



**College of Engineering and Technology**  
**Electrical and Computer Engineering Department**  
**Communication and Electronics Engineering**

**Bachelor Thesis**

**Graduation Project**

**Wireless Optical Pen**

**Project Team**

**Mousa abu Aljaraiesh**

**Tamer Rabah**

**Moaffak Abu Hamdia**

**Project Supervisor**

**Eng. Ahmad Qudaimat**

**Hebron- Palestine**  
**June, 2013**





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## Acknowledgment

We would like to thank all people who helped us and have a direct or indirect contributions in our project.

Our deepest gratitude goes to our supervisor, Eng. Ahmad Qudaimat for his enlightening guidance, supports, encouragement and unending patience throughout the entire period of the project.

Special thanks to our parents, who always encourage, support and care for our throughout our life. We are also grateful to all our friends in the Communications engineering field at the Department of Electrical and Computer Engineering of Palestine Polytechnic University.

## Abstract

The goal of our project was to design and build a device that will monitor and transmit via Bluetooth the hand movements of a person writing. The device is constructed from a PIC, optical sensor, and Bluetooth transmitter.

On the software side, we put together a PC program that will receive the data transmitted from the device via a Bluetooth module. The program uses this information to move the cursor and draw the user's corresponding movements, and have ability to write in three different colors.

This project would be great for teachers, artists, etc. to easily digitize notes and diagrams directly from the writing surface to their own personal computer where the necessary expensive equipment to record notes is not available or impractical as in Palestine.

## المخلص

إنّ هدف مشروعنا هو بناء نظام إلكتروني قادر على تتبع حركة الكتابة بواسطة تحليل البيانات المرسلّة باستخدام تقنية "البلوتوث" اللاسلكية ثم محاكاتها في جهاز الكمبيوتر الشخصي. إن هذا المشروع يتكون من مستشعر ضوئي، معالج دقيق، وأداة البلوتوث.

أما في الجانب البرمجيّ، فإنه يتكون بالأساس من برنامج قادر على استقبال البيانات المرسلّة من البلوتوث، ثم استخدام هذه البيانات في تحريك مؤشر الكتابة في نافذة برمجية تبعاً للإحداثيات المرسلّة من القلم الإلكتروني الذي لديه القدرة على الكتابة بثلاثة ألوان مختلفة هي: الأزرق، الأصفر، الأحمر، وهناك اللون الرابع وهو الأبيض والذي سنستخدمه كمحاة.

إن هذا المشروع سيكون رائعاً بالنسبة للأساتذة، والفنانين، والمهتمين على حد سواء؛ إذ سينتقل مشروعنا النهائي بنقل رسوماتهم إلى جهاز الكمبيوتر دون الحاجة إلى كوابل، ودون الحاجة أيضاً إلى أجهزة غالية الثمن يندر وجودها في فلسطين بشكل عام، ومدينة الخليل بشكل خاص.

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### List of Abbreviations

- PC:** personal computer
- PIC:** peripheral interface controller
- USB:** Universal Serial Bus
- GSM:** global system for mobile communication
- SMS:** in short message service
- LAN :** Local Area Network
- PAN :** Personal Area Network
- IAS:** Image Acquisition System
- CMOS:** Complementary Metal Oxide Semiconductor
- DSP:** Digital Signal Processor
- LED:** light-emitting diode
- WPAN:** A wireless personal area network
- IEEE:** Institute of Electrical and Electronics Engineers
- UWB:** Ultra Wide Band
- FH:** Frequency Hopping
- PIN:** *personal identification number*
- FHSS:** Frequency Hopping spread Spectrum
- ACL:** Asynchronous Connection-Less
- GPS:** *Global Positioning System*
- CPU:** Central Processing Unit
- RAM:** Read Access Memory
- ROM:** Read Only Memory
- I/O:** Input\Output
- PC:** Personal Computer
- AD:** Analog/Digital

**PWM:** Pulse Width Modulation  
**ABS:** Antilock Brake System  
**CLR:** Common Language Runtime  
**SDK:** Software Development Kit  
**IL:** intermediate language  
**DC:** direct current  
**ISM :** Industrial, Scientific and Medical  
**SPI :**Serial Peripheral Interface  
**SQUAL :**Surface Quality  
**MSB:** most significant bit  
**SPP:** Serial Port Profile  
**OCR :**Optical Character Recognition

# 1

## Chapter one Introduction

- 1.1 Introduction
- 1.2 Project Objectives
- 1.3 General Idea
- 1.4 Literature Review
- 1.5 Motivations
- 1.6 Time Plan
- 1.7 Estimated costs
- 1.8 Project Risk Management
- 1.9 Project Contents

