electronic article surveillance tags, which are still used in packaging today, have a 1-bit tag. The bit is either on or off. If someone pays for the item, the bit is turned off, and a person can leave the store. But if the person doesn't pay and tries to walk out of the store, readers at the door detect the tag and sound an alarm.

The First RFID Patents Mario W. Cardullo claims to have received the first U.S. patent for an active RFID tag with rewritable memory on January 23, 1973. That same year, Charles Walton, a California entrepreneur, received a patent for a passive transponder used to unlock a door without a key. A card with an embedded transponder communicated a signal to a reader near the door. When the reader detected a valid identity number stored within the RFID tag, the reader unlocked the door. Walton licensed the technology to Schlage Lock of San Francisco, a lock maker, and other companies.

Later, comanies developed a low-frequency (125 kHz) system, featuring smaller transponders. A transponder encapsulated in glass could be injected under the cows' skin. This system is still used in cows around the world today. Low-frequency transponders were also put in cards and used to control the access to buildings.

Over time, companies commercialized 125 kHz systems and then moved up the radio spectrum to high frequency (13.56 MHz), which was unregulated and unused in most parts of the world. High frequency offered greater range and faster data transfer rates. Companies, particularly those in Europe, began using it to track reusable containers and other assets. Today, 13.56 MHz RFID systems are used for access control, payment systems (Mobile Speedpass) and contactless smart cards. They're also used as an anti-theft device in cars. A reader in the steering column reads the passive RFID tag in the plastic housing around the key. If it doesn't get the ID number it is programmed to look for, the car won't start.

In the early 1990s, IBM engineers developed and patented an ultra-high frequency (UHF) RFID system. UHF offered longer read range (up to 20 feet under good conditions) and faster data transfer. IBM did some early pilots with Wal-Mart, but never commercialized this technology. When it ran into financial trouble in the mid-1990s, IBM sold its patents to Intermec, a bar code systems provider. Intermec RFID systems have been installed in numerous different applications, from warehouse tracking to farming. But the technology was expensive at the time due to the low volume of sales and the lack of open, international standards.

### 2.1.2 RFID Reader

RFID (radio frequency identification) is a technology that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency (RF) portion of the electromagnetic spectrum to uniquely identify an object, animal, or person. RFID is coming into increasing use in industry as an alternative to the bar code. The advantage of RFID is that it does not require direct contact or line-of-sight scanning. An RFID system consists of three components: an antenna and transceiver (often combined into one reader) and a transponder (the tag). The antenna uses radio frequency waves to transmit a signal that activates the transponder. When activated, the tag transmits data back to the antenna. [3]

The scanning antenna puts out radio-frequency signals in a relatively short range. The RF radiation does two things; it provides a means of communicating with the transponder tag (the RFID chip) and (in the case of passive RFID tags) it provides the RFID device with the energy to communicate. The tag is composed of an antenna coil and a silicon chip that includes basic modulation circuitry and non-volatile memory. The tag is energized by a time-varying electromagnetic radio frequency (RF) wave that is transmitted by the reader. This RF signal is called a *carrier signal*. This is an absolutely key part of the technology; RFID devices do not need to contain batteries, and can therefore remain usable for very long periods of time (maybe decades).

When the RF field passes through an antenna coil, there is an AC voltage generated across the coil. This voltage is rectified to result in a DC voltage for the device operation. The device becomes functional when the DC voltage reaches a certain level. The information stored in the device is transmitted back to the reader. This is often called backscattering. By detecting the backscattering signal, the information stored in the device can be fully identified. The scanning antennas can be permanently affixed to a surface; handheld antennas are also available. They can take whatever shape you need; you could build them into a door frame to accept data from persons or objects passing through. When an RFID tag passes through the field of the scanning antenna, it detects the activation signal from the antenna. That "wakes up" the RFID chip, and it transmits the information on its microchip to be picked up by the scanning antenna. [1]

Nowadays lot of RFID reader sold with multiple brands such as Mifare, Hitachi, and Philip. Because of the major application used in worldwide, many systems require the simultaneous use of more than one operating frequency. Most systems available on the world market at present operate at one of the following frequencies or frequency ranges: below 135 kHz (125 kHz, 134.2kHz for example), 13.56MHz, UHF (860/960 MHz), 2.45GHz and 5.8GHz. The operating and control characteristics are different for each of these frequencies, and therefore each of them is more appropriate for certain types of application or certain countries.

