PARKING MONITORING SYSTEM WITH SECURITY SYSTEM FEATURES

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Specially dedicated to

My beloved family and those people who have guided and inspired me

throughout my journey of education

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ABSTRACT

To easily find an unoccupied parking space in larger car park is a problem for many drivers. During the last four-decade, there are many parking models are develop. But, the models still cannot solve the parking problem. Another problem in parking systems is about security systems. The problem is about how to make sure that the car is safe and this kind of problem involves the security systems. Thus, we have to design a system that can help driver to find parking space easily and at the same time the car that has been park is safe. This project is especially design for private parking space and this system is not suitable for open parking space. The parking space will be monitor by magnetic sensors and the security systems is applied when the user enter the password. So, the user must have a password before they can enter the parking space. Some examples of application for this system are at exclusive club, country club and any private places.

ABSTRAK

Untuk mencari kawasan tempat letak kereta yang kosong bukanlah suatu pekerjaan yang mudah kepada setiap pemandu. Selama empat dekad, pelbagai modul tempat letak kereta telah direka dan diaplikasikan. Namun kesemua modul tersebut masih tidak dapat menyelesaikan masalah tersebut. Di samping itu juga terdapat beberapa masalah lain apabila kereta di letak di tempat letak kereta. Masalah tersebut adalah bagaimana untuk memastikan kereta yang diletakkan di situ selamat. Oleh yang demikian kita hendaklah membuat suatu system di mana system tersebut dapat membantu setiap pemandu mudah mencari tempat letak kereta yang kosong dan selamat. Namun begitu, projek ini hanyalah dibuat terutamanya untuk tempat letak kereta yang eklusif dan tidak sesuai untuk tempat letak kereta yang terbuka. Salah satu contoh tempat letak kereta yang peribadi adalah kelab eklusif, country club, dan lain-lain.

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LIST OF ABBREVIATIONS

Component	The description
ADC	Analog to Digital converter
CPU	Central processing unit
CCTV	Close-Circuit Television
CTS	Clear To Send
DAC	Digital to Analog converter
EPC	Electronic product code
ISR	Interrupt Service Routine
MCU	Microcontroller Unit
RF	Radio Frequency
RFID	Radio Frequency Identification
RTS	Ready to Send
OSC	Oscillation
MAC	Medium access control
RAM	Random access memory
ROM	Read only memory
WWW	World wide web
IR	Infra Red

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

To easily find an unoccupied parking space in larger car park is a problem for drivers. It is because the car on the road increases every year especially in town. On the other hand, it is more difficult to find the parking space during peak time and holidays because this is the time people want to release their stress and to spend time with family. There are not many existing solutions attempting to address the problem. Thus, it is useful to have some technical solutions that can provide information on parking space occupancy [1]-[2]. The efficient parking monitoring system must be design to overcome the problem.

During the last four-decade, numerous parking search models have been developed [6]. But, the models still cannot solve the parking problem. In many decision-making situations in transportation (modal split, choice of air carrier, choice of airport, etc.) the competitive alternatives and their characteristics are reasonably well known in advance to the decision maker (passenger, driver). On the other hand, the drivers usually discover different parking alternatives one by one in a temporal sequence. Clearly, this temporal sequence has a very strong influence on the driver’s final decision about the parking place [7].

Vehicle detection technology has evolved quite a bit in the last couple decades. From the air hoses to inductive loops embedded in roadways, most legacy detection methods were concentrated on getting vehicle presence information to a decision making set of control systems [1-5]. Today we want so much more information, and such information is about speed or direction of traffic, the quantity of the vehicle per time on a stretch of pavement and so on as an example.

When the driver has park their car at car parking space, there are another problem will occur. The problem is about how to make sure the car is safe and these kinds of problem involve the security systems. All drivers want to have a comfortable parking place with security when park their car. Thus, we have to design a system that can help driver to find parking space easily and at the same time the car that has been park is also safe.

The title of this project is “Parking monitoring system with Security system Features”. This project is design to overcome the problem in car parking space at private place such as Condominium, Country clubs (a club with sporting and social facilities), exclusive club and so on. It is because this place is privacy and need more security compare to the public parking space.

Generally, the system will consist of several electronic components such as magnetic field sensors, a microcontroller, servo motor, the gate itself, and sensor. Nowadays, there are so many sensors in the market. From the report of “sensor market 2008”, there are about ten most popular sensors develop today. The sensors are Temperature sensors, Pressure sensors, Flow sensors, Binary position sensors (proximity switches, light barriers), Position sensor, Chemical sensors for measurement in liquids, Level sensors, Speed sensors, Chemical sensors for measurement in gasses, Flue gas and Fire detectors sensors.

Magnetic field sensors will use in this project and it is a main part of the parking monitoring system. Another element consist in this system is about security system. The magnetic field sensor is choose because this sensor has more reliability and can be apply at many fields. Even this sensor is still new, it become more popular form a day to another because of it application. For the example, it can be applied at Automatic Door/gate opening, Railroad Crossing Control (for trains), Parking Meters, Drive through retail (Banking, Fast-Food, etc.) and so on.

Magnetic field sensor will be attached with microcontroller as brain of this system. The sensor is design to detect the car at the car park and sent 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 microcontroller in order to identify and monitor the car parking space before someone is given to enter the car park.

For the security system features in this project, it will design only for basic security. It is means that, the user only have to put or key in their password and the gate will open. If the password is wrong, then the gate will remain close.

This final project is divided into 3 main sections:-

(1) Electronic design consists of Microcontroller design integrated with Magnetic Field sensors.

(2) Develop Software to detect the vehicle at car park and at the gate. Besides that develop basic program of security system.

(3) Mechanical design consists of gate model and motor to control the open and closed gate.

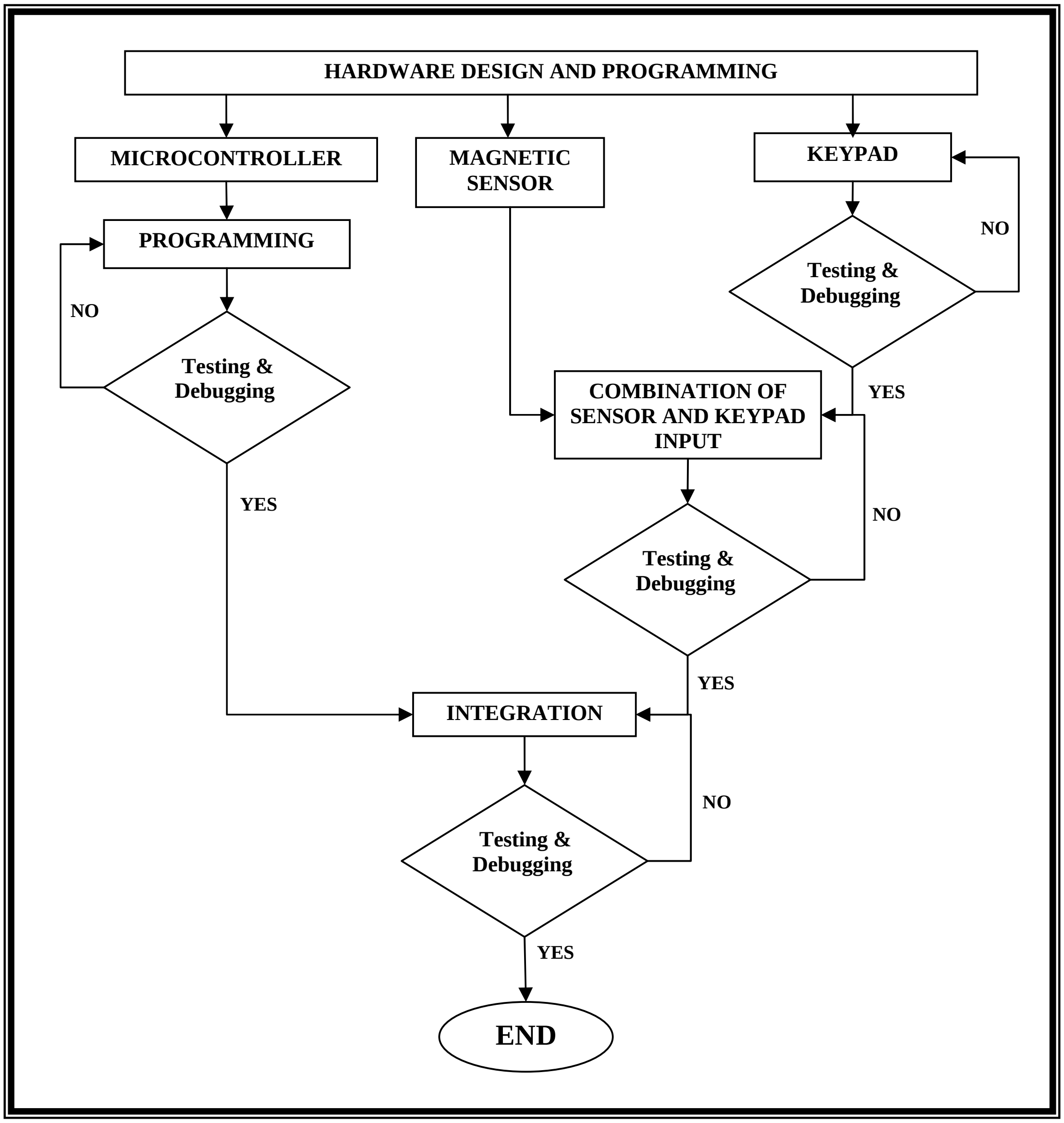

Figure 1.0: Product Flow for the whole project

1.2 OBJECTIVES

1.2.1 To explore the function of Magnetic Field Sensor

This sensor is still new in the market and it doesn’t include in syllabus. A deep understanding about Magnetic Sensor is needed before this sensor technology can be applied into any system.

1.2.2 To develop a model of Parking Monitoring System with Security System Features

The main objective is to develop Parking Monitoring System using Magnetic Field sensors. In this project, the sensor will be attached to a microcontroller. Everything regarding of this system such as flow of system and etc is controlled totally by microcontroller. A model of parking system will be build integrated with microcontroller and Magnetic Field Sensor.

1.3 PROJECT SCOPE

The main goal of this project is develop a parking monitoring system using Magnetic Field sensor technology. There is 2 scope will be cover in this project. Firstly is to use appropriate Magnetic Sensor for this application. Secondly is to design a model of parking monitoring system using microcontroller combined with sensor and keypad include to the system.

1.3.1 Use appropriate Magnetic field sensor

There is lots of sensor in the market. Not only brand, but also the applications of the sensor itself need to be considered. This sensor will then interface with micro-controller and the result will display at the LCD Display. The LCD then shows the result of parking space available.

1.3.2 Develop a model of Parking Monitoring system by using Magnetic field sensor with Security system features

Because this system will be applied at entrance of building or area, a model of car park with monitoring system and entrance gate will be build. In general, when a person key in the password, the magnetic field sensor will send the data to microcontroller then the data will be processes either access will be given or not to the owner of the password. If yes, the gate will automatically open and at the same time the LCD will display an unoccupied parking space. If the parking lot is full, the gate will not open. Besides that, if the password is wrong, the gate will remain closed.

1.4 THESIS OVERVIEW

This “Parking monitoring system with security system features” 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 Parking monitoring system with security system features. Everything related to the project will be describe generally in this chapter

Chapter 3 will be focused on hardware design of the Parking Monitoring System. This chapter included six 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

2.0 INTRODUCTION

Parking Monitoring System with Security System Features is design especially for private places. The main part of this project is sensor. It is about how to manipulate Magnetic field sensors as an indicator to detect the car in the parking monitoring system. This system consists of three modules which are **Sensors 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.

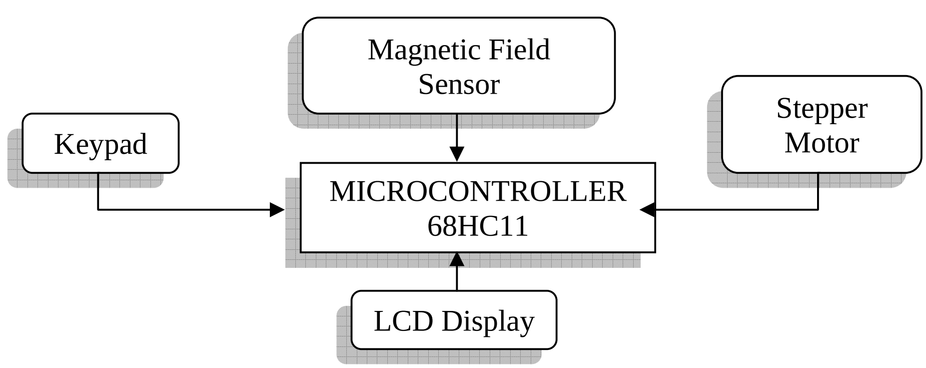

Figure 2.0: Overall System of Parking Monitoring System with Security System Features.

2.1 SENSOR MODULE

2.1.1 Sensors Overview

Today’s cities are increasingly congested by cars. In average, a considerable part of a drive is spent by searching for an unoccupied parking space. The impact on environment, living quality and national economy is considerable since fuel is consumed, exhaust gas is produced and time is spent unnecessarily [1]-[5].

Finding an unoccupied parking space in the maze of a downtown area often works on a trial-and-error basis. Time needed and distance to drive could be significantly reduced if drivers were directed to an unoccupied parking space. First system indicating the remaining capacities of car parks are operational and there are visions of on board navigation systems guiding the driver to the next unoccupied parking space [1], [3].

All those systems require reliable information about occupancy situation in car parks. Currently there are two common approaches to detect whether there are unoccupied parking spaces: inductive loops and ultrasonic sensors [2], [3], [6].Parking is the act of stopping a vehicle and leaving it unoccupied for more than a brief time. It is against the law virtually everywhere to park a vehicle in the middle of a highway or road; parking on one or both sides of a road, however, is commonly permitted. Parking facilities are constructed in combination with most buildings, to facilitate the coming and going of the buildings' users.

There is no specific solution to the parking space problem. Every problem should have the different method to solve. The more popular systems in place today are the pre-trip parking, lot-specific parking, aisle-specific parking, and reservation parking. Pre-trip parking consists of using maps of a certain area before arrival to learn where available parking is located. Lot-specific parking information system uses sensors which relay information to a main board/map that shows which parts of the parking lot are open. The aisle-specific parking is very much like the lot-specific parking except that it is used for parking garages. Lastly is the parking reservation system, which allows customers to pre-rent a parking spot before they arrive to save time (“APMS- What Are They”) [8].

Furthermore, nowadays, an efficient parking system is important for business man. In addition most “Business is continually striving to upgrade their service and increase their return on investment. It is therefore not surprising that the quality or parking lots is increasing in importance”. In order for a business such as a mall to maximize revenue and profits, it is vital that the parking lot be efficient for shoppers because a business with “in efficient parking facilities could lose hundreds of thousands of proud in retail business every year” [8].

Today, inductive loops prevail in detecting moving traffic. An alternating magnetic field is applied, which is affected by the conductivity of metallic objects. The change of the Impedance of the loop is evaluated and used for the detection of a vehicle. Since this technique requires a moving vehicle, the occupancy status of a parking space cannot be observed directly. Instead, the number of cars in a car park, or in a section of it, is determined by monitoring the entrance and exit lanes. The durability, the considerable installation effort and the energy consumption are further major drawbacks in the employment of inductive loops [1], [6].

A sensor is a type of transducer. Direct-indicating sensors, for example, a mercury thermometer, are human-readable. Other sensors must be paired with an indicator or display, for instance a thermocouple. Most sensors are electrical or electronic, although other types exist. Sensor will be use to monitor the parking space whether it is free or full. There are many types of sensor nowadays. For the example magnetic field sensor, thermal sensor, electromagnetic sensor, optical sensor and so on.

Ultrasonic sensors are capable of determining whether a specific parking space is occupied or not. Since they need a direct line-of-sight to the parked car or to the empty parking pace and are hard to protect against dust, accidental damage or vandalism, the only feasible position for those sensors is the ceiling directly above the area to be monitored. Thus, ultrasonic sensors can only be used in multi-story car parks. There is no possibility to monitor the occupancy situation of a single parking space without a ceiling above [1], [3], [7].

2.1.2 Magnetic Field Sensor

Magnetic sensors have been in use for well over 2,000 years. Early applications were for direction finding, or navigation. Today, magnetic sensors are still a primary means of navigation but many more uses have evolved. The technology for sensing magnetic fields has also evolved driven by the need for improved sensitivity, smaller size, and compatibility with electronic systems. An integrated circuit based magnetic sensor, optimized for use within the earth’s magnetic field, will be presented—anisotropic magneto resistive (AMR) sensors. Applications using AMR magnetic sensors are emphasized [1]-[12].

The main part of this project is to monitoring the car parking space by using magnetic field sensor. The Honeywell`s Anisotropic Magneto-Resistive (AMR) sensors will be use for this project. This sensor is an upgrade from the older and simpler vehicle detection systems. With the small size and simplicity of these whetstone bridge based sensors, many applications are now able to deploy many of these sensors cost-effectively, and gain more information on nearby vehicles.

Appealing to the fact that almost all road vehicles have significant amounts of ferrous metals in their chassis (iron, steel, nickel, cobalt, etc.), magnetic sensors are a good candidate for detecting vehicles. Today, most magnetic sensor technologies are fairly miniature in size, and thanks to solid state technology, both the size and the electrical interfacing have improved to make integration easier [1]-[8].

But not all vehicles emit magnetic fields that magnetic sensors could use in detection. This fact eliminates most “high field” magnetic field sensing devices like Hall Effect sensors. But mother-nature provides us with earth’s magnetic field that permeates everything between the south and north magnetic poles. The earth’s magnetic field is around a half-gauss in magnetic flux density; so “low field” magnetic sensors are used to pickup this field, and also the field disturbances that nearby vehicles will create.

2.1.3 Magnetic Fields Sensor Application

Typical vehicle detection applications using magnetic sensors and earth`s field are:

a) Railroad Crossing Control (for trains)
b) Drive through Retail (Banking, Fast-Food, etc.)
c) Automatic Door/Gate opening
d) Traffic monitoring (Speed, Direction)
e) Parking Lot Space Detection
f) Parking Meters

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 Keypad
2.2.3 Stepper Motor
2.2.4 LCD Display
2.2.5 Infrared Sensor
2.2.6 HMC1021Z Magnetic field sensor

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.

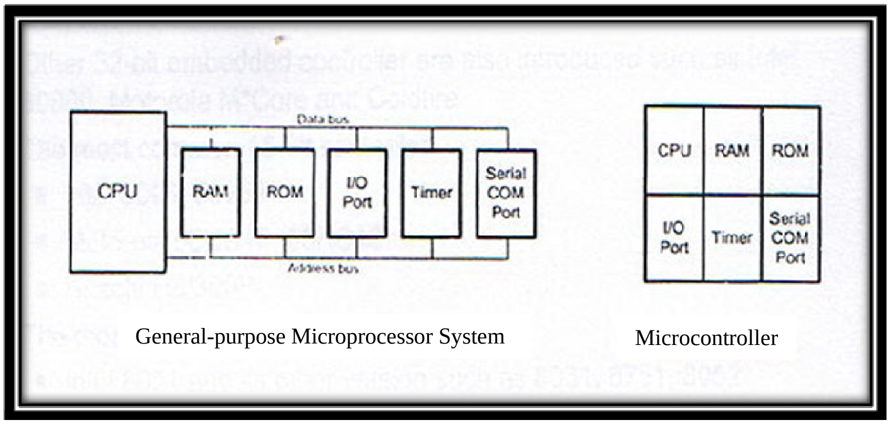

Figure 2.1: Microprocessor versus microcontroller

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.

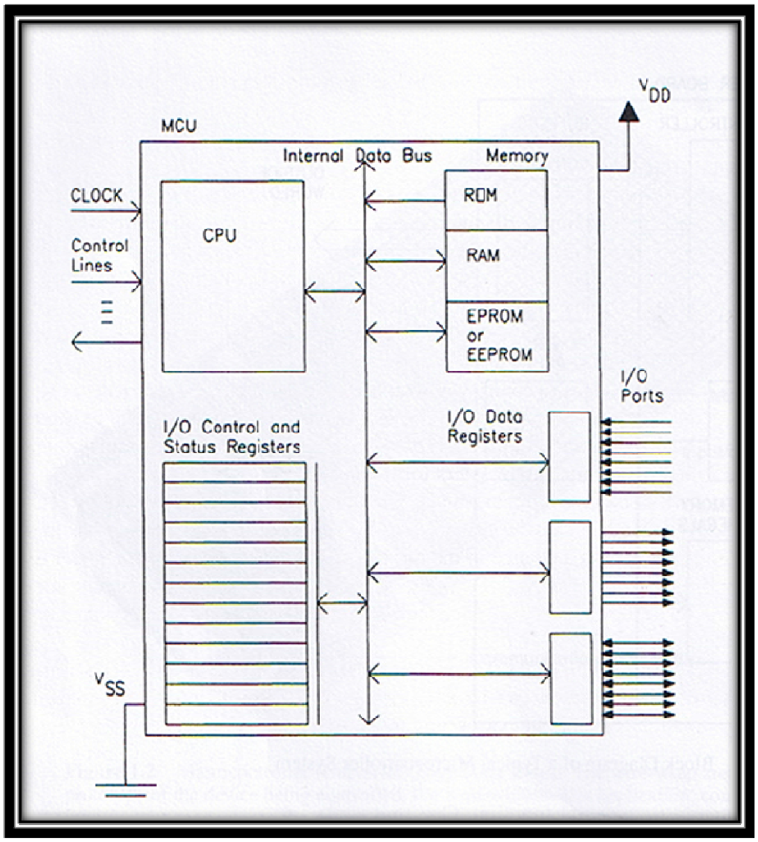

Figure 2.2: Block diagram of a Typical Microcontroller in a Single-Chip Mode.

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.

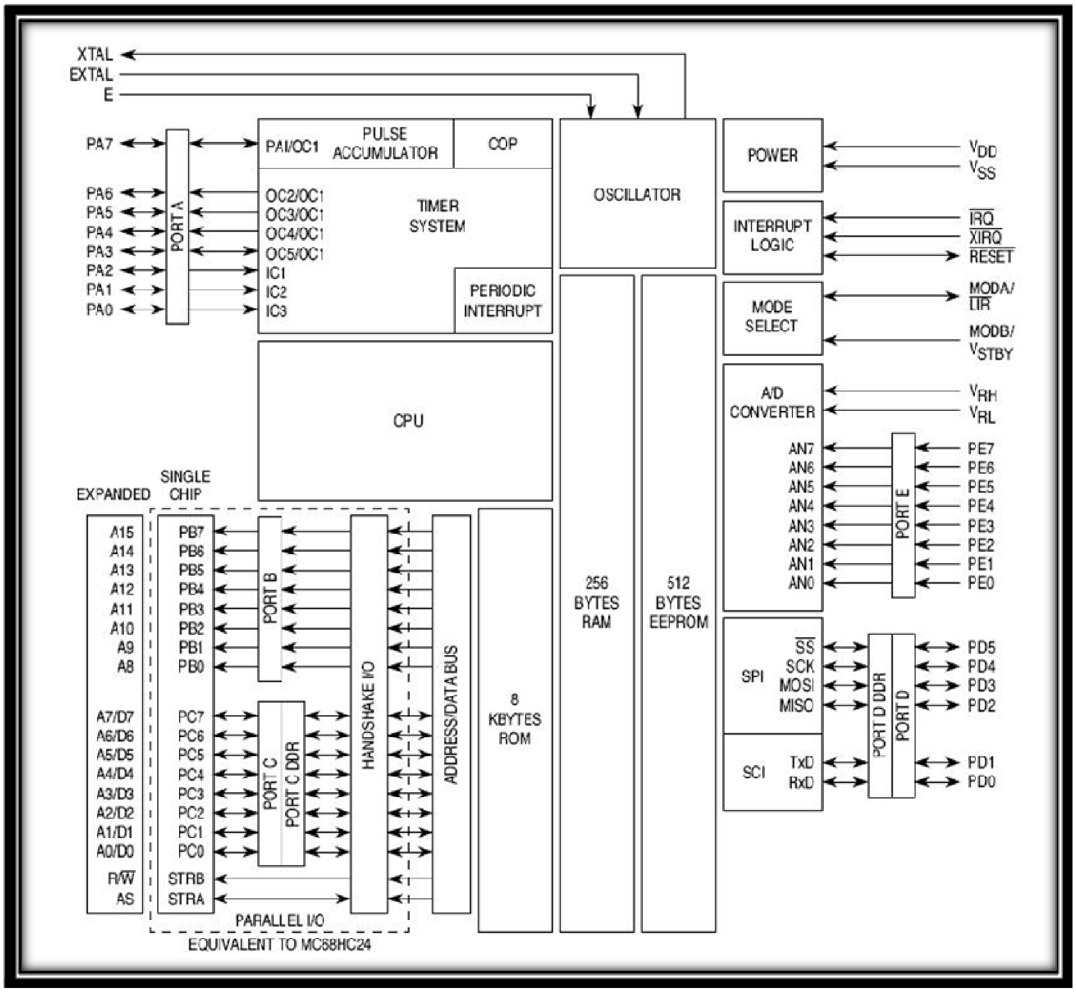

Figure 2.3: 68HC11 Architecture

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 Keypad

A keypad is a set of buttons arranged in a block which usually bear digits and other symbols but not a complete set of alphabetical letters. If it mostly contains numbers then it can also be called a numeric keypad. Keypads are found on many alphanumeric keyboards and on other devices such as calculators, combination locks and telephones which require largely numeric input.

A computer keyboard usually contains a small numeric keypad with a calculator-style arrangement of buttons duplicating the numeric and arithmetic keys on the main keyboard to allow efficient entry of numerical data. This number pad (commonly abbreviated to "numpad") is usually positioned on the right side of the keyboard because most people are right handed.

Many laptop computers have special function keys which turn part of the alphabetical keyboard into a numerical keypad as there is insufficient space to allow a separate keypad to be built into the laptop's chassis. Separate plug-in keypads can be purchased.

By convention, the keys on calculator-style keypads are arranged such that 123 are on the bottom row. In contrast, a telephone keypad has the 123 keys at the top. It also has buttons labeled * (star) and # (number sign, "pound" or "hash") either side of the zero. Most of the keys also bear letters which have had several auxiliary uses, such as remembering area codes or whole telephone numbers.

The keypad of a calculator contains the digits 0 through 9, together with the four arithmetic operations, the decimal point and other more advanced functions. Keypads are also a feature of some combination locks. This type of lock is often used on doors, such as that found at the main entrance to some offices. Figure 2.5 is a sample of keypad 4×4 which widely used in various applications.

Figure 2.5: Keypad 4×4

2.2.3 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

2.2.3.1 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 2.6.

Figure 2.6: Unipolar Stepper Motor

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.

2.2.4.1 JHD162A LCD Display

The JHD162A dot-matrix liquid crystal display controller and driver LSI displays alphanumeric, Japanese kana characters, and symbols. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4- or 8- bit microprocessor. Since all the functions such as display RAM, character generator, and liquid crystal driver, required for driving a dot-matrix liquid crystal display are internally provided on one chip, a minimal system can be interfaced with this controller/driver.

A single JHD162A can display up to one 8-character line or two 8-character lines. The JHD162A has pin function compatibility with the HD44780U which allows the user to easily replace an LCD-II with a JHD162A. The JHD162A character generator ROM is extended to generate 208 5×8 dot character fonts and 32 5×10 dot character fonts for a total of 240 different character fonts. The low power supply (2.7V to 5.5V) of the HD44780U is suitable for any portable battery-driven product requiring low power dissipation. A sample of LCD display is in figure 2.7 below.

Figure 2.7: 2 lines (8 character) JHD162A LCD display

2.2.5 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 2.8 shows how the IR sense objects.

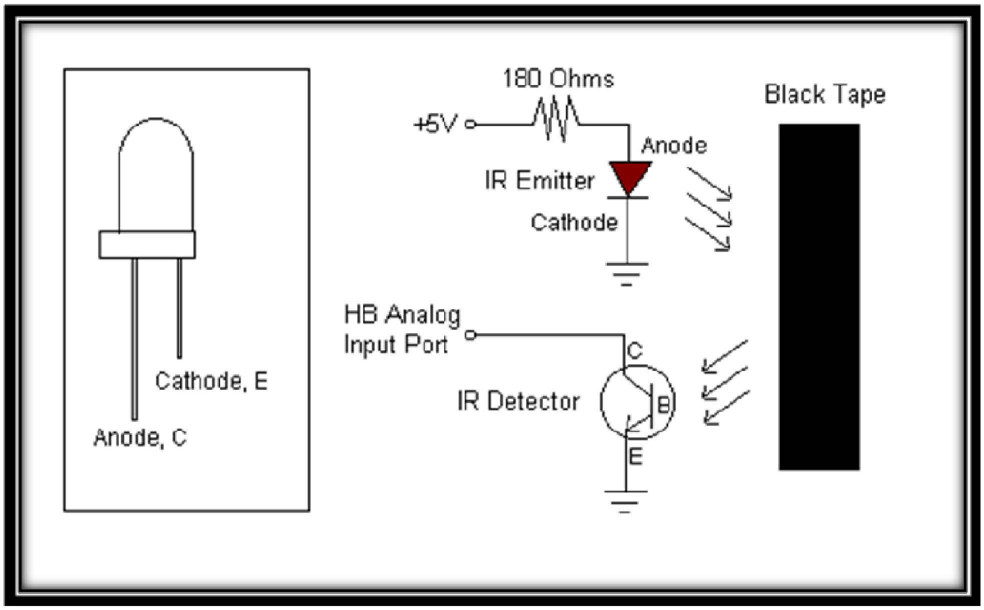

Figure 2.8: How IR operation

2.2.6 HONEYWELL HMC1021Z Magnetic field sensor

Actually, it is not easy to find an appropriate magnetic field sensor in the market nowadays. It is because of the sensor is still new develop and hard to find in the market. Honeywell is one of the companies that produce magnetic field sensor. There are a lot of model and specification of magnetic sensor produce by this company such as HMC1022, HMC1052L, HMC1021S and so on.

The HMC1021Z is the one single axis magnetic field sensor that will be used in this project. The cost to buy one magnetic sensor is still too high and as a result only one magnetic sensor is use. There are many parts of circuit to be design before the magnetic sensor can be use.

The first part is the hardware itself. The designer must to make sure that the connection of the hardware is correct. The second part of magnetic sensor is SET/RESET Strap driver circuit. The Set/Reset driver is important to activate the sensor ON and detect the car. After that the driver circuit will set it to the origin. Figure 2.9 and 2.10 below are the example of magnetic circuit and the actual hardware of HMC1021Z.

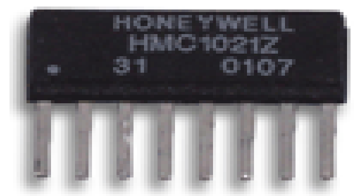

Figure 2.9: Actual hardware of HONEYWELL 1021Z

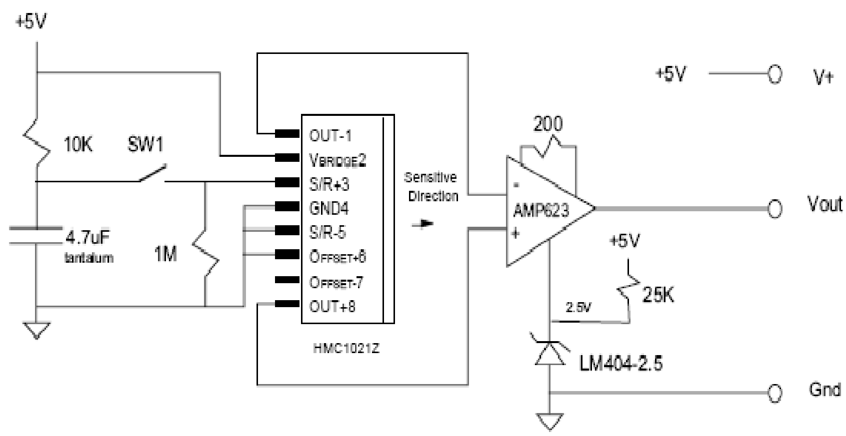

Figure 2.10: Simple circuit combining with zener diode

2.3 SOFTWARE MODULE

2.3.1 WP11

WP11.EXE is a Windows program that is used to program 68HC11 microcontrollers by controlling hardware that supports the special bootstrap mode of these devices. WP11 uses a serial port to communicate with the programming hardware, which can be the P11 board, or any circuit that uses the HC11 special bootstrap mode.

WP11 is usually started from the “START” menu of your Windows PC or by double clicking on the WP11.EXE file name from within Windows Explorer. This program can be used with any programming hardware that has the capability to boot

HC11 chips into the bootstrap mode and has the required programming voltages and a serial port interface available. Figure 2.11 shows the interface of WP11 software.

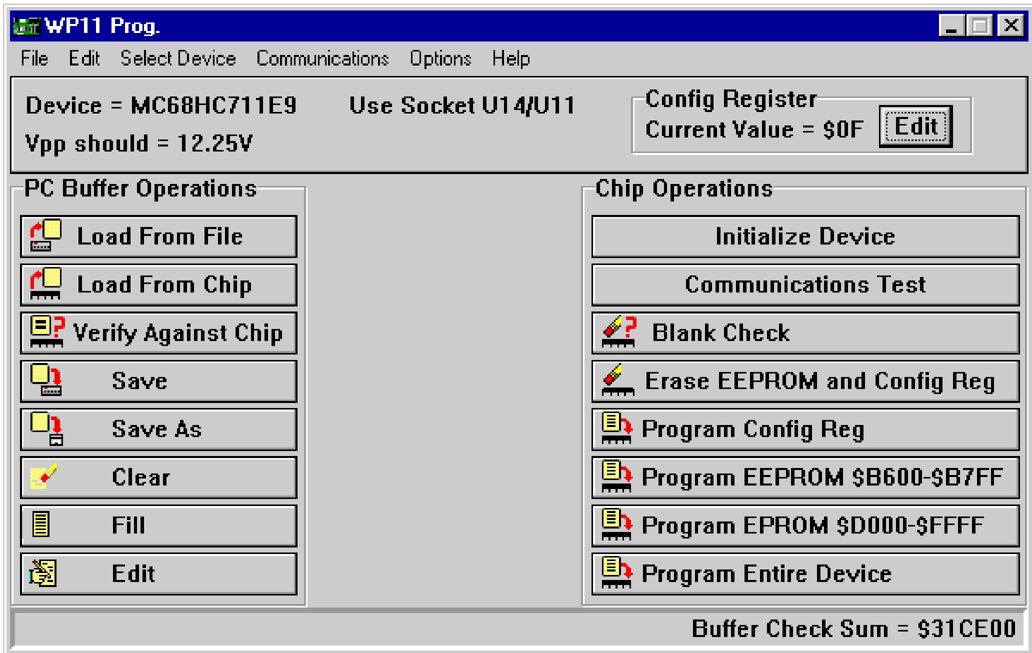

Figure 2.11: Interface of WP11

WP11 is am simple and ready to use without install it. By using WP11, 68HC11 can be easily programmed through serial port. Besides of program, WP11 can initialize circuit before programmed it. For example if initialize error, meaning that there is exist error in connection or maybe the 68HC11 is damage. Once it pass the initialize check, then it can process to other configuration.

2.3.2 THRSim11

The Motorola 68HC11 microcontroller is a popular microcontroller used in many applications. The THRSim11 program is design to edit, assemble, simulate and debug programs for the 68HC11 on windows PC. Figure 2.12 shows the interface of THRSim11 software. The simulator can simulate the CPU, ROM, RAM, and all memory mapped I/O ports. It also simulates the on board peripherals such as:

a) timer (including pulse accumulator),

b) analog to digital converter,

c) parallel ports (including handshake),
d) serial port,
e) I/O pins (including analog and interrupt pins).

THRSim11 can communicate with the Motorola EVM and assembly program is loaded into the target boar, the graphical user interface makes it possible to view and control every register (CPU registers and I/O registers) and memory location (data, program, and stack) of the real microcontroller. It is possible to stop the execution at any address and inspect or change the registers and memory. For example: stop when RxD becomes low and RAM location $003F contains $BD or I/O register TCNT is greater than $3456. A number of (simulated) external components can be connected to the pins of the simulated 68HC11 while debugging. For example:

a) LED's,
b) switches,
c) Analog sliders (variable voltage potential).
d) Serial transmitter and receiver.

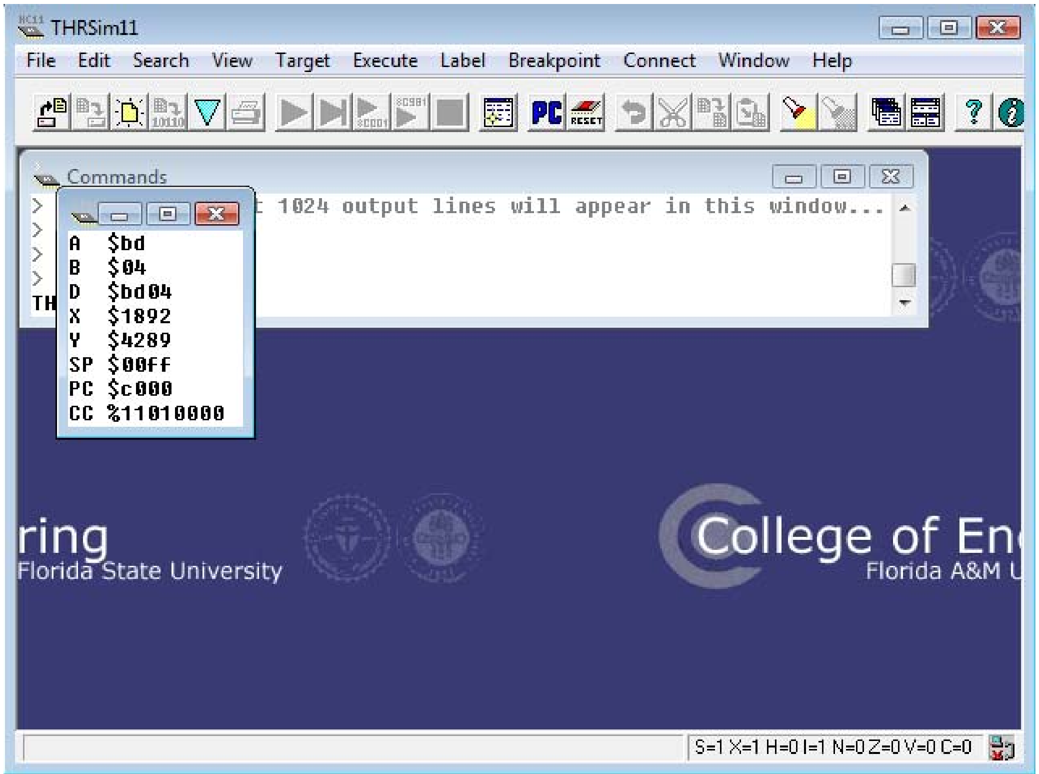

Figure 2.12: Interface of THRSim11

2.3.3 Proteus VSM

Proteus Virtual System Modeling (VSM) combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. For the first time ever, it is possible to develop and test such designs before a physical prototype is constructed.

This is possible because it can interact with the design using on screen indicators such as LED and LCD displays and actuators such as switches and buttons. The simulation takes place in real time (or near enough to it): a 300 MHz Pentium II can simulate a basic 8051 system clocking at over 12MHz. Proteus VSM also provides extensive debugging facilities including breakpoints, single stepping and variable display for both assembly code and high level language source.

The VSM architecture allows additional animated models to be created by anyone, including end users. Whilst many types of animated model can be produced without resort to coding, a documented interface has been provided for developers to write their own models packaged as Windows DLLs. These models can implement purely electrical behavior or combine this with graphical behavior so that almost any kind of application specific peripheral can be simulated. Figure 2.13 shows the basic interface of Proteus VSM software.

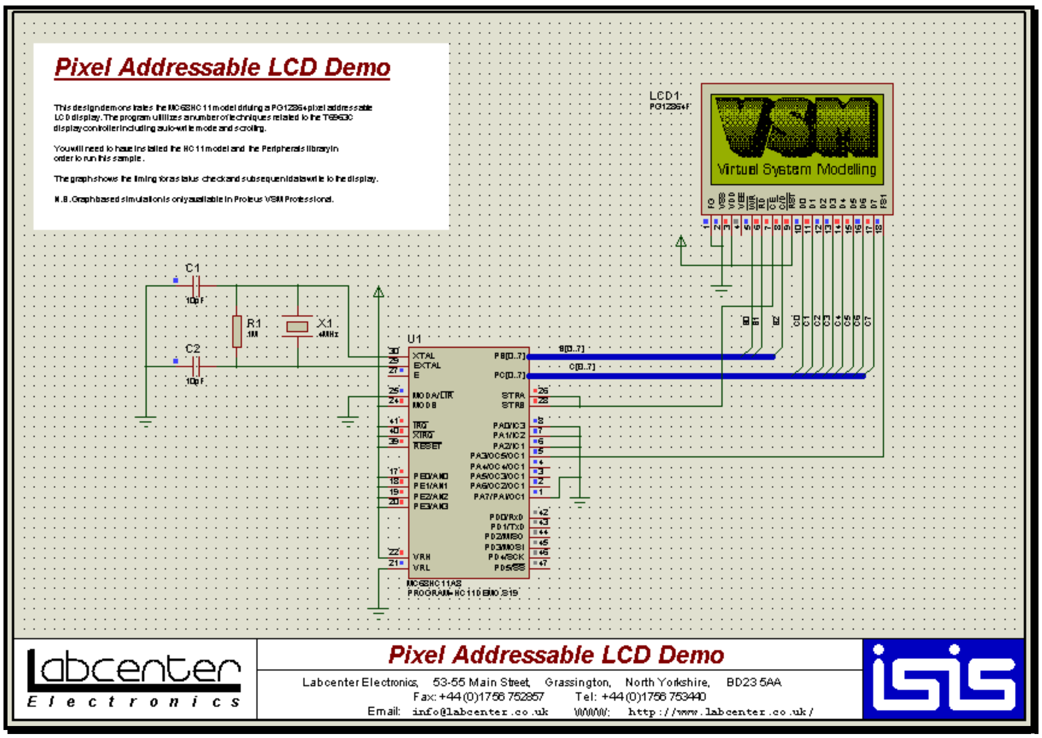

Figure 2.13: Interface of Proteus 7

CHAPTER 3

HARDWARE DESIGN

This chapter will discuss more details about hardware part involved for project “Parking Monitoring System with Security System Features”. This project contains microcontroller, keypad, LCD display, and the main part is Magnetic field sensor. Figure 3.0 and 3.1 shows the actual hardware and full circuit design.

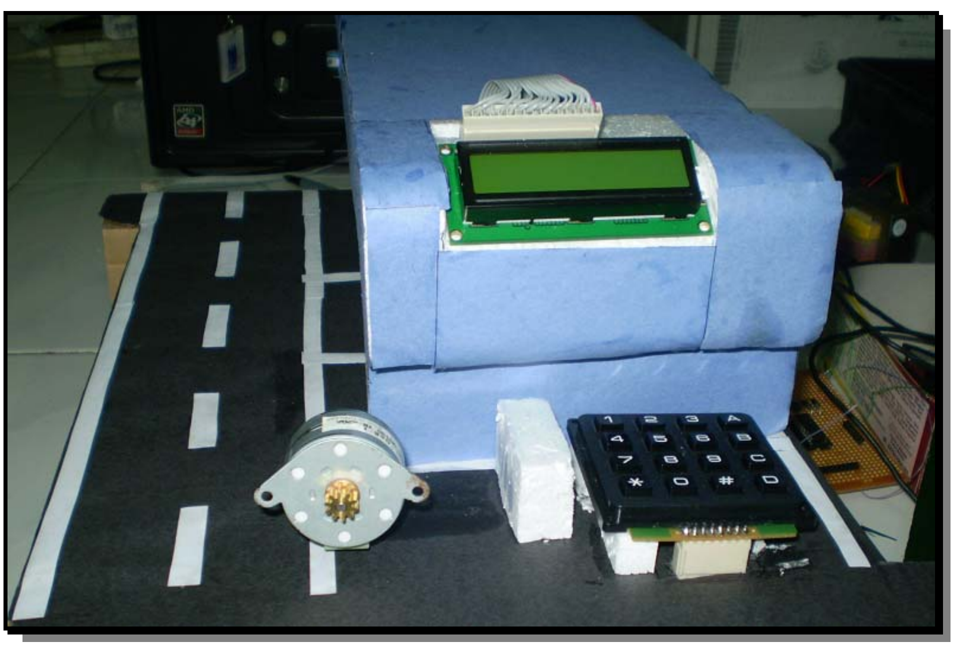

Figure 3.0: Actual hardware

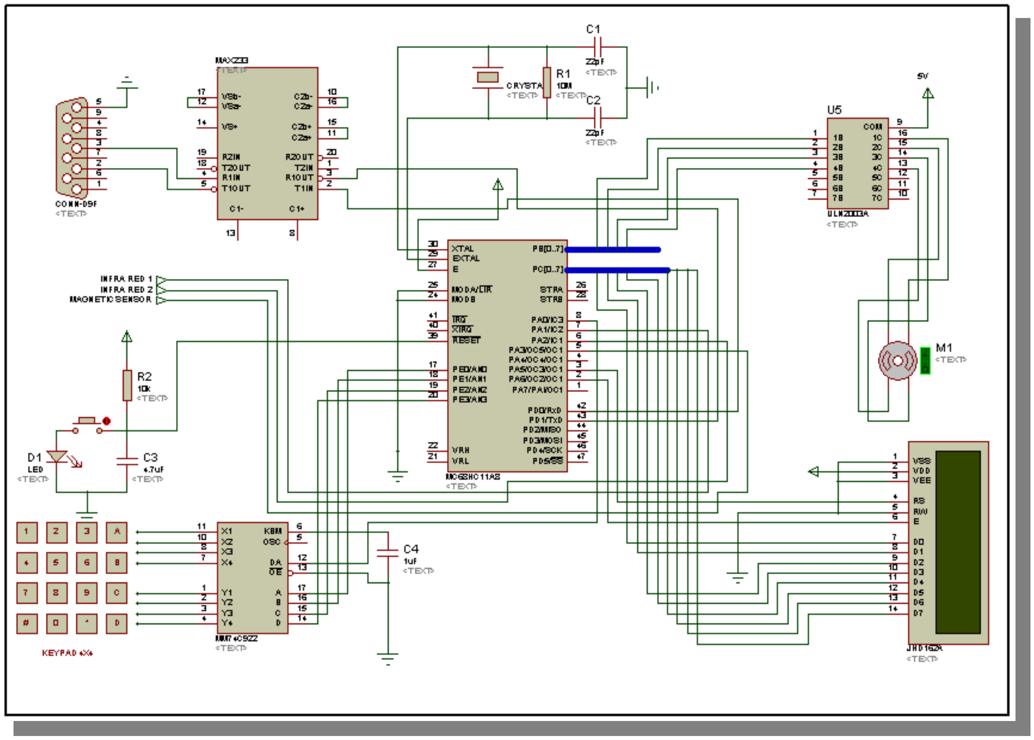

Figure 3.1: Full circuit design

3.1 MICROCONTROLLER BOARD DESIGN

Under this subtopic, there will be discussing about basic connection of MC68HC11. To operate MC68HC11, it needs four basic circuit integrated with it which are Clock circuit, Power circuit, Reset circuit and RS232 circuit through EIA232 module as shown in figure 3.2.

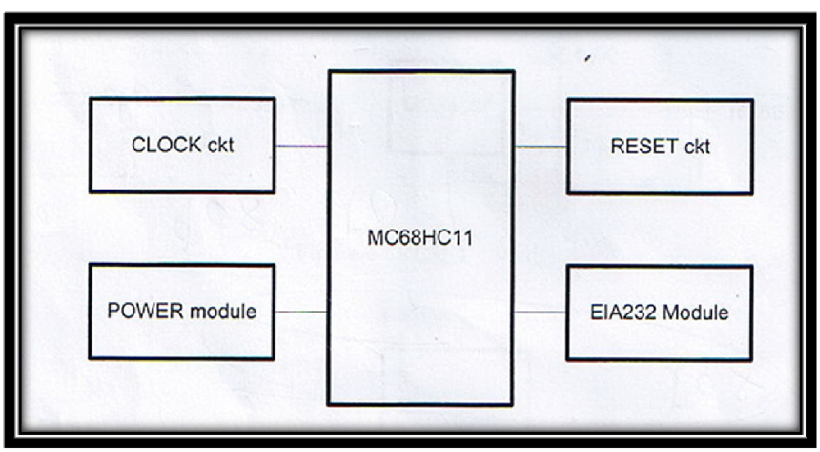

Figure 3.2: A simplified block diagram of MC68HC11-based system

3.1.1 Single-Chip Operating Mode

Figure 3.3 shows the connection for single-chip operating mode or commonly called bootstrap mode. As implied by the name of single chip, only one chip is required. There is no need extra memory or I/O chips. Hence an external bus is not required. In single-chip mode, ports B and C and strobe pins A (STRA) and B (STRB) are available for general-purpose parallel input/output (I/O). In this mode, all software needed to control the MCU is contained in internal resources. If present, read-only memory (ROM) and/or erasable, programmable read-only memory (EPROM) will always be enabled out of reset, ensuring that the reset and interrupt vectors will be available at locations $FFC0–$FFFF. Using single-chip mode results in cost saving, and it improves reliability because it minimizes the use of external connections, which can be subject to failure.

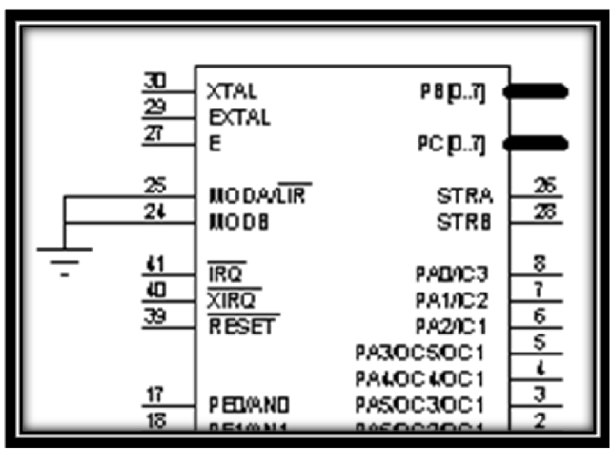

Figure 3.3: Single-chip operating mode connection

3.1.2 Reset Circuit

RESET is a power-on reset signal. When the push button is not pressed, the 47K pull-up resistor keeps the signal high. Pressing the push button causes the pin to be pulled low, thus forcing a reset. A bidirectional control signal, RESET, acts as an input to initialize the MCU to a known startup state. It also acts as an open-drain output to indicate that an internal failure has been detected in either the clock monitor or computer operating properly (COP) watchdog circuit. Figure 3.4 show reset circuit connection to 68HC11.

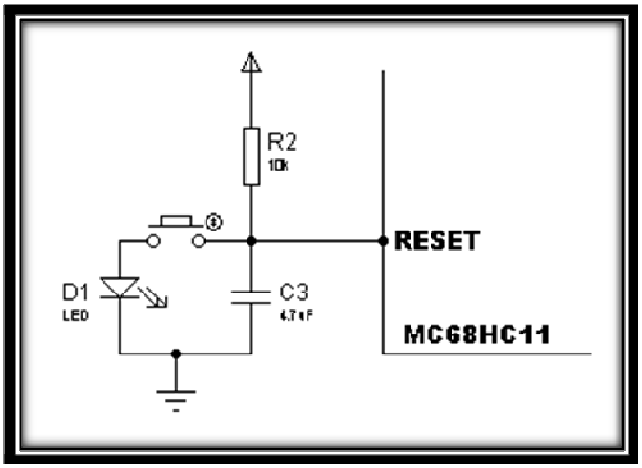

Figure 3.4: Reset circuit

3.1.3 Clock Circuit

The clock signal is periodic sequence of pulses. It is not necessary a square wave, although it resembles one. The 68HC11 can generate its own internal clock signal. A crystal is connected to the crystal pins (XTAL and EXTAL) as shown in figure 3.5. The internal clock frequency is one-fourth of that supplied to the crystal pins. A typical system designed for maximum clock frequency uses an 8 MHz crystal.

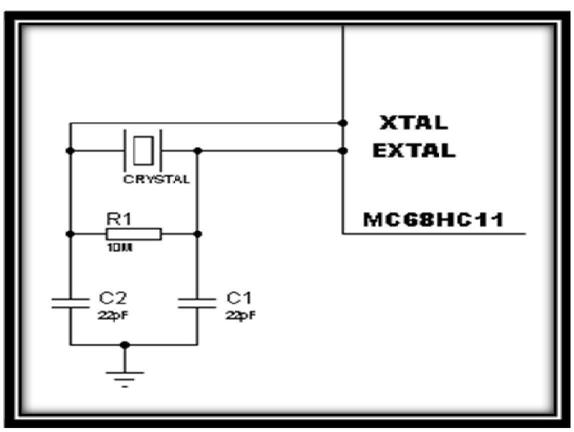

Figure 3.5: Clock circuit

3.1.4 Line Driver: RS-232

The 68HC11A1 provides two pins (TxD and RxD) to be used specifically to transfer and receive data serially. Since the pins are TTL compatible, they require line driver to allow data to be transmitted at a longer distance. The most common line drivers are RS-232, RS422 and RS423. However, RS-232 (EIA 232) is widely used as it s the simplest and the cheapest line driver. Some examples of the ICs that provide the EIA-232 line driver are MAX 233, MAX 232 and MC145407. For this project, MAX 233 is used as it line driver.

EIA-232 line driver is widely used for serial interface standard. Logic ‘1’ is represented by -30 to -25 V and logic “0” is +3 to +25 V allowing the communication to be up to 10 meter. There are two type of RS232 connectors; DB-25 and DB-9. Figure 3.6 shows the pin and the description for DB-9 female connector.

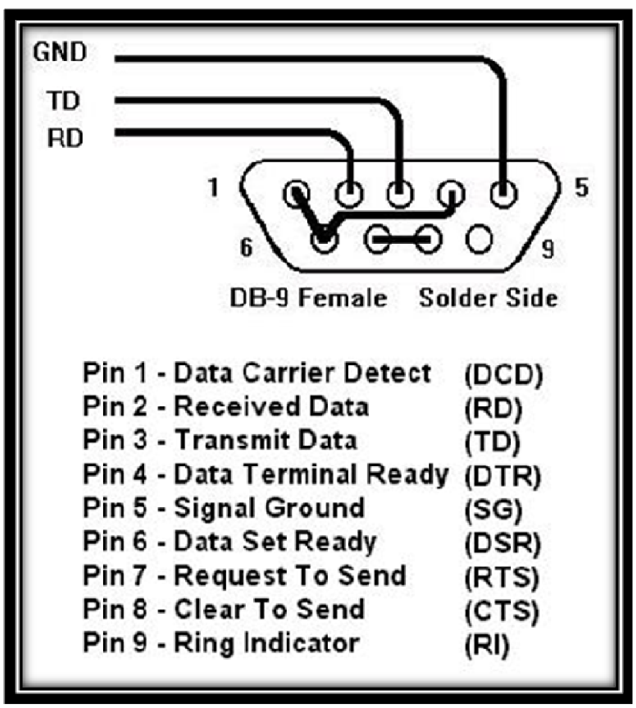

Figure 3.6: Pin and description for DB-9.

In this project, serial communication will be used for two purposes. One of it is for programmed the 68HC11. Using software WP11, 68HC11 can be easily program and reprogram through serial communication. This is much easier compare to PIC microcontroller, which need programmer to program the PIC chip. This will be discus more in chapter 5. The second function of serial is for transmitting data from RFID reader to 68HC11. Figure 3.7 show the actual hardware of DB-9 female connector.

Figure 3.7: DB-9 female connector

3.2 HONEYWELL HMC1021Z Magnetic field sensor

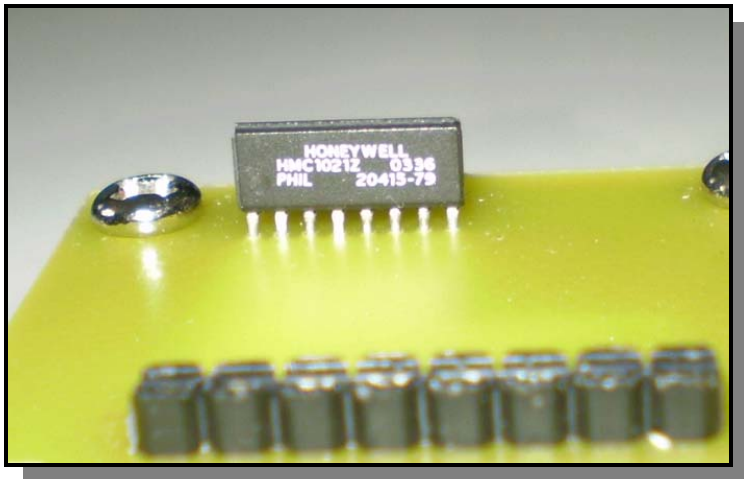

Figure 3.8: The actual hardware HMC1021Z

The HMC1021Z is a single-axis magneto resistive sensor in an 8-pin SIP package. Field range is +/-6 gauss, resolution is 85 micro gauss and sensitivity is 1mV/V/gauss. This sensor used as a single-axis sensor or with an HMC1022 for three-axis applications. The actual size of the sensor is 10 x 77mm and it is very small to integrate to the independent board. The actual hardware is show on figure 3.8 above.   .

There are some features that can be use as a reference. The HMC1021Z is wide field range. The field range is up to ±6 gauss, (earth's field = 0.5 gauss) Small Package: Designed for 1- and 2-axis to work together to provide 3-axis (x, y, z) sensing. The 1-axis part in 8-pin SIP or 8-pin SOIC or a ceramic 8-pin DIP package. 2-axis part in a 16-pin or 20-pin SOIC package. Solid State: These small devices reduce board assembly costs, improve reliability and ruggedness compared to mechanical fluxgates. On-Chip Coils: Patented on-chip set/reset straps to reduce effects of temperature drift, non-linearity errors and loss of signal output due to the presence of high magnetic fields. Patented on-chip offset straps for elimination of the effects of hard iron distortion.

The HMC1021Z is cost effective because the sensors were specifically designed to be affordable for high volume OEM applications.

3.3 LCD DISPLAY

Most LCD conforms to a standard interface. A 14-pin access is provided having eight data lines, three control lines and three power lines. The connections are laid out in one of two common configurations either two rows of seven pins or single rows of 14 pin. The function of each of the connection is shown in Table 3.0.

Table 3.0: Function of each connection of LCD

Pin No.	Name	Function
1	Vss	Ground
2	Vdd	+ve supply
3	Vee	Contrast
4	RS	Register Select
5	R/W	Read/Write
6	E	Enable
7	D0	Data Bit 0
8	D1	Data Bit 1
9	D2	Data Bit 2
10	D3	Data Bit 3
11	D4	Data Bit 4
12	D5	Data Bit 5
13	D6	Data Bit 6
14	D7	Data Bit 7

Pin 1 and 2 are the power supply lines, V_{ss} and V_{dd}. The V_{dd} pin is connected to the positive supply and V_{ss} to the ground as shown in figure 3.13. Pin 3 is a control pin, V_{ee} which is used to alter the contrast of the display. Pin 4 is the Register Select (RS) line, the first of the three command control inputs. When this line is low, data bytes transfer to the display are treated as command, and data bytes read from the display indicates its status. By setting the RS line high, character data can be transferred to and from the LCD.

Pin 5 is the Read/Write (R/W) line. This lined is pulled low in order to write commands or character to the LCD, or pulled high to read character data or status information from its registers. In this project, R/W line is connected to ground as it only is used for transmitted data from 68HC11 to LCD. Pin 6 is the Enable (E) line. This input is used to initiate the actual transfer of commands or character data between the LCD and data lines. When writing to the display, data is transferred only on the high to low transition of this signal. However, when reading from the display, data will become available shortly after the low to high transition and remain available until the signal falls low again. Pin 7 to 14 are the eight data bus lines (D0 to D7). Data can be transferred to and from the display, either as a single 8-bit byte or as two 4-bit “nibbles”. For this project, the entire pin for data bus lines is connected to Port C, as shown in figure 3.9.

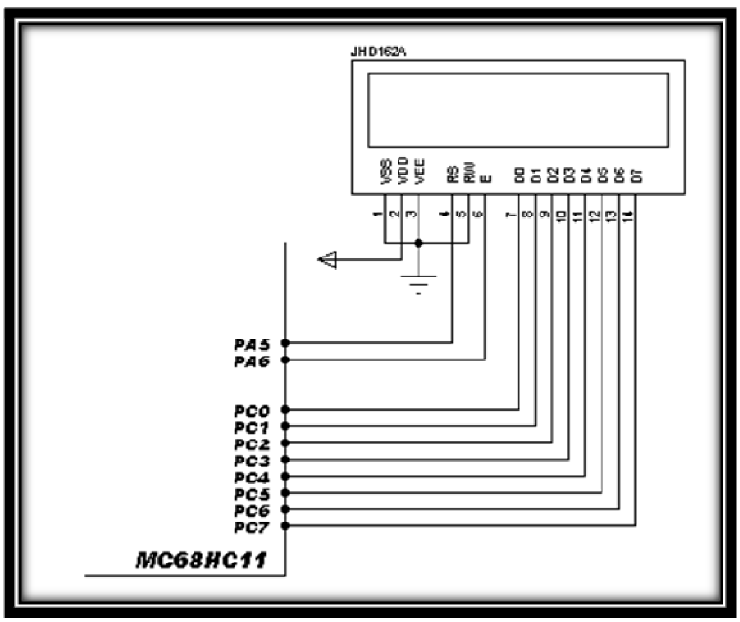

Figure 3.9: Circuit diagram for LCD display

3.4 KEYPAD

To decode the XY row/column output of the keypad, 74C923 4 x 4 matrix encoder will be used as the driver. This chip produces a binary output corresponding to the current button being pressed. The 74C923 also performs debouncing and latching. The 74C923is nearly self-contained but does require two capacitors which set the oscillation rate (rate at which keys are checked) and debounce time. The figure 3.10 shows the connections of a 4x4 keypad to the 74C923 then to 68HC11. Next figure shows the actual keypad used in this project.

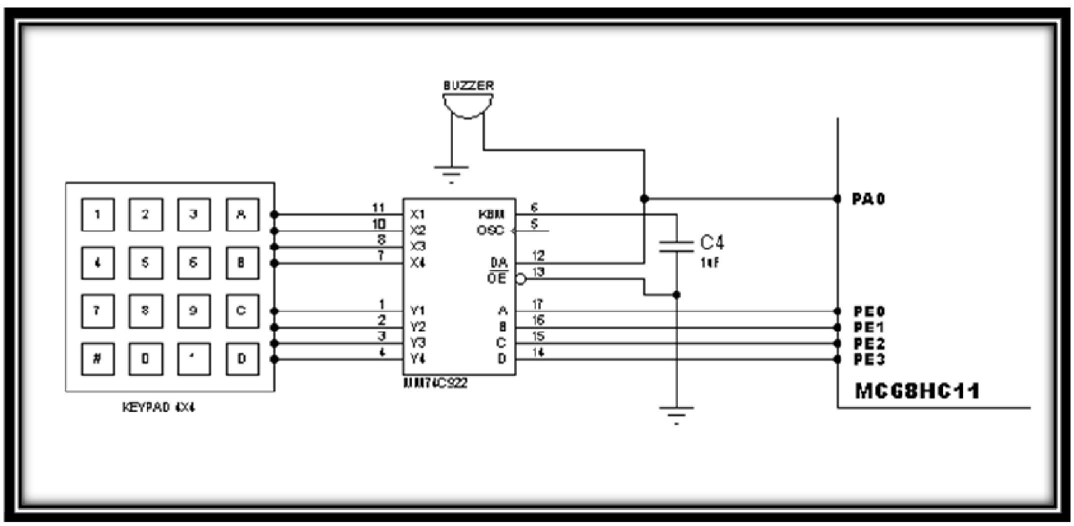

Figure 3.10: Keypad circuit diagram

When a button is pressed on the keypad the Data Available (DA) line, which is normally low, goes high for the duration of that button press and the binary code representing the button is latched onto the A-D outputs. If the Output Enable (OE) line is low, the data can be read from the output pins. When the OE line is high, the A-E outputs are tri-stated or 'floating'. Even if the button is released and the DA line goes low, the code for the last button press remains available, and can be read again if required by pulling the OE line low. A buzzer also used as the signal sensor if any number at the keypad is entered. The buzzer will sound “BEEP” but the system will only run if the correct password is entered.

3.5 STEPPER MOTOR

In this project, a 5V DC unipolar stepper motor is used to control the gate model. Stepper motor is select as the control of the gate model base on these advantages;

a) Step movement allowing a precise position control.
b) It can be controlled in closed or open loop without the need of sensor for feedback programming
c) Only simple programming is required.
d) The rotational angle of the motor is proportional to the input pulse.
e) Excellent response to staring, stopping and reversing

Since 68HC11 lack of sufficient current to drive the stepper motor windings, a driver is required to energize the stator. Moreover if the stepper motor is connected directly to the 68HC11, it may cause damage to the controller. There are several ways to drive the stepper motor either using transistor or IC driver such as SAA 1027, L297/8, L293D and ULN2003A.

In this project, ULN2003 chip is used as the driver for the stepper motor as shown in figure 3.14. ULN2003A is high current, high voltage darlington arrays each containing seven open collector darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout. The stepper motor in this project runs on low voltage DC which is 6 V to 12 V range. It's important to make sure that the voltage doesn't exceed motor's rated voltage. In this project, 5 V power supply is used to drive the motor alone. To make stepper motor run smoothly, we have to increase the current of the power supply.

Unipolar stepper motor consists of 5 wires as mention in chapter 2. All of this wire must connect correctly otherwise the motor won't operate. Figure 3.11 is a circuit diagram for uniipolar stepper motor. Driving a unipolar stepper motor with the ULN2003A is very similar to driving a bipolar stepper motor. The pulse sequence is the same and it can use the code fragment in table 3.1 to generate the pulse sequence. The only difference between driving a unipolar stepper motor and driving a bipolar stepper motor is that there is an extra wire in a unipolar stepper motor. However these wires don't affect the movement of the motor. Only 4 wires are considered. As shown in figure 3.12, wire colour blue is a common for the motor.

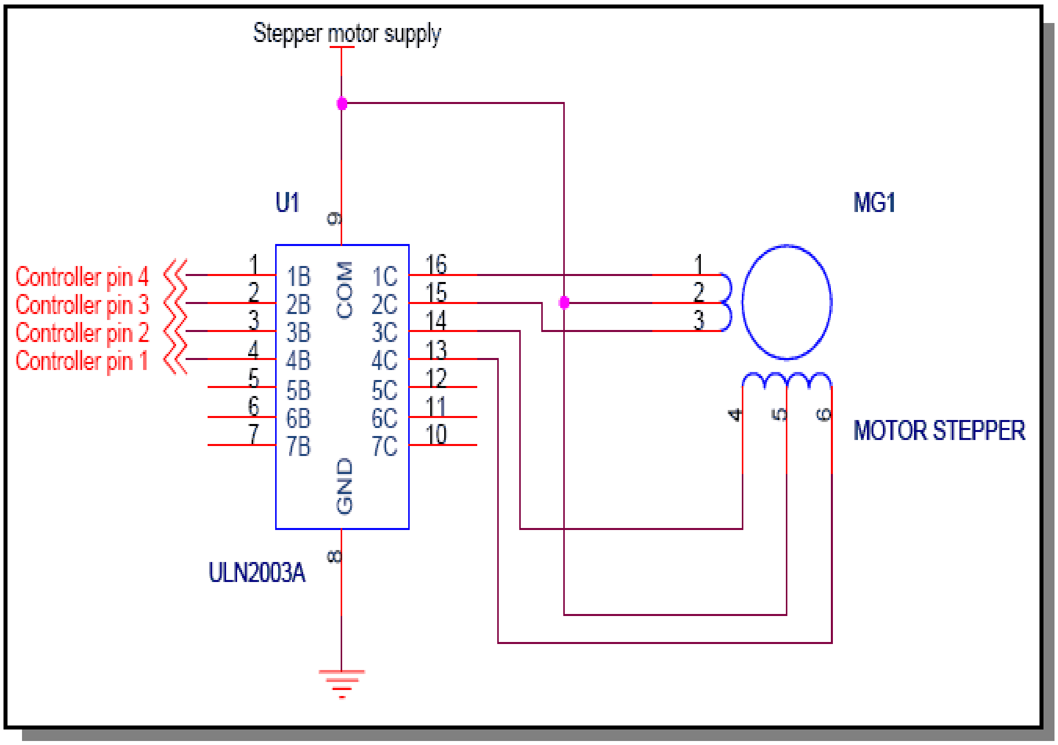

Figure 3.11: ULN2003A Motor Driver Connection

Figure 3.12: 5-wire Unipolar Stepper Motor Connection

Table 3.1: Step movement for stepper motor

	Coil 1a	**Coil 2a**	**Coil 1b**	**Coil 2b**
Step 1	High	High	Low	Low
Step 2	Low	High	High	Low
Step 3	Low	Low	High	High
Step 4	High	Low	Low	High

3.6 INFRARED SENSOR

An infrared sensor in its simplest form is a sensor capable of detecting a contrast between adjacent surfaces, such as difference in color, roughness, or magnetic properties, for example. The simplest would be detecting a difference in color, for example black and white surfaces. Using simple optoelectronics, such as infrared photo-transistors, color contrast can easily be detected. Infrared emitter/detectors or photo-transistors are inexpensive and are easy to interface to a microcontroller. In addition, standard red LEDs and Cds photocells work well too and fall in the same price range as the infrared photo-transistors.

The theory of operation is simple and for brevity, only the basics will be considered. When light shines on a white surface, most of the incoming light is reflected away from the surface. In contrast, most of the incoming light is absorbed if the surface is black. Therefore, by shining light on a surface and having a sensor to detect the amount of light that is reflected, a contrast between black and white surfaces can be detected. Figure 3.13 shows an illustration of the basics just covered.

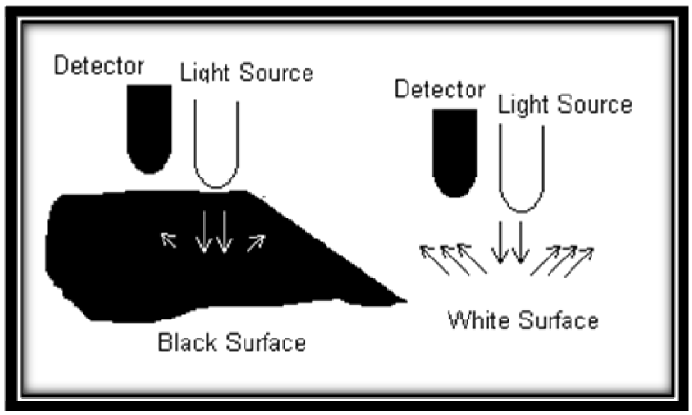

Figure 3.13: Light reflecting off a white and black surface

Figure 3.14 shows the circuit diagram used in this project. When the IR receiver receives infrared, it will generate voltage at its pin. The generated voltage is in the range from 0V to 5V depends on the intensity of infrared it received. The voltage will drop to zero if there is no infrared received. The problem arise where 68HC11 only recognize digital input which is 0V and 5V. If the infrared reflected is less, the receiver would probably produce a 2V or 3V and 68HC11 is unable to deal with these analog values. Thus, a comparator (LM358) is used to solve this problem. By using this comparator, the output voltage from IR receiver will compare to an input voltage through a variable resistor. The comparator able to compare both input voltage and generate either 0V or 5V where it can be connected to 68HC11. Actual hardware is shown in figure 3.15.

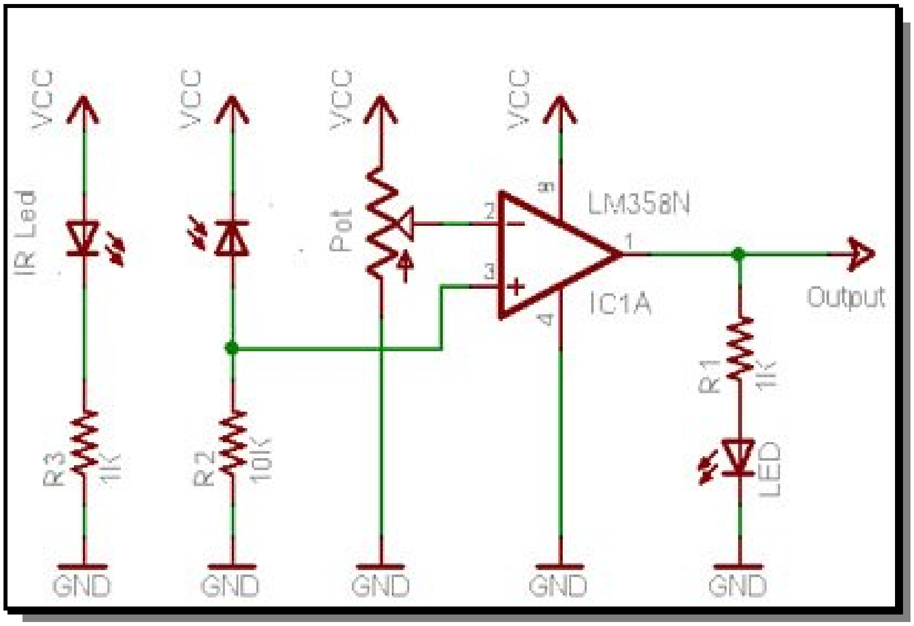

Figure 3.14: Circuit diagram for Infrared

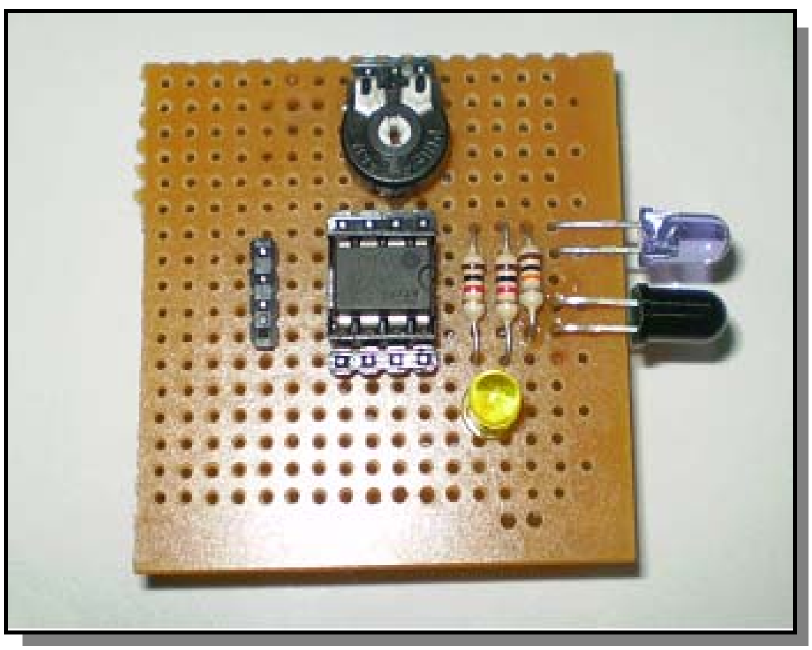

Figure 3.15: Actual hardware for Infrared

CHAPTER 4

SOFTWARE DEVELOPMENT

This chapter will discuss more details about software that been used in this project. Since 68HC11 only understand machine code, programming through assembly language need to be develops and then converted to machine code. Generally it will be divided into several sub topics which are;

4.1 The Magnetic Field sensors and Infrared
4.2 Stepper Motor
4.3 Keypad
4.4 LCD

Figure below shows the system flow develops for “Parking Monitoring Systems with Security Systems Features”.

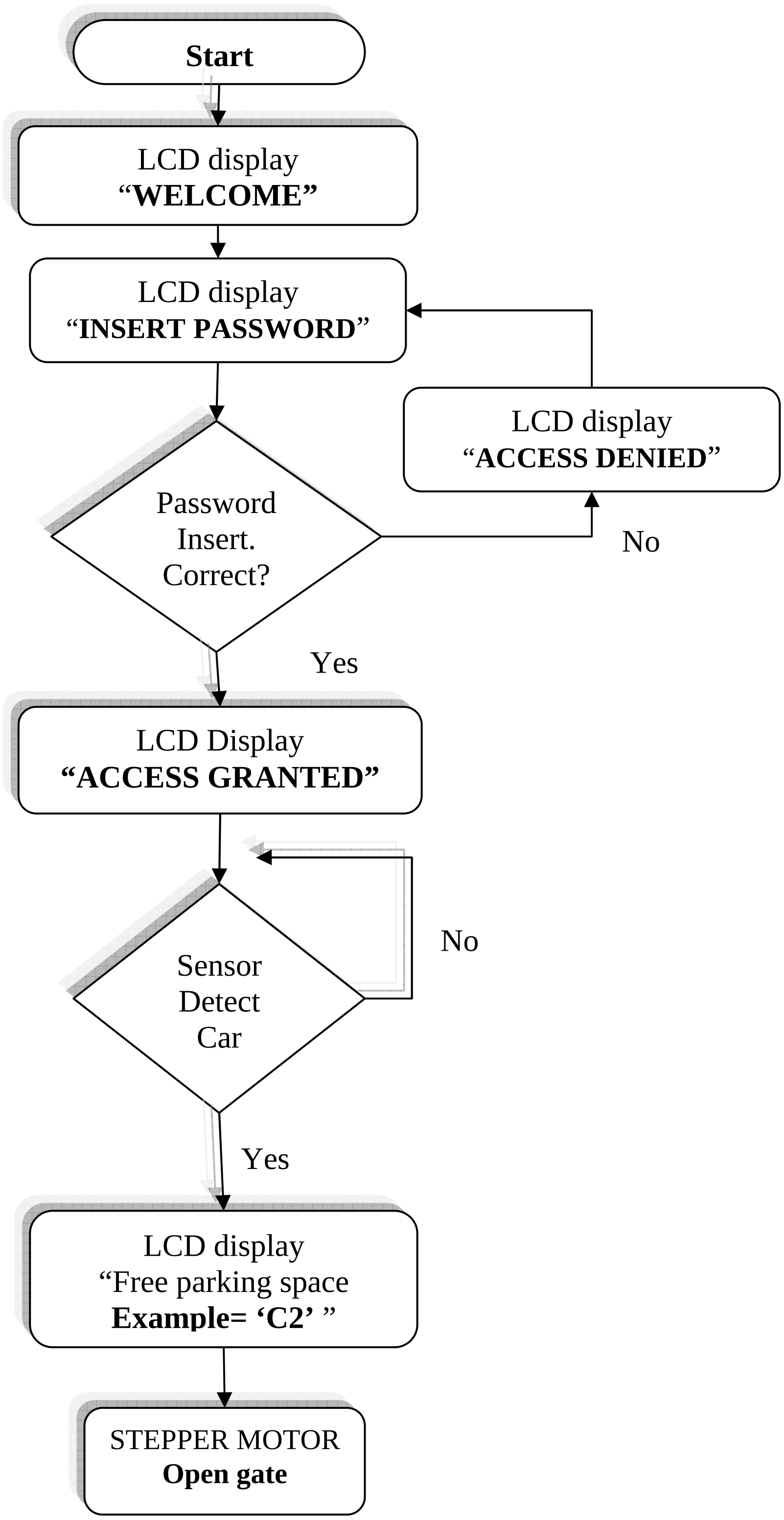

Figure 4.0: Sytems flowchart the whole systems

4.1 MAGNETIC FIELD SENSOR AND INFRARED SENSOR

The magnetic field sensor is the main part or instrument to monitor unoccupied parking space in this project. Besides, that, the infrared sensor are also including in this project to show there are other alternative to detect any car at the parking space. The sensor will sens if there is any car are at the parking lot and send the data to the microcontroller. The data will then display at the LCD.

There are only one magnetic sensor use in this project. It is because the cost to buy a sensor is expensive. Magnetic sensor is a sensor that can be use to detect the metal under the car body. It can be place in front of the car or at behind. The concept of this sensor is, the sensor will produce magnetic flux density around the sensors. If the flux density is cut, the sensor will sens there is a car and send the data to microcontroller. To make sure the magnetic sensor is well functioning, the distance between the car and the sensor must be consider.

In the other hand, the infrared sensor is also including in this project to detect the car. There are two infrared sensor use in this project. If the LED of the infrared sensor is turn off, it is mean that the infrared sensor have transmit a data to the microcontroller. All sensors have theire own label. For the example, each of the infrared is label C1 and C2. The label for magnetic sensor is C3. Figure 4.1 below is the example of the programming of the infrared sensors.

```
IRDA     LDAB     PORTA, X
BITB     #$2
BEQ      DOL
LDY      #PARK1
JSR      YAYA
DOL      BITB     #$4
BEQ      DUL
 LDY     #PARK2
JSR      YAYA
DUL      RTS

ORG      $B777
PARK1    FCC      "C1"
FCB      0
PARK2    FCC      "C2"
```

Figure 4.1: Program example of Infrared sensors

4.2 STEPPER MOTOR

Stepper motor will be used to control the gate entranced in this project. Controlling stepper motor is not easy as DC motor and servo motor. Figure 4.2 shows a simple flows chart for the forward control stepper motor. Details of the sequence already explained in chapter 3 under subtopic 3.3 Stepper Motor. When 1st sequence on the data is sent to the stepper motor, motor will start to move step. After that, when 2nd, 3rd and 4th sequence is sent to stepper motor, the motor will continue moved step by step. In order to make the motor continually run, the sequence need to be sent repeatedly.

A sample programming of forward control stepper motor is shown in figure 4.3. Since the IC driver ULN2003A is connected through Port B, the sequence of data is sent to Port B. The 4th complete sequence data will be sent repeatedly 6 times for forward direction and then stop.

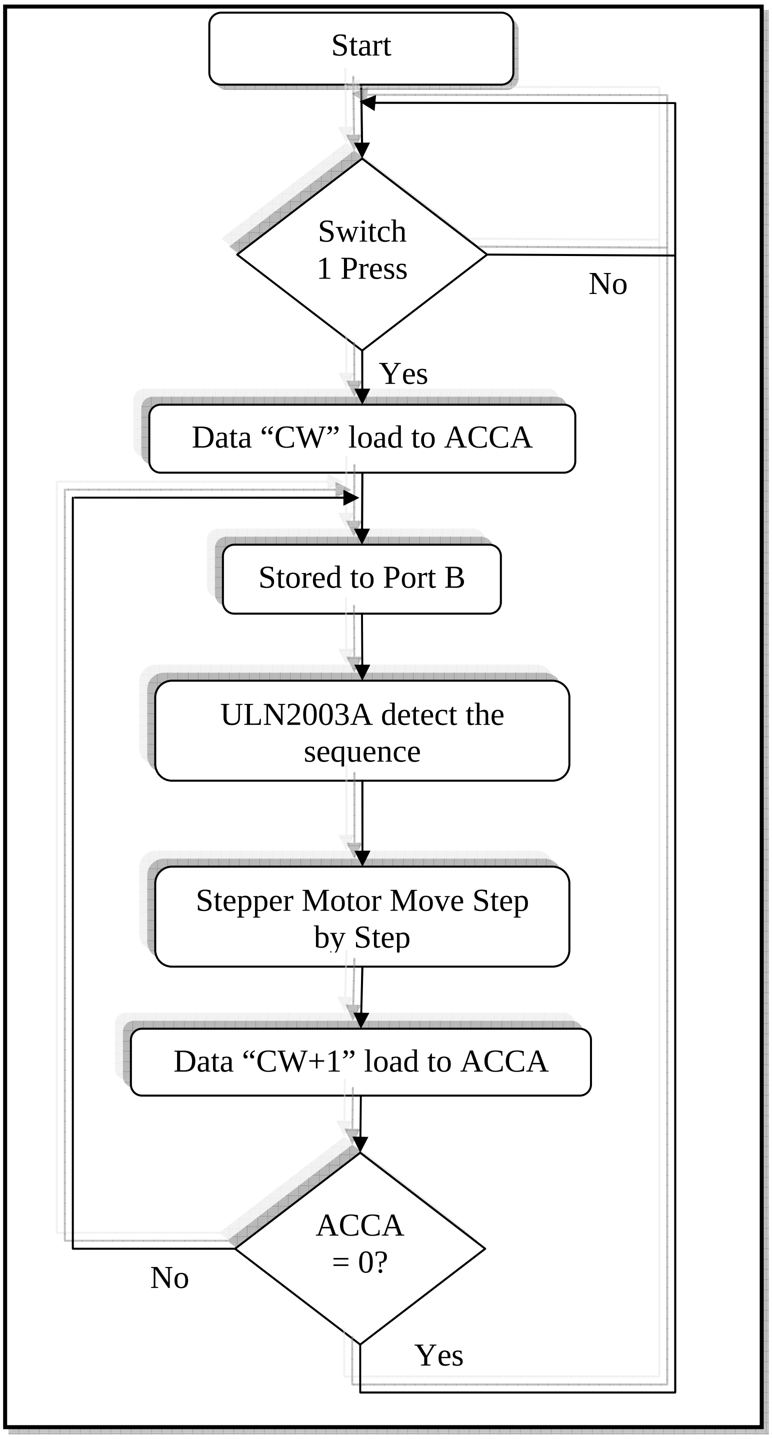

Figure 4.2: Flow Chart for Stepper Motor

```
            ORG     $B600

            LDS     #$FF
            LDX     #REGS
            BSET    PORTB, X    $FF

SCAN        BRCLR   PORTE, X    $FE     SWCH1
            BRA     SCAN

SWCH1       LDAB    #6
ULG         LDY     #CW
SMULA       LDAA    0, Y
            STAA    PORTB, X
            BSR     DELAY
            INY
            CPY     #CCW+4
            BNE     SMULA
            DECB
            BNE     ULG
            BRA     SCAN

            ORG     $B700
CW          FCB     $09, $0A, $06, $05, 0
```

Figure 4.3: Sample programming for Stepper Motor

4.3 KEYPAD

Keypad is used as the security for the system itself. The system will only functioning if the correct password is press. Otherwise LCD will display will display "ACCEESS DENIED" and all the systems is malfunction. As mention before, keypad will be connect through keypad decoder, 74C923 before connect to 68HC11. Each time when any key is press, DA will indicate a data is available. The 68HC11 will receive the data and display a character at the LCD. The flow chart of the keypad is shown in figure 4.4.

Figure 4.5 is a sample of simple programming tested. When any button at keypad is press, DA will send an indicator to 68HC11 and then data is sent to 68HC11. Data will load to ACCA from port E then sent to Port B to be view at LCD. Since the program tested is fully functioning, the module is successful for this part.

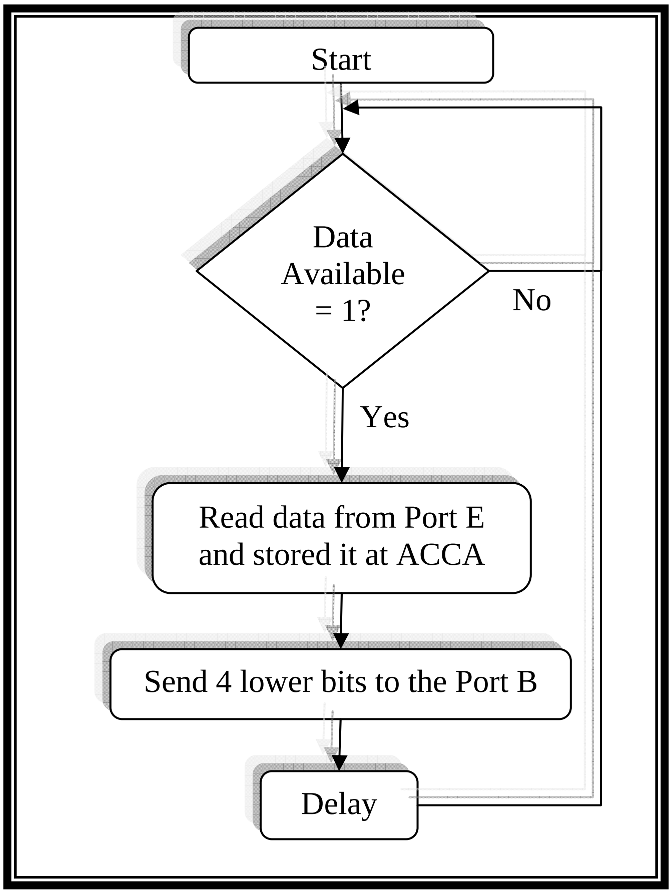

Figure 4.4: Flow chart for Keypad

```
                ORG         $B600
                LDS         #$FF
                LDX         #REGS
                BCLR        DDRC, X         $FF
                BSET        PORTB, X        $FF


LOOP            BRCLR       PORTC, X        %00010000       LOOP

                LDAA        PORTC, X
                ANDA        #$0F
                STAA        PORTB, X

LOOP1           BRSET       PORTC, X        %00010000       LOOP1
                BRA         LOOP

                END
```

Figure 4.5: Sample programming for Keypad

4. 4 LCD

Programming for LCD is the complex if compare with the others. Besides the more character display in the LCD, the more address it will used. Basically there are several steps before LCD can display character correctly. As shown is figure 4.6 is flow chart how to view character in LCD display. Pins RS and E need to be configuring correctly otherwise the LCD won’t work. However LCD needs to be initializing once before it can be used.

Sample programming for LCD is shown in figure 4.7. For this sample, LCD will display “Insert Password”. The character will be shifted to the right if the character is more than 16 characters.

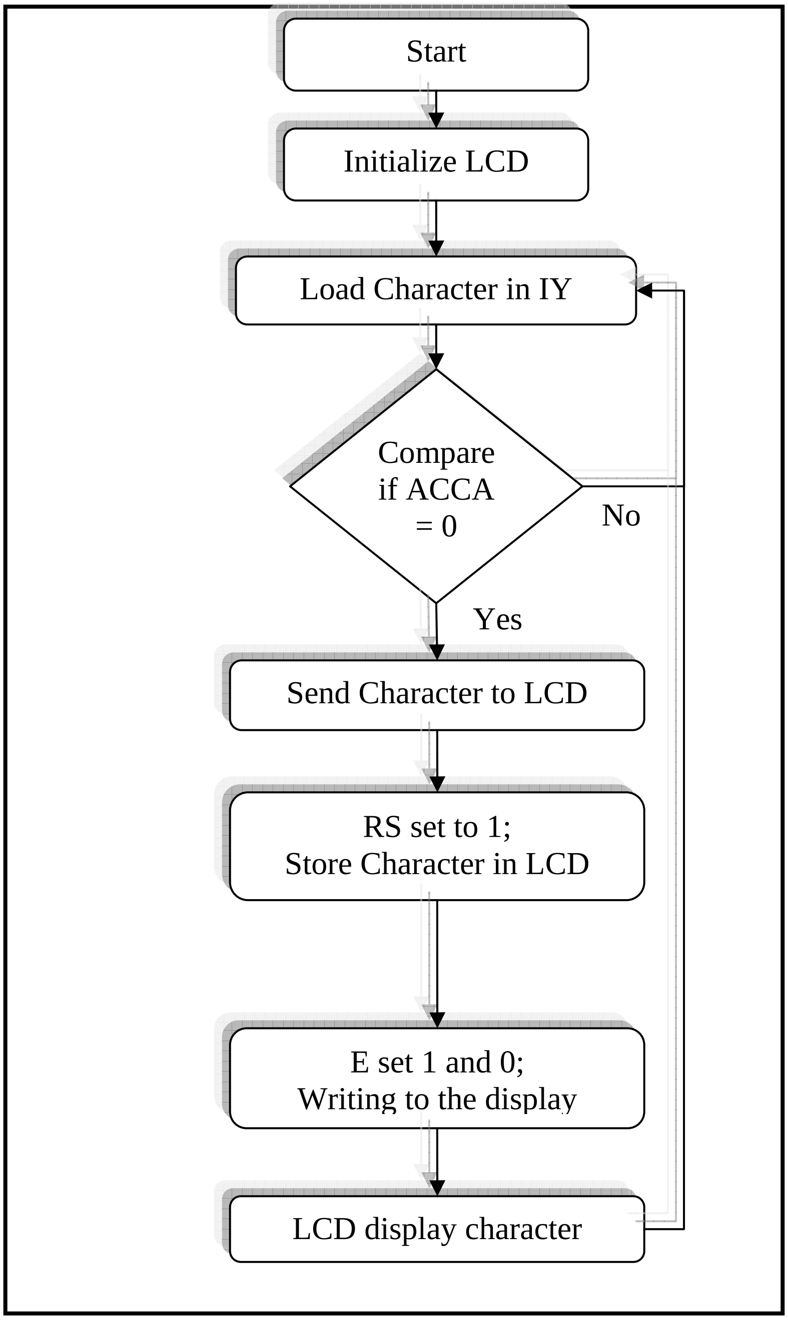

Figure 4.6: Flow chart for LCD Display

```
COMMAND     BCLR    PORTA,X     %00001000     ; R/S = 0, COMMAND MODE
            STAA    PORTC,X                   ; STORE COMMAND
            BSET    PORTA,X     %00010000
            BCLR    PORTA,X     %00010000      ; TRIGER ENABLE
            BSR     DELAY
            RTS

DISP        LDY     #DATA                ;DISPLAY DATA
NEXT1       LDAA    $0,Y
            BEQ     AKU
            BSET    PORTA,X   %00001000        ; R/S = 1, CHARACTER MODE
            STAA    PORTC,X              ; WRITE CHARACTER
            BSET    PORTA,X   %00010000
            BCLR    PORTA,X   %00010000
            LDAA    #$01
            BSR     COMMAND
            INY
            BRA     NEXT1


AKU         LDAA    #$C0
            JSR     COMMAND
            LDY     #DATA2
NEXT2       LDAA    $0,Y
            BEQ     SAYA
            BSET    PORTA,X   %00001000        ; R/S = 1, CHARACTER MODE
            STAA    PORTC,X              ; WRITE CHARACTER
            BSET    PORTA,X   %00010000
            BCLR    PORTA,X   %00010000
            LDAA    #$01
            BSR     COMMAND
            INY
            BRA     NEXT2

SAYA        BRA     SAYA

DELAY       PSHX
            LDX     #$FFF
REPEAT      DEX
            BNE     REPEAT
            PULX
            RTS

            ORG     $B699
INI         FCB     $80,$01,$02,$06,$0F,$1C,$38,0
DATA        FCC     "Insert Password:"              ;DATA WILL BE DISPLAY
            FCB     0

DATA2       FCC     "="
            FCB     0
```

Figure 4.7: Sample programming for LCD Display

CHAPTER 5

RESULT & DISCUSSION

This chapter will be focuses on the final result for this project. All the devices are finally integrated with single-chip 68HC11 in developing this project entitle “Parking Monitoring System with Security System features”. Based on the result of single programming for each module as in chapter four, a complete combined programming is developing to suite the system successfully. Everything regarding of this final result of the system will be discuss details in this chapter.

The entire device with complete programming is successfully done and the system flows smoothly as shown in figure 5.0. While figure 5.1 and 5.2 shows the complete actual hardware develops for this project. The complete programming can be referred at appendix B.

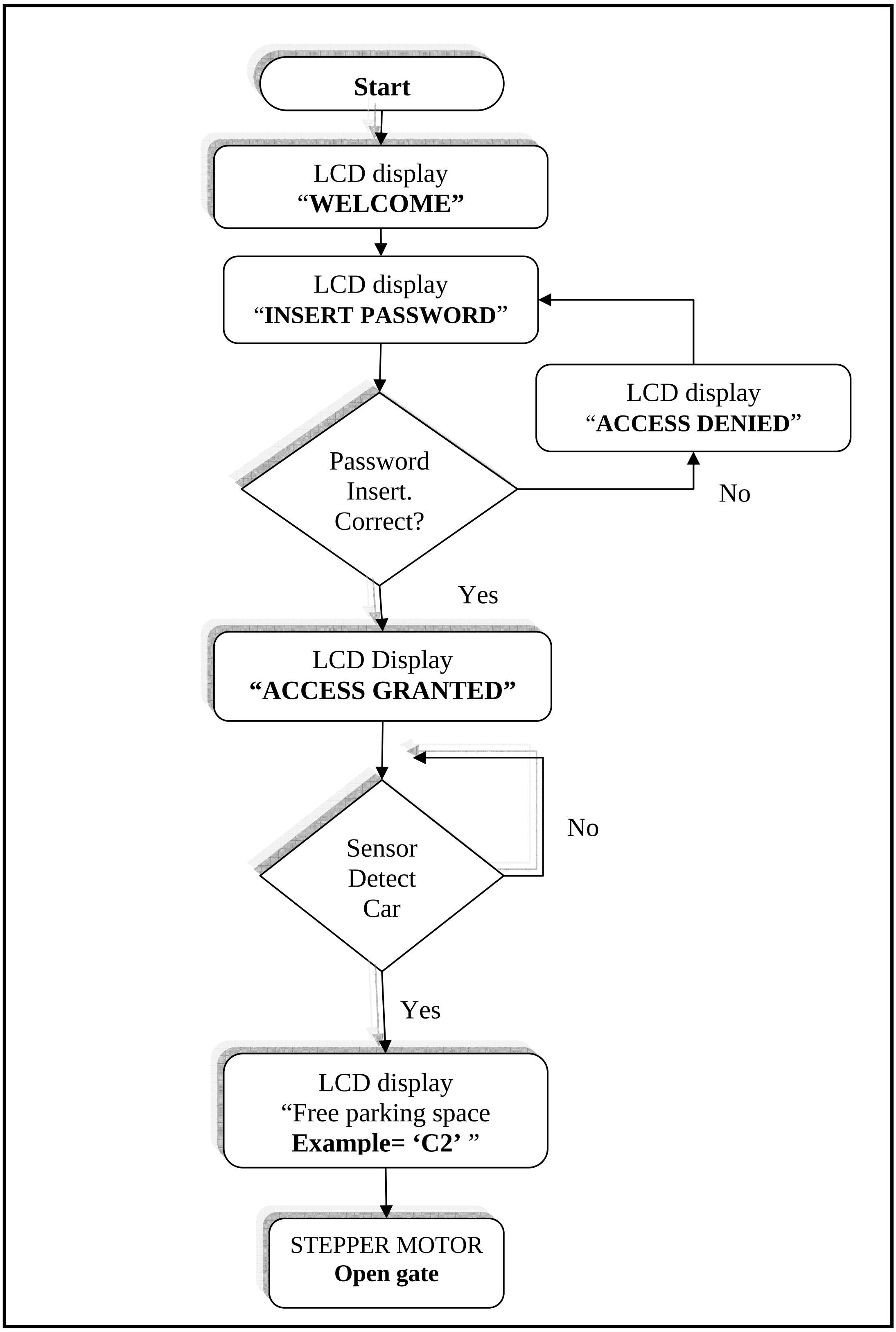

Figure 5.0: Flow chart of the whole systems

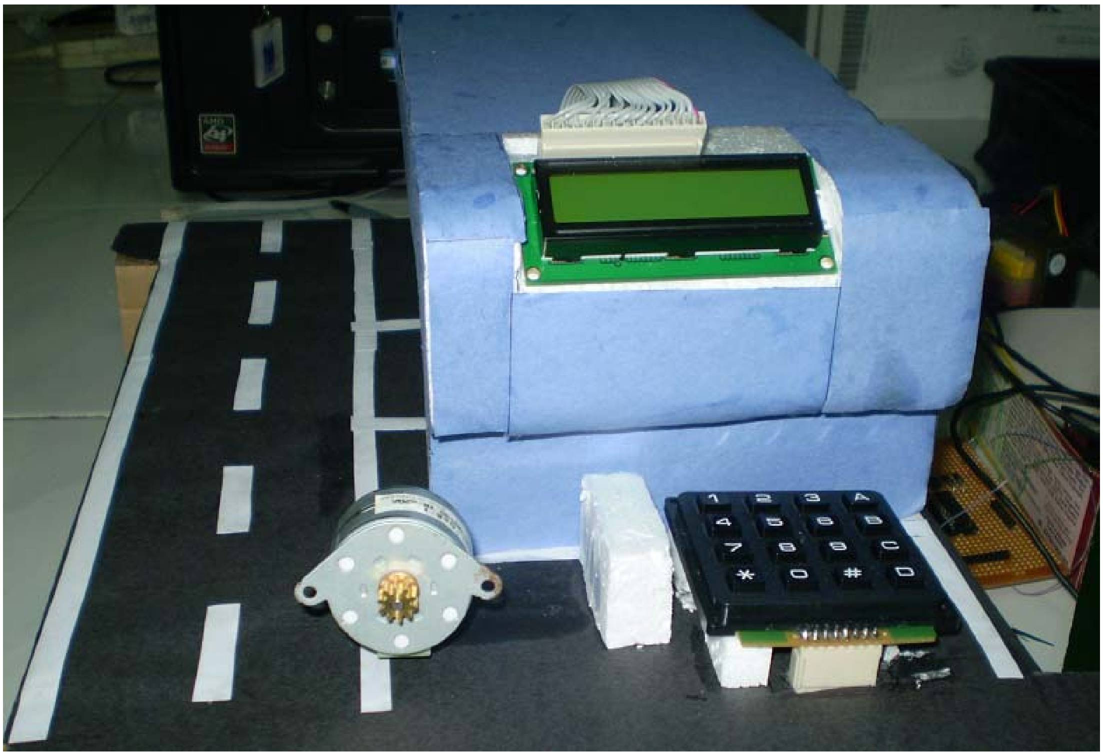

Figure 5.1: Actual Hardware

Figure 5.2: Actual Hardware with sensors embedded

5.1 RESULTS ON ENTIRE SYSTEM

Based on the full systems of the flowchart shows in figure 4.0, the details explanation of the systems will discuss under this sub topic. All of the systems wil run sequence by sequence and at the end the sysytem will remain looping at certain level.

When the power on, the system will start running. The LCD will automatically turn on and it will not display any character before the reset button is press. After the reset button is press, the LCD will display “ WELCOME” and there is a delay for a few second before the LCD will turn to display “INSERT PASSWORD”.

After that, the user must insert a password by using keypad. If the password is correct, the LCD will display “ACCESS GRANTED” and the systems run to the next stage which is sensor part. But, if the user key in the wrong password, the LCD display will show “ACCESS DENIED”. The LCD still remain shows “INSERT PASWORD” if the user key in the wrong password.

Sensors are one of the main parts of this project. The sensor is use to detect whether there is a car or not. If there is no car, the systems will looping and send the data to microcontroller 68HC11. If there is any car detect by the sensor, the data also send to microcontroller. After inserting the password, the sensors at car parking space will send the data to the microcontroller 68HC11. The microcontroller then processes the data and sent to the LCD. For the example the LCD will display “C1”.

After completing all the flow of the systems, the last part is open the gate. When the LCD displays the free parking space, the gate will open automatically. The user will then can enter the parking lot.

This system will continuously looping until the power system is switch off. The efficiency of the system is not really accurate since the programming is not completely stable.

5.2 ACTUAL HARDWARE DESIGN

Figure 5.3: LCD display "WELCOME"

Figure 5.4: LCD display "INSERT PASSWORD"

Figure 5.5: LCD display "ACCESS GRANTED"

Figure 5.6: LCD display "ACCESS DENIED"

CHAPTER 6

CONCLUSION AND FUTURE DEVELOPMENT

6.1 CONCLUSION

In general these projects complete the entire objective within the scope of project given. “Parking Monitoring System with Security System Features” can be implemented directly to real life, just little modification need to be configured at the gate itself and some components. Using the magnetic field sensor technology, this system has an ability to detect the car more accurate and efficiently. Besides, with the help of powerful Motorola 68HC11 microcontroller, this project have been develop successfully with multiple functioning operate at best condition.

As an improvement for this project, the selection of sensor should be considered well. Besides, the programming can be improved in order to gain stability for the system at any condition.

6.2 FUTURE DEVELOPMENT

Even though this project successful, however some add on enhancement can be applied to the system. This addition somehow can improve the performance of the system. Below are some of the suggestions for future development:

- Used servo motor as the controller of the gate. In reality, stepper motor can't be used because the speed of the motor is too slow. Servo motor should be better if replace it since the speed of rotating motor can be controlled with more efficiency.

- For advance security, the system can be improve by using more additional features such as alarm systems and more complicated password design. The programmer must be more creative to make sure the system is safe and well functioning.

- This project is a combination of several electronics device which used lot of address to control all of it. Because of the limitation of address on 68HC11 itself, this project will be more success if run in expended mode. Additional EEPROM can be added and extra port also can be done.

- Keypad function security also needs to be upgraded. In this project, there are some lacks of security systems occur. The user only has to key in three numbers to activate the systems and this is not well secure to the user.

- We can replace the keypad with RFID reader because the readers have their own identity.

- Use GPS to detect the unoccupied parking space.

6.2.1 Costing and Commercialization

When we want to design a project, the important part is to make any calculation involve to designing the project. All the cost must be considered to make sure the project is cheap and also effective to commercialize.

Parking Monitoring System with Security System Features is a project that involves high costing. Total cost for this project is RM411.64. This is because these projects use magnetic field and infrared sensor as an indicator to detect the car. The cost to purchase one magnetic sensor is RM150 each. It is too expensive if we want to buy more magnetic fields sensor. But, infrared sensors are cheapest then the magnetic sensor. The details about the item can be view at appendix H.

Regarding to this project, it is wasting if the project design cannot be apply to the real world. The Parking Monitoring System with Security System Features is a project that can be commercialize in real world. But, we have to change some of the component involves in this project to make it more effective.

Actually, this project is only a model to run the systems. The systems now can be commercialized with some modification to the hardware. In addition, technology is growth rapidly and we can change the magnetic sensor with other cheap component to reduce the cost.

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APPENDIX A

Program of “Parking Monitoring System with Security System Features” Project

```
REG         EQU     $1000
PORTA       EQU     $0
PORTB       EQU     $4
PORTC       EQU     $3
PORTD       EQU     $8
PORTE       EQU     $A
PACTL       EQU     $26
DDRC        EQU     $7


BUFFER      ORG     $12
            RMB     8

            ORG     $B600
            LDS     #$7F
            LDX     #REG
            BSET    DDRC,X   %11111111


MULA        JSR     INIT_LCD
            JSR     DELAY1
GOGO        JSR     DISP1
            JSR     KEYPAD
            BRA     GOGO


INIT_LCD    LDY     #INI
NEXT        LDAA    $0,Y
            BEQ     DISP0
            BSR     COMMAND
            INY
            BRA     NEXT

DISP0       LDAA    #$85
            JSR     COMMAND
            LDY     #DATA0
            JSR     YAYA
            RTS

DISP1       LDAA    #$1
            JSR     COMMAND
            LDAA    #$80
            JSR     COMMAND
            LDY     #DATA1
```

```
            JSR     YAYA
            LDAA    #$C0
            JSR     COMMAND
            RTS


COMMAND     BCLR    PORTA, X   %00001000   ; R/S = 0, COMMAND MODE
            BSR     ENABLE
            RTS

CHARAC      BSET    PORTA, X   %00001000   ; R/S = 1, CHARACTER MODE
            BSR     ENABLE
            RTS

ENABLE      STAA    PORTC,X   ; STORE COMMAND or CHARACTER
            BSET    PORTA,X    %00010000
            BCLR    PORTA,X    %00010000   ; TRIGER ENABLE
            JSR     DELAY
            RTS

YAYA        LDAA    $0,Y
            BEQ     YOYO
            JSR     CHARAC
            INY
            BRA     YAYA
YOYO        RTS


KEYPAD      CLRA
            LDY     #3
SCANK       BRCLR   PORTA,X   %00000001    SCANK
            LDAB    PORTE,X
            BSR     TITIK
            JSR     DELAY0
            JSR     DELAY0
            NDB     #$0F
            ABA
            DEY
            BNE     SCANK
            CMPA    #6
            BNE     ERROR
            BSR     DISP2
            JSR     S1
            JSR     DELAY1
```

```
                JSR     DELAY1
                JSR     S2
                RTS


ERROR           LDAA     #$1
                JSR     COMMAND
                LDAA     #$80
                JSR     COMMAND
                LDY     #DATA3
                JSR     YAYA
                BRA     DELAY1
                RTS

DISP2           LDAA     #$1
                JSR     COMMAND
                LDAA     #$80
                JSR     COMMAND
                LDY     #DATA2
                JSR     YAYA
                BSR     DELAY1
                LDAA    #$C0
                JSR     COMMAND
                BSR     IRDA
                BSR     DELAY1
                RTS

TITIK           PSHA
                LDAA    #$2A
                JSR     CHARAC
                PULA
                RTS


IRDA             LDAB   PORTA,X
                BITB    #$2
                BEQ     DOL
                LDY     #PARK1
                JSR     YAYA
DOL             BITB    #$4
                BEQ     DUL
                LDY     #PARK2
                JSR     YAYA
DUL             RTS
```

```
S1          LDY     #CW                 ;STEPPER 1
S111        LDAA    0,Y
            STAA    PORTB,X
            BSR     DELAY
             INY
            CPY     #CW+8
            BNE     S111
            RTS


S2          LDY     #CCW                ;STEPPER 2
S222        LDAA     0,Y
            STAA    PORTB,X
            BSR     DELAY
            INY
            CPY      #CCW+10
            BNE      S222
            RTS



DELAY       PSHX
            LDX     #$FFF
REPEAT      DEX
            BNE     REPEAT
            PULX
            RTS

DELAY0      PSHX
            LDX     #$FFFF
REPEAT0     DEX
            BNE     REPEAT0
            PULX
            RTS


DELAY1      PSHA
            PSHX
            LDAA    #9
REPEAT1     LDX     #$FFFF
LAGI1       DEX
            BNE     LAGI1
```

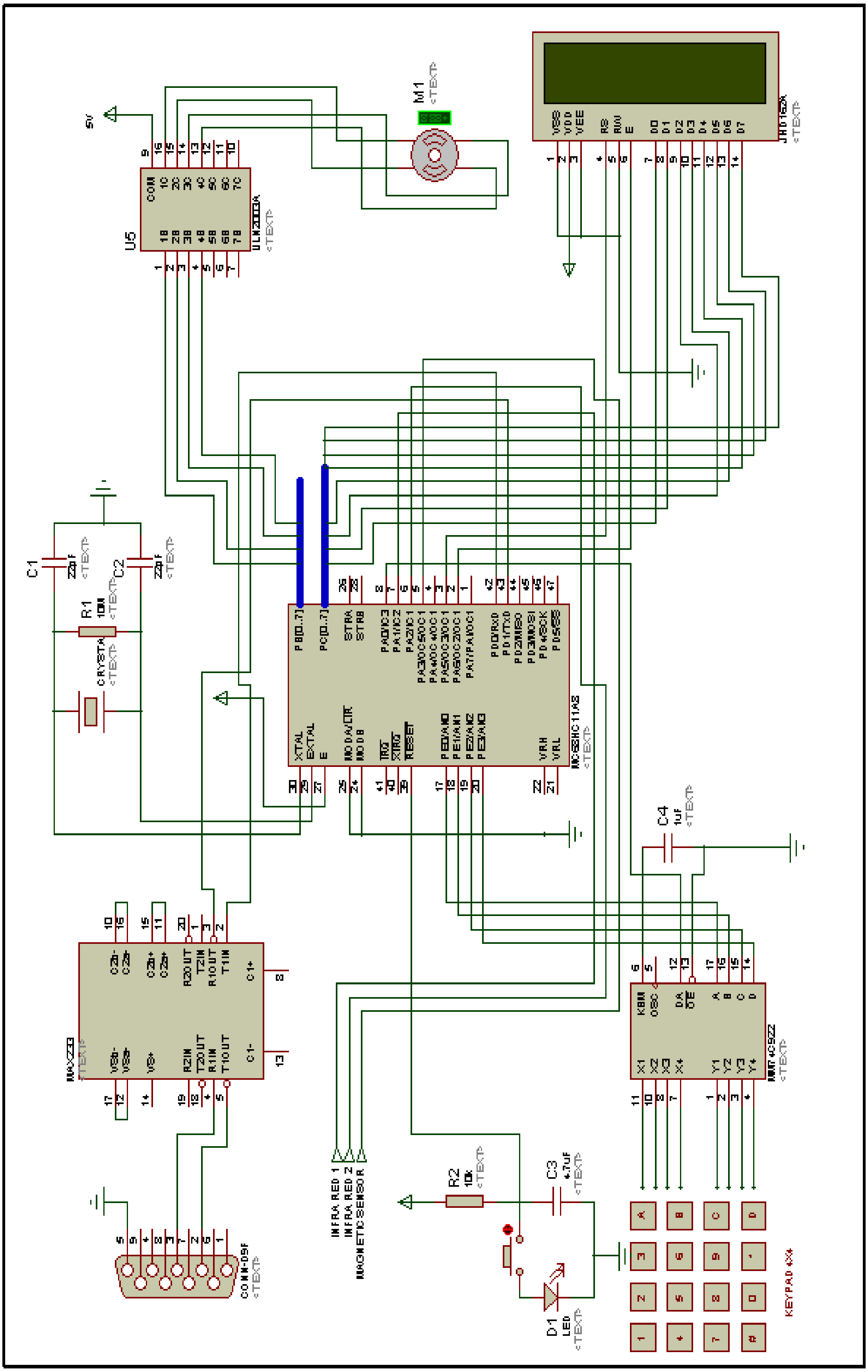
```
            DECA
            BNE     REPEAT1
            PULX
            PULA
            RTS


            ORG     $B777
INI         FCB     $01,$02,$06,$0C,$38,0
DATA0       FCC     "WELCOME"
            FCB     0
DATA1       FCC     "INSERT PASSWORD"
            FCB     0
DATA2       FCC     "ACCESS GRANTED"
            FCB     0
DATA3       FCC     "ACCESS DENIED"
            FCB     0
PARK1       FCC     "C1"
            FCB     0
PARK2       FCC     "C2"
            FCB     0
CCW         FCB     $01,$02,$04,$08,$01,$02,$04,$08,$01,$02,0
CW          FCB     $08,$04,$02,$01,$08,$04,$02,$01,0

            END
```

APPENDIX B

Full Schematic Circuit of the Project

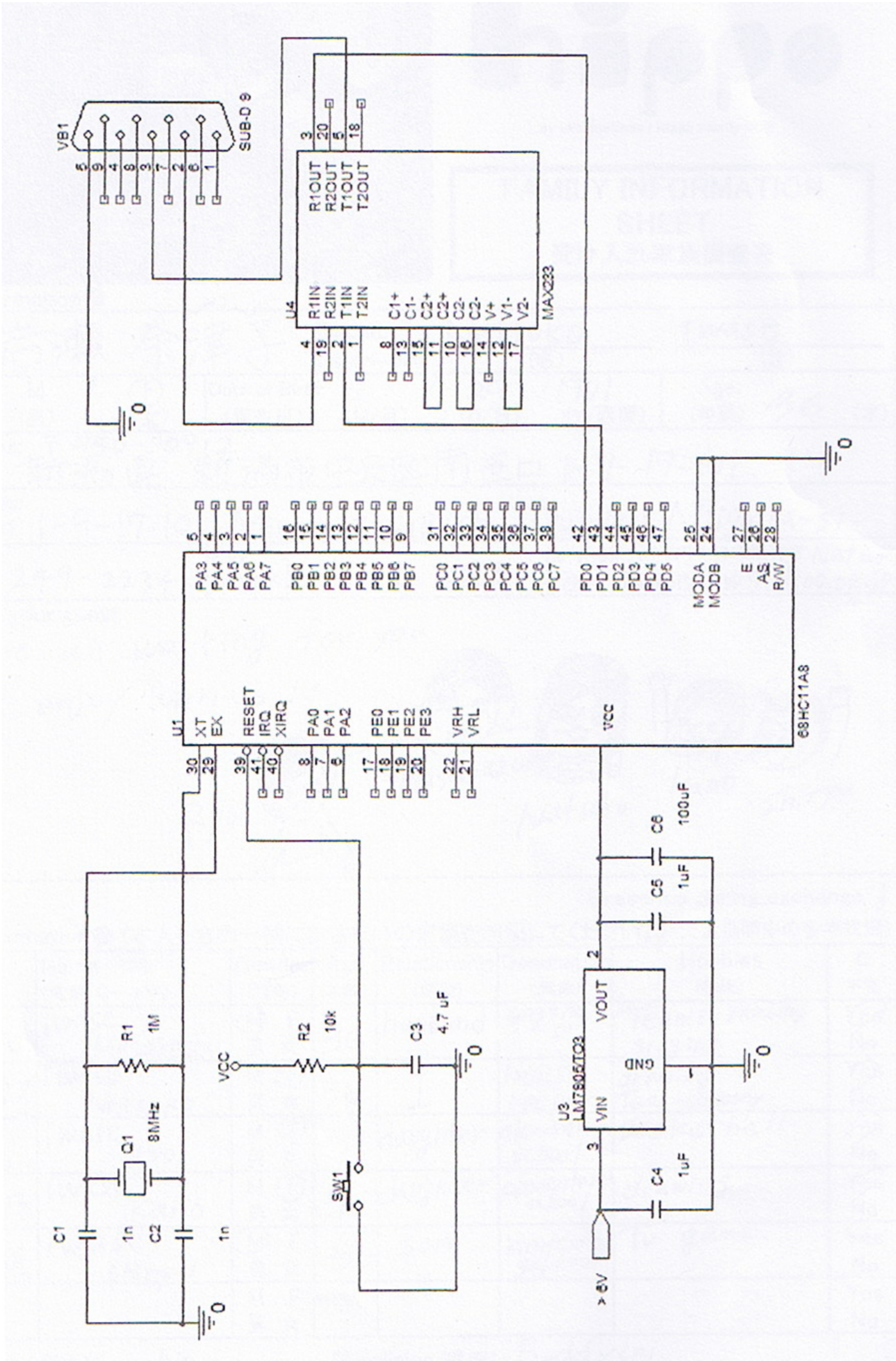
CIRCUIT I

Complete Full Circuit



CIRCUIT II

68HC11 Basic Circuit


VB1
SUB-D 9
U4
MAX233
U1
68HC11A8
U3
LM7805/TO3
VIN
VOUT
GND
Q1
8MHz
C1
1n
C2
1n
R1
1M
R2
10k
C3
4.7 uF
SW1
VCC
C4
1uF
C5
1uF
C6
100uF
>6V

CIRCUIT III

HMC1021Z Magnetic Field Sensor circuit

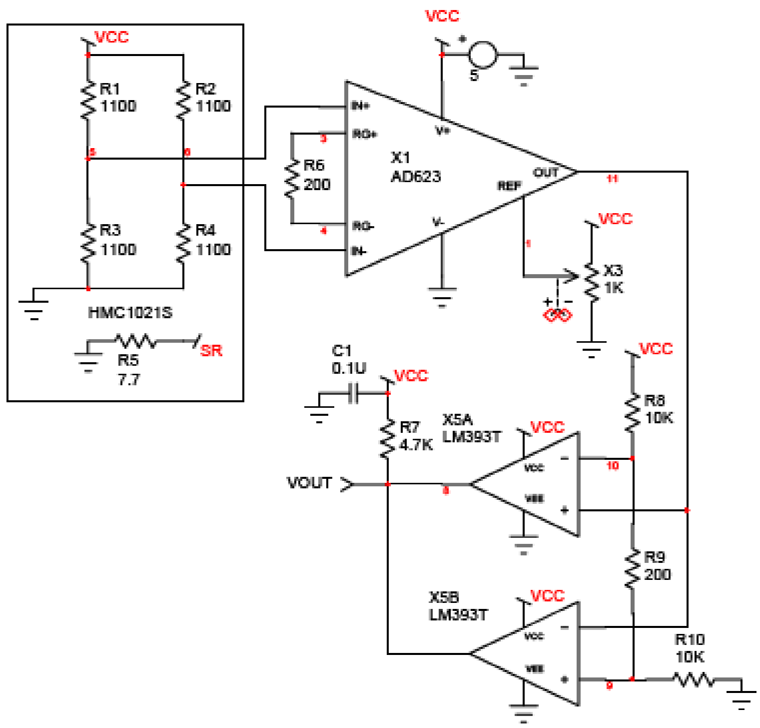


Figure 12 - Simple Vehicle Detection Circuit

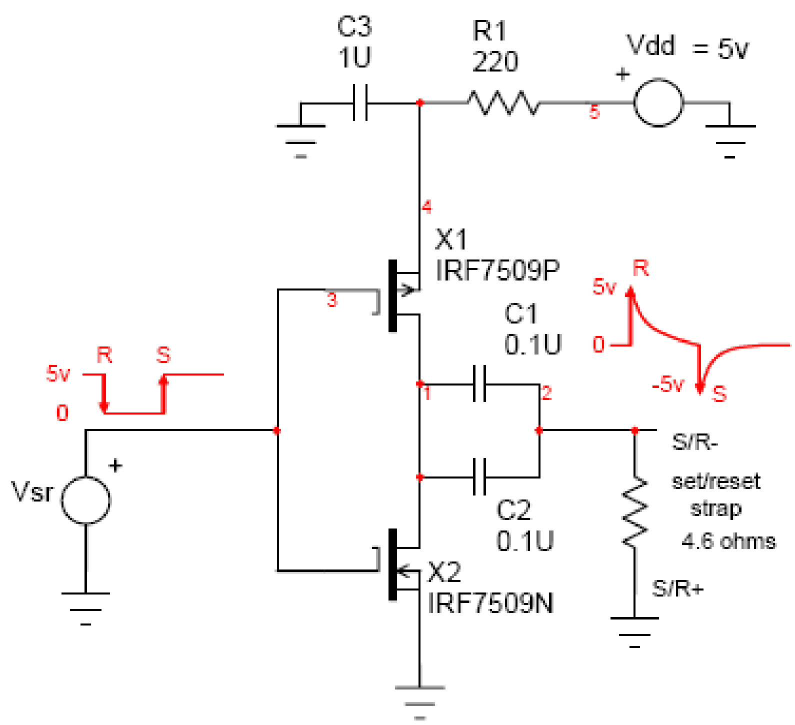
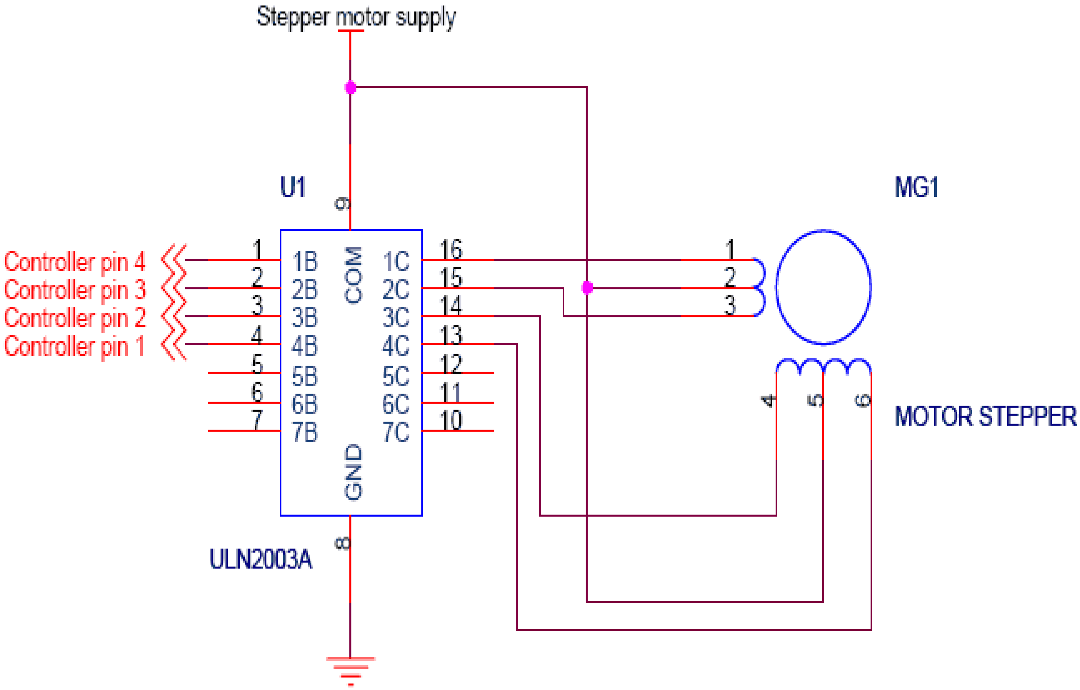


Figure 6 - Set/Reset Strap Driver Circuit

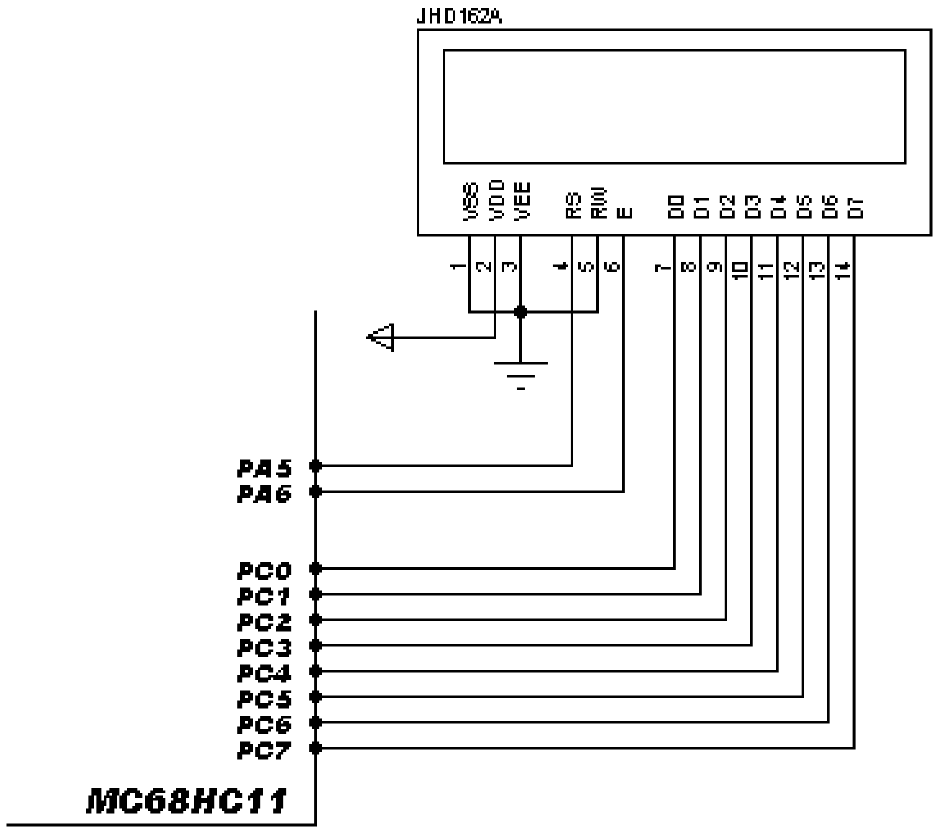
CIRCUIT IV

Stepper Motor Circuit


Stepper motor supply
U1
MG1
Controller pin 4
Controller pin 3
Controller pin 2
Controller pin 1
1B
2B
3B
4B
5B
6B
7B
COM
GND
1C
2C
3C
4C
5C
6C
7C
ULN2003A
MOTOR STEPPER

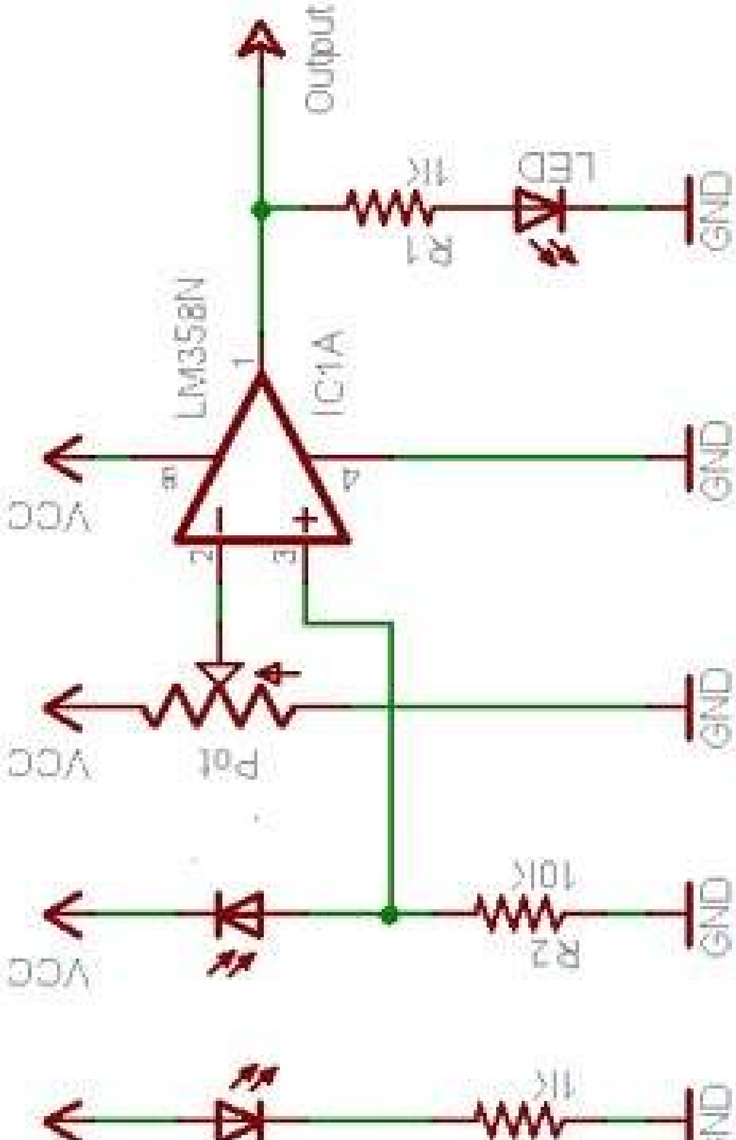
CIRCUIT V

LCD Circuit


JHD162A
VSS
VDD
VEE
RS
R/W
E
D0
D1
D2
D3
D4
D5
D6
D7
1
2
3
4
5
6
7
8
9
10
11
12
13
14
PA5
PA6
PC0
PC1
PC2
PC3
PC4
PC5
PC6
PC7
MC68HC11

CIRCUIT VI

Infrared Circuit


Output
R1
1K
LED
GND
LM358N
IC1A
VCC
Pot
R2
10K
R3
1K
IR Led

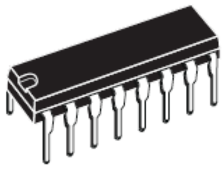
APPENDIX C

ULN2003A Datasheet

ULN2001A-ULN2002A
ULN2003A-ULN2004A

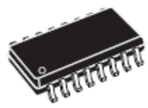
SEVEN DARLINGTON ARRAYS

- SEVEN DARLINGTONS PER PACKAGE
- OUTPUT CURRENT 500mA PER DRIVER (600mA PEAK)
- OUTPUT VOLTAGE 50V
- INTEGRATED SUPPRESSION DIODES FOR INDUCTIVE LOADS
- OUTPUTS CAN BE PARALLELED FOR HIGHER CURRENT
- TTL/CMOS/PMOS/DTL COMPATIBLE INPUTS
- INPUTS PINNED OPPOSITE OUTPUTS TO SIMPLIFY LAYOUT



DIP16

ORDERING NUMBERS: ULN2001A/2A/3A/4A



SO16

ORDERING NUMBERS: ULN2001D/2D/3D/4D

DESCRIPTION

The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current darlington arrays each containing seven open collector darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

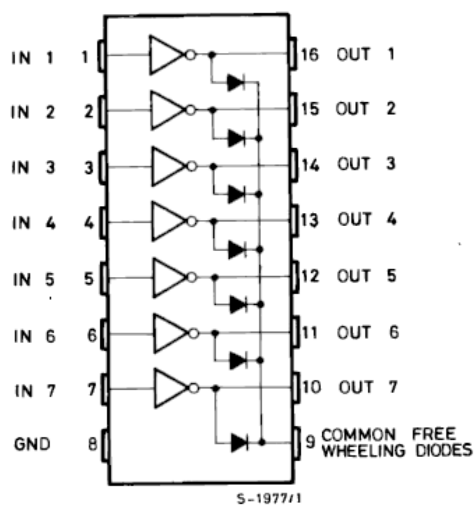
The four versions interface to all common logic families :

ULN2001A	General Purpose, DTL, TTL, PMOS, CMOS
ULN2002A	14-25V PMOS
ULN2003A	5V TTL, CMOS
ULN2004A	6–15V CMOS, PMOS

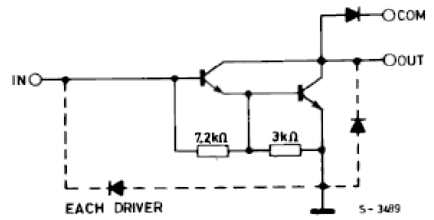
These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors, LED displays filament lamps, thermal printheads and high power buffers.

The ULN2001A/2002A/2003A and 2004A are supplied in 16 pin plastic DIP packages with a copper leadframe to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D/2002D/2003D/2004D.

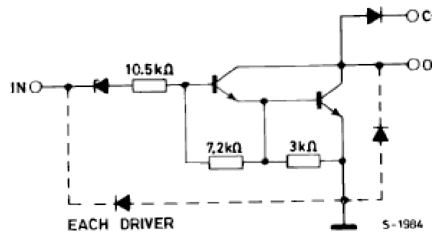
PIN CONNECTION



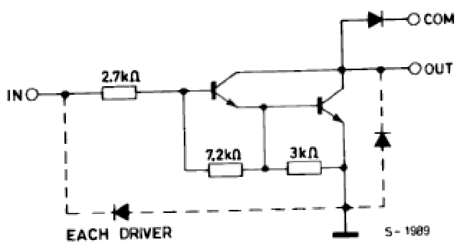
SCHEMATIC DIAGRAM



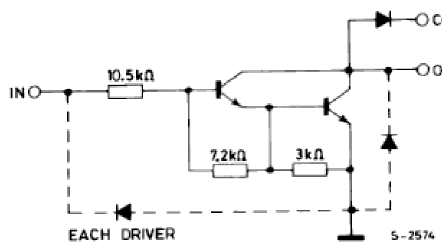
Series ULN-2001A
(each driver)



Series ULN-2002A
(each driver)



Series ULN-2003A
(each driver)



Series ULN-2004A
(each driver)

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_o	Output Voltage	50	V
V_{in}	Input Voltage (for ULN2002A/D - 2003A/D - 2004A/D)	30	V
I_c	Continuous Collector Current	500	mA
I_b	Continuous Base Current	25	mA
T_{amb}	Operating Ambient Temperature Range	– 20 to 85	°C
T_{stg}	Storage Temperature Range	– 55 to 150	°C
T_j	Junction Temperature	150	°C

THERMAL DATA

Symbol	Parameter		DIP16	SO16	Unit
$R_{th\ j\text{-}amb}$	Thermal Resistance Junction-ambient	Max.	70	120	°C/W

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit	Fig.
I_{CEX}	Output Leakage Current	V_{CE} = 50V T_{amb} = 70°C, V_{CE} = 50V T_{amb} = 70°C for ULN2002A V_{CE} = 50V, V_i = 6V for ULN2004A V_{CE} = 50V, V_i = 1V			50 100 500 500	µA µA µA µA	1a 1a 1b 1b
$V_{CE(sat)}$	Collector-emitter Saturation Voltage	I_C = 100mA, I_B = 250µA I_C = 200 mA, I_B = 350µA I_C = 350mA, I_B = 500µA		0.9 1.1 1.3	1.1 1.3 1.6	V V V	2 2 2
$I_{i(on)}$	Input Current	for ULN2002A, V_i = 17V for ULN2003A, V_i = 3.85V for ULN2004A, V_i = 5V V_i = 12V		0.82 0.93 0.35 1	1.25 1.35 0.5 1.45	mA mA mA mA	3 3 3 3
$I_{i(off)}$	Input Current	T_{amb} = 70°C, I_C = 500µA	50	65		µA	4
$V_{i(on)}$	Input Voltage	V_{CE} = 2V for ULN2002A I_C = 300mA for ULN2003A I_C = 200mA I_C = 250mA I_C = 300mA for ULN2004A I_C = 125mA I_C = 200mA I_C = 275mA I_C = 350mA			 13 2.4 2.7 3 5 6 7 8	V	5
h_{FE}	DC Forward Current Gain	for ULN2001A V_{CE} = 2V, I_C = 350mA	1000				2
C_i	Input Capacitance			15	25	pF	
t_{PLH}	Turn-on Delay Time	0.5 V_i to 0.5 V_o		0.25	1	µs	
t_{PHL}	Turn-off Delay Time	0.5 V_i to 0.5 V_o		0.25	1	µs	
I_R	Clamp Diode Leakage Current	V_R = 50V T_{amb} = 70°C, V_R = 50V			50 100	µA µA	6 6
V_F	Clamp Diode Forward Voltage	I_F = 350mA		1.7	2	V	7

TEST CIRCUITS

Figure 1a.

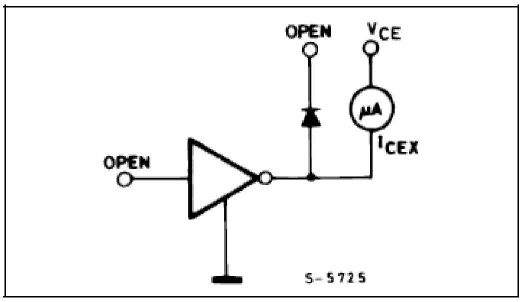


Figure 1b.

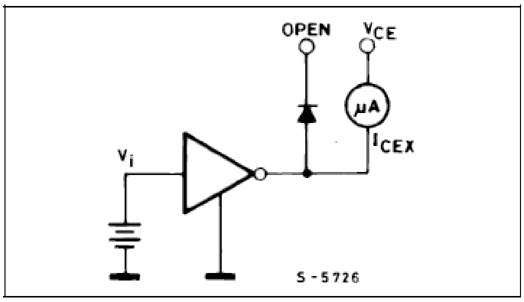


Figure 2.

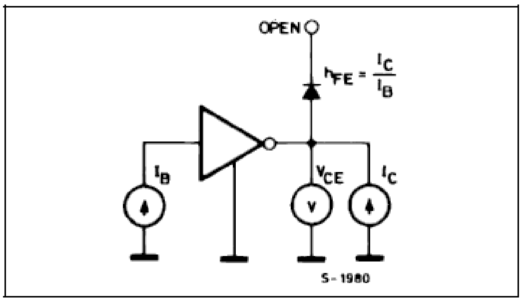


Figure 3.

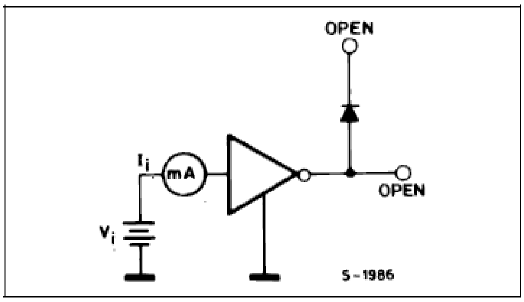


Figure 4.

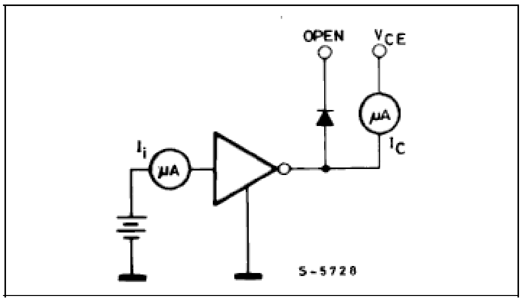


Figure 5.

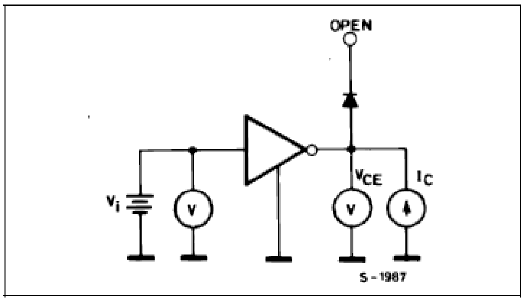


Figure 6.

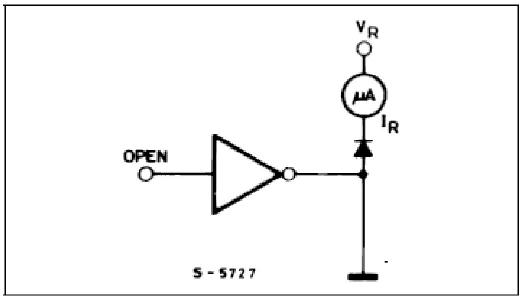
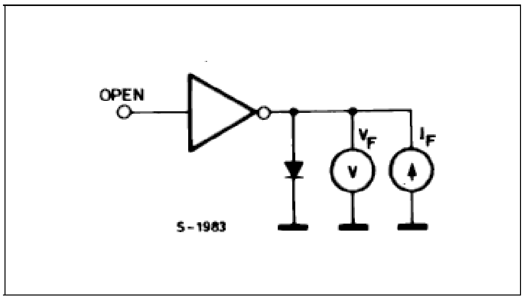


Figure 7.

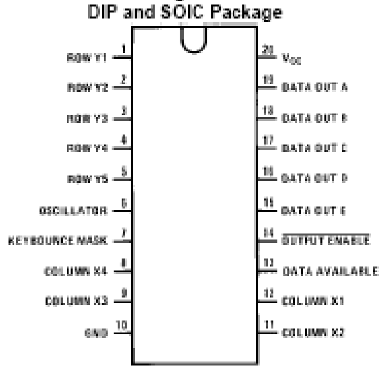


APPENDIX D

74C923 Datasheet

Connection Diagrams (Continued)

Pin Assignment for
DIP and SOIC Package



Top View
MM74C923

Truth Tables

(Pins 0 through 11)

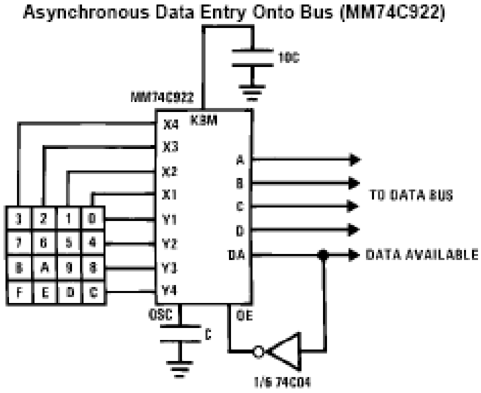
Switch Position		0 Y1,X1	1 Y1,X2	2 Y1,X3	3 5 Y1,X4	4 Y2,X1	Y2,X2	6 Y2,X3	7 Y2,X4	8 Y3,X1	9 Y3,X2	10 Y3,X3	11 Y3,X4
D													
A	A	0	1	0	1	0	1	0	1	0	1	0	1
T	B	0	0	1	1	0	0	1	1	0	0	1	1
A	C	0	0	0	0	1	1	1	1	0	0	0	0
O	D	0	0	0	0	0	0	0	0	1	1	1	1
U	E (Note 1)	0	0	0	0	0	0	0	0	0	0	0	0
T													

(Pins 12 through 19)

Switch Position		12 Y4,X1	13 Y4,X2	14 Y4,X3	15 Y4,X4	16 Y5(Note 1), X1	17 Y5 (Note 1), X2	18 Y5 (Note 1), X3	19 Y5 (Note 1), X4
D									
A	A	0	1	0	1	0	1	0	1
T	B	0	0	1	1	0	0	1	1
A	C	1	1	1	1	0	0	0	0
O	D	1	1	1	1	0	0	0	0
U	E (Note 1)	0	0	0	0	1	1	1	1
T									

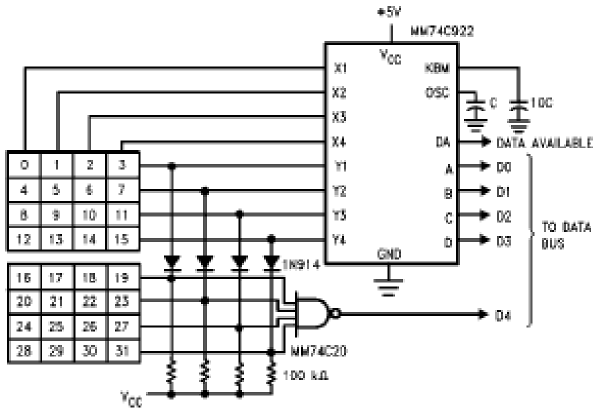
Note 1: Omit for MM74C922

Asynchronous Data Entry Onto Bus (MM74C922)



Outputs are in 3-STATE until key is pressed, then data is placed on bus. When key is released, outputs return to 3-STATE.

Expansion to 32 Key Encoder (MM74C922)



Theory of Operation

The MM74C922/MM74C923 Keyboard Encoders implement all the logic necessary to interface a 16 or 20 SPST key switch matrix to a digital system. The encoder will convert a key switch closer to a 4(MM74C922) or 5(MM74C923) bit nibble. The designer can control both the keyboard scan rate and the key debounce period by altering the oscillator capacitor, C_{OSE}, and the key bounce mask capacitor, C_{MSK}. Thus, the MM74C922/MM74C923's performance can be optimized for many keyboards.

The keyboard encoders connect to a switch matrix that is 4 rows by 4 columns (MM74C922) or 5 rows by 4 columns (MM74C923). When no keys are depressed, the row inputs are pulled high by internal pull-ups and the column outputs sequentially output a logic "0". These outputs are open drain and are therefore low for 25% of the time and otherwise off. The column scan rate is controlled by the oscillator input, which consists of a Schmitt trigger oscillator, a 2-bit counter, and a 2–4-bit decoder.

When a key is depressed, key 0, for example, nothing will happen when the X1 input is off, since Y1 will remain high. When the X1 column is scanned, X1 goes low and Y1 will go low. This disables the counter and keeps X1 low. Y1 going low also initiates the key bounce circuit timing and locks out the other Y inputs. The key code to be output is a combination of the frozen counter value and the decoded Y inputs. Once the key bounce circuit times out, the data is latched, and the Data Available (DAV) output goes high.

If, during the key closure the switch bounces, Y1 input will go high again, restarting the scan and resetting the key bounce circuitry. The key may bounce several times, but as soon as the switch stays low for a debounce period, the closure is assumed valid and the data is latched.

A key may also bounce when it is released. To ensure that the encoder does not recognize this bounce as another key closure, the debounce circuit must time out before another closure is recognized.

The two-key roll-over feature can be illustrated by assuming a key is depressed, and then a second key is depressed. Since all scanning has stopped, and all other Y inputs are disabled, the second key is not recognized until the first key is lifted and the key bounce circuitry has reset.

The output latches feed 3-STATE, which is enabled when the Output Enable ($\overline{OE}$) input is taken low.

APPENDIX E

AD623 Datasheet

ANALOG DEVICES

Single Supply, Rail-to-Rail, Low Cost Instrumentation Amplifier

AD623

FEATURES
- Easy to Use
- Higher Performance than Discrete Design
- Single and Dual Supply Operation
- Rail-to-Rail Output Swing
- Input Voltage Range Extends 150 mV Below Ground (Single Supply)
- Low Power, 575 μA Max Supply Current
- Gain Set with One External Resistor
  - Gain Range 1 (No Resistor) to 1,000

HIGH ACCURACY DC PERFORMANCE
- 0.1% Gain Accuracy (G = 1)
- 0.35% Gain Accuracy (G > 1)
- 25 ppm Gain Drift (G = 1)
- 200 μV Max Input Offset Voltage (AD623A)
- 2 μV/°C Max Input Offset Drift (AD623A)
- 100 μV Max Input Offset Voltage (AD623B)
- 1 μV/°C Max Input Offset Drift (AD623B)
- 25 nA Max Input Bias Current

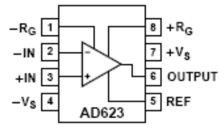
NOISE
- 35 nV/√Hz RTI Noise @ 1 kHz (G = 1)

EXCELLENT AC SPECIFICATIONS
- 90 dB Min CMRR (G = 10); 84 dB Min CMRR (G = 5) (@ 60 Hz, 1K Source Imbalance)
- 800 kHz Bandwidth (G = 1)
- 20 μs Settling Time to 0.01% (G = 10)

APPLICATIONS
- Low Power Medical Instrumentation
- Transducer Interface
- Thermocouple Amplifier
- Industrial Process Controls
- Difference Amplifier
- Low Power Data Acquisition

CONNECTION DIAGRAM

8-Lead Plastic DIP (N), SOIC (R) and μSOIC (RM) Packages



PRODUCT DESCRIPTION

The AD623 is an integrated single supply instrumentation amplifier that delivers rail-to-rail output swing on a single supply (+3 V to +12 V supplies). The AD623 offers superior user flexibility by allowing single gain set resistor programming, and conforming to the 8-lead industry standard pinout configuration. With no external resistor, the AD623 is configured for unity gain (G = 1) and with an external resistor, the AD623 can be programmed for gains up to 1,000.

The AD623 holds errors to a minimum by providing superior AC CMRR that increases with increasing gain. Line noise, as well as line harmonics, will be rejected since the CMRR remains constant up to 200 Hz. The AD623 has a wide input common-mode range and can amplify signals that have a common-mode voltage 150 mV below ground. Although the design of the AD623 has been optimized to operate from a single supply, the AD623 still provides superior performance when operated from a dual voltage supply (±2.5 V to ±6.0 V).

Low power consumption (1.5 mW at 3 V), wide supply voltage range, and rail-to-rail output swing make the AD623 ideal for battery powered applications. The rail-to-rail output stage maximizes the dynamic range when operating from low supply voltages. The AD623 replaces discrete instrumentation amplifier designs and offers superior linearity, temperature stability and reliability in a minimum of space. Until the AD623, this level of instrumentation amplifier performance has not been achieved.

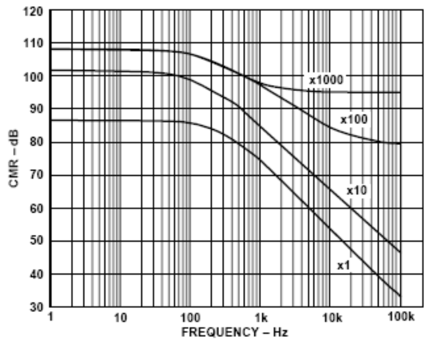


Figure 1. CMR vs. Frequency, +5 V_S, 0 V_S

REV. C

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781/329-4700 World Wide Web Site: http://www.analog.com
Fax: 781/326-8703

AD623–SPECIFICATIONS

SINGLE SUPPLY (typical @ +25°C Single Supply, V_S = +5 V, and R_L = 10 kΩ, unless otherwise noted)

Model Specification	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Units
GAIN	G = 1 + (100 k/R_G)										
Gain Range		1		1000	1		1000	1		1000	
Gain Error[1]	G1 V_{OUT} = 0.05 V to 3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1			0.03	0.10		0.03	0.10		0.03	0.05	%
G = 10			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 100			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 1000			0.10	0.35		0.10	0.35		0.10	0.35	%
Nonlinearity,	G1 V_{OUT} = 0.05 V to 3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1–1000			50			50			50		ppm
Gain vs. Temperature											
G = 1			5	10		5	10		5	10	ppm/°C
G > 1[1]			50			50			50		ppm/°C
VOLTAGE OFFSET	Total RTI Error = V_{OSI} + V_{OSO}/G										
Input Offset, V_{OSI}			25	200		200	500		25	100	µV
Over Temperature				350			650			160	µV
Average TC			0.1	2		0.1	2		0.1	1	µV/°C
Output Offset, V_{OSO}			200	1000		500	2000		200	500	µV
Over Temperature				1500			2600			1100	µV
Average TC			2.5	10		2.5	10		2.5	10	µV/°C
Offset Referred to the Input vs. Supply (PSR)											
G = 1		80	100		80	100		80	100		dB
G = 10		100	120		100	120		100	120		dB
G = 100		120	140		120	140		120	140		dB
G = 1000		120	140		120	140		120	140		dB
INPUT CURRENT											
Input Bias Current			17	25		17	25		17	25	nA
Over Temperature				27.5			27.5			27.5	nA
Average TC			25			25			25		pA/°C
Input Offset Current			0.25	2		0.25	2		0.25	2	nA
Over Temperature				2.5			2.5			2.5	nA
Average TC			5			5			5		pA/°C
INPUT											
Input Impedance											
Differential			2‖2			2‖2			2‖2		GΩ‖pF
Common-Mode			2‖2			2‖2			2‖2		GΩ‖pF
Input Voltage Range[2]	V_S = +3 V to +12 V	$(-V_S) - 0.15$		$(+V_S) - 1.5$	$(-V_S) - 0.15$		$(+V_S) - 1.5$	$(-V_S) - 0.15$		$(+V_S) - 1.5$	V
Common-Mode Rejection at 60 Hz with 1 kΩ Source Imbalance											
G = 1	V_{CM} = 0 V to 3 V	70	80		70	80		77	86		dB
G = 10	V_{CM} = 0 V to 3 V	90	100		90	100		94	100		dB
G = 100	V_{CM} = 0 V to 3 V	105	110		105	110		105	110		dB
G = 1000	V_{CM} = 0 V to 3 V	105	110		105	110		105	110		dB
OUTPUT											
Output Swing	R_L = 10 kΩ	+0.01		$(+V_S) - 0.5$	+0.01		$(+V_S) - 0.5$	+0.01		$(+V_S) - 0.5$	V
	R_L = 100 kΩ	+0.01		$(+V_S) - 0.15$	+0.01		$(+V_S) - 0.15$	+0.01		$(+V_S) - 0.15$	V
DYNAMIC RESPONSE											
Small Signal –3 dB Bandwidth											
G = 1			800			800			800		kHz
G = 10			100			100			100		kHz
G = 100			10			10			10		kHz
G = 1000			2			2			2		kHz
Slew Rate			0.3			0.3			0.3		V/µs
Settling Time to 0.01%	V_S = +5 V										
G = 1	Step Size: 3.5 V		30			30			30		µs
G = 10	Step Size: 4 V, V_{CM} = 1.8 V		20			20			20		µs

DUAL SUPPLIES (typical @ +25°C Dual Supply, V_S = ±5 V, and R_L = 10 kΩ, unless otherwise noted)

Model Specification	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Units
GAIN	G = 1 + (100 k/R_G)										
Gain Range		1		1000	1		1000	1		1000	
Gain Error[1]	G1 V_{OUT} = –4.8 V to 3.5 V G > 1 V_{OUT} = 0.05 V to 4.5 V										
G = 1			0.03	0.10		0.03	0.10		0.03	0.05	%
G = 10			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 100			0.10	0.35		0.10	0.35		0.10	0.35	%
G = 1000			0.10	0.35		0.10	0.35		0.10	0.35	%
Nonlinearity,	G1 V_{OUT} = –4.8 V to 3.5 V G > 1 V_{OUT} = –4.8 V to 4.5 V										
G = 1–1000			50			50			50		ppm
Gain vs. Temperature											
G = 1			5	10		5	10		5	10	ppm/°C
G > 1[1]			50			50			50		ppm/°C
VOLTAGE OFFSET	Total RTI Error = V_{OSI} + V_{OSO}/G										
Input Offset, V_{OSI}			25	200		200	500		25	100	µV
Over Temperature				350			650			160	µV
Average TC			0.1	2		0.1	2		0.1	1	µV/°C
Output Offset, V_{OSO}			200	1000		500	2000		200	500	µV
Over Temperature				1500			2600			1100	µV
Average TC			2.5	10		2.5	10		2.5	10	µV/°C
Offset Referred to the Input vs. Supply (PSR)											
G = 1		80	100		80	100		80	100		dB
G = 10		100	120		100	120		100	120		dB
G = 100		120	140		120	140		120	140		dB
G = 1000		120	140		120	140		120	140		dB
INPUT CURRENT											
Input Bias Current			17	25		17	25		17	25	nA
Over Temperature				27.5			27.5			27.5	nA
Average TC			25			25			25		pA/°C
Input Offset Current			0.25	2		0.25	2		0.25	2	nA
Over Temperature				2.5			2.5			2.5	nA
Average TC			5			5			5		pA/°C
INPUT											
Input Impedance											
Differential			2‖2			2‖2			2‖2		GΩ‖pF
Common-Mode			2‖2			2‖2			2‖2		GΩ‖pF
Input Voltage Range[2]	V_S = +2.5 V to ±6 V	(–V_S) – 0.15		(+V_S) – 1.5	(–V_S) –0.15		(+V_S) – 1.5	(–V_S) – 0.15		(+V_S) – 1.5	V
Common-Mode Rejection at 60 Hz with 1 kΩ Source Imbalance											
G = 1	V_{CM} = +3.5 V to –5.15 V	70	80		70	80		77	86		dB
G = 10	V_{CM} = +3.5 V to –5.15 V	90	100		90	100		94	100		dB
G = 100	V_{CM} = +3.5 V to –5.15 V	105	110		105	110		105	110		dB
G = 1000	V_{CM} = +3.5 V to –5.15 V	105	110		105	110		105	110		dB
OUTPUT											
Output Swing	R_L = 10 kΩ, V_S = ±5 V	(–V_S) +0. 2		(+V_S) – 0.5	(–V_S) + 0.2		(+V_S) – 0.5	(–V_S) + 0.2		(+V_S) – 0.5	V
	R_L = 100 kΩ	(–V_S) + 0.05		(+V_S) – 0.15	(–V_S) + 0.05		(+V_S) – 0.15	(–V_S) + 0.05		(+V_S) – 0.15	V
DYNAMIC RESPONSE											
Small Signal –3 dB Bandwidth											
G = 1			800			800			800		kHz
G = 10			100			100			100		kHz
G = 100			10			10			10		kHz
G = 1000			2			2			2		kHz
Slew Rate			0.3			0.3			0.3		V/µs
Settling Time to 0.01%	V_S = ±5 V, 5 V Step										
G = 1			30			30			30		µs
G = 10			20			20			20		µs

AD623–SPECIFICATIONS

BOTH DUAL AND SINGLE SUPPLIES

Model Specification	Conditions	AD623A Min	AD623A Typ	AD623A Max	AD623ARM Min	AD623ARM Typ	AD623ARM Max	AD623B Min	AD623B Typ	AD623B Max	Units
NOISE											
Voltage Noise, 1 kHz	Total RTI Noise = $\sqrt{(e_{ni})^2 + (e_{no}/G)^2}$										
Input, Voltage Noise, e_{ni}			35			35			35		nV/√Hz
Output, Voltage Noise, e_{no}			50			50			50		nV/√Hz
RTI, 0.1 Hz to 10 Hz											
G = 1			3.0			3.0			3.0		μV p-p
G = 1000			1.5			1.5			1.5		μV p-p
Current Noise	f = 1 kHz		100			100			100		fA/√Hz
0.1 Hz to 10 Hz			1.5			1.5			1.5		pA p-p
REFERENCE INPUT											
R_{IN}			100	±20%		100	±20%		100	±20%	kΩ
I_{IN}	V_{IN+}, V_{REF} = 0		+50	+60		+50	+60		+50	+60	μA
Voltage Range		$-V_S$		$+V_S$	$-V_S$		$+V_S$	$-V_S$		$+V_S$	V
Gain to Output			1 ± 0.0002			1 ± 0.0002			1 ± 0.0002		V
POWER SUPPLY											
Operating Range	Dual Supply	±2.5		±6	±2.5		±6	±2.5		±6	V
	Single Supply	+2.7		+12	+2.7		+12	+2.7		+12	V
Quiescent Current	Dual Supply		375	550		375	550		375	550	μA
	Single Supply		305	480		305	480		305	480	μA
Over Temperature				625			625			625	μA
TEMPERATURE RANGE											
For Specified Performance			–40 to +85			–40 to +85			–40 to +85		°C

NOTES
[1]Does not include effects of external resistor R_G.
[2]One input grounded. G = 1.
Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage . . . . ±6 V
Internal Power Dissipation[2] . . . . 650 mW
Differential Input Voltage . . . . ±6 V
Output Short Circuit Duration . . . . Indefinite
Storage Temperature Range
(N, R, RM) . . . . –65°C to +125°C
Operating Temperature Range
(A) . . . . –40°C to +85°C
Lead Temperature Range
(Soldering 10 seconds) . . . . +300°C

NOTES
[1]Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
[2]Specification is for device in free air:
8-Lead Plastic DIP Package: θ_{JA} = 95°C/W
8-Lead SOIC Package: θ_{JA} = 155°C/W
8-Lead μSOIC Package: θ_{JA} = 200°C/W

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option	Brand Code
AD623AN	–40°C to +85°C	8-Lead Plastic DIP	N-8	
AD623AR	–40°C to +85°C	8-Lead SOIC	SO-8	
AD623ARM	–40°C to +85°C	8-Lead μSOIC	RM-8	J0A
AD623AR-REEL	–40°C to +85°C	13" Tape and Reel	SO-8	
AD623AR-REEL7	–40°C to +85°C	7" Tape and Reel	SO-8	
AD623ARM-REEL	–40°C to +85°C	13" Tape and Reel	RM-8	J0A
AD623ARM-REEL7	–40°C to +85°C	7" Tape and Reel	RM-8	J0A
AD623BN	–40°C to +85°C	8-Lead Plastic DIP	N-8	
AD623BR	–40°C to +85°C	8-Lead SOIC	SO-8	
AD623BR-REEL	–40°C to +85°C	13" Tape and Reel	SO-8	
AD623BR-REEL7	–40°C to +85°C	7" Tape and Reel	SO-8	

ESD SUSCEPTIBILITY

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 volts, which readily accumulate on the human body and on test equipment, can discharge without detection. Although the AD623 features proprietary ESD protection circuitry, permanent damage may still occur on these devices if they are subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid any performance degradation or loss of functionality.

APPENDIX F

Max-233 Datasheet

19-4323; Rev 15; 1/06

+5V-Powered, Multichannel RS-232 Drivers/Receivers

MAX220–MAX249

General Description

The MAX220–MAX249 family of line drivers/receivers is intended for all EIA/TIA-232E and V.28/V.24 communications interfaces, particularly applications where ±12V is not available.

These parts are especially useful in battery-powered systems, since their low-power shutdown mode reduces power dissipation to less than 5μW. The MAX225, MAX233, MAX235, and MAX245/MAX246/MAX247 use no external components and are recommended for applications where printed circuit board space is critical.

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multidrop RS-232 Networks

AutoShutdown and UCSP are trademarks of Maxim Integrated Products, Inc.

Next-Generation Device Features

- **For Low-Voltage, Integrated ESD Applications**
  MAX3222E/MAX3232E/MAX3237E/MAX3241E/MAX3246E: +3.0V to +5.5V, Low-Power, Up to 1Mbps, True RS-232 Transceivers Using Four 0.1μF External Capacitors (MAX3246E Available in a UCSP™ Package)
- **For Low-Cost Applications**
  MAX221E: ±15kV ESD-Protected, +5V, 1μA, Single RS-232 Transceiver with AutoShutdown™

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX220CPE	0°C to +70°C	16 Plastic DIP
MAX220CSE	0°C to +70°C	16 Narrow SO
MAX220CWE	0°C to +70°C	16 Wide SO
MAX220C/D	0°C to +70°C	Dice*
MAX220EPE	-40°C to +85°C	16 Plastic DIP
MAX220ESE	-40°C to +85°C	16 Narrow SO
MAX220EWE	-40°C to +85°C	16 Wide SO
MAX220EJE	-40°C to +85°C	16 CERDIP
MAX220MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.
**Contact factory for dice specifications.*

Selection Table

Part Number	Power Supply (V)	No. of RS-232 Drivers/Rx	No. of Ext. Caps	Nominal Cap. Value (μF)	SHDN & Three-State	Rx Active in SHDN	Data Rate (kbps)	Features
MAX220	+5	2/2	4	0.047/0.33	No	—	120	Ultra-low-power, industry-standard pinout
MAX222	+5	2/2	4	0.1	Yes	—	200	Low-power shutdown
MAX223 (MAX213)	+5	4/5	4	1.0 (0.1)	Yes	✔	120	MAX241 and receivers active in shutdown
MAX225	+5	5/5	0	—	Yes	✔	120	Available in SO
MAX230 (MAX200)	+5	5/0	4	1.0 (0.1)	Yes	—	120	5 drivers with shutdown
MAX231 (MAX201)	+5 and +7.5 to +13.2	2/2	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; same functions as MAX232
MAX232 (MAX202)	+5	2/2	4	1.0 (0.1)	No	—	120 (64)	Industry standard
MAX232A	+5	2/2	4	0.1	No	—	200	Higher slew rate, small caps
MAX233 (MAX203)	+5	2/2	0	—	No	—	120	No external caps
MAX233A	+5	2/2	0	—	No	—	200	No external caps, high slew rate
MAX234 (MAX204)	+5	4/0	4	1.0 (0.1)	No	—	120	Replaces 1488
MAX235 (MAX205)	+5	5/5	0	—	Yes	—	120	No external caps
MAX236 (MAX206)	+5	4/3	4	1.0 (0.1)	Yes	—	120	Shutdown, three state
MAX237 (MAX207)	+5	5/3	4	1.0 (0.1)	No	—	120	Complements IBM PC serial port
MAX238 (MAX208)	+5	4/4	4	1.0 (0.1)	No	—	120	Replaces 1488 and 1489
MAX239 (MAX209)	+5 and +7.5 to +13.2	3/5	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; single-package solution for IBM PC serial port
MAX240	+5	5/5	4	1.0	Yes	—	120	DIP or flatpack package
MAX241 (MAX211)	+5	4/5	4	1.0 (0.1)	Yes	—	120	Complete IBM PC serial port
MAX242	+5	2/2	4	0.1	Yes	✔	200	Separate shutdown and enable
MAX243	+5	2/2	4	0.1	No	—	200	Open-line detection simplifies cabling
MAX244	+5	8/10	4	1.0	No	—	120	High slew rate
MAX245	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, two shutdown modes
MAX246	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, three shutdown modes
MAX247	+5	8/9	0	—	Yes	✔	120	High slew rate, int. caps, nine operating modes
MAX248	+5	8/8	4	1.0	Yes	✔	120	High slew rate, selective half-chip enables
MAX249	+5	6/10	4	1.0	Yes	✔	120	Available in quad flatpack package

+5V-Powered, Multichannel RS-232 Drivers/Receivers

ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243 (continued)

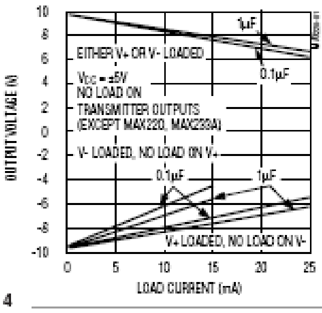
(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Receiver Propagation Delay RS-232 to TLL (Normal Operation), Figure 2	t_{PHLR}	MAX222/MAX232A/MAX233/ MAX242/MAX243		0.5	1	µs
		MAX220		0.6	3	
	t_{PLHR}	MAX222/MAX232A/MAX233/ MAX242/MAX243		0.6	1	
		MAX220		0.8	3	
Receiver Propagation Delay RS-232 to TLL (Shutdown), Figure 2	t_{PHLS}	MAX242		0.5	10	µs
	t_{PHLS}	MAX242		2.5	10	
Receiver-Output Enable Time, Figure 3	t_{ER}	MAX242		125	500	ns
Receiver-Output Disable Time, Figure 3	t_{DR}	MAX242		160	500	ns
Transmitter-Output Enable Time ($\overline{SHDN}$ Goes High), Figure 4	t_{ET}	MAX222/MAX242, 0.1µF caps (includes charge-pump start-up)		250		µs
Transmitter-Output Disable Time ($\overline{SHDN}$ Goes Low), Figure 4	t_{DT}	MAX222/MAX242, 0.1µF caps		600		ns
Transmitter + to - Propagation Delay Difference (Normal Operation)	t_{PHLT} - t_{PLHT}	MAX222/MAX232A/MAX233/ MAX242/MAX243		300		ns
		MAX220		2000		
Receiver + to - Propagation Delay Difference (Normal Operation)	t_{PHLR} - t_{PLHR}	MAX222/MAX232A/MAX233/ MAX242/MAX243		100		ns
		MAX220		225		

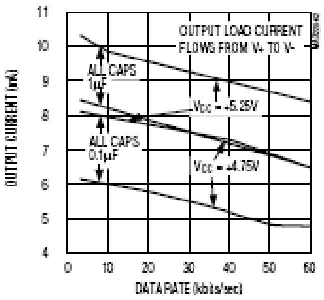
Typical Operating Characteristics

MAX220/MAX222/MAX232A/MAX233A/MAX242/MAX243

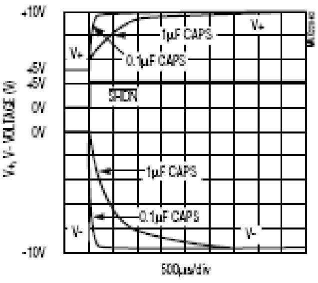
OUTPUT VOLTAGE vs. LOAD CURRENT



AVAILABLE OUTPUT CURRENT vs. DATA RATE



MAX222/MAX242 ON-TIME EXITING SHUTDOWN



MAXIM

+5V-Powered, Multichannel RS-232 Drivers/Receivers

ABSOLUTE MAXIMUM RATINGS—MAX225/MAX244–MAX249

Supply Voltage (V_{CC}) ....-0.3V to +6V
Input Voltages
T_{IN}, ENA, ENB, ENR, ENT, ENRA,
ENRB, ENTA, ENTB ....-0.3V to (V_{CC} + 0.3V)
R_{IN} ....±25V
T_{OUT} (Note 5)........................±15V
R_{OUT} ....-0.3V to (V_{CC} + 0.3V)
Short Circuit (one output at a time)
T_{OUT} to GND........................Continuous
R_{OUT} to GND........................Continuous

Continuous Power Dissipation (T_A = +70°C)
28-Pin Wide SO (derate 12.50mW/°C above +70°C) 1W
40-Pin Plastic DIP (derate 11.11mW/°C above +70°C) ...611mW
44-Pin PLCC (derate 13.33mW/°C above +70°C) 1.07W
Operating Temperature Ranges
MAX225C_ _, MAX24_C_ _ ....0°C to +70°C
MAX225E_ _, MAX24_E_ _ ....-40°C to +85°C
Storage Temperature Range........................-65°C to +160°C
Lead Temperature (soldering,10s) (Note 6) ....+300°C

Note 5: Input voltage measured with transmitter output in a high-impedance state, shutdown, or V_{CC} = 0V.
Note 6: Maximum reflow temperature for the MAX225/MAX245/MAX246/MAX247 is +225°C.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—MAX225/MAX244–MAX249

(MAX225, V_{CC} = 5.0V ±5%; MAX244–MAX249, V_{CC} = +5.0V ±10%, external capacitors C1–C4 = 1µF; T_A = T_{MIN} to T_{MAX}; unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 TRANSMITTERS						
Input Logic Threshold Low				1.4	0.8	V
Input Logic Threshold High			2	1.4		V
Logic Pull-Up/Input Current	Tables 1a–1d	Normal operation		10	50	µA
		Shutdown		±0.01	±1	
Data Rate	Tables 1a–1d, normal operation			120	64	kbps
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to GND		±5	±7.5		V
Output Leakage Current (Shutdown)	Tables 1a–1d	ENA, ENB, ENT, ENTA, ENTB = V_{CC}, V_{OUT} = ±15V		±0.01	±25	µA
		V_{CC} = 0V, V_{OUT} = ±15V		±0.01	±25	
Transmitter Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V (Note 7)		300	10M		Ω
Output Short-Circuit Current	V_{OUT} = 0V		±7	±30		mA
RS-232 RECEIVERS						
RS-232 Input Voltage Operating Range					±25	V
RS-232 Input Threshold Low	V_{CC} = 5V		0.8	1.3		V
RS-232 Input Threshold High	V_{CC} = 5V			1.8	2.4	V
RS-232 Input Hysteresis	V_{CC} = 5V		0.2	0.5	1.0	V
RS-232 Input Resistance			3	5	7	kΩ
TTL/CMOS Output Voltage Low	I_{OUT} = 3.2mA			0.2	0.4	V
TTL/CMOS Output Voltage High	I_{OUT} = -1.0mA		3.5	V_{CC} - 0.2		V
TTL/CMOS Output Short-Circuit Current	Sourcing V_{OUT} = GND		-2	-10		mA
	Shrinking V_{OUT} = V_{CC}		10	30		
TTL/CMOS Output Leakage Current	Normal operation, outputs disabled, Tables 1a–1d, 0V ≤ V_{OUT} ≤ V_{CC}, ENR_ = V_{CC}			±0.05	±0.10	µA

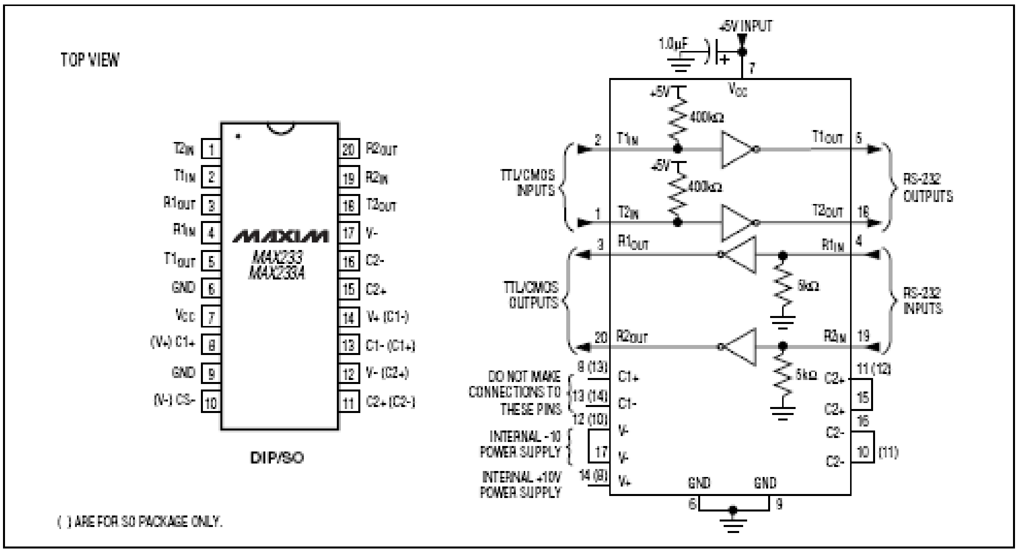


Figure 11. MAX233/MAX233A Pin Configuration and Typical Operating Circuit

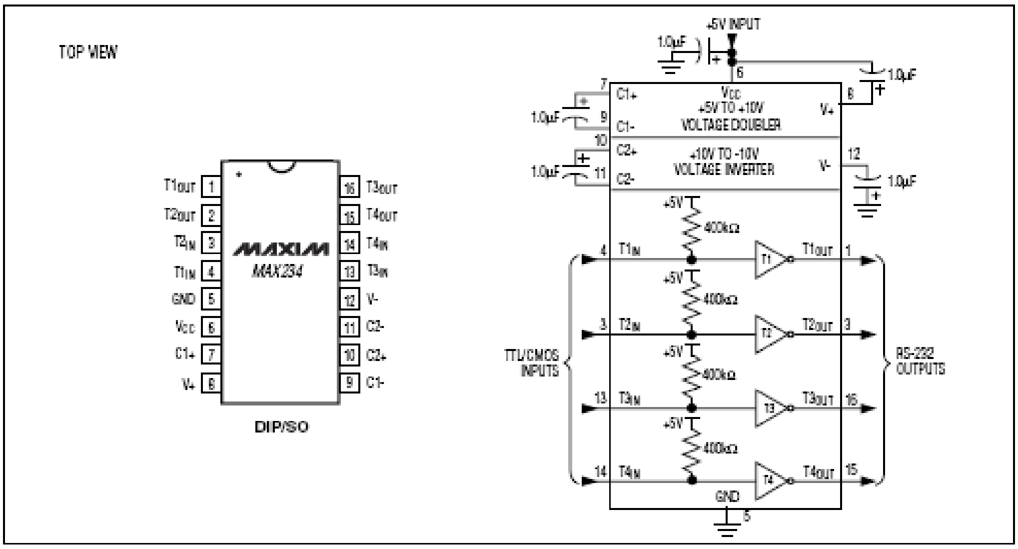


Figure 12. MAX234 Pin Configuration and Typical Operating Circuit

APPENDIX G

LCD JHD162A Datasheet

JHD162A SERIES

■CHARACTERISTICS： DISPLAY CONTENT：16 CHAR x 2ROW

CHAR. DOTS： 5 x 8

DRIVING MODE： 1/16D

AVAILABLE TYPES：

TN，STN(YELLOW GREEN、GREY、B/W)

REFLECTIVE、WITH EL OR LED BACKLIGHT

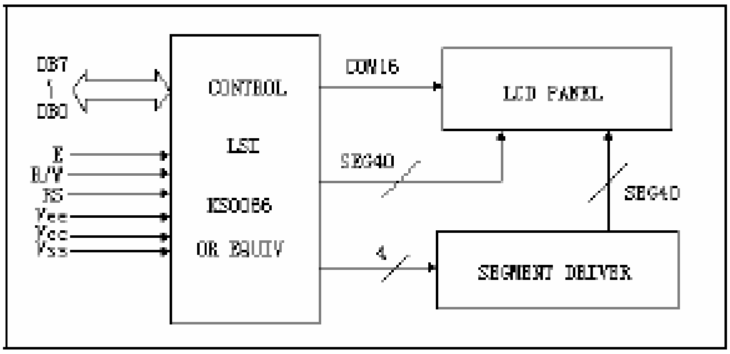
EL/100VAC，400HZ

LED/4.2VDC

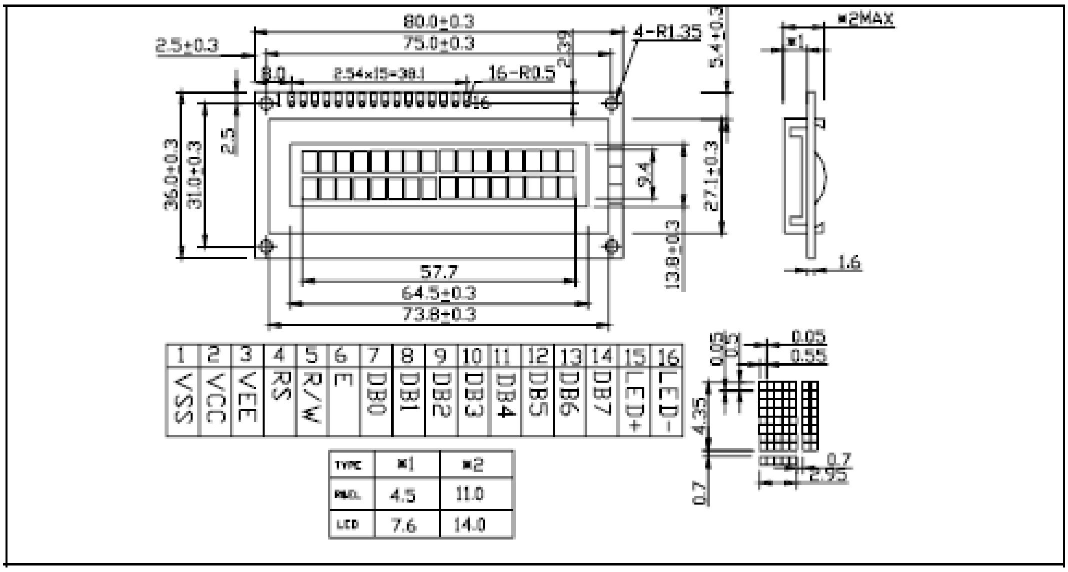
■PARAMETER （V_{DD}=5. 0V±10%, V_{SS}=0V, T_a=25℃）

Parameter	Symbol	Testing Criteria	Standard Values Min.	Typ.	Max	Unit
Supply voltage	V_{DD}-V_{SS}	-	4.5	5.0	5.5	V
Input high voltage	V_{IH}	-	2.2	-	V_{DD}	V
Input low voltage	V_{IL}	-	-0.3	-	0.6	V
Output high voltage	V_{OH}	-I_{OH}=02mA	2.4	-	-	V
Output low voltage	V_{OL}	I_{OL}=1.2mA	-	-	0.4	V
Operating voltage	I_{DD}	V_{DD}=5.0V	-	1.5	3.0	mA

■APPLICATION CIRCUIT



■DIMENSIONS/DISPLAY CONTENT

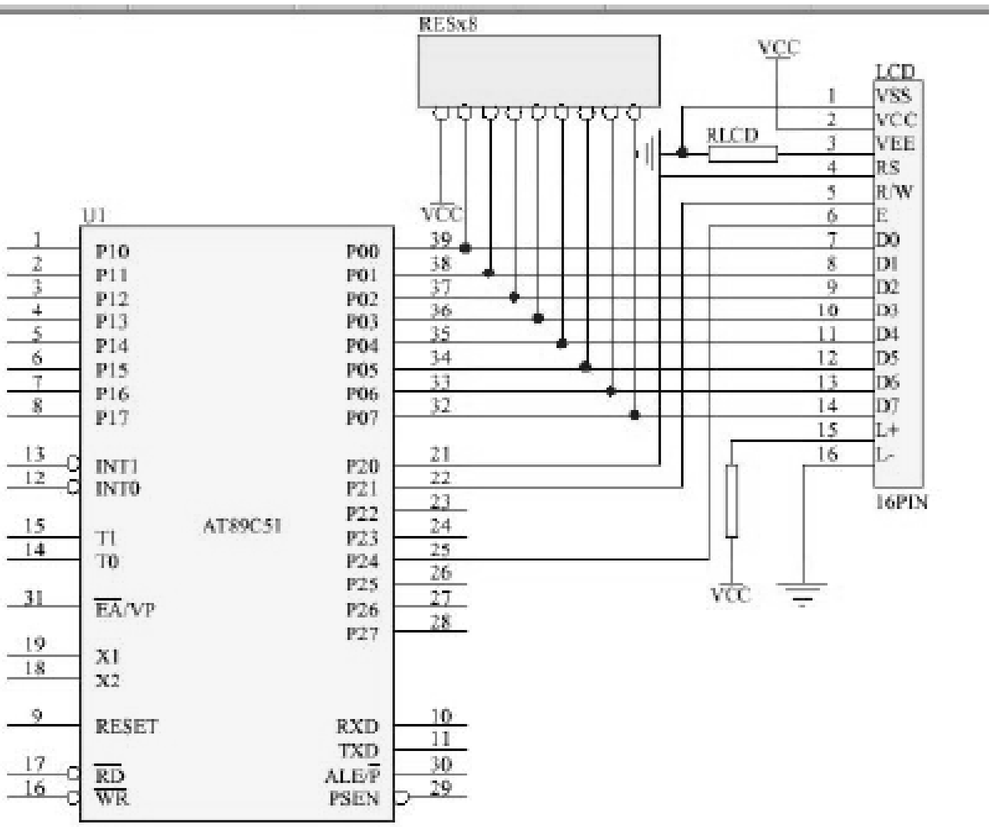


PIN CONFIGURATION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
VSS	VCC	VEE	RS	R/W	E	DB0	DB1	DB2	DB3	DB4	DB5	DB6	DB7	LED+	LED-

AC Characteristics Read Mode Timing Diagram

Connection



CGROM

APPENDIX H

Costing

Bil	Bahan/Komponen	Price / Unit	Quantity	Anggaran Harga
1	MC68HC11	RM40.00	1	RM 40.00
2	REGULATOR 7805	RM1.00	1	RM 1.00
3	PCB HEADER	RM0.80	20	RM 16.00
4	I.C BASE	RM0.50	8	RM 4.00
5	CRYSTAL 8MHz	RM1.20	1	RM 1.20
6	STRIP BOARD 10” x 4”	RM4.00	3	RM 12.00
7	RIBBON CABLE	RM3.00	1 METER	RM3.00
8	MAX233	RM9.50	1	RM 9.50
9	CAPACITOR	RM0.12	10	RM 1.20
10	RESISTOR	RM0.10	20	RM 2.00
11	DB9 FEMALE	RM0.60	1	RM 0.60
12	DB9 COVER	RM0.60	1	RM 0.60
13	HEAT SINK	RM0.90	1	RM 0.90
14	WRAPING WIRE	RM15.00	1	RM 15.00
15	HMC1021Z(magnetic field sensor)	RM 150.00	1	RM 150.00
16	IC 74C923	RM23.00	1	RM23.00
17	LCD JHD162A	RM30.00	1	RM30.00
18	STEPPER MOTOR	RM16.00	1	RM16.00
19	ULN2003A	RM8.00	1	RM8.00
20	LED	RM0.15	4	RM0.60
21	KEYPAD	RM23.00	1	RM23.00
22	IRF7509:PBF MOSFET	RM3.62	1	RM3.62
23	RE903 ADAPTOR,SMD,MSOP-08	RM37.81	1	RM37.81
24	AD623	RM12.61	1	RM12.61
TOTAL ESTIMATION PRICE				**RM411.64**

```
REG          EQU     $1000
PORTA        EQU     $0
PORTB        EQU     $4
PORTC        EQU     $3
PORTD        EQU     $8
PORTE        EQU     $A
PACTL        EQU     $26
DDRC         EQU     $7


BUFFER       ORG     $12
             RMB     8

             ORG     $B600
             LDS     #$7F
             LDX     #REG
             BSET    DDRC,X      %11111111


MULA         JSR     INIT_LCD
             JSR     DELAY1
GOGO         JSR     DISP1
             JSR     KEYPAD
             BRA     GOGO


INIT_LCD     LDY     #INI
NEXT         LDAA    $0,Y
             BEQ     DISP0
             BSR     COMMAND
             INY
             BRA     NEXT

DISP0        LDAA    #$85
             JSR     COMMAND
             LDY     #DATA0
             JSR     YAYA
             RTS

DISP1        LDAA    #$1
             JSR     COMMAND
             LDAA    #$80
             JSR     COMMAND
             LDY     #DATA1
             JSR     YAYA
             LDAA    #$C0
             JSR     COMMAND
             RTS


COMMAND      BCLR    PORTA,X     %00001000       ; R/S = 0, COMMAND MODE
             BSR     ENABLE
             RTS

CHARAC       BSET    PORTA,X     %00001000       ; R/S = 1, CHARACTER MODE
             BSR     ENABLE
             RTS

ENABLE       STAA    PORTC,X                     ; STORE COMMAND or CHARACTER
             BSET    PORTA,X     %00010000
             BCLR    PORTA,X     %00010000       ; TRIGER ENABLE
             JSR     DELAY
             RTS
```

```
YAYA        LDAA    $0,Y
            BEQ     YOYO
            JSR     CHARAC
            INY
            BRA     YAYA
YOYO        RTS


KEYPAD      CLRA
            LDY     #3
SCANK       BRCLR   PORTA,X     %00000001      SCANK
            LDAB    PORTE,X
            BSR     TITIK
            JSR     DELAY0
            JSR     DELAY0
            ANDB    #$0F
            ABA
            DEY
            BNE     SCANK
            CMPA    #6
            BNE     ERROR
            BSR     DISP2
            JSR     S1
            JSR     DELAY1
            JSR     DELAY1
            JSR     S2
            RTS


ERROR       LDAA    #$1
            JSR     COMMAND
            LDAA    #$80
            JSR     COMMAND
            LDY     #DATA3
            JSR     YAYA
            BRA     DELAY1
            RTS

DISP2       LDAA    #$1
            JSR     COMMAND
            LDAA    #$80
            JSR     COMMAND
            LDY     #DATA2
            JSR     YAYA
            BSR     DELAY1
            LDAA    #$C0
            JSR     COMMAND
            BSR     IRDA
            BSR     DELAY1
            RTS

TITIK       PSHA
            LDAA    #$2A
            JSR     CHARAC
            PULA
            RTS


IRDA        LDAB    PORTA,X
            BITB    #$2
            BEQ     DOL
            LDY     #PARK1
```

```
                JSR     YAYA
DOL             BITB    #$4
                BEQ     DUL
                LDY     #PARK2
                JSR     YAYA
DUL             RTS


S1              LDY     #CW                             ;STEPPER 1
S111            LDAA    0,Y
                STAA    PORTB,X
                BSR     DELAY
                INY
                CPY     #CW+8
                BNE     S111
                RTS


S2              LDY     #CCW                                    ;STEPPER 2
S222            LDAA    0,Y
                STAA    PORTB,X
                BSR     DELAY
                INY
                CPY     #CCW+10
                BNE     S222
                RTS



DELAY           PSHX
                LDX     #$FFF
REPEAT          DEX
                BNE     REPEAT
                PULX
                RTS

DELAY0          PSHX
                LDX     #$FFFF
REPEAT0         DEX
                BNE     REPEAT0
                PULX
                RTS


DELAY1          PSHA
                PSHX
                LDAA    #9
REPEAT1         LDX     #$FFFF
LAGI1           DEX
                BNE     LAGI1
                DECA
                BNE     REPEAT1
                PULX
                PULA
                RTS


                ORG     $B777
INI             FCB     $01,$02,$06,$0C,$38,0
DATA0           FCC     "WELCOME"
                FCB     0
DATA1           FCC     "INSERT PASSWORD"
                FCB     0
```

```
DATA2       FCC     "ACCESS GRANTED"
            FCB     0
DATA3       FCC     "ACCESS DENIED"
            FCB     0
PARK1       FCC     "C1"
            FCB     0
PARK2       FCC     "C2"
            FCB     0
CCW         FCB     $01,$02,$04,$08,$01,$02,$04,$08,$01,$02,0
CW          FCB     $08,$04,$02,$01,$08,$04,$02,$01,0


            END
```