# 1

## Chapter one Introduction

### 1.1 Introduction

### 1.2 Project Objectives

### 1.3 General Idea

### 1.4 Literature Review

### 1.5 Motivations

### 1.6 Time Plan

### 1.7 Estimated costs

### 1.8 Project Risk Management

### 1.9 Project Contents

### 1.3 General Idea

Our project aims to making it easy for everybody to write on a computer using a wireless hand pen through LAN (Bluetooth), instead of a keyboard, that's by depending on the electronic

## 1.1 Introduction

Any ordinary computer user who needs to write using a keyboard for any reason faces many challenges, such as having a hard time finding letters on the keyboard to write a paragraph which may be time consuming, especially if the user is new to using computers adding that the user may not be concentrating very well when searching for letters or certain chips on the keyboard. And so on.

However, some techniques were found to overcome those problems such as the intelligent electronic board which u can carry everywhere to write on whenever you want .Although, we found a solution to replace the intelligent board with the intelligent pen which does the same job with more flexibility in dealing with everything around, it is also cheaper, it can write on a paper and find the written down at the computer screen simultaneously.

## 1.2 Project Objective

- To understand the principle of the optical pen as a new technology for writing instead of the intelligent board.
- To make it possible such pen drawing on a screen through software programming and hardware structure.
- To facilitate the transfer of student information quickly to the computer, especially when there is a need for a scanner so it aims to saving time.
- To help students with the process of drawing complicated shapes and graphics and to help painters and artists transfer their sketch's and drawings easily to the computer.

## 1.3 General Idea

Our project aims to making it easy for everybody to write on a computer using a wireless hand pen through LAN(Bluetooth) , instead of a keyboard, that's by depending on the electronic

pen that sends the coordinates of writing on a personal computer to show what's written as useful and clear as possible.

## 1.4 Literature Review

In this section we briefly present some of the research literature that is related to our project. However, there are many projects around the world have similar points to this project, but we try to be different, and make it suitable for our budget and components. Meanwhile, we will mention similar products and projects, that related to our work, and show the difference between our work and their works.

### 1.4.1 Wireless Writing Monitor [1]

#### Description

This project presents a wireless writing monitor system using accelerometer sensor and Bluetooth technology. The main goal of this project is to design and build a device that will monitor and transmit via Bluetooth the hand movements of a person writing on a chalkboard. Also, intend to implement a program that will receive the information transmitted by the device and output it to the screen. The software will give the user the option to save the text so that even if the chalk is erased, the data will not be.

#### Advantages:

- Compact design makes device easily transportable, and Low power consumption.

#### Disadvantage:

- Limited use, it's for chalkboards only.
- High delay between the person writing on the chalkboard and it appearing on the computer.

**Differences:**

- We want to use optical sensor instead of accelerometer sensor :ADXL330  $\pm 3g$  3-axis, and we will use PIC18F2550 instead of PIC16F688.
- Our project aimed to design electrical pen to serve as much as fields not only for chalkboards.
- We will use different software code, that depends on C# program.
- We will provide the electrical pen with buttons to change the cooler of font.

**Similarities:**

Use the Bluetooth technology to transfer data from sensor to PC.

**1.4.2 USB optical pen project[2]****Description**

This project is designed to allow a user to write to a computer screen. It was also required that the device be plug and play; meaning that no additional software would need to be installed on the computer.

**Advantage**

- The pen is designed to be fast and; the microchip 18F2550 microcontroller allows for full speed.

**Disadvantage**

- High cost; because they use two microprocessors.
- The optical pen acts like a mouse, Therefore, no software programs in PC side.
- Doesn't use wireless methods to transfer the data.

**Differences:**

- We will use Bluetooth wireless technology to transfer data between the PIC and PC, that's mean, we have a software program on PC side.
- We will use only microcontroller.

**Similarities:**

Use PIC18F2550 and optical sensor to know the movement of pen.

### 1.4.3 The Anoto Digital Pen[3] [4]

#### Description:

Digital pens act like ordinary ball pens and leave visible ink traces on paper. In addition, a built-in camera detects a specific dot pattern printed on the paper sheets, which uniquely encodes position information. The Anoto technology uses a non-repetitive pattern printed on paper to enable a camera-equipped pen to locate its absolute position on that pattern. The Anoto pen is an active pen that includes a tiny camera with optics as well as a microprocessor for image analysis. A non-repetitive pattern printed on plain paper can be seen by the camera. By analyzing this pattern, the pen can detect its absolute position.

#### Advantage:

- Using the digital pen you can capture, store and then securely send handwritten information from any surface.
- The digital pen user transfers data in one of two ways: wirelessly, or via USB port.

#### Disadvantage:

- Use specific paper, also, to make sure that the pattern is detected correctly, carbon based ink is required.