### 2.1.3 RFID Tag

RFID tags come in two general varieties which are passive and active tag. Passive tags require no internal power source, thus being pure passive devices (they are only active when a reader is nearby to power them), whereas active tags require a power source, usually a small battery.

#### 2.1.3.1 Passive Tag

Passive RFID tags have no internal power supply. The minute electrical current induced in the antenna by the incoming radio frequency signal provides just enough power for the CMOS integrated circuit in the tag to power up and transmit a response. Most passive tags signal by backscattering the carrier signal from the reader. This means that the antenna has to be designed to both collect powers from the incoming signal and also to transmit the outbound backscatter signal. The response of a passive RFID tag is not necessarily just an ID number; the tag chip can contain non-volatile EEPROM for storing data. The lack of an onboard power supply means that the device can be quite small: commercially available products exist that can be embedded in a sticker, or under the skin in the case of low frequency RFID tags. [2]

The major disadvantages of a passive RFID tag are:

a) The tag can be read only at very short distances, typically a few feet at most. This greatly limits the device for certain applications.

b) It may not be possible to include sensors that can use electricity for power.

c) The tag remains readable for a very long time, even after the product to which the tag is attached has been sold and is no longer being tracked.

The advantages of a passive tag are:

a) The tag functions without a battery; these tags have a useful life of twenty years or more.

b) The tag is typically much less expensive to manufacture

c) The tag is much smaller (some tags are the size of a grain of rice). These tags have almost unlimited applications in consumer goods and other areas.

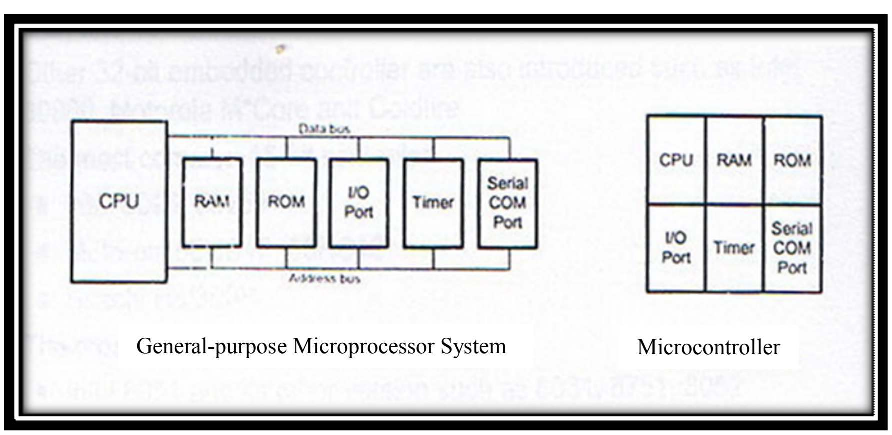
## 2.2 ELECTRONIC MODULES

Under this module, most of the electronic component will be discuss. Electronics modules consist of:

2.2.1 Microcontroller
2.2.2 Stepper Motor
2.2.3 Infrared Sensor
2.2.4 LCD display
2.2.5 Keypad
2.2.6 Digital Clock
2.2.7 Power Supply

### 2.2.1 Microcontroller

Many things should be considered before choosing Microcontroller as the controller. Generally there are 2 types of controller which are Microprocessor and Microcontroller. General purpose microprocessor such as Intel's x86 family (8086, 80286, 80386, 80486 and Pentium) or Motorola's 680x0 family (68000, 68010, etc) contain no RAM, ROM or I/O on the chip itself. They require these devices externally to make them functioning. A microcontroller consists of CPU, ROM, embedded together in a single chip. It is an ideal for many applications. Figure 2.1 show the diagram of microprocessor and microcontroller.




