Palestine Polytechnic University

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Graduation Project

Portable Security System Using Communication Cards

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كلية الهندسة والتكـنولوجيا
دائرة الهندسة الكهربائية

اسم المشروع

Portable Security System Using Communication Cards

اسماء الطلبة

مروة السلايمة　　　ميسم البابا

بناء على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندســـة الكهربائية وذلك للوفاء بمتطلبات درجة البكالـــوريوس في الهندســـة تخصص هندســـة أنظمـــة حـــاسوب.

توقيع المشرف

....

توقيع اللحنة الممتحة

....

توقيع رئيس الدائرة

....

Dedication

To our first teacher

Our fathers

....

To our heart lover

Our mothers

...

To the flower of the earth & the stars of the sky

Our sisters & brothers

...

To whom we love & can't forget

Our friends, beloved & teachers

...

To the soul of Martyrs

...

To all of the Islamic countries

Thank you very deep from our hearts for all
the love and supports that
you have given to us.

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Abstract (English)

Portable Security System Using Communication Cards

BY

Marwa Salaimeh Maysam Albaba

Our project is based on wireless communication between two plastic cards; each card has been adjusted to be sensitive in receiving and sending signals from the other card. This idea is based on PIC 18F4520 microcontroller which is the main part in our project. PIC 18F4520 microcontroller controls and performs the main activities in this project.

Each communicating signal between the two cards holds identifying code known to the other card. Receiving or sending signals between the two cards will compare the held code according to the code stored in the microcontroller memory. If this comparison process is correct, every thing goes well and the alarm system will not activated, but in case of error the alarm system will be activated by the microcontroller.

This microcontroller is having very sensitive specifications through its influence on activating the alarm system to give sounds on both sides in case of danger.
Our aim is implementing this idea for saving valuable things from being taken by thieves and also protecting children from kidnapping or abduction.

Abstract (Arabic)

إن المشروع الذي نود تقديمه عبارة عن بطاقتين يكون الإتصال بينهما لاسلكيا، وكل بطاقة من هاتين البطاقتين قد تم تصميمها لتكون حساسة لإستقبال وإرسال إشارات الى البطاقة الثانية. إن هذه الفكرة تم ايجادها لتحتوي على منظم(microcontroller) الذي هو الجزء الرئيسي في المشروع. لقد استخدمنا في مشروعنا المنظم (PIC 18F4520 microcontroller) لتطبيق هذا المشروع. أي إشارات إتصال تصدر بين البطاقتين تكون محملة برمز معين معروف لدى البطاقة الثانية، عند إرسال أو استلام إشارة إتصال يتم مقارنة الرمز المحمول عليها طبقا للرمز الذي تم تخزينه في ذاكرة المنظم(microcontroller)، في حالة كون هذه المقارنة سليمة وصحيحة لن يتم تفعيل جهاز الانذار لكون الامور تسير على ما يرام , ولكن في حالة الخطأ فإنه يتم تفعيل نظام الإنذار بواسطة المنظم(microcontroller) ليصدر صوت في كلتا البطاقتين.

الهدف من تطبيق هذا المشروع هو حماية الأشياء الثمينة من اللصوص و السرقة وكذلك الأطفال من الضياع أو الخطف.

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Chapter

1 INTRODUCTION

Chapter One

Introduction

1.1 Preface:

This project is about a portable security system that based on maintaining a wireless communication between two or more cards within a defined distance. In the simplest form, card no.1 intermittently transmits specific signal to card no.2. Card no.2 will be receiving the incoming signal from card no.1 and after receiving that signal it must respond by sending a specific signal to card no.1. If card no.1 successfully receives signal from card no.2, this means that card no.2 is in the safe domain. For any reason if the communication between two cards failed and there is a loss in communication between the two cards, the alarm should be activated

The project is based on using these two cards between separate human bodies that is between the mother and her child. So this project relates to a system and method for monitoring the departure of a child from a retail store or other area. Another important feature about this project is that the system can be used to protect personal valuable objects like wallets. In this case the first card will be placed on the person shirt pocket and the other card will be placed on the valuable object. Therefore this project can easily be upgraded in the future to make it more robust and practical.

1.2 Project Importance:

Every body wants to keep his valuable objects safe. Losing or kidnapping a child is the parent's greatest fear. While shopping with a small child, parents will be constantly watching to make sure that the child does not go out from the store's door. This constant concern is the present's major distraction, and is leading to loss of sales. Many retail stores have installed a children's play area to minimize the shopping parent's distraction. These play areas do not effectively prevent a child from wandering unless the play area is supervised. So we need a project that has an advantage of portability with no tether or other device of physical connection was required between parent's child, valuable object and the alarm. The system should be small enough in size to be virtually invisible to the person using it. It would not be only desirable to have an alarm that sounds when a valuable object such as a wallet was taken from the owner, but also sounds when such object has been inadvertently left behind the owner.

One intended use of this project is the protection of children from being lost. One pair of the cards is placed for instance in the child's shirt pocket, and the other card is also placed in the parent's shirt pocket. The two alarms on both cards are activated when the child is far away or being lost from his/her parent. So, parents will be able to point and locate where their child is.

1.3 Project objectives:

- Protection of children or any valuable objects from being lost
- Developing a portable security and protection system based on maintaining a wireless communication between two or more cards within a defined distance.
- Developing a small system that can be invisible to the person using it and easy to carry.
- Developing a portable security system with alarm on both cards that sounds if the son is far away or being lost from his mother

1.4 Literature Review:

- 'Anti- Pickpocket Alarm', granted on March.13, 1990, to Julian j. Yanotti and Tomas Johnson. This device involves the attachment of a tether to both a wallet and other valuable objects and to an alarm on the person carrying such that improper removal of the object from the person actuates the alarm. The alarm system of that patent suffers from disadvantages of awkwardness and the need to have a tether extending from the valuable object.

- 'Tracking Radio Frequency System', issued on Nov. 27, 1990 to Maletta. This tracking system uses radio frequency signals that is a bracelet secured to a convinced felon, who communicates with a tracking device at a central location, such systems, however differ from the subject invention in that the device at the central location is relatively a large piece of equipment.

1.5Time Plan:

This section provides chart diagram that shows the stages of this project according to time; which we will obtain our project associating the time spent doing each stage.

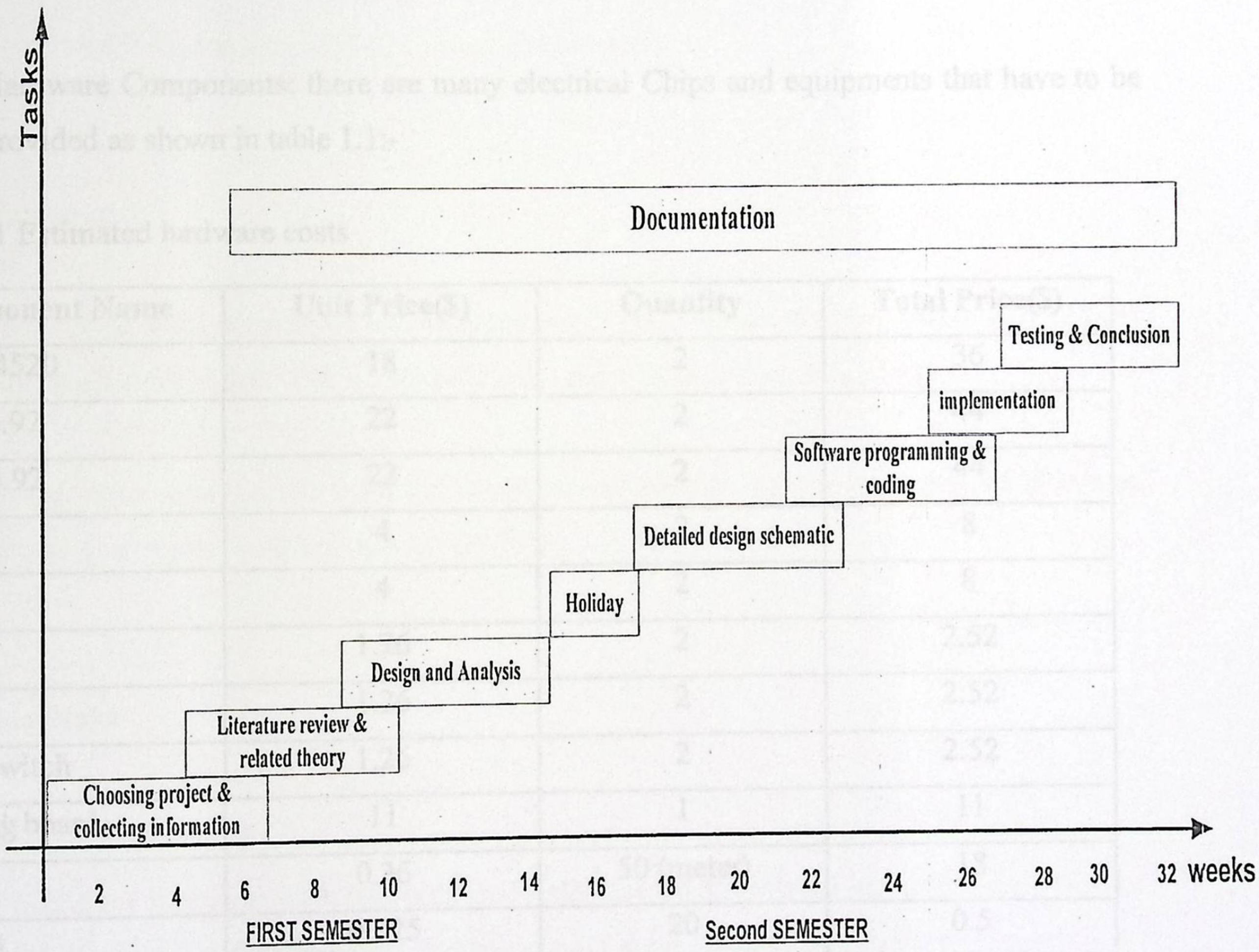

Fig1.1 Project time plan.

1.6 Estimated Cost:

The project needs both hardware equipments and software programs that run on the computer, so we will purchase all the needed electronic components and software programs. So this section shows the estimated hadware, software costs as a challenge of every activity we do.

- Hardware Components: there are many electrical Chips and equipments that have to be provided as shown in table 1.1:-

Table 1.1 Estimated hadware costs

Component Name	Unit Price($)	Quantity	Total Price($)
PIC 18F4520	18	2	36
RT4-433.92	22	2	44
RR3-433.92	22	2	44
HT-E	4	2	8
HT-D	4	2	8
2N2219	1.26	2	2.52
Buzzer	1.26	2	2.52
Toggle switch	1.26	2	2.52
Wrapping board	11	1	11
Wires	0.36	50 (meter)	18
Resistors	0.025	20	0.5
Breadboards	8	6	48
Battery	1.7	4	24
Crystal oscillator	1.26	1	1.26
			250.32

- Software such as:-
    1. Windows XP or more it costs (299$).
    2. Microsoft Office (145$).
    3. MPLAB IDE program (free from internet).
    4. WinPic800 software programmer (free from the internet).
    5. PIC18 Simulator IDE (free from the internet).

- Human cost:

The project team consists of two students, work in 27 weeks, 4 hours a day with 12$ per hour. So each student get 1296 $ (4x12x27) and the total human cost is 2592$

The total cost: - the total cost contains the hardware equipments, software programs and human costs, the total cost reach about approximately (3286.32)

1.7 Project Risks:

The project may face some problems and risks that we have to declare in the early time of the project designing and manipulation, and the project must avoid those problems to work in its high efficiency, so when we find a risk we will try to solve it without effect on the total project much as we can.

1. One of the group member died or is sick

2. Unavailability of some project needed components under the pressure of political environments
3. Some of project parts do not work correctly; it will break the whole system, ex: transmitter or receiver may not work properly
4. Lack of experience in using lab. Instruments, ex: high and low voltage in using power supply.
5. The needed time for response is so long that makes the user nervous.
6. The scheduling and dependency of the all system parts must be in the correct direction and expectation, otherwise we will fail and late in producing the complete and integrated program. Like the receiver circuit that depends on existing a compatible address transmitter circuit, if there is no such compatible address, a problem occurs and it refers to no executed system.

1.8 Road Map:

The project consists of six chapters, each chapter talks about a specific area of the project.

Chapter One: "Introduction", this chapter gives an introduction about the system, its importance, other related systems, project time plan and project cost.

Chapter Two: "Theoretical Background", this chapter gives a clear picture about the system theoretical background related to the main concepts of wireless communication and system basic components.

Chapter Three:	"Design Concepts", this chapter shows what other options could be chosen instead of those we used, project design block diagram and how each unit interfaces with other units to implement the aimed system.
Chapter Four:	"Hardware System Design", this chapter shows system design and circuit schematics for each part of the project, brief description of the work each schematic does.
Chapter Five:	"Software System Design ", this chapter describes the program that operates the project, psudocode and algorithms that describe project systems processes.
Chapter Six:	"System Implementation and Testing', this chapter discusses the actual project testing and implementation in details.
Chapter Seven:	"Conclusion and Future Work", this chapter is simplifying the conclusions and results achieved after implementing the entire project and gives suggestions for the future system developing.

Chapter

2 *THEORETICAL BACKGROUND*

Chapter Two

Theoretical Background

2.1 Preface

As mentioned previously this portable security system based on using two cards. Each card contains a PIC microcontroller with its sub components such as memory, control unit and comparator means. It also houses a transmitter with modulation means and a receiver with demodulation means, an antenna as well as the alarm system.

This chapter provides an illustrative theoretical background for the project basic components, and how each component communicates with other components at the same card and between the two communicating cards as well.

2.2 Wireless Communication

This project will be fully constructed over a communication between two cards. In the most fundamental sense, communication between two cards involves implicitly the transmission of information that is the identification code between the two cards through a succession of processes that involves the generation of the message containing identification code; this message is encoded in a form that is suitable for transmission over a wireless channels. As reaching its destination, the encoded signal will be decoded in order to reproduce the original message signal and hence the original identification code.

There are three basic elements to every communication system, namely, transmitter, channel, and receiver. Each card has a transmitter that performs modulation process and a receiver that performs demodulation as will be discussed in the following sections and the project channel is based on a wireless communication with an RF signal. [1]

- **Modulation Process**

The purpose of this project is to deliver a signal containing one card identification code in recognizable form to the other card. To do this, the transmitter modifies the message signal into a form suitable for transmission over the wireless channel. This modification is achieved by means of a process known as modulation, which involves varying some parameter of a carrier wave in accordance with the message signal. The receiver re-creates the original message signal from a degraded version of the transmitted signal after propagation through the channel. This re-creation is accomplished by using a process known as demodulation, which is the reverse of the modulation process used in the transmitter. However, owing to the unavoidable presence of noise and distortion in the received signal, the receiver cannot re-create the original message signal exactly. The resulting degradation in overall system performance is influenced by the type of modulation scheme used. Specifically, we find that some modulation schemes are less sensitive to the effects of noise and distortion than others.

Two forms of modulation are generally distinguished, although they have many properties in common: If the modulating signal's amplitude varies continuously with time, it is said to be an analog signal and the modulation is referred to as analog. In the case where the modulating signal may vary its amplitude only between a finite number of values and the change may occur only at discrete moments in time, the modulating signal is said to be a digital signal and the modulation is referred to as digital.

If the modulating signal is digital, the modulation is termed amplitude-shift keying (ASK), frequency-shift keying (FSK), or phase-shift keying (PSK), since in this case the discrete amplitudes of the digital signal can be said to shift the parameter of the carrier signal between a finite number of values. For a modulating signal with only two amplitudes, "binary" is sometimes added before these terms. [2]

- **Digital modulation:**

The aim of **digital modulation** is to transfer a digital bit stream over an analog band pass channel, for example over a limited radio frequency band. This can be described as a form of digital-to-analog conversion. The changes in the carrier signal are chosen from a finite number of alternative symbols (the **modulation alphabet**).

These are the most findamental digital modulation techniques:

- In the case of PSK, a finite number of phases are used.
- In the case of FSK, a finite number of frequencies are used.
- In the case of ASK, a finite number of amplitudes are used.

Each of these phases, frequencies or amplitudes are assigning a unique pattern of binary bits. Usually, each phase, frequency or amplitude encodes an equal number of bits. This number of bits comprises the *symbol* that is represented by the particular phase.

If the alphabet consists of $M = 2^N$ alternative symbols, each symbol represents a message consisting of N bits. If the symbol rate (the **symbol rate** is the bit rate divided by the number of bits transmitted in each symbol, measured in symbols-per-second, (Hz))

For example, with an alphabet consisting of 16 alternative symbols, each symbol represents 4 bits.

Being common to all digital communication systems, the design of both the modulator and demodulator must be done simultaneously. Digital modulation schemes are possible because the transmitter-receiver pair have prior knowledge of how data is encoded and represented in the communications system. In all digital communication systems, both the modulator at the transmitter and the demodulator at the receiver are structured so that they perform inverse operations. [3]

- **Amplitude-shift keying (ASK):**

Amplitude-shift keying (ASK) is a form of modulation which represents digital data as variations in the amplitude ofa carrier wave.

The amplitude of an analog carrier signal varies in accordance with the bit stream (modulating signal), keeping frequency and phase constant. The level of amplitude can be used to represent binary logic 0s and 1s. We can think of a carrier signal as an ON or OFF switch. In the modulated signal, logic 0 is represented by the absence of a carrier, thus giving OFF/ON keying operation and hence the name given.

Like AM, ASK is also linear and sensitive to atmospheric noise, distortions, propagation conditions on different routes in PSTN, etc. It requires excessive bandwidth and is therefore a waste of power. Both ASK modulation and demodulation processes are relatively inexpensive. The ASK technique is also commonly used to transmit digital data over optical fiber. For LED transmitters, binary 1 is represented by a short pulse of light and binary 0 by the absence of light. [3]

- **Demodulation process:**

Detectors or demodulators extract information riding on a carrier that was encoded before transmission and returns it to its original form. This process called demodulation. So, demodulation is the act of removing the modulation from an analog signal.

There are several ways of demodulation depending on what parameters of the base-band signal are transmitted in the carrier signal, such as amplitude, frequency or phase.

However, the received signal is likely to be a corrupted version of the original transmitted signal; it is distorted due to channel imperfections, many techniques are used to limit localized interference and noise. [2]

- **Noise**

Noise is unwanted electrical signals presents in any electrical systems also it could be considered as data without meaning. This noise can be characterized as random, unpredictable electrical signals from any of the noise source. Noise sources could be man made (using special devices to produce noise over certain system) or natural (any elements such: atmosphere and the sun, etc).

As we know noise can block, distort, or change the meaning of a message or data sent in both human and electronic communication, so communication systems should use filters to extract data and achieve receiving pure information (data). [2]

- **Filtering:**

Filter is a device which transmits only part of the incident energy and may thereby change the spectral distribution of energy, so filtering is the process of limiting localized interference and noise. There are three types of filters and those are:

a. Low-Pass Filter:

This filter is designed to transmit electromagnetic frequencies below a certain value, while excluding or reduces those of a higher frequency by blocking them. The actual amount of attenuation for each frequency varies from filter to filter. It is sometimes called a high-cut filter, or treble cut filter when used in audio applications

b. High-Pass-Filter:

This filter is designed to transmit electromagnetic frequencies above a certain value, while excluding those of a lower frequency by blocking them. Contrast with low-pass filter. The actual amount of attenuation for each frequency varies from filter to filter. It is sometimes called a low-cut filter; the terms bass-cut filter or rumble filter are also used in audio applications. It is useful as a filter to block any unwanted low frequency components of a complex signal while passing the higher frequencies. Of course, the meanings of 'low' and 'high' frequencies are relative to the cutoff frequency chosen by the filter designer.

c. Band-Pass-Filter:

A filter designed to transmit a particular band of electromagnetic frequencies between a lower cut-off frequency (f_1) and a higher cut-off frequency (f_2) while excluding those of higher or lower frequencies. It can be made by a combination of a low-pass filter and a high pass filter.

An ideal filter would have a complete flat passband (e.g. with no gain/attenuation throughout) and would completely attenuate all frequencies outside the passband. Additionally, the transition out of the passband would be instantaneous in frequency. In practice, no bandpass filter is ideal. The filter does not attenuate all frequencies outside the desired frequency range completely; in particular, there is a region just outside the intended passband where frequencies are attenuated, but not rejected. This is known as the filter roll-off. Generally, the design of a filter seeks to make the roll-off as narrow as possible, thus allowing the filter to perform as close as possible to its intended design.

However, in this project the low pass filter is used in the receiver circuits to obtain the original signal. [2]

- **Types of wireless technologies:**

During the last few years, many wireless technologies came out for serving in the short-range field for commercial applications. Many solutions are possible but need further investigation, such a solution is:

A. Infra red (IR) technology.
B. Radio frequency (RF) technology.
C. Blue tooth technology.

A. <u>Infra red (IR) technology:</u>

1. Based on the technology of infra red based.
2. Directional system which means that the transmitter should be directed to the receiver, and if something is blocking the signal like a wall, the system will not work.
3. Short range, the distance in which the system can cover few meters.
4. The signal could be affected by a noise signals.

B. **Radio frequency (RF) technology:**

1. Based on radio frequency.
2. Non directional system, nothing can block the signal from the transmitter to reach the receiver.
3. Wide range, this system covers a wide distance up to miles and this depends on the used modules.
4. The signal could be affected by noise signals.

C. **Blue tooth technology:**

1. It is a new technology.
2. We can't say that it is limited because the technology we have in our country is limited up to 100 m, but it's over that range at the outside world.
3. It is a unidirectional system.

From the previous comparison we are going to use the second technology that is the radio frequency (RF) signal.Because:

1. It is not limited for a couple of meters.
2. It is unidirectional technology in which we will serve our project.
3. Easy to implement.
4. Cheap
5. We believe that this is the actual way for the wireless communication and covers all what this project need.

- **Radio Frequency (RF) signal:**

RF (*Radio Frequency*) is any frequency within the electromagnetic spectrum associated with radio waves propagation and suitable for utilization in radio communication. Some of these waves serve as carriers of the lower-frequency audio waves; others are modulated by video or digital information. Radio waves are identified by their frequencies, expressed in kilohertz (kHz), i.e., thousands of cycles per second, in megahertz (MHz), i.e., millions of cycles per second, or in gigahertz, i.e., billions of cycles per seconds. The frequencies cover a significant portion of the electromagnetic radiation spectrum, extending from nine kilohertz (9 kHz), the lowest allocated wireless communications frequency (it's within the range of human hearing), to thousands of gigahertz (GHz).

The electromagnetic waves can be generated by alternating current fed to an antenna. When an RF current is supplied to an antenna, it gives rise to an electromagnetic field that propagates through space. This field is sometimes called an RF field; in less technical jargon it is a "radio wave." Any RF field has a wave length that is inversely proportional to the frequency; short waves have relatively high frequencies; long waves have relatively low frequencies

RF is a good way to pass information between two things. In the last few years, many cheap RF boards have become available on the market. Some wireless devices operate at IR or visible-light frequencies, whose electromagnetic wave lengths are shorter than those of RF fields. [4]

- **Antenna:**

Antenna is a conductive device that converts electromagnetic waves into electric current and vice versa also designed to transmit or receive radio waves. Antennas are used in systems using wireless communication such as radio, television broadcasting, wireless LAN, radar and …etc. The antenna radiate the modulated signal through the air so that the destination can receive it and usually work in air or outer space, but can also be operated under water or even through soil and rock at certain frequencies for short distances.

The Antenna in Physical manner is an arrangement of conductors that generate a radiating electromagnetic field in response to an applied alternating voltage and the associated alternating electric current, or can be placed in an electromagnetic field so that the field will induce an alternating current in the antenna and a voltage between its terminals.

There are two fundamental types of antennas, which, with reference to a specific three dimensional (usually horizontal or vertical) plane are:

Either Omni-directional (radiates equally in all directions), or Directional (radiates more in one direction than in the other).

Antenna parameters

There are several critical parameters that affect an antenna's performance and can be adjusted during the design process. These are:

1. Resonant frequency that is related to the electrical length of the antenna.
2. Gain which measures the directionality of a given antenna. Low gain emits radiation in all directions equally, whereas a high-gain antenna will preferentially radiate in particular directions.
3. Impedance that results as electro-magnetic wave travels through the different parts of the antenna systems.
4. Bandwidth that is the range of frequencies over which it is effective, usually centered on the resonant frequency.
5. Effeciency in transferring power.

Transmit antennas may also have a maximum power rating, and receive antennas differ in their noise rejection properties

Depending on their use and operating frequency, antennas can take the form of a single piece of wire, a dipole grid such as a yagi array, a horn, a helix, a sophesticated parabolic-shaped dish, or a phase array of active electronic elements of virtually any flat or convoluted surface.

The size and shape of antennas are determined primarily by the frequency of the signal they are designed to transmit or to receive. In our project we will use antenna as a single piece of wire. [2]

2.3 Hypothesis:

The hypothesis of this project evolved from the research collected about every theme related to the project.

- Hypothesizing every component needed to make up this project is available and will perform its aimed operation.
- Hypothesizing lab. instruments and tools needed for testing and implementing the project are available.
- Hypothesizing this project can be developed and controlled using PIC microcontroller.
- Hypothesizing this project can be developed and implemented using wireless communication with radio frequency (RF) signal.
- Hypothesizing the project software can be programmed by any high level or assembly language.

- **Project hardware:**

This project is made up from the following hardware components:

1. PIC microcontroller that will control all system operations
2. Transmitter with its encoder that will send needed data
3. Receiver with its decoder that will receive data sent by the transmitter
4. Alarm system that will give a special sound like buzzer

- **Project software:**

Here are the following can be used:

1. MPLAB IDE software program to write the software code that will operate our project. This software code will be written using a high level language that is C language.
2. WinPIC800 software programmer to download our project program to the PIC microcontroller.
3. PIC18 simulator IDE to simulate our program and check it before downloading.

2.4 Project integraty:

- The system does not have anything illegal related to relegion and operates within low, for example we use RF singnal and this signal is more acceptable in low in our countries than bluetooth signal.

- The system has no illegal input or response and also does not have bad ethicals.
- The system is secure since each card has its own secret identification code and each transmitter operates only with its compatable receiver with both must have the same 8-bit address.
- This project is safe since no unsafe and harmful component is used and the alarm system chosen is very simple and unharmful.

2.5 Project Components:

Of course the basic unit of the system is the control unit that will control all the aimed applications, this unit is the microcontroller. The microcontroller is needed to perform security calculations wanted to examine if there is any break of the system work (e.g. if the separation distance between the two cards became longer than that specified, means when the child is getting away from his/her mother).

In the following sections we provide a detailed explanation of each component and each part of this project.

2.5.1 Microcontroller:

A microcontroller is a cheap single-chip microcomputer. Single-chip microcomputer indicates that the complete microcomputer system lies within the confine of the integrated circuit chip. Microcontrollers are capable of storing and running the program that was written and downloaded into it. The main parts of a microcontroller generally consist of the Central

Processing Unit (CPU), Random Access Memory (RAM), Read Only Memory (ROM), input/output lines (I/O lines), serial and parallel ports, timers and other peripherals such as analog to digital (A/D) converter and digital to analog (D/A) converter.

Microcontrollers are inexpensive microcomputers. The microcontroller's ability to store and run unique programs makes it very flexible. For example, one can program a microcontroller to perform functions based on predetermined situations (1/O line logic) and selections. The microcontroller's capability to carry out mathematical and logic functions allows it to imitate complicated logic and electronic circuits. [5]

Other programs can make the microcontroller behave like a neural circuit or a fuzzy logic controller.

- **PIC 18F4520 microcontroller:**

This subsection provides a theoretical background about the PIC18F4520. Different tasks related to this microcontroller, plus the problems faced and how they were solved.

The PIC18f4520 is a very powerful 8-bit enhanced flash microcontroller based on Risk architecture with a nano watt technology, easy-to-program since it has only 75 single word instructions as well as an extended set of 8 new instructions designed to optimize re-entrant code, operates at 40 MHZ frequency and is packed into 40- or 44-pin package. The main features of PIC18F4520 are given below:

PIC18F4520 main features:

- 256 bytes of EEPROM data memory.
- 32K enhanced flash program memory.
- Self programming under software control.
- Up to 13 channel 10-bit Analog-to-Digital (A/D) converter module.
- 2 additional timers.
- Capture/compare/PWM functions (CCP).
- Enhanced capture/compare/PWM (ECCP) module.
- Master synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I^2C™) bus and
- Enhanced Universal Asynchronous Receiver Transmitter (USART) module.

All of these features make this PIC ideal in serving our needs for the project in single chip, since we need memory to hold digitized identification data, and modulation to modulate the carrier signal with the identification data, transmitter that is connected to the antenna for intermittent transmission of the carrier signal to the other card, receiver that is connected to the antenna for intermittent reception of a modulated carrier signal from the other card, and a comparator for comparing identification data in its memory with data carried in the modulated carrier signal received from the other card, all of these components can be carried over one chip that is **PIC 18F4520**. [6]

As mentioned previously, the microcontroller that has been selected in this project is the PIC 18F4520 from Microchip Technology Incorporate. This was done after a long search, reading and comparison between it and other potential microcontrollers that can be used in this project. Simply, we have chosen this chip for its convincing key features as shown in table 2.1. The following points summarize why we select the PIC18F4520:

- Up to 32K x 16 words of FLASH Program Memory, this is quite enough for this project.
- Only 75 single word instructions to learn with Assembly, therefore, it is not so hard to learn.
- C compiler optimized architecture.
- Serial communication through Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART) module.
- Low price (about 18$).

Table 2.1shows a comparison between our PIC18F4520 and other microcontrollers.

Table 2.1: Key Features of Different 18F Microcontrollers

Key Features	PIC 18F2420	PIC 18F2520	PIC 18F4420	PIC 18F4520
Flash program memory	16K	32K	16K	32K
# Single word instructions	8192	16384	8192	16384
SPRAM	768	1536	768	1536
EEPROM (bytes)	256	256	256	256
I/O	25	25	36	36
CCP/ECCP (PWM)	2/0	2/0	1/1	1/1
Timers	1/3	1/3	1/3	1/3

- **Transmitter:**

Simply, a transmitter is any object (source) which sends information to an observer (receiver).

A transmitter propagates an electromagnetic signal such as radio with the aid of an antenna. A transmitter usually has a power supply, an oscillator, a modulator, and amplifiers for Audio Frequency (AF) and Radio Frequency (RF). The modulator is the device which piggybacks (or modulates) the signal information onto the carrier frequency, which is then broadcasted. To transmit a new signal, oscillators create sine waves which are encoded and broadcasted as radio signals.

Transmitter is needed to convert the message signal that contains the identification code produced by the frequency generator into a form suitable for transmission through a wireless communication to the other card. However, as the transmitted signal propagates along the channel, it is distorted due to channel imperfections. Moreover, noise and interfering signals (originating from other sources) are added to the channel output, with the result that the received signal is a corrupted version of the transmitted signal.

- **Receiver:**

A receiver is an electronic circuit that receives a radio signal from an antenna and converts the signal into sound, pictures, navigational-position information, etc. So the receiver operates on the received signal so as to reconstruct a recognizable form of the original message signal for a user. Receiver usually has demodulator or detector, filters and RF power amplifier.

In this project receiver is needed to receive the message signal containing the transmitted card identification code. [8]

2.2.3 Alarm

This project has been basically designed utilizing two or more cards in intermittent wireless communication with each other within a defined communication range.

Coming to this point the importance of the alarm arises. We need an alarm on card no.1 which gives special sound when the alarm system activated and another alarm on card no.2 which also should generate sound in certain sequence, so we can use it later in specifying the location of this card. We should notice that this alarm system is activated if communication between two cards is broken.

Alarm system is an electrical or electronic device that serves in case of danger by means of a sound or signal. There are many alarm systems that can serve what is needed in this project, buzzer is considered as a simple cheap alarm and can serve this project perfectly. [2]

- buzzer

A buzzer or beeper is a signaling device, usually electronic that consists commonly of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound.

The word "buzzer" comes from the rasping noise that buzzers made when they were electromechanical devices, operated from stepped-down AC line voltage at 50 or 60 cycles. Other sounds commonly used to indicate that a button has been pressed to ring.

Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise). Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC-connected devices was to implement a circuit to make the AC current into a noise loud enough to drive a loudspeaker and hook this circuit up to a cheap 8-ohm speaker. Nowadays, it is more popular to use a ceramic-based piezoelectric sounder. [2]

2.2.4 Batteries:

A battery is an electrochemical device that stores chemical energy which can be converted into electrical energy by producing electrons through chemical reactions that is Electro-Chemical reactions. Chemical energy is stored and then converted to electrical energy on demand, thereby providing a direct-current voltage source. Although the term "battery" is properly applied to a group of two or more electrochemical cells connected together electrically, both single-cell and multi cell devices are called battery.

There are two general types of batteries; the primary (non rechargeable) battery and the secondary (chargeable) battery. [9]

- **Primary (non rechargeable) battery:**

The primary known as non rechargeable and delivers current as the result of a chemical reaction that is not efficiently reversible. Practically, this makes the primary battery non rechargeable. Only one intermittent or continuous discharge can be obtained before the chemicals placed in it during manufacturing are consumed. Then the discharged primary battery must be replaced.

- **Secondary (rechargeable) battery:**

The secondary or storage battery is rechargeable because it delivers current as the result of a chemical reaction that is easily reversible. They come in many different designs using different chemicals.

Rechargeable batteries operate very much in the same way as regular battery when they are being discharged. However; when the battery is charged, the electrons flow in the opposite direction of the discharge until it is fully charged. They can take electrical energy and store it as chemical energy for later use.

Non chargeable batteries can be replaced with higher capacity, environmentally friendly, rechargeable butteries that last for longer each time they are charged and can be used many hundreds of times saving us a lot of money. So future applications are proposed to use rechargeable batteries and this project uses them. [9]

There are several types of rechargeable-battery chemistries:

1. Nickel-Cadmium (NiCad) batteries.
2. Nickel-metal-hydride (NIMH).
3. Lithium-ion.

4. Zinc-Air.
5. Rechargeable alkaline.

But which type is most suitable for this project? Really, there are three main considerations:

- Cost.
- Performance for a given application.
- Environmental friendliness.

Since one objective of this project is to develop a portable system that is invisible to the person using it and easy to carry, we need a small sized rechargeable buttery that gives as the needed voltage and last for the longest possible time. However, we didn't find a specific buttery that has all features that we just provided, but we found that Lithium-ion is the most suitable available rechargeable buttery for this project for the following reasons:

1. These butteries produce the same energy as NIMH butteries but are 40% smaller, half the weight.
2. Cheap
3. Very good power to weight ratio
4. Better for the environment because they don't contain toxic materials such as cadmium or mercury.

Chapter

3 DESIGN CONCEPTS

3.1 Project Objectives

3.2 Design Options.

3.3 Design Realization Approach.

3.4 General block diagram

Chapter three

Design Concepts

The project objectives and its general block and sub blocks diagram will be shown in this chapter.

3.1 Project Objectives:

This section gives a clear picture about objectives that we aim to achieve after implementing this project. The main objectives are listed below:

- To develop a portable security system that is small enough to be virtually invisible to the person using it so that each card is sized to be sufficiently small and easy to carry.
- Designing and programming a system controller unit and interface it with other components.
- To achieve security by means of placing two identification codes in the memory of each card and use a comparator for determining if a correspondence exists between the identification code in the memory and code carried in the modulated carrier signal received from the other card.

- To develop a portable security system with an alarm that sounds if such a correspondence is not created in the comparator means on the first card after defined number of transmissions of the modulated carrier signal by the first card.
  This alarm should be activated on both cards when mismatch code generated and when the other card will be out of the defined range.

3.2 Design options:

There are many issues that we must consider in order to build a functional, successful and reliable portable security system using communication cards. That issue involves proper design, choice of major components, methods for modulation and others, which are a challenge on its own. There are many alternative options for choosing each component and this section talks about each available option.

3.2.1 Microcontroller:

Microcontroller controls different needed functions for the entire project. We have two available suitable options:

1. PIC 16F877
2. PIC 18F4520

- To develop a portable security system with an alarm that sounds if such a correspondence is not created in the comparator means on the first card after defined number of transmissions of the modulated carrier signal by the first card.

  This alarm should be activated on both cards when mismatch code generated and when the other card will be out of the defined range.

3.2 Design options:

There are many issues that we must consider in order to build a functional, successful and reliable portable security system using communication cards. That issue involves proper design, choice of major components, methods for modulation and others, which are a challenge on its own. There are many alternative options for choosing each component and this section talks about each available option.

3.2.1 Microcontroller:

Microcontroller controls different needed functions for the entire project. We have two available suitable options:

1. PIC 16F877
2. PIC 18F4520

- **PIC 16F877:**

The PIC 16f877 is an 8-bit microcontroller based on Risk architecture, easy-to-program since it has only 35 single word instructions with 200 nanoseconds execution time and is packed into 40- or 44-pin package. The convincing features for choosing this microcontroller are:

- Up to 8K x 14 words of FLASH Program Memory, that is quite enough for this project.
- Only 35 single word instructions to learn with Assembly, therefore, it is not so hard to learn.
- Low price (about $12-$20).

But the problem in choosing this PIC is the difficulty in programming because it does not have a high level language compiler specially that its programmer is not available in our university and very expensive to be purchased.

- **PIC 18F4520:**

This project uses PIC18F4520. Its key features are explained in chapter two and are closely related to PIC 16F877 features microcontroller, and the option of choosing PIC18F4520 refers to:

- High computational performance.
- Economical price.
- High endurance.
- Enhanced Flash program memory.
- Its programmer availability in our university.
- It is C compiler optimized architecture so it is programmed using C language that the project team familiar with.
- Availability of Mp lab program used in programming it.
- Mplab already provides built functions that makeprogramming easier.

3.2.2 Transmitter:

The transmitter is used to transmit the identification code. Two suitable options are available:

1. RTQ4-XXX transmitter.
2. RT4-XXX transmitter.

- **RTQ4-XXX transmitter:**

It is an ASK radio transmitter with crystal oscillator and external Antenna that allows to realize a complete radio transmitter adding a coding circuit and shows stable electric characteristics. It has the following features:

- High Output Power.
- Range 100+ meters.
- Working frequency (433.92, 868.35, 915 MHz) and available as 433, 868 MHz.

It seems an excellent choice for this project, but the problem is that we don't have much availability of components.

- **RT4-XXX transmitter:**

Fortunately RTQ4-XXX is a pin out compatible with RT4 Transmitter that is much available at a suitable price. This transmitter is discussed in detail in chapter two and here we give the key features that convince us in choosing this excellent transmitter.

- Available as 315, 418, 433 MHz
- Range up to 70 metros
- Available In DIL or SIL Package
- Wide Operating Voltage

It seems that its range is less than RTQ4 transmitter. But indeed, 70m is enough for this project and does not need more.

3.2.3 Alarm system:

Alarm system is needed to give a special sound that indicates both mother and child locations. We have two available suitable options:

1. Alarm system using 555
2. A simple buzzer

- **Using 555 timer:**

It is circuit built from: 555 timer and RC circuit edged by a simple speaker. This circuit is activated when PIC 18F4520 microcontroller command it to work according to certain conditions. The circuit gives a good sound, but in order to achieve a relatively reliable high sound, we can connect an amplifier, thereby giving a much stronger sound good enough to indicate both mother and child location at a longer distance. The circuit schematic is shown below:

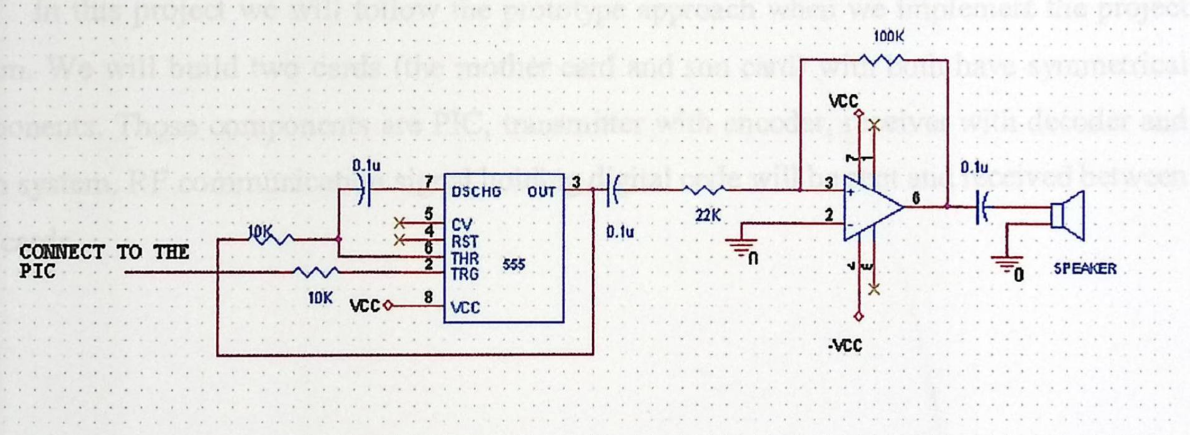

Fig.3.1 Alarm using 555 schematic

- **A simple buzzer:**

This option is what we will take in this project. It is a simple circuit that has only a simple buzzer connected to a transistor. This buzzer when triggered by PIC 18F4520 gives a special sound indicating the location of both mother and her child. The reasons for choosing this option is that

1. It is a relatively very simple circuit with only two components.
2. Buzzer is much available in our market.
3. Gives us the needed sound and this buzzer can be replaced with a much higher sound circuit like piezoelectic alarm.

3.3 Design realization approach:

In this project we will follow the prototype approach when we implement the project system. We will build two cards (the mother card and son card) with both have symmetrical components. Those components are PIC, transmitter with encoder, receiver with decoder and alarm system. RF communication signal holding digital code will be sent and received between both cards.

3.4 General block diagram:

This section illustrates all general components of the system, their block diagrams and routines embedded in the two cards.

Fig3.2 illustrates two thin cards with their major components. These major components are microcontroller, transmitter, receiver as well as the alarm.

The transmitting/receive part acts on both the reception and transmission of a radio frequency (RF) carrier signal through which card no.1 intermittently transmits specific signal to card no.2. The controller at card no.2 continuously monitors the received demodulated signal, and on sensing the commencement of such signal the controller prepares other embedded circuit parts as shift register and comparator for comparing this signal with an identification code in the card memory. Meanwhile, card no.1 has started monitoring for any sign of a return carrier signal and on sensing the commencement of that carrier signal; card no.1 controller prepares other circuit component as shift register and comparator for comparing the received signal with code in card no.1 memory. On matching those codes, we reset a timer and card no.2 is in safe domain. If the timer is not reset during a defined number of transmissions by the first card, the alarm circuit will be immediately activated on both cards.

In the following section we will show each component block diagram and the interfacing between those components in more details.

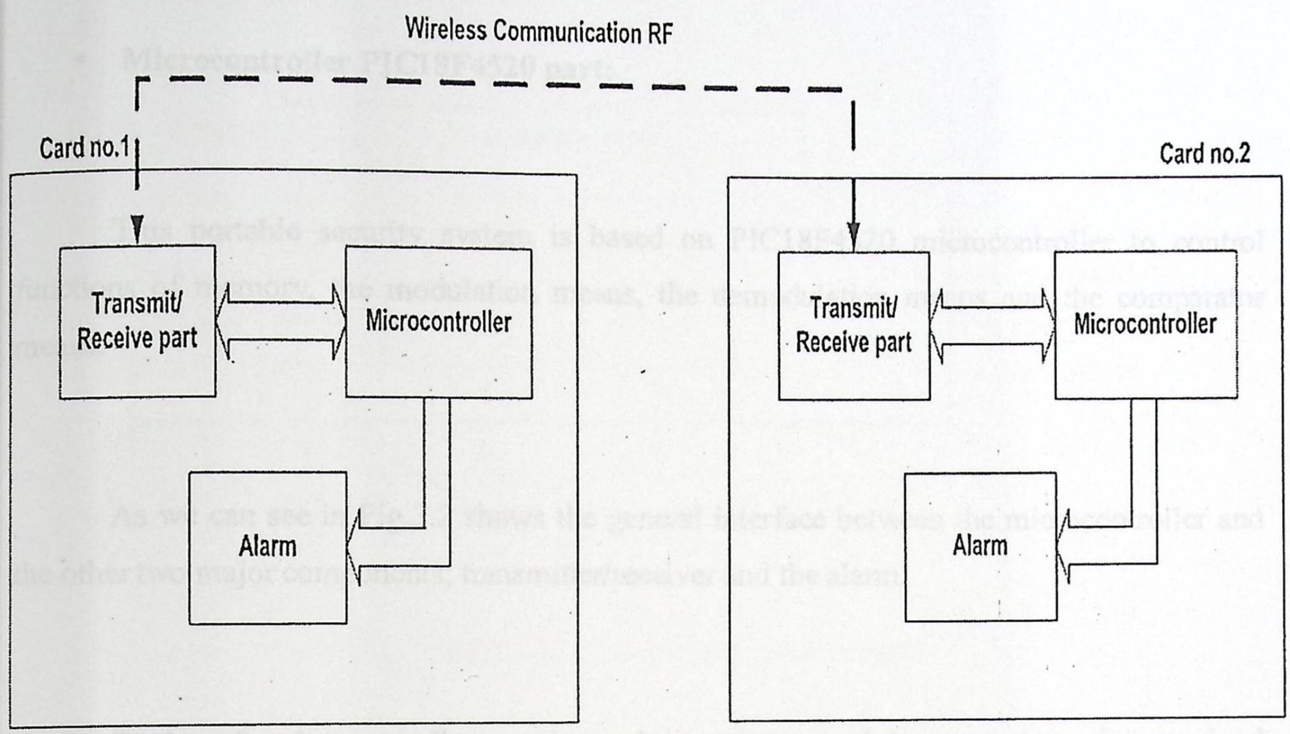

Fig. 3.2: General Block diagram

3.5 Interfacing of the main components & sub components

This section illustrates interfacing between all components of the system, their detailed block diagrams and detailed system circuits operations.

- **Microcontroller PIC18F4520 part:**

This portable security system is based on PIC18F4520 microcontroller to control functions of memory, the modulation means, the demodulation means and the comparator means.

As we can see in Fig.3.2 shows the general interface between the microcontroller and the other two major components; transmitter/receiver and the alarm.

Card no.2 microcontroller continuously monitors receiving any sign of a received carrier signal and on sensing such a signal the controller prepares it to be compared with an identification code placed in the card memory (PIC 18F4520 memory). If both are matched then the microcontroller order the transmit/receive part to generate carrier signal and prepared it to be sent by transmitter to card no.1. At this moment, controller on card no.1 has started monitoring receiver for a return carrier signal from card no.2. On sensing that signal, controller prepares it for comparing with identification code placed at card no.1 memory. If matched, the controller restarts an internal timer. If this timer is not restarted during a defined number of transmissions by the first card, the controller activates the alarm.

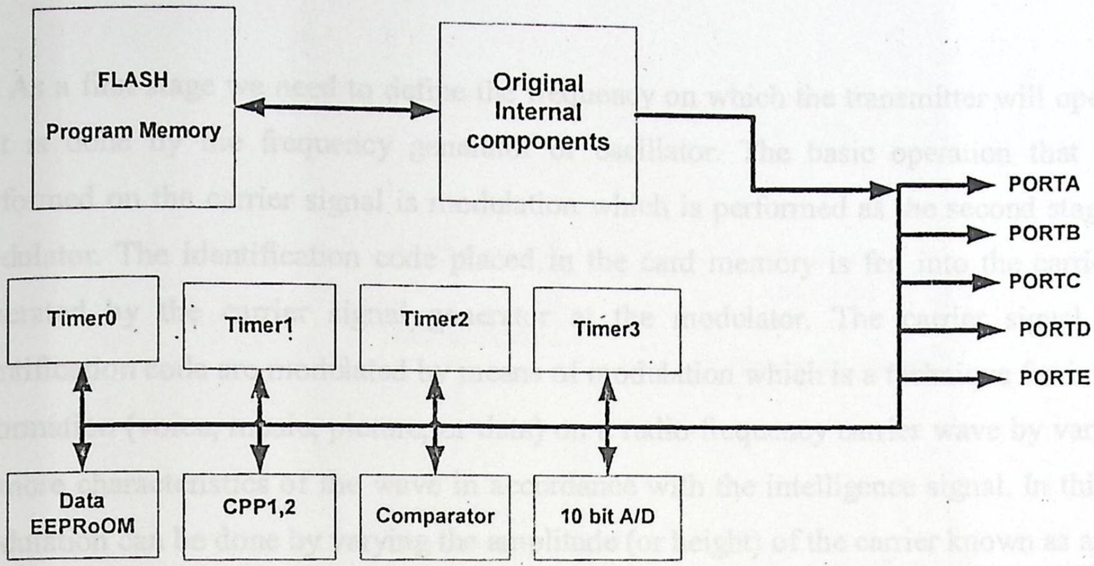

Fig. 3.3 PIC18F4520 detailed block diagram.

- **Transmitter/Receiver part:**

On both cards a transmitter/receiver is mounted that is acting on both transmission and reception of a radio frequency (RF) carrier signal.

The card receiver receives the modulated carrier signal coming from the other card intermittently. The demodulator placed at the receiver demodulates the carrier signal coming to the card in order to obtain a digital code carried in that signal. That code will be prepared for comparing operation done by the comparator with the identification code placed in that card memory. In case that both codes are matched, carrier signal is generated and the contents of identification code register are fed into the carrier signal at the modulator housed in the transmitter. The transmitter then sends the carrier signal to the other card intermittently.

As a first stage we need to define the frequency on which the transmitter will operate and that is done by the frequency generator or oscillator. The basic operation that must be performed on the carrier signal is modulation which is performed as the second stage by the modulator. The identification code placed in the card memory is fed into the carrier signal generated by the carrier signal generator at the modulator. The carrier signal and the identification code are modulated by means of modulation which is a technique for impressing information (voice, music, picture, or data) on a radio-frequency carrier wave by varying one or more characteristics of the wave in accordance with the intelligence signal. In this project modulation can be done by varying the amplitude (or height) of the carrier known as amplitude shift keying modulation (ASK). However, there are various forms of modulation, each designed to alter a particular characteristics of the carrier wave.

The power amplification of the radio signal is carried out in the final stage of the block diagram. It makes the signal stronger so that it can be transmitted into the aerial. However, the RF power amplifier output must be connected to a correctly matched antenna (the "Load") to work properly. The carrier signal is sent and received between two cards through this antenna. Using wrong antenna, or no antenna, can cause damage to the transmitter.

Fig. 3.4 shows our detailed transmitter block diagram. As we can see, the transmitter has three major parts: modulator, frequency generator and the radio frequency power amplifier. Transmitter is connected to the antenna for the transmission of the carrier signal to the other card

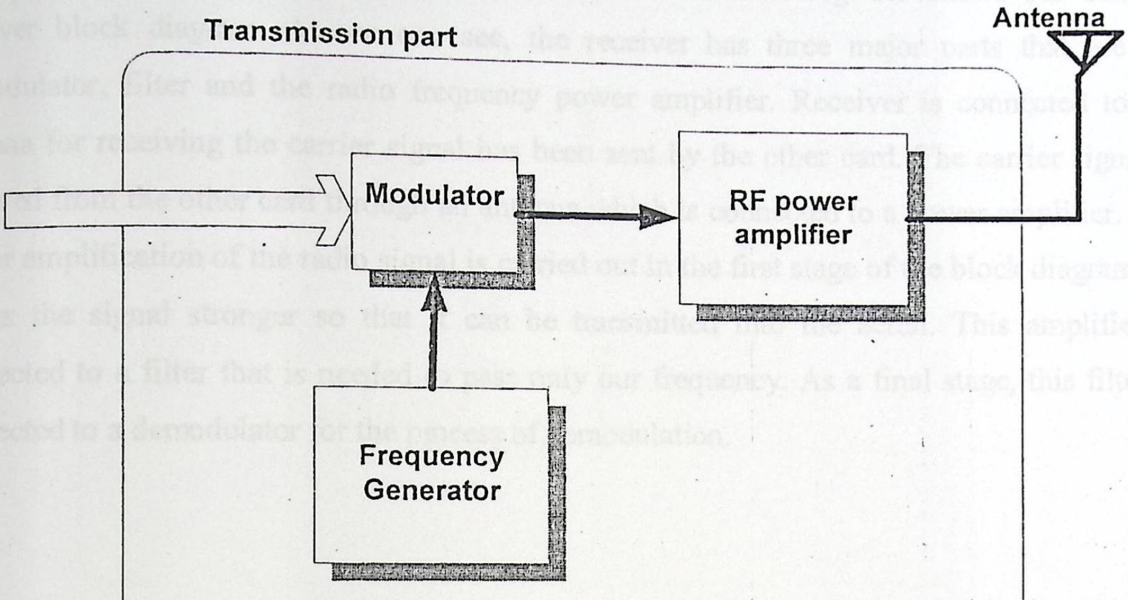

Fig.3.4 Transmitter block diagram

- **RT4-433.92 Radio Transmitter:**

This project uses RT4-433.92 as its transmitter. RT4-433 is a hybrid circuit that allows realizing a complete radio transmitter adding a coding circuit with SAW resonator and external antenna.

We have chosen this transmitter for its features; its high reliability in a DIL package (Dual In-line Package) with stable electric characteristics "thick film hybrid technology". 433.92 MHZ is enough for this project as it serves about 70m which is a good distance for determining if the child has been away from his mother.

Coming to this point, we will talk about the receiver. Fig. 3.5 shows our detailed receiver block diagram. As we can see, the receiver has three major parts that are the demodulator, filter and the radio frequency power amplifier. Receiver is connected to the antenna for receiving the carrier signal has been sent by the other card. The carrier signal is received from the other card through an antenna which is connected to a power amplifier. The power amplification of the radio signal is carried out in the first stage of the block diagram. It makes the signal stronger so that it can be transmitted into the aerial. This amplifier is connected to a filter that is needed to pass only our frequency. As a final stage, this filter is connected to a demodulator for the process of demodulation.

Demodulation is the act of removing the modulation from an analog signal. Demodulating is necessary because the receiver system receives a modulated signal with specific characteristics and it needs to turn it to its original characteristics.

There are several ways of demodulation depending on what parameters of the signal are transmitted in the carrier signal, such as amplitude, frequency or phase. And because our signal has been modulated with a linear modulation ASK (Amplitude shift keying Modulated), we need an ASK demodulator. After this process, we get the original identification code that is ready to be sent to the shift register to be compared by the comparator with the previously stored identification code. [10]

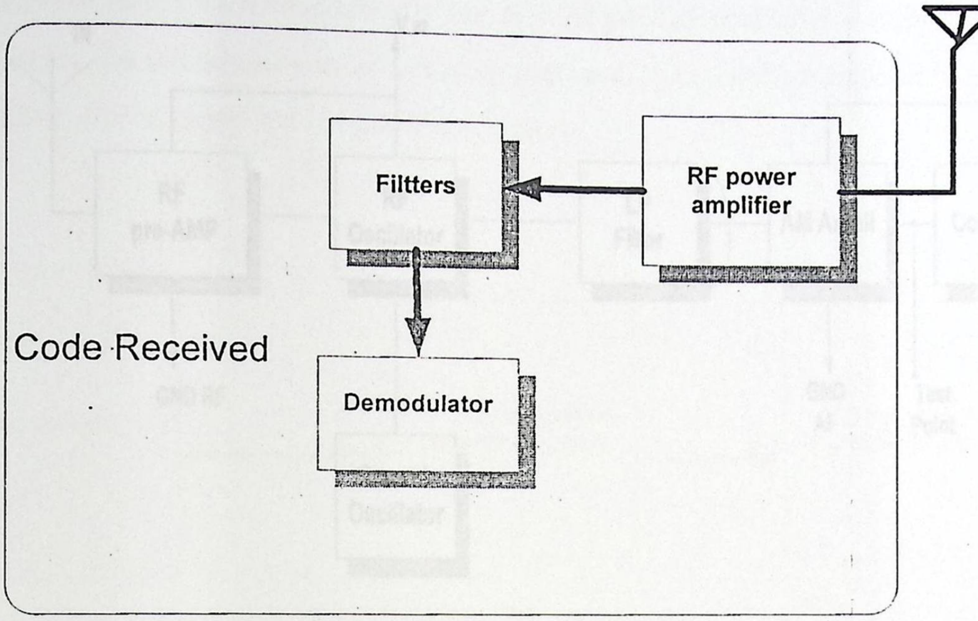

Fig. 3.5 Receiver block diagram

- **RR3-433.92 Radio Receiver:**

This project uses RR3-433.92 as its receiver. RR3-433.92 is a super regenerative amplitude shift keying (ASK) radio receiver with laser trimmed inductor.

We have chosen this receiver for its features; that its high frequency stability in presence of mechanical vibrations, manual handling and in a wide range of temperature. The frequency accuracy is very high, thanks to laser trimming process. Fig. 3.6 shows RR3 block diagram. [10]

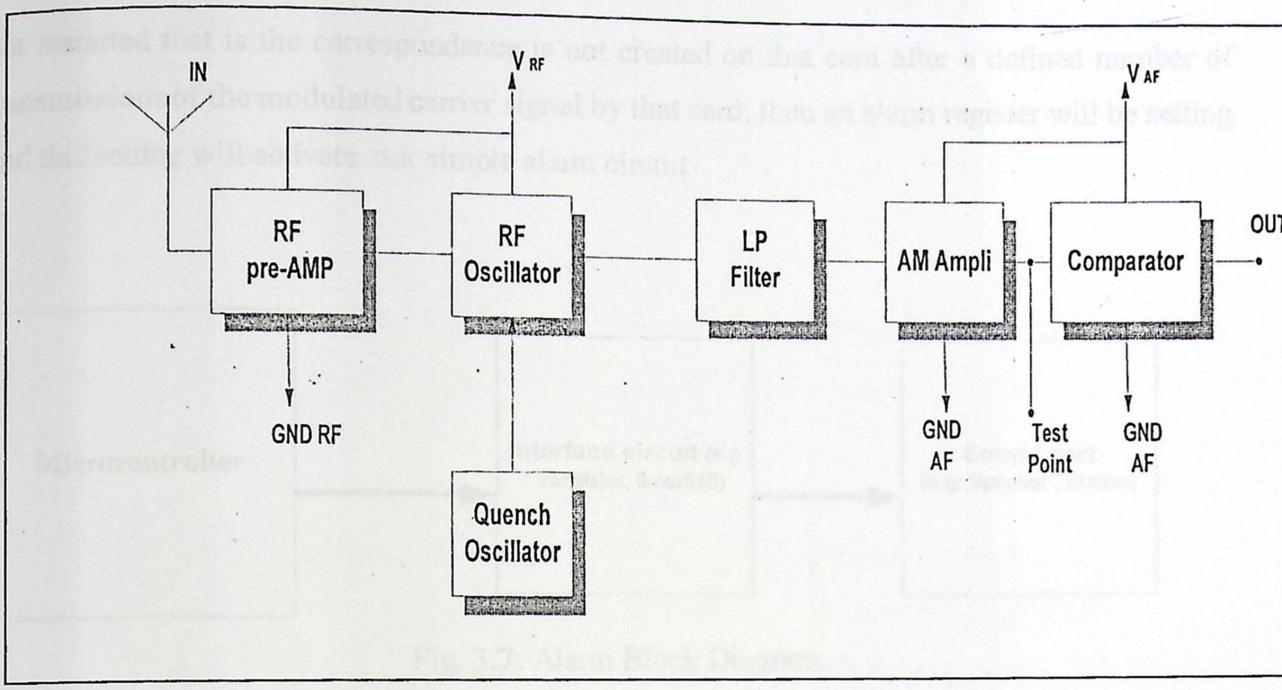

Fig. 3.6 RR3 block diagram

- **Alarm part:**

Both cards houses a simple alarm that is activated if no correspondence is created after defined number of transmissions of the modulated carrier signal between the two cards.

Simply, within a defined communication range, a modulated carrier signal intermittently transmitted by the first card is adapted to create a correspondence on the other card, on finding such correspondence; the other card is adapted to transmit a return modulated carrier signal to the first card. The return modulated carrier signal is adapted to create a correspondence in the first card after resetting an internal timer as we refereed previously. However, if the timer is not restarted that is the correspondence is not created on that card after a defined number of transmissions of the modulated carrier signal by that card, then an alarm register will be setting and this setting will activate our simple alarm circuit

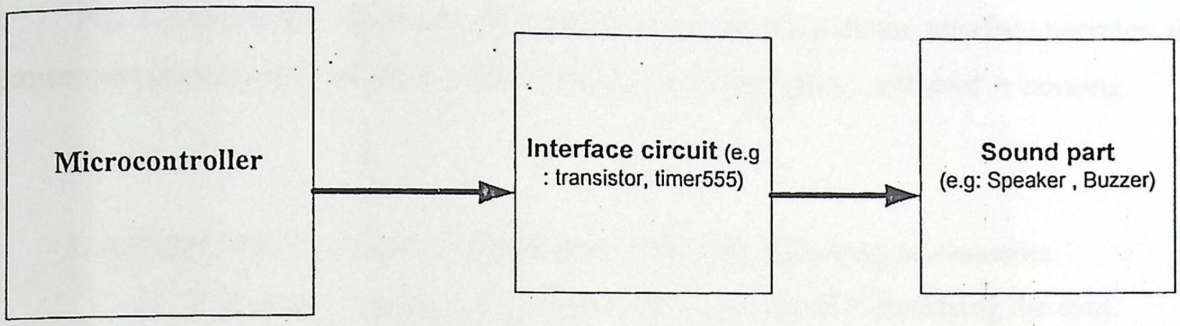

Fig. 3.7: Alarm Block Diagram

As shown in fig. 3.7 the alarm system can be implemented using either a transistor connected to a buzzer or by using timer 555 connected to a sound speaker. PIC 18F4520 microcontroller will trigger the buzzer through the transistor base that is connected to one of the PIC 18F4520 output ports, or will activate timer 555 and though speaker gives sound. However, this alarm activation can only occur if such mismatching between both cards codes occur or if there is no respond between both cards.

- **Embedded card circuitry**

Fig. 3.8 shows the two card of the project more details with the interface between all the project components and sub components. As shown in the figure, each card is housing:

1. A PIC18F4520 microcontroller that embodies the following components:
    a. A memory holding a digital identification code for identifying the card.
    b. A comparator means for determining if a correspondence exists between the identification code in the memory and the digital code carried in the modulated carrier signal received from the other card.
2. Also each card housing an antenna.
3. A transmitter connected to the antenna for intermittently transmitting the modulated carrier signal to the other card.
4. A receiver connected to the antenna for intermittently receiving a modulated carrier signal from the other card.
5. Modulation means for modulating the carrier signal with the identification code in the memory.
6. Demodulation means for demodulating the carrier signal to obtain a signal code carried in that signal.
7. Both cards housing an alarm means that it is activated if the correspondence is not created in the comparator means on the first card after a defined number of transmissions of the modulated carrier signal by the first card.

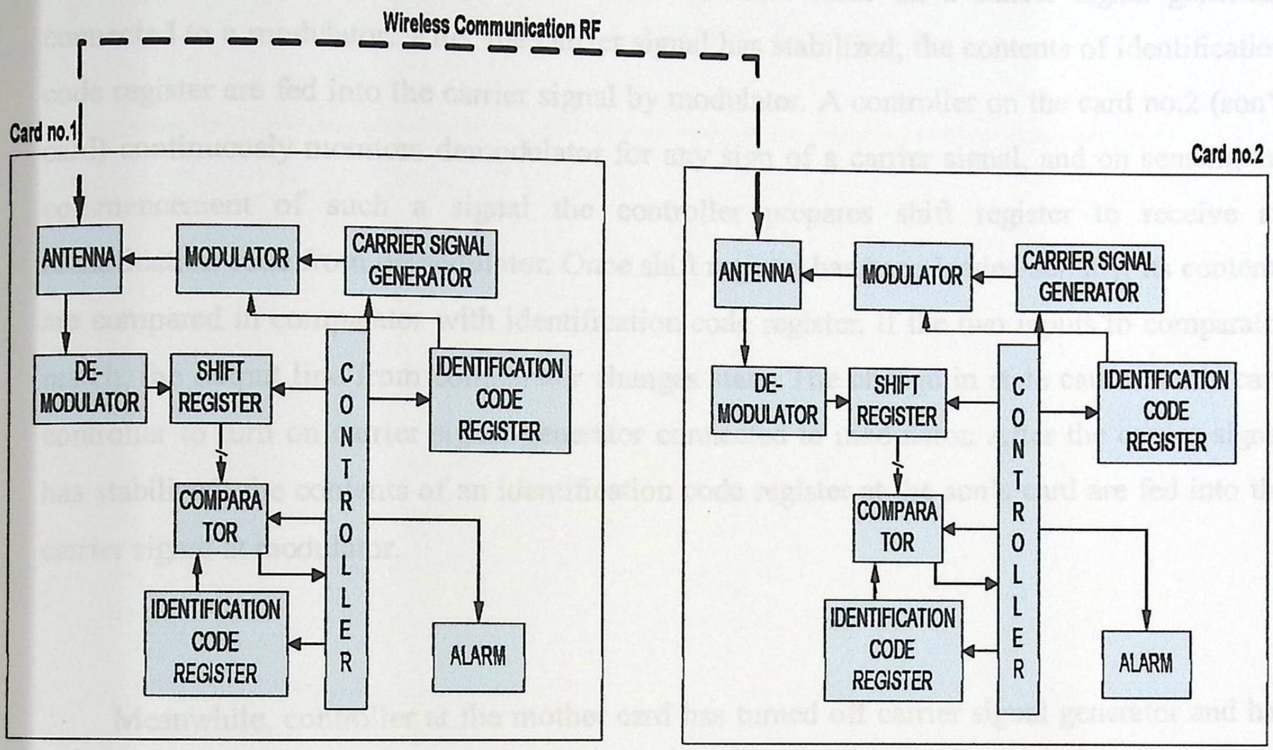

Fig3.8 Complete project block diagram

On card no.1 (mother card) is mounted an antenna that acts on both the reception and transmission of a radio frequency (RF) carrier signal. The antenna is connected to signal demodulator, and to a signal modulator. Signal demodulator removes the digital identification code from the carrier signal, and that code is shifted serially into a shift register. Once register has been loaded, its contents are compared in a comparator with the contents of the identification code register. If the contents of both registers are matched, comparator produces a code match signal on output line to the controller. The second card has similar components. The differences between the two cards will be discussed later.

An antenna is mounted on mother card and initiates the intermittent communication between the two cards. A controller on mother card turns on a carrier signal generator connected to a modulator. After the carrier signal has stabilized, the contents of identification code register are fed into the carrier signal by modulator. A controller on the card no.2 (son's card) continuously monitors demodulator for any sign of a carrier signal, and on sensing the commencement of such a signal the controller prepares shift register to receive an identification code from demodulator. Once shift register has been loaded serially, its contents are compared in comparator with identification code register. If the two inputs to comparator match, the output line from comparator changes state. The change in state causes son's card controller to turn on carrier signal generator connected to modulator. After the carrier signal has stabilized, the contents of an identification code register at the son's card are fed into the carrier signal at modulator.

Meanwhile, controller at the mother card has turned off carrier signal generator and has started monitoring demodulator for any sign of a return carrier signal from the son's card. On sensing the commencement of that return carrier signal, controller at mother card prepares shift register to receive an identification code from demodulator. The shift register is then loaded serially, and its output compared in parallel with the identification code register on mother card by comparator on that card. If the comparator output line changes state, indicating a match, controller at mother card restarts operation again. If mismatching occurs or no signal sensed, it waits for checking for approximately 2.25 second, if this period finished without matching or sensing any signal, controller at both cards activates an alarm circuit that is housed within mother card as well as son's card.

Chapter

4 *Hardware System Design*

4.1 Preface.

4.2 Project Phases.

4.3 Schematic Design.

Chapter Four

Hardware System Design

4.1 Preface:

This chapter gives a big look about the options can be used in implementing this project. For example is there any choice can be used to implement this project using another microcontroller, another transmitter or another alarm system. It also provides the full schematic view to this project for each subsystem in it and also for the complete system.

4.2 Project phases:

1. Transmitter at the mother card will send identification code to the receiver of the son card.
2. If data reaches sons card successfully, receiver demodulates data and data will be ready to be compared with the stored son identification code.
3. If both codes match each other, son's card reply with a signal holds sons identification code and send it to be compared at the mother card.
4. If codes do not match or no data received, PIC will activate alarm system at son's card.
5. If the mother's card receive signal from her son, then comparison operation with the stored mother's identification code will be done.

6. If both codes match each other, mother card intern replies with a signal holds mother's identification code and send it to be compared at the son card.
7. If both codes do not match or no data received, PIC will activate alarm system at mother's card.

4.3 Schematic design

This chapter illustrates a detailed schematic design for the major components that make up this project as well as the interfacing schematic design for all of these components together. The components are:

1. Transmitter RT4-433.9
2. Receiver RR3-433.92
3. PIC 18F4520 microcontroller
4. Alarm system

4.3.1 Transmitter RT4-433.9:

Simply, the transmitter is used to convert the message signal that contains the identification code produced by the frequency generator into a form suitable for transmission through a wireless communication to the other card.

This project uses RT4-433.92 as its transmitter. RT4-433 is an AM/ASK complete RF hybrid transmitter with very stable frequency at a range up to 70m. It allows realizing a complete radio transmitter adding a coding circuit with SAW resonator and external antenna. The transmitter is shown in fig.4.1:

It has four pins:

1. Pin1 is connected to the supply voltage (+5v)
2. Pin2 is connected to the ground
3. Pin3 is a data input connected to the output of the encoder
4. Pin4 is connected to the antenna to transmit the data serially.

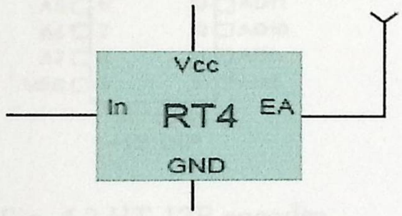

Fig. 4.1 RT4-433.9 transmitter

RT4-433.9 transmitter transmits information (address + data) that is previously encoded via an encoder and this project uses HT-12E encoder.

- **Encoder HT-12E:**

HT-12E encoder is one of 2^{12} series of encoders that is used for remote control system applications. These encoders are capable of encoding information which consists of N address bits and 12-N data bits. Each address/data input can be set to one of the two logic states. The programmed addresses/data are transmitted together with the header bits via an RF transmission medium upon receipt of a trigger signal. The capability to select a TE trigger on the HT-12E enhances the application flexibility of the 2^{12} series of encoders. HT-12E is shown in fig.4.2

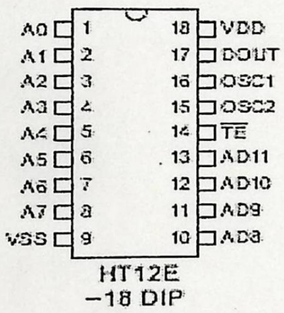

Fig. 4.2 HT-12E encoder

As it shown in the figure, this encoder has 18 pin:

1. Pins (1-8) are input pins for encoder address (A0-A7) setting
2. Pin 9 is connected to ground
3. Pin (10-13) are input pins for address/data (AD8-AD11) setting
4. Pin 14 is a transmission enable for this encoder
5. Pins 15/16 come from output/input oscillator pins and are connected to 1MΩ that gives the best oscillating frequency.
6. Pin 17 is encoder data serial transmission output
7. Pin 18 is connected to the positive power supply(+5v)

- **Transmitter schematic:**

The HT-12E encoder has to take a specific address; in this project we give it an 8-bit address (A0-A7). The four AD8-AD11 pins are considered as data pins that will take the identification code needed to be carried over the RF signal to be transmitted to the other card. As the transmission enable (TE) is enabled; the information (address + data) would be available at the output pin (D out) that is connected to pin 3 of RT4 transmitter and that encoded information would be carried over RF signal. Fig 4.3 shows the transmitter schematic with its combatable encoder.

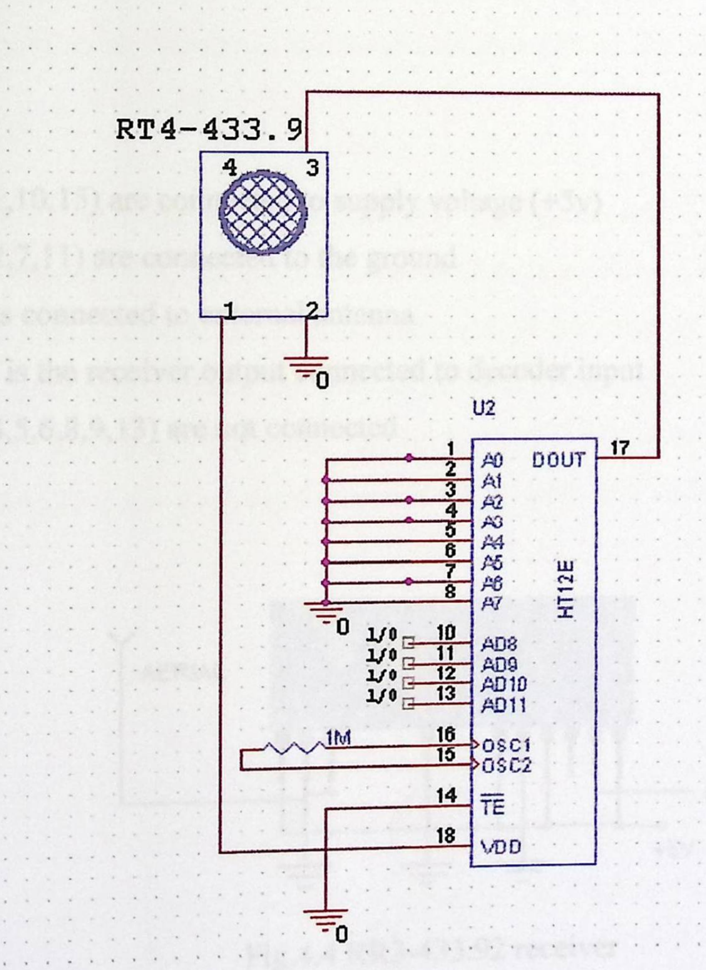

Fig. 4.3 Transmitter schematic

4.3.2 Receiver RR3-433.92:

Simply, we need a receiver in order to receive the message signal containing the transmitted card identification code.

This project uses RR3-433.92 as its receiver. RR3-433.92 is an AM/ASK super regenerative radio receiver with laser trimmed inductor that is combatable with the used transmitter. The receiver is shown in fig.4.4.

It has 15 pins:

1. Pins (1,10,15) are connected to supply voltage (+5v)
2. Pins (2,7,11) are connected to the ground
3. Pin 3 is connected to external antenna
4. Pin 14 is the receiver output connected to decoder input
5. Pins (4,5,6,8,9,13) are not connected

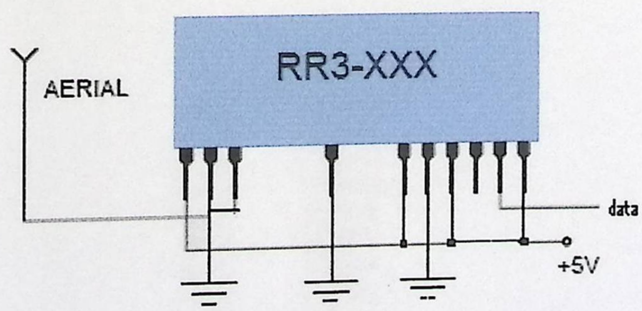

Fig.4.4 RR3-433.92 receiver

The RR3.433.92 receiver gives the information received to a decoder that will perform the demodulation process in order to get our needed previously transmitted identification code. The decoder used in this project is HT-12D decoder.

- **Decoder HT-12D:**

HT-12D decoder is one of 2^{12} series of decoders that is used for remote control system applications and is combatable with HT-12E encoder. For proper operation, a pair of encoder/decoder with the same number of addresses and data format should be chosen.

The decoders receive serial addresses and data from a programmed 2^{12} series of encoders that are transmitted by a carrier using an RF transmission medium. They compare the serial input data three times continuously with their local addresses. If no error or unmatched codes are found, the input data codes are decoded and then transferred to the output pins. The 2^{12} series of decoders are capable of decoding information that consists of N bits of address and 12_N bits of data. Of this series, the HT-12D is arranged to provide 8 address bits and 4 data bits. HT-12D is shown in Fig. 4.5.

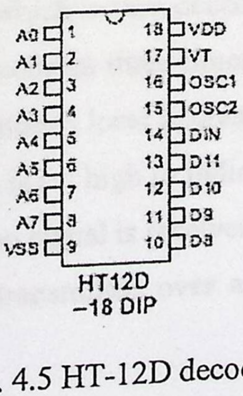

Fig. 4.5 HT-12D decoder

As it shown in the figure, this decoder has 18 pin:

8. Pins (1-8) are input pins for decoder address (A0-A7) setting
9. Pin 9 is connected to ground
10. Pin (10-13) are output data pins (D8-D11) setting
11. Pin 14 is a serial data input pin acts as a trigger for the decoder
12. Pins 15/16 come from output/input oscillator pins and are connected to 47 KΩ that gives the best oscillating frequency.
13. Pin 17 for valid transmission
14. Pin 18 is connected to the positive power supply(+5v)

- **Receiver schematic:**

The receiver output pin (14) is connected to the HT-12D input (DIN). This HT-12D decoder has a specific 8-bit address (A0-A7) combatable with the used encoder address. The decoder receive data that are transmitted by an encoder and interpret the first N bits of code period as addresses and the last 12-N bits as data, where N is the address code number. A signal on the DIN pin activates the oscillator which in turn decodes the incoming address and data. The decoders will then check the received address three times continuously. If the received address codes all match the contents of the decoder's local address, the 12-N bits of data are decoded to activate the output pins and the VT pin is set high to indicate a valid transmission. This will last unless the address code is incorrect or no signal is received. At the end of this process we get our original identification code that was transmitted over an RF signal and now is ready to be compared by the microcontroller. Fig 4.6 shows the receiver schematic with its combatable decoder.

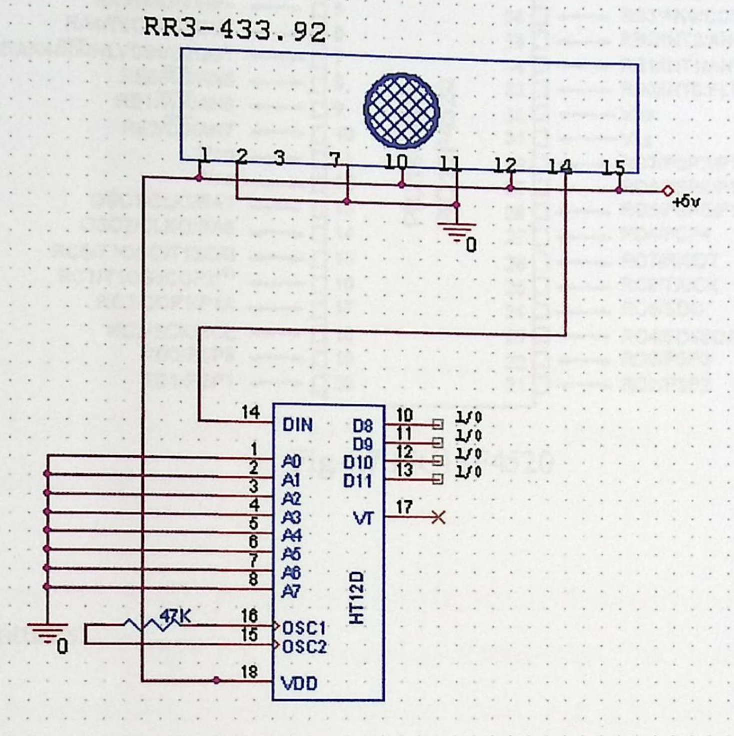

Fig.4.6 Receiver schematic

4.3.3 PIC 18F4520 Microcontroller:

This project uses PIC 18F4520 to control the functions of transmitter, receiver and alarm system. This microcontroller is packed into a 40 pin package as shown in Fig. 4.7

40-pin PDIP

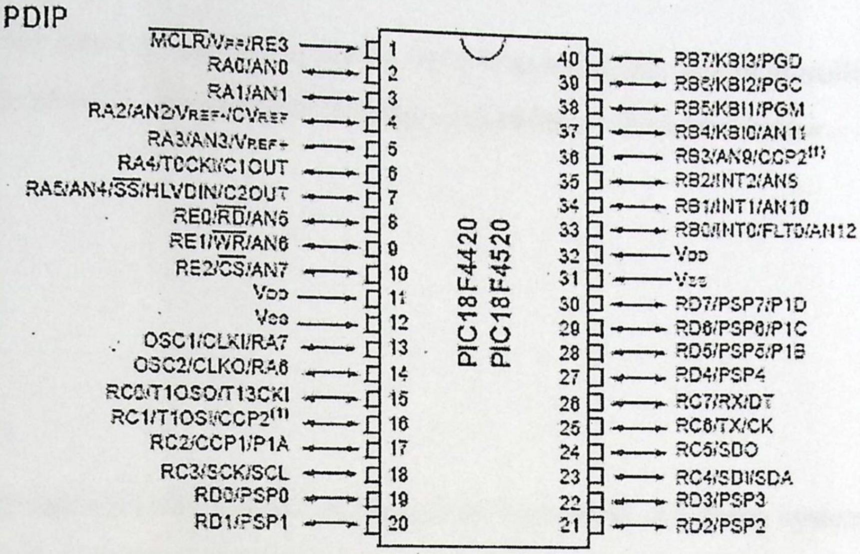

Fig.4.7 PIC18F4520

It has the following features:

1. 20 MHZ operating frequency.
2. Memory: 32768 bytes memory, 16384 bytes program memory, 1536 bytes data memory
3. Five I/O resources: A, B , C, D, E
4. Four timers
5. One capture/compare/PWM module with another enhanced capture/compare/PWM
6. 20 interrupt sources
7. MSSP with enhanced USART serial communication
8. Parallel communications PSP
9. Programmable high low voltage detects.
10. Programmable brown out reset
11. Instruction set: 75 instuctions with 83 extended instructions enabled.

All the other project components are connected to this microcontroller in a way that each of them can perform its proper operation as discussed below.

4.3.4 Alarm:

This project uses two alarm systems housed on both cards. An alarm system is needed to give a special sound if communication between two cards is broken; this sound is useful to indicate both mother and child's location.

The alarm system used in this project is a simple buzzer that has two edges. With edge 1 is connected to Vcc (5v) while edge 2 is connected to a transistor. This buzzer gives a special sound to indicate the location of both mother and her child. Fig. 4.8 shows the alarm system circuit.

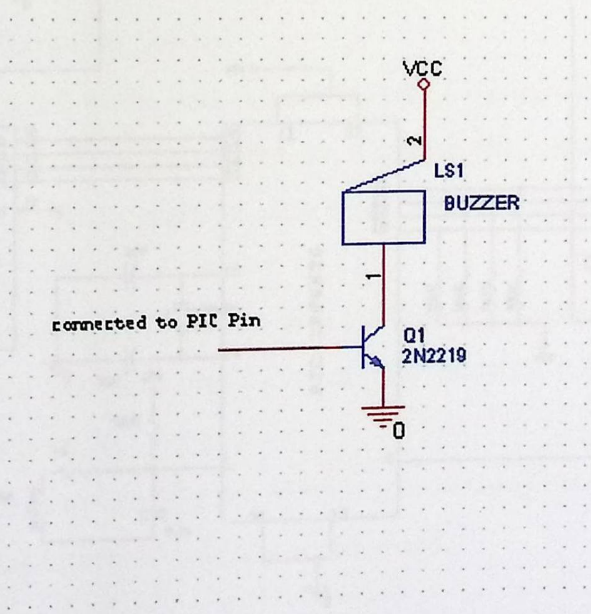

Fig. 4.8 Alarm schematic

As shown in the figure, edge 1 of the buzzer is connected to the collector of the transistor while the transistor emitter is connected to ground and the transistor base is connected to an output pin of the microcontroller; this output pin works a trigger that activates the alarm when needed.

4.3.5 Whole system schematic:

As we can see from fig. 4.8, PIC 18F4520 is connected to all project components. Those are: transmitter, receiver and the alarm.

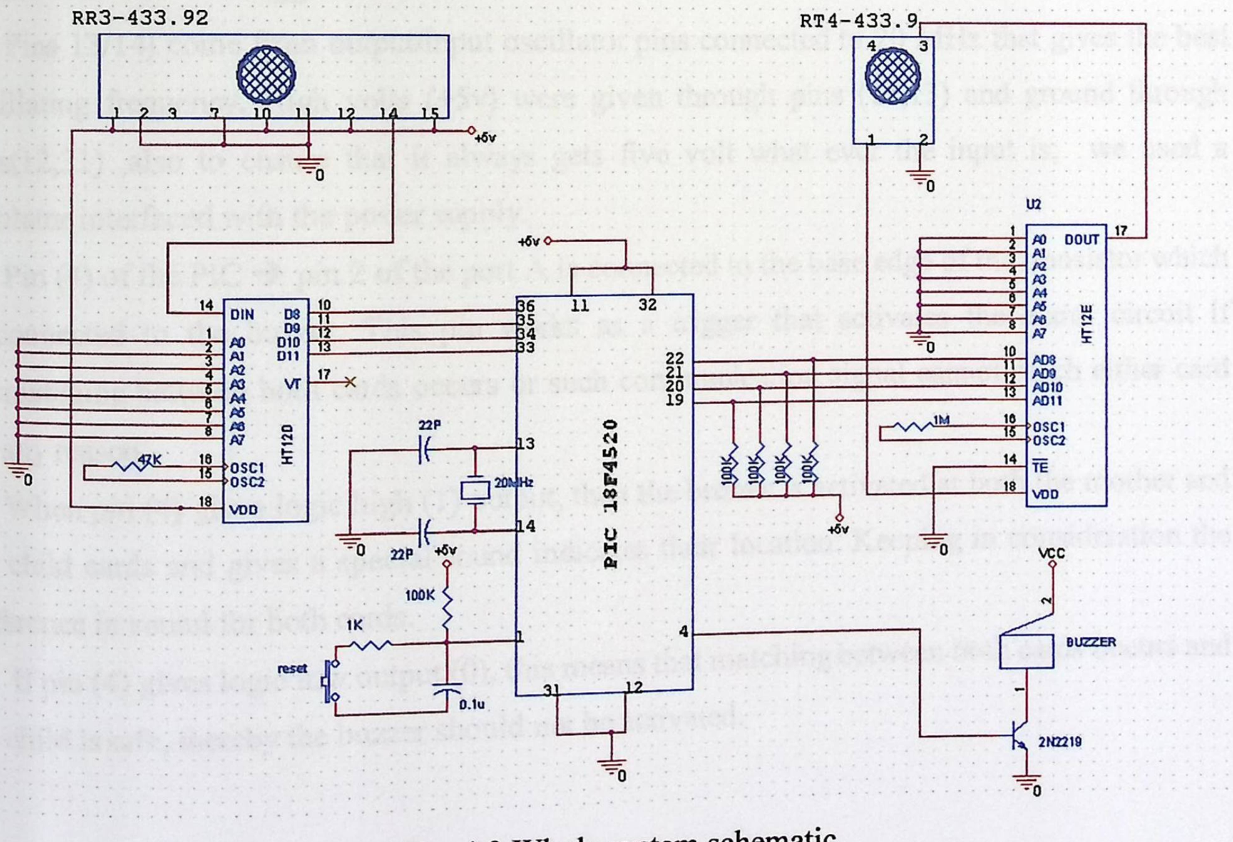

Fig. 4.9 Whole system schematic

As the stored identification code needed to be checked is a four bit code. We need four pins to send a specific 4 bit identification code to the encoder input, four input pins to receive four bit code from the encoder output, one output pin connected to the alarm, in addition to two ground pins and another two for Vcc and one pin for reset (MCLR/VPP/RE3).

PIC 18F4520 uses four pins of port A specifically pins(A0-A3) from the LSB till the MSB as input pins to receive four bit data from the output of the decoder which is connected to RR3 receiver. This code is compared with a four bit identification code stored in one of the PIC internal registers. If they are matched, PIC will use four pins of port B as output pins specifically pins (B0-B3) from the LSB till the MSB to send four bit data to the input of the encoder that is connected to RT4 transmitter in order to be sent to the other card. But if both codes are mismatched PIC will trigger the alarm circuit.

Pins 13/14) come from output/input oscillator pins connected to 20 MHz that gives the best oscillating frequency. High volts (+5v) were given through pins (11,13) and ground through pins(12,31) ,also to ensure that it always gets five volt what ever the input is; we used a regulator interfaced with the power supply.

Pin (4) of the PIC → pin 2 of the port A is connected to the base edge of the transistor which is connected to the buzzer. This pin works as a trigger that activates the alarm circuit if mismatching between both cards occurs or such communication signal cannot reach either card for any reason.

When pin (4) gives logic high (1) output, then the buzzer is activated at both the mother and her child cards and gives a special sound indicates their location. Keeping in consideration the difference in sound for both cards.

If pin (4) gives logic low output (0), this means that matching between both cards occurs and the child is safe, thereby the buzzer should not be activated.

Chapter 5 *Software System Design*

5.1 Preface.

5.2 WinPIC800.

5.3 MPLAB IDE.

5.4 Simulation.

5.5 System Algorithm.

5.6 Program Code.

Chapter Five
Software System Design

5.1 Preface:

This chapter describes the basic program used to operate PIC 18F4520. Some methods and psudocode are used to simplify this program, it also contains algorithms describe both cards processes from first step in the project (initialize the ports & transmitting the signal) to the final step (receiving signal and perform the action related to the signal).

The overall software is programmed by using C language.

5.3 WinPIC800:

Being that PIC has the ability to be programmed more than one time, so there must be an interface circuit between the PIC and the PC (personal computer) so we can read from and write to it (programming). Also the PC should have software which we can program PIC18F4520 through it and that software used is WinPIC800.

WinPIC800 is free download software used to operate along with the corresponding programmer built for our PIC 18F4520.

The WinPIC800 and its programmer support multiple series from the Microchip PIC (for 8 pin 18 pin, 28 pin, 40 pin). There are many devices that are compatible with WinPIC800. This winpic800 programmer downloads the HEX file that represents the program we want to download it on the PIC.

Winpic800 Software is very easy to deal with, and use through its friendly UI (User Interface). Before that the software should be downloaded to the PC (which can be downloaded as free from internet), then the programmer circuit is connected to the PC through Parallel port, then we can work easily with programmer.

First of all the PIC 18F4520 should be fixed in its place on the programmer circuit. Be sure that there is power supply connected to the circuit, then start Winpic800 Software. Through its window first we detect the connected device and in our case the program should give us that "the detected device is 18F4520", then we open the .HEX file stored on the PC, download it on the PIC through "program all button". To be sure that the program downloaded correctly we use "verify button" which checks the downloaded code. There is property on this software that we can read the code stored on the PIC. Fig5.1 shows Winpic800 Software interface.

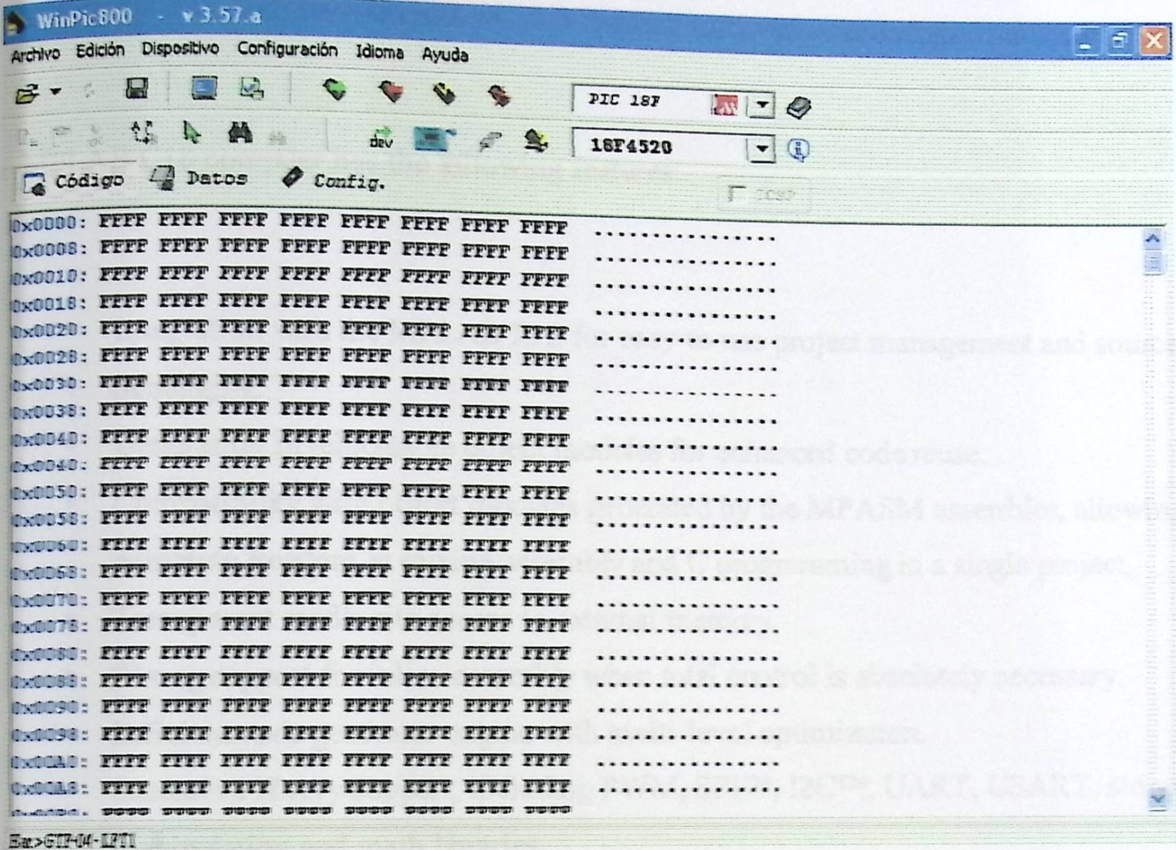

Fig. 5.1:Winpic800 Software.

5.3 MPLAB IDE:

MPLAB IDE is a Windows®-based Integrated Development Environment (IDE) for the Microchip Technology Incorporated PICmicro® microcontroller. MPLAB IDE allows the user to write, debug, and optimize PICmicro microcontroller (MCU) applications. MPLAB IDE includes a text editor, simulator, and project manager. MPLAB IDE also is easy-to-learn and use Integrated Development Environment (IDE).

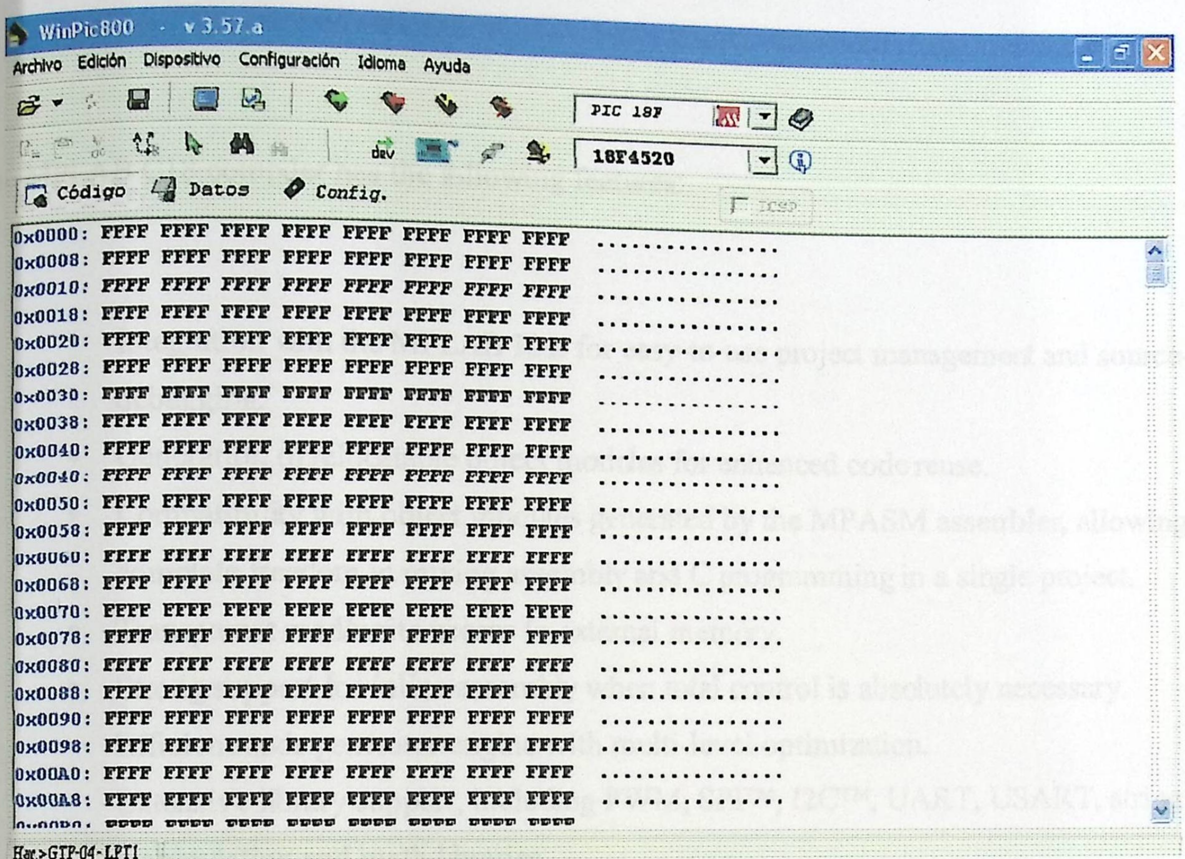

Fig. 5.1:Winpic800 Software.

5.3 MPLAB IDE:

MPLAB IDE is a Windows®-based Integrated Development Environment (IDE) for the Microchip Technology Incorporated PICmicro® microcontroller. MPLAB IDE allows the user to write, debug, and optimize PICmicro microcontroller (MCU) applications. MPLAB IDE includes a text editor, simulator, and project manager. MPLAB IDE also is easy-to-learn and use Integrated Development Environment (IDE).

The MPLAB C18 compiler has the following features:

- Integration with the MPLAB IDE for easy-to-use project management and source-level debugging.
- Generation of relocatable object modules for enhanced code reuse.
- Compatibility with object modules generated by the MPASM assembler, allowing complete freedom in mixing assembly and C programming in a single project.
- Transparent read/write access to external memory.
- Strong support for inline assembly when total control is absolutely necessary.
- Efficient code generator engine with multi-level optimization.
- Extensive library support, including PWM, SPI™, I2C™, UART, USART, string manipulation and math libraries.
- Full user-level control over data and code memory allocation.

Using MPLAB IDE helps us writing code and testing it to make the project works in a proper way. After building the program (executing the build command in the MPLAB so it compiles the code) we write for any of system cards, it automatically creates (.hex) file having the same name of the project which includes the hex translated code of the C code. This hex file can be used in PIC18 simulator IDE program; we will talk more about this program in chapter six. Fig5.2 gives simple view of MPLAB interface.

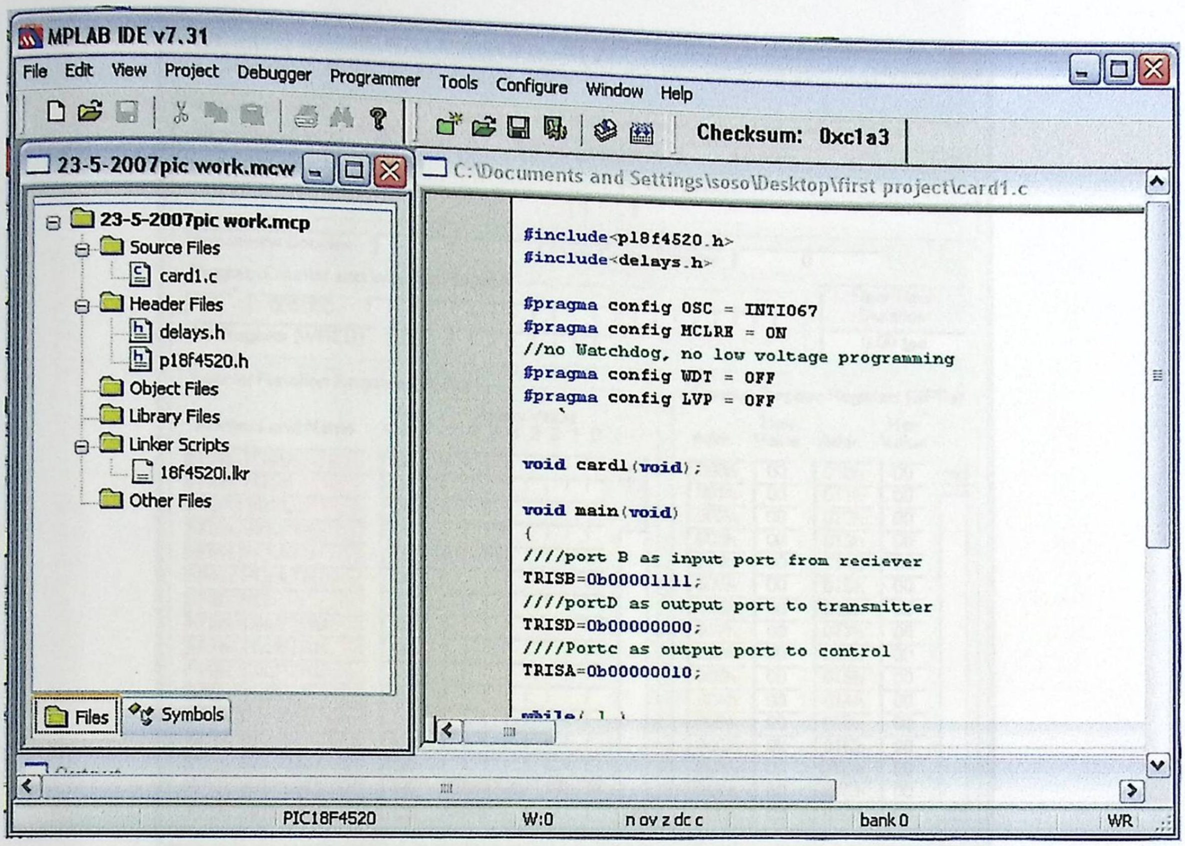

Fig. 5.2 MPLAB IDE.

5.4 Simulation:

At The first stage we simulate card operation by using PIC18 Simulator IDE software. This software is shown at the figure below.Fig.5.3: PIC18 Simulator IDE.

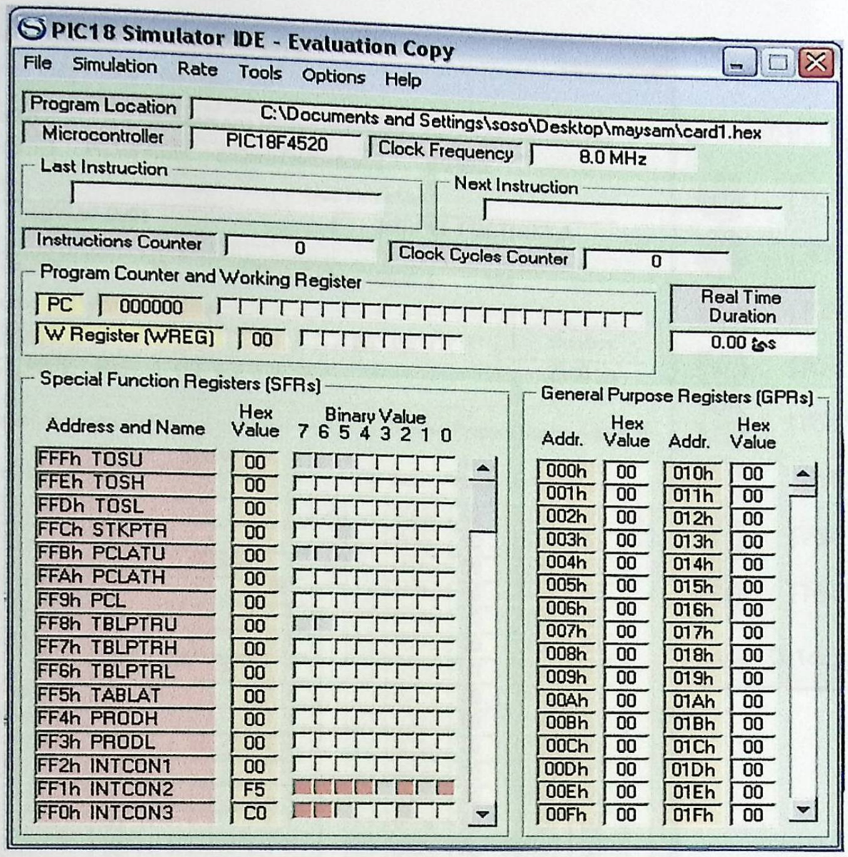

Fig. 5.3 PIC18 Simulator IDE

We load the .hex program that performs the first card operation and then start simulation. The card operation can be seen using two tools; 8xLed board and oscilloscope.

The following figure shows how 4-bit code (1111) is sent through transmitter at ports D0-D3.

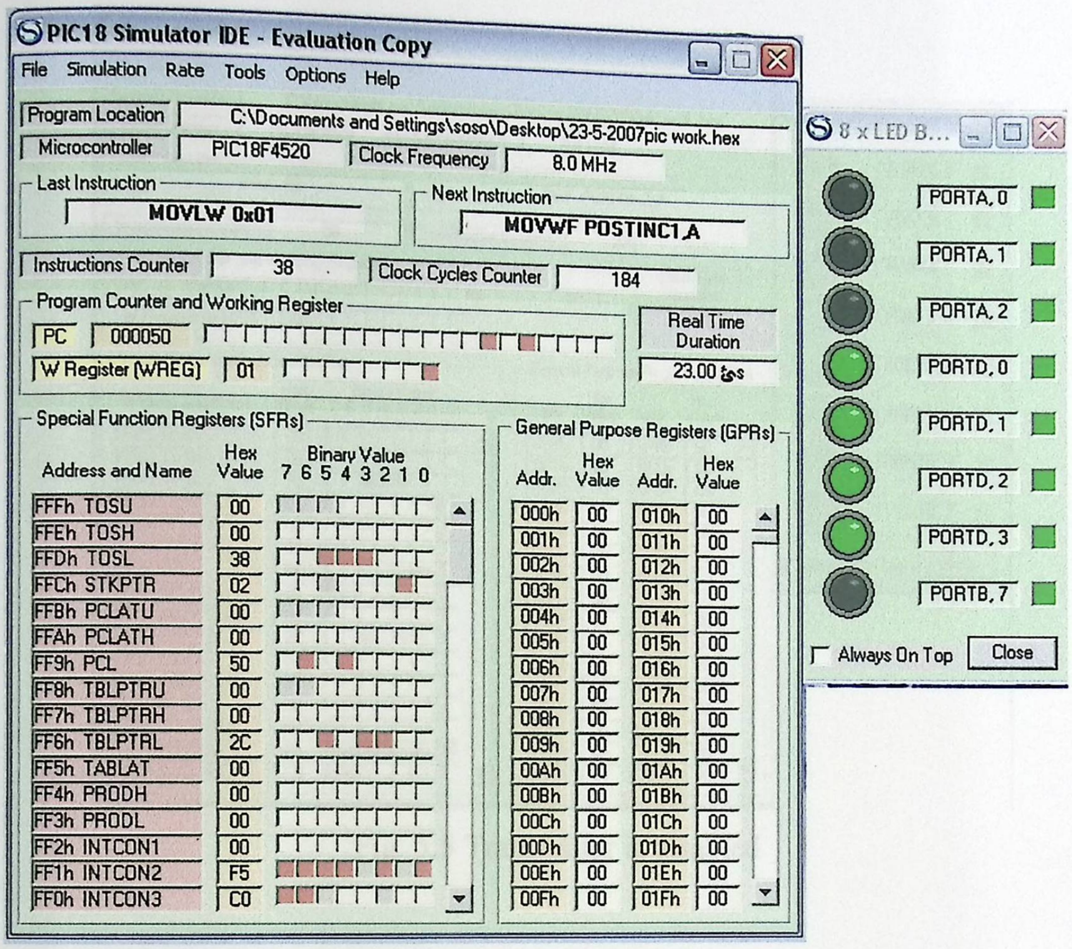

Fig. 5.4 transmitting data (1111)

The following figure shows the moment when the transmitter is disabled as pin TE goes high at port A0 when finishing transmitting data.

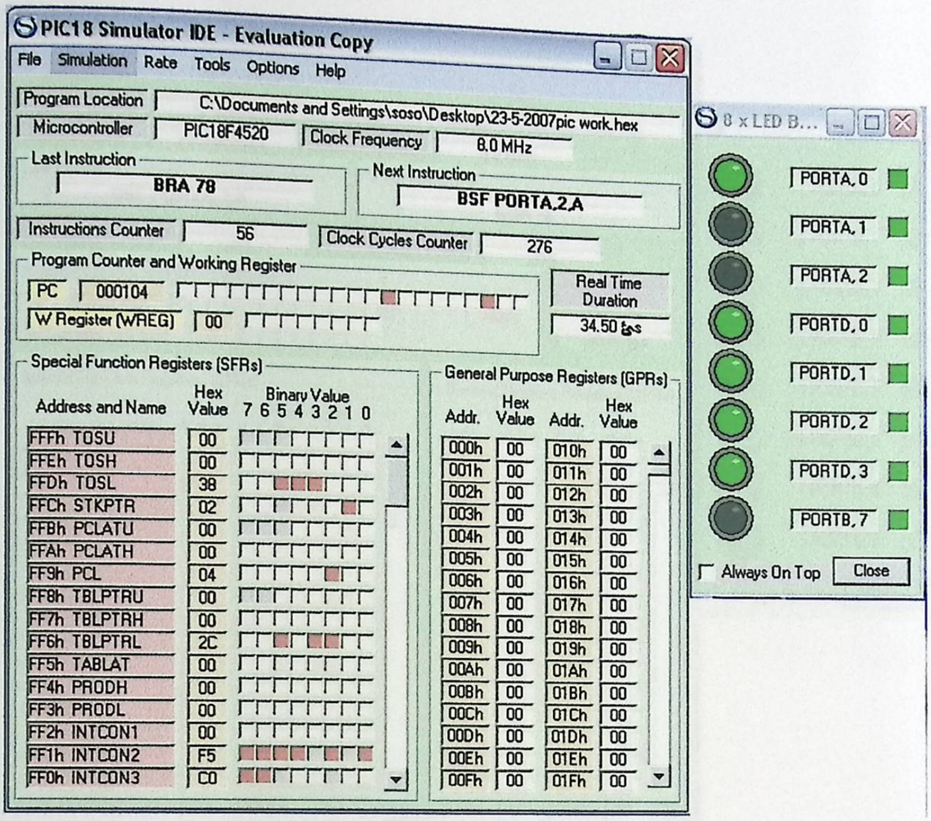

Fig. 5.5 Transmitter is disabled

The alarm is activated as no signal is received at receiver of the first card. Buzzer is connected to port A2 and at that moment this pin goes high as shown in the figure below. Fig 5.6 Alarm is activated

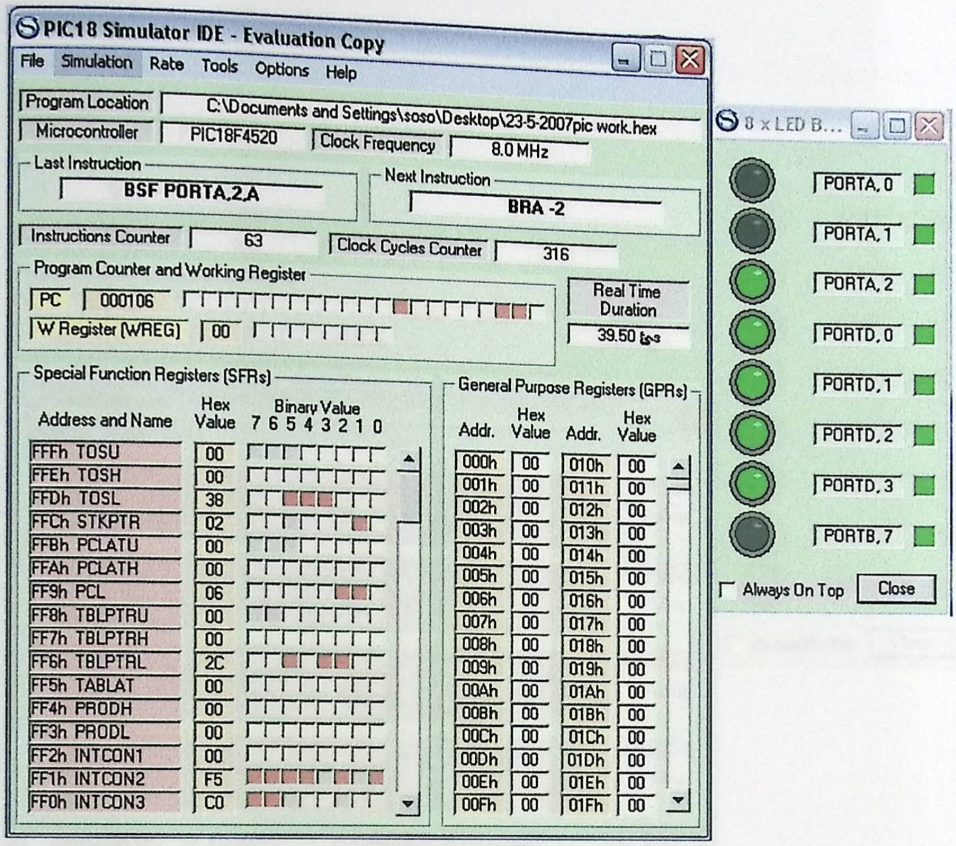

Fig 5.6 Alarm is activated

The following figure shows the result of the operation using oscilloscope tool

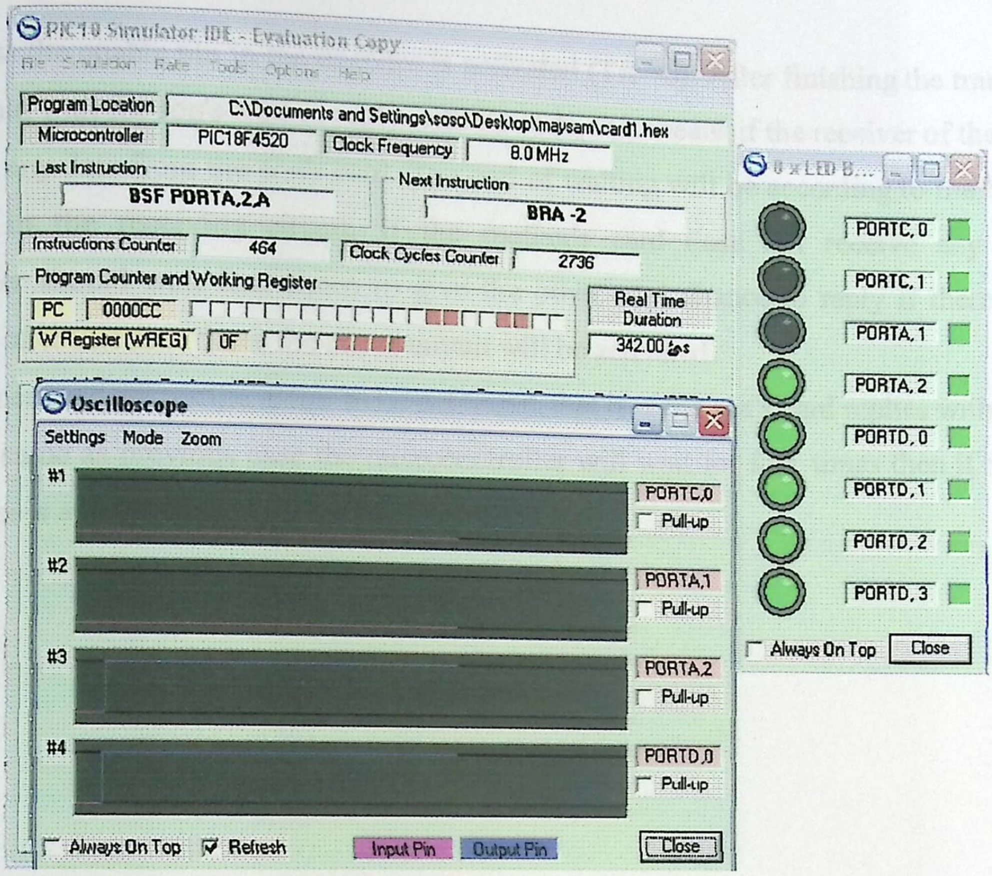

Fig 5.7 output using oscilloscope tool

5.5 System Algorithm:

This section shows routines and functions of the programs and algorithms written to make the system work properly. Each card has an algorithm written to control the function of the card and each card has a flowchart describes how this card will work.

Fig5.8 shows the flowchart of mother's card, which represents the start with initialization done to configure the work of each port we used in PIC18F4520 .then the mother's code will be prepared on PORTD for transmitting it through transmission circuit. This transmission could not be done unless the enable pin in the encoder is activated (TE =0). After finishing the transmission this card should wait for son's card to reply with its code, this means if the receiver of the mother's card receives any data from the son's card. The end of waiting will be according to the VT pin of the decoder in the receiving circuit. If the mother's card dose not receive any data the microcontroller should wait four times to give the other card chance to reply if there were no received data after this four times the alarm circuit will be activated.

There is another case causes the alarm to be activated, that is if the son's card replies with incorrect code and the same as previous case the microcontroller will wait for four times then if no correct reply the alarm is activated.

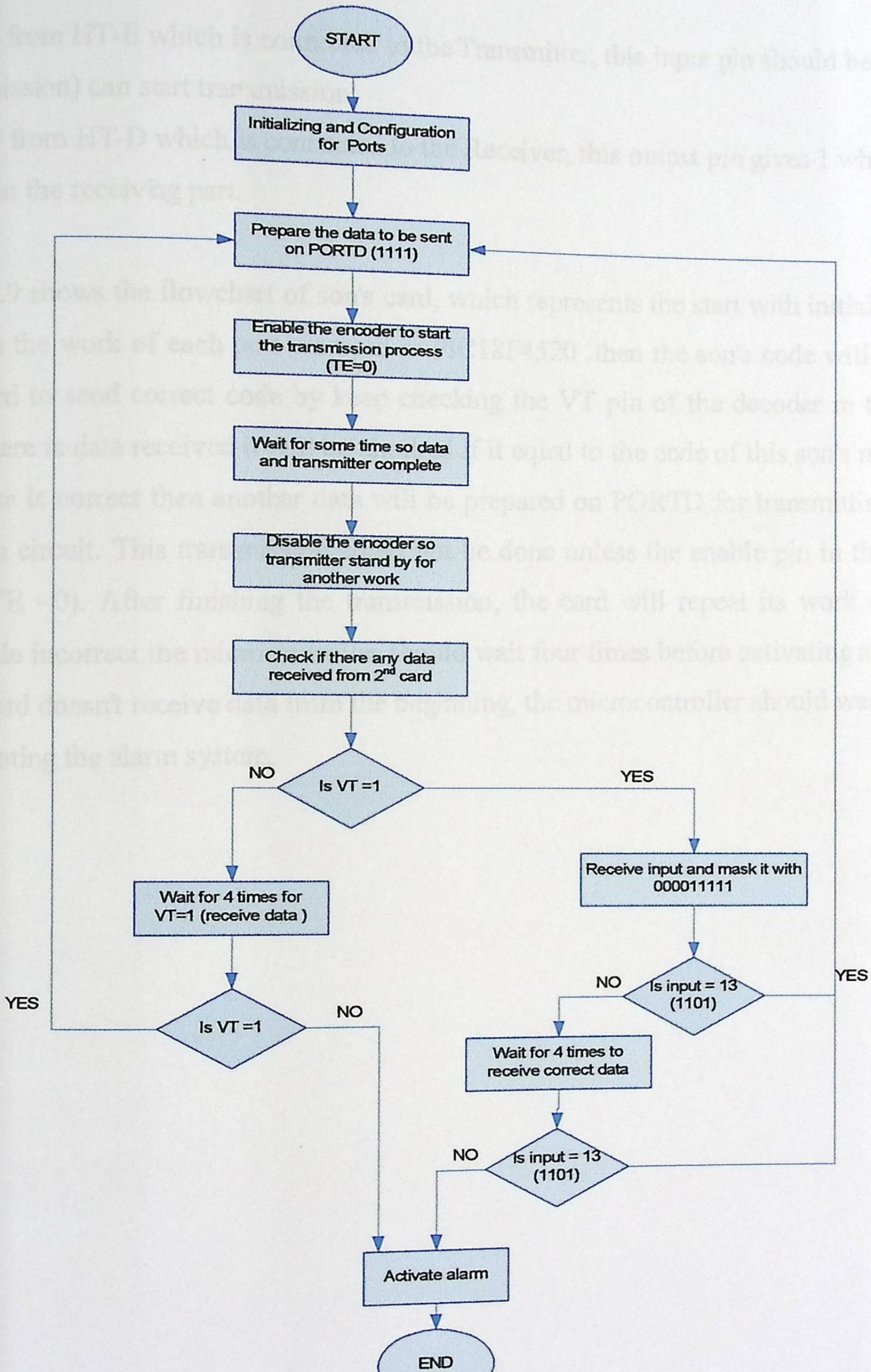

Fig5.8 Mothers card flowchart

*TE: pin 14 from HT-E which is connected to the Transmitter, this input pin should be 0 so this part (transmission) can start transmission.
*VT: pin 17 from HT-D which is connected to the Receiver, this output pin gives 1 when there is any action on the receiving part.

Fig5.9 shows the flowchart of son's card, which represents the start with initialization done to configure the work of each port we used in PIC18F4520 .then the son's code will wait for the mother's card to send correct code by keep checking the VT pin of the decoder in the receiving circuit. If there is data received it will be checked if it equal to the code of this son's mother. If the received data is correct then another data will be prepared on PORTD for transmitting it through transmission circuit. This transmission could not be done unless the enable pin in the encoder is activated (TE =0). After finishing the transmission, the card will repeat its work again. If the received code incorrect the microcontroller should wait four times before activating alarm. Beside this if the card doesn't receive data from the beginning, the microcontroller should wait for 4 times before activating the alarm system.

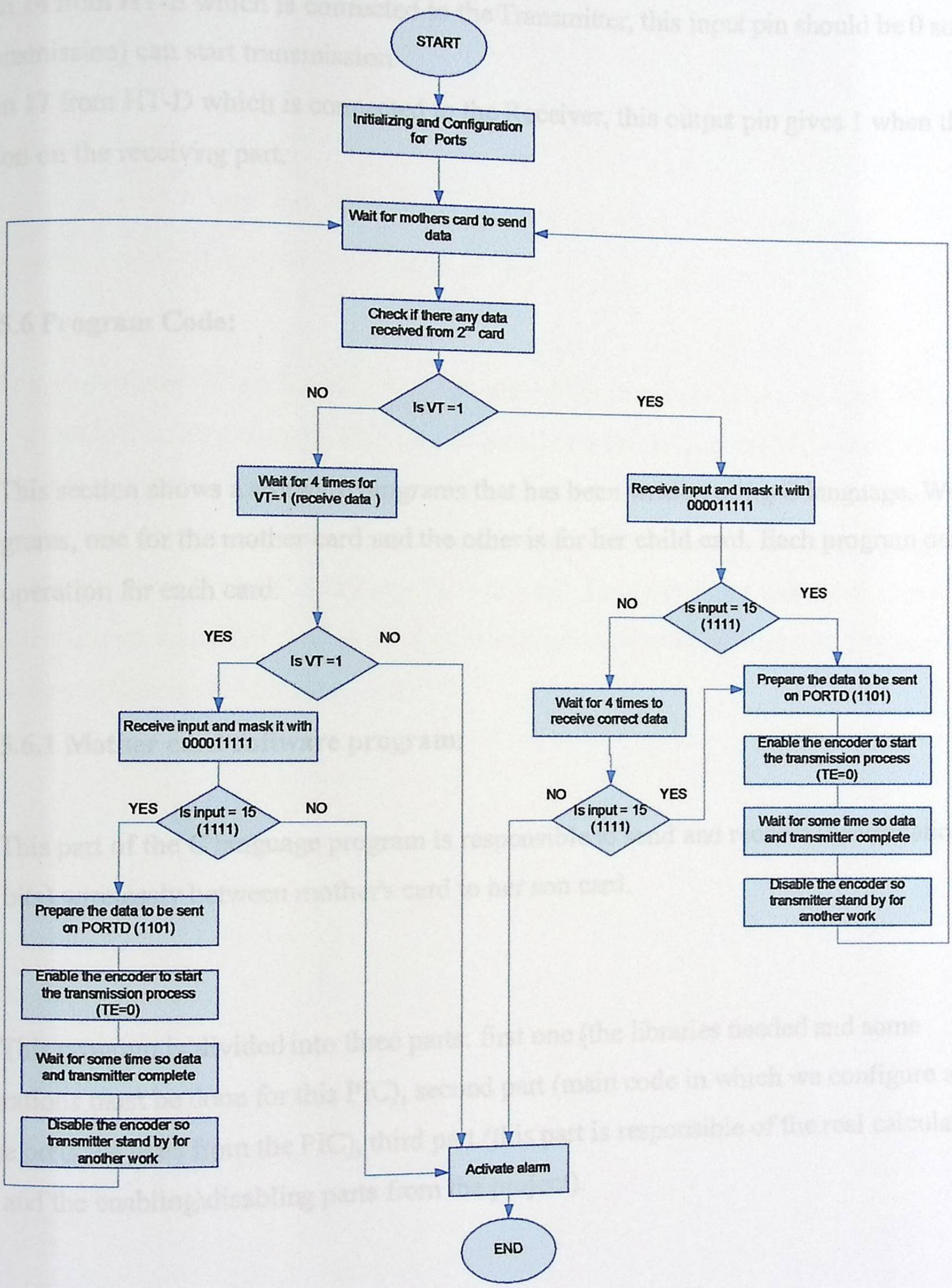

Fig5.9 Sons card flowchart

*TE: pin 14 from HT-E which is connected to the Transmitter, this input pin should be 0 so this part (transmission) can start transmission.
*VT: pin 17 from HT-D which is connected to the Receiver, this output pin gives 1 when there is any action on the receiving part.

5.6 Program Code:

This section shows a software programs that has been written using C language. We have two programs, one for the mother card and the other is for her child card. Each program describes the full operation for each card.

5.6.1 Mother card software program:

This part of the C language program is responsible to send and receive identification code (digital bits) wirelessly between mother's card to her son card.

This program is divided into three parts: first one (the libraries needed and some configurations must be done for this PIC), second part (main code in which we configure and initialize ports we used from the PIC), third part (this part is responsible of the real calculation needed and the enabling\disabling parts from the project).

PART ONE:

```
#include<p18f4520.h>
#include<delays.h>

#pragma config OSC = INTIO67
#pragma config MCLRE = ON
#pragma config WDT = OFF//no Watchdog, no low voltage programming
#pragma config LVP = OFF
#pragma config PBADEN = OFF// to turn of ADc
```

This part shows calling for PIC18F4520 related libraries (`p18f4520.h`), also delays library (`delays.h`) needed in the program. This part is specifying the oscillation PIC18F4520 work at, it can work either at internal oscillation or connecting external oscillator between pin13 and pin14 of the PIC. The code shown indicates that the oscillation will be internally which means 8MHz. PIC18F4520 has internally ADC (Analog –To – Digital Converter), we can work with it through PORTB, because we need this port as input port so first we should disable this property by using the following configuration "`PBADEN = OFF`".

PART TWO:

```
void card1(void);

void main(void)
{
//port B as input port from reciever
TRISB=0b00001111;
//portD as output port to transmitter
TRISD=0b00000000;
//Porta as output port to control
TRISA=0b00000010;
ADCON0=0x3c;
ADCON1=0x0F;
while( 1 )
{
card1();
}
}
```

This part shows the initialization of the ports we used. PORTB as input port which will be connected to the data lines received from the Receiver, PORTD as output port which will be connected to the data lines transmitted through Transmitter and PORTA as output port which will be used to control the transmitter, receiver, and alarm system.

This part contains while (1) at which this statement will achieve the continuous working of the PIC according to program downloaded to it. The last thing in this part is the calling of card1 () function in which we have all work in it.

PART THREE:

```
void card1(void)
{     int input1;
      int output;
      int i,j;

      PORTD=15; // == 1111
      //send 0 to set encoder "TE transmit"
      PORTC=0;
      Delay100TCYx(0);
      //disable the transmitter
      PORTC=15;
      Delay100TCYx(0);
      if ( PORTAbits.RA1)//RA1 connected to VT
        {
        input1=PORTB & 0b00001111;

        //start to compare
        if(input1 == 13) // 1101
          { card1();}
        else
        {for(i=0;i<4;i++)
              {if ( PORTAbits.RA1)//RA1 connected to VT
                    {input1=PORTB & 0b00001111;
                     //start to compare
                     if(input1 == 13){card1();}
                     }

              }
        while(1){
```

```
        //set alarm circuit
        PORTAbits.RA2=1;}
    }
else
{for(i=0;i<4;i++)
 {if ( PORTAbits.RA1)//RA1 connected to VT
      { input1=PORTB & 0b00001111;
        //start to compare
        if(input1 == 13){card1();}
      }
 }
while(1){//set alarm circuit
        PORTAbits.RA2=1;}}}
```

This part starts by preparing the code that mothers card will transmit (1101) then enable the encoder to receive this data and send it through transmitter (this enabling done by sending 0 to TE pin in the encoder since its active low pin).then call for delay function from delays.h library which gives the encoder some time to completely prepare data for transmitting. After the delay complete the encoder will be disabling by sending 1 to TE pin in the encoder so that the transmitter will not send more data until the PIC order that.

After sending this code the PIC will wait for another code comes from the sons card, the PIC will recognize that data received by checking the VT pin from the decoder at which this pin will be 1 if there any correct action on the receiver ,in other words if the receiver received code from the correct address (sons card address) the VT will be 1, the PIC then compares the received code (send by sons card) to that one stored in side the PIC .if the two codes are matched then the previous process will be restarted. If the two codes are not matched the card will wait four times before starting the alarm. If it receives correct code through these four times the process will restart, If not the alarm will be activated by the PIC after finishing four times.

If the PIC doesn't receive signal from start, the program will be transferred to the last else statements at which will wait four times to receive any data, if there is no data received the alarm system will be activated.

5.6.2 Son card software program:

This part of the C language program responsible to receive and send identification code (digital bits) wirelessly between the son card and his/her mother.

This program is divided into three parts: first one (the libraries needed and some configurations must be done for this PIC), second part (main code in which we configure and initialize ports we used from the PIC), third part (this part is responsible of the real calculation needed and the enabling\disabling parts from the project).

PART ONE:

```
#include<p18f4520.h>
#include<delays.h>

#pragma config OSC = INTIO67
#pragma config MCLRE = ON
#pragma config WDT = OFF//no Watchdog, no low voltage programming
#pragma config LVP = OFF
#pragma config PBADEN = OFF// to turn of ADc
```

This part shows calling for PIC18F4520 related libraries, also delays library needed in the program. This part is specifying the oscillation PIC18F4520 work at, it can work either at internal oscillation or connecting external oscillator between pin13 and pin14 of the PIC. The code shown indicates that the oscillation will be internally which means 8MHz. PIC18F4520 have internally

ADC (Analog –To – Digital Converter), we can work with it through PORTB, because we need this port as input port, so first we should disable this property by using the following configuration "PBADEN = OFF". (Note: the two cards will have the same configurations)

PART TWO:

```
void card2(void);

void main(void)
{
//port B as input port from receiver
TRISB=0b00001111;
//portD as output port to transmitter
TRISD=0b00000000;
//Porta as output port to control
TRISA=0b00000010;

ADCON0=0x3c;
ADCON1=0x0F;
while( 1 )
{
Card2();
}
}
```

This part shows the initialization of the ports we used. PORTB as input port which will be connected to the data lines received from the Receiver, PORTD as output port which will be connected to the data lines transmitted through Transmitter and PORTA as output port which will be used to control the transmitter, receiver and alarm system.

This part contains while (1) at which this statement will achieve the continuously working of the PIC according to program download to it. The last thing in this part is the calling of card2 () function in which we have all work in it.

PART THREE:

```
void card2(void)
{
int i,j;
int input0,input1;
int output;

if(PORTAbits.RA1==1) //if any data recieved
  {input1=PORTB & 0b00001111;
   //start to compare
   if (input1 == 15 )
    {output=13;
     PORTD=output;
     PORTAbits.RA0=0b0; //send 1 high to set encoder "TE transmitt"
     Delay100TCYx(0);
     Delay100TCYx(0);
     PORTAbits.RA0=0b1; //disable the transimtter
    }
   else{for (i=0;i<4;i++){
      if(PORTAbits.RA1==1) //if any data recieved
        {input1=PORTB & 0b00001111;
         //start to compare
          if (input0 == 15 )
          {
          output=13;
          PORTD=output;
          PORTAbits.RA0=0b0; //send 1 high to set encoder "TE
          transmitt"
          Delay100TCYx(0);
          Delay100TCYx(0);
          PORTAbits.RA0=0b1; //disable the transimtter
          card2();}
        }
     }if (i==4){while (1)
               {//set alarm circuit
               PORTAbits.RA2=0b1;}
               }}}
else
{for(i=0;i<4;i++)
    {if ( PORTAbits.RA1)//RA1 connected to VT
     { input1=PORTB & 0b00001111;
       //start to compare
      if(input1 == 13){card2();}
     }
     while (1)
         {//set alarm circuit
          PORTAbits.RA2=0b1;}}}
```

PIC on this card will wait for mothers card to send its code (the mothers card should start the whole process) , the PIC will recognize that data received by checking the VT pin from the decoder at which this pin will be 1 if there any correct action on the receiver, in other words if the receiver received code from the correct address (mothers card address) the VT will be 1 , the PIC then compare the received code to that one stored in side the PIC (1111) .if the two codes are matched then the PIC prepares the code that sons card will transmit (1011) then enable the encoder to receive this data and send it through transmitter (this enabling done by sending 0 to TE pin in the encoder since its active low pin), then call for delay function from delays.h library which gives the encoder some time to completely prepare data for transmitting. After the delay completes, the encoder will be disabled by sending 1 to TE pin in the encoder so that the transmitter will not send more data until the PIC order that. After this, previous process will be restarted. If the two codes are not matched the card will wait four times before starting the alarm. If it receives correct code through these four times the process will restart if not after finishing 4 times the alarm will be activated by the PIC.

If the PIC from the start doesn't receive (means VT pins hadn't been active "1") any data the program will be transferred to the last else statements at which will wait four times to receive any data if there is no data received the alarm system will be activated

Chapter

6 *Implementation & Testing*

Chapter Six
Implementation and Testing

6.1 Preface:

In this chapter we are going to show the implementation and testing processes for our system. System testing is an important and crucial step in implementing any system. This system has more than one issue to be tested, however some testing parts reflect software and others reflect hardware.

After testing each component and each subsystem that makes up this project, the implementation process is done and will take many testing to ensure that there are no errors. This implementation process will be done using different components and tools as it will be discussed later in this chapter.

6.2 Implementation:

This section illustrates the implementation of both cards system. We implement the system by using prototype model in which two cards were built with both have symmetrical components that are PIC, transmitter with its encoder, receiver with its decoder and buzzer as an alarm system.

The mother card was built and a signal with a 4-bit identification code is sent by the mother transmitter to her son's card. The son's card intem receives that signal and after some processes as demodulation and decoding, this signal was compared with a stored 4-bit cod at the son's card. According to comparison process, both codes were match and the alarm system didn't activate. And the son's card sent a signal with a 4-bit code to be compared at the mother card.

We tried another case as shown in fig. 6.1 in which the mother card sent a signal, but that signal was not received by the son's card, because we kept it away from the mother card. Because there was no specific signal received, the alarm was activated at both the son's and mother card.

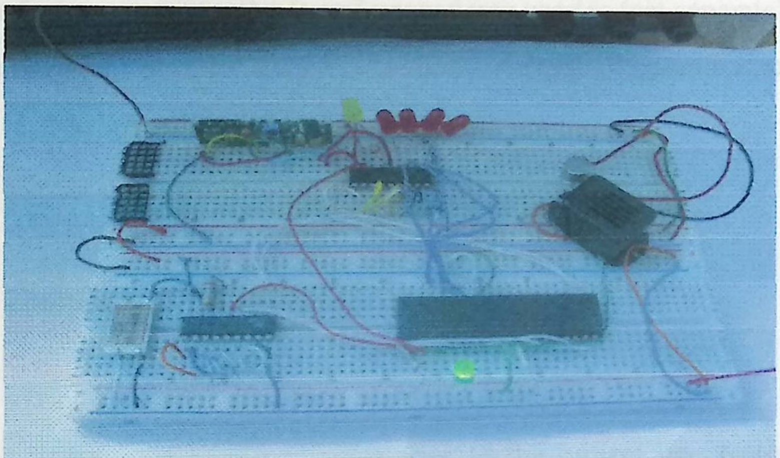

Fig. 6.1 Mother card

However, project was implemented successfully through those two cases where the alarm system once activated and once didn't.

We will implement these two cards prototype model in the following days using wire rapping tool. This implementation process was done by using the following tools and components:

- Connectors with different colors.

- IC stands.
- 10*20 cm bread board.
- All the ICs that are depicted in the design chapter (see chapter 4).
- Wrapper tool for wrapping the connectors on the ICs stands.
- A wire grabber and a wire cutter.

6.3 Testing:

This section demonstrates methods and procedures used to test separately each project components, each subsystem in order to examine the whole system operation and behavior.

6.3.1 Project components testing:

In this section we show how each component in the project was tested. And those major components are:

1. Transmitter
2. Receiver
3. PIC 18F4520 microcontroller
4. Buzzer

- **Transmitter Testing:**

We made use of multi-channel oscilloscope to get the waveform for the transmitted signal from the transmitter. So we connected RT4-433.9 transmitter with the HT-12E encoder as shown below in fig. 6.2. We specified the address of the transmitter and receiver to be the same through the 8-bit address lines at encoding /decoding chips. Putting pin 4 of the transmitter connected to the antenna.

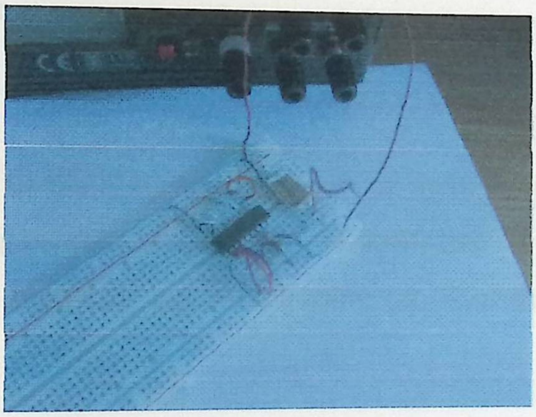

Fig. 6.2: RT4-433.9 transmitter with encoder circuit.

We turned on the Transmitter circuit through its TE pin. The output of the data pins depends on whether the signal being transmitted with four bit data. The signal itself can be seen by attaching the oscilloscope to pin 17 of the encoder. The waveform below was taken from transmitter test out tests.

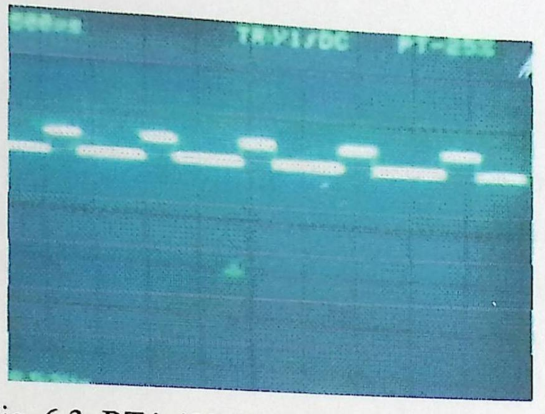

Fig. 6.3: RT4-433.9 Transmitter data signal.

- **Receiver Testing:**

As we did with the transmitter, we made use of multi-channel oscilloscope to get the waveform for the received signal at the receiver. So we connected the RR3-433.9 receiver with the HT-12D decoder as shown below in Fig. 6.4. Putting pin 3 of the receiver connected to the antenna.

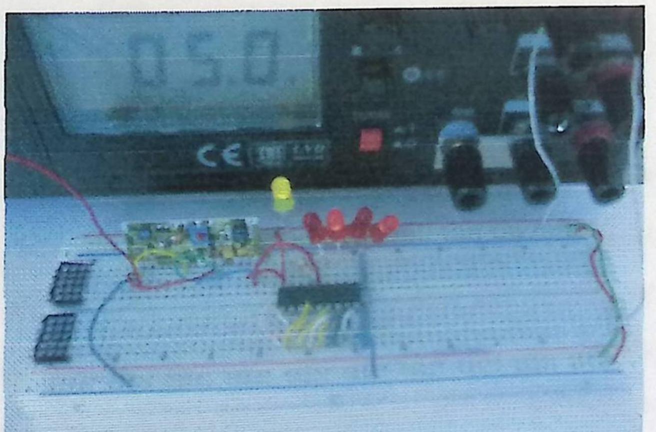

Fig. 6.4: RR3-433.9 receiver with decoder circuit.

We turned on the Transmitter circuit. The output of the data pins depends on whether the signal being transmitted. The signal itself can be seen by attaching the oscilloscope to pin 17 of the encoder. The waveform below was taken from receiver test, this signal shows how the decoding circuit checks the incoming address in order to specify accepting or rejecting data, here the sent address was 00000000.

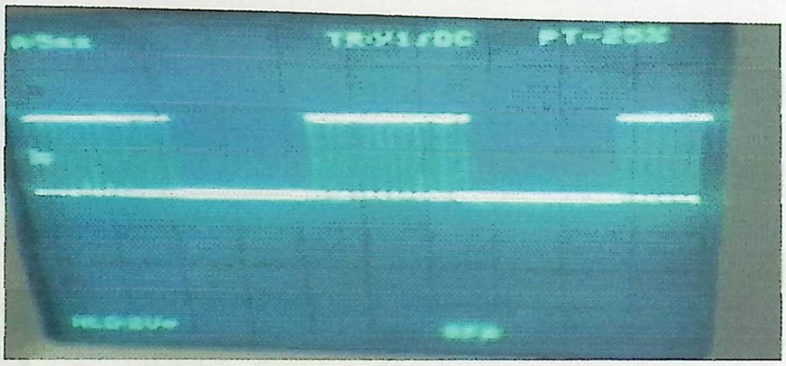

Fig. 6.5 RR3-433.9-Receiver address signal.

- **PIC 18F4520 testing:**

We tested PIC 18F4520 trough its ability to download programs. And to get the newly code into 18F4520 we used a WinPIC800 programmer that we referred previously at chapter 5 with a PIC Pocket Programmer (PP-Prog) circuit that has a chip slot where we put PIC 18F4520. PP-Prog is a PIC programmer for program PIC Microcontroller devices via PC parallel port which supports different software such as WinPic800. There are two indicators LED and PCB, One for power supply and one for programming in progress. Fig. 6.6 shows the complete assembly of this hardware programmer.

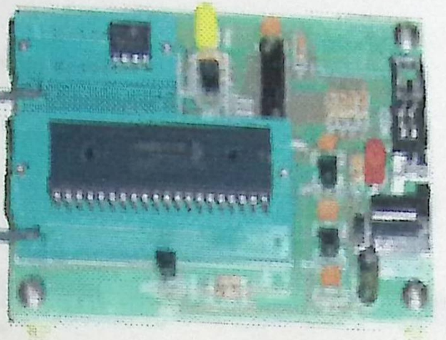

Fig. 6.6 PIC Pocket Programmer (PP-Prog)

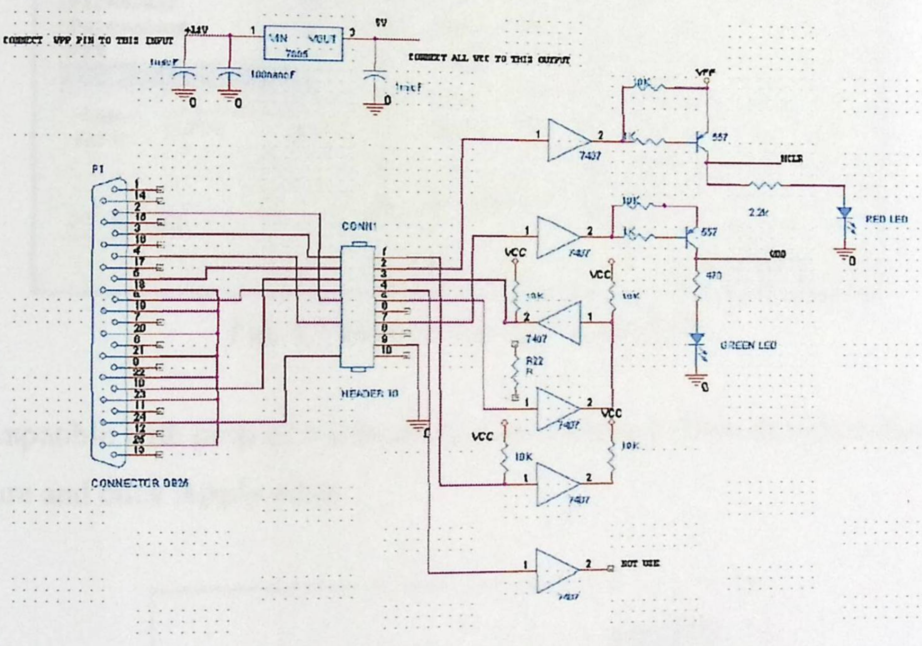

Fig. 6.7: PPC-Prog schematic

- **How to use with WinPic800:**

To use this project with winPic800 we must set hardware as the following picture.

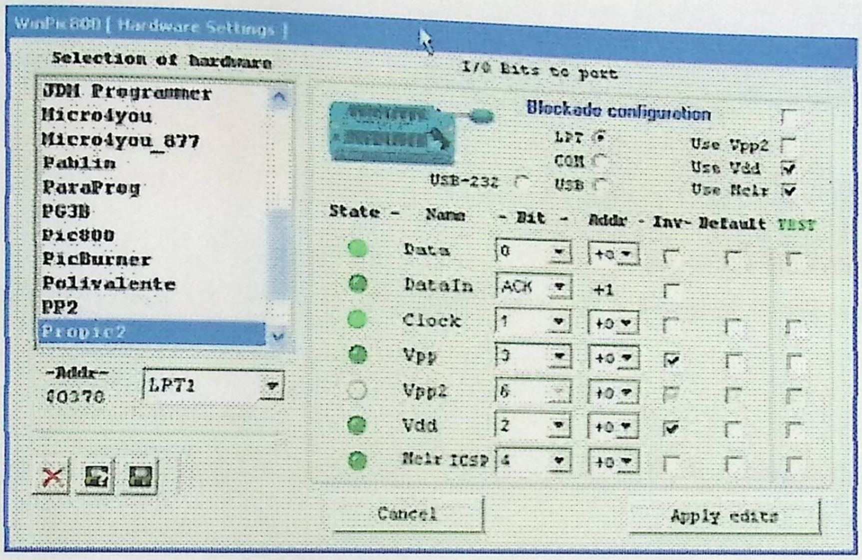

Fig. 6.8 How to use with winPic800

This circuit compatible with propic2 hardware so it was selected .Then we select all check box like the above picture and click **Apply edits**

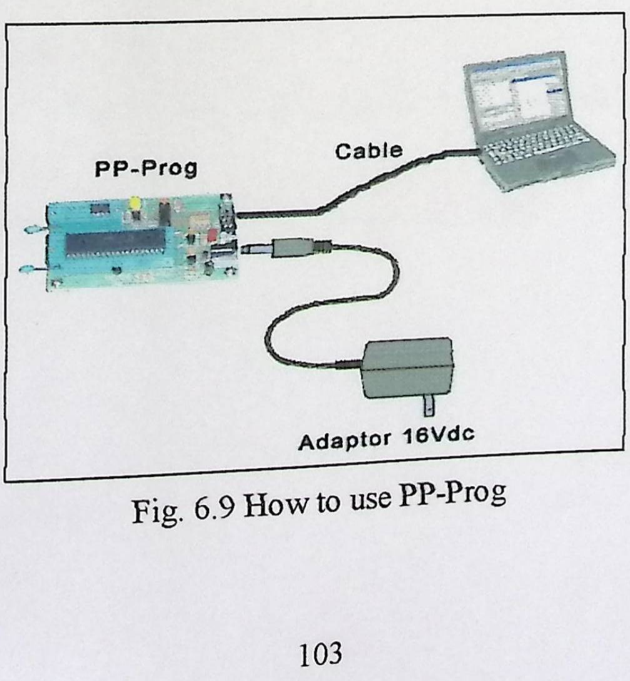

Fig. 6.9 How to use PP-Prog

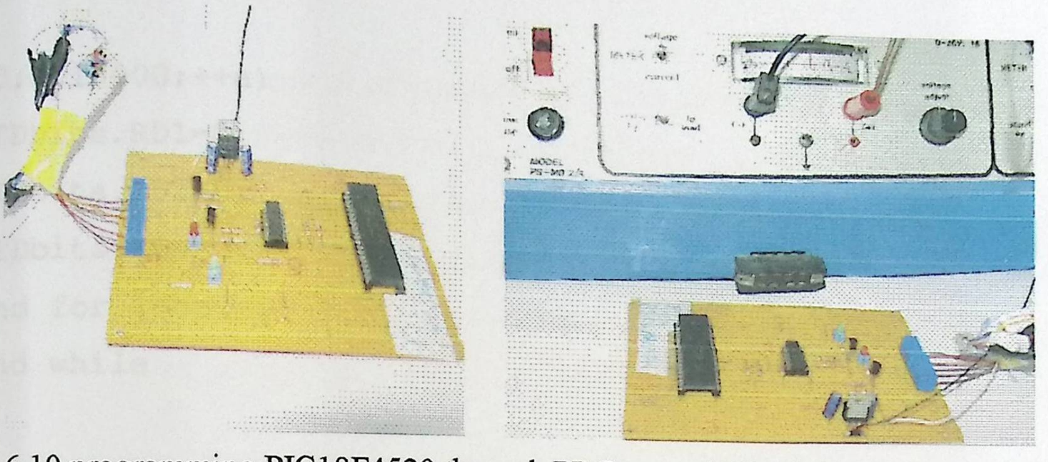

Fig. 6.10 programming PIC18F4520 through PP-Prog and Winpic800 software program

The following testing code is used to flash leds ON and OFF on ports D that works as an output port for the circuit shown in figure 6.11.

```
#include<p18f4520.h>
#include<delays.h>
#pragma config OSC = INTIO67
#pragma config MCLRE = ON
#pragma config WDT = OFF//no Watchdog, no low voltage programming
#pragma config LVP = OFF
#pragma config PBADEN = OFF// to turn of ADc
void main()
{int a;
TRISD=0b00000000;
while(1)
 {for(a=0;a<10000;++a)
  {PORTDbits.RD1=1;
```

```
    PORTDbits.RD2=1;
    PORTDbits.RD3=1;
   }
 for(a=0;a<10000;++a)
   {PORTDbits.RD1=0;
    PORTDbits.RD2=0;
    PORTDbits.RD3=0;
   }//end for loop
 }}//end while
```

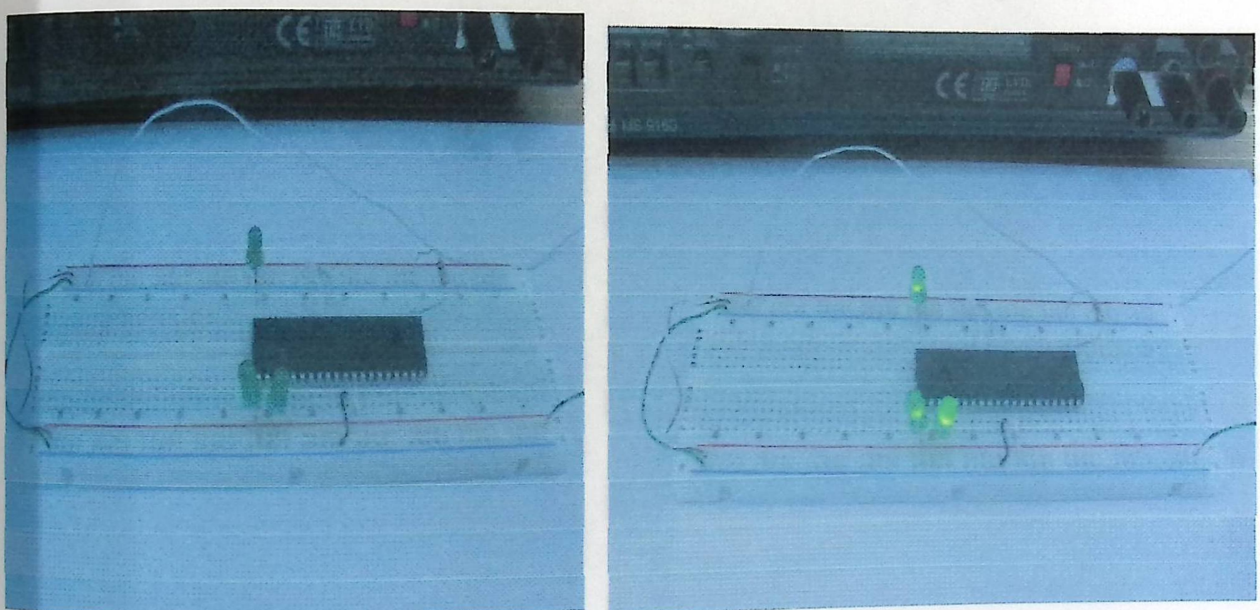

Fig 6.11 PIC18f4520 testing

- **Buzzer testing:**

We build an alarm circuit as shown in fig.6.12. This alarm circuit contains a simple buzzer that has two edges and a transistor. The transistor collector is connected to the buzzer with high voltage (+5v), the other edge of the buzzer is connected to ground (0v), the transistor emitter is connected to ground, and the transistor base is given a high voltage. As a result the buzzer is activated giving a good clear sound. Fig 6.12 shows buzzer testing.

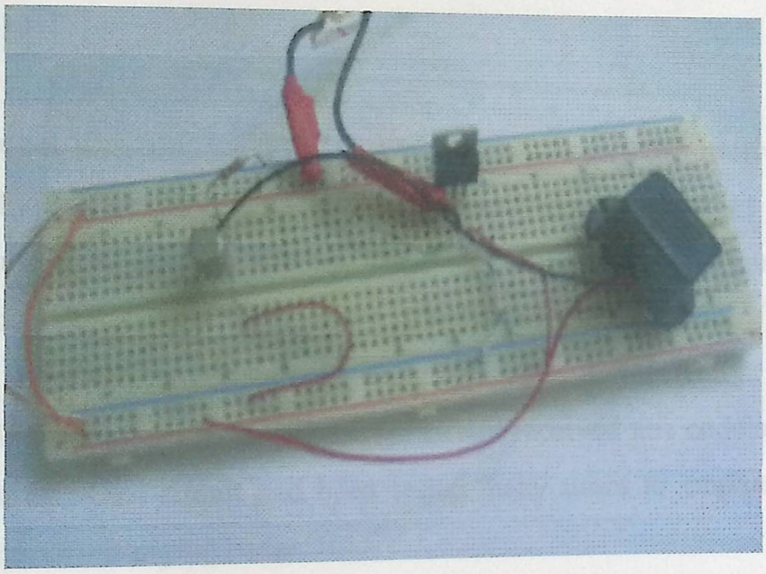

Fig 6.12: Buzzer testing

6.3.2 Project subsystems testing:

Transmitter testing was done synchronized with the receiver testing. As referred previously transmitter circuit was used to transmit a digital code through an RF signal. This code was expected to be received at receiver circuit. We tested communication subsystems through two stages as illustrated below:

- **First stage:**

At the first stage we tested one transmitter and one receiver at a single circuit performing one card, the transmitter was used to transmit a 4-bit digital code and this code was expected to be received by the receiver housed in the same circuit. This circuit was built over a breadboard as shown in fig. 6.13

RT4-433 transmitter was connected to HT-12E encoder while RR3 receiver was connected to HT-12D decoder which intern was connected to four leds through its D8-D11 pins. We gave this encoder a specific 8-bit digital address that was (11111110) through A0-A7 pins. This address is compatible with the decoder address. We gave a 4-bit digital code that was (1111) trough pins (AD8-AD11) as Data to be sent, this data code was expected to be received at RR3-433 receiver and then decoded by HT-12D decoder. Our receiver circuit received this code and though all leds through D0-D3 turned on. This circuit had been tested many times to emphasize better results, each time with a different 4-bit digital code.

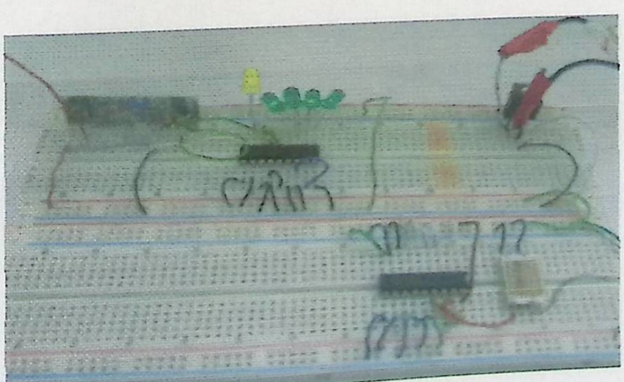

Fig 6.13 testing transmitter with its compatible receiver

- **Second stage:**

At this stage we build two circuits simplifying two cards. Each circuit had same components as in first stage. In first stage, encoder at the first circuit was given a special 8-bit address that was (00000000) and was combatable with decoder address at the second circuit, also TE pin should have 0 value to enable the transmission process, where as encoder in second card should be disabled (with high value 1) this done with second card when it transmits. Transmitter at the first circuit was used to transmit a special 4-bit digital code that was (1111), and this code was received at receiver at the second circuit and though turns all leds on based. Encoder at the second circuit was given a specific address (11111111) which was combatable with receiver decoder at first circuit. Second transmitter was used to transmit a different 4-bit digital code that was (0101), and this code was received at receiver in the first circuit and though turns the second and the four leds on. Both circuits had been tested many times to emphasize better results, each time with a different 4-bit digital code. This circuit was built over a breadboard as shown in fig. 6.14

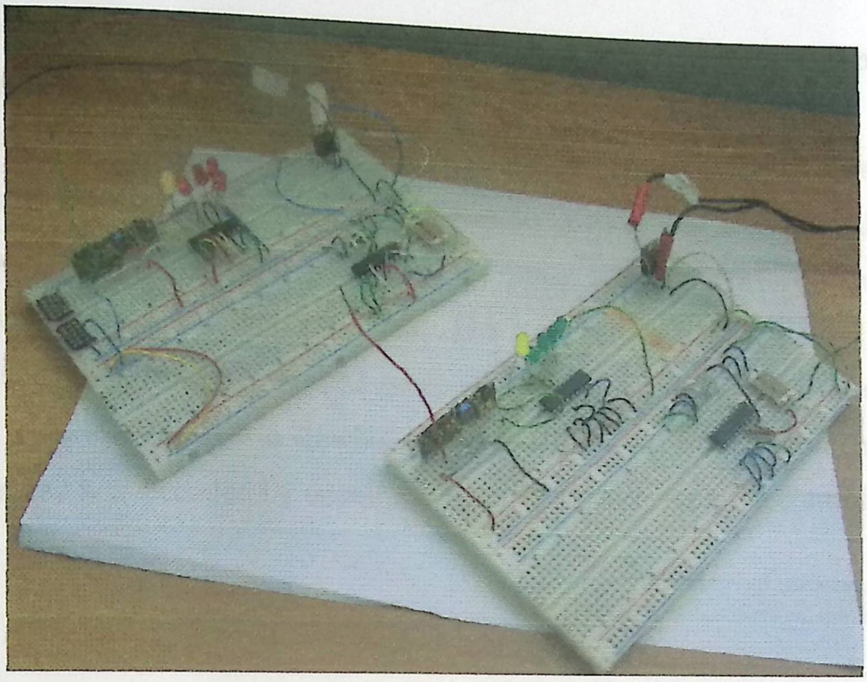

Fig 6.14 two communication circuits

6.3.3 Integrated system testing:

As we tested project major components and subsystems that make up this project, now we are ready to connect all these subsystems together to perform the whole system testing. The project integrated system simply contains two symmetric cards systems that have the same components and subsystems. Both have a communication subsystem that consists of a transmitter with its encoder and a receiver with its decoder, alarm system that has a simple buzzer with its transistor and the microcontroller that is PIC 18f4520 which controls all operations.

We tested the first card which simplifies the mother card in isolation from the other card that simplifies the son's card. We connected RT4-433 transmitter with HT-12E encoder. We gave this encoder a specific 8-bit digital address that was (11111111) through A0-A7 pins. The 4-bit code to be transmitted came from the specified PIC output port that was port D and that code had a value 1111. That code was expected to be received at the son's card and performs the comparison operation at the microcontroller of the son's card. The mother card now waits for a signal to be received from the son's card through its RR3 receiver. We connected that RR3 receiver with HT-12D decoder. We gave that receiver a specific address that was 00000000 through A0-A7. Data expected to be received was decoded by decoder and act as input to the microcontroller through its input port B.

Since there was only one card system there was no signal received at the mother card receiver. So there was no specific input code received at port B of the PIC and the comparison operation was failed, so the alarm system was activated and the buzzer gave a continuous sound. Fig. 6.15 below shows the mother card system with a led connected the transistor base to indicate that the buzzer is activated and works on.

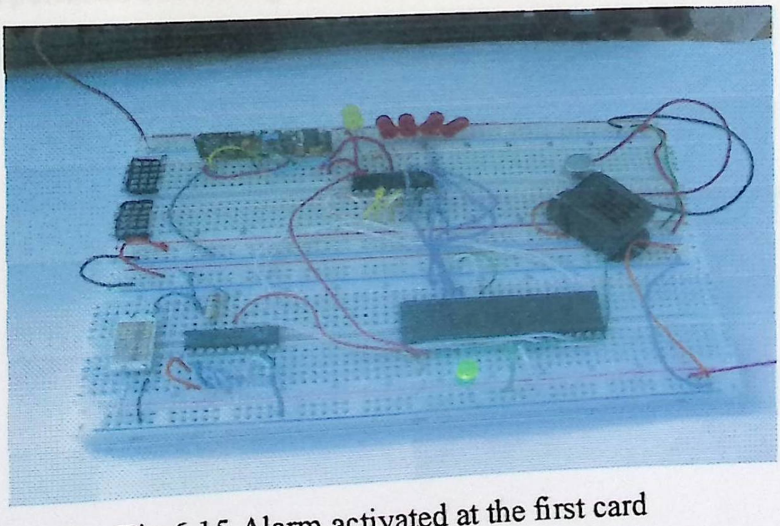

Fig 6.15 Alarm activated at the first card

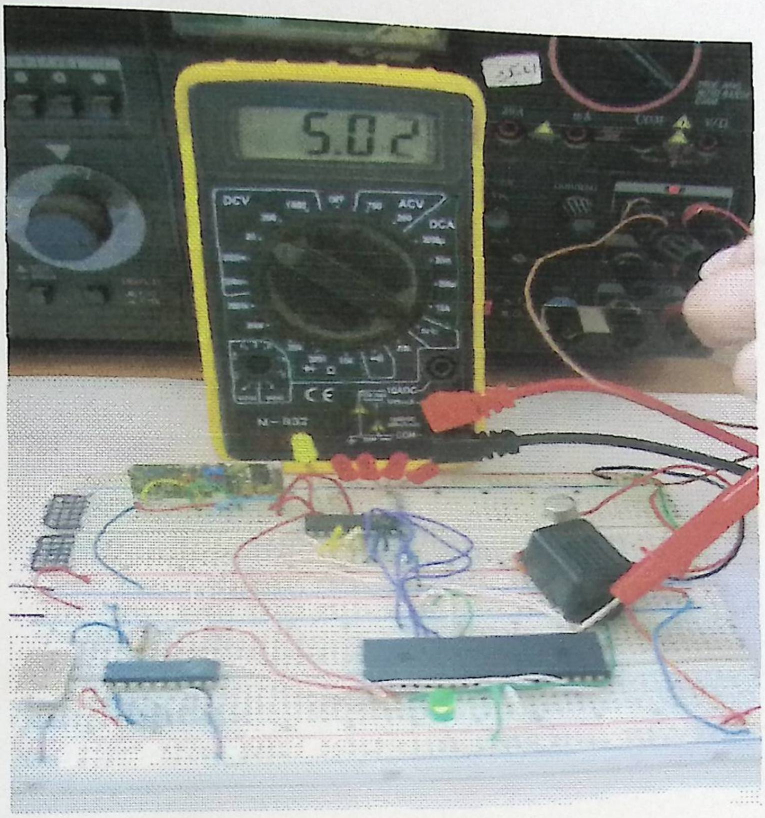

Fig. 6.16 Data to be transmitted at the first card

The same steps performed in testing the mother card. Were used in testing the son's card and gave good results.

Chapter

7 *Conclusion & Future Work*

7.1 Preface.

7.2 Conclusion.

7.3 Problems.

7.4 Future Work & Developing Suggestions.

Chapter Seven
Conclusion & Future Work

7.1 Preface:

This chapter describes and gives a complete look over the entire project from the beginning; produced problems faced the implementation, so those who will upgrade and develop this idea can avoid these problems. It also provides suggestions that could be useful for developing the idea in future.

7.2Conclusion:

If we go back to our subject and reevaluate the full discussion in details the following notes can be seen:

The project is a wireless communication system between two or more plastic cards to be used in security and safety of kids and valuables. The project is depending on a special system having a microcontroller, transmitter, receiver and alarm. They are arranged in a way to be sensitive in giving what is needed from. In the mean time it is still in need for more trials and developments.

We should point out the good knowledge we got in this subject, the many new things we came to know about microcontroller and related items which all gave us more professional and practical ideas especially in using less components.

Going back to the good results have been achieved we find many ideas in this field can be implemented as what we have done in this project such as Haj season and related circumstances. More over, this also can be implemented in many branches of the community practical life. It is of great value to let this project directed to the happiness of the humanity.

Our estimation to the benefits and success of this project can be considered of good value in the field of the security. Beside that the sophisticated instruments came through the implementation of the project systems like signal transmission and alarm system gave us new understanding in this field.

We advice those who are coming later to have this project in mind and try to develop it to better instruments for the sake of good and peaceful life for all.

7.3 Problems:

The problems we faced during this year have two phases hardware and software problems and the sections below illustrate them.

7.3.1 Hardware Problems:

- The first and the most difficult problem was the waiting for components (PIC18f4520, RT4-433.92, and RR3-433.92) to be available. This late extended from last month of the first semester to the second month on the current semester.
- When start testing the transmitter and receiver circuit for both cards, there were no data received or transmitted correctly between the related transmitter and receiver. Also the two circuits were not working correctly.

- After PIC programmer crash, we waited for another one for at least three weeks, and then we worked together and built our own programmer. It has percentage of error but it works.
- Finding a small sound circuit so we can use it as alarm in the card. This circuit should have small size, that sound should be loud enough to be heard from a distance and has the fewest number of components.
- One of the PIC18F4520 has broken leg, because of putting on the PIC on the base and removing it many times, and this base is very hard to the PIC.
- Also one of the problems , connecting wrong wires in the wrong places , such as swapping the high and low voltage to the circuit, or providing high voltage or current that the circuit cannot work with it and in some times damaged the component.

7.3.2 Software Problems:

- Since that each PIC should have programmer so that PIC could be programmed, there was only one PIC programmer for 5 graduation groups.
- The unavailability of this device caused a great latency in microcontroller programming which was the most important operation in system testing and implementation.
- Programming PIC 18f4520 at first was difficult not in using C-programming language, but because of the considerations that we must study to configure PIC18f4520 to work correctly and others that the person achieves it by experience in programming this PIC. So during writing and running the programs on the microcontroller we faced some problems that the program doesn't work as the project needed to be working.

7.4 Future Work & developing suggestions:

The system could be applied with more cards all communicate with one master card, so mother with two or more sons can use this system.

The system can have more than one alarm system the user can choose between them, when alarm caused it may: call certain number e.g. police number, or add vibration system.

Provide the ability to reprogram the system through removal serial port with computer. So the user can program the system according to the distance he wants, also the number of cards used and can program many other features like the type of alarm used.

It also gives the user ability to change the alarm sound, used by using more than one card will recognize the alarm from which card came.

The project could be updated by connecting to it LCD so the user can read the status of the system at any moment.

System can use modern technologies in communication like using the Bluetooth technology that makes it to communicate with cell phones, so if there is any emergency situation such as mother loses her son the system call directly to her phone and with some cooperation with internet or satellites the system will specify the exact location of the son.

References

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[2]Modulation, demodulation, noise, filtering and antenna, http://www.answers.com
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MPLAB user guide
http://ww1.microchip.com/downloads/en/DeviceDoc/51519a.pdf
MPLAB quick start
http://ww1.microchip.com/downloads/en/DeviceDoc/51281d.pdf

APPENDIX A

DATASHEETS

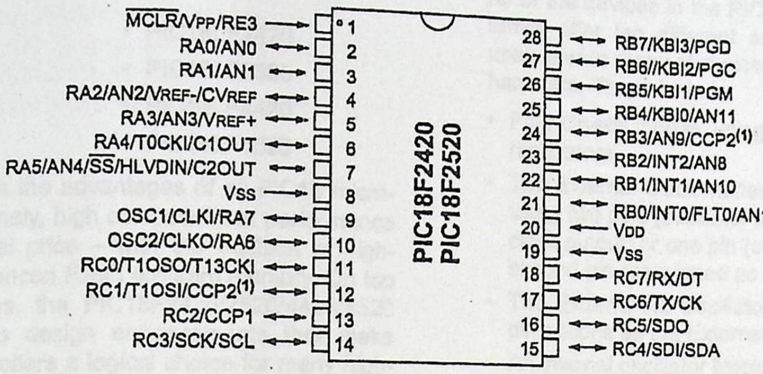
MICROCHIP

PIC18F2420/2520/4420/4520 Data Sheet

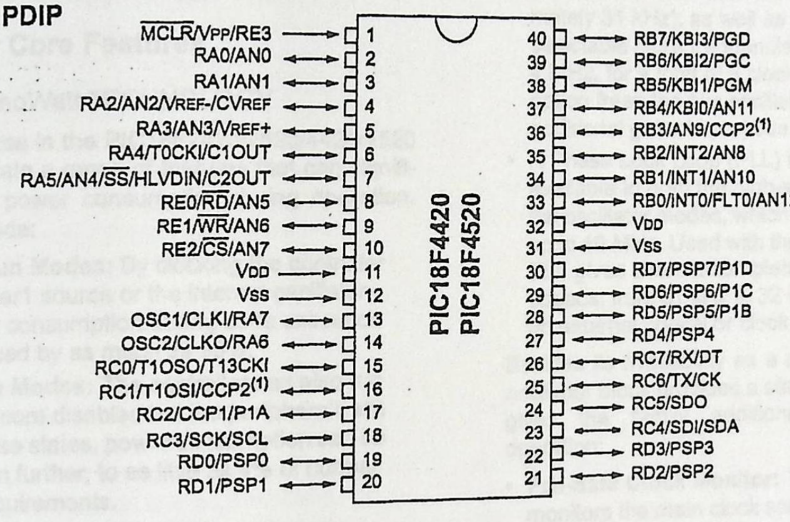
Enhanced Flash Microcontrollers with 10-Bit A/D and nanoWatt Technology

Pin Diagrams

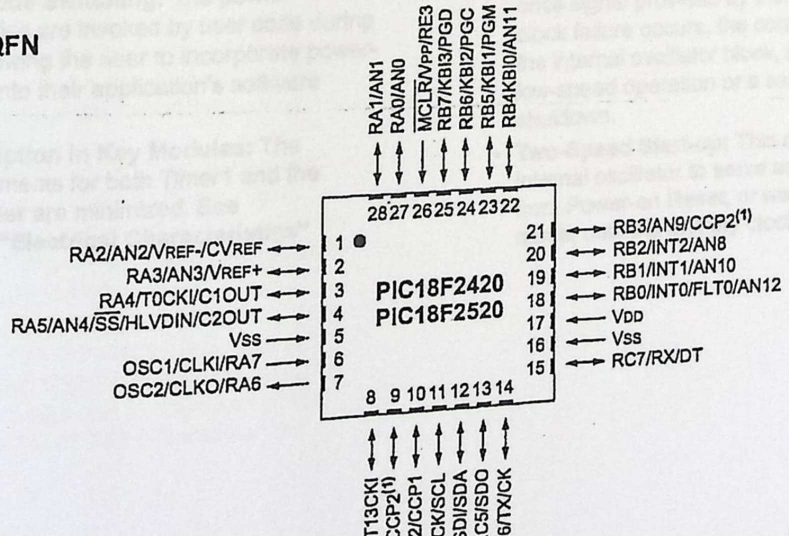
28-pin PDIP, SOIC



40-pin PDIP



28-pin QFN



Note 1: RB3 is the alternate pin for CCP2 multiplexing.

1.0 DEVICE OVERVIEW

This document contains device specific information for the following devices:

- PIC18F2420
- PIC18F2520
- PIC18F4420
- PIC18F4520
- PIC18LF2420
- PIC18LF2520
- PIC18LF4420
- PIC18LF4520

This family offers the advantages of all PIC18 microcontrollers – namely, high computational performance at an economical price – with the addition of high-endurance, Enhanced Flash program memory. On top of these features, the PIC18F2420/2520/4420/4520 family introduces design enhancements that make these microcontrollers a logical choice for many high-performance, power sensitive applications.

1.1 New Core Features

1.1.1 nanoWatt TECHNOLOGY

All of the devices in the PIC18F2420/2520/4420/4520 family incorporate a range of features that can significantly reduce power consumption during operation. Key items include:

- **Alternate Run Modes:** By clocking the controller from the Timer1 source or the internal oscillator block, power consumption during code execution can be reduced by as much as 90%.
- **Multiple Idle Modes:** The controller can also run with its CPU core disabled but the peripherals still active. In these states, power consumption can be reduced even further, to as little as 4% of normal operation requirements.
- **On-the-fly Mode Switching:** The power managed modes are invoked by user code during operation, allowing the user to incorporate power-saving ideas into their application's software design.
- **Low Consumption in Key Modules:** The power requirements for both Timer1 and the Watchdog Timer are minimized. See **Section 26.0 "Electrical Characteristics"** for values.

1.1.2 MULTIPLE OSCILLATOR OPTIONS AND FEATURES

All of the devices in the PIC18F2420/2520/4420/4520 family offer ten different oscillator options, allowing users a wide range of choices in developing application hardware. These include:

- Four Crystal modes, using crystals or ceramic resonators
- Two External Clock modes, offering the option of using two pins (oscillator input and a divide-by-4 clock output) or one pin (oscillator input, with the second pin reassigned as general I/O)
- Two External RC Oscillator modes with the same pin options as the External Clock modes
- An internal oscillator block which provides an 8 MHz clock and an INTRC source (approximately 31 kHz), as well as a range of 6 user selectable clock frequencies, between 125 kHz to 4 MHz, for a total of 8 clock frequencies. This option frees the two oscillator pins for use as additional general purpose I/O.
- A Phase Lock Loop (PLL) frequency multiplier, available to both the high-speed crystal and internal oscillator modes, which allows clock speeds of up to 40 MHz. Used with the internal oscillator, the PLL gives users a complete selection of clock speeds, from 31 kHz to 32 MHz – all without using an external crystal or clock circuit.

Besides its availability as a clock source, the internal oscillator block provides a stable reference source that gives the family additional features for robust operation:

- **Fail-Safe Clock Monitor:** This option constantly monitors the main clock source against a reference signal provided by the internal oscillator. If a clock failure occurs, the controller is switched to the internal oscillator block, allowing for continued low-speed operation or a safe application shutdown.
- **Two-Speed Start-up:** This option allows the internal oscillator to serve as the clock source from Power-on Reset, or wake-up from Sleep mode, until the primary clock source is available.

1.2 Other Special Features

- **Memory Endurance:** The Enhanced Flash cells for both program memory and data EEPROM are rated to last for many thousands of erase/write cycles – up to 100,000 for program memory and 1,000,000 for EEPROM. Data retention without refresh is conservatively estimated to be greater than 40 years.
- **Self-programmability:** These devices can write to their own program memory spaces under internal software control. By using a bootloader routine located in the protected Boot Block at the top of program memory, it becomes possible to create an application that can update itself in the field.
- **Extended Instruction Set:** The PIC18F2420/2520/4420/4520 family introduces an optional extension to the PIC18 instruction set, which adds 8 new instructions and an Indexed Addressing mode. This extension, enabled as a device configuration option, has been specifically designed to optimize re-entrant application code originally developed in high-level languages, such as C.
- **Enhanced CCP module:** In PWM mode, this module provides 1, 2 or 4 modulated outputs for controlling half-bridge and full-bridge drivers. Other features include Auto-Shutdown, for disabling PWM outputs on interrupt or other select conditions and Auto-Restart, to reactivate outputs once the condition has cleared.
- **Enhanced Addressable USART:** This serial communication module is capable of standard RS-232 operation and provides support for the LIN bus protocol. Other enhancements include automatic baud rate detection and a 16-bit Baud Rate Generator for improved resolution. When the microcontroller is using the internal oscillator block, the USART provides stable operation for applications that talk to the outside world without using an external crystal (or its accompanying power requirement).
- **10-bit A/D Converter:** This module incorporates programmable acquisition time, allowing for a channel to be selected and a conversion to be initiated without waiting for a sampling period and thus, reduce code overhead.
- **Extended Watchdog Timer (WDT):** This enhanced version incorporates a 16-bit prescaler, allowing an extended time-out range that is stable across operating voltage and temperature. See **Section 26.0 "Electrical Characteristics"** for time-out periods.

1.3 Details on Individual Family Members

Devices in the PIC18F2420/2520/4420/4520 family are available in 28-pin and 40/44-pin packages. Block diagrams for the two groups are shown in Figure 1-1 and Figure 1-2.

The devices are differentiated from each other in five ways:

1. Flash program memory (16 Kbytes for PIC18F2420/4420 devices and 32 Kbytes for PIC18F2520/4520).
2. A/D channels (10 for 28-pin devices, 13 for 40/44-pin devices).
3. I/O ports (3 bidirectional ports on 28-pin devices, 5 bidirectional ports on 40/44-pin devices).
4. CCP and Enhanced CCP implementation (28-pin devices have 2 standard CCP modules, 40/44-pin devices have one standard CCP module and one ECCP module).
5. Parallel Slave Port (present only on 40/44-pin devices).

All other features for devices in this family are identical. These are summarized in Table 1-1.

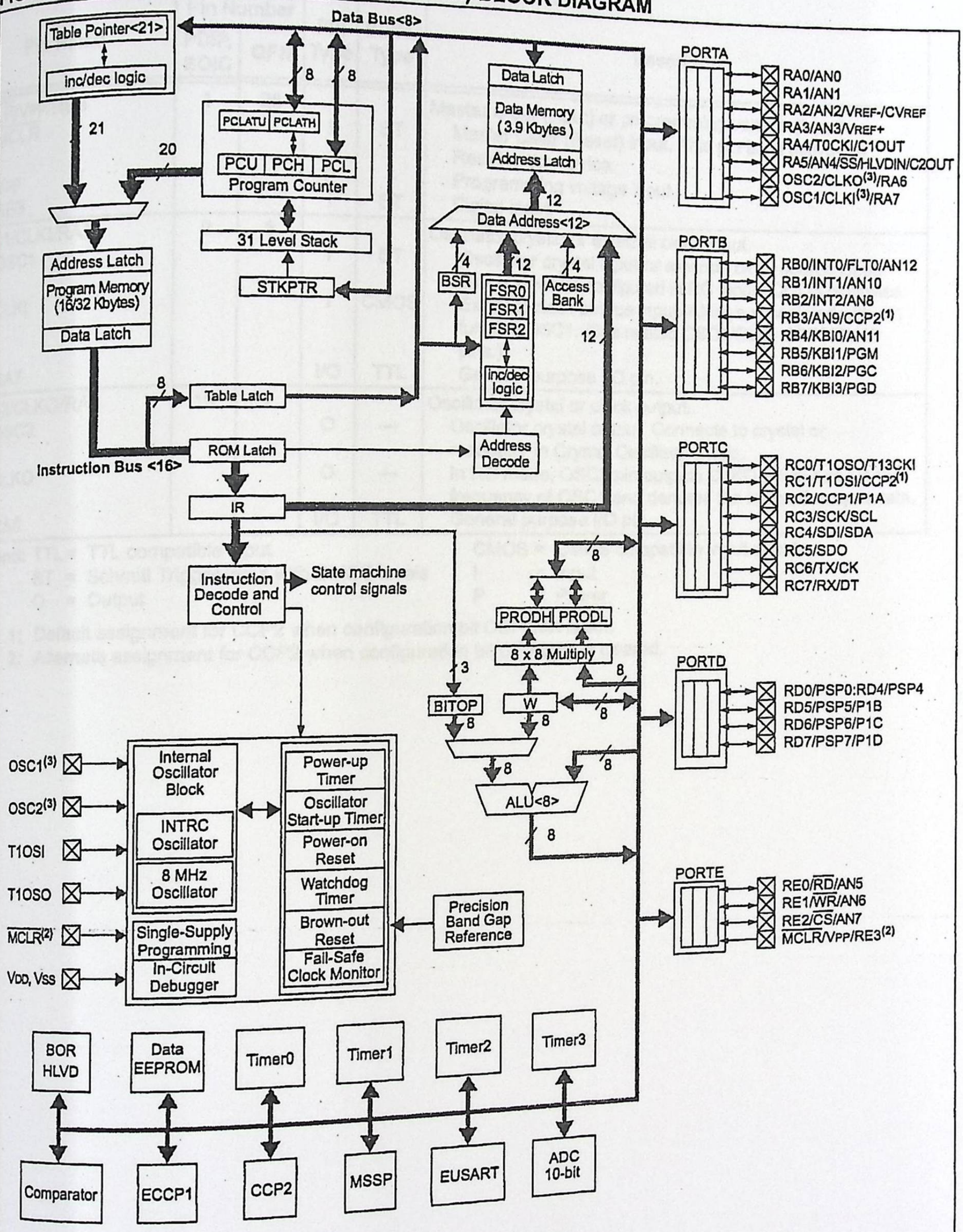
The pinouts for all devices are listed in Table 1-2 and Table 1-3.

Like all Microchip PIC18 devices, members of the PIC18F2420/2520/4420/4520 family are available as both standard and low-voltage devices. Standard devices with Enhanced Flash memory, designated with an "F" in the part number (such as PIC18F2420), accommodate an operating V_{DD} range of 4.2V to 5.5V. Low-voltage parts, designated by "LF" (such as PIC18**LF**2420), function over an extended V_{DD} range of 2.0V to 5.5V.

TABLE 1-1: DEVICE FEATURES

Features	PIC18F2420	PIC18F2520	PIC18F4420	PIC18F4520
Operating Frequency	DC – 40 MHz	DC – 40 MHz	DC – 40 MHz	DC – 40 MHz
Program Memory (Bytes)	16384	32768	16384	32768
Program Memory (Instructions)	8192	16384	8192	16384
Data Memory (Bytes)	768	1536	768	1536
Data EEPROM Memory (Bytes)	256	256	256	256
Interrupt Sources	19	19	20	20
I/O Ports	Ports A, B, C, (E)	Ports A, B, C, (E)	Ports A, B, C, D, E	Ports A, B, C, D, E
Timers	4	4	4	4
Capture/Compare/PWM Modules	2	2	1	1
Enhanced Capture/Compare/PWM Modules	0	0	1	1
Serial Communications	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART
Parallel Communications (PSP)	No	No	Yes	Yes
10-bit Analog-to-Digital Module	10 Input Channels	10 Input Channels	13 Input Channels	13 Input Channels
Resets (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT
Programmable High/Low-Voltage Detect	Yes	Yes	Yes	Yes
Programmable Brown-out Reset	Yes	Yes	Yes	Yes
Instruction Set	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled
Packages	28-pin PDIP 28-pin SOIC 28-pin QFN	28-pin PDIP 28-pin SOIC 28-pin QFN	40-pin PDIP 44-pin QFN 44-pin TQFP	40-pin PDIP 44-pin QFN 44-pin TQFP

FIGURE 1-2: PIC18F4420/4520 (40/44-PIN) BLOCK DIAGRAM



Note 1: CCP2 is multiplexed with RC1 when configuration bit CCP2MX is set, or RB3 when CCP2MX is not set.

2: RE3 is only available when $\overline{MCLR}$ functionality is disabled.

3: OSC1/CLKI and OSC2/CLKO are only available in select oscillator modes and when these pins are not being used as digital I/O. Refer to **Section 2.0 "Oscillator Configurations"** for additional information.

TABLE 1-2: PIC18F2420/2520 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number		Pin Type	Buffer Type	Description
	PDIP, SOIC	QFN			
MCLR/VPP/RE3	1	26			Master Clear (input) or programming voltage (input).
MCLR			I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP			P		Programming voltage input.
RE3			I	ST	Digital input.
OSC1/CLKI/RA7	9	6			Oscillator crystal or external clock input.
OSC1			I	ST	Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; CMOS otherwise.
CLKI			I	CMOS	External clock source input. Always associated with pin function OSC1. (See related OSC1/CLKI, OSC2/CLKO pins.)
RA7			I/O	TTL	General purpose I/O pin.
OSC2/CLKO/RA6	10	7			Oscillator crystal or clock output.
OSC2			O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO			O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6			I/O	TTL	General purpose I/O pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Default assignment for CCP2 when configuration bit CCP2MX is set.
2: Alternate assignment for CCP2 when configuration bit CCP2MX is cleared.

TABLE 1-3: PIC18F4420/4520 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number PDIP	Pin Number QFN	Pin Number TQFP	Pin Type	Buffer Type	Description
MCLR/VPP/RE3	1	18	18			Master Clear (input) or programming voltage (input).
MCLR				I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP				P		Programming voltage input.
RE3				I	ST	Digital input.
OSC1/CLKI/RA7	13	32	30			Oscillator crystal or external clock input.
OSC1				I	ST	Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; analog otherwise.
CLKI				I	CMOS	External clock source input. Always associated with pin function OSC1. (See related OSC1/CLKI, OSC2/CLKO pins.)
RA7				I/O	TTL	General purpose I/O pin.
OSC2/CLKO/RA6	14	33	31			Oscillator crystal or clock output.
OSC2				O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO				O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6				I/O	TTL	General purpose I/O pin.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
CMOS = CMOS compatible input or output
I = Input
P = Power

Note 1: Default assignment for CCP2 when configuration bit CCP2MX is set.
2: Alternate assignment for CCP2 when configuration bit CCP2MX is cleared.

Preliminary

TABLE 1-3: PIC18F4420/4520 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTA is a bidirectional I/O port.
RA0/AN0	2	19	19			
RA0				I/O	TTL	Digital I/O.
AN0				I	Analog	Analog input 0.
RA1/AN1	3	20	20			
RA1				I/O	TTL	Digital I/O.
AN1				I	Analog	Analog input 1.
RA2/AN2/VREF-/CVREF	4	21	21			
RA2				I/O	TTL	Digital I/O.
AN2				I	Analog	Analog input 2.
VREF-				I	Analog	A/D reference voltage (low) input.
CVREF				O	Analog	Comparator reference voltage output.
RA3/AN3/VREF+	5	22	22			
RA3				I/O	TTL	Digital I/O.
AN3				I	Analog	Analog input 3.
VREF+				I	Analog	A/D reference voltage (high) input.
RA4/T0CKI/C1OUT	6	23	23			
RA4				I/O	ST	Digital I/O.
T0CKI				I	ST	Timer0 external clock input.
C1OUT				O	—	Comparator 1 output.
RA5/AN4/SS/HLVDIN/C2OUT	7	24	24			
RA5				I/O	TTL	Digital I/O.
AN4				I	Analog	Analog input 4.
SS				I	TTL	SPI slave select input.
HLVDIN				I	Analog	High/Low-Voltage Detect input.
C2OUT				O	—	Comparator 2 output.
RA6						See the OSC2/CLKO/RA6 pin.
RA7						See the OSC1/CLKI/RA7 pin.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
CMOS = CMOS compatible input or output
I = Input
P = Power

Note 1: Default assignment for CCP2 when configuration bit CCP2MX is set.
2: Alternate assignment for CCP2 when configuration bit CCP2MX is cleared.

TABLE 1-3: PIC18F4420/4520 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTB is a bidirectional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/INT0/FLT0/AN12	33	9	8			
RB0				I/O	TTL	Digital I/O.
INT0				I	ST	External interrupt 0.
FLT0				I	ST	PWM Fault input for Enhanced CCP1.
AN12				I	Analog	Analog input 12.
RB1/INT1/AN10	34	10	9			
RB1				I/O	TTL	Digital I/O.
INT1				I	ST	External interrupt 1.
AN10				I	Analog	Analog input 10.
RB2/INT2/AN8	35	11	10			
RB2				I/O	TTL	Digital I/O.
INT2				I	ST	External interrupt 2.
AN8				I	Analog	Analog input 8.
RB3/AN9/CCP2	36	12	11			
RB3				I/O	TTL	Digital I/O.
AN9				I	Analog	Analog input 9.
CCP2(1)				I/O	ST	Capture 2 input/Compare 2 output/PWM 2 output.
RB4/KBI0/AN11	37	14	14			
RB4				I/O	TTL	Digital I/O.
KBI0				I	TTL	Interrupt-on-change pin.
AN11				I	Analog	Analog input 11.
RB5/KBI1/PGM	38	15	15			
RB5				I/O	TTL	Digital I/O.
KBI1				I	TTL	Interrupt-on-change pin.
PGM				I/O	ST	Low-Voltage ICSP™ Programming enable pin.
RB6/KBI2/PGC	39	16	16			
RB6				I/O	TTL	Digital I/O.
KBI2				I	TTL	Interrupt-on-change pin.
PGC				I/O	ST	In-Circuit Debugger and ICSP programming clock pin.
RB7/KBI3/PGD	40	17	17			
RB7				I/O	TTL	Digital I/O.
KBI3				I	TTL	Interrupt-on-change pin.
PGD				I/O	ST	In-Circuit Debugger and ICSP programming data pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power

Note 1: Default assignment for CCP2 when configuration bit CCP2MX is set.
2: Alternate assignment for CCP2 when configuration bit CCP2MX is cleared.

TABLE 1-3: PIC18F4420/4520 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTC is a bidirectional I/O port.
RC0/T1OSO/T13CKI	15	34	32			
RC0				I/O	ST	Digital I/O.
T1OSO				O	—	Timer1 oscillator output.
T13CKI				I	ST	Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2	16	35	35			
RC1				I/O	ST	Digital I/O.
T1OSI				I	CMOS	Timer1 oscillator input.
CCP2(2)				I/O	ST	Capture 2 input/Compare 2 output/PWM 2 output.
RC2/CCP1/P1A	17	36	36			
RC2				I/O	ST	Digital I/O.
CCP1				I/O	ST	Capture 1 input/Compare 1 output/PWM 1 output.
P1A				O	—	Enhanced CCP1 output.
RC3/SCK/SCL	18	37	37			
RC3				I/O	ST	Digital I/O.
SCK				I/O	ST	Synchronous serial clock input/output for SPI™ mode.
SCL				I/O	ST	Synchronous serial clock input/output for I²C™ mode.
RC4/SDI/SDA	23	42	42			
RC4				I/O	ST	Digital I/O.
SDI				I	ST	SPI data in.
SDA				I/O	ST	I²C data I/O.
RC5/SDO	24	43	43			
RC5				I/O	ST	Digital I/O.
SDO				O	—	SPI data out.
RC6/TX/CK	25	44	44			
RC6				I/O	ST	Digital I/O.
TX				O	—	EUSART asynchronous transmit.
CK				I/O	ST	EUSART synchronous clock (see related RX/DT).
RC7/RX/DT	26	1	1			
RC7				I/O	ST	Digital I/O.
RX				I	ST	EUSART asynchronous receive.
DT				I/O	ST	EUSART synchronous data (see related TX/CK).

Legend: TTL = TTL compatible input; ST = Schmitt Trigger input with CMOS levels; O = Output; CMOS = CMOS compatible input or output; I = Input; P = Power

Note 1: Default assignment for CCP2 when configuration bit CCP2MX is set.
2: Alternate assignment for CCP2 when configuration bit CCP2MX is cleared.

TABLE 1-3: PIC18F4420/4520 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
						PORTD is a bidirectional I/O port or a Parallel Slave Port (PSP) for interfacing to a microprocessor port. These pins have TTL input buffers when PSP module is enabled.
RD0/PSP0	19	38	38			
RD0				I/O	ST	Digital I/O.
PSP0				I/O	TTL	Parallel Slave Port data.
RD1/PSP1	20	39	39			
RD1				I/O	ST	Digital I/O.
PSP1				I/O	TTL	Parallel Slave Port data.
RD2/PSP2	21	40	40			
RD2				I/O	ST	Digital I/O.
PSP2				I/O	TTL	Parallel Slave Port data.
RD3/PSP3	22	41	41			
RD3				I/O	ST	Digital I/O.
PSP3				I/O	TTL	Parallel Slave Port data.
RD4/PSP4	27	2	2			
RD4				I/O	ST	Digital I/O.
PSP4				I/O	TTL	Parallel Slave Port data.
RD5/PSP5/P1B	28	3	3			
RD5				I/O	ST	Digital I/O.
PSP5				I/O	TTL	Parallel Slave Port data.
P1B				O	—	Enhanced CCP1 output.
RD6/PSP6/P1C	29	4	4			
RD6				I/O	ST	Digital I/O.
PSP6				I/O	TTL	Parallel Slave Port data.
P1C				O	—	Enhanced CCP1 output.
RD7/PSP7/P1D	30	5	5			
RD7				I/O	ST	Digital I/O.
PSP7				I/O	TTL	Parallel Slave Port data.
P1D				O	—	Enhanced CCP1 output.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output
ST = Schmitt Trigger input with CMOS levels; I = Input
O = Output; P = Power

Note 1: Default assignment for CCP2 when configuration bit CCP2MX is set.
2: Alternate assignment for CCP2 when configuration bit CCP2MX is cleared.

2.0 OSCILLATOR CONFIGURATIONS

2.1 Oscillator Types

PIC18F2420/2520/4420/4520 devices can be operated in ten different oscillator modes. The user can program the configuration bits, FOSC3:FOSC0, in Configuration Register 1H to select one of these ten modes:

1. LP — Low-Power Crystal
2. XT — Crystal/Resonator
3. HS — High-Speed Crystal/Resonator
4. HSPLL — High-Speed Crystal/Resonator with PLL enabled
5. RC — External Resistor/Capacitor with FOSC/4 output on RA6
6. RCIO — External Resistor/Capacitor with I/O on RA6
7. INTIO1 — Internal Oscillator with FOSC/4 output on RA6 and I/O on RA7
8. INTIO2 — Internal Oscillator with I/O on RA6 and RA7
9. EC — External Clock with FOSC/4 output
10. ECIO — External Clock with I/O on RA6

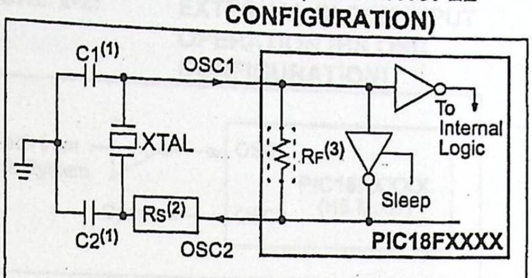
2.2 Crystal Oscillator/Ceramic Resonators

In XT, LP, HS or HSPLL Oscillator modes, a crystal or ceramic resonator is connected to the OSC1 and OSC2 pins to establish oscillation. Figure 2-1 shows the pin connections.

The oscillator design requires the use of a parallel cut crystal.

Note:	Use of a series cut crystal may give a frequency out of the crystal manufacturer's specifications.

FIGURE 2-1: CRYSTAL/CERAMIC RESONATOR OPERATION (XT, LP, HS OR HSPLL CONFIGURATION)



Note 1: See Table 2-1 and Table 2-2 for initial values of C1 and C2.

2: A series resistor (RS) may be required for AT strip cut crystals.

3: RF varies with the oscillator mode chosen.

TABLE 2-1: CAPACITOR SELECTION FOR CERAMIC RESONATORS

Typical Capacitor Values Used:			
Mode	**Freq**	**OSC1**	**OSC2**
XT	3.58 MHz	15 pF	15 pF
	4.19 MHz	15 pF	15 pF
	4 MHz	30 pF	30 pF
	4 MHz	50 pF	50 pF

Capacitor values are for design guidance only.

Different capacitor values may be required to produce acceptable oscillator operation. The user should test the performance of the oscillator over the expected VDD and temperature range for the application.

See the notes following Table 2-2 for additional information.

Note:	When using resonators with frequencies above 3.5 MHz, the use of HS mode, rather than XT mode, is recommended. HS mode may be used at any VDD for which the controller is rated. If HS is selected, it is possible that the gain of the oscillator will overdrive the resonator. Therefore, a series resistor should be placed between the OSC2 pin and the resonator. As a good starting point, the recommended value of RS is 330Ω.

TABLE 2-2: CAPACITOR SELECTION FOR CRYSTAL OSCILLATOR

Osc Type	Crystal Freq	Typical Capacitor Values Tested:	
		C1	C2
LP	32 kHz	30 pF	30 pF
XT	1 MHz	15 pF	15 pF
	4 MHz	15 pF	15 pF
HS	4 MHz	15 pF	15 pF
	10 MHz	15 pF	15 pF
	20 MHz	15 pF	15 pF
	25 MHz	0 pF	5 pF
	25 MHz	15 pF	15 pF

Capacitor values are for design guidance only.

These capacitors were tested with the crystals listed below for basic start-up and operation. **These values are not optimized.**

Different capacitor values may be required to produce acceptable oscillator operation. The user should test the performance of the oscillator over the expected VDD and temperature range for the application.

See the notes following this table for additional information.

Crystals Used:	
32 kHz	4 MHz
25 MHz	10 MHz
1 MHz	20 MHz

Note 1: Higher capacitance increases the stability of the oscillator but also increases the start-up time.

2: When operating below 3V VDD, or when using certain ceramic resonators at any voltage, it may be necessary to use the HS mode or switch to a crystal oscillator.

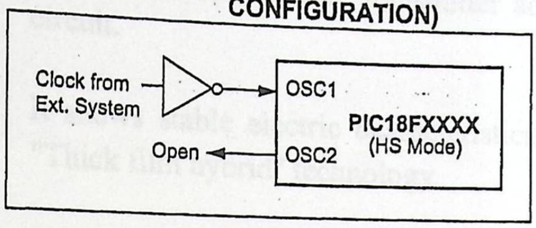
3: Since each resonator/crystal has its own characteristics, the user should consult the resonator/crystal manufacturer for appropriate values of external components.

4: Rs may be required to avoid overdriving crystals with low drive level specification.

5: Always verify oscillator performance over the VDD and temperature range that is expected for the application.

An external clock source may also be connected to the OSC1 pin in the HS mode, as shown in Figure 2-2.

FIGURE 2-2: EXTERNAL CLOCK INPUT OPERATION (HS OSC CONFIGURATION)

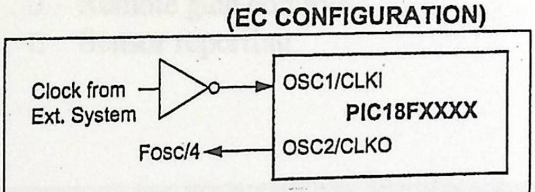


2.3 External Clock Input

The EC and ECIO Oscillator modes require an external clock source to be connected to the OSC1 pin. There is no oscillator start-up time required after a Power-on Reset or after an exit from Sleep mode.

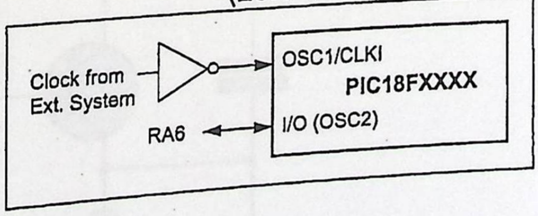
In the EC Oscillator mode, the oscillator frequency divided by 4 is available on the OSC2 pin. This signal may be used for test purposes or to synchronize other logic. Figure 2-3 shows the pin connections for the EC Oscillator mode.

FIGURE 2-3: EXTERNAL CLOCK INPUT OPERATION (EC CONFIGURATION)



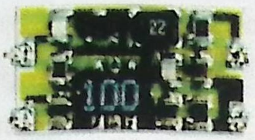
The ECIO Oscillator mode functions like the EC mode, except that the OSC2 pin becomes an additional general purpose I/O pin. The I/O pin becomes bit 6 of PORTA (RA6). Figure 2-4 shows the pin connections for the ECIO Oscillator mode.

FIGURE 2-4: EXTERNAL CLOCK INPUT OPERATION (ECIO CONFIGURATION)



RT4-XXX

Radio Transmitter Module with SAW Resonator and External Antenna



General description

The RT4-XXX is an hybrid circuit that allows to realize a complete radio transmitter adding a coding circuit.

It shows stable electric characteristics thanks to the "Thick film hybrid" technology.

XXX : working frequency (315, 418, 433.92 MHz)

I-ETS 300 220 Compliance (RT4-433.92-IETS)

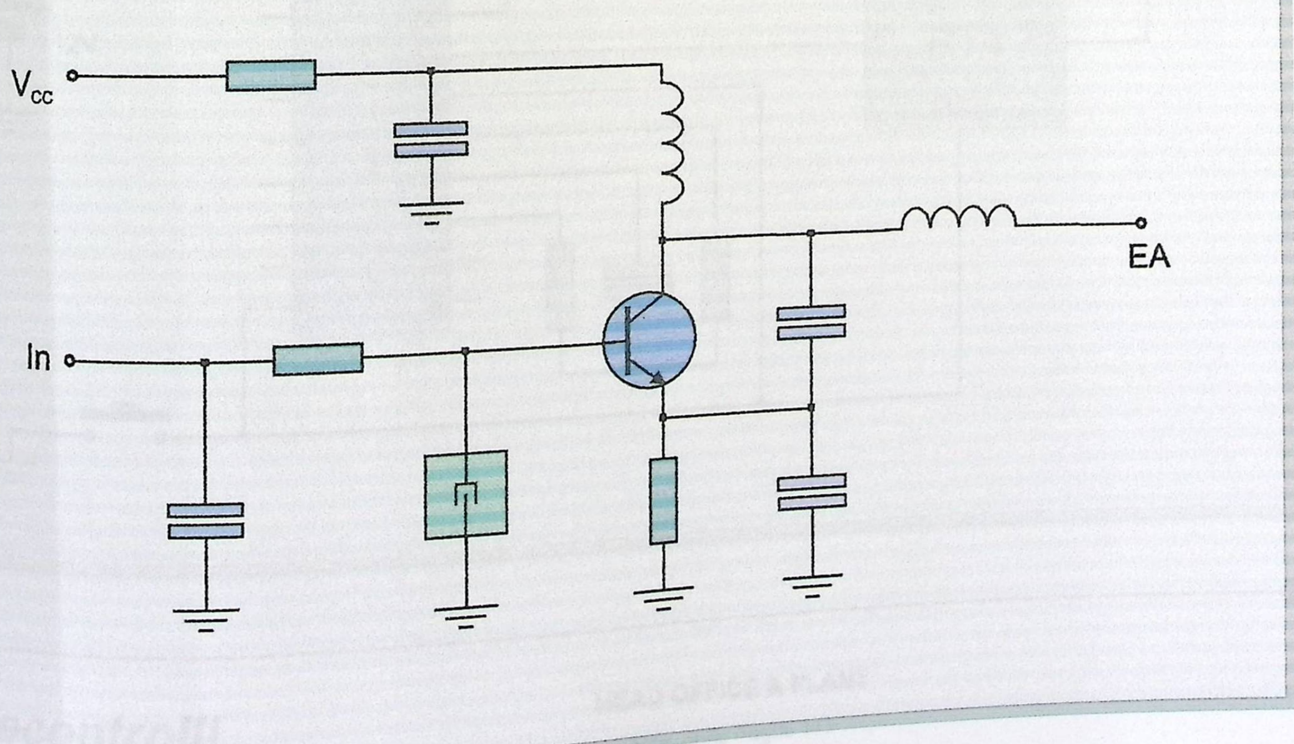
Applications

- Wireless security systems
- Car Alarm systems
- Remote gate controls
- Sensor reporting

Features

- High Reliability
- DIL Package

CIRCUIT SCHEMATIC



Electrical Characteristics

Ta = 25°C unless otherwise specified

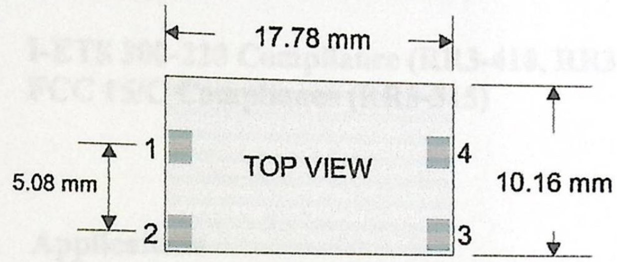
	CHARACTERISTICS	MIN	TYP	MAX	UNIT
V_{cc}	Supply Voltage	2		14	VDC
I_s	Supply Current (Vcc=5V IN=1KHz Square Wawe)		4		mA
F_w	Working Frequency	303.8		433.92	MHz
P_o	RF Output Power into 50 (Vi=5V, Vcc=12V)		7	10	dBm
	Harmonic Spurious Emission		-30		dBc
V_{IH}	Input High Voltage	2		V_{cc}	V
	Max Data Rate			4	KHz
T_{OP}	Operating Temperature Range	-25		+80	°C

...ically, equipment utilizing this device requires emissions testing and government approval, wich is the responsibility of the equipment manufacturer.

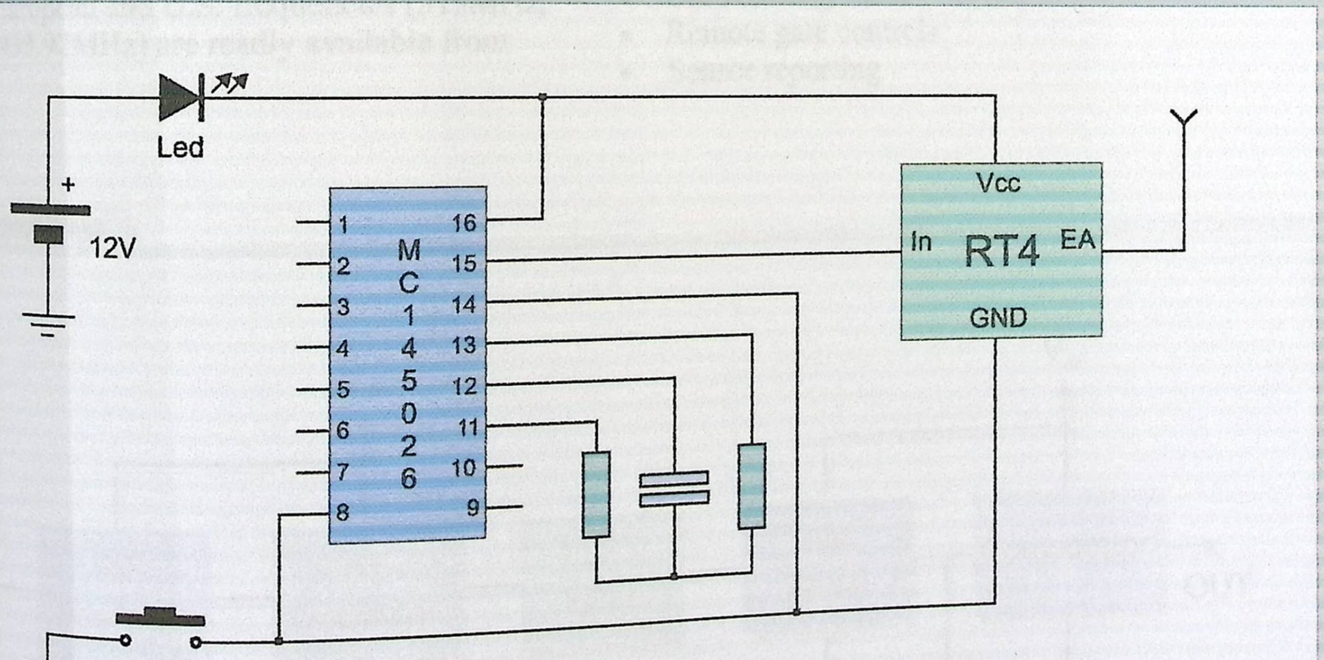
Pin Description

V_{cc}	Supply Voltage
GND	Ground
IN	Modulation Input
EA	External Antenna

Mechanical Dimensions



TYPICAL APPLICATION



telecontrolli

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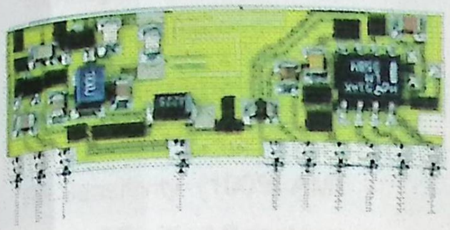
RR3-XXX

Super Regenerative Radio Receiver With Laser Trimmed Inductor



XX: custom-specified working frequency (200 ÷ 450 MHz)

andard European and U.S. frequencies (315MHz, 8MHz, 433.92MHz) are readily available from ock.

General description

The RR3-XXX is a super regenerative data receiver.

Sensitivity typically exceedes -100dBm (2.2uVrms) when matched to 50 ohm.

It shows high frequency stability also in presence of mechanical vibrations, manual handling and in a wide range of temperature.

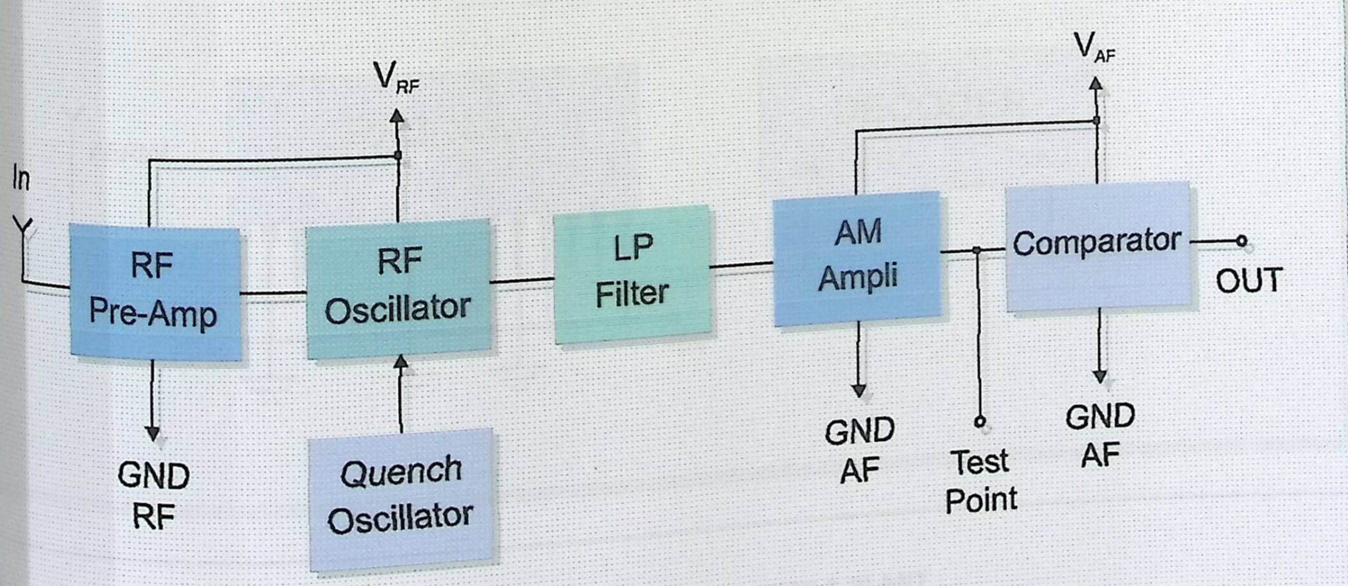
The frequency accuracy is very high thanks to laser trimming process. PATENTED.

I-ETS 300-220 Compliance (RR3-418, RR3-433.92)
FCC 15/C Compliance (RR3-315)

Applications

- Home security systems
- Car Alarm systems
- Remote gate controls
- Sensor reporting

BLOCK DIAGRAM



ctrical Characteristics

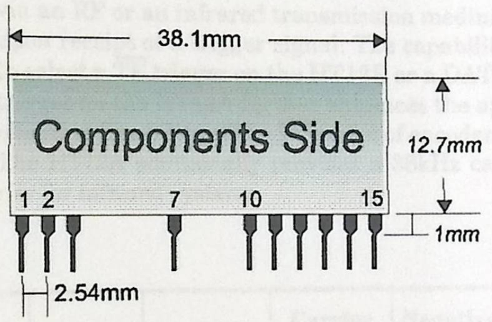
Ta = 25°C unless otherwise specified

CHARACTERISTICS	MIN	TYP	MAX	UNIT
RF Supply Voltage	4.5	5	5.5	VDC
AF Supply Voltage	4.5	5	5.5	VDC
Supply Current		2.5	3	mA
Working Frequency	200		450	MHz
Tuning Tolerance		±0.2	±0.5	MHz
-3dB Bandwidth		±2	±3	MHz
Max Data Rate			2	KHz
RF Sensitivity (100% AM)	-100	-105		dBm
Level of Emitted Spectrum		-65	-60	dBm
Low-Level Output Voltage			0.6	V
High-Level Output Voltage	3.6			V
Operating Temperature Range	-25		+80	°C

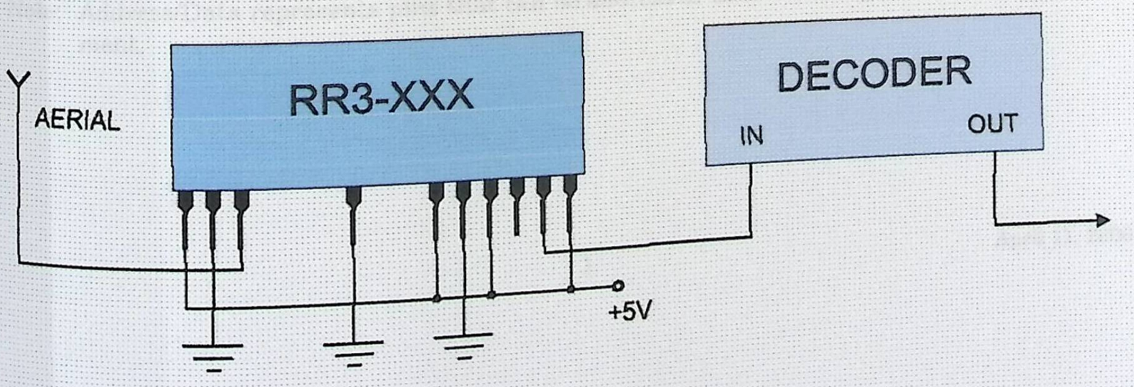
Description

RF $+V_{cc}$	9	NC
RF GND	10	AF $+V_{cc}$
IN	11	AF GND
NC	12	AF $+V_{cc}$
NC	13	Test Point
NC	14	OUT
RF GND	15	AF $+V_{cc}$
NC		

Mechanical Dimensions



TYPICAL APPLICATION



telecontrolli

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Fax: +39 081 7596494

HOLTEK

HT12A/HT12E
2^{12} Series of Encoders

Features

- Operating voltage
  - 2.4V~5V for the HT12A
  - 2.4V~12V for the HT12E
- Low power and high noise immunity CMOS technology
- Low standby current: 0.1μA (typ.) at V_{DD}=5V
- HT12A with a 38kHz carrier for infrared transmission medium
- Minimum transmission word
  - Four words for the HT12E
  - One word for the HT12A
- Built-in oscillator needs only 5% resistor
- Data code has positive polarity
- Minimal external components
- HT12A/E: 18-pin DIP/20-pin SOP package

Applications

- Burglar alarm system
- Smoke and fire alarm system
- Garage door controllers
- Car door controllers
- Car alarm system
- Security system
- Cordless telephones
- Other remote control systems

General Description

The 2^{12} encoders are a series of CMOS LSIs for remote control system applications. They are capable of encoding information which consists of N address bits and 12–N data bits. Each address/data input can be set to one of the two logic states. The programmed addresses/data are transmitted together with the header bits via an RF or an infrared transmission medium upon receipt of a trigger signal. The capability to select a $\overline{TE}$ trigger on the HT12E or a DATA trigger on the HT12A further enhances the application flexibility of the 2^{12} series of encoders. The HT12A additionally provides a 38kHz carrier for infrared systems.

Selection Table

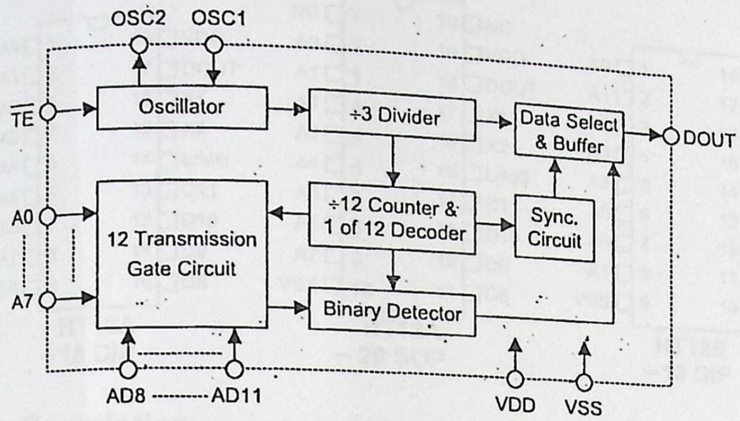
Part No. \ Function	Address No.	Address/ Data No.	Data No.	Oscillator	Trigger	Package	Carrier Output	Negative Polarity
HT12A	8	0	4	455kHz resonator	D8~D11	18 DIP 20 SOP	38kHz	No
HT12E	8	4	0	RC oscillator	$\overline{TE}$	18 DIP 20 SOP	No	No

Note: Address/Data represents pins that can be address or data according to the decoder requirement.

Block Diagram

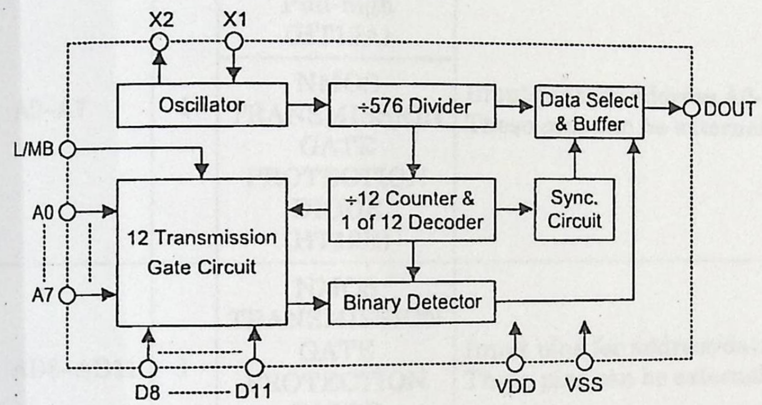
TE trigger

HT12E



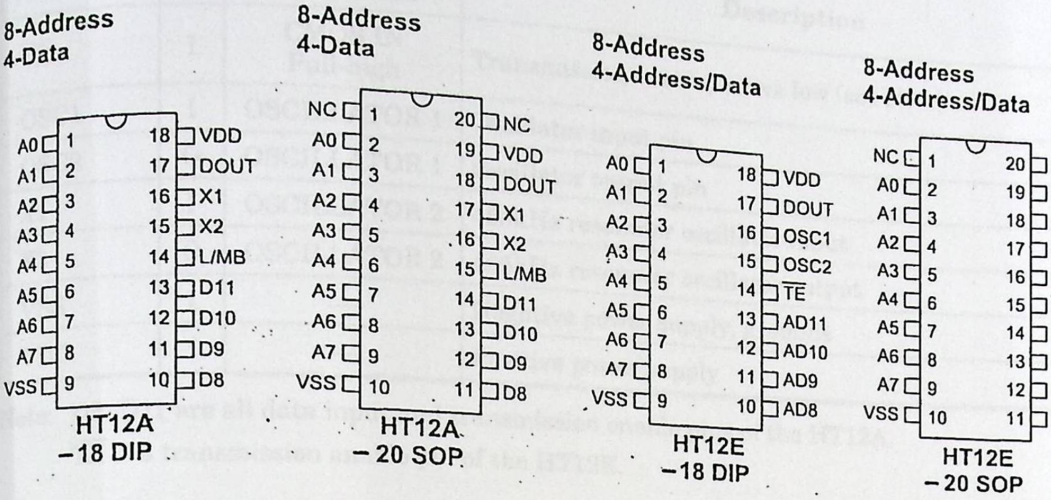
DATA trigger

HT12A



Note: The address data pins are available in various combinations (refer to the address/data table).

Pin Assignment



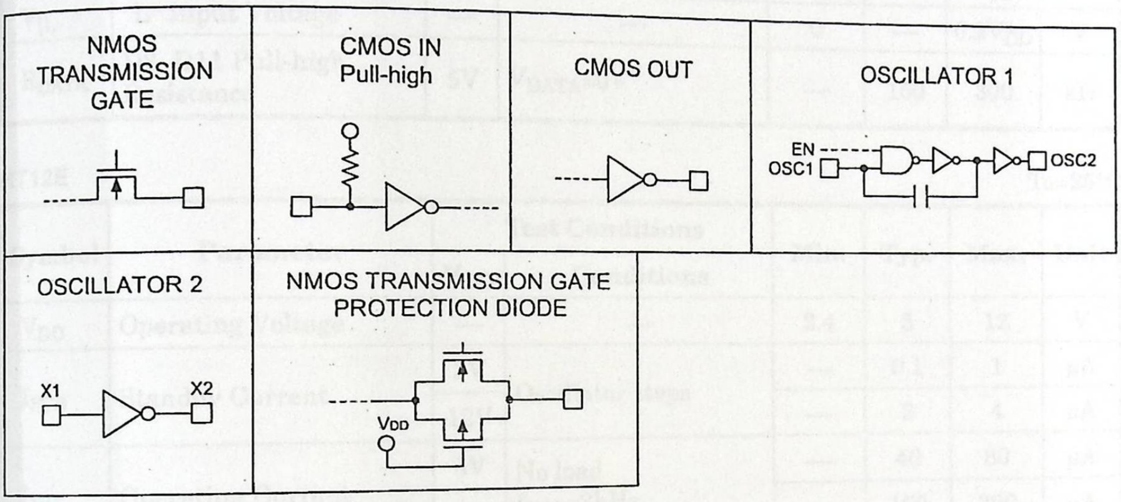
Pin Description

Pin Name	I/O	Internal Connection	Description
A0~A7	I	CMOS IN Pull-high (HT12A) NMOS TRANSMISSION GATE PROTECTION DIODE (HT12E)	Input pins for address A0~A7 setting These pins can be externally set to VSS or left open
AD8~AD11	I	NMOS TRANSMISSION GATE PROTECTION DIODE (HT12E)	Input pins for address/data AD8~AD11 setting These pins can be externally set to VSS or left open
D8~D11	I	CMOS IN Pull-high	Input pins for data D8~D11 setting and transmission enable, active low These pins should be externally set to VSS or left open (see Note)
DOUT	O	CMOS OUT	Encoder data serial transmission output
L/MB	I	CMOS IN Pull-high	Latch/Momentary transmission format selection pin: Latch: Floating or VDD Momentary: VSS

Pin Name	I/O	Internal Connection	Description
$\overline{TE}$	I	CMOS IN Pull-high	Transmission enable, active low (see Note)
OSC1	I	OSCILLATOR 1	Oscillator input pin
OSC2	O	OSCILLATOR 1	Oscillator output pin
X1	I	OSCILLATOR 2	455kHz resonator oscillator input
X2	O	OSCILLATOR 2	455kHz resonator oscillator output
VSS	I	—	Negative power supply, grounds
VDD	I	—	Positive power supply

Note: D8~D11 are all data input and transmission enable pins of the HT12A. $\overline{TE}$ is a transmission enable pin of the HT12E.

Approximate internal connections



Absolute Maximum Ratings

Supply Voltage (HT12A) ....−0.3V to 5.5V

Supply Voltage (HT12E) ....−0.3V to 13V

Input Voltage.....................V_{SS}−0.3 to V_{DD}+0.3V

Storage Temperature................−50°C to 125°C

Operating Temperature..............−20°C to 75°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Electrical Characteristics

HT12A

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	2.4	3	5	V
I_{STB}	Standby Current	3V	Oscillator stops	—	0.1	1	μA
		5V		—	0.1	1	μA
I_{DD}	Operating Current	3V	No load f_{OSC}=455kHz	—	200	400	μA
		5V		—	400	800	μA
I_{DOUT}	Output Drive Current	5V	$V_{OH}=0.9V_{DD}$ (Source)	−1	−1.6	—	mA
			$V_{OL}=0.1V_{DD}$ (Sink)	2	3.2	—	mA
V_{IH}	"H" Input Voltage	—	—	$0.8V_{DD}$	—	V_{DD}	V
V_{IL}	"L" Input Voltage	—	—	0	—	$0.2V_{DD}$	V
R_{DATA}	D8~D11 Pull-high Resistance	5V	V_{DATA}=0V	—	150	300	kΩ

HT12E

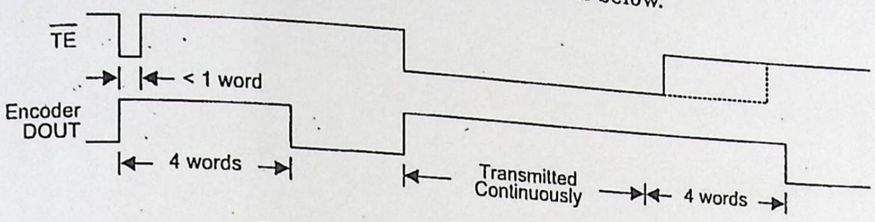
Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	2.4	5	12	V
I_{STB}	Standby Current	3V	Oscillator stops	—	0.1	1	μA
		12V		—	2	4	μA
I_{DD}	Operating Current	3V	No load f_{OSC}=3kHz	—	40	80	μA
		12V		—	150	300	μA
I_{DOUT}	Output Drive Current	5V	$V_{OH}=0.9V_{DD}$ (Source)	−1	−1.6	—	mA
			$V_{OL}=0.1V_{DD}$ (Sink)	1	1.6	—	mA
V_{IH}	"H" Input Voltage	—	—	$0.8V_{DD}$	—	V_{DD}	V
V_{IL}	"L" Input Voltage	—	—	0	—	$0.2V_{DD}$	V
f_{OSC}	Oscillator Frequency	5V	R_{OSC}=1.1MΩ	—	3	—	kHz
$R_{\overline{TE}}$	$\overline{TE}$ Pull-high Resistance	5V	$V_{\overline{TE}}$=0V	—	1.5	3	MΩ

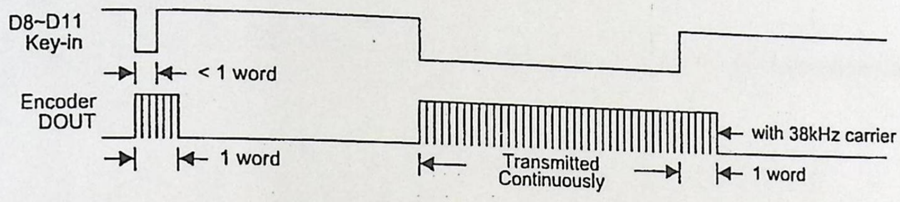
Functional Description

Operation

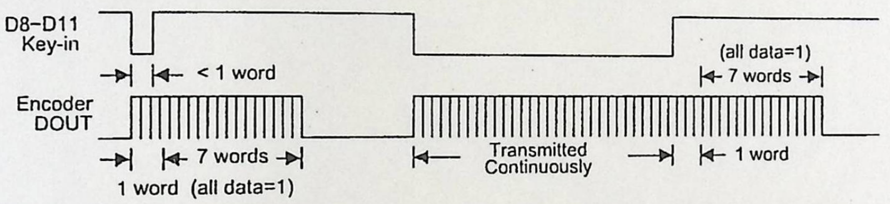
The 2^{12} series of encoders begin a 4-word transmission cycle upon receipt of a transmission enable ($\overline{TE}$ for the HT12E or D8~D11 for the HT12A, active low). This cycle will repeat itself as long as the transmission enable ($\overline{TE}$ or D8~D11) is held low. Once the transmission enable returns high the encoder output completes its final cycle and then stops as shown below.



Transmission timing for the HT12E



Transmission timing for the HT12A (L/MB=Floating or VDD)

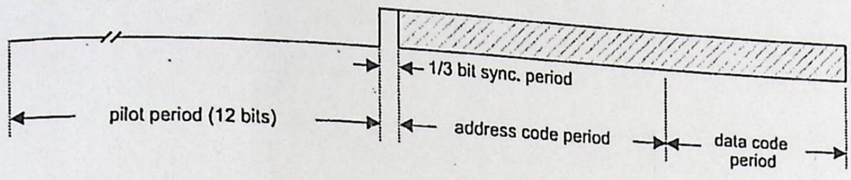


Transmission timing for the HT12A (L/MB=VSS)

Information word

If L/MB=1 the device is in the latch mode (for use with the latch type of data decoders). When the transmission enable is removed during a transmission, the DOUT pin outputs a complete word and then stops. On the other hand, if L/MB=0 the device is in the momentary mode (for use with the momentary type of data decoders). When the transmission enable is removed during a transmission, the DOUT outputs a complete word and then adds 7 words all with the "1" data code.

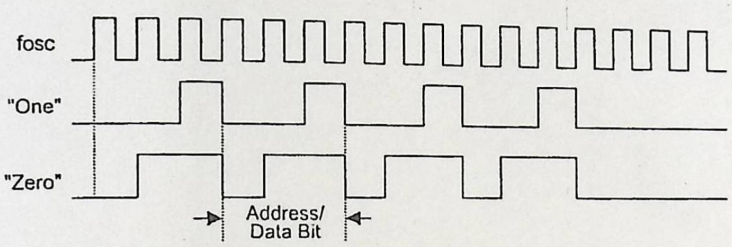
An information word consists of 4 periods as illustrated below.



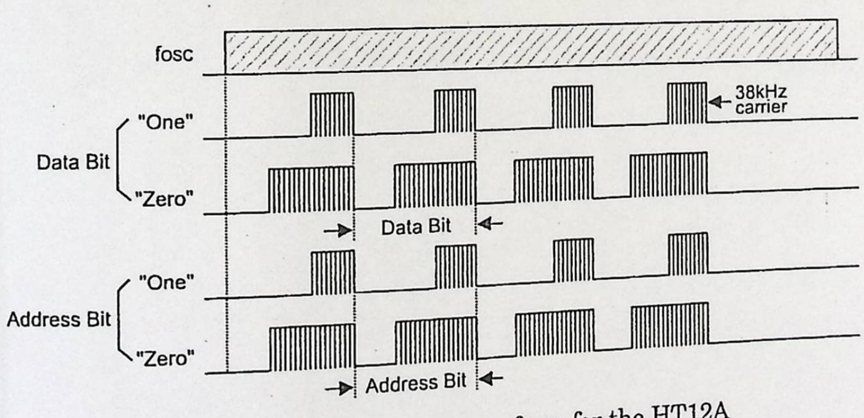
Composition of information

Address/data waveform

Each programmable address/data pin can be externally set to one of the following two logic states as shown below.



Address/Data bit waveform for the HT12E



Address/Data bit waveform for the HT12A

The address/data bits of the HT12A are transmitted with a 38kHz carrier for infrared remote controller flexibility.

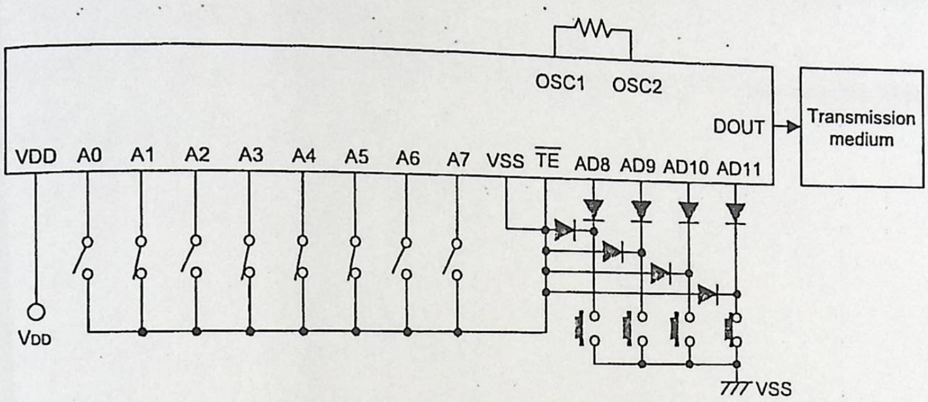
Address/data programming (preset)

The status of each address/data pin can be individually pre-set to logic "high" or "low". If a transmission-enable signal is applied, the encoder scans and transmits the status of the 12 bits of address/data serially in the order A0 to AD11 for the HT12E encoder and A0 to D11 for the HT12A encoder.

During information transmission these bits are transmitted with a preceding synchronization bit. If the trigger signal is not applied, the chip enters the standby mode and consumes a reduced current of less than 1μA for a supply voltage of 5V.

Usual applications preset the address pins with individual security codes using DIP switches or PCB wiring, while the data is selected by push buttons or electronic switches.

The following figure shows an application using the HT12E:



The transmitted information is as shown:

Pilot & Sync.	A0	A1	A2	A3	A4	A5	A6	A7	AD8	AD9	AD10	AD11
	1	0	1	0	0	0	1	1	1	1	1	0

Address/Data sequence

The following provides the address/data sequence table for various models of the 2^{12} series of encoders. The correct device should be selected according to the individual address and data requirements.

Part No.	Address/Data Bits											
	0	1	2	3	4	5	6	7	8	9	10	11
HT12A	A0	A1	A2	A3	A4	A5	A6	A7	D8	D9	D10	D11
HT12E	A0	A1	A2	A3	A4	A5	A6	A7	AD8	AD9	AD10	AD11

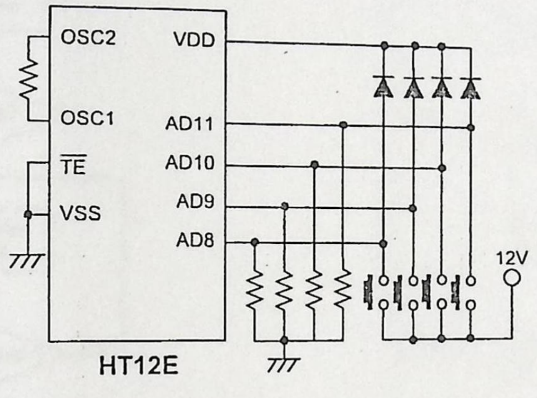
Transmission enable

For the HT12E encoders, transmission is enabled by applying a low signal to the $\overline{TE}$ pin. For the HT12A encoders, transmission is enabled by applying a low signal to one of the data pins D8~D11.

Two erroneous HT12E application circuits

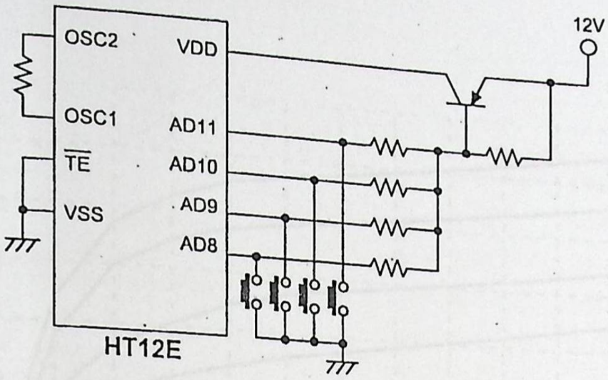
The HT12E must follow closely the application circuits provided by Holtek (see the "Application circuits").

- Error: AD8~AD11 pins input voltage > V_{DD}+0.3V



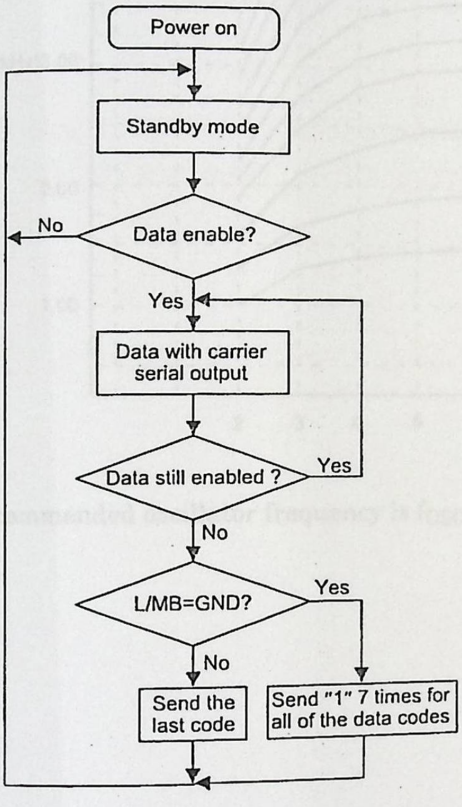
April 11, 2000

• Error: The IC's power source is activated by pins AD8~AD11

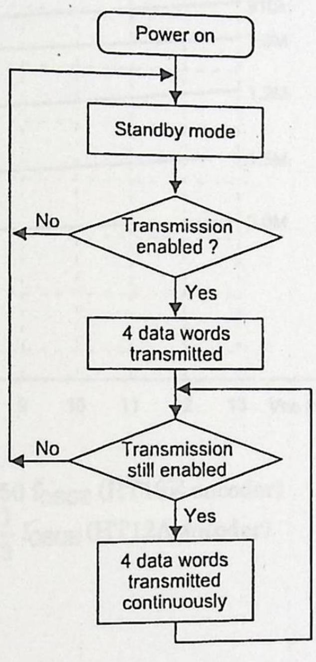


Flowchart

• HT12A

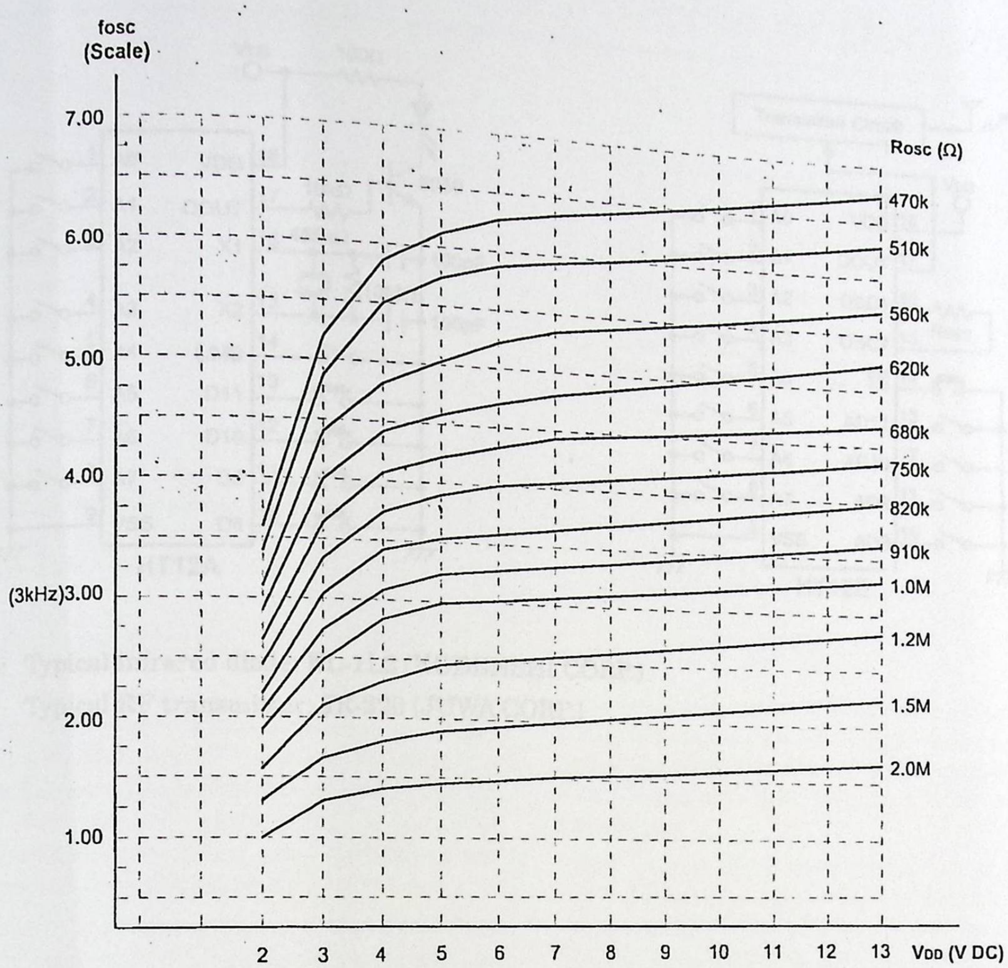


• HT12E



Note: D8~D11 are transmission enables of the HT12A.
$\overline{\text{TE}}$ is the transmission enable of the HT12E.

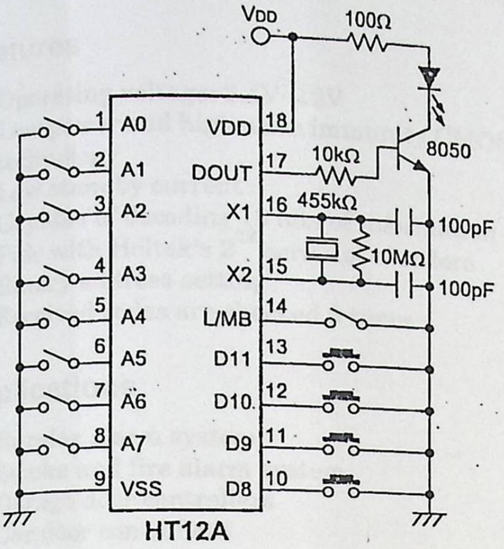
Oscillator frequency vs supply voltage

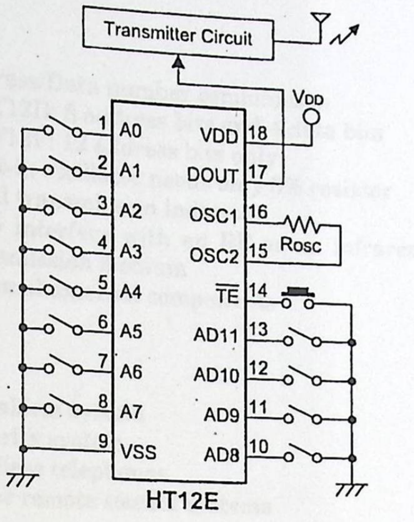


The recommended oscillator frequency is f_{OSCD} (decoder) $\cong 50\ f_{OSCE}$ (HT12E encoder)

$\cong \frac{1}{3}\ f_{OSCE}$ (HT12A encoder)

Application Circuits





Note: Typical infrared diode: EL-1L2 (KODENSHI CORP.)
Typical RF transmitter: JR-220 (JUWA CORP.)

2^{12} Series of Decoders

Features

- Operating voltage: 2.4V~12V
- Low power and high noise immunity CMOS technology
- Low standby current
- Capable of decoding 12 bits of information
- Pair with Holtek's 2^{12} series of encoders
- Binary address setting
- Received codes are checked 3 times
- Address/Data number combination
  - HT12D: 8 address bits and 4 data bits
  - HT12F: 12 address bits only
- Built-in oscillator needs only 5% resistor
- Valid transmission indicator
- Easy interface with an RF or an infrared transmission medium
- Minimal external components

Applications

- Burglar alarm system
- Smoke and fire alarm system
- Garage door controllers
- Car door controllers
- Car alarm system
- Security system
- Cordless telephones
- Other remote control systems

General Description

The 2^{12} decoders are a series of CMOS LSIs for remote control system applications. They are paired with Holtek's 2^{12} series of encoders (refer to the encoder/decoder cross reference table). For proper operation, a pair of encoder/decoder with the same number of addresses and data format should be chosen.

The decoders receive serial addresses and data from a programmed 2^{12} series of encoders that are transmitted by a carrier using an RF or an IR transmission medium. They compare the serial input data three times continuously with their local addresses. If no error or unmatched codes are found, the input data codes are decoded and then transferred to the output pins. The VT pin also goes high to indicate a valid transmission.

The 2^{12} series of decoders are capable of decoding informations that consist of N bits of address and 12–N bits of data. Of this series, the HT12D is arranged to provide 8 address bits and 4 data bits, and HT12F is used to decode 12 bits of address information.

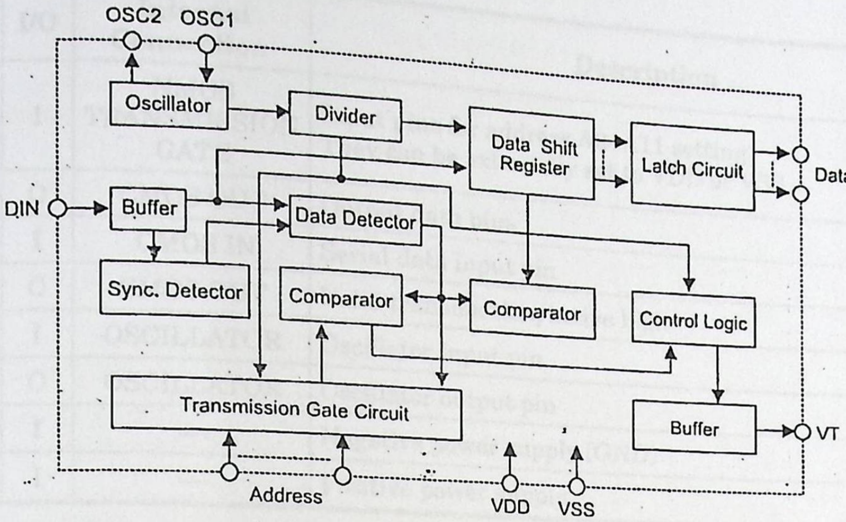
Selection Table

Function / Part No.	Address No.	Data No.	Data Type	VT	Oscillator	Trigger	Package
HT12D	8	4	L	√	RC oscillator	DIN active "Hi"	18 DIP/20 SOP
HT12F	12	0	—	√	RC oscillator	DIN active "Hi"	18 DIP/20 SOP

Notes: Data type: L stands for latch type data output.

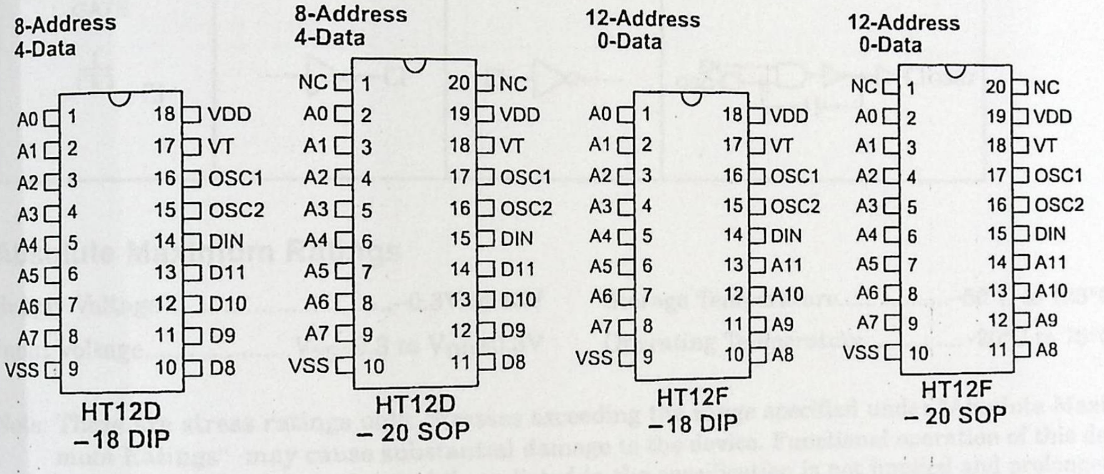
VT can be used as a momentary data output.

Block Diagram



Note: The address/data pins are available in various combinations (see the address/data table).

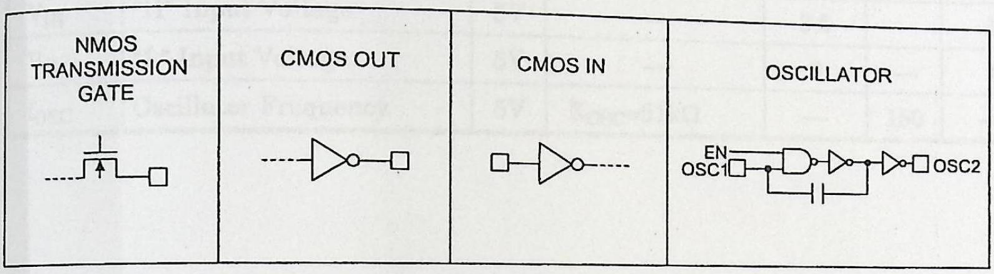
Pin Assignment



Pin Description

Pin Name	I/O	Internal Connection	Description
A0~A11	I	NMOS TRANSMISSION GATE	Input pins for address A0~A11 setting They can be externally set to VDD or VSS.
D8~D11	O	CMOS OUT	Output data pins
DIN	I	CMOS IN	Serial data input pin
VT	O	CMOS OUT	Valid transmission, active high
OSC1	I	OSCILLATOR	Oscillator input pin
OSC2	O	OSCILLATOR	Oscillator output pin
VSS	I	—	Negative power supply (GND)
VDD	I	—	Positive power supply

Approximate internal connection circuits



Absolute Maximum Ratings

Supply Voltage..............................–0.3V to 13V

Input Voltage...................V_{SS}–0.3 to V_{DD}+0.3V

Storage Temperature................–50°C to 125°C

Operating Temperature ....–20°C to 75°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Electrical Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	—	—	2.4	5	12	V
I_{STB}	Standby Current	5V	Oscillator stops	—	0.1	1	μA
		12V		—	2	4	μA
I_{DD}	Operating Current	5V	No load f_{OSC}=150kHz	—	200	400	μA
I_O	Data Output Source Current (D8~D11)	5V	V_{OH}=4.5V	–1	–1.6	—	mA
	Data Output Sink Current (D8~D11)	5V	V_{OL}=0.5V	1	1.6	—	mA
I_{VT}	VT Output Source Current	5V	V_{OH}=4.5V	–1	–1.6	—	mA
	VT Output Sink Current		V_{OL}=0.5V	1	1.6	—	mA
V_{IH}	"H" Input Voltage	5V	—	3.5	—	5	V
V_{IL}	"L" Input Voltage	5V	—	0	—	1	V
f_{OSC}	Oscillator Frequency	5V	R_{OSC}=51kΩ	—	150	—	kHz

Functional Description

Operation

The 2^{12} series of decoders provides various combinations of addresses and data pins in different packages so as to pair with the 2^{12} series of encoders.

The decoders receive data that are transmitted by an encoder and interpret the first N bits of code period as addresses and the last 12–N bits as data, where N is the address code number. A signal on the DIN pin activates the oscillator which in turn decodes the incoming address and data. The decoders will then check the received address three times continuously. If the received address codes all match the contents of the decoder's local address, the 12–N bits of data are decoded to activate the output pins and the VT pin is set high to indicate a valid transmission. This will last unless the address code is incorrect or no signal is received.

The output of the VT pin is high only when the transmission is valid. Otherwise it is always low.

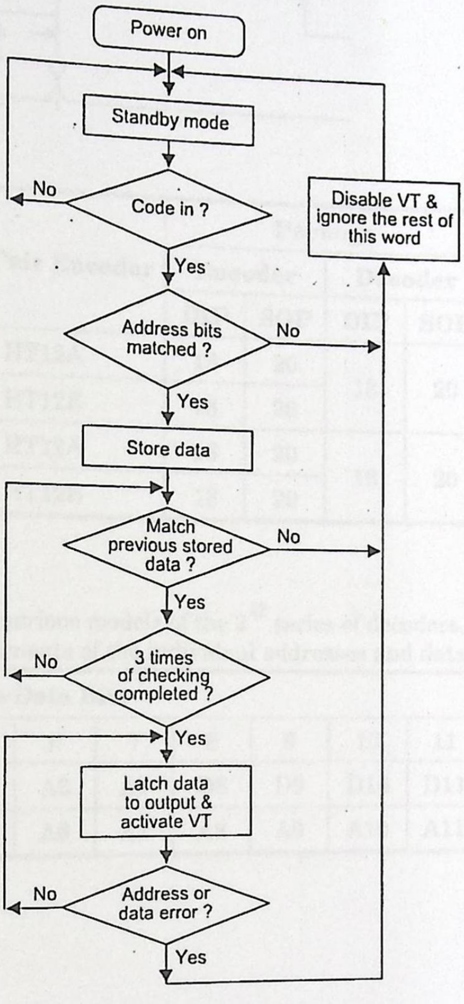
Output type

Of the 2^{12} series of decoders, the HT12F has no data output pin but its VT pin can be used as a momentary data output. The HT12D, on the other hand, provides 4 latch type data pins whose data remain unchanged until new data are received.

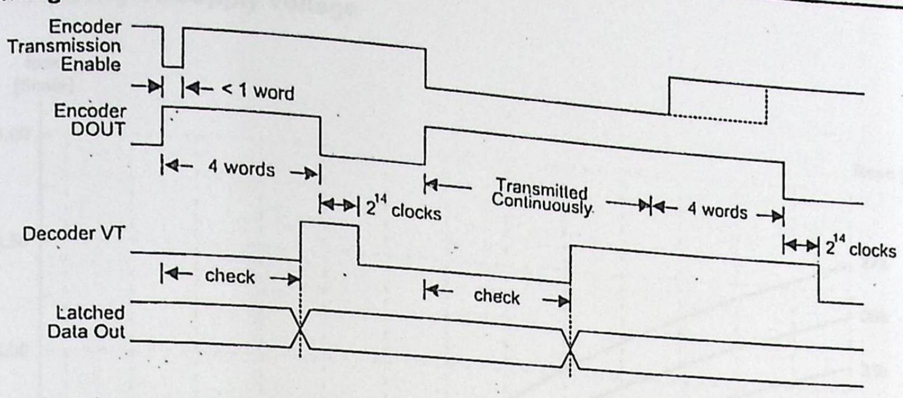
Part No.	Data Pins	Address Pins	Output Type	Operating Voltage
HT12D	4	8	Latch	2.4V~12V
HT12F	0	12	—	2.4V~12V

Flowchart

The oscillator is disabled in the standby state and activated when a logic "high" signal applies to the DIN pin. That is to say, the DIN should be kept low if there is no signal input.



Decoder timing



Encoder/Decoder cross reference table

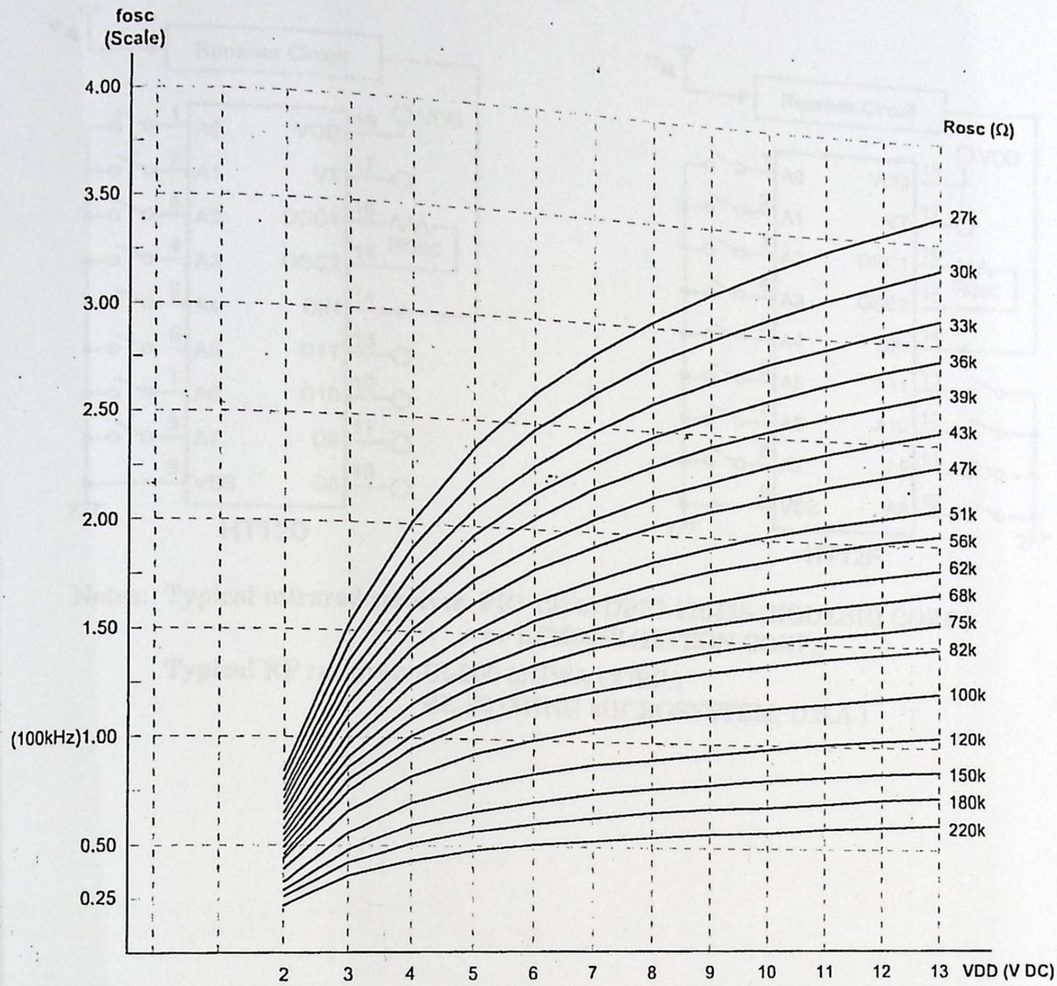
Decoders Part No.	Data Pins	Address Pins	VT	Pair Encoder	Package			
					Encoder		Decoder	
					DIP	SOP	DIP	SOP
HT12D	4	8	√	HT12A	18	20	18	20
				HT12E	18	20		
HT12F	0	12	√	HT12A	18	20	18	20
				HT12E	18	20		

Address/Data sequence

The following table provides address/data sequence for various models of the 2^{12} series of decoders. A correct device should be chosen according to the requirements of the individual addresses and data.

Part No.	Address/Data Bits											
	0	1	2	3	4	5	6	7	8	9	10	11
HT12D	A0	A1	A2	A3	A4	A5	A6	A7	D8	D9	D10	D11
HT12F	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11

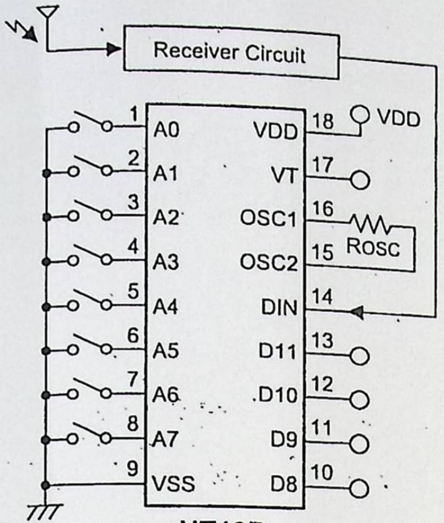
Oscillator frequency vs supply voltage



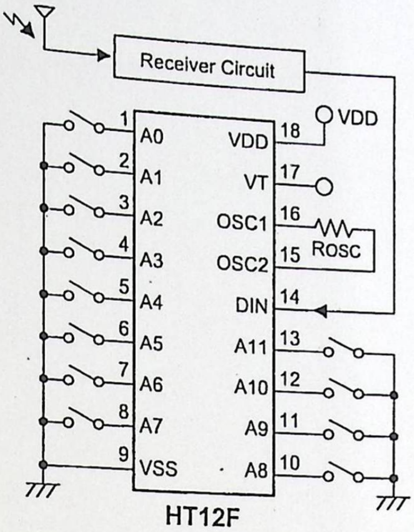
The recommended oscillator frequency is f_{OSCD} (decoder) $\cong 50\ f_{OSCE}$ (HT12E encoder)

$\cong \frac{1}{3} f_{OSCE}$ (HT12A encoder).

Application Circuits



HT12D



HT12F

Notes: Typical infrared receiver: PIC-12043T/PIC-12043S (KODESHI CORP.)
or LTM9052 (LITEON CORP.)

Typical RF receiver: JR-200 (JUWA CORP.)
RE-99 (MING MICROSYSTEM, U.S.A.)

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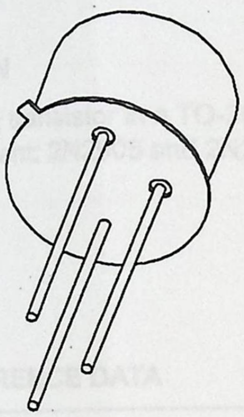
DISCRETE SEMICONDUCTORS

DATA SHEET



2N2219; 2N2219A
NPN switching transistors

1997 Sep 03

Product specification
Supersedes data of 1997 May 07
File under Discrete Semiconductors, SC04

Philips
Semiconductors

PHILIPS

FEATURES

- High current (max. 800 mA)
- Low voltage (max. 40 V).

APPLICATIONS

- High-speed switching
- DC and VHF/UHF amplification, for 2N2219 only.

DESCRIPTION

NPN switching transistor in a TO-39 metal package.
PNP complement: 2N2905 and 2N2905A.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector, connected to case

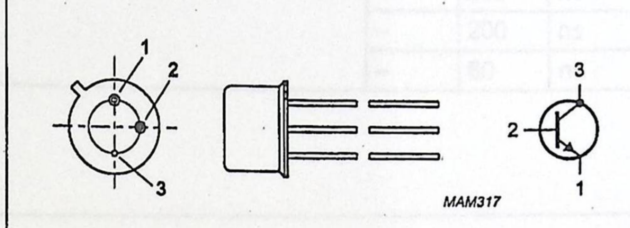


Fig.1 Simplified outline (TO-39) and symbol.

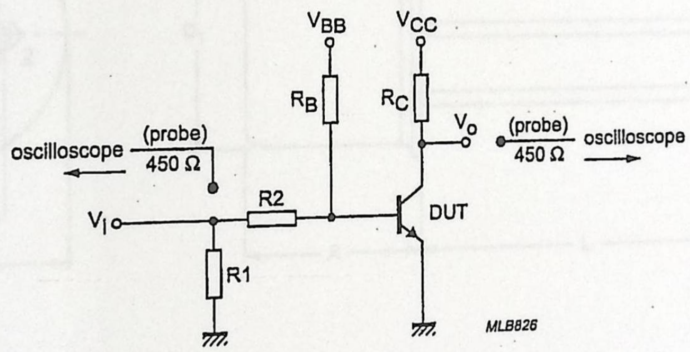
QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	2N2219		–	60	V
	2N2219A		–	75	V
V_{CEO}	collector-emitter voltage	open base			
	2N2219		–	30	V
	2N2219A		–	40	V
I_C	collector current (DC)		–	800	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	–	800	mW
h_{FE}	DC current gain	$I_C = 10$ mA; $V_{CE} = 10$ V	75	–	
f_T	transition frequency	$I_C = 20$ mA; $V_{CE} = 20$ V; f = 100 MHz			
	2N2219		250	–	MHz
	2N2219A		300	–	MHz
t_{off}	turn-off time	$I_{Con} = 150$ mA; $I_{Bon} = 15$ mA; $I_{Boff} = -15$ mA	–	250	ns

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
Switching times (between 10% and 90% levels) for type 2N2219A; see Fig.2					
t_{on}	turn-on time	I_{Con} = 150 mA; I_{Bon} = 15 mA; I_{Boff} = −15 mA	−	35	ns
t_d	delay time		−	15	ns
t_r	rise time		−	20	ns
t_{off}	turn-off time		−	250	ns
t_s	storage time		−	200	ns
t_f	fall time		−	60	ns

Note

1. Pulse test: $t_p \leq 300$ µs; $\delta \leq 0.02$.



V_I = 9.5 V; T = 500 µs; t_p = 10 µs; $t_r = t_f \leq 3$ ns.
R1 = 68 Ω; R2 = 325 Ω; R_B = 325 Ω; R_C = 160 Ω.
V_{BB} = −3.5 V; V_{CC} = 29.5 V.
Oscilloscope: input impedance Z_I = 50 Ω.

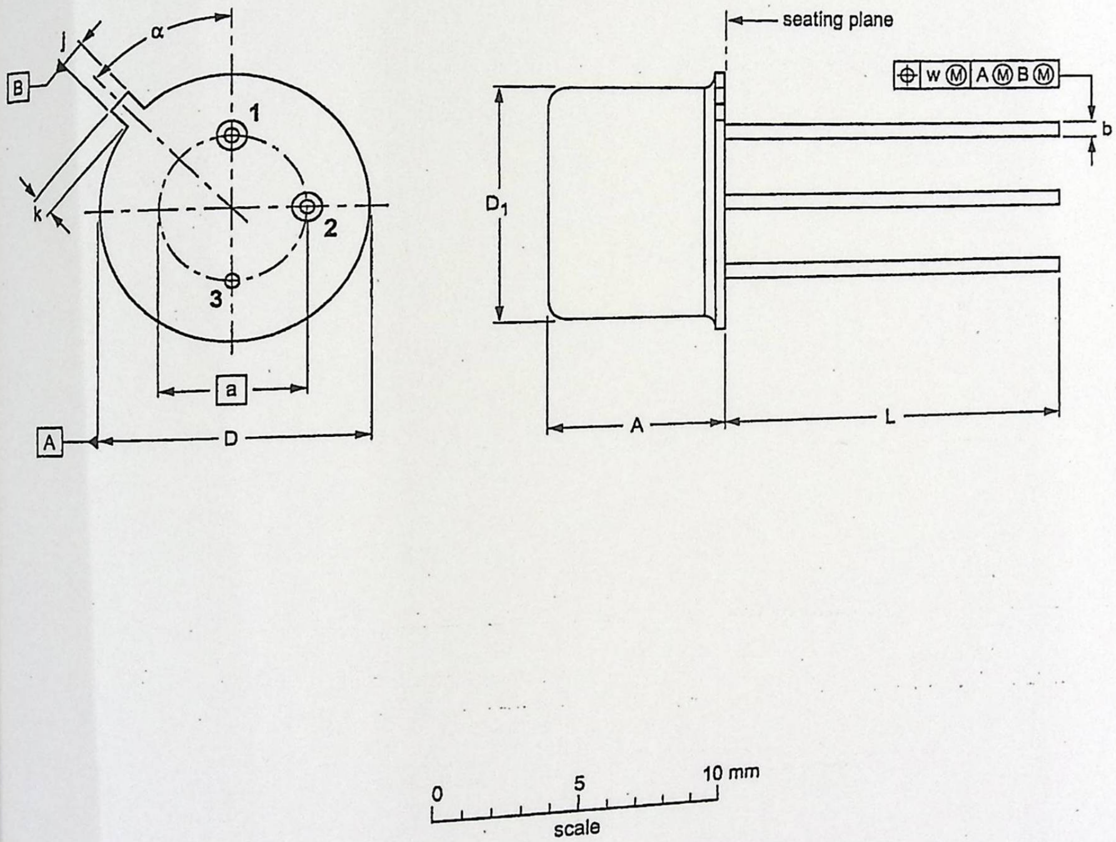
Fig.2 Test circuit for switching times.

NPN switching transistors

2N2219; 2N2219A

PACKAGE OUTLINE

Metal-can cylindrical single-ended package; 3 leads **SOT5/11**



DIMENSIONS (mm are the original dimensions)

UNIT	A	a	b	D	D_1	j	k	L	w	α
mm	6.60 6.35	5.08	0.48 0.41	9.39 9.08	8.33 8.18	0.85 0.75	0.95 0.75	14.2 12.7	0.2	45°

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			97-04-11
SOT5/11		TO-39				