#### Differences:

- In our project we don't use specific papers as Anoto, also we don't use cameras or image analyzing or carbon based ink.

## 1.5 Motivations

This project finds a solution for those that face problems to deal with writing on a regular board, moreover it opens the door for additional Improvements to be added in the future such as streaming the writing for a specific period of time, or sending the written data through GSM in SMS. One more important thing is that this project has an effective role in teaching presses in college or schools as well. It aims to exploit the available resources to the farthest boundaries.

## 1.6 Time Plan

The following tables define the main tasks in the project introduction and project itself:



Table1. 1: Time scheduled table for project introduction

<b>T1</b>	Project Definition	<b>1 Week</b>
<b>T2</b>	Collecting Data	<b>12 Week</b>
<b>T3</b>	Analysis	<b>6 Week</b>
<b>T4</b>	Theoretical Calculation	<b>4 Week</b>
<b>T5</b>	Documentation	<b>9 Week</b>
<b>T6</b>	Prepare for Presentation	<b>2 Week</b>

The time of the project introduction is scheduled over 16 weeks; table 1.2 shows how the work was scheduled over this time:

Table1. 2: Time plan table for project introduction

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Task																
<b>T1</b>	█															
<b>T2</b>		█	█	█	█	█	█	█	█	█	█	█	█			
<b>T3</b>					█	█	█	█	█	█						
<b>T4</b>						█	█	█	█							
<b>T5</b>						█	█	█	█	█	█	█	█	█		
<b>T6</b>															█	█

The following table defines the main tasks in the project:

Table1. 3: Time scheduled table for project

<b>T1</b>	Collecting Data	<b>3 Week</b>
<b>T2</b>	Implementations	<b>10 Week</b>
<b>T3</b>	Analysis	<b>5 Week</b>
<b>T4</b>	Building and Testing the System	<b>8 Week</b>
<b>T5</b>	Documentation	<b>10 Week</b>
<b>T6</b>	Prepare for Presentation	<b>2 Week</b>

The time of the project is scheduled over 16 weeks, table 1.4 shows how the work was scheduled over this time:

Table 1. 4: Time plan table for project

Week Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T1																
T2																
T3																
T4																
T5																
T6																

### 1.7 Estimated Costs

Table 1. 5: Estimated Costs.

Number	Object	Cost\Unit (\$)	Quantity	Cost (\$)
1	Microchip PIC	100	2	200
3	Optical sensors	10	2	20
4	Super bright red LED	2	1	1
5	Battery	3	3/4	12
6	RGB LED	—	—	3
7	Other components	—	—	50 -100
8	Metals (Core)	—	—	20
9	Serial Bluetooth RF Transceiver Module	25	1	100
<b>Total cost:</b>				<b>470</b>

### 1.8 Project Risk Management

- **Hardware:** This project contains many of the hardware components such as Microchips & optical sensors.

- Software: Labview and C# are used in chip and software desktop programming which is part of this project.
- **Team Risk:** There is no similarity in the study of programs that are affected in the connection of team members. Adding , lack of suitable places for meetings between team members.
- **Project Risk:** Team work faced difficulty in determining a good idea for the graduation project and many of the ideas that were offered from team members were reject because they were not applicable here.

## 1.9 Project Contents

The project is divided to five chapters, the chapters follow each other logically to get the complete idea about the project:

### Chapter 1:

Discusses the definition of the project from multiple sides, its objectives and importance. After that the time plane and the estimated cost of the system components and how they needed to implement the designed system was taken to discuss. Finally, the difficulties that the group has faced .

### Chapter 2:

This chapter contains sections that discussed optical sensor , pic Microcontroller and wireless communication technology, specifically Bluetooth communication.

### Chapter 3:

In this chapter, we will talk about the design concepts, the general block diagram that show how the system works, the system flow chart, the data flow diagram, and the functional block diagram that mention all the implemented functions in the system.

### Chapter 4:

This chapter is talking about the design details and implementation of the project and block testing for each part in the system.

### Chapter 5:

In this chapter, the whole testing stage will be described, that's mean a test of entire system, and we will talk about testing of each part of the system.

### **Chapter 6:**

In this chapter, we will mention what we achieved in this project and the conclusion for all things that we have done, also we will talk about the challenges that we faced, and ending with recommendation needed for the future work.

## Chapter Two

### Theoretical Background

2.1 Introduction

2.2 The Idea

2.3 Motion navigation system and typical sensor

2.4 Bluetooth

2.5 Microcontroller

2.6 Software Program

2.7 Power Supply

# 2

## Chapter Two

### Theoretical Background

#### 2.1 Introduction

#### 2.2 The idea

#### 2.3 Motion navigation system and Optical sensor

#### 2.4 Bluetooth

#### 2.5 Microcontroller

#### 2.6 Software Program

#### 2.7 Power Supply

Under this topic, converting the hand writing motion to electrical signals to be processed will be discussed. One of the technologies related to this topic is the optical navigation system, this system is included in an optical sensor which is used commonly in a computer optical mouse device mainly. In addition to many accurate and sensitive applications such as the camera.

In this project we will study the digital optical mouse sensor principles because it achieves the ultimate goal of the project.

##### 2.3.1 Inner sensor construction [3]

This innovative digital sensor operates by actually "taking a picture" of the surface on which it is navigating and comparing images sequentially, then an optical flow algorithm

## **2.1 Introduction**

Existing technologies that are used in some applications can be used again in other applications with a more effective and useful way, so that a new and more innovative product will result.

## **2.2 The idea**

This project depends on coordinates that read and analyze hand writing pen motion path with the appropriate computer software program in order to display this motion on the user's PC screen with the use of proper PAN network to transmit the coordinates information and other writing related data from the pen, taking into account the characteristics of the application with convenient parameters such as the inner electrical elements size compatibility.

In our project to achieve its objective two helpful technologies were relied on, one is motion navigation system and the other is PAN network, both will be analyzed with the principles of operation of these technologies and the benefit from the related applications as much as possible in practical side.

## **2.3 Motion navigation system and Optical sensor**

Under this topic, converting the hand writing motion to electrical signals to be processed will be discussed. One of the technologies related to this topic is the optical navigation system, this system is included in an optical sensor which is used commonly in a computer optical mouse device mainly. In addition to many accurate and sensitive applications such as the camera.

In this project we will study the digital optical mouse sensor principles because it achieves the ultimate goal of the project.

### **2.3.1 Inner sensor construction [5]**

This innovative digital sensor operates by actually "taking a picture" of the surface on which it is Navigating and comparing images sequentially, then an optical flow algorithm

calculates the speed and direction of movement , which is called a compact image acquisition system (IAS).

Image acquisition system (IAS) consists of high speed Complementary metal–oxide–semiconductor (CMOS) photo detectors, which are arranged in an array as shown in figure2.1. These photo detectors convert the change of reflected light density from obstacles to change in analogue levels of electrical flow.

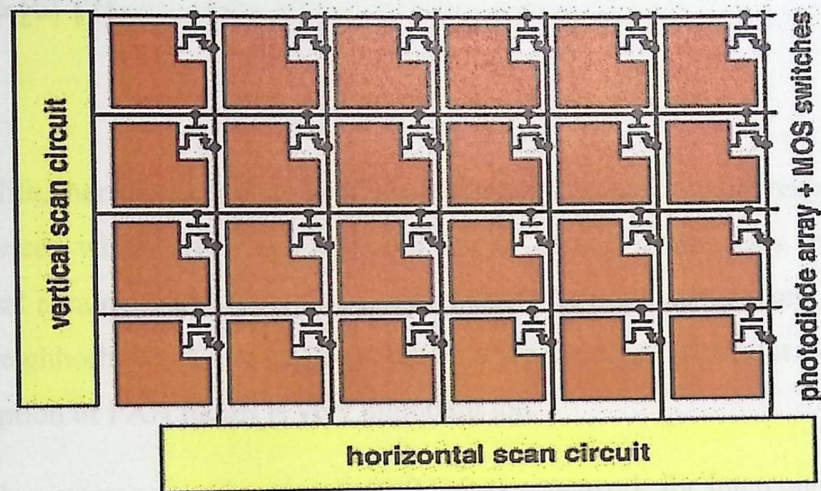


Figure2.1: Photodetectors arranged in an array

The second objective of the image acquisition system is to convert an analogue optical image to a digital image since a continuous analogue representation cannot be conveniently interpreted by a computer. This is achieved by first using the sensor to sample the analogue optical image, generating an analogue video signal, and then by subsequently re-sampling the video signal and generating the digital signal.

Then these digital signals are processed by a basic Digital Signal Processor (DSP) to determine the direction and distance of motion. The DSP generates the x and y relative displacement values which are stored and registered inside the sensor.

The IAS acquires microscopic surface images via the lens and illumination system provided by a light-emitting diode (LED) which illuminates the surface underneath the mouse. The light from the LED reflects microscopic textural features in the area. A plastic lens collects the reflected light and forms an image on a sensor. If you were to look at the image, it would be a

black-and-white picture of a tiny section of the surface. The sensor continuously takes pictures as it moves. The sensor takes pictures quickly 1500-2000 pictures (frames) per second or more fast enough so that sequential pictures overlap. The images are then sent to the optical navigation engine for processing.

This device is placed very close to the surface (nominal distance of 2.0- 2.4 mm) and detects small variations in the roughness of the surface.

## 2.4 Bluetooth [6] [7]

### 2.4.1 Overview

In Our life, there are many applications that don't have many range requirements, such as connecting devices wirelessly to a mobile device or adding components to a home theater system. Personal area networks (PANs) are a perfect fit for these applications, they offer signal ranges in the neighborhood of 1 m to 100 m, and a wide variety of data rates. Moreover, the low power consumption of PAN radios is very important too.

A wireless personal area network (WPAN) is a network for interconnecting devices in which the connections are wireless . The Institute of Electrical and Electronics Engineers (IEEE) has formed the 802.15 working group to define standards for wireless PAN's. However, the most popular WPAN standards are: Bluetooth IEEE 802.15.1 , Zigbee IEEE 802.15.4 , Ultra Wide Band (UWB) IEEE 802.15.3a .

Bluetooth technology will be focused on since it is what we will use in our project.

### 2.4.2 About the Bluetooth.



Figure2.2: Bluetooth Logo



Bluetooth is a WPAN technology also known as *IEEE 802.15.1* for exchanging data over short distances without need of cables, Bluetooth has many advantages:

- low power consumption makes Bluetooth ideal for small, battery-powered devices.
- Bluetooth's short range "10 meters" is ideal for the concept of personal operating Space.
- Bluetooth's transmission speed of 800 Kbps works well for transferring small to medium-sized files.

#### 2.4.2.1 Bluetooth specifications

Bluetooth technology Allows up to 8 devices to communicate in a local network called a Piconet, also known as a PAN. Bluetooth uses a 74 MHz slice of the 2.4 GHz radio band.

The Bluetooth use Frequency Hopping (FH) which is a method where the signal is switched from one channel to another in accordance with a pre-established pseudo-random pattern, and Frequency Hopping happens at 1600 times a second over 79 channels (United States and Europe) or 23 channels (Japan). Adding, Bluetooth bit rate is 1Mbps headers and handshaking overhead that take about 20% of this bandwidth.

Bluetooth implements confidentiality, authentication and key derivation with custom algorithms. Bluetooth key generation is generally based on a Bluetooth PIN, which must be entered into both devices. This procedure might be modified if one of the devices has a fixed PIN (e.g., for headsets or similar devices with a restricted user interface as in our project).

There are three classes of Bluetooth devices:

- Class 1: with range around 100 m and maximum power equal to 20 dBm power.
- Class 2: with range around 10m and maximum power of 4 dBm.
- Class 3: with range around 1m at 0 dBm power.

#### **2.4.2.2 How does Bluetooth work?**

Any Bluetooth device can be a master or a slave, depending on the application scenario. Bluetooth employs frequency hopping spread spectrum (FHSS) to communicate.

So in order for multiple Bluetooth devices to communicate, they must all synchronize to the same hopping sequence. The master sets the hopping sequence, and the slaves synchronize to the Master. A piconet (an ad-hoc computer network using Bluetooth technology) is formed by a master and up to seven active slaves. The slaves in a piconet only communicate with the master. A scatter net can be formed by linking two or more piconets. When a device is present in more than one piconet, it must time-share and synchronize to the master of the piconet with which it is currently communicating.

#### **2.4.2.3 Typical Bluetooth pairing.**

During the pairing process, the two devices involved establish a relationship by creating a shared secret known as a link key. If a link key is stored by both devices they are said to be paired or bonded. A device that wants to communicate only with a bonded device can cryptographically authenticate the identity of the other device, and so be sure that it is the same device it previously paired with. Once a link key has been generated, an authenticated Asynchronous Connection-Less (ACL) link between the devices may be encrypted so that the data that they exchange over the airwaves is protected against eavesdropping. In our project there will be a special unit to receive the signal, Bluetooth and we will be ready to receive the signal without the consent of the user. This gives the project flexibility when dealing with.

#### **2.4.2.4 Application of Bluetooth**

The Bluetooth technology is used for many applications, for example:

- Wireless control and communication between a mobile phone and a hands free headset. This was one of the earliest applications to become popular.
- Wireless control and communication between a mobile phone and a Bluetooth compatible car stereo system
- Wireless Bluetooth headset and Intercom.
- Wireless networking between PCs in a confined space and where little bandwidth is required.

- Wireless communication with PC input and output devices, the most common being the mouse, keyboard and printer.
- Transfer of files, contact details, calendar appointments, and reminders between devices.
- Replacement of previous wired RS-232 serial communications in test equipment, GPS receivers, medical equipment, bar code scanners, and traffic control devices.