General-purpose Microprocessor System Microcontroller

**Figure 2.1**: Microprocessor versus microcontroller

Both chip offer their own advantages and disadvantages. For microprocessor, it a high performance IC, more flexibility and can easily expended. However, it's more expensive as it required additional ICs and used large space. While for microcontroller, it is a high integration IC with small space for PCB. Its cost is cheaper compare to microprocessor. It also has special architecture with low power consumption. However, it has limited expansion due to extra features offer in microcontroller. In this project, microcontroller is used due to its advantages compare to microprocessor. . Figure 2.2 show the block diagram of a Typical Microcontroller shown in a Single-Chip Mode.

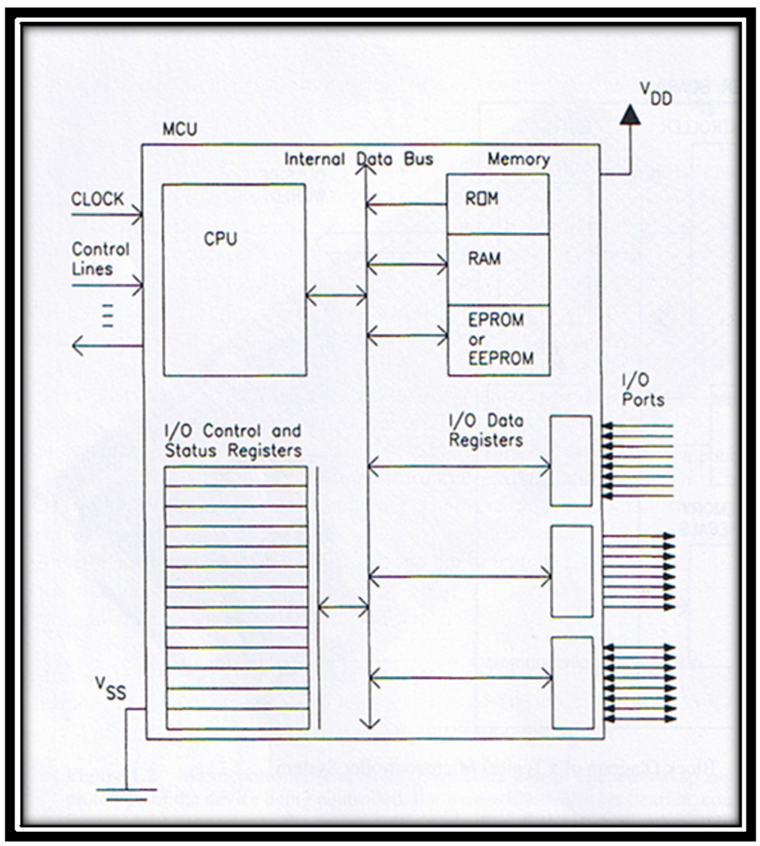



**Figure 2.2:** Block diagram of a Typical Microcontroller in a Single-Chip Mode.

#### 2.2.1.1 Motorola MC68HC11 Microcontroller Unit (MCU)

The most commonly microcontroller used nowadays are 8-bit and 16-bit microcontroller. Other 32-bit embedded controller are also introduced such as Intel 80960, Motorola M*Core and Coldfire. The most common 16-bit controller is Intel 8096, 80251, Motorola 68HC12, 68HC16 and Hitachi H8/300H. For 8-bit microcontroller, commonly used are Intel 8051 and its other version such as 8031 8751, 8052, Microchip PIC such as P1C16F84 and BASIC STAMP and Motorola 68H 005, 68HC08, 68HC1 1 and Zilog Z8.

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When choosing correct microcontroller, several things also need to be considered such as meet the computing needs for the task at cost efficiency, software availability, wide availability and reliable sources. For this project, 8-bit Motorola MC68HC11 family microcontroller is used as the main controller for the system. Commonly this model more synonyms with name 68HC11. This model of microcontroller offer several features which meets the requirement for the task at the lowest cost. 68HC11 offers various subsystems such as ADC, interrupts, timers and so on. Besides, it uses simple assembly language because the processor uses the Von Neumann architecture. Table 2.0 shows the version of MC68HC11.

**Table 2.0:** Version of Motorola MC68HC11

| Part Number | EPROM | ROM | EE-PROM | RAM | CONFIG[2] | Comments |
|---|---|---|---|---|---|---|
| MC68HC11A8 | — | — | 512 | 256 | $0F | Family Built Around This Device |
| MC68HC11A1 | — | — | 512 | 256 | $0D | 'A8 with ROM Disabled |
| MC68HC11A0 | — | — | — | 256 | $0C | 'A8 with ROM and EEPROM Disabled |
| MC68HC811A8 | — | — | 8K + 512 | 256 | $0F | EEPROM Emulator for 'A8 |
| MC68HC11E9 | — | 12K | 512 | 512 | $0F | Four Input Capture/Bigger RAM 12K ROM |
| MC68HC11E1 | — | — | 512 | 512 | $0D | 'E9 with ROM Disabled |
| MC68HC11E0 | — | — | — | 512 | $0C | 'E9 with ROM and EEPROM Disabled |
| MC68HC811E2 | — | — | 2K[1] | 256 | $FF[3] | No ROM Part for Expanded Systems |
| MC68HC711E9 | 12K | — | 512 | 512 | $0F | One-Time Programmable Version of 'E9 |
| MC68HC11D3 | — | 4K | — | 192 | N/A | Low-Cost 40-Pin Version |
| MC68HC711D9 | 4K | — | — | 192 | N/A | One-Time Programmable Version of 'D3 |
| MC68HC11F1 | — | — | 512[1] | 1K | $FF[3] | High-Performance Non-Multiplexed 6B-Pin |
| MC68HC11K4 | — | 24K | 640 | 768 | $FF | > 1 Mbyte memory space, PWM, $C_S$, 84-Pin |
| MC68HC711K4 | 24K | — | 640 | 768 | $FF | One-Time Programmable Version of 'K4 |
| MC68HC11L6 | — | 16K | 512 | 512 | $0F | Like 'E9 with more ROM and more I/O, 64/68 |
| MC68HC711L6 | 16K | — | 512 | 512 | $0F | One-Time Programmable Version of 'L4 |

#### 2.2.1.2 Motorola 68HC11 Architecture

The MicroStamp11 module is built around the Motorola 68HC11 micro-controller IC. In order to program the MicroStamp11, you'll need to have a closer look at the 68HC11's architecture. The 68HC11's basic architectural blocks are shown in figure 2.3. This figure explicitly shows the peripheral subsystems in the Motorola 68HC11 micro-controller and it shows which pins those subsystems are tied to.

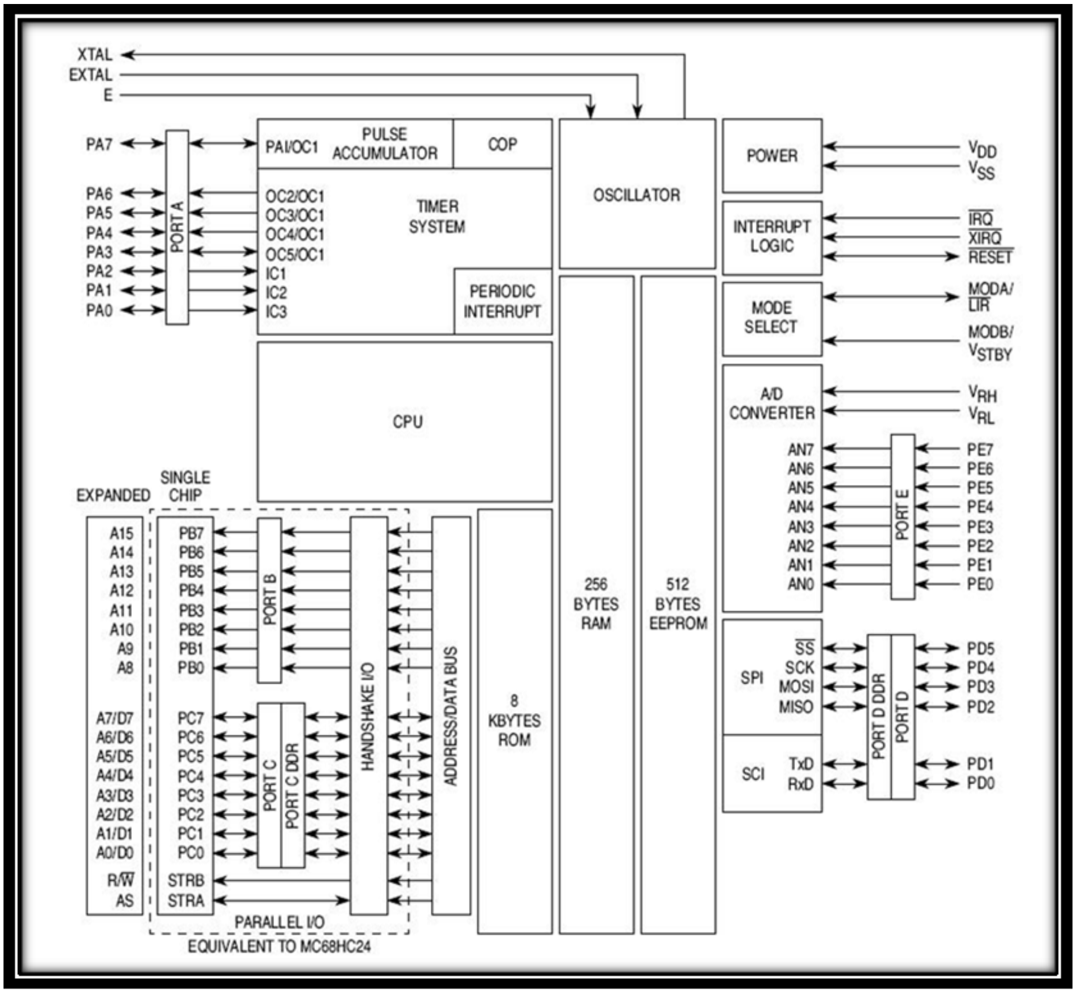


**Figure 2.3:** 68HC11 Architecture

From figure 2.3, we see that the 68HC11 has a number of pins. Some of these pins are used to control the micro-controller's operating mode, clock logic, special interrupts, or power. The majority of the pins, however, have been organized into four 8-bit input/output ports. These ports have the logical names PORTA, PORTB, PORTC, PORTD and PORTE. It is through these five ports that the 68HC11 channels most of its interactions with the outside world.

Below are the descriptions of each port while figure 2.4 shows the pin configuration for MC68HC11 microcontroller.

a) Port A - parallel I/O or timer/counter
b) Port B - Output port or upper address (A8 - M5) in expanded mode

c) Port C - I/O port or lower address (A0 - A7) and data bus (DO - D7) in expanded mode

d) Port D - 6-bits I/O port or serial communication interface (SCI) and serial peripheral interface (SPI)

e) Port E - Input port or 8-channels input analog for ADC

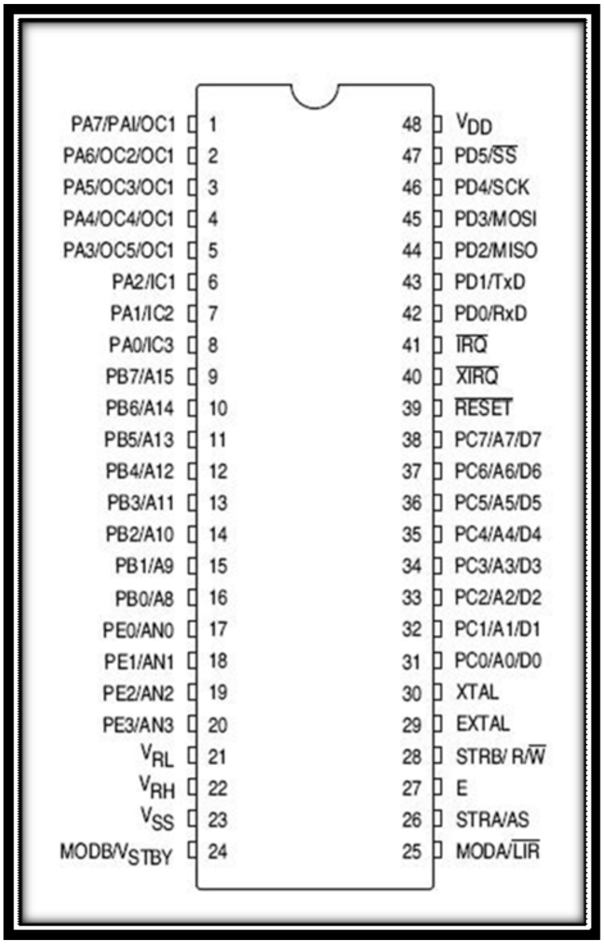


**Figure 2.4:** 48-Pin DIP Pin Assignments

As mentioned earlier, a micro-controller is often distinguished by the fact that its input/output devices are directly mapped into RAM. This is also true of the I/O ports in the 68HC11. The logical names for the I/O ports are associated with absolute addresses in RAM and these addresses are in turn tied to hardware registers. When an input pin, for example, is set to a high logical level, then that logic level directly sets the value in the port's hardware register. Since that hardware register is mapped directly into the micro-controller's address space, a program can then directly read that register's value by accessing memory.

The I/O ports and other device pins are connected to special subsystems in the 68HC11. The subsystems shown in figure 2.3 are briefly described below:

a) **EPROM:** Some versions of the 68HC11 have as much as 4 kilo-bytes of internal EEPROM. If your program is sufficiently small, then your micro-controller system would not need external memory chips and could be operated in single-chip mode.

b) **RAM:** The version of the 68HC11 in your MicroStamp11 has 256 bytes of internal RAM. As mentioned above, some of these bytes are mapped into hardware registers that are used to control the micro-controller. In reality the MicroStamp11 programmer only has 192 bytes of RAM that can be used for program variables.

c) **Serial Peripheral Interface (SPI):** This subsystem allows the 68HC11 to communicate with synchronous serial devices such as serial/parallel slave devices.

d) **Serial Communication Interface (SCI):** This subsystem allows the 68HC11 to communicate with asynchronous serial devices. The SCI interface is used to communicate with laptop computers.

e) **Parallel I/O Interface:** This subsystem is generally used to provide the 68HC11 with a way of writing digital data in parallel to an external device. The usual parallel device is a memory device. If we need to augment the EEPROM in the micro-controller with additional memory, we use the parallel I/O interface to address, read, and write data to this external memory chip. When we do this we usually operate the chip in so-called **expanded mode**. Running the chip in expanded mode greatly reduces the number of I/O Ports available to the system. This is because PORTB and PORTC are connected to the memory chip and hence are unavailable for other external devices. Since the MicroStamp11 uses an external memory chip, it is running the 68HC11 in expanded mode and hence only PORTA and PORTD can be used by the programmer for interfacing with the external world.

f) **Mode Selection System:** This subsystem selects whether the 68HC11 runs in expanded or single-chip mode. In single chip mode, the 68HC11 allows the user to have complete control over all four I/O ports. In expanded mode, the 68HC11 uses ports B and C to address, read, and write to external memory; hence the programmer can only use PORTA and PORTD. In the MicroStamp11 module, the chip is usually in expanded mode.

g) **Clock logic:** An important feature of micro-controllers is that they work in **real-time**. By real-time, we mean that instruction executions are completed by specified time deadlines. This means that the micro-controller needs a clock. The clock logic subsystem provides the real-time clock for the 68HC11. The rate of the clock is determined by a crystal that is connected to the clock logic pins. The MicroStamp11 has a crystal on the module, so these pins are not available to the programmer.

h) **Interrupt Logic:** Micro-controllers must be able to respond quickly to asynchronous events. The interrupt logic subsystems provide three pins that can be used to trigger hardware interrupts. Hardware interrupts automatically transfers software execution to a specified memory address in response to the hardware event (such as the pin's logic state going low). We say that this interrupt is generated *asynchronously* because the event can occur between ticks of the system's real-time clock. Hardware interrupts provide a means for assuring that micro-controllers respond in a timely manner to external events.

i) **Timer Interrupts:** This subsystem generates interrupts that are associated with an internal timer. Remember that the 68HC11 executes instructions in step with a clock tick provided by the clock logic subsystem. With each tick of the clock, an internal register called a timer is incremented.

### 2.2.2 Stepper Motor

A stepper motor is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps, for example, 200 steps. When commutated electronically, the motor's position can be controlled precisely, without any feedback mechanism.

A stepper motor's design is virtually identical to that of a low-speed synchronous AC motor. In that application, the motor is driven with two phase AC, one phase usually derived through a phase shifting capacitor. Another similar motor is the switched reluctance motor, which is a very large stepping motor with a reduced pole count, and generally closed-loop commutated.

Steppers exhibit more vibration than other motor types, as the discrete step tends to snap the rotor from one position to another. This vibration can become very bad at some speeds and can cause the motor to lose torque. The effect can be mitigated by accelerating quickly through the problem speed range, physically dampening the system, or using a micro-stepping driver. Motors with greater number of phases also exhibit smoother operation than those with fewer phases.

Stepper motors operate much differently from normal DC motors, which rotate when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central metal gear. The electromagnets are energized by an external control circuit, such as a microcontroller. To make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet. When the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step." In that way, the motor can be turned a precise angle

#### 2.2.2.1 Unipolar Stepper Motor

A unipolar stepper motor has logically two windings per phase, one for each direction of current. Since in this arrangement a magnetic pole can be reversed without switching the direction of current, the commutation circuit can be made very simple (eg. a single transistor) for each winding. Typically, given a phase, one end of each winding is made common: giving three leads per phase and six leads for a typical two phase motor. Often, these two phase commons are internally joined, so the motor has only five leads.

A microcontroller or stepper motor controller can be used to activate the drive transistors in the right order, and this ease of operation makes unipolar motors popular with hobbyists; they are probably the cheapest way to get precise angular movements. A sample of unipolar stepper motor is shows in figure 2.5.

**Figure 2.5:** Unipolar Stepper Motor

### 2.2.3 Infrared Sensor

IR (Infra-Red) is the typical light source used as a sensor to sense opaque object. The basic principle of IR sensor is based on an IR emitter and an IR receiver. IR emitter will emit infrared continuously when provide power source to it. Since there is no source of power for IR receiver, it would not emit any light. It will only receive infrared if there is any. Figure 2.6 shows how the IR sense objects.

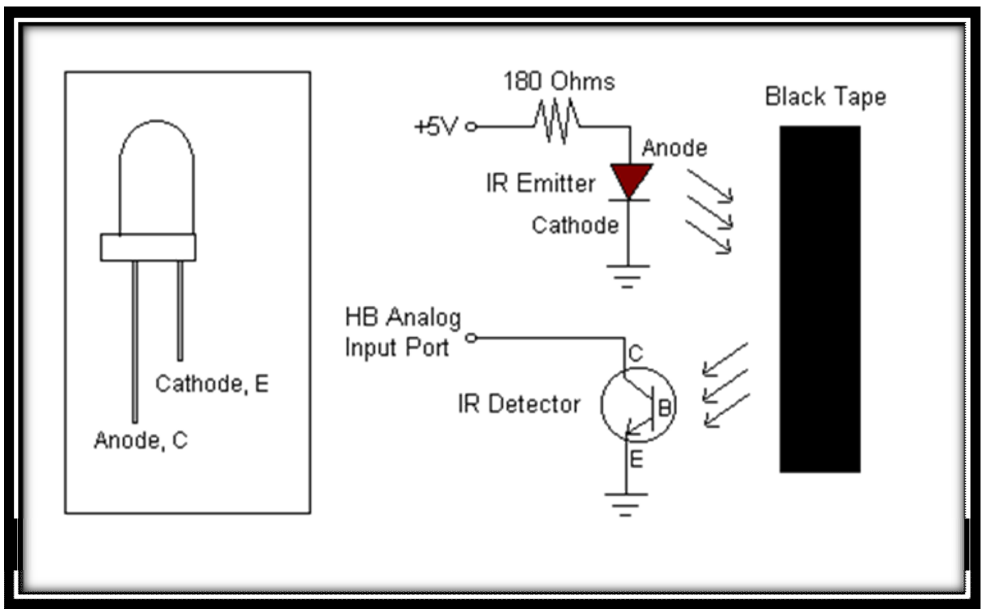


**Figure 2.6:** How IR operation

### 2.2.4 LCD Display

A liquid crystal display (commonly abbreviated LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power.

LCDs with a small number of segments, such as those used in digital watches and pocket calculators, have individual electrical contacts for each segment. An external dedicated circuit supplies an electric charge to control each segment. This display structure is unwieldy for more than a few display elements.