Palestine Polytechnic University

College of Engineering and Technology

Electrical and Computer Engineering Department

Graduation Project

Automated Home System

Project Team

Ahmad Abdelsameh Abu-Sneineh

Shurooq Farid Al-Qawasmi

Wedad Wajeeh Al-Hadad

Project Supervisor
Eng. Hiba Tamimi

Hebron – Palestine
June-07

الخليل – فلسطين
كلية الهندسة والتكنولوجيا
دائرة الهندسة الكهربائية والحاسوب

Automated Home System

أحمد عبد السميع أبو سنينه   شروق فريد القواسمي   وداد وجيه الحداد

بناء على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر على المشروع و موافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية والحاسوب وذلك للوفاء بمتطلبات درجة البكالوريوس في الهندسة تخصص هندسة أنظمة الحاسوب.

توقيع المشرف

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توقيع اللجنة الممتحنة

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توقيع رئيس الدائرة

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Abstract

The Automated Home System project is a stand-alone system that controls some house applications automatically. This system is designed to provide better living environment for disabled people whom form an important partition of the society by making their houses controlled automatically.

The Automated Home System project includes main components to control homes independently such as opening or closing a door, a window, turning on/off a heat system. This system will be implemented using many components which communicate with each other using radio frequency technology.

ملخص المشروع

مشروع نظام المنزل الاتوماتيك هو عبارة عن نظام مستقل بحد ذاته و هو يقوم بالتحكم في بعض مكونات المنزل اتوماتيكيا . لقد صمم هذا النظام لتوفير بيئة معيشية افضل للاشخاص المعاقين جسديا او المرضى والذين يشكلون جزءاً هاماً من المجتمع عن طريق التحكم بمنازلهم اتوماتيكيا.

مشروع نظام المنزل الاتوماتيك يعمل على التحكم بأجهزة المنزل بشكل منفرد مثل التحكم بعمليات فتح وإغلاق الأبواب أو النوافذ ، و عمليات تشغيل وإطفاء نظام التدفئة، كل مكونات النظام(مثل وحدة التحكم و الأجهزة المراد التحكم فيها) تتصل مع بعضها البعض باستخدام الموجات الراديوية.

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Introduction

Chapter One

Introduction

This chapter gives a general overview of the Automated Home System project and the project importance, also this chapter presents some previous projects that worked on similar systems, finally the estimated cost and the time plan for the project are illustrated briefly.

1.1 Overview

Automated home system is a stand-alone system that controls home components remotely and automatically. This system produces control signals depending on predefined parameters; the recognized system parameters are temperature degree in the room, the human motion near the door and the light intensity.

Home automation system has many definitions; for some it means simple remote or automatic control of a few lights, for others, it means security control system. But this project takes the whole room components and automatically controls them.

Many studies and projects were employed in home automation using various technologies in implementation such as systems infrared and Bluetooth. The most important issue in this system refers to the use of the radio frequency wireless technique which transfers the system parameters as signals to the basic system controller, so this system establishes more flexibility and efficiency levels of controlling.

The automated home system will be placed in disabled people room, therefore this system should produce the highest degree of comfort for them, so many home components must be controlled automatically in order to employ the new technology services towards those people needs.

1.2 Project Importance

The automated home system project has many important issues; the most important one is that the system is designed to help disabled people as one of the human obligations, so these people will not suffer from practicing their daily activities again. For example this system will open or close the room door or window automatically .

Besides, this system could be used to save the total power consumption at home. For example, if a person leaves the room the lights will turn off automatically. on the other hand the system may be used by ordinary people as a luxury tool; if these people will not impress themselves to turning on or off any light or the heating system, or they don't like to open or close their doors and windows manually.

1.3 Project Objectives

The project has the following objectives:

1- Encourage the disabled people to feel the value of technology, by letting them uses such system.

2- Simplify human daily activities by controlling some of them automatically (control the heat level in the room, control the opening or closing operation of the door and window).

3-Save the total consumed power in the room.

4- Create a reliable and sensitive system in order to get the right action at the right moment.

5- Establish portable system. (Using PIC microcontroller instead of PC makes the system portable and could be placed in any room).

1.4 Literature Review

There are some researches and projects that worked on this topic, some of these are:

- **A Personal Computer Based General Purpose Control System Using General Remote Control [4]**. This project used remote control that works with infrared light to send control signal to the PC which is connected to the receiver at the serial port, the user can control the PC by remote such as displaying start menu, open and close programs. Also the user can control other applications that connected with PC via the parallel port. The software driver of the project was implemented using VB.net.
- **Smart Home [8]**. This project includes internal communication network which is used for monitoring various house parameters such as light, temperature, and fire detection. It early detects the changes in these parameters, if one of these parameters indicates risk state the internal network contacts with external network through telephone to ask for help.
- **Smart care flats [6]**. This is a project that is used in hospitals. it is divided into two parts, the first one is the control system, the room of patient is controlled by server room in the hospital. If a risk occurs the system triggers an alarm siren sounds, and turns on all corridor lights. The second part includes weight sensor placed under the patient bed leg, if the patient wake up and leave the bed, lights are automatically switched on in the bedroom and the bathroom, and turned off again since the person returns to bed.

1.5 Time Plan

The time plan views the stages in designing and building the system components. This section includes two time schedules; the first one shows what is done in the first semester while the second shows the tasks scheduling for the second semester. Table1-2 shows the first semester tasks; all tasks are referred to the theoretical background and the whole system analysis.

Table 1-1 Time Planning (first semester)

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project determination	■															
Data Collection		■	■	■	■	■	■	■	■	■	■					
Literature Review			■	■	■	■	■	■	■	■						
Design and Analysis							■	■	■	■	■	■	■	■	■	
Documentation			■	■	■	■	■	■	■	■	■	■	■	■	■	

Table1-2 Time Planning (second semester).

Task/Week	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Software Design	■	■	■	■	■	■										
Hardware Implementation	■	■	■	■	■	■	■	■	■	■	■	■				
Software Testing							■	■	■	■	■	■	■			
Hardware Testing				■	■	■	■	■	■	■	■	■	■			
Integrated System Testing											■	■	■	■	■	
Documentation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	

1.6 Cost Estimation and Budget Breakdown

This section lists the overall cost of the project, the cost includes the hardware cost, the software cost, and the human recourses budget.

- **Hardware cost:** includes the cost of the components that was used to implement the project. Table 1-3 shows these costs.

Table 1-3 Hardware cost.

Component	Quantity	Price
PIC 18F4520	2	$40
RF-transmitter	4	$80
RF-receiver	4	$80
Decoders and Encoders	8	$30
Light sensor	1	$1
Temperature sensor	1	$3
Motion sensor	1	$20
Breadboards, wires, wirerraping boards	10	$50
IC houses	25	$30
Resistors, Capacitors, Switches	30,10,2	$10
DC motors	2	$5
PC (personal computer(rent))	1	$500
Function Generator (rent)	2	$180
Digital Multimeter (rent)	2	$30
Oscilloscope (rent)	2	$160
Other services (inter net, printing)		$50
Total		**$ 1269**

• **Software cost:** includes the cost of software used to implement the project. Table 1-4 shows the cost of each component.

Table 1-4 Software cost.

Component	Price
WindowsXp	$90
Mplab IDE	$50
Microsoft office 2003	$70
PIC18 Simulator IDE	$10
Orcad Family Release 9.2	$40
Total	**$260**

• **Human Recourses Budget** includes the budget of human operation. The cost is distributed on three engineers; each engineer costs $250 weekly. So human cost is equivalent to $4000.

1.7 Risk Management

The implementation of any project may face many risks during each stage of the project; determining and analyzing the system requirements, designing, implementing and testing the whole system. This section illustrates what are the problems which occurred during the implementation.

1.7.1 Technology Risk

Technology risks can be classified as hardware and software risks:

- Hardware risks include :

- Malfunction of many chips such as PIC microcontroller and the encoding chip which is used in the interfacing circuit.
- Some chips were unavailable at the beginning of the semester, so there was a late in time waiting for these chips (RF-transmitters and RF-receivers).

- Software risks include:

- The program may follow undesirable algorithm, but this project algorithm was clear and understandable.

1.7.2 Risks Avoidance:

- Taking care when using hardware components and using them according to their specifications.
- Taking care of the team member's health during the project development.
- Including an extra amount of the hardware components, so when any problem occurs the alternative components could be found and replaced easily.

1.8 The Structure of the Report

The documentation for this project is categorized into seven chapters, the report structure views the outline for the discussed subjects in each chapter. The outline of all chapters is summarized briefly as follows:

Chapter One: Introduction

Demonstrates an overview about the system, project importance, a literature review, estimated cost and time planning, risk management and risk avoidance, finally this chapter shows the structure of the project report.

- Chapter Two: Theoretical Background

Focuses on theories and materials that are related to the project. It mentions the laws behind the used hardware or software project components.

- Chapter Three: Design Concepts

Describes the detailed system objectives, design options, a general block diagrams and the system interaction with the surrounding environment.

- Chapter Four: Hardware System Design

Describes the detailed subsystems design, overall system design (schematic diagrams) and the user- system interfacing circuits.

- Chapter Five: Software System Design

Describes the detailed system algorithms, flowcharts, pseudo code for the overall procedures in the project.

- Chapter Six: System Implementation and Testing

Describes the actual project implementation, prototypes. it shows the individual components testing, subsystem testing, software testing and the integrated system testing.

- Chapter Seven: Conclusions and Future work

Describes some suggestions for future enhancements, explains the conclusions and the problems that faced the team.

1.9 Summary

This chapter introduced an overview about the project, and presented the importance of the project, and discussed some previous projects which deal with home automation, then presented the estimated cost, time plane, finally the structure of the project report.

Chapter Two

Theoretical Background

Chapter Two

Theoretical Background

This chapter focuses on the theoretical subject related to the main idea of the project, and information about the components used in the project. Also this chapter talks about the hardware and software related to the project and explains these components operations theoretically.

2.1 Theoretical Background of the Project

This project supposes that putting a stand-alone system in a patient room simplifying the life complications around this person; so this system will be managed by a central controlling unit which is called PIC microcontroller. This control unit accepts the data remotely from the surrounding environment detectors and after processing this data, the control decision is sent remotely to the desired unit in the room (door, window, lighting and heating system).

2.2 The Hardware /Software of the Project

The hardware needed for implementing this project is classified into 4 modules:-

1- Microcontroller unit module.
2- Door control module.
3- Window control module.
4- Heater control module.

2.2.1 Microcontroller Unit Module

In this module the microcontroller is connected to the interfacing circuits which are used to synchronize the transmitting/receiving operations. The PIC microcontroller uses one of its 5-ports to receive data, process it and send the control signals through an other port to be transmitted to one of the other modules.

2.2.2 Door Control Module

In this module there is a transmitter with an encoding circuit are connected to the motion sensor; which will detect if there is any person near the door. This part sends the detection signals to the microcontroller. On other hand there is a receiver with a decoding circuit which are connected to a DC motor on the door; when the receiver get the control signal from the microcontroller it should turn on the motor and specify its direction in order to open/close the door.

2.2.3 Window Control Module

As the previous module, using the light sensor to detect the light intensity in the room and send this value to the microcontroller through the transmitter. Besides, the receiver passes the control signal to the DC motor to perform the opening/closing operation of the window. Beside, this module is related with the lighting system in the room; so if the window is opened the lighting system should be turned OFF, if the window is closed the lighting system should be turned ON.

2.2.4 Heater Control Module

In this module there is a temperature sensor that connected directly to the A/D pin of the microcontroller, so the temperature degree is entered to the microcontroller. On the other hand the heater power switch is connected to the receiver circuit, when the control signal comes from the microcontroller the power switch of the heater is turned ON/OFF depending on the received signal.

2.3 Theoretical Background of Project Components

This section includes the theoretical background of each independent component in the project (hardware components).

2.3.1 The Microcontroller

A microcontroller is a cheap single-chip microcomputer. A Single-chip microcomputer indicates that the complete microcomputer system lies within 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) .

- **PIC 18F4520 microcontroller**

The PIC18F4520 is a very powerful 8-bit enhanced flash microcontroller based on RISC (Reduced Instruction Set Computer) 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 following are the main features of 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 (about18$).

This microcontroller is chosen for its features to guarantee the project specifications. Also because of its internal architecture up to 10 MIPS performance, 10-bit ADC, 13 channels, and 5 ports A, B, C, D, and E.

2.3.2 Wireless Technologies

As an implementation requirements for Automated Home System, the system should use a wireless technique in order to transfer data from outer world to the controlling unit of the project, this project uses the Home-RF technology to send and receive data.

1- The RF-Transmitter :

In order to make the information signal pass through the air, it must be modulated on to a carrier signal which is sufficiently stable with temperature and other factors to allow detection by a tuned receiver in the presence of interference. Figure 2-1 shows the general block diagram of the RF-transmitter module.

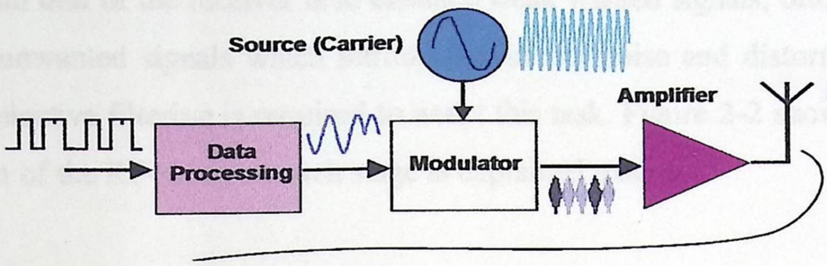

Figure 2-1 Block diagram of the RF-transmitter.[21]

- Modulation

The method of imposing the information signal onto the carrier signal is termed modulation which can be of different classifications; this project uses the AM modulation of the transferred signals.

Amplitude modulation (AM) is a method of impressing data onto an alternating-current (AC) carrier waveform. The highest frequency of the modulating data is normally less than 10 percent of the carrier frequency. The AM modulation must be accomplished cost effectively and accurately for maximum range and minimum interference.

- Amplification

The amplifier is a key part of the transceiver, and must be efficient which means low cost and possibly linear.

2- The RF-Receiver

The antenna catches the transmitted signal and passes it to the receiver module. The main task of the receiver is to enhance weak wanted signals, often in the presence of strong unwanted signals which introduce minimal noise and distortion. In many cases, some selective filtering is required to assist this task. Figure 2-2 shows the general block diagram of the RF-receiver, each stage is explained exactly.

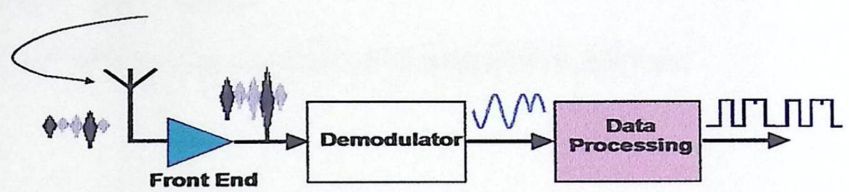

Figure 2-2 Block diagram of the RF-receiver.[21]

- Demodulation

The process of removing the information signal from the carrier is termed demodulation. Demodulation should be done to have optimal signal in the presence of noise, interference, in addition of being power efficient and cheap.

- Data Processing

Pre and post processing of the information signal is often implying some form of microprocess with the supposed complexity, cost, and power consumption. The benefits of matched filtering, error detection and correction (coding) are however significant in terms of range, power conservation and data rate optimisation.

3- RF Advantages:

- Not line of sight (no need to put the transmitter straight ahead in front of the receiver).
- Can not be blocked by common materials: can penetrate most solids and pass through walls.
- It has longer range.
- It is not light sensitive.
- It is not sensitive to weather/environmental conditions.

4- RF Disadvantages:

- Interference: communication devices using similar frequencies - wireless phones, scanners, wrist radios and personal locators can interfere with transmission.
- Lack of security: easier to spy on transmissions since signals are spread out in space rather than confined to a wire.
- RF has higher cost than infrared.
- Federal Communications Commission (FCC) licenses required for some products.
- Lower speed: data rate transmission is lower than wired and infrared transmission.

2.3.3 Sensors

Sensor can be defined as a device which takes information about a physical stimulus (such as temperature, light intensity, pressure) and turns it into a signal which can be measured.

Sensors Types:

Sensors can be classified in more than one aspect such as physical principles; sensor types in terms of physical principles can be classified into resistive sensors or capacitive sensors:

a) Resistive sensors:

The resistance of the sensors varies according to variations of measured input. Such sensors include potentiometer, resistance thermometer and photo conductive cells. They are used as elements in measurement system for measuring the temperature, the light intensity, the displacement.

b) Capacitive sensors:

At this type of sensors the capacity of the sensors varies according to variations of measured input. This sensor which is a capacitor has two parallel plates, so the capacity depends on the area of the plates, the separation between them, and the relative permittivity. This type is applied in displacement sensors, and liquid level sensors.

The main sensors used in this project are:

1- Temperature Sensor.

2- Light Sensor.

3- Motion Sensor.

1- Temperature Sensor:

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C) .the LM35 sensor has an output voltage that is proportional to the Celsius temperature, the scale factor is .01V/°C and it does not require any external calibration and maintains an accuracy of +/-0.4 °C at room temperature and +/- 0.8 °C over a range of 0 °C to +100 °C.

Another important characteristic of the LM35 is that it draws only 60 micro amperes from its supply and possesses a low self-heating capability

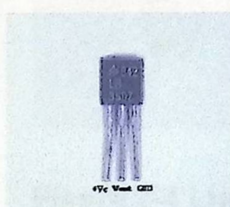

Figure 2-3 LM35 temperature sensor [16].

Sensor Features:

- The sensor has a sensitivity of 10mV / °C.
- Use a conversion factor that is the common, that is 100 °C/V.
- The general equation used to convert output voltage to temperature is:

Temperature (° C) = Vout * (100 °C/V) .So if Vout is 1V , then,

Temperature = 100 °C, the output voltage varies linearly with temperature.

2- Light Sensor:

The optical sensor cell consists of a thin line of CdS (cadmium sulfide) that goes between two terminals. As light hits the Cadmium Sulfide electrons are dislodged within the material and become free to carry current, thereby lowering the material's resistance. The CdS cell is put into a circuit in series with a 5 volt source and a resistor as shown. The circuit may look a little funny because there is not a complete loop, but this is OK. The drawing uses a convention that has a 5 volt source implicitly in the circuit between the nod labeled "+5V" and the node labeled "Ground". The current (I) through the circuit is voltage (V=5 volts) divided by the total resistance, $R_{total}=R_{resistor}+R_{CdS}$.

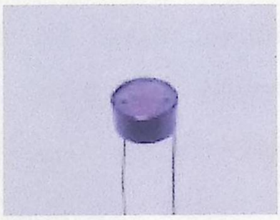

Figure 2-4 Light sensor [17].

So as light hits the CdS cell, its resistance decreases, as does the voltage across the cell. By monitoring this voltage we can measure the light hitting the sensor.

3-Motion Sensor

The motion sensing feature on most security systems is a passive system that detects infrared energy. These sensors are therefore known as PIR (passive infrared) detectors or pyroelectric sensors. In order to make a sensor that can detect a human being, the sensor should be sensitive to the temperature of a human body. Humans, having a skin temperature of about 20 degrees Celsius, radiate infrared energy with a wavelength between 9 and 10 micrometers. Therefore, the sensors are typically sensitive in the range of 8 to 12 micrometers.

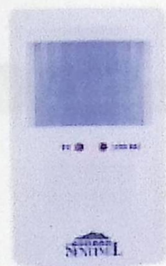

Figure 2-5 Motion sensor[18].

The sensors themselves are simple electronic components not unlike a photo sensor. The motion sensor is sensitive to motion, but not to a person who is standing still. That's because the sensor is designed to detect a fairly rapid change in the amount of infrared energy in front of it. When a person walks by, the amount of infrared energy in the field of view changes rapidly and is easily detected.

2.4 Summary

this chapter the theoretical background of the project main idea was demonstrated, then this chapter described the hardware and software related to the project. The chapter talked about the PIC microcontroller, after that it presented the used wireless technology radio frequency (RF). Finally it talked about the sensors and its types.

Chapter Three

Design Concepts

3.1 PROJECT OBJECTIVES

3.2 PROJECT REQUIREMENTS

3.3 GENERAL BLOCK DIAGRAM OF THE PROJECT

3.4 DESIGN OPTION

3.5 SYSTEM MODELING

3.6 SUMMARY

Chapter Three

Design Concepts

This chapter describes the main objectives and requirements of the Automated Home System project. It presents the general block diagram and main components of the system, such as microcontrolling unit, sensors, transmitter and receivers. It explains how the system works. Finally this chapter shows the system modeling which includes data flow model and state machine model.

3.1 Project Objectives

The automated home system project was chosen to satisfy many goals, this system has the following basic objectives:

1- Encourage the disabled people to feel the value of technology:

As the technology goes ahead those people have the right to get some benefits of he new technology products, this project will enhance the living level of disabled people by letting them uses such system, so when the handicap person wants to leave his room the action of opening the door automatically to him and turning OFF the lights will give him a feel of self comfort i.e. he do not need to call any body to ask him open the door or turn off the lights, he will get rid of the deficiency feel.

2- Simplify human daily activities by controlling some of them automatically.

Controls the heat level in the room, controls the opening or closing operation of the door and window. Nowadays, every thing in life changes for the better using the available techniques, also this is the speed time of life; opening /closing doors, windows automatically guarantees the present life style.

3- Save the total power consumed in the room.

Saving power is an important economical issue, so turning OFF the lighting system in the room in the morning and if there is any one in the room helps people in saving their home consumed power and their money.

4- Create a reliable and sensitive system.

In order to get the right action at the right moment the system must be reliable and sensitive. Generating a real time, fast response system is very important feature introduced with any product.

5- Establish safe and portable system.

Safety is a very essential issue in any home system. Also portability is very important key feature for any system.

3.2 Project Requirements

In order to achieve system goals many requirements for the system are required, these requirements can be classified into:

1- Functional Requirements: these requirements have a direct relation with the system services, how the system should react in particular input. These requirements are:

- Sensing the light intensity.
- Sensing temperature level.
- Checking if a person is walking near the door.
- Sending this data to the microcontrolling unit (MCU).
- Using wireless technology for sending this data.
- The MCU receives the data and analyzes it, then takes the appropriate command.
- The MCU sends this command to a predefined actuator.
- The actuator should receive this control signal and do the required action.

2- Non-Functional Requirements: these requirements are constraints on the services or functions offered by the system. These requirements are:

- Flexibility: the system parameters can be configured by users.
- Fast response.
- Low power consumption.

3.3 General Block Diagram of the Project

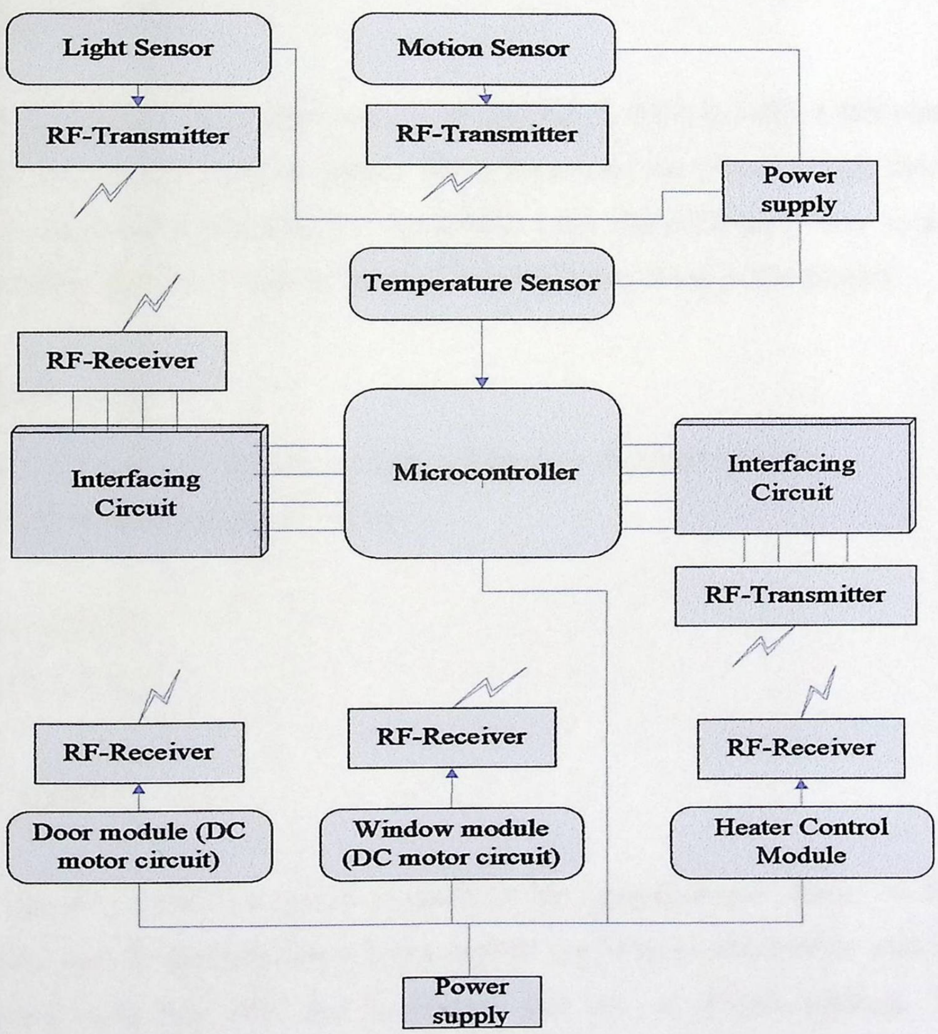

Figure 3-1 General Block Diagram of the System.

As shown in Figure 3-1 the general block diagram of the system, the sensors are put in the room independently to measure different parameters (temperature degree, light intensity and motion detection). These measured values are sent to the microcontroller through the RF-transmitter/receiver. The microcontroller receives theses data and analyzes it and takes the right decision as control commands. Also the output control commands transfers via the RF-transmitter/receiver to reach the wanted actuator.

3.4 Design Options:

There are many issues that must be considered in order to build a functional, successful and reliable portable system. These issues involve proper design, choice of major components, methods for modulation and demodulation. This section illustrates many alternative options for choosing each component in this project.

3.4.1 Microcontroller:

Microcontroller controls different needed functions for the entire project.
There are two available suitable options:

1. PIC 16F877
2. PIC 18F4520

▪**PIC 16F877:**

The PIC 16f877 is a very powerful 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, this 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 microcontroller features, and the option of choosing PIC18F4520 refers to:

- High computational performance.
- Economical price.
- Enhanced Flash program memory.
- Its programmer availability in the university.
- Availability of Mplab program used in programming it.
- Mplab already provides built functions that make programming easier.

3.4.2 Transmitter:

The transmitter is used to transmit the desired data and specific control commands. There are two available suitable options:

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

- **RTQ4-XXX transmitter:**

It is a 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 this transmitter is not available in Palestine.

- **RT4-XXX transmitter:**

Fortunately RTQ4-XXX is a pin out compatible with RT4 Transmitter that is available at a suitable price. This transmitter has the following key features:

- Available as 315, 418, 433 MHz frequency.
- Range up to 70 meters.
- Available in DIL (Dual In Line) package shape or SIL (Serial In Line) package shape.
- Wide Operating Voltage (5-12 volts).

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

3.5 System Modeling

The models of the system are viewed to explain the functionality of the system components, this modeling simplify the understood of the structure of the system.

3.5.1 Data Flow Model

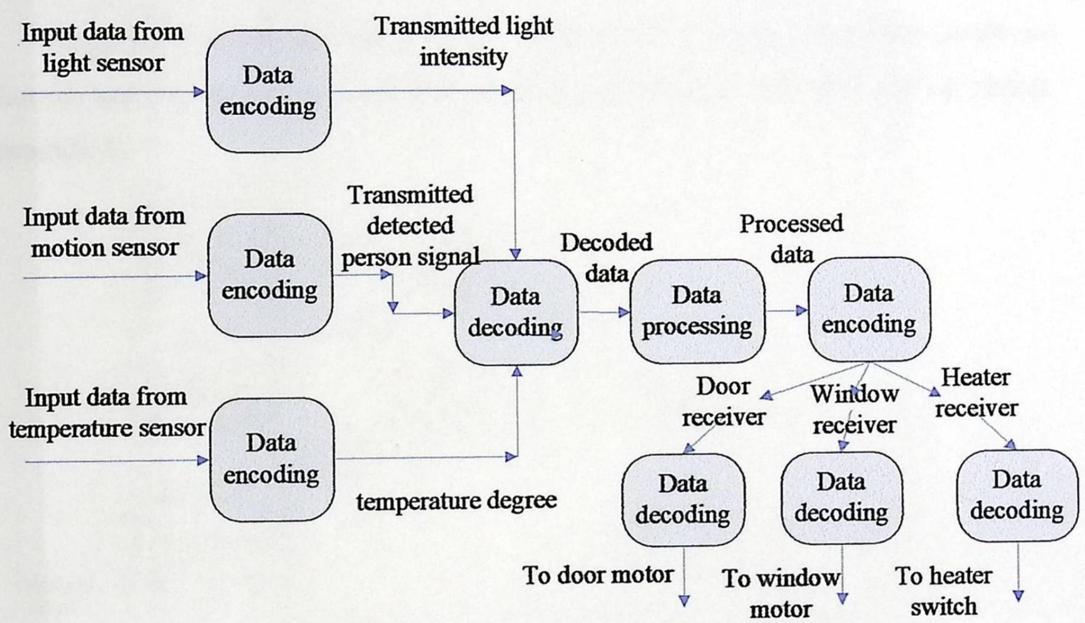

Figure 3-2 Data flow model.

Figure 3-2 shows the data flow model of the system. it shows how the sequence of data start with enter the data from sensors that gather data about the surrounded environment, these data is encoded through the interfacing circuit in order to transmit it to the microcontroller, the sent data is carried out using RF-wireless technique, when the microcontroller gets this decoded data from the receiver converts it from analog to digital data in order to determine the address of the source transmitter.

After that the microcontrolling unit analyzes this data, and takes the appropriate decision, this decision is transmitted via the RF-transmitter attached to the microcontrolling unit. Finally the transmitter sends the data to the address generated from the microcontroller to the receiver that is attached to the actuator in order to do the desired action, such as opening the door, opening the window, turn on the heater.

3.5.2 State Machine Model

Figure 3-3 shows the state machine diagram of the system, this diagram shows that the system moves from one state to other depending on the input and the output commands.

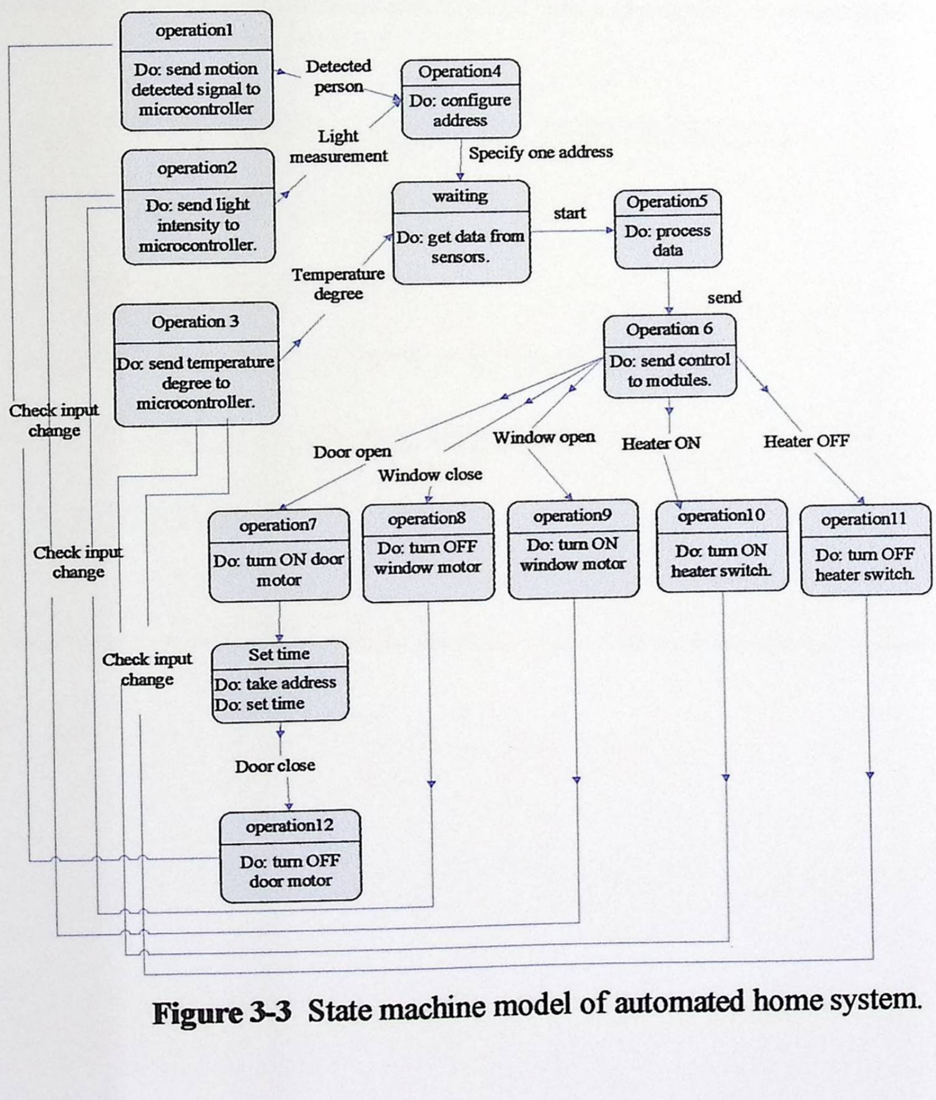

Figure 3-3 State machine model of automated home system.

3.6 Summary

This chapter contained the main objectives and requirements in the project, and showed the general block diagram of the project, and it presented the available design options. Finally it explained the functionality of the system by viewing system models.

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Chapter Four

Hardware System Design

Chapter Four

Hardware System Design

This chapter shows the detailed structure of the system circuits. It describes each system part circuit independently, PIC18f4520 microcontroller, RT4-433.9 RF-Transmitter , RR3-433.9 RF-Receiver, LM35 Temperature sensor, LDR light sensor, Motion sensor, DC Motors, Power supply.

4.1 The Microcontroller (PIC18F4520)

PIC 18F4520 is the main part of the system; it should receive the value of environment parameters and send the right decision to the right actuator. Figure 4-1 shows the microcontroller with oscillating circuit and power on reset (POR) circuit. The option of choosing this microcontroller (PIC) because its features:

- High computational performance.
- Its hardware and software programmer available.

- **PIC Internal Architecture**

PIC 18F4520 microcontroller internal architecture includes many effective features, some of these are: Performance of its CPU is 10-MIPS (Millions Instruction per Second), the microcontroller has 13 10-bit channels of analog to digital converter, and it has five input output ports and four hardware timers.

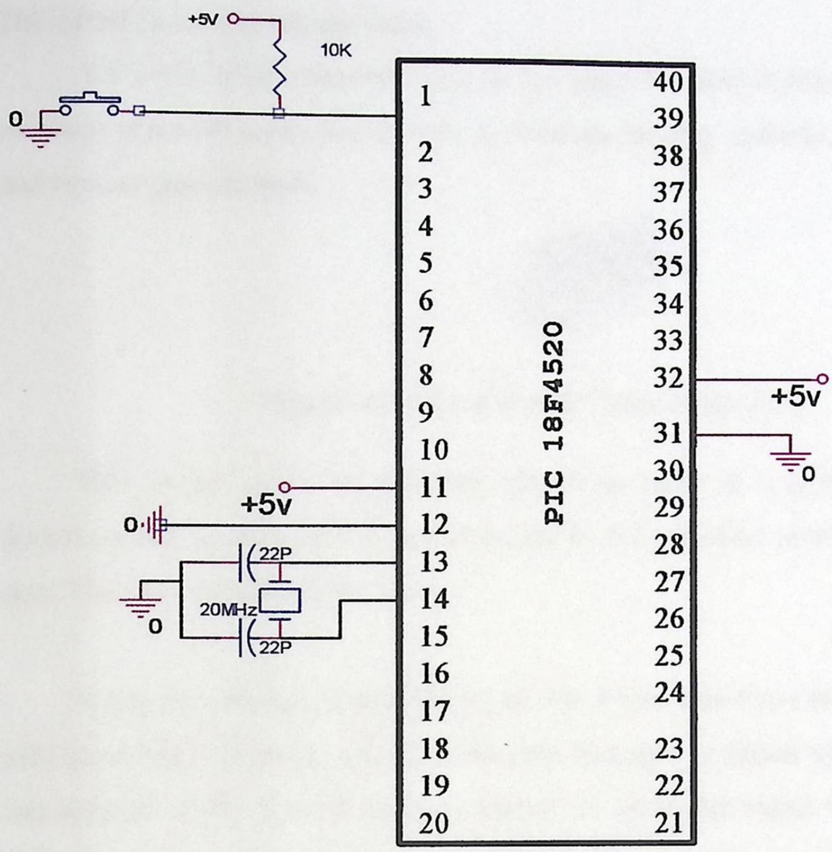


Figure 4-1 PIC 18F4520 microcontroller with oscillator and POR.

4.2 Wireless Communication:

This section talks about the data transfer between the surrounded environment and the PIC microcontroller unit, this data guides the microcontroller to do the right decision at the right moment.
The system uses RF technology for sending and receiving the data.

4.2.1 RF-Transmitter:

In this project the used transmitter is RT4-433.9 which is a hybrid circuit that realizes a complete radio transmitter; it has many features such as high reliability and

DIL (Dual In Line) package shape.

RT4-433.9 RF-transmitter shown in Figure 4-2 used in this project and is used in many practical applications such as wireless security systems, car alarm systems and remote gate controls.

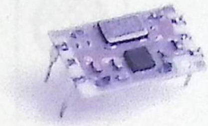


Figure 4-2 RT4-433.9 RF-Transmitter.[19]

This circuit needs an encoding circuit to work in a right way without any distortion and to transmit the required data to the specified receiver in the receiving side. The used encoder is HT12-E.

While the encoder is enabled it gets the 4-bits data from the data sources (PIC microcontroller or sensor circuit), it encodes this data as digital signal and adds the 8-bits address of the desired receiver, then it forwards this signal to the transmitter to be transmitted wirelessly. Figure 4-3 shows the schematic circuit of the transmitter with the encoding circuit.

Although every transmitter has a distinct address, but one transmitter must be enabled at a time, so software and hardware components used to control the transmitter enable. The hardware used to generate a free running frequenter is 555 chip (pronounced triple five) with other components. The output frequency is calculated as the following equation:

Freq out = ***1.44 / t =1.44 / ((Ra + 2Rb) * C)***

We need Freq out = 1Hz

Suppose Rb = 10Kohm, $C = 22 * 10^{-6}$

Ra = (1.44 / C) – 2Rb

$$Ra = 1.44 / 22 * 10^{-6} - 20 * 10^{3}$$
$$= 47K\ ohm$$

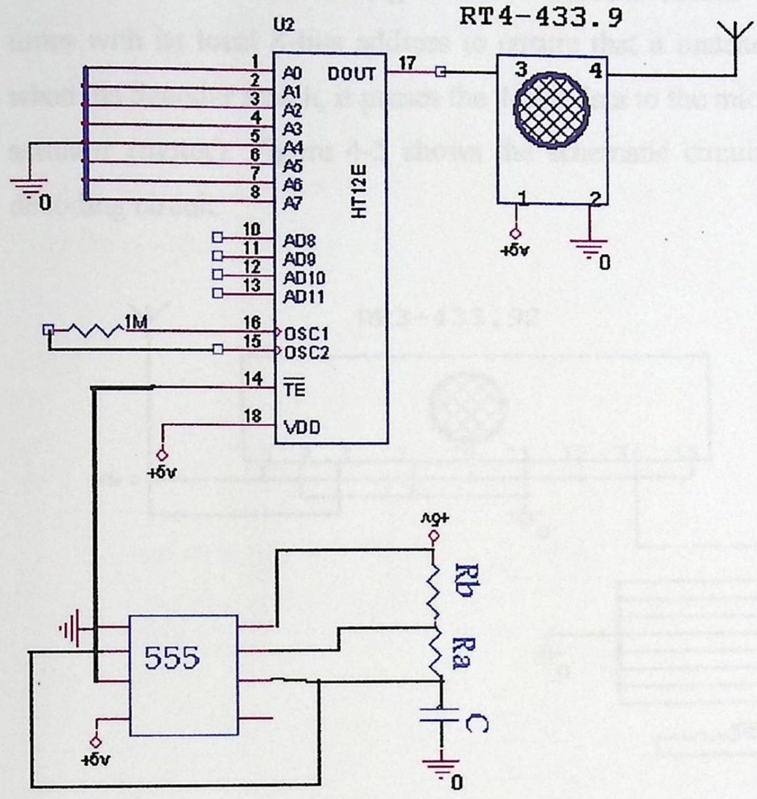


Figure 4-3 RT4-433.9 RF-Transmitter with HT-12E encoder.

4.2.2 RF-Receiver:

The RR3-433.9 is a super regenerative data receiver. Its sensitivity typically exceeds 100dB/m (decibel/meter), and the frequency accuracy is very high. RR3-433.9 RF-Receiver shown in Figure 4-4 is the used receiver in the project.

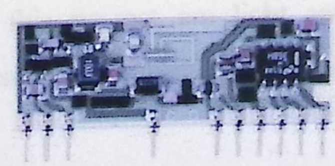


Figure 4-4 RR3-433.9 RF-Receiver. [20]

…r should be connected with HT-12D decoding … this decoder checks the serial input data three … to ensure that it matches the transmitter address, … es the 4-bits data to the microcontroller or the desired … shows the schematic circuit of the receiver with the

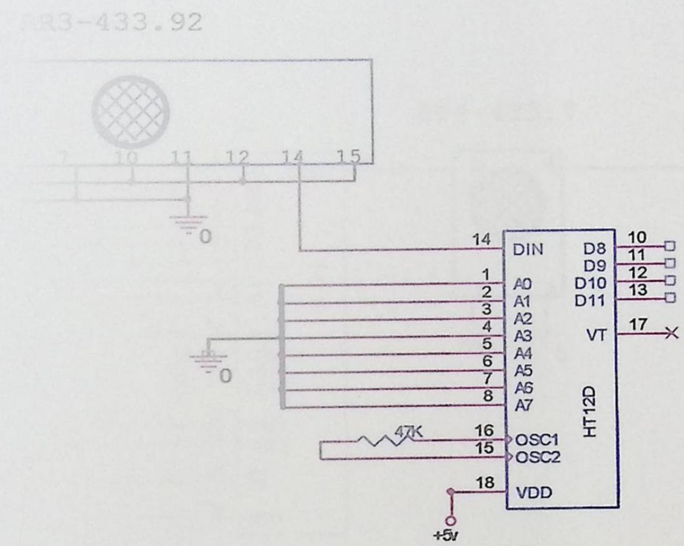


Figure 4-5 RR3-433.9 RF-Receiver with HT-12D decoder.

Sensing Circuits:

Sensing circuits are designed to realize the environment parameters; these parameters are measured in order to guide the microcontroller to response in a right manner. Sensors used in this project are light sensor, temperature sensor, and temperature sensor. Each sensor has a distinct circuit used to get the desired and functional output.

At the receiving side, the receiver should be connected with HT-12D decoding circuit to realize the incoming data, this decoder checks the serial input data three times with its local 8-bits address to ensure that it matches the transmitter address, when the decoder match, it passes the 4-bits data to the microcontroller or the desired actuator (motor). Figure 4-5 shows the schematic circuit of the receiver with the decoding circuit.

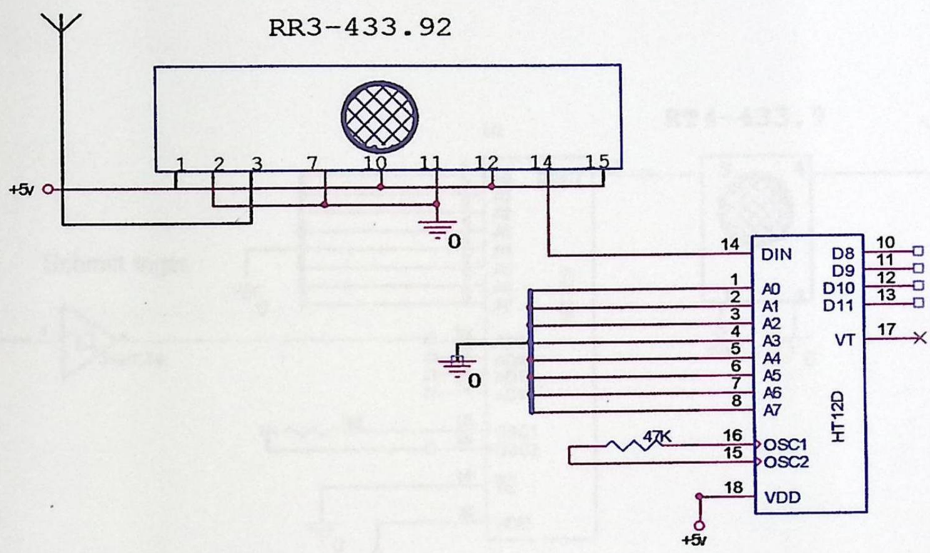


Figure 4-5 RR3-433.9 RF-Receiver with HT-12D decoder.

4.3 Sensing Circuits:

Sensing circuits are designed to realize the environment parameters; these parameters are measured in order to guide the microcontroller to response in a right manner. Sensors used in this project are light sensor, temperature sensor, and temperature sensor. Each sensor has a distinct circuit used to get the desired and functional output.

4.3.1 Light Sensing Circuit:

Figure 4-6 shows the schematic circuit of light sensing with RF-Transmitter and HT-12E encoder, the LDR (light detecting resistor) light sensor is manufactured to work on 5 volts power supply. In order to have a specific value of the output the 74HC14 Schmitt trigger logical gate was used , the sensing principle is to output 5 volts at night (i.e. when the light intensity is very low), 0 volt at day (i.e the light intensity is high).

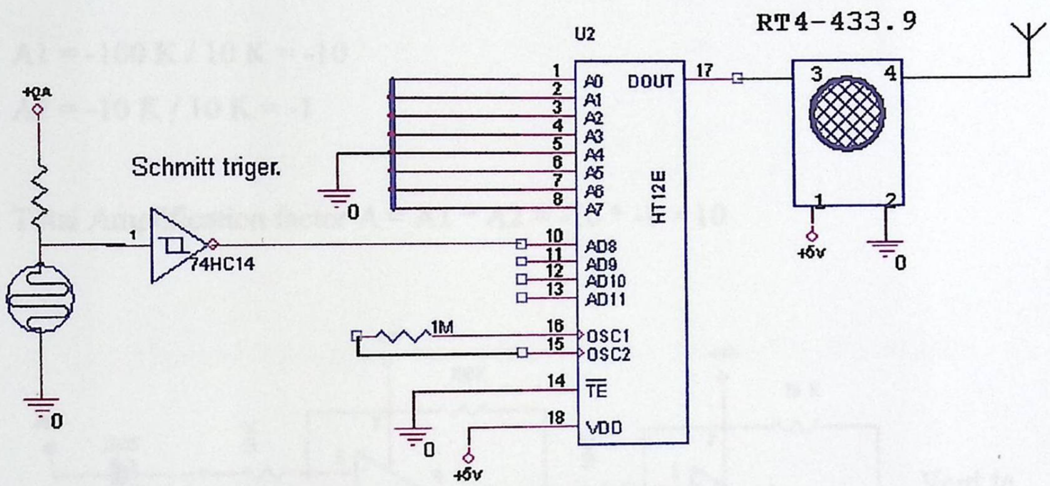


Figure 4-6 Light sensor circuit with RT4-433.9 RF-Transmitter and HT-12E encoder.

4.3.2 Temperature Sensing Circuit:

Figure 4-7 shows the schematic circuit of temperature sensing. The LM 35 temperature sensor is configured to work on 5 volts power supply. This sensor is directly connected to the PIC microcontroller at A/D (Analog to Digital) PORT channel 0 (pin A0).

The value of the measured temperature is converted internally to digital value. An amplifier is needed because the measured value from the sensor is too small (in mV). The output voltage obtained from the first amplifier is in negative value, so another amplifier is used to get positive value of temperature.

The amplification factor at first amplifier is -10, and the amplification factor at second amplifier is -1. Amplification factor calculated by the following equation:

Amplification factor **A = -Ra / Rb**

A1 = -100 K / 10 K = -10

A2 = -10 K / 10 K = -1

Total Amplification factor A = A1 * A2 = -10 * -1 = 10

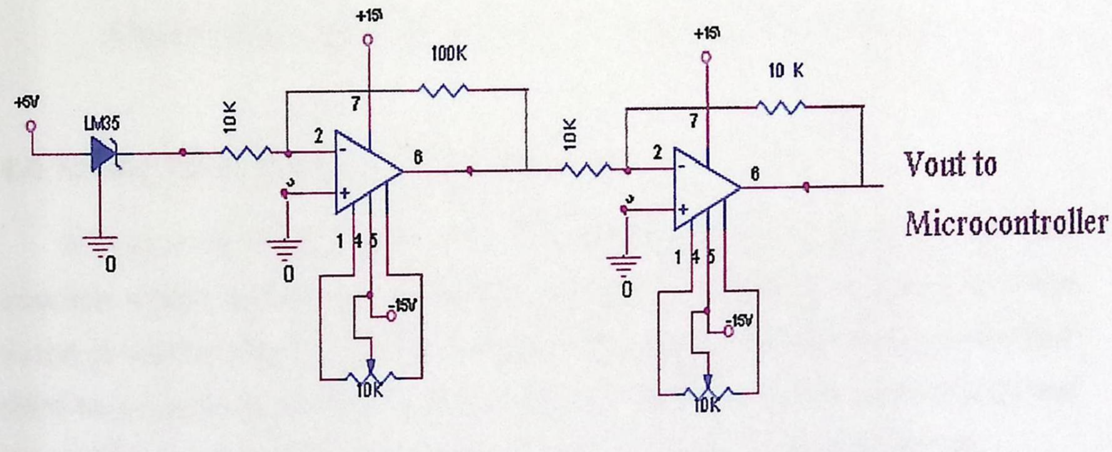


Figure 4-7 Temperature sensor circuit.

4.3.3 Motion Sensing Circuit:

Figure 4-8 shows the schematic circuit of motion sensing with RF-Transmitter and HT-12E encoder, this sensor works on 12 volts power supply, it has four pins: Vcc, Vss and 2 pins for the switch. The operation principle of this circuit is to produce 5 volts when the sensor detects any body motion, it outputs 0 volt otherwise.

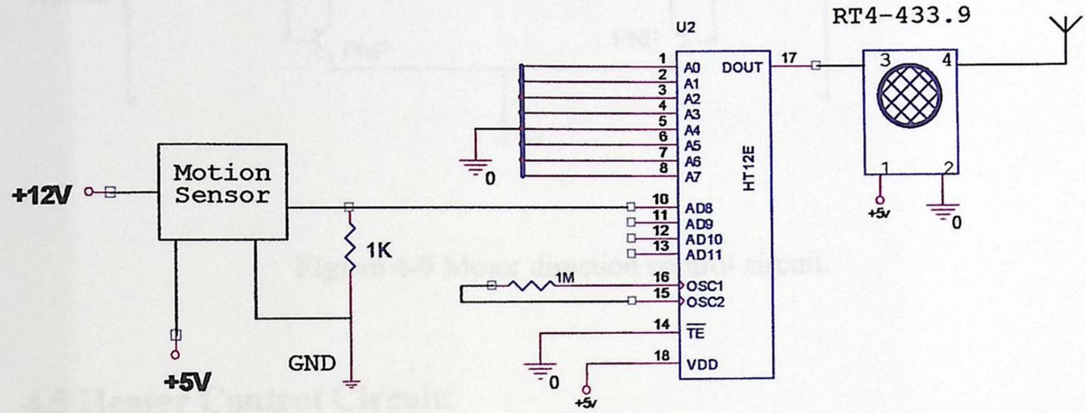


Figure 4-8 Motion sensor circuit with RF-Transmitter and encoder.

4.4 Motor Direction Control Circuit:

Motors used in the project are DC motors which operated on 12V into two direction modes reverse and forward. To control the direction of motor H-bridge circuit is needed which is shown in Figure 4-9. Two NPN (BD243c) and two PNP (BD244c) transistors used to build this circuit, in addition to two transistors Q1 and Q2 used as switch transistors to isolate 12V power supply from other devices.

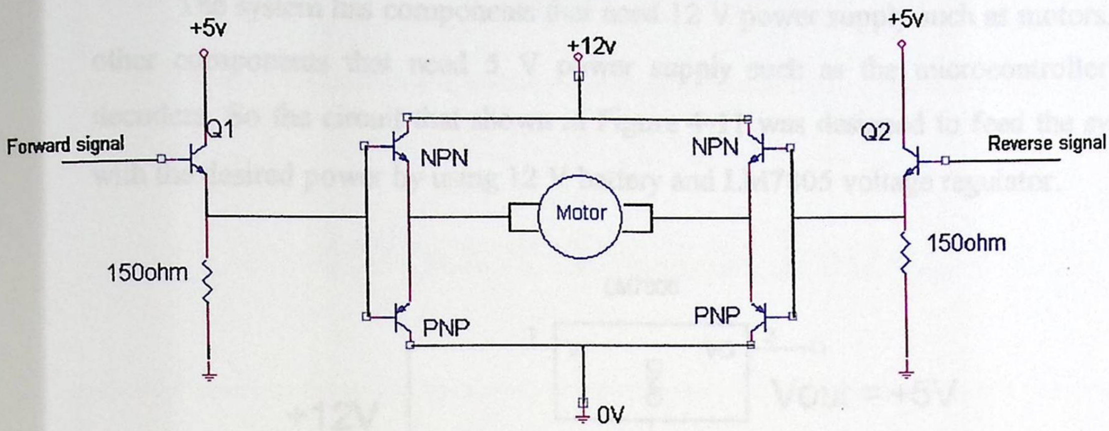


Figure 4-9 Motor direction control circuit.

4.5 Heater Control Circuit:

In order to control the operation of heater circuit that shown in Figure 4-10 was designed. This circuit consists of an MOC3020 which is an optocoupler used as an isolator between DC power supply devices and AC power supply devices, and consists of a triac used as a three-terminal high-voltage switch to turn on or turn off the heater.

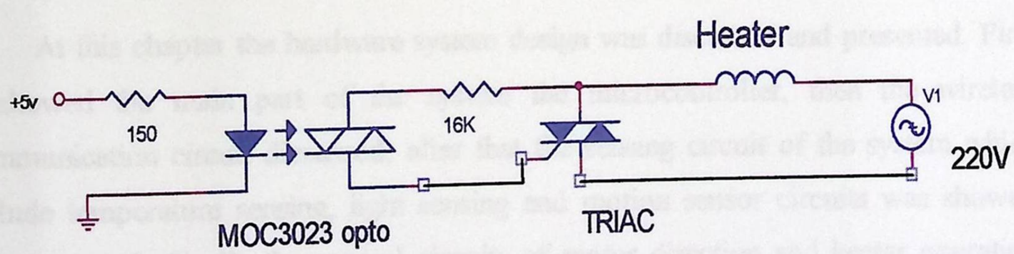


Figure 4-10 Heater control circuit.

4.6 Power Circuit:

The system has components that need 12 V power supply such as motors, and other components that need 5 V power supply such as the microcontroller and decoders. So the circuit that shown in Figure 4-11 was designed to feed the system with the desired power by using 12 V battery and LM7805 voltage regulator.

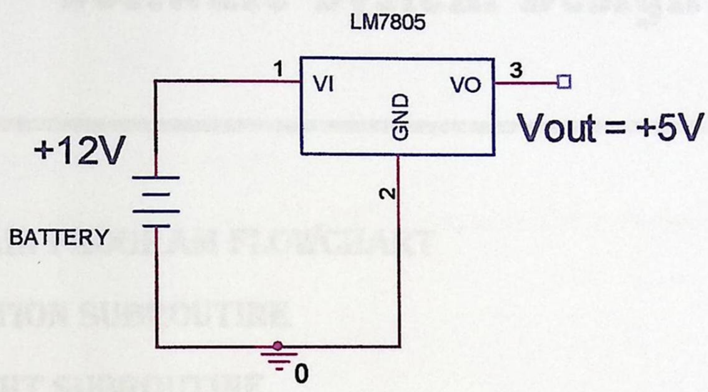


Figure 4-11 System power supply circuit.

4.7 Summary

At this chapter the hardware system design was discussed and presented. First it showed the main part of the system the microcontroller, then the wireless communication circuit discussed, after that the sensing circuit of the system which include temperature sensing, light sensing and motion sensor circuits was showed and discussed. Finally the control circuits of motor direction and heater operation was presented and discussed in addition to the system power supply circuit.

Chapter Five

Software System Design

Chapter Five

Software System Design

This chapter describes the general and detailed program flowcharts which were designed to program the microcontroller of the system. The overall software is programmed using C language. The MPLAB software description is proposed in the appendix B.

5.1 Main Program Flowchart

In this section the general program of the PIC microcontroller is explained.

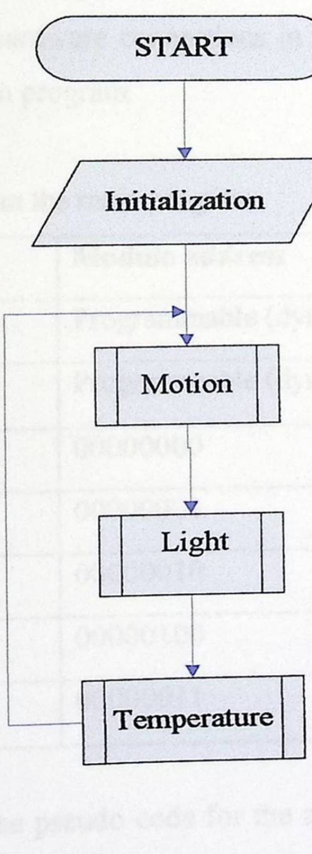


Figure 5-1 General flowchart of the PIC microcontroller program.

The previous flowchart describes how the microcontroller follows a specific sequence in order to match the desired results. This sequence indicates that the program initializes the microcontroller ports using the built-in libraries in the MPLAB IDE software.

Firstly, the program initializes the microcontroller ports as inputs or outputs, then the program enters a continuous loop in order to keep track with all parameters changes in the room all day and night, at this loop motion subroutine then light subroutine finally temperature subroutine is invoked. Implementing each subroutine service needs the use of the delay routines in order to synchronize the test operations.

The following table shows the supposed addresses for all modules in the system, these addresses are wired as hardware connections in the subsystem modules, and software configured in the main program.

Table 5-1 Modules addresses in the main program.

Module name	Module address
Microcontroller receiver	Programmable (dynamic)
Microcontroller transmitter	Programmable (dynamic)
Door receiver	00000000
Door transmitter	00000001
Window receiver	00000010
Window transmitter	00000100
Heater receiver	00000011

The following code presents the pseudo code for the main program flowchat of the system:

```
Main ( ) {
    Initialization ( )
        While (1) {
            Motion ( )              call motion subroutine.
            Light ( )               call light subroutine.
            Temperature ( )         call temperature subroutine.
        } // end while
} // end main
```

5.2 Motion Subroutine

The first subroutine is the Motion service routine. This section of code accepts detected digital signals if this value equals 0 or 1, the code will turn OFF or ON the DC motor the door depending on the detected signal. Figure 5-2 shows the flowchart for the motion subroutine.

After the control enters motion subroutine the program configures the microcontroller receiver address as door transmitter address, and the program configures microcontroller transmitter address as door receiver address then the subroutine checks if there is any person moving near the door; OPEN control command is sent to the specified receiver on the door, which will turns ON the motor, also delay subroutine is invoked to allow enough time to the person to get out, then CLOSE control command is sent to the same receiver to close the door of the room. If there is no one near the door the control returns to the main program.

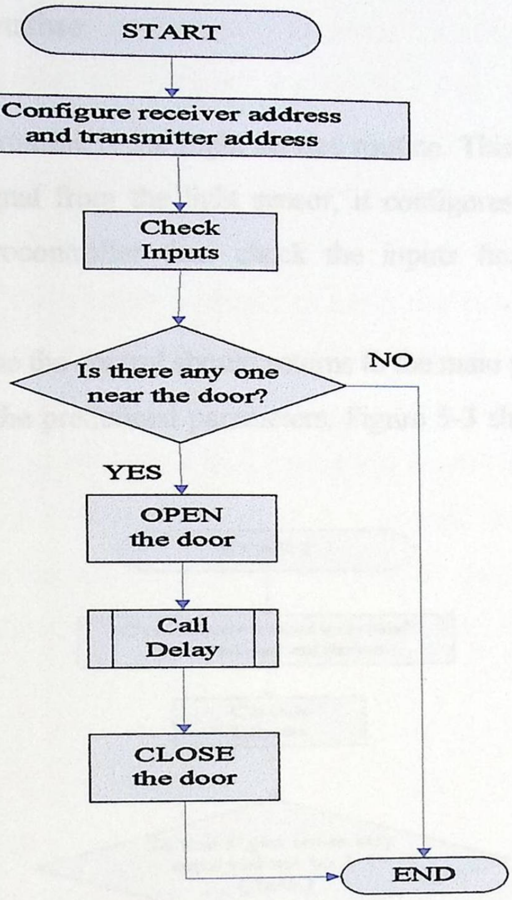


Figure 5-2 Motion subroutine flowchart.

The following code is the pseudo code for the motion subroutine.

```
Motion ( ) {
    String data
    Configure address of receiver
    Data = received data from the door transmitter
        If (data = "detect person")
            configure address of transmitter
            Open door ( )
            Delay ()
            Close door ()
}// End motion.
```

5.3 Light Subroutine

The next subroutine is the Light service routine. This section of code receives detected digital signal from the light sensor, it configures receiver and transmitter addresses of microcontroller then check the inputs finally outputs the control commands.

At end of subroutine the control should returns to the main program in order to check another change in the predefined parameters. Figure 5-3 shows the flowchart for the Light subroutine.

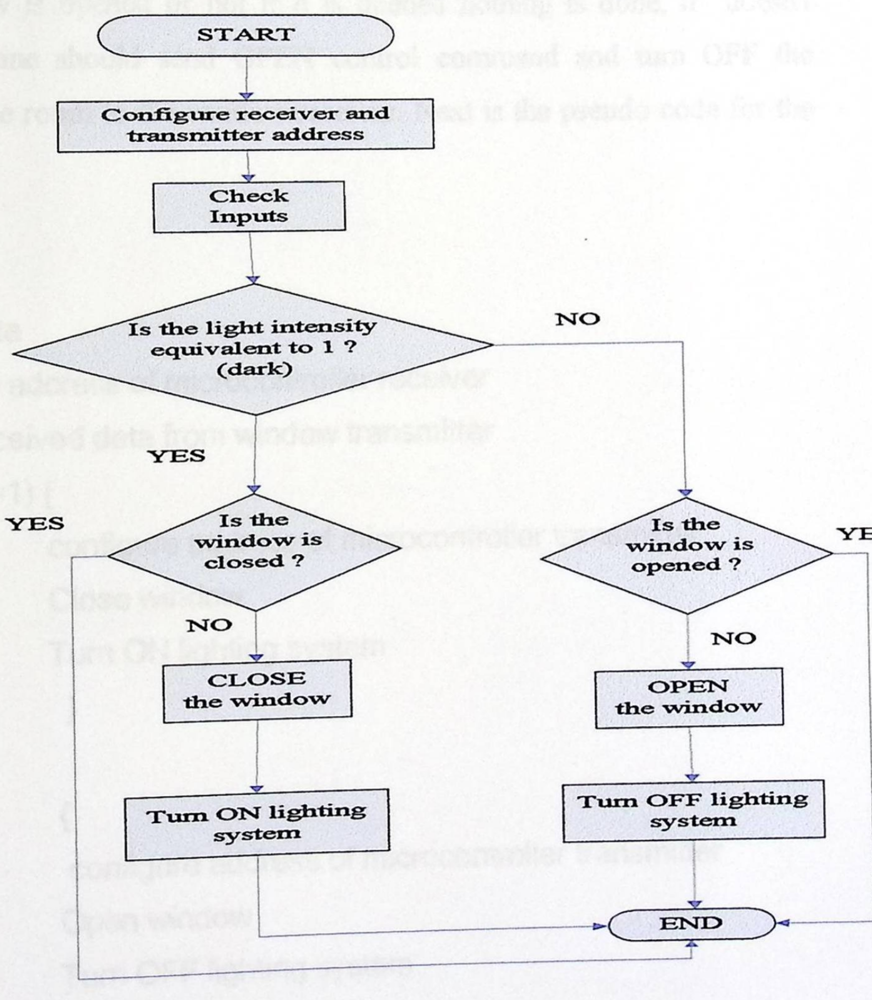


Figure 5-3 Light subroutine flowchart.

When the control enters the light subroutine it configures the receiver address of the microcontroller as window transmitter, and the program configures microcontroller transmitter address as window receiver address then the subroutine checks if the light intensity equivalent to 1 or not in order to decide whether to open the window or not. If the light intensity equals 1 that means it is night or dark so the subroutine check if the window is closed or not if it is closed nothing is done, if the window doesn't closed the subroutine should send the CLOSE control command to the window receiver and to turn ON the lighting system in the room.

If the light intensity is equivalent to 0 (zero) that means it is day so the subroutine check if the window is opened or not if it is opened nothing is done, if doesn't opened the subroutine should send OPEN control command and turn OFF the lighting system in the room to the window receiver. Next is the pseudo code for the light subroutine.

```
Light ()
 {
  String data
  configure address of microcontroller receiver
  Data= received data from window transmitter
 If (data ==1) {
              configure address of microcontroller transmitter
              Close window
              Turn ON lighting system
               }
 Else
               {
                configure address of microcontroller transmitter
               Open window
               Turn OFF lighting system
                }
   } // end of light subroutine.
```

5.4 Temperature Subroutine

The following subroutine is the temperature subroutine. This subroutine is programmed in order to control the heating system in the room, at the beginning A/D channel must be configured to be work in right manner, the value of temperature is stored in temp value, after that there is must be a comparison to the value of temp if it decreased less than 13 °C so the Heat ON control command is sent to the heater module, if it increased more than 25 °C Heat OFF control command is sent to the heater module, if the temperature is more than 13 °C and less than 25 °C nothing will be done. Figure 5-4 is the flowchart for the temperature subroutine:

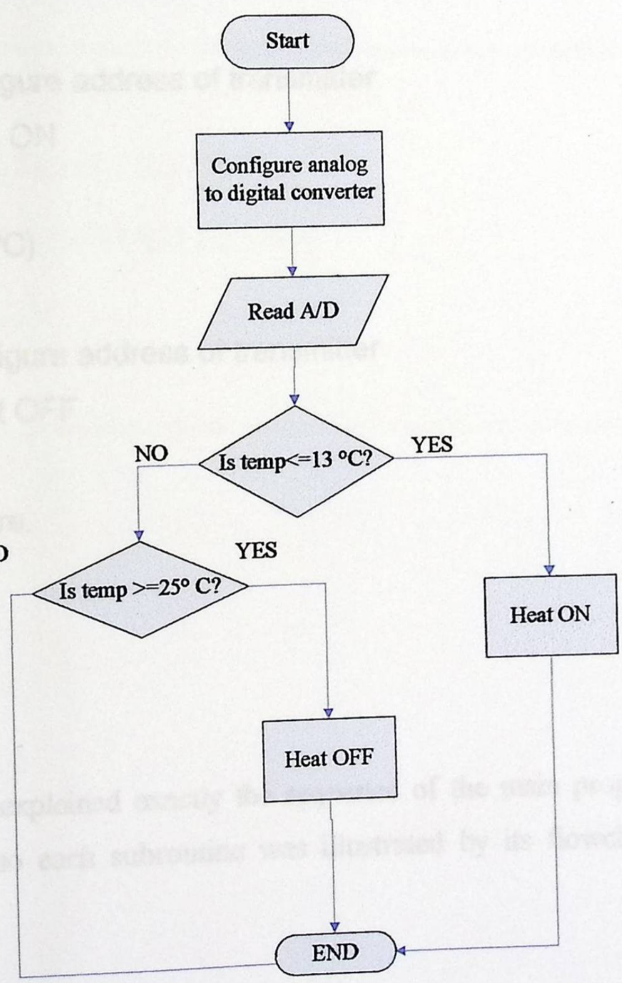


Figure 5-4 Temperature subroutine flowchart.

The following code shows the pseudo code for the temperature subroutine:

```
Temperature ()
{
    Int temp;
     Configure A/D converter

   Temp = Read ADC () //temperature is directly entered to
                                          // the microcontroller.
    If (temp <13 °C)
             {
              configure address of transmitter
              Heat ON
             }
    If (temp>25 °C)
             {
              configure address of transmitter
              Heat OFF
             }
} // end temperature.
```

5.5 Summary

This chapter explained exactly the sequence of the main program of the PIC microcontroller, also each subroutine was illustrated by its flowchart and pseudo code.

Chapter Six

System Testing

Chapter Six

System Testing

This chapter demonstrates how the system was tested. Each subsystem is tested independently. Software and hardware of the subsystem is included in the same subsection. Finally complete system testing is presented. The algorithms for the codes in this chapter was explained in chapter five.

6.1 Subsystems Testing

At this stage each subsystem was tested independently, to ensure that the subsystem realizes its specified function .This way of testing simplify trouble shooting detection.

6.1.1 PIC18F4520 Microcontroller Testing

PIC 18F4520 Microcontroller with the oscillating circuit and the external reset circuit was built as shown in Figure 6-1, this testing needs the use of the programmer in order to download the test program in order to ensure that the PIC Microcontroller response to its desired function. RJ45 is used to connect the PIC microcontroller with the programmer, RJ45 has 5 wires connected to Vcc, Vss, and to pin 1, 40 and 39 of the microcontroller.

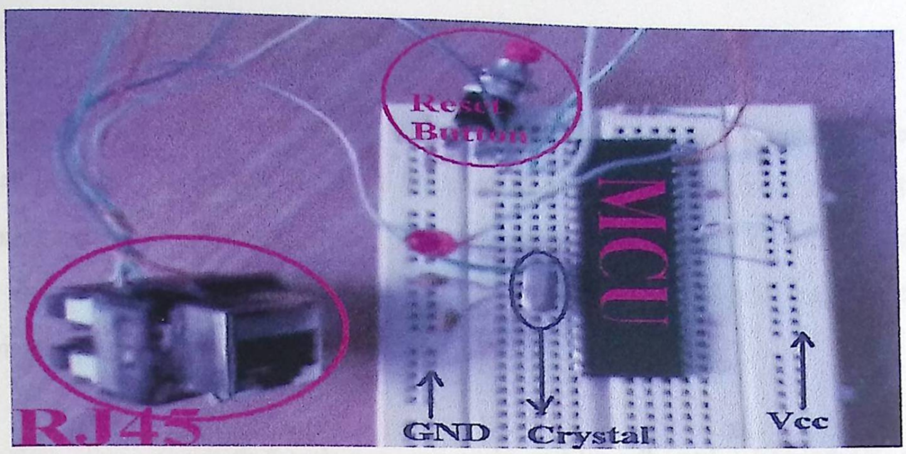


Figure 6-1 18F4520 PIC microcontroller test circuit.

The following program initializes the PIC ports as inputs or outputs, which is used as testing program.

```
#include<p18f4520.h>
void main (void)
  {
    int value;
    TRISC=0b11110000;  //pin0,1,2 and 3 are outputs, pin 4,5,6 and
7 inputs
     TRISA=0x7F;
     TRISD=0x00;
     TRISB=0x00;
     PORTAbits.RA7=0;          //write value to port A pin7
   value=PORTCbits.RC5;   //reading value from port C pin 5


     }
```

6.1.2 Wireless Communication Testing

The testing and verification of the wireless communication between the different parts of the system requires the presence and use of both the transmitter unit with the encoder at the transmitting side and use of the receiver unit with the decoder at the receiving side. This testing was accomplished in several stages using the following equipments:

- Function generator with 5 volt power supply and breadboard, LED indicators.
- Multi-meter capable of measuring voltage.
- Multi-channel Oscilloscope.
- RT4-433.9 Transmitter with HT-12E encoder.
- RR3-433.9 Receiver with HT-12D decoder.

RT4-433.9 transmitter Wired with the HT-12E encoder as shown below in Figure 6-2. Specifying 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.

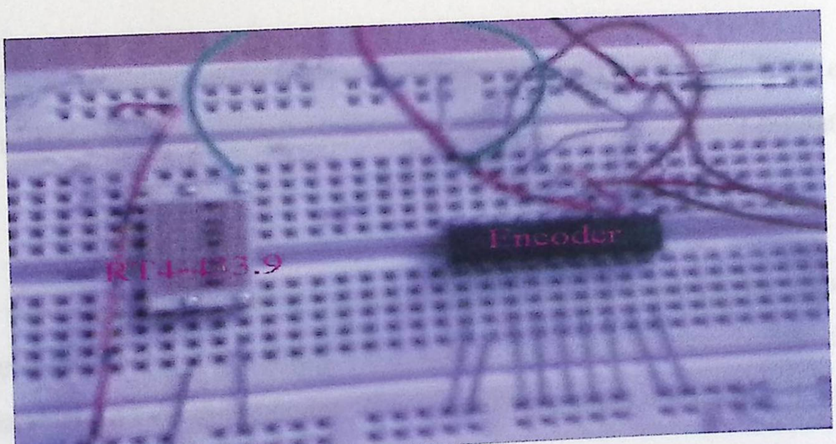


Figure 6-2 RT4-433.9 transmitter with encoder circuit.

RR3-433.9 receiver Wired with the HT-12D decoder as shown below in Figure 6-3. Putting pin 3 of the receiver connected to the antenna. the address at the receiver must be the same address at the transmitter.

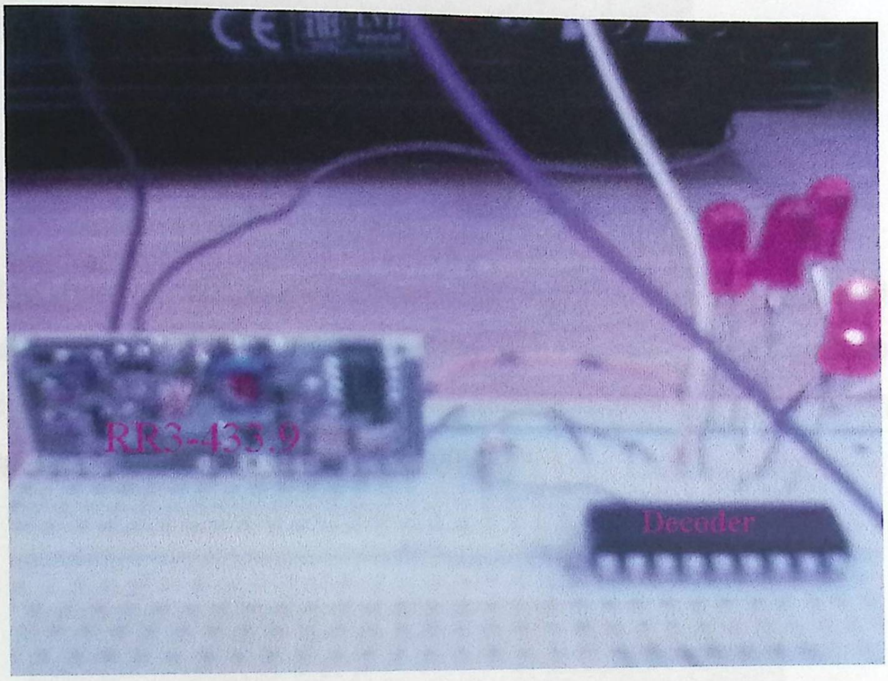


Figure 6-3 RR3-433.9 receiver with decoder circuit.

In order to test this circuit four bit data was sent at the data pins in the encoder, to ensure this data at the receiving side four LEDs was put on the four bit data on the decoder.

Now turn 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 shown in Figure 6-4 was taken from transmitter test out.

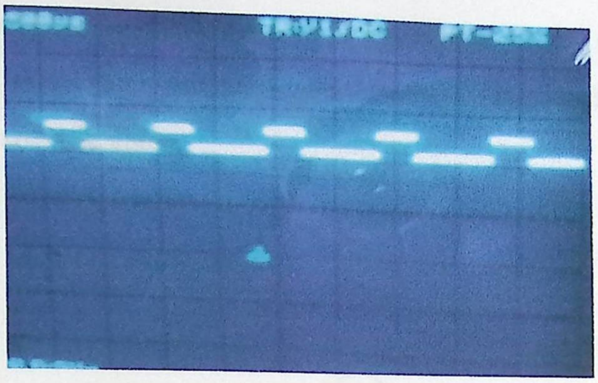


Figure 6-4 RF-transmitter signal.

Now turn on the receiver circuit. The signal can be seen by attaching the oscilloscope to pin 14 of the decoder as shown in Figure 6-5. 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.

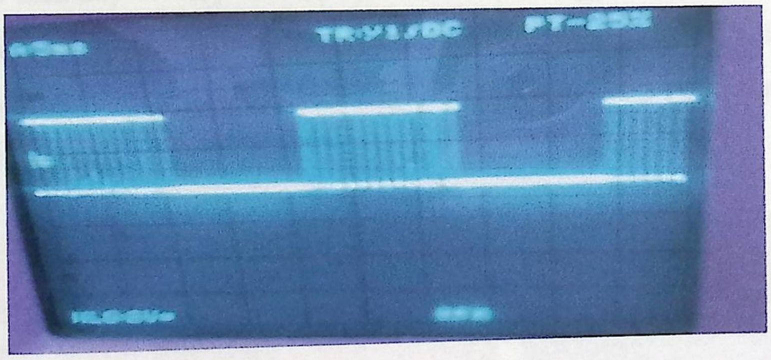


Figure 6-5 RF-Receiver signal.

6.1.3 Light Sensor Testing

The initial light sensing circuit which was built in the laboratory shown in Figure 6-6. The 150 Ω resistor was wired in series with the first edge of the LDR sensor, the second edge was connected to the GND. The test of this circuit needs the use of multi-meter device to indicate the output voltage. But there was a problem in this circuit that the voltage obtained when the light intensity changes is very low and not stable on a specific value.

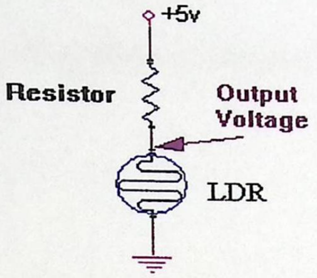
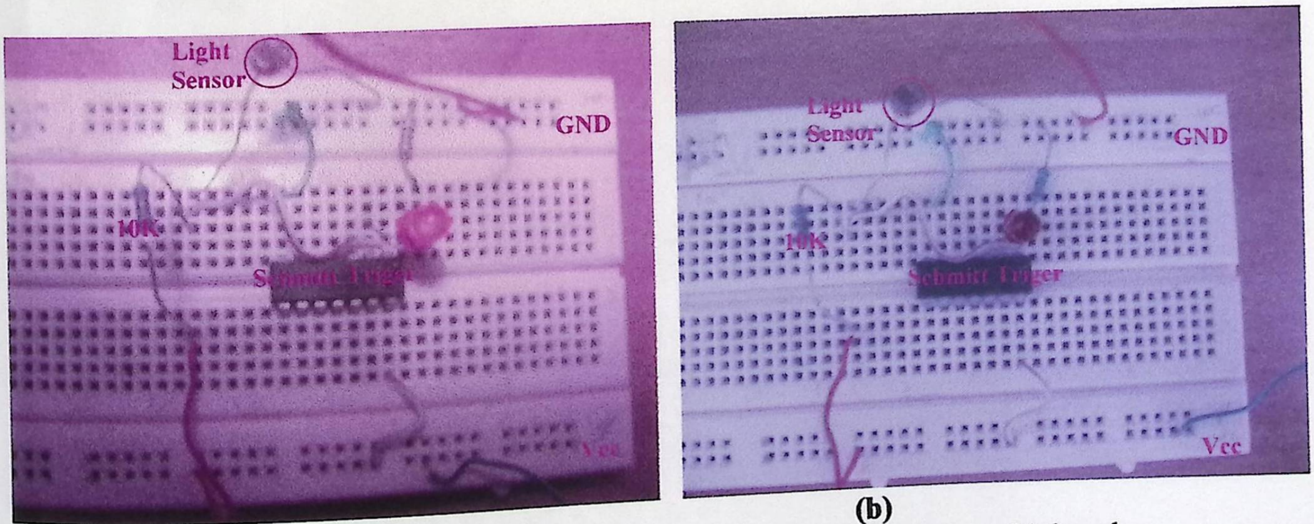


Figure 6-6 Initial light sensor circuit.

So the circuit modified as Figure 6-7, by adding schmitt trigger which enhanced the performance and stabilized the output voltage, schmitt trigger was connected to the output of the LDR sensor so the circuit worked successfully. When the light intensity is very low (dark) the schmitt trigger output is 5 volt, when the light intensity is very high the schmitt trigger output is 0 volt, this circuit will be connected to the transmitting circuit in order to inform the PIC microcontroller with the light intensity.



(a) (b)

Figure 6-7 The enhanced light sensor circuit. (a) the light intensity is very high and the red LED is on. (b) the light intensity is low and the red LED is off.

The following code is implemented to control the window opening or closing operation depending on the inputs from light sensor.

```
void light(void}(

//modify address of decoder to address of window
PORTDbits.RD0=0؛
PORTDbits.RD1=0؛
PORTDbits.RD2=1؛
PORTDbits.RD3=0؛

//Delay10TCYx(20)؛

if(PORTAbits.RA1==1)
{
        open window

 If (PORTCbits.RC0==0؛}(

        //modify address of encoder to address of window
        PORTDbits.RD4=0؛
        PORTDbits.RD5=1؛
        PORTDbits.RD6=0؛
        PORTDbits.RD7=0؛

        OPEN

        PORTCbits.RC4=0؛
        PORTCbits.RC5=0؛
        PORTCbits.RC6=1؛
        PORTCbits.RC7=1  ؛

        PORTAbits.RA2=0;//TE'
        Delay10TCYx(10)؛
        PORTAbits.RA2=1;//TE'
        }
   }

 if(PORTAbits.RA1==1)
 {
        //close window
 if(PORTCbits.RC0==1)
 {
```

```
        //modify address of encoder to address of window
        PORTDbits.RD4=0؛
        PORTDbits.RD5=1؛
        PORTDbits.RD6=0؛
        PORTDbits.RD7=0؛


//CLOSE

        PORTCbits.RC4=1؛
        PORTCbits.RC5=1؛
        PORTCbits.RC6=0؛
        PORTCbits.RC7=0 ؛

        PORTAbits.RA2=0;//TE'
        Delay10TCYx(20)
        PORTAbits.RA2=1;//TE'
                }
        }
} //end light
```

6.1.4 Temperature Sensor Testing

Temperature sensor circuit was built as shown in Figure 6-8. The output of temperature sensor forwarded to the amplifier, then the amplifier amplify it. The output from amplifier goes to the microcontroller. The potentiometer used to configure the amplifier (to reset the amplifier).

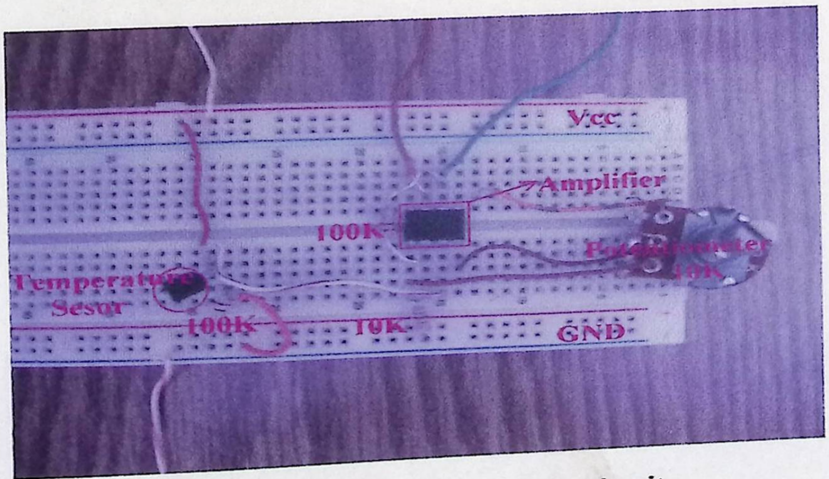


Figure 6-8 Temperature sensor circuit.

The previous circuit was tested and the results were gathered in Table 6-1, depending on using the amplifier.

Table 6-1 Temperature degree reading varies to voltage

Temperature degree in ° C	Voltage
60	5.9
40	4
20	2
15	1.4
10	0.9
8	0.8
5	0.7

The voltages obtained from the amplifier passed to the Analog-to-Digital (A/D) port in the microcontroller, where the microcontroller reading values were calculated depending on the following rules:

- The (A/D) converts an analog input signal to a corresponding 10-bit digital number as shown in Figure 6-9.
- 10-bit digital number can be read as integer number (N).
- N is converted to its corresponding voltage value using the following equation:

$$N = Vin * 2^{10} / (Vref+ - Vref-) \quad [3]$$

Where:
Vreff- = 0Volt and Vref+ = 5 Volt.

For example if the temperature is 25° C, then

N = 1024 / (5-0) * 2.5 = 512

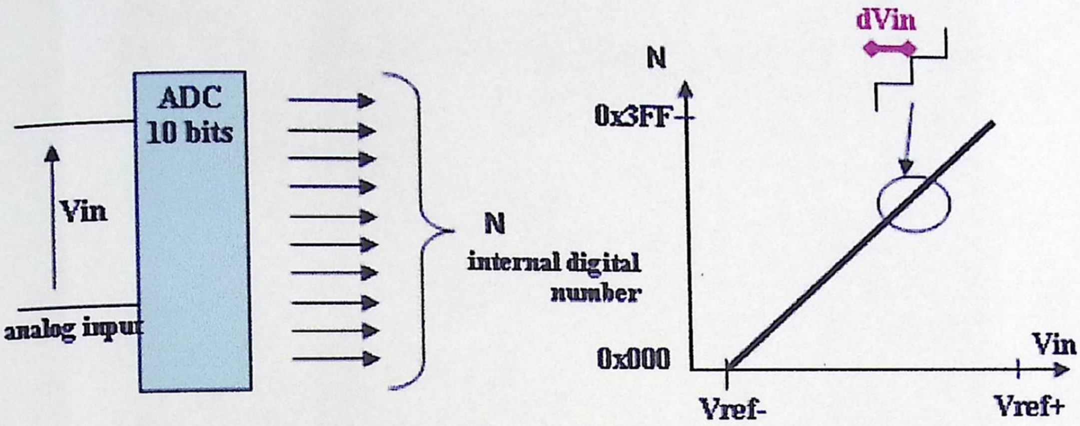


Figure 6-9 Analog-to-Digital (A/D) converter module.[5]

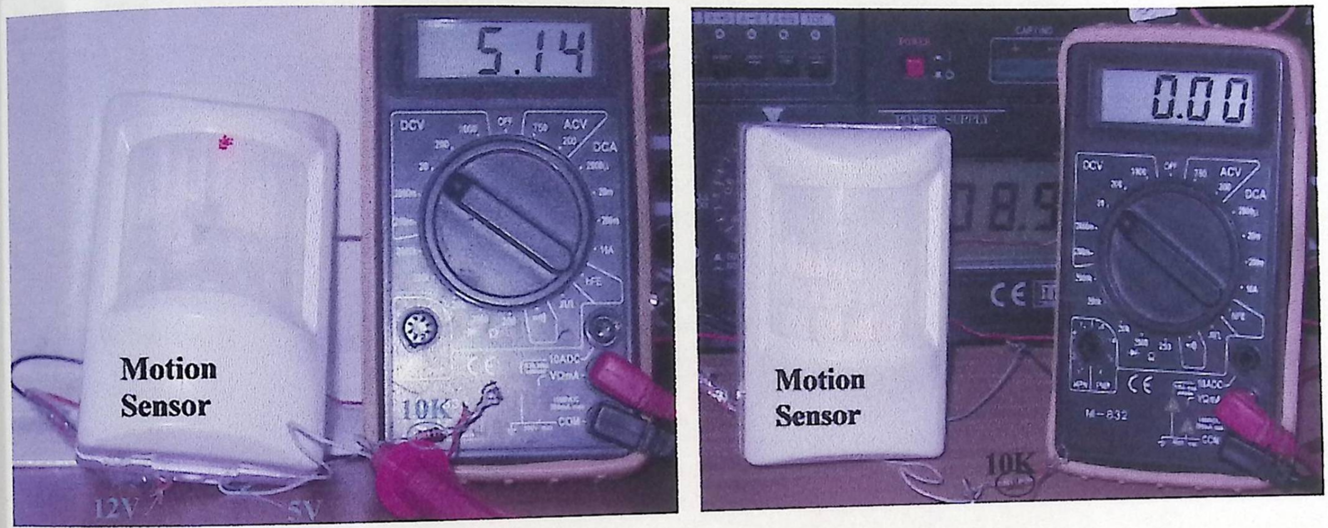
The following code was written to read the value of temperature and according to this value the desired action (turn on/off the heater) will be taken.

```
ADCON0=0x01;
ADCON1=0x0E;
TRISA=0b00000011;
void temp(void){

int result;

// configure A/D converter

OpenADC( ADC_FOSC_32 &
ADC_RIGHT_JUST & ADC_2_TAD,ADC_CH0 &
ADC_INT_OFF & ADC_VREFPLUS_VDD & ADC_VREFMINUS_VSS , 0x01
);

ConvertADC(); // Start conversion

while( BusyADC() ); // Wait for completion

result = ReadADC(); // Read result

CloseADC(); // Disable A/D converter
```

```
if (result<270) //IF TEMP <13 C
{
        //heatON
        //MODIFY ADDRESS OF ENCODER TO ADRESS OF HEATEAR
        PORTDbits.RD4=1;
        PORTDbits.RD5=1;
        PORTDbits.RD6=0;
        PORTDbits.RD7=0;

        //HEAT ON
        PORTCbits.RC4=1;
        PORTCbits.RC5=1;
        PORTCbits.RC6=0;
        PORTCbits.RC7=0;

        //TE'
        PORTAbits.RA2=0;
        Delay10TCYx(20);
        PORTAbits.RA2=1;
            }

 If (result>390) //IF TEMP>20 C
 {

        //MODIFY ADDRESS OF ENCODER TO ADRESS OF HEATEAR
        PORTDbits.RD4=1;
        PORTDbits.RD5=1;
        PORTDbits.RD6=0;
        PORTDbits.RD7=0;

        //HEAT OFF
        PORTCbits.RC4=0;
        PORTCbits.RC5=0;
        PORTCbits.RC6=1;
        PORTCbits.RC7=1;
        //TE'
        PORTAbits.RA2=0;
        Delay10TCYx(20);
        PORTAbits.RA2=1;
   }

  } //END temp
```

6.1.5 Motion Sensor Testing

The circuit shown in Figure 6-10 is a motion sensor circuit that tested independently, this circuit requires 12 V power supply. This circuit tested by reading the value of the voltage a cross the resistor that connected with the motion sensor. The sensor can be adjusted to work at different distances, so it tested to 0.4, 0.7, 1.3 and 2 Meter. When the sensor detects motion of bodies the voltage across the resistor is 5 V and the red photo led is turned on, when no bodies detection the voltage across the resistor is 0 V.



(a) **(b)**

Figure 6-10 (a) Motion circuit detects human body motion. **(b)** Motion circuit does not detect human body motion.

The following code was implemented to control the door opening and closing operation depending on the input from the motion sensor.

```
void motion(void){

        //modify address of decoder to address of door
        PORTDbits.RD0=0;
```

```
        PORTDbits.RD1=0;
        PORTDbits.RD2=0;
        PORTDbits.RD3=0;

        Delay10TCYx(20);

if(PORTAbits.RA1==1) //check VT
        Door();


}//END motion
```

6.1.6 Motor Direction Control Circuit Testing

The circuit shown in Figure 6-11 is the first circuit tested to control the direction of motor but it does not get any correct result because the circuit doesn't offer -5V in forward signal. So another circuit was tested which is shown in Figure6-12 that use built in H-bridge but this circuit also doesn't work because the motor needs more power to operate which this circuit doesn't offer it. Circuit that shown in Figure 6-13 was built and tested which was worked correctly, the schematic circuit of this circuit shown in Figure4-12.

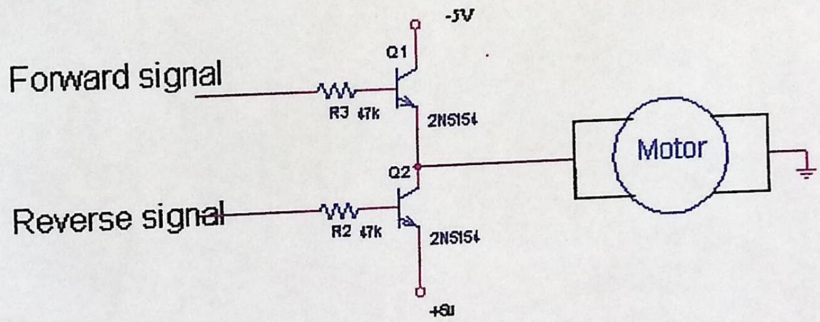


Figure 6-11 Motor direction control circuit using 2-NPN transistors.

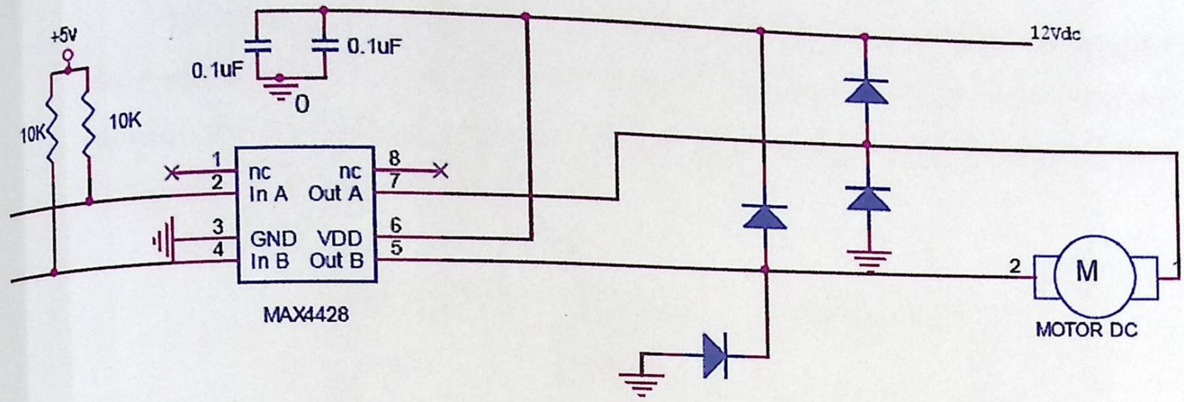


Figure 6-12 Motor circuit using built-in H-bridge .

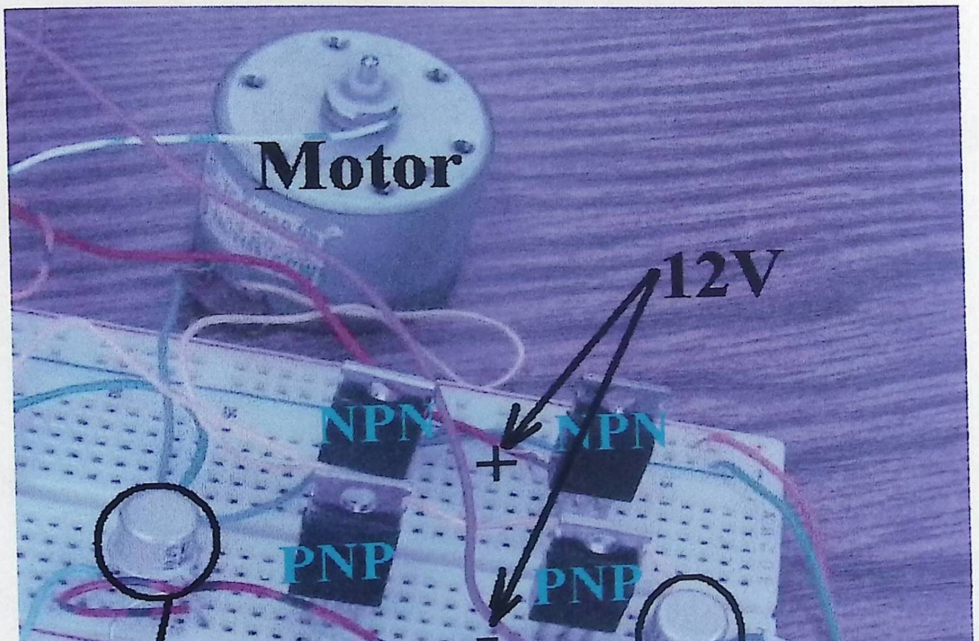


Figure 6-13 Motor circuit using NPN and PNP transistors.

In circuit shown in Figure 6-13 the input signal from the receiver was passed to the manually built H-bridge which is protected by the pre and post switch transistor circuits, this switching circuits used for indicating the direction of the motor, Table6-2 illustrates the logic of this circuit:-

Table 6-2 Motor rotation logic

Forward signal	Reverse signal	Rotation mode
0	0	stop
0	1	reverse
1	0	forward
1	1	stop

This logic indicates that there is no sudden change between forward and reverse unless the stop rotation mode is performed.

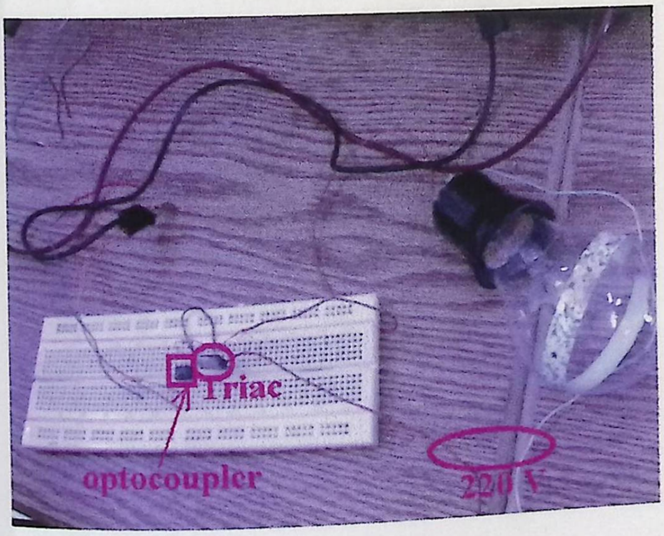
The following code was implemented to control the opening and closing the door.

```
void Door(void){

        //openDoor
        //modify address of encoder to address of door
        PORTDbits.RD4=1;
        PORTDbits.RD5=0;
        PORTDbits.RD6=0;
        PORTDbits.RD7=0;
        //OPEN DOOR
        PORTCbits.RC4=0;
        PORTCbits.RC5=0;
        PORTCbits.RC6=1;
        PORTCbits.RC7=1;
        PORTAbits.RA2=0;//TE'
        Delay10TCYx(20);
        //stop signal for motor
        PORTCbits.RC4=1;
        PORTCbits.RC5=1;
        PORTCbits.RC6=1;
```

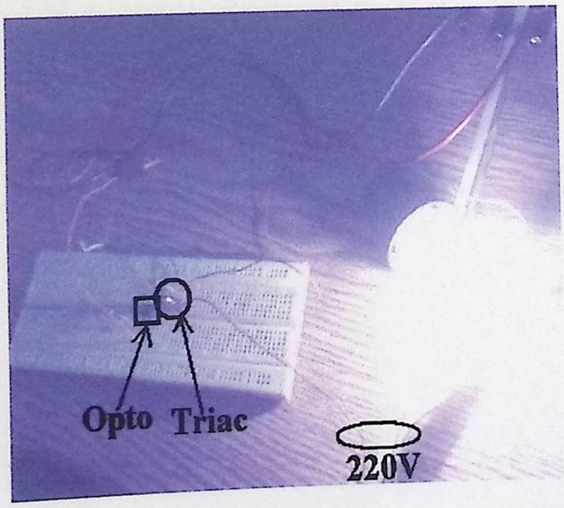
```
        PORTCbits.RC7=1;
        PORTAbits.RA2=0;//TE'
        Delay10TCYx(20);
        /* delay */
        Delay10TCYx(100); //at this moment door is opened
        //CLOSE DOOR
        PORTCbits.RC4=0;
        PORTCbits.RC5=0;
        PORTCbits.RC6=1;
        PORTCbits.RC7=1;
        PORTAbits.RA2=0;//TE'
        Delay10TCYx(20);
} //end Door
```

6.1.7 Heater Control Circuit Testing

The circuit that controls turning on/off the heater was build and tested as shown in Figure 6- 14. The lamp was used to simulate the heater that requires 220V AC power supply, this circuit operates as follows: when the optocoupler gets an input of 5 V it will activates the triac which works as a switch to connect the 220 V to the heater. The input of 5 V will be taken from the attached receiver circuit. The code for control the operation of turning on/off operation was presented at section 6.1.4



(a)



(b)

Figure 6-14 Heater circuit (a)heater is turned off (b)heater is turned on.

6.2 Summary

At this chapter every part of the system was tested, this chapter presented the results that obtained from implementing the system. at first the chapter showed the testing of the microcontroller then sensing circuits, finally the control circuit of motor and heater.

Chapter Seven

Conclusions and Future Work

Chapter Seven

Conclusions and Future Work

This chapter presents some conclusions that resulted from implementing and testing the project, also it explains in details the goals that were achieved from the project. Finally, it proposes some suggestions and recommendations for developing the system in the future.

7.1 Conclusions

Although there were many difficulties during the implementation, we have succeeded to solve them, on the other hand these difficulties enhanced the work team experience; through implementation of new technologies that was covered briefly in the text books, through some hardware components that were all new, and through improving the team ability to deal with the used software. The following are the obtained outputs from the whole project work:

1- The team work of the project put the aims of the project and studied the theoretical part of the project (theories and laws). The team proved that theoretical methods can be executed in real world and they are can be applicable.

2- After using RF-technology and comparing it with other methods the result was using RF- technique is more reliable, accurate, and easy to configure.

3- Dealing with the PIC microcontroller made the controlling easier and more attractive than using PC.

4- Implementing the specified interfacing circuits (decoding and encoding) stabilized the system outputs and help the microcontroller to distinguish between several transmitters and receivers.

5- Using wireless techniques made the system more comfort through reducing the wires connections and the need for signals modification (amplification and repetition, i.e. extra hardware).

6- The choice of using the indicated sensors in the project was very successful; it provided the controller with an optimal measurements from the surrounding environment.

7.2 Remarks

This project has many discriminating signs that must be found in any successful project. Firstly, automated home system is real time, fast, accurate and multifunctional system that used to control many home components. Beside that this system is flexible because it is programmable system.

Also this project is robust system; any malfunction of any chip of the project can be easily replaced by alternative active chips. In addition this system is portable to be placed in any home beside the acceptable cost for the whole system.

7.3 Problems

Every project may face several problems while working in. These problems can be divided into two parts Hardware problems and Software problems.

7.3.1 Hardware Problems:

- The implementation of the H-bridge circuit to control the direction of the DC motor failed; the team build three circuits to have the desired output correctly, the use of H-bridge (MAX4428) chip that provides less than the enough current that is needed to control the motor direction. So the team was forced to build alternative circuit manually.

- Late arrival of some of the essential components such as wireless components and the microcontroller.

- The work was paused for three weeks at least, because the PIC programmer was destroyed completely, and there was no spare PIC programmer, and it was so hard to provide us with this programmer in the limited time. An alternate programmer was build manually to complete the project implementation.

- The PIC microcontroller was destroyed because of the programmer malfunction. So another microcontroller was bought.

- Some inputs of system were unstable. This problem solved by using extra hardware components such as Schmitt trigger for stabilize the value of light sensor.

- Some circuits were worked successfully, but when we return to it at another time the circuits didn't work. The team was forced to rebuild it.

- The big problem appeared while testing the overall system is: to receive data from transmitter only the specified transmitter must be enabled. (One transmitter enabled at a time). This problem solved by software at microcontroller unit module. And by adding extra hardware components (555 timers) to control the transmitter enable at another modules.

7.3.2 Software Problems:

- Self-study of MPLAB IDE software in order to program the PIC microcontroller takes more time.

- Difficulties that appears through configuring the A/D convertor inside the PIC microcontroller.

- Calculations of delay at software are different from the real time delay, so many trials are tested to get the actual needed delay

7.4 Future Work

We can add some ideas that the students can work on in the future such that:

- Develop system to be more clear to the users by adding LCD display to display the system parameters.

- Replace the build H-bridge with LMD18200 H-bridge chip that provide many features that will develop the speed of rotation to the motors.

- Develop the system to control the whole home room and entries.

- Adding some features to the system in order to be placed in any security system.

- The system can use a camera to control outside the room or to provide the person with additional information about the outdoor.

7.5 Summary

This chapter summarized the conclusions that came from implementing the project; it describes the problems that occurred during the project implementation. Finally it suggests some future ideas for the interested researchers.

References

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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

PIC datasheet

http://ww1.microchip.com/downloads/en/DeviceDoc/39631a.pdf

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[19] http://www.rogercom.com/pparalela/PinosRT4.gif&imgrefurl
[20] http://www.rogercom.com/pparalela/LptWireless.htm
[21] http://www.radiotronix.com

Appendix A

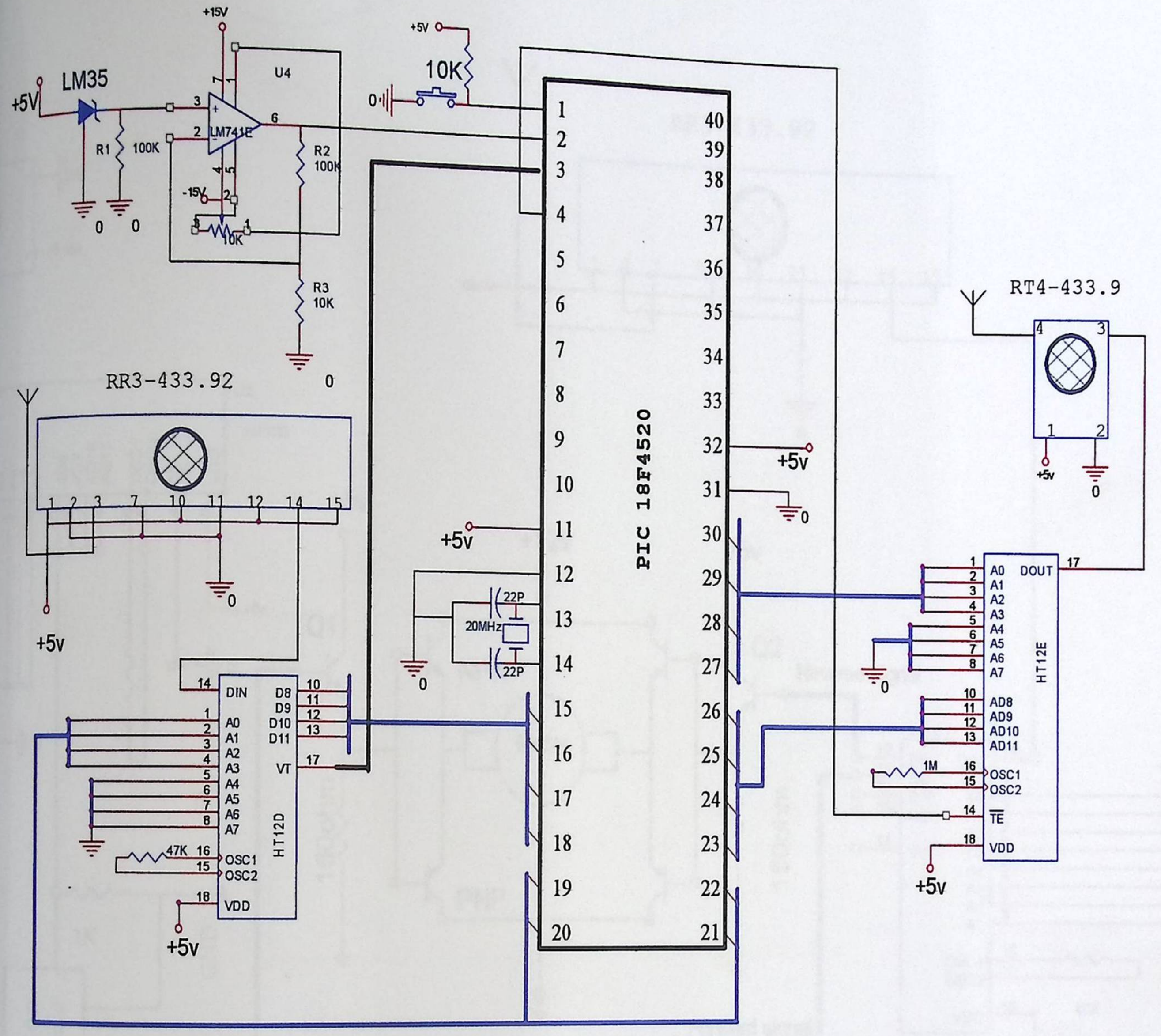
System Schematic Circuits

A.1 MICROCONTROLLER MODULE

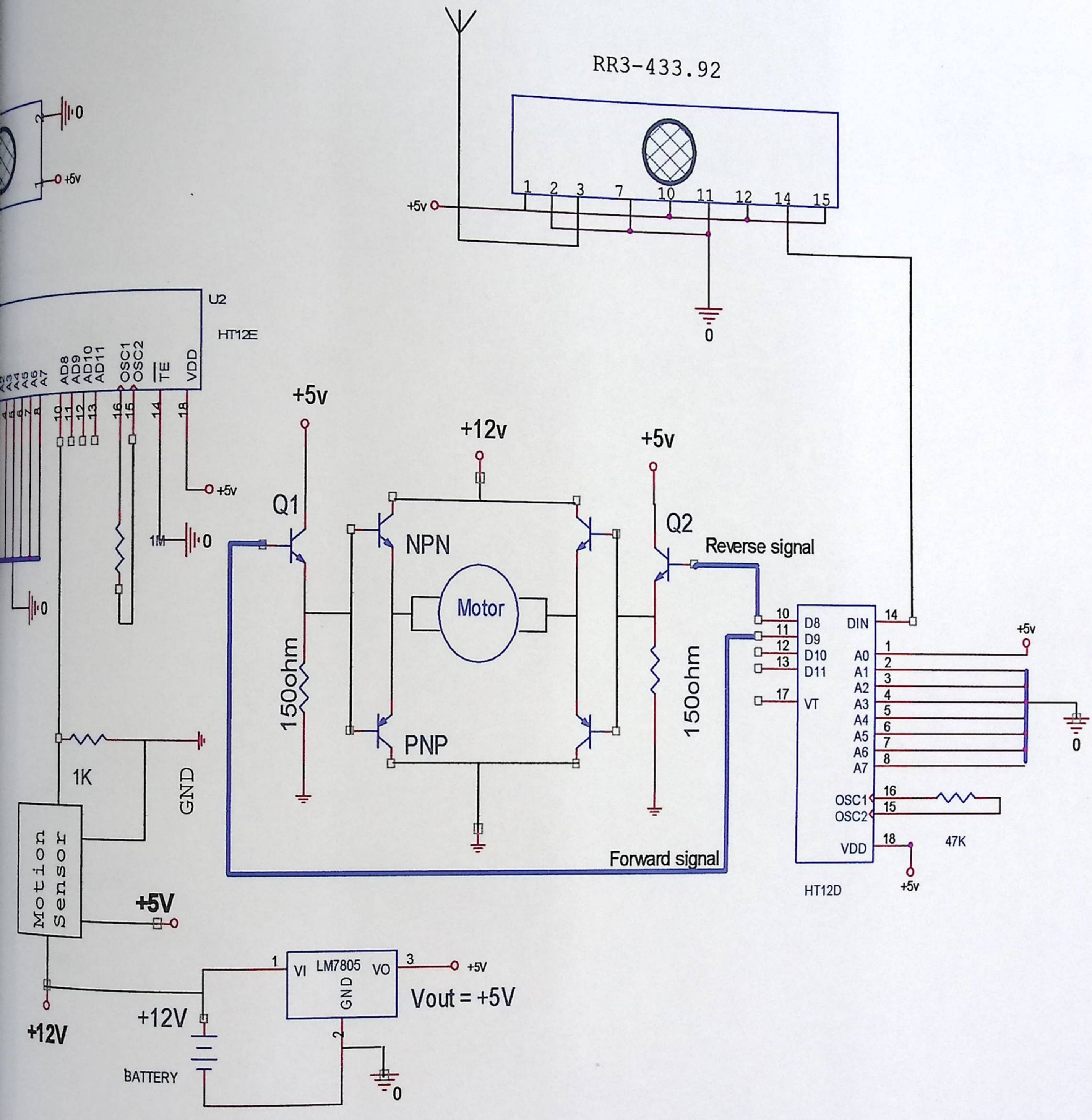
A.2 DOOR MODULE

A.3 WINDOW MODULE

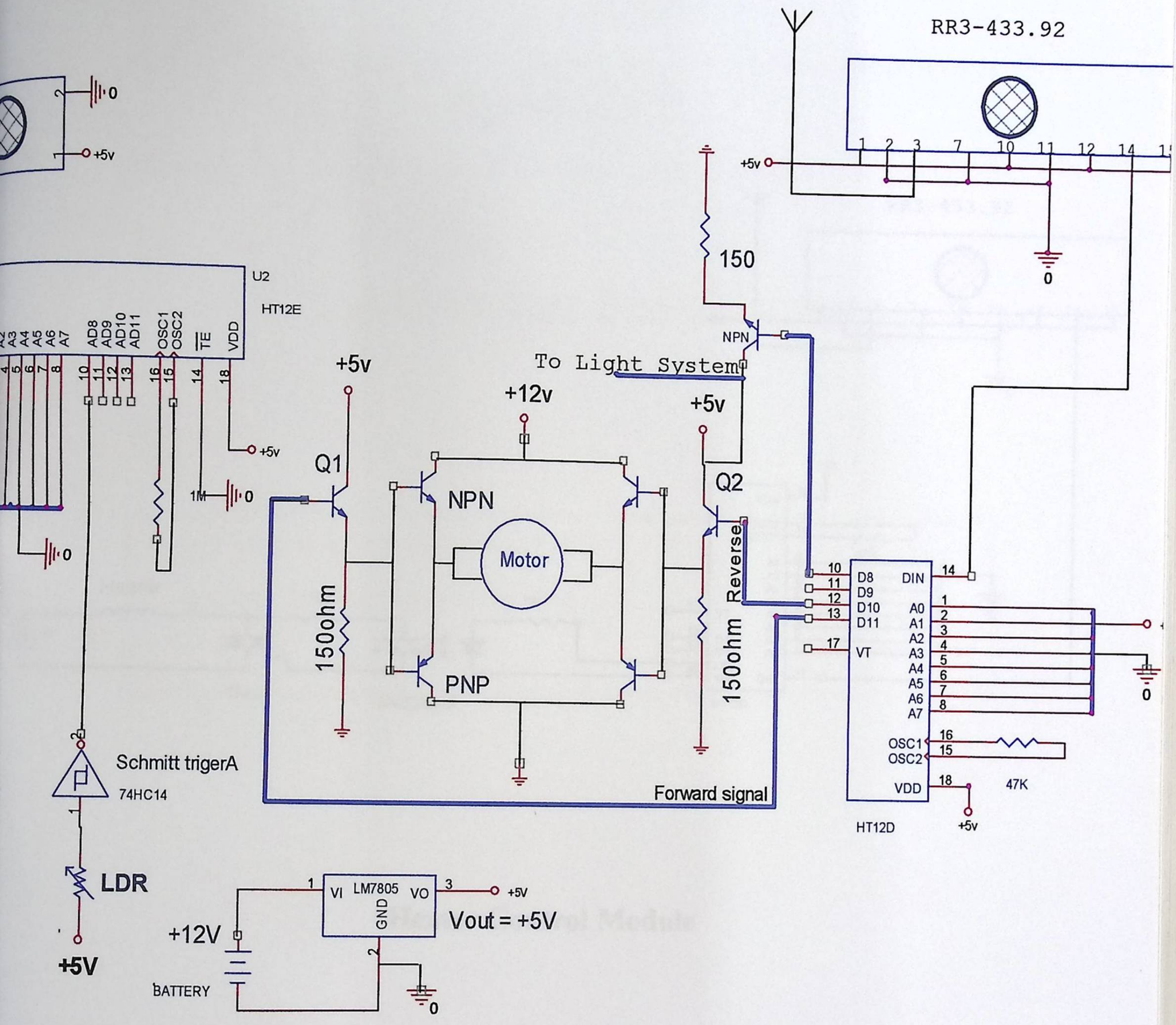
A.4 HEATER MODULE



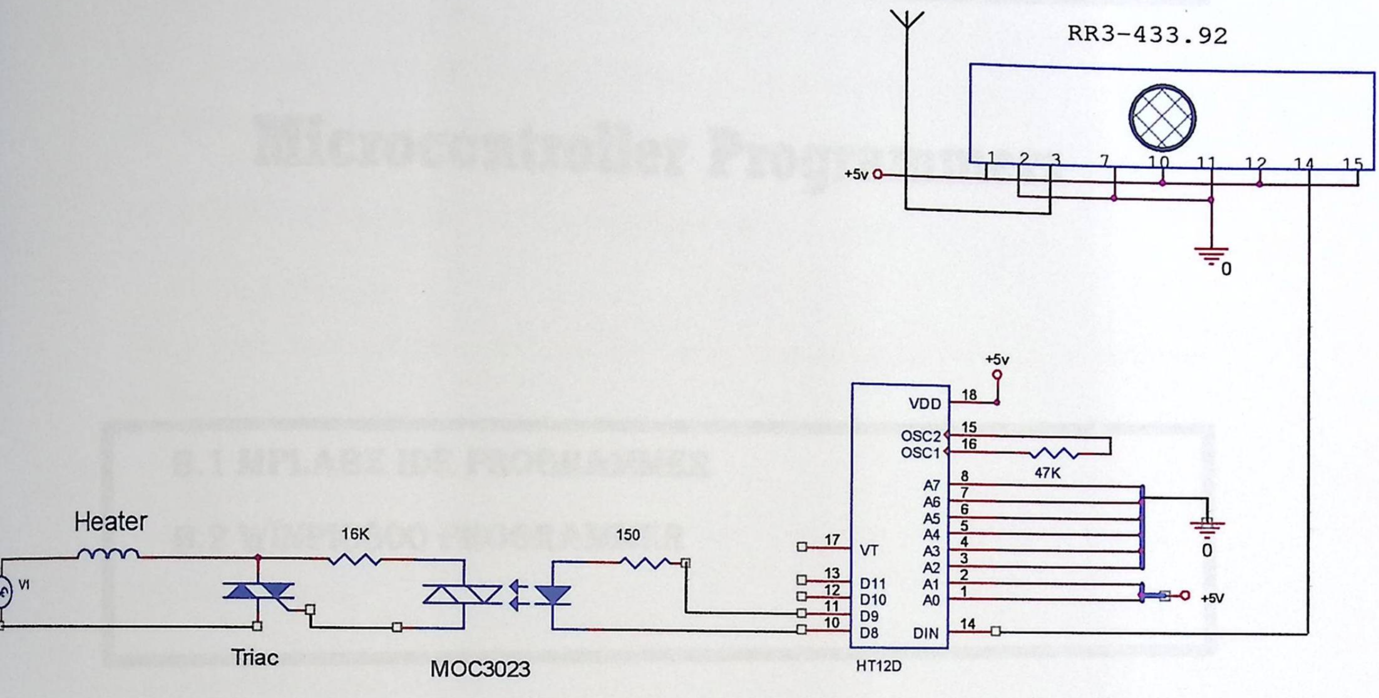
Microcontroller Module



Door Control Module



Window Control Module



Heater Control Module

Appendix B

Microcontroller Programmers

B.1 MPLABE IDE PROGRAMMER

B.2 WINPIC800 PROGRAMMER

1- MPLAB IDE

MPLAB IDE is a software program that runs on a PC to develop applications for Microchip microcontrollers. It is called an Integrated Development Environment, or IDE, because it provides a single integrated "environment" to develop code for embedded microcontrollers.

MPLAB IDE program has many components which they are:

- **Project Manager**

The project manager provides integration and communication between the IDE and the language tools.

- **Editor**

The editor is a full-featured programmer's text editor that also serves as a window into the debugger.

- **Assembler and Linker**

The assembler can be used standalone to assemble a single file, or can be used with the linker to build a project from separate source files, libraries and recompiled objects. The linker is responsible for positioning the compiled code into memory areas of the target microcontroller.

- **Execution Engines**

There are software simulators in MPLAB IDE for all PICmicro and dsPIC devices. These simulators use the PC to simulate the instructions and some peripheral functions of the PICmicro and dsPIC devices. Optional in-circuit emulators and in-circuit debuggers are also available to test code as it runs in the applications hardware.

- **Compiler Language Tools**

MPLAB C17, MPLAB C18 and MPLAB C30 from Microchip provide fully integrated, optimized code. Along with compilers from HI-TECH, IAR, microEngineering Labs, CCS and Byte Craft, they are invoked by the MPLAB IDE project manager to compile code that is automatically loaded into the target debugger for instant testing and verification.

- **Programmers**

PICSTART Plus, PRO MATE II, MPLAB PM3 as well as MPLAB ICD 2 can program code into target microcontrollers. MPLAB IDE offers full control over programming both code and data.

- **In-Circuit Emulators**

MPLAB ICE 2000 and MPLAB ICE 4000 are full-featured emulators for the PICmicro and dsPIC devices. They connect to the PC via I/O ports and allow full control over the operation of microcontroller in the target applications.

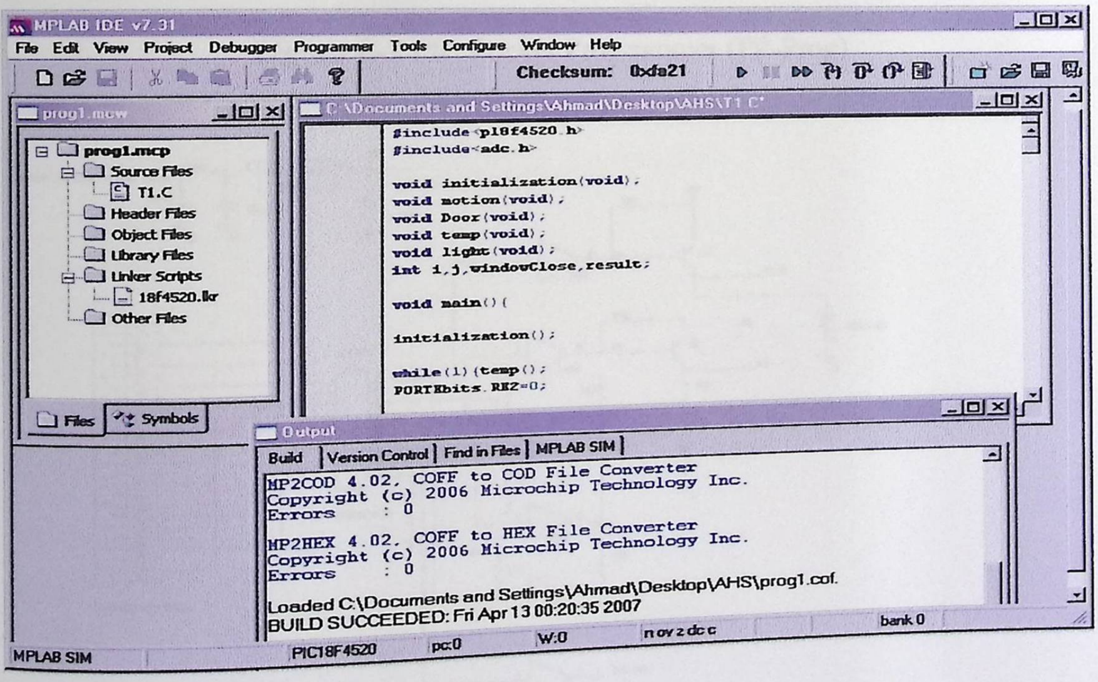


Figure B-1 MPLAB IDE program screen

2- WinPIC800

PIC 18F4520 tested trough its ability to download programs. And to get the newly code into 18F4520 a WinPIC800 programmer used with a PIC Pocket Programmer (PP-Prog) circuit that has a chip slot where PIC 18F4520 put. 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. 6.5 shows the complete assembly of this hardware programmer.

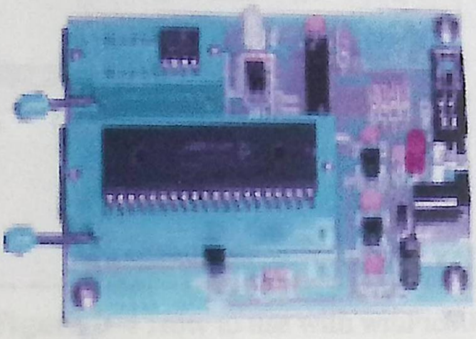


Figure B-2 PIC Pocket Programmer (PP-Prog)

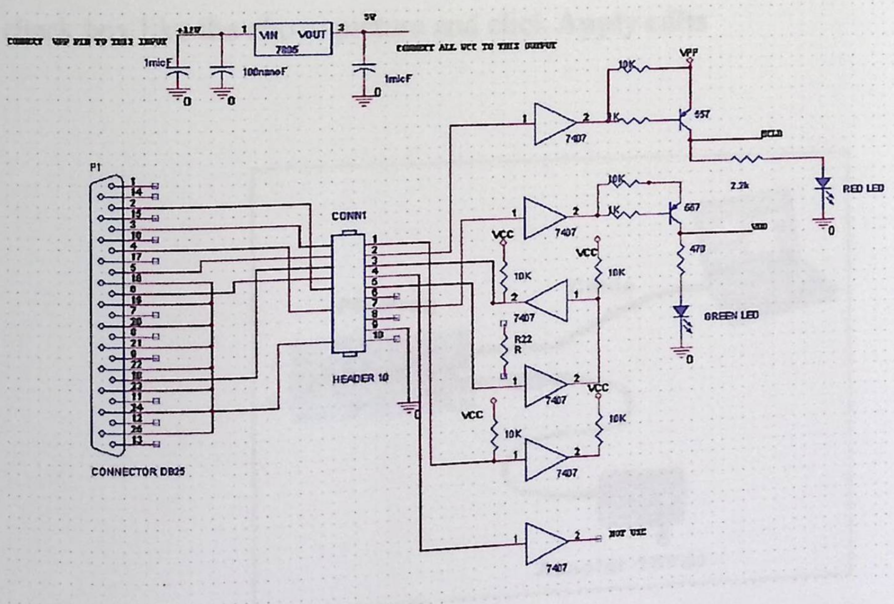


Figure B-3 PPC-Prog schematic

- **How to use with WinPic800:**

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

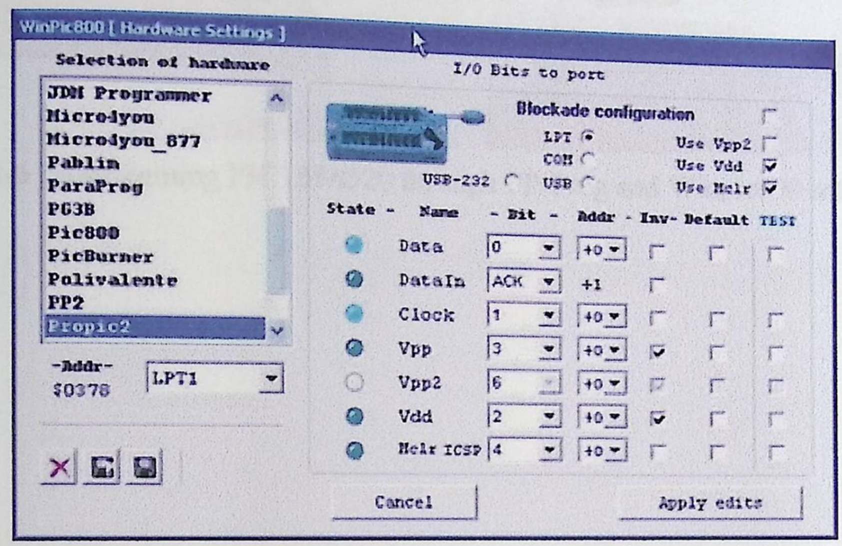


Figure B-4 How to use with winPic800

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

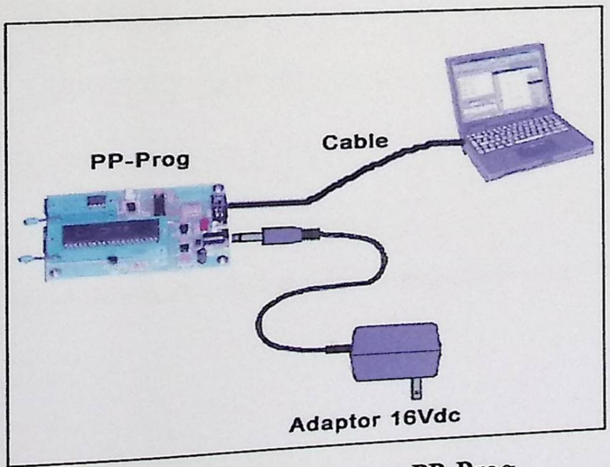


Figure B-5 How to use PP-Prog

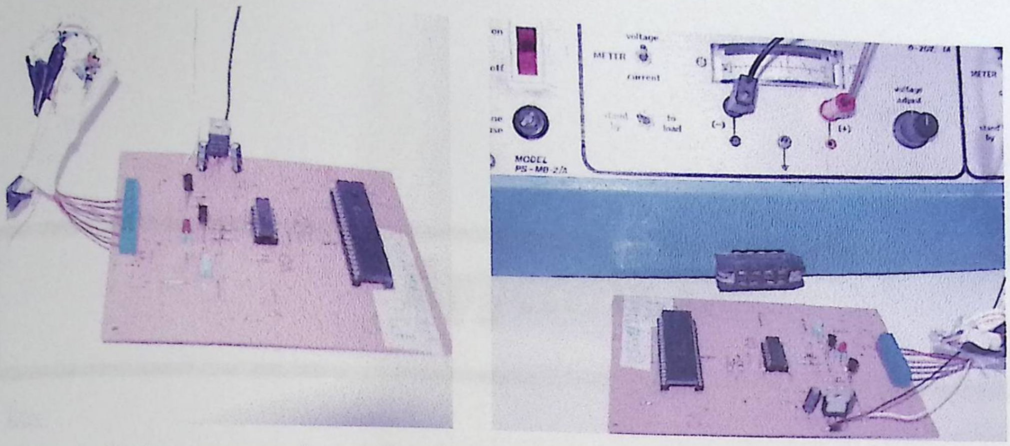


Figure B-6 programming PIC18F4520 through PP-Prog and Winpic800 software program

Appendix C

System Components Data Sheets

- C.1 PIC 18F4520
- C.2 RT4-433.9
- C.3 RR3-433.9
- C.4 HT-12E ENCODER
- C.5 HT-12D DECODER
- C.6 LM-35 TEMPERATURE SENSOR
- C.7 MOC3023 OPTOCOUPLLER
- C.7 BD244 & BD243 TRANSISTOR

MICROCHIP

PIC18FXX2
Data Sheet

High Performance, Enhanced FLASH Microcontrollers with 10-Bit A/D

DS39564B

Note the following details of the code protection feature on PICmicro® MCUs.

- The PICmicro family meets the specifications contained in the Microchip Data Sheet.
- Microchip believes that its family of PICmicro microcontrollers is one of the most secure products of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the PICmicro microcontroller in a manner outside the operating specifications contained in the data sheet. The person doing so may be engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable".
- Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our product.

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Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999 and Mountain View, California in March 2002. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, non-volatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.

PIC18FXX2

28/40-pin High Performance, Enhanced FLASH Microcontrollers with 10-Bit A/D

High Performance RISC CPU:

- C compiler optimized architecture/instruction set
  - Source code compatible with the PIC16 and PIC17 instruction sets
- Linear program memory addressing to 32 Kbytes
- Linear data memory addressing to 1.5 Kbytes

Device	On-Chip Program Memory		On-Chip RAM (bytes)	Data EEPROM (bytes)
	FLASH (bytes)	# Single Word Instructions		
PIC18F242	16K	8192	768	256
PIC18F252	32K	16384	1536	256
PIC18F442	16K	8192	768	256
PIC18F452	32K	16384	1536	256

- Up to 10 MIPs operation:
  - DC - 40 MHz osc./clock input
  - 4 MHz - 10 MHz osc./clock input with PLL active
- 16-bit wide instructions, 8-bit wide data path
- Priority levels for interrupts
- 8 x 8 Single Cycle Hardware Multiplier

Peripheral Features:

- High current sink/source 25 mA/25 mA
- Three external interrupt pins
- Timer0 module: 8-bit/16-bit timer/counter with 8-bit programmable prescaler
- Timer1 module: 16-bit timer/counter
- Timer2 module: 8-bit timer/counter with 8-bit period register (time-base for PWM)
- Timer3 module: 16-bit timer/counter
- Secondary oscillator clock option - Timer1/Timer3
- Two Capture/Compare/PWM (CCP) modules. CCP pins that can be configured as:
  - Capture input: capture is 16-bit, max. resolution 6.25 ns (TCY/16)
  - Compare is 16-bit, max. resolution 100 ns (TCY)
  - PWM output: PWM resolution is 1- to 10-bit, max. PWM freq. @: 8-bit resolution = 156 kHz; 10-bit resolution = 39 kHz
- Master Synchronous Serial Port (MSSP) module, Two modes of operation:
  - 3-wire SPI™ (supports all 4 SPI modes)
  - I^{2}C™ Master and Slave mode

Peripheral Features (Continued):

- Addressable USART module:
  - Supports RS-485 and RS-232
- Parallel Slave Port (PSP) module

Analog Features:

- Compatible 10-bit Analog-to-Digital Converter module (A/D) with:
  - Fast sampling rate
  - Conversion available during SLEEP
  - Linearity ≤ 1 LSb
- Programmable Low Voltage Detection (PLVD)
  - Supports interrupt on-Low Voltage Detection
- Programmable Brown-out Reset (BOR)

Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced FLASH program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory
- FLASH/Data EEPROM Retention: > 40 years
- Self-reprogrammable under software control
- Power-on Reset (POR), Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own On-Chip RC Oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options including:
  - 4X Phase Lock Loop (of primary oscillator)
  - Secondary Oscillator (32 kHz) clock input
- Single supply 5V In-Circuit Serial Programming™ (ICSP™) via two pins
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

- Low power, high speed FLASH/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Industrial and Extended temperature ranges
- Low power consumption:
  - < 1.6 mA typical @ 5V, 4 MHz
  - 25 µA typical @ 3V, 32 kHz
  - < 0.2 µA typical standby current

MICROCHIP

PIC18FXX2

28/40-pin High Performance, Enhanced FLASH Microcontrollers with 10-Bit A/D

High Performance RISC CPU:

- C compiler optimized architecture/instruction set
  - Source code compatible with the PIC16 and PIC17 instruction sets
- Linear program memory addressing to 32 Kbytes
- Linear data memory addressing to 1.5 Kbytes

Device	On-Chip Program Memory		On-Chip RAM (bytes)	Data EEPROM (bytes)
	FLASH (bytes)	# Single Word Instructions		
PIC18F242	16K	8192	768	256
PIC18F252	32K	16384	1536	256
PIC18F442	16K	8192	768	256
PIC18F452	32K	16384	1536	256

- Up to 10 MIPs operation:
  - DC - 40 MHz osc./clock input
  - 4 MHz - 10 MHz osc./clock input with PLL active
- 16-bit wide instructions, 8-bit wide data path
- Priority levels for interrupts
- 8 x 8 Single Cycle Hardware Multiplier

Peripheral Features:

- High current sink/source 25 mA/25 mA
- Three external interrupt pins
- Timer0 module: 8-bit/16-bit timer/counter with 8-bit programmable prescaler
- Timer1 module: 16-bit timer/counter
- Timer2 module: 8-bit timer/counter with 8-bit period register (time-base for PWM)
- Timer3 module: 16-bit timer/counter
- Secondary oscillator clock option - Timer1/Timer3
- Two Capture/Compare/PWM (CCP) modules. CCP pins that can be configured as:
  - Capture input: capture is 16-bit, max. resolution 6.25 ns (TCY/16)
  - Compare is 16-bit, max. resolution 100 ns (TCY)
  - PWM output: PWM resolution is 1- to 10-bit, max. PWM freq. @: 8-bit resolution = 156 kHz; 10-bit resolution = 39 kHz
- Master Synchronous Serial Port (MSSP) module. Two modes of operation:
  - 3-wire SPI™ (supports all 4 SPI modes)
  - I²C™ Master and Slave mode

Peripheral Features (Continued):

- Addressable USART module:
  - Supports RS-485 and RS-232
- Parallel Slave Port (PSP) module

Analog Features:

- Compatible 10-bit Analog-to-Digital Converter module (A/D) with:
  - Fast sampling rate
  - Conversion available during SLEEP
  - Linearity ≤ 1 LSb
- Programmable Low Voltage Detection (PLVD)
  - Supports interrupt on-Low Voltage Detection
- Programmable Brown-out Reset (BOR)

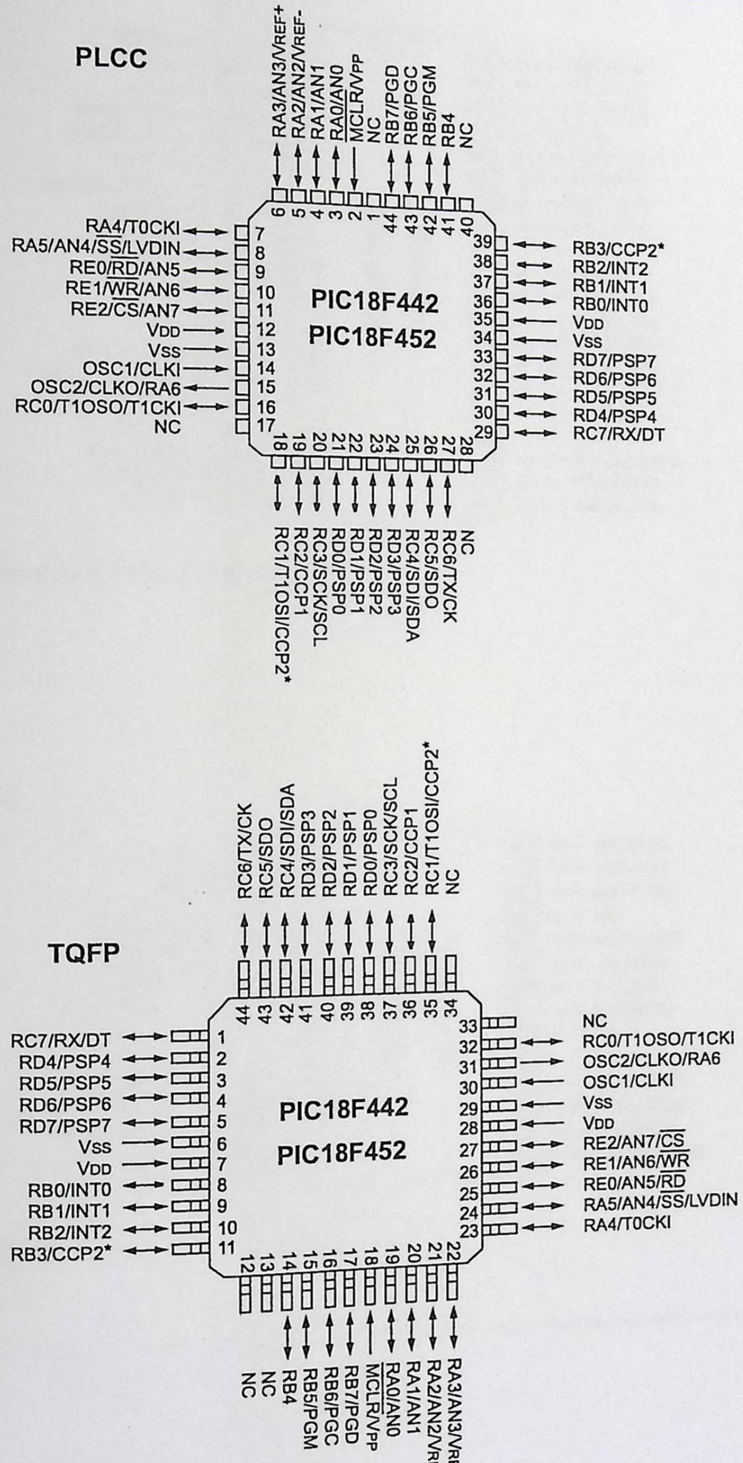
Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced FLASH program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory
- FLASH/Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- Power-on Reset (POR), Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own On-Chip RC Oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options including:
  - 4X Phase Lock Loop (of primary oscillator)
  - Secondary Oscillator (32 kHz) clock input
- Single supply 5V In-Circuit Serial Programming™ (ICSP™) via two pins
- In-Circuit Debug (ICD) via two pins

CMOS Technology:

- Low power, high speed FLASH/EEPROM technology
- [illegible]

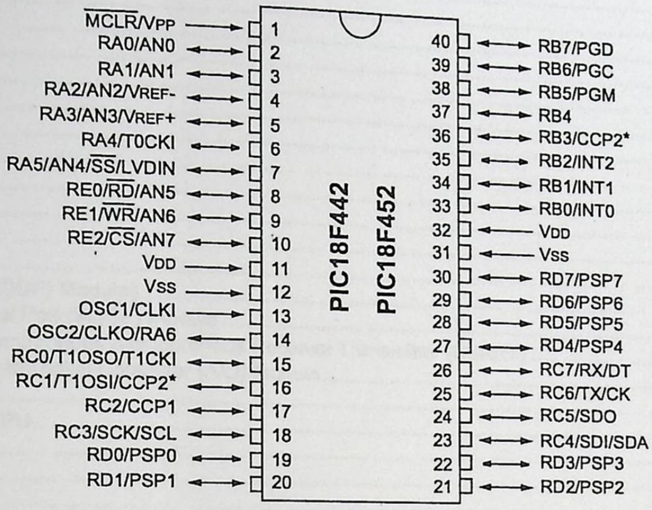
Pin Diagrams



* RB3 is the alternate pin for the CCP2 pin multiplexing.

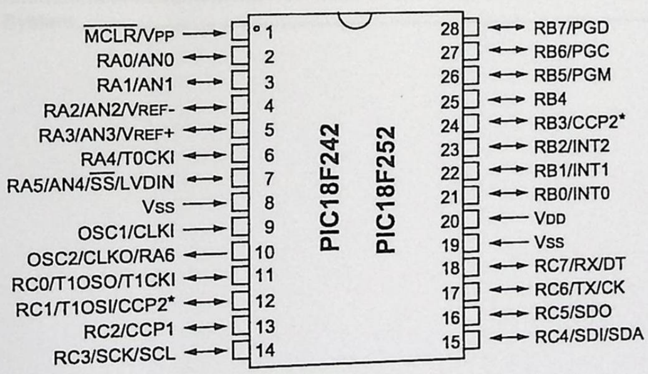
Pin Diagrams (Cont.'d)

DIP



Note: Pin compatible with 40-pin PIC16C7X devices.

DIP, SOIC



* RB3 is the alternate pin for the CCP2 pin multiplexing.

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NOTES:

1.0 DEVICE OVERVIEW

This document contains device specific information for the following devices:

- PIC18F242
- PIC18F252
- PIC18F442
- PIC18F452

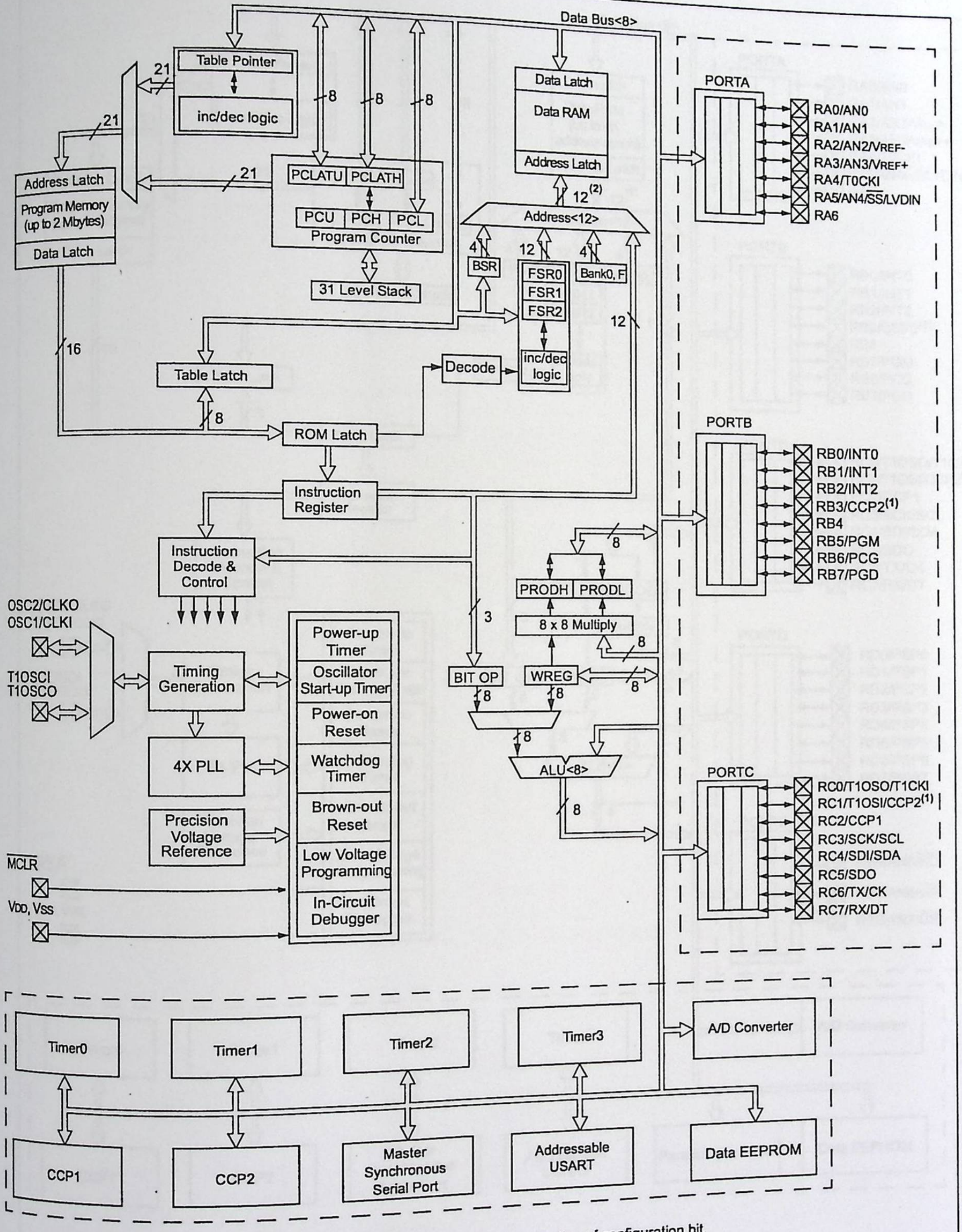
These devices come in 28-pin and 40/44-pin packages. The 28-pin devices do not have a Parallel Slave Port (PSP) implemented and the number of Analog-to-Digital (A/D) converter input channels is reduced to 5. An overview of features is shown in Table 1-1.

The following two figures are device block diagrams sorted by pin count: 28-pin for Figure 1-1 and 40/44-pin for Figure 1-2. The 28-pin and 40/44-pin pinouts are listed in Table 1-2 and Table 1-3, respectively.

TABLE 1-1: DEVICE FEATURES

Features	PIC18F242	PIC18F252	PIC18F442	PIC18F452
Operating Frequency	DC - 40 MHz	DC - 40 MHz	DC - 40 MHz	DC - 40 MHz
Program Memory (Bytes)	16K	32K	16K	32K
Program Memory (Instructions)	8192	16384	8192	16384
Data Memory (Bytes)	768	1536	768	1536
Data EEPROM Memory (Bytes)	256	256	256	256
Interrupt Sources	17	17	18	18
I/O Ports	Ports A, B, C	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C, D, E
Timers	4	4	4	4
Capture/Compare/PWM Modules	2	2	2	2
Serial Communications	MSSP, Addressable USART	MSSP, Addressable USART	MSSP, Addressable USART	MSSP, Addressable USART
Parallel Communications	—	—	PSP	PSP
10-bit Analog-to-Digital Module	5 input channels	5 input channels	8 input channels	8 input channels
RESETS (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST)
Programmable Low Voltage Detect	Yes	Yes	Yes	Yes
Programmable Brown-out Reset	Yes	Yes	Yes	Yes
Instruction Set	75 Instructions	75 Instructions	75 Instructions	75 Instructions
Packages	28-pin DIP 28-pin SOIC	28-pin DIP 28-pin SOIC	40-pin DIP 44-pin PLCC 44-pin TQFP	40-pin DIP 44-pin PLCC 44-pin TQFP

FIGURE 1-1: PIC18F2X2 BLOCK DIAGRAM

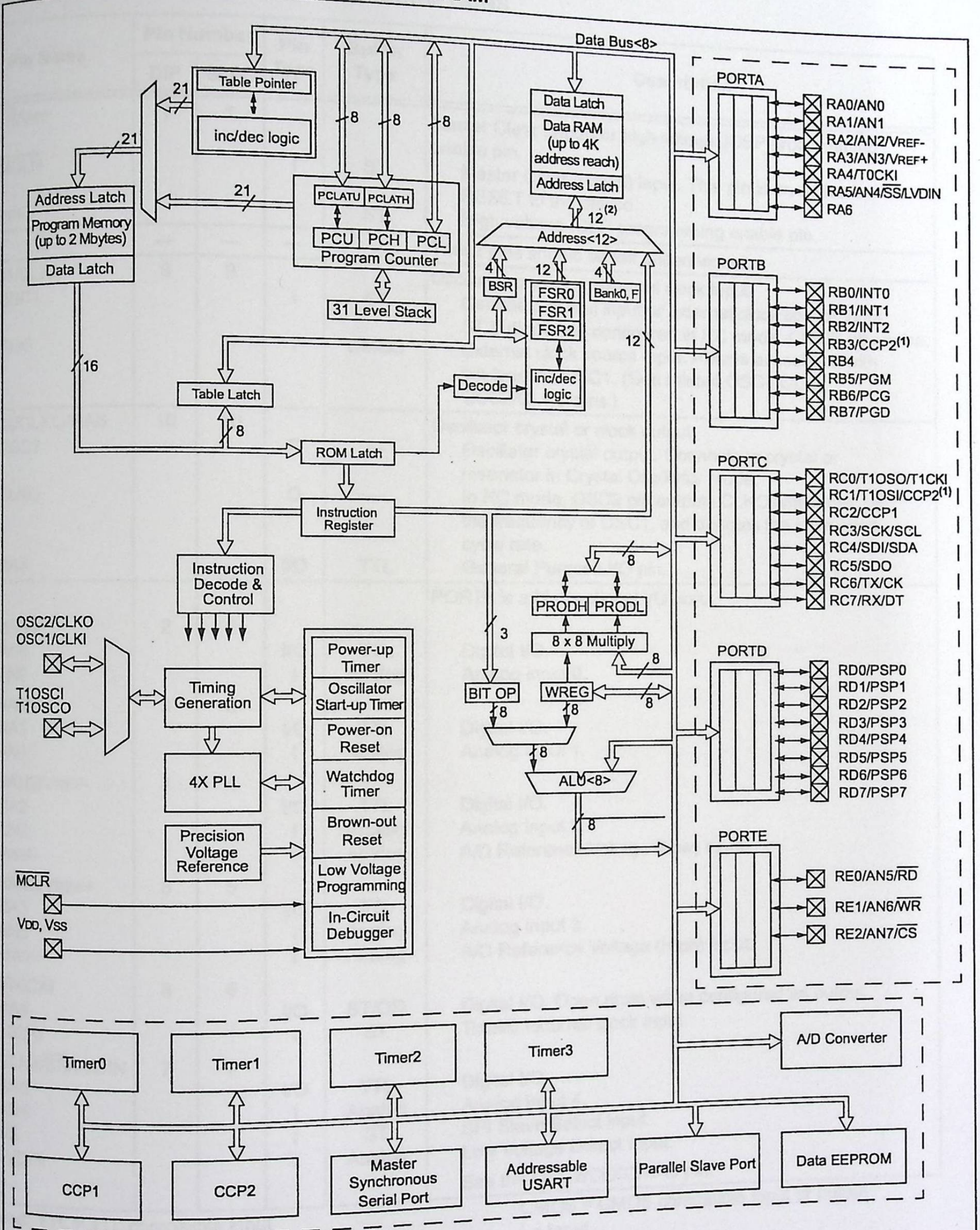


Note 1: Optional multiplexing of CCP2 input/output with RB3 is enabled by selection of configuration bit.

2: The high order bits of the Direct Address for the RAM are from the BSR register (except for the MOVFF instruction).

3: Many of the general purpose I/O pins are multiplexed with one or more peripheral module functions. The multiplexing combinations are device dependent.

FIGURE 1-2: PIC18F4X2 BLOCK DIAGRAM



Note 1: Optional multiplexing of CCP2 input/output with RB3 is enabled by selection of configuration bit.

2: The high order bits of the Direct Address for the RAM are from the BSR register (except for the `MOVFF` instruction).

3: Many of the general purpose I/O pins are multiplexed with one or more peripheral module functions. The multiplexing combinations are device dependent.

TABLE 1-2: PIC18F2X2 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number		Pin Type	Buffer Type	Description
	DIP	SOIC			
$\overline{\text{MCLR}}$/VPP	1	1			Master Clear (input) or high voltage ICSP programming enable pin.
$\overline{\text{MCLR}}$			I	ST	Master Clear (Reset) input. This pin is an active low RESET to the device.
VPP			I	ST	High voltage ICSP programming enable pin.
NC	—	—	—	—	These pins should be left unconnected.
OSC1/CLKI	9	9			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.)
OSC2/CLKO/RA6	10	10			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.
					PORTA is a bi-directional I/O port.
RA0/AN0	2	2			
RA0			I/O	TTL	Digital I/O.
AN0			I	Analog	Analog input 0.
RA1/AN1	3	3			
RA1			I/O	TTL	Digital I/O.
AN1			I	Analog	Analog input 1.
RA2/AN2/VREF-	4	4			
RA2			I/O	TTL	Digital I/O.
AN2			I	Analog	Analog input 2.
VREF-			I	Analog	A/D Reference Voltage (Low) input.
RA3/AN3/VREF+	5	5			
RA3			I/O	TTL	Digital I/O.
AN3			I	Analog	Analog input 3.
VREF+			I	Analog	A/D Reference Voltage (High) input.
RA4/T0CKI	6	6			
RA4			I/O	ST/OD	Digital I/O. Open drain when configured as output.
T0CKI			I	ST	Timer0 external clock input.
RA5/AN4/$\overline{\text{SS}}$/LVDIN	7	7			
RA5			I/O	TTL	Digital I/O.
AN4			I	Analog	Analog input 4.
$\overline{\text{SS}}$			I	ST	SPI Slave Select input.
LVDIN			I	Analog	Low Voltage Detect Input.
RA6					See the OSC2/CLKO/RA6 pin.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to VDD)
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-2: PIC18F2X2 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number		Pin Type	Buffer Type	Description
	DIP	SOIC			
					PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/INT0	21	21			
RB0			I/O	TTL	Digital I/O.
INT0			I	ST	External Interrupt 0.
RB1/INT1	22	22			
RB1			I/O	TTL	
INT1			I	ST	External Interrupt 1.
RB2/INT2	23	23			
RB2			I/O	TTL	Digital I/O.
INT2			I	ST	External Interrupt 2.
RB3/CCP2	24	24			
RB3			I/O	TTL	Digital I/O.
CCP2			I/O	ST	Capture2 input, Compare2 output, PWM2 output.
RB4	25	25	I/O	TTL	Digital I/O. Interrupt-on-change pin.
RB5/PGM	26	26			
RB5			I/O	TTL	Digital I/O. Interrupt-on-change pin.
PGM			I/O	ST	Low Voltage ICSP programming enable pin.
RB6/PGC	27	27			
RB6			I/O	TTL	Digital I/O. Interrupt-on-change pin.
PGC			I/O	ST	In-Circuit Debugger and ICSP programming clock pin.
RB7/PGD	28	28			
RB7			I/O	TTL	Digital I/O. Interrupt-on-change pin.
PGD			I/O	ST	In-Circuit Debugger and ICSP programming data pin.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to VDD)
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-2: PIC18F2X2 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number DIP	Pin Number SOIC	Pin Type	Buffer Type	Description
					PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	11	11			
RC0			I/O	ST	Digital I/O.
T1OSO			O	—	Timer1 oscillator output.
T1CKI			I	ST	Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2	12	12			
RC1			I/O	ST	Digital I/O.
T1OSI			I	CMOS	Timer1 oscillator input.
CCP2			I/O	ST	Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	13	13			
RC2			I/O	ST	Digital I/O.
CCP1			I/O	ST	Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL	14	14			
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	15	15			
RC4			I/O	ST	Digital I/O.
SDI			I	ST	SPI Data In.
SDA			I/O	ST	I²C Data I/O.
RC5/SDO	16	16			
RC5			I/O	ST	Digital I/O.
SDO			O	—	SPI Data Out.
RC6/TX/CK	17	17			
RC6			I/O	ST	Digital I/O.
TX			O	—	USART Asynchronous Transmit.
CK			I/O	ST	USART Synchronous Clock (see related RX/DT).
RC7/RX/DT	18	18			
RC7			I/O	ST	Digital I/O.
RX			I	ST	USART Asynchronous Receive.
DT			I/O	ST	USART Synchronous Data (see related TX/CK).
VSS	8, 19	8, 19	P	—	Ground reference for logic and I/O pins.
VDD	20	20	P	—	Positive supply for logic and I/O pins.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to VDD)
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-3: PIC18F4X2 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number DIP	PLCC	TQFP	Pin Type	Buffer Type	Description
$\overline{MCLR}$/VPP	1	2	18			Master Clear (input) or high voltage ICSP programming enable pin.
$\overline{MCLR}$				I	ST	Master Clear (Reset) input. This pin is an active low RESET to the device.
VPP				I	ST	High voltage ICSP programming enable pin.
NC	—	—	—	—	—	These pins should be left unconnected.
OSC1/CLKI	13	14	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, CMOS otherwise.
CLKI				I	CMOS	External clock source input. Always associated with pin function OSC1. (See related OSC1/CLKI, OSC2/CLKO pins.)
OSC2/CLKO/RA6	14	15	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.
						PORTA is a bi-directional I/O port.
RA0/AN0	2	3	19			
RA0				I/O	TTL	Digital I/O.
AN0				I	Analog	Analog input 0.
RA1/AN1	3	4	20			
RA1				I/O	TTL	Digital I/O.
AN1				I	Analog	Analog input 1.
RA2/AN2/VREF-	4	5	21			
RA2				I/O	TTL	Digital I/O.
AN2				I	Analog	Analog input 2.
VREF-				I	Analog	A/D Reference Voltage (Low) input.
RA3/AN3/VREF+	5	6	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	6	7	23			
RA4				I/O	ST/OD	Digital I/O. Open drain when configured as output.
T0CKI				I	ST	Timer0 external clock input.
RA5/AN4/$\overline{SS}$/LVDIN	7	8	24			
RA5				I/O	TTL	Digital I/O.
AN4				I	Analog	Analog input 4.
$\overline{SS}$				I	ST	SPI Slave Select input.
LVDIN				I	Analog	Low Voltage Detect Input.
RA6						(See the OSC2/CLKO/RA6 pin.)

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to VDD)
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-3: PIC18F4X2 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	DIP	PLCC	TQFP			
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-ups on all inputs.
RB0/INT0	33	36	8			
RB0				I/O	TTL	Digital I/O.
INT0				I	ST	External Interrupt 0.
RB1/INT1	34	37	9			
RB1				I/O	TTL	
INT1				I	ST	External Interrupt 1.
RB2/INT2	35	38	10			
RB2				I/O	TTL	Digital I/O.
INT2				I	ST	External Interrupt 2.
RB3/CCP2	36	39	11			
RB3				I/O	TTL	Digital I/O.
CCP2				I/O	ST	Capture2 input, Compare2 output, PWM2 output.
RB4	37	41	14	I/O	TTL	Digital I/O. Interrupt-on-change pin.
RB5/PGM	38	42	15			
RB5				I/O	TTL	Digital I/O. Interrupt-on-change pin.
PGM				I/O	ST	Low Voltage ICSP programming enable pin.
RB6/PGC	39	43	16			
RB6				I/O	TTL	Digital I/O. Interrupt-on-change pin.
PGC				I/O	ST	In-Circuit Debugger and ICSP programming clock pin.
RB7/PGD	40	44	17			
RB7				I/O	TTL	Digital I/O. Interrupt-on-change pin.
PGD				I/O	ST	In-Circuit Debugger and ICSP programming data pin.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to VDD)
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-3: PIC18F4X2 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	DIP	PLCC	TQFP			
						PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	15	16	32			
RC0				I/O	ST	Digital I/O.
T1OSO				O	—	Timer1 oscillator output.
T1CKI				I	ST	Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2	16	18	35			
RC1				I/O	ST	Digital I/O.
T1OSI				I	CMOS	Timer1 oscillator input.
CCP2				I/O	ST	Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1	17	19	36			
RC2				I/O	ST	Digital I/O.
CCP1				I/O	ST	Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL	18	20	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 I^{2}C mode.
RC4/SDI/SDA	23	25	42			
RC4				I/O	ST	Digital I/O.
SDI				I	ST	SPI Data In.
SDA				I/O	ST	I^{2}C Data I/O.
RC5/SDO	24	26	43			
RC5				I/O	ST	Digital I/O.
SDO				O	—	SPI Data Out.
RC6/TX/CK	25	27	44			
RC6				I/O	ST	Digital I/O.
TX				O	—	USART Asynchronous Transmit.
CK				I/O	ST	USART Synchronous Clock (see related RX/DT).
RC7/RX/DT	26	29	1			
RC7				I/O	ST	Digital I/O.
RX				I	ST	USART Asynchronous Receive.
DT				I/O	ST	USART Synchronous Data (see related TX/CK).

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to V_{DD})
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-3: PIC18F4X2 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	DIP	PLCC	TQFP			
						PORTD is a bi-directional 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	21	38	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD1/PSP1	20	22	39	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD2/PSP2	21	23	40	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD3/PSP3	22	24	41	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD4/PSP4	27	30	2	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD5/PSP5	28	31	3	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD6/PSP6	29	32	4	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD7/PSP7	30	33	5	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
						PORTE is a bi-directional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	I/O		
RE0					ST	Digital I/O.
$\overline{RD}$					TTL	Read control for parallel slave port (see also $\overline{WR}$ and $\overline{CS}$ pins).
AN5					Analog	Analog input 5.
RE1/$\overline{WR}$/AN6	9	10	26	I/O		
RE1					ST	Digital I/O.
$\overline{WR}$					TTL	Write control for parallel slave port (see $\overline{CS}$ and $\overline{RD}$ pins).
AN6					Analog	Analog input 6.
RE2/$\overline{CS}$/AN7	10	11	27	I/O		
RE2					ST	Digital I/O.
$\overline{CS}$					TTL	Chip Select control for parallel slave port (see related $\overline{RD}$ and $\overline{WR}$).
AN7					Analog	Analog input 7.
VSS	12, 31	13, 34	6, 29	P	—	Ground reference for logic and I/O pins.
VDD	11, 32	12, 35	7, 28	P	—	Positive supply for logic and I/O pins.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to VDD)
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-3: PIC18F4X2 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number DIP	Pin Number PLCC	Pin Number TQFP	Pin Type	Buffer Type	Description
						PORTD is a bi-directional 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	21	38	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD1/PSP1	20	22	39	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD2/PSP2	21	23	40	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD3/PSP3	22	24	41	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD4/PSP4	27	30	2	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD5/PSP5	28	31	3	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD6/PSP6	29	32	4	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD7/PSP7	30	33	5	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
						PORTE is a bi-directional I/O port.
RE0/$\overline{\text{RD}}$/AN5	8	9	25	I/O		
RE0					ST	Digital I/O.
$\overline{\text{RD}}$					TTL	Read control for parallel slave port (see also $\overline{\text{WR}}$ and $\overline{\text{CS}}$ pins).
AN5					Analog	Analog input 5.
RE1/$\overline{\text{WR}}$/AN6	9	10	26	I/O		
RE1					ST	Digital I/O.
$\overline{\text{WR}}$					TTL	Write control for parallel slave port (see $\overline{\text{CS}}$ and $\overline{\text{RD}}$ pins).
AN6					Analog	Analog input 6.
RE2/$\overline{\text{CS}}$/AN7	10	11	27	I/O		
RE2					ST	Digital I/O.
$\overline{\text{CS}}$					TTL	Chip Select control for parallel slave port (see related $\overline{\text{RD}}$ and $\overline{\text{WR}}$).
AN7					Analog	Analog input 7.
VSS	12, 31	13, 34	6, 29	P	—	Ground reference for logic and I/O pins.
VDD	11, 32	12, 35	7, 28	P	—	Positive supply for logic and I/O pins.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to VDD)
CMOS = CMOS compatible input or output
I = Input
P = Power

TABLE 1-3: PIC18F4X2 PINOUT I/O DESCRIPTIONS (CONTINUED)

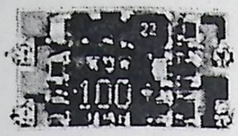
Pin Name	Pin Number			Pin Type	Buffer Type	Description
	DIP	PLCC	TQFP			
						PORTD is a bi-directional I/O port, or a Parallel Slave Port (PSP) for interfacing to a microprocessor port. These pins have TTL input buffers when PSP module is enabled.
RD0/PSP0	19	21	38	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD1/PSP1	20	22	39	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD2/PSP2	21	23	40	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD3/PSP3	22	24	41	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD4/PSP4	27	30	2	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD5/PSP5	28	31	3	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD6/PSP6	29	32	4	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
RD7/PSP7	30	33	5	I/O	ST TTL	Digital I/O. Parallel Slave Port Data.
						PORTE is a bi-directional I/O port.
RE0/$\overline{RD}$/AN5	8	9	25	I/O		
RE0					ST	Digital I/O.
$\overline{RD}$					TTL	Read control for parallel slave port (see also $\overline{WR}$ and $\overline{CS}$ pins).
AN5					Analog	Analog input 5.
RE1/$\overline{WR}$/AN6	9	10	26	I/O		
RE1					ST	Digital I/O.
$\overline{WR}$					TTL	Write control for parallel slave port (see $\overline{CS}$ and $\overline{RD}$ pins).
AN6					Analog	Analog input 6.
RE2/$\overline{CS}$/AN7	10	11	27	I/O		
RE2					ST	Digital I/O.
$\overline{CS}$					TTL	Chip select control for parallel slave port (see related $\overline{RD}$ and $\overline{WR}$).
AN7					Analog	Analog input 7.
V_{SS}	12, 31	13, 34	6, 29	P	—	Ground reference for logic and I/O pins.
V_{DD}	11, 32	12, 35	7, 28	P	—	Positive supply for logic and I/O pins.

Legend: TTL = TTL compatible input
ST = Schmitt Trigger input with CMOS levels
O = Output
OD = Open Drain (no P diode to V_{DD})

telecontrolli

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)

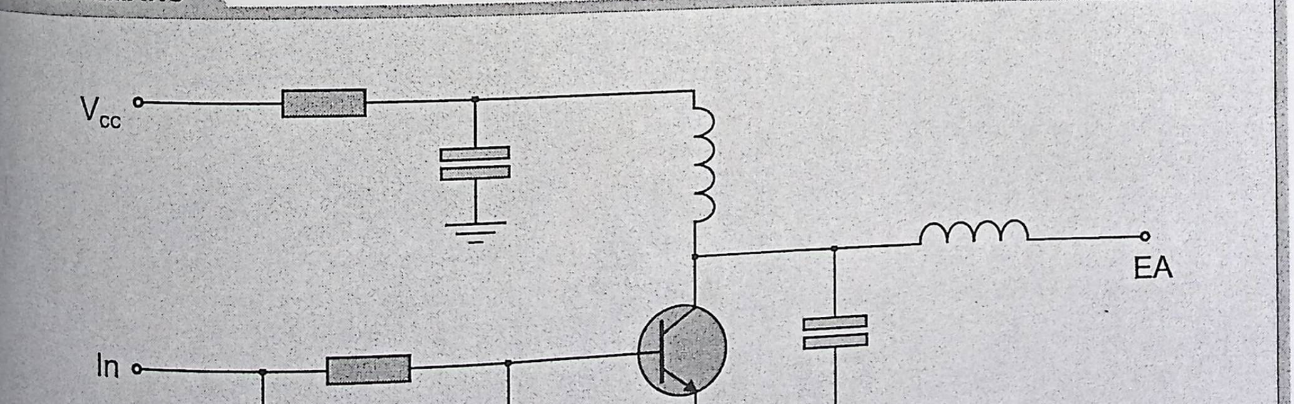
ures

igh Reliability
IL Package

Applications

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

CUIT SCHEMATIC



Electrical Characteristics

Ta = 25°C unless otherwise specified

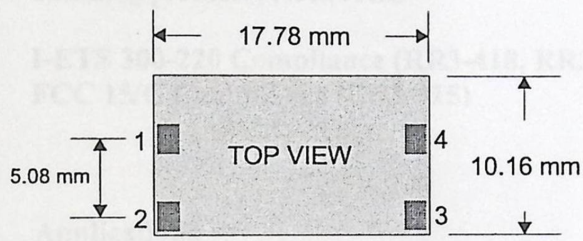
	CHARACTERISTICS	MIN	TYP	MAX	UNIT
V_{CC}	Supply Voltage	2		14	VDC
I_s	Supply Current (Vcc=5V IN=1KHz Square Wawe)		4		mA
F_W	Working Frequency	303.8		433.92	MHz
P_O	RF Output Power into 50Ω (Vi=5V, Vcc=12V)		7	10	dBm
	Harmonic Spurious Emission		-30		dBc
V_{IH}	Input High Voltage	2		V_{CC}	V
	Max Data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

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

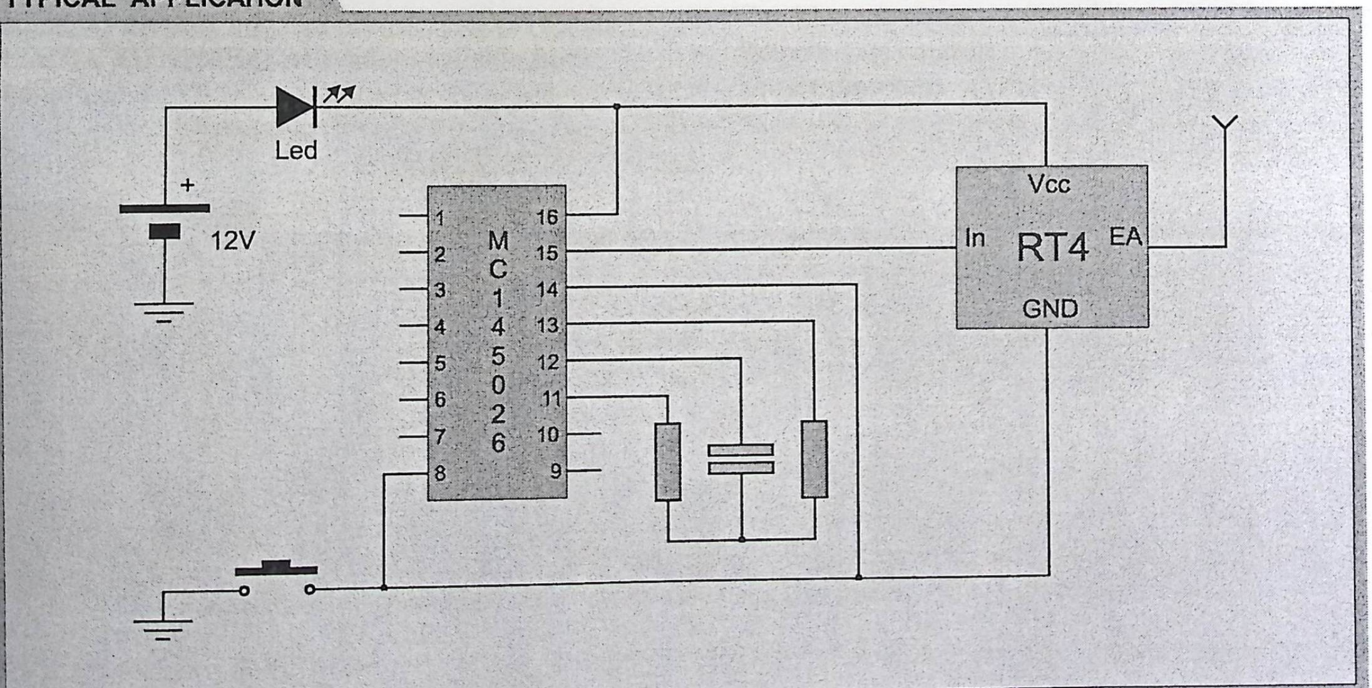
Pin Description

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

Mechanical Dimensions



TYPICAL APPLICATION



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HEAD OFFICE & PLANT

Via Naz. delle Puglie 177
80026 Casoria (NA), Italy
Tel: +39 081 7599033
Fax: +39 081 7596494

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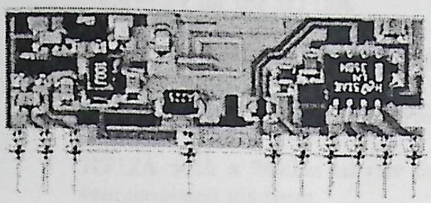
RR3-XXX

Super Regenerative Radio Receiver With Laser Trimmed Inductor



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)

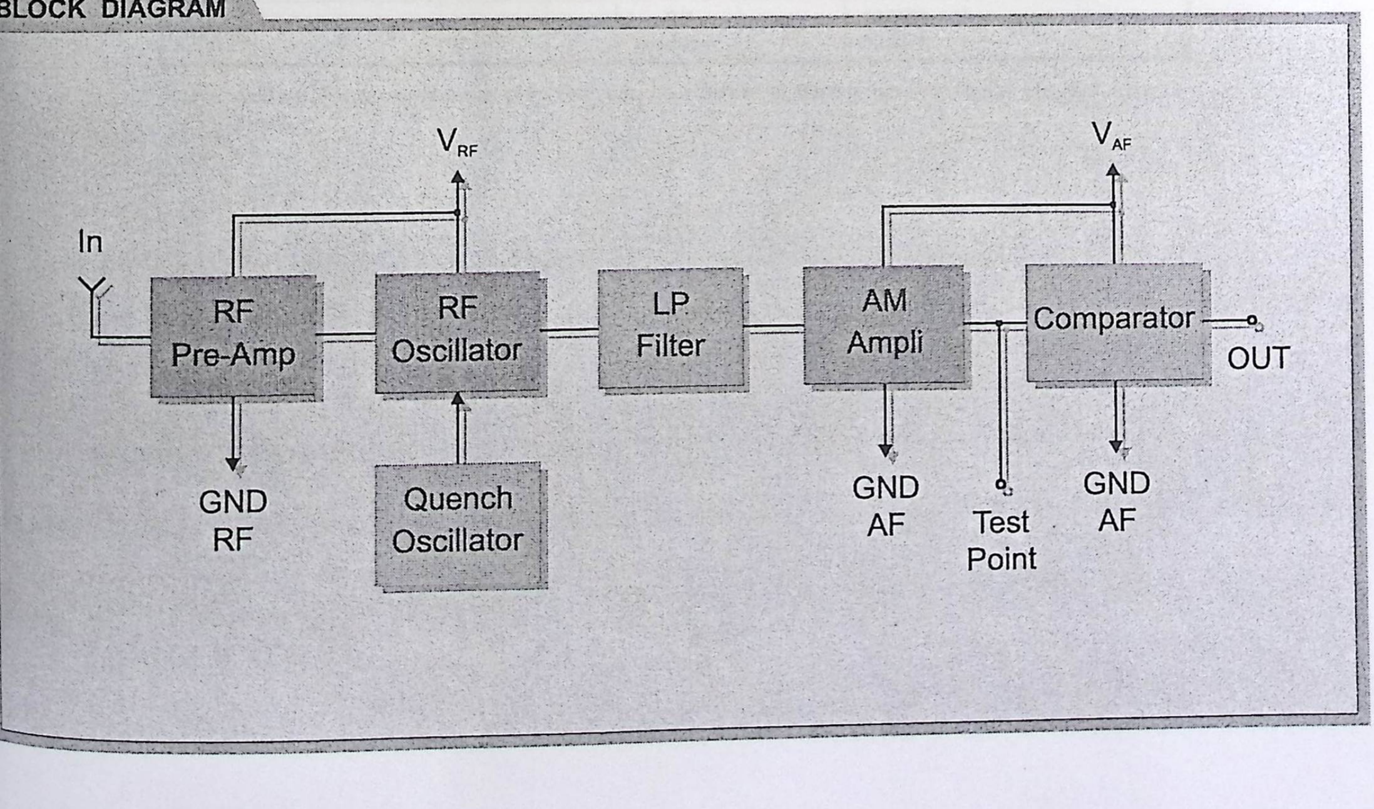
XX: custom-specified working frequency (200 ÷ 450 MHz)

tandard European and U.S. frequencies (315MHz, 18MHz, 433.92MHz) are readly available from ock.

Applications

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

BLOCK DIAGRAM



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

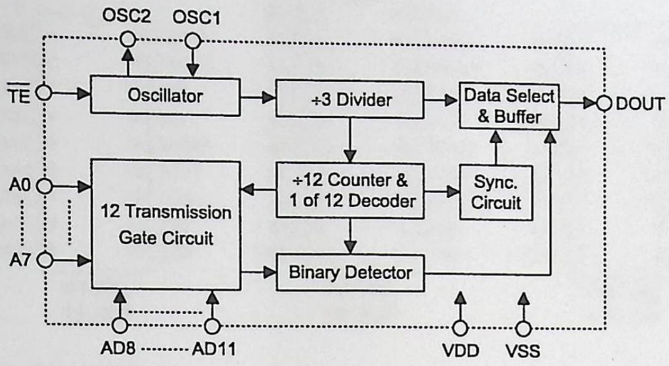
Part No. \ Function	Address No.	Address/ Data No.	Data No.	Oscillator	Trigger	Package	Carrier Output	Negative Polarity
HT12A	8	0	4	455kHz resonator	D8~D11	18 DIP 20 SOP	38kHz	No
HT12E	8	4	0	RC oscillator	$\overline{TE}$	18 DIP 20 SOP	No	No

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

Block Diagram

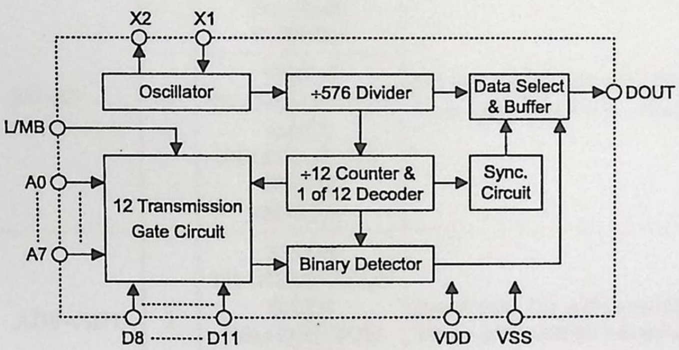
TE trigger

HT12E



DATA trigger

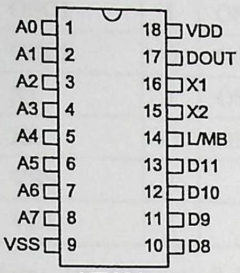
HT12A



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

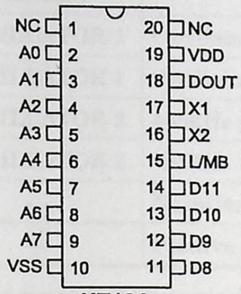
Pin Assignment

8-Address 4-Data



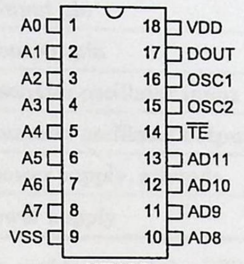
HT12A –18 DIP

8-Address 4-Data



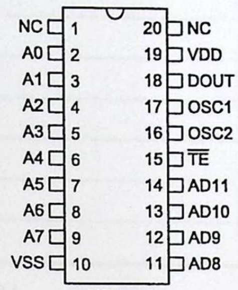
HT12A – 20 SOP

8-Address 4-Address/Data



HT12E –18 DIP

8-Address 4-Address/Data



HT12E – 20 SOP

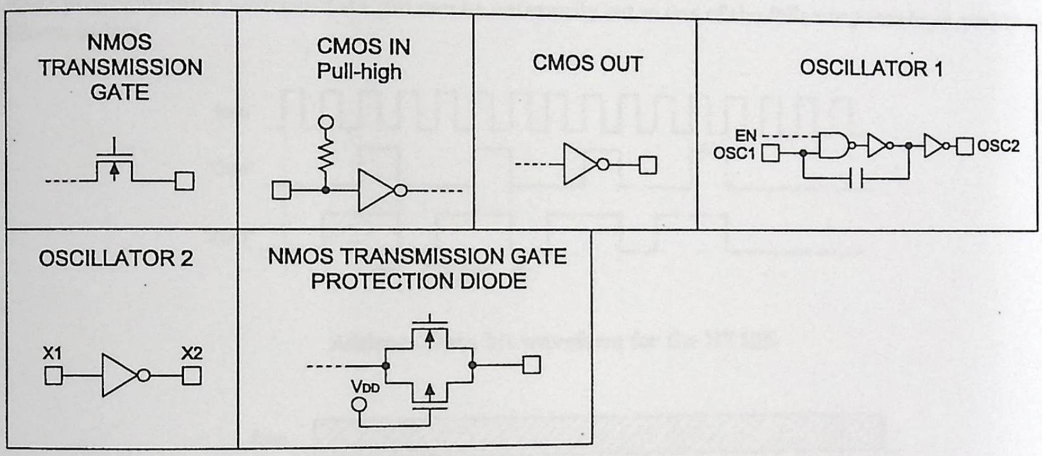
Pin Description

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

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

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

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

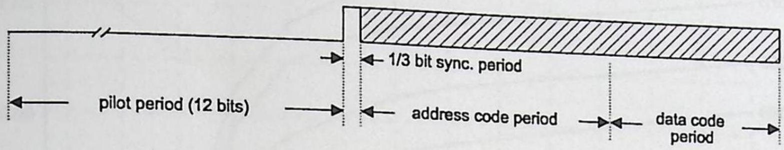
Storage Temperature................–50°C to 125°C

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.

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.

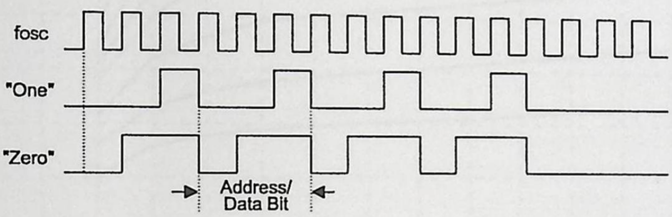
An information word consists of 4 periods as illustrated below.



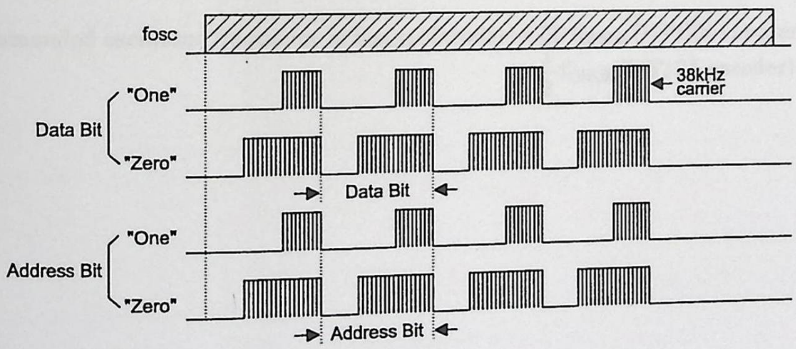
Composition of information

Address/data waveform

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

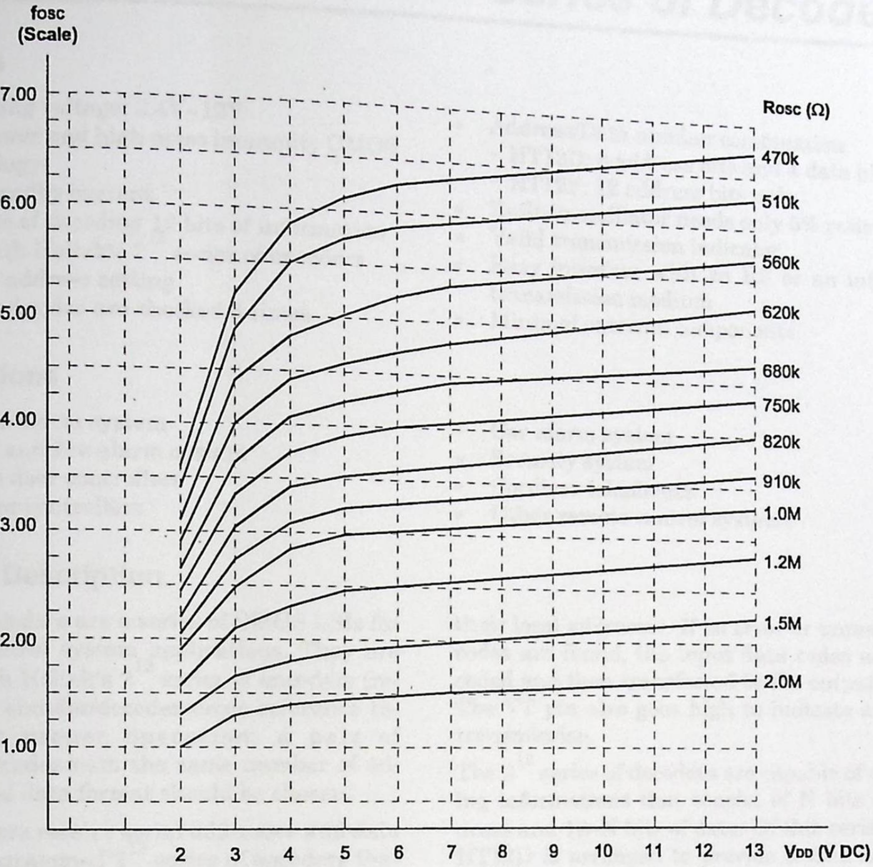


Address/Data bit waveform for the HT12E



Address/Data bit waveform for the HT12A

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)

HOLTEK

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.

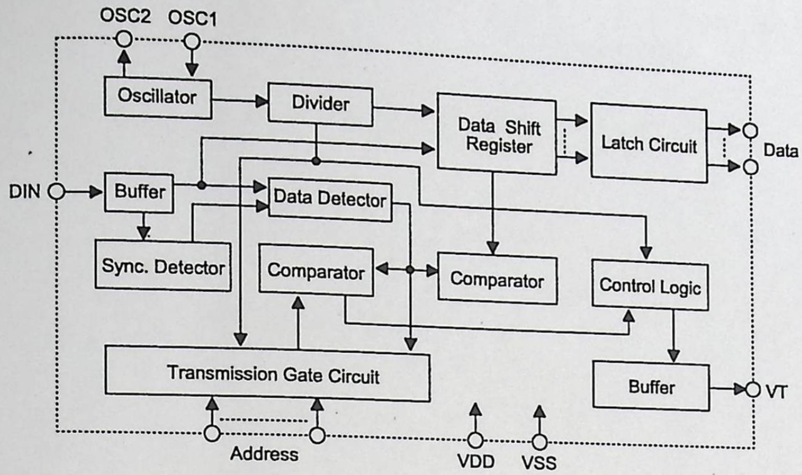
Selection Table

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.

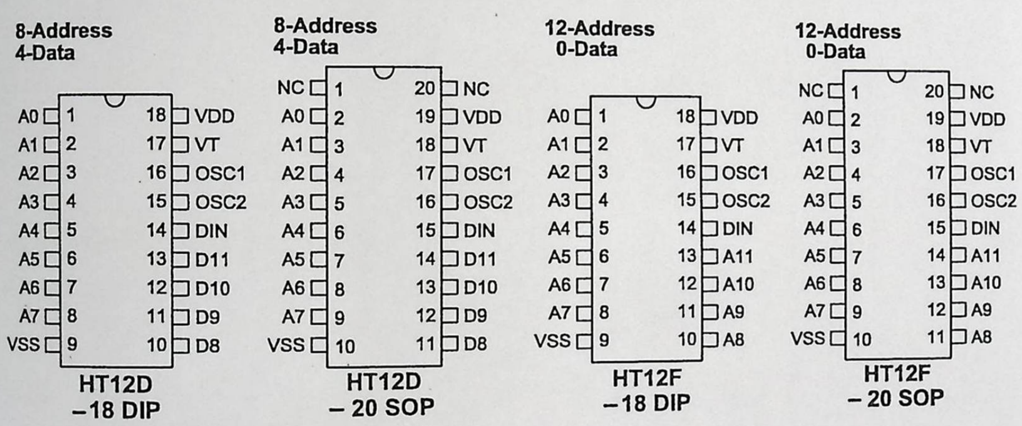
VT can be used as a momentary data output.

Block Diagram



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

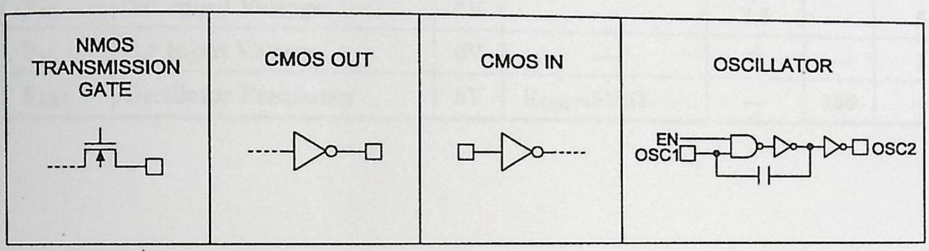
Pin Assignment



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.

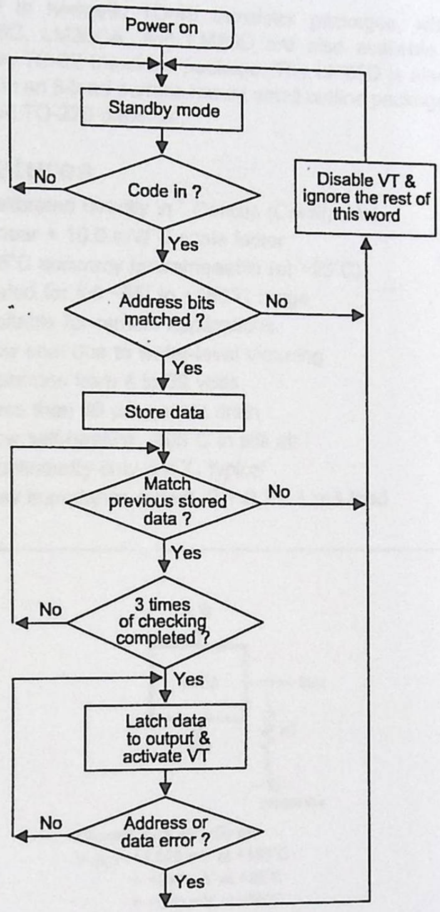
Output type

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.



National Semiconductor

November 2000

LM35
Precision Centigrade Temperature Sensors

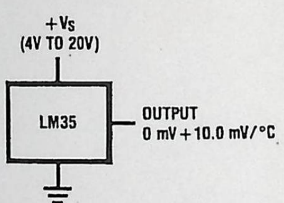
General Description

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼˚C at room temperature and ±¾˚C over a full −55 to +150˚C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a −55˚ to +150˚C temperature range, while the LM35C is rated for a −40˚ to +110˚C range (−10˚ with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

Features

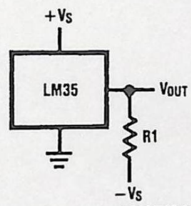
- Calibrated directly in ˚ Celsius (Centigrade)
- Linear + 10.0 mV/˚C scale factor
- 0.5˚C accuracy guaranteeable (at +25˚C)
- Rated for full −55˚ to +150˚C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08˚C in still air
- Nonlinearity only ±¼˚C typical
- Low impedance output, 0.1 Ω for 1 mA load

Typical Applications



DS005516-3

FIGURE 1. Basic Centigrade Temperature Sensor (+2˚C to +150˚C)



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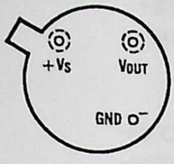
Choose $R_1 = -V_S/50\ \mu A$

V_{OUT} = +1,500 mV at +150˚C
= +250 mV at +25˚C
= −550 mV at −55˚C

FIGURE 2. Full-Range Centigrade Temperature Sensor

Connection Diagrams

TO-46
Metal Can Package*

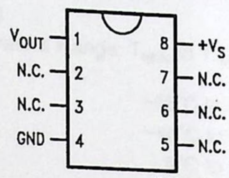


BOTTOM VIEW
DS005516-1

*Case is connected to negative pin (GND)

Order Number LM35H, LM35AH, LM35CH, LM35CAH or LM35DH
See NS Package Number H03H

SO-8
Small Outline Molded Package



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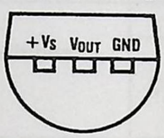
N.C. = No Connection

Top View
Order Number LM35DM
See NS Package Number M08A

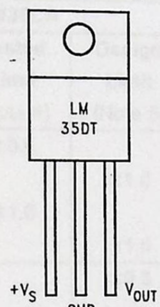
TO-92
Plastic Package



BOTTOM VIEW
DS005516-2

Order Number LM35CZ, LM35CAZ or LM35DZ
See NS Package Number Z03A

TO-220
Plastic Package*



DS005516-24

*Tab is connected to the negative pin (GND).
Note: The LM35DT pinout is different than the discontinued LM35DP.

Order Number LM35DT
See NS Package Number TA03F

Absolute Maximum Ratings (Note 10)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	+35V to −0.2V
Output Voltage	+6V to −1.0V
Output Current	10 mA
Storage Temp.;	
TO-46 Package,	−60°C to +180°C
TO-92 Package,	−60°C to +150°C
SO-8 Package,	−65°C to +150°C
TO-220 Package,	−65°C to +150°C
Lead Temp.:	
TO-46 Package, (Soldering, 10 seconds)	300°C
TO-92 and TO-220 Package, (Soldering, 10 seconds)	260°C
SO Package (Note 12)	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 11)	2500V
Specified Operating Temperature Range: T_{MIN} to T_{MAX} (Note 2)	
LM35, LM35A	−55°C to +150°C
LM35C, LM35CA	−40°C to +110°C
LM35D	0°C to +100°C

Electrical Characteristics

(Notes 1, 6)

Parameter	Conditions	LM35A			LM35CA			Units (Max.)
		Typical	Tested Limit (Note 4)	Design Limit (Note 5)	Typical	Tested Limit (Note 4)	Design Limit (Note 5)	
Accuracy (Note 7)	T_A=+25°C	±0.2	±0.5		±0.2	±0.5		°C
	T_A=−10°C	±0.3			±0.3		±1.0	°C
	$T_A=T_{MAX}$	±0.4	±1.0		±0.4	±1.0		°C
	$T_A=T_{MIN}$	±0.4	±1.0		±0.4		±1.5	°C
Nonlinearity (Note 8)	$T_{MIN}\le T_A\le T_{MAX}$	**±0.18**		**±0.35**	**±0.15**		**±0.3**	°C
Sensor Gain (Average Slope)	$T_{MIN}\le T_A\le T_{MAX}$	**+10.0**	**+9.9, +10.1**		**+10.0**		**+9.9, +10.1**	mV/°C
Load Regulation (Note 3) $0\le I_L\le 1$ mA	T_A=+25°C	±0.4	±1.0		±0.4	±1.0		mV/mA
	$T_{MIN}\le T_A\le T_{MAX}$	**±0.5**		**±3.0**	**±0.5**		**±3.0**	mV/mA
Line Regulation (Note 3)	T_A=+25°C	±0.01	±0.05		±0.01	±0.05		mV/V
	$4V\le V_S\le 30V$	**±0.02**		**±0.1**	**±0.02**		**±0.1**	mV/V
Quiescent Current (Note 9)	V_S=+5V, +25°C	56	67		56	67		μA
	V_S=+5V	**105**		**131**	**91**		**114**	μA
	V_S=+30V, +25°C	56.2	68		56.2	68		μA
	V_S=+30V	**105.5**		**133**	**91.5**		**116**	μA
Change of Quiescent Current (Note 3)	$4V\le V_S\le 30V$, +25°C	0.2	1.0		0.2	1.0		μA
	$4V\le V_S\le 30V$	**0.5**		**2.0**	**0.5**		**2.0**	μA
Temperature Coefficient of Quiescent Current		**+0.39**		**+0.5**	**+0.39**		**+0.5**	μA/°C
Minimum Temperature for Rated Accuracy	In circuit of *Figure 1*, I_L=0	+1.5		+2.0	+1.5		+2.0	°C
Long Term Stability	$T_J=T_{MAX}$, for 1000 hours	±0.08			±0.08			°C

BD243B/BD243C
BD244B/BD244C

COMPLEMENTARY SILICON POWER TRANSISTORS

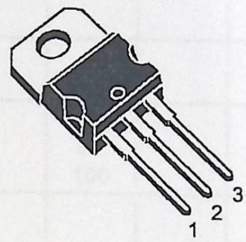
- STMicroelectronics PREFERRED SALESTYPES

DESCRIPTION

The BD243B and BD243C are silicon Epitaxial-Base NPN transistors mounted in Jedec TO-220 plastic package.

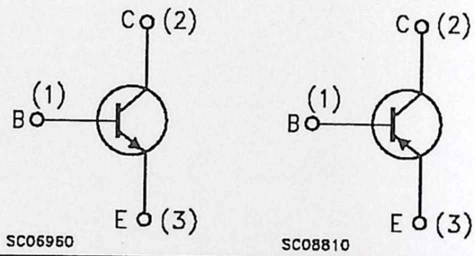
They are inteded for use in medium power linear and switching applications.

The complementary PNP types are BD244B and BD244C respectively.



TO-220

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value		Unit
		NPN	BD243B	BD243C	
		PNP	BD244B	BD244C	
V_{CBO}	Collector-Base Voltage ($I_E = 0$)		80	100	V
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)		80	100	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)		5		V
I_C	Collector Current		6		A
I_{CM}	Collector Peak Current		10		A
I_B	Base Current		2		A
P_{tot}	Total Dissipation at $T_c \leq 25$ °C		65		W
T_{stg}	Storage Temperature		-65 to 150		°C
T_j	Max. Operating Junction Temperature		150		°C

For PNP types voltage and current values are negative.

THERMAL DATA

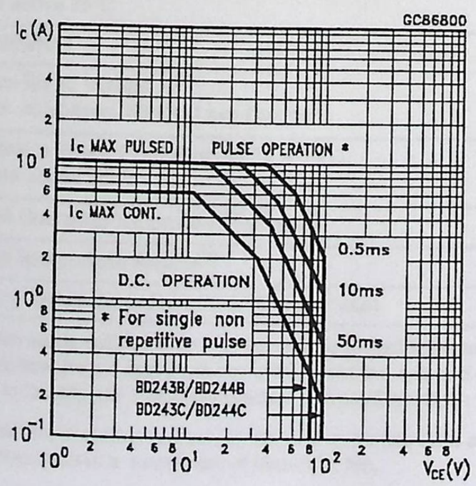
$R_{thj-case}$	Thermal Resistance Junction-case	Max	1.92	°C/W
$R_{thj-amb}$	Thermal Resistance Junction-ambient	Max	62.5	°C/W

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

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CES}	Collector Cut-off Current (V_{BE} = 0)	V_{CE} = rated V_{CEO}			0.4	mA
I_{CEO}	Collector Cut-off Current (I_B = 0)	V_{CE} = 60 V			0.7	mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			1	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage (I_B = 0)	I_C = 30 mA for **BD243B/BD244B** for **BD243C/BD244C**	 80 100			 V V
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 6 A I_B = 1 A			1.5	V
V_{BE}*	Base-Emitter Voltage	I_C = 6 A V_{CE} = 4 V			2	V
h_{FE}*	DC Current Gain	I_C = 0.3 A V_{CE} = 4 V I_C = 3 A V_{CE} = 4 V	30 15			
h_{fe}	Small Signal Current Gain	I_C = 0.5 A V_{CE} = 10 V f = 1MHz I_C = 0.5 A V_{CE} = 10 V f = 1KHz	3 20			

* Pulsed: Pulse duration = 300 µs, duty cycle ≤ 2 %
For PNP types voltage and current values are negative.

Safe Operating Area



GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

6-Pin DIP Optoisolators Transistor Output

4N25*
4N25A*
4N26*
[CTR = 20% Min]
4N27
4N28
[CTR = 10% Min]

*Motorola Preferred Devices

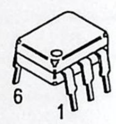
The 4N25/A, 4N26, 4N27 and 4N28 devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

- Most Economical Optoisolator Choice for Medium Speed, Switching Applications
- Meets or Exceeds All JEDEC Registered Specifications
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

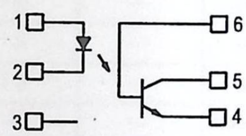
- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- I/O Interfacing
- Solid State Relays

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector	P_D	120	mW
Derate above 25°C		1.41	mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED	P_D	150	mW
Derate above 25°C		1.76	mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C	P_D	250	mW
Derate above 25°C		2.94	mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.
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REV 5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	T_A = 25°C T_A = –55°C T_A = 100°C	V_F	— — —	1.15 1.3 1.05	1.5 — —	Volts
Reverse Leakage Current (V_R = 3 V)		I_R	—	—	100	μA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C	4N25,25A,26,27 4N28	I_{CEO}	— —	1 1	50 100	nA
(V_{CE} = 10 V, T_A = 100°C)	All Devices	I_{CEO}	—	1	—	μA
Collector–Base Dark Current (V_{CB} = 10 V)		I_{CBO}	—	0.2	—	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	7	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)		h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)		C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0)		C_{CB}	—	19	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0)		C_{EB}	—	9	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)	4N25,25A,26 4N27,28	I_C (CTR)(2)	2 (20) 1 (10)	7 (70) 5 (50)	— —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2 mA, I_F = 50 mA)		$V_{CE(sat)}$	—	0.15	0.5	Volts
Turn–On Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{on}	—	2.8	—	μs
Turn–Off Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{off}	—	4.5	—	μs
Rise Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_r	—	1.2	—	μs
Fall Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_f	—	1.3	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.