#### 2.4.2.5 Reason for choosing Bluetooth

Many of the services offered over Bluetooth can expose private data or allow the connecting party to control the Bluetooth device. For security reasons, it is necessary to be able to recognize specific devices and thus enable control over devices that are allowed to connect to a given Bluetooth device. At the same time, it is useful for Bluetooth devices to be able to establish a connection without user intervention (for example, as soon as they are in range)

## 2.5 Microcontroller[8][9]

A microcontroller is a highly integrated chip that contains all the components comprising a controller, typically this includes a Central Processing unit (CPU) , Read Access Memory (RAM), some form of Read Only Memory (ROM) ,Input\Output (I/O) ports , and timers which make them a strong choice when implementing control systems.

Unlike a general-purpose computer, which also includes all of these components, a microcontroller is designed for a very specific task, to control a particular system.

Microcontrollers are sometimes called embedded microcontrollers , which means that they are part of an embedded system , that is, one part of a larger device or system as it's in our project , they represent the core of the control system for electronic devices in dedicated applications. Thus, in contrast the microprocessors that are used in general purpose applications like personal computers need high-performance, and multitasking.

Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, appliances, power tools, and toys. The size and cost of the microcontroller compared to a design that uses a separate

microprocessor, memory, and input/output devices makes it more economical , more money saving .

In our project, the microcontroller manages inputs from the sensor, then processes the information, and outputs the data.

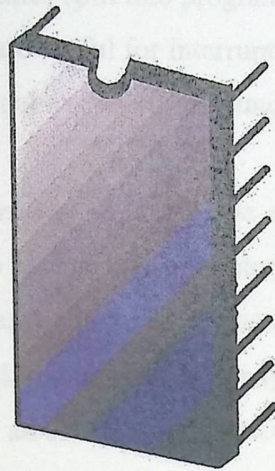


Figure 2.3 : Microcontroller.

### 2.5.1 Microcontroller Component

The basic internal design of microcontrollers are pretty similar. Figure 2.6 shows the block diagram of a typical microcontroller. All components are connected via an internal bus and are all integrated on one chip. The modules are connected to the outside world via I/O pins.

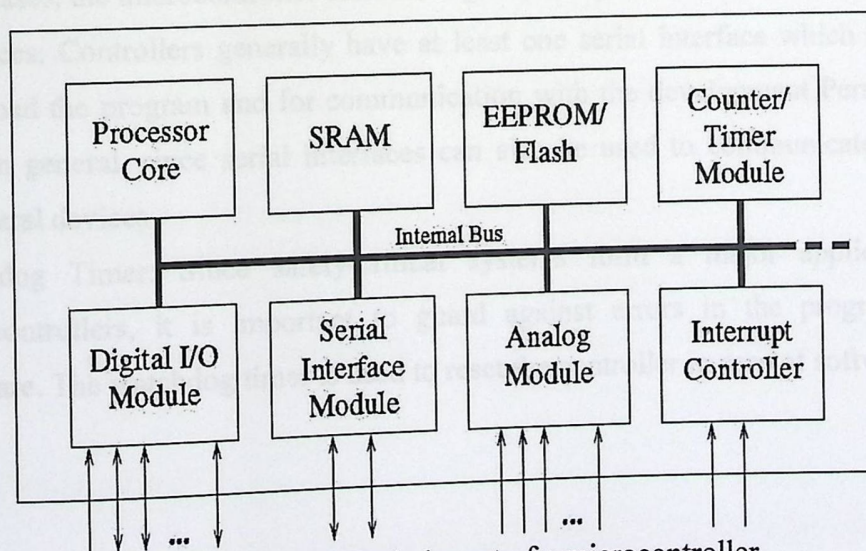


Figure 2.4 : Basic layout of a microcontroller.

The following list contains the modules typically found in a microcontroller:

- **Processor Core:** The CPU of the controller. It contains the arithmetic logic unit, the control unit and the registers (stack pointer, program counter, accumulator register, register file, . . .).
- **Memory:** The memory is sometimes split into program memory and data memory.
- **Interrupt Controller:** Interrupts are useful for interrupting the normal program flow in case of "important" external or internal events. In conjunction with sleep modes, they help to conserve power.
- **Timer/Counter:** Most controllers have at least one and more likely 2-3 timer/Counters, which can be used to timestamp events, measure intervals, or count events.
- Many controllers also contain pulse width modulation ( PWM) outputs, which can be used to drive motors or for safe breaking antilock brake system (ABS). Furthermore the PWM output can, in conjunction with an external filter, be used to realize a cheap digital/analog converter.
- **Digital I/O:** Parallel digital I/O ports are one of the main features of microcontrollers. The number of I/O pins varies from 3-4 to over 90, depending on the controller family and the controller type .
- **Analog I/O:** Apart from a few small controllers, most microcontrollers have integrated analog/digital (A/D) converters, which differ in the number of channels (2-16) and their resolution (8-12 bits). The analog module also generally features an analog comparator. In some cases, the microcontroller includes digital/analog converters.
- **Interfaces:** Controllers generally have at least one serial interface which can be used to download the program and for communication with the development Personal computer (PC) in general, since serial interfaces can also be used to communicate with external peripheral devices .
- **Watchdog Timer:** Since safety-critical systems form a major application area of microcontrollers, it is important to guard against errors in the program and/or the hardware. The watchdog timer is used to reset the controller in case of software crashes.

## 2.6 Software Program

We will use in our project two main programs , one for microcontroller programming and the other for programming and processing the data which is transferred to the PC device via Bluetooth technology .

### 2.6.1 C# Programming Language[10]

C# (which is pronounced C sharp) is a powerful programming language that support the power of C++ and simplicity of Visual Basic. However, C# supposed to be the best language for Microsoft's .NET programming.

C# developed at Microsoft by team led by Scott Wiltamuth and Andres Hejlsberg, was designed specifically for the .NET platform as a language that would enable programmers to migrate easily to .NET.

C# has roots in C, C++, and Java, adapting the best features of each and adding new features of its own. Also, C# and .NET are set both to revolutionize the way that you write programs. And to make programming on Windows much easier than it has been, where C# provides a means for to code up almost any type of software that you might need to write for the windows platform.

The main C# architecture can be described below:

- 1) Common Language Runtime (CLR): it manages code execution and provides services.
- 2) Compiler: always the source code you develop for any programming language needs to be compiles before it can be executed by the CLR. C# compiler is part of .NET Framework Software Development Kit (SDK), where in .NET compilation occurs in two steps, first: compilation of source code to intermediate language (IL). Second: compilation of IL to platform specific code by the CLR.

C# in our project will be the main programming language, where the interface to our pen system will be, deal with data, process the x-y coordinates, and display the path of pen.

## 2.7 Power supply

The power supply converts providing the entire device with stable power. There is also a push button, which the user can use to power the device on and off.

# 3

## Chapter Three Project Design

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### 3.1 Introduction

### 3.2 Block Diagram

### 3.3 Project Design

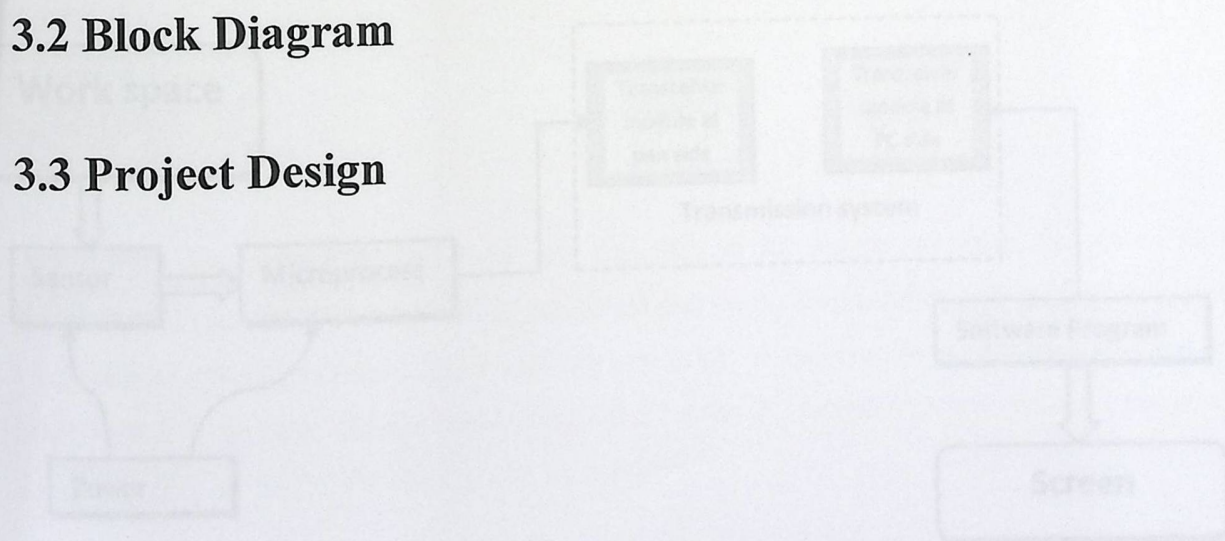


Figure 3.2: Block diagram for the system in detail.

### 3.1 Introduction

This chapter shows the overall wireless writing system in block diagrams, and the modules used by explaining the work of each one of them, then it describes in details the operations that are addressed in the block diagram by determining the power needed and the input and output of each module, finally it shows how the signal flow and how will send.

### 3.2 Block Diagram

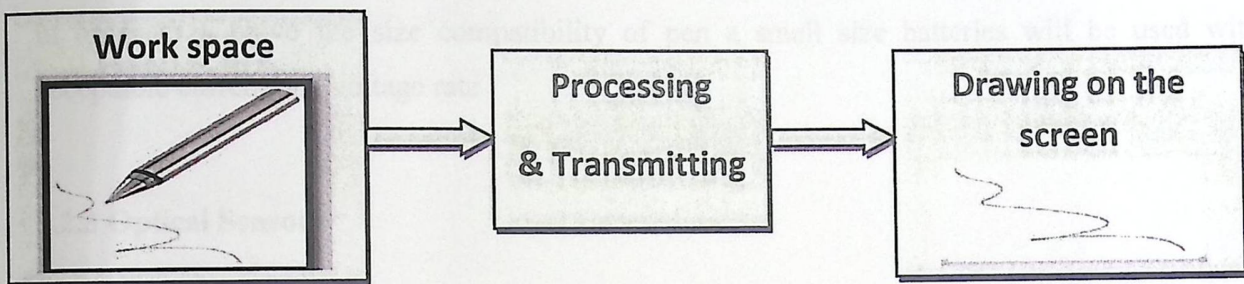


Figure 3.1: General block diagram for the system.

The project has two phases in work “hardware & software”. In this project the scenario is to collect data that related to motion from the electrical pen and transfer it to a software program in pc which will make a proper process on the data to show the same motion of pen printed on the screen.

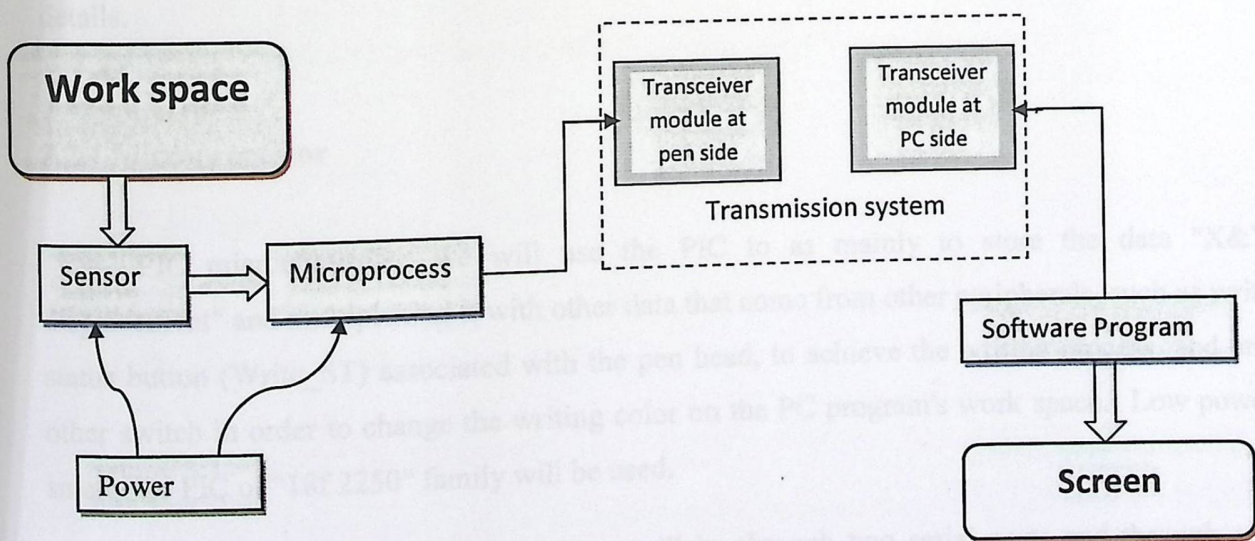


Figure 3.2: Block diagram for the system in detail.



### 3.2.1 Block Description

When write on a surface, the sensor will track the movement of the pen, then a controller will process data and coordinates, after that data will be sent through the transmission system to wireless receiver module in the personal computer, there are a program in the personal computer that handles received data, storing and displaying it on the screen. Now, description for each block as below.

### 3.2.2 Power Supply

The power supply will be a DC voltages source powering the sensor and microprocessor, in order to a chive the size compatibility of pen a small size batteries will be used with acceptable current and voltage rate

### 3.2.3 Optical Sensor

An optical navigation sensor is simply a low resolution intelligent digital camera with a fixed focal length. The camera consists of a CMOS image sensor that captures low resolution images as pixels arrays of up to 30x30 at a certain frame rate (defined as the total of images captured per second) and an on-chip image processing capability to process the sequential images to determine the direction and displacement of motion detected, one of Avago's optical sensor will be used, and the general idea of optical sensor had been discussed in chapter two in details.

### 3.2.4 Microprocessor

PIC microcontroller, we will use the PIC to as mainly to store the data "X&Y displacement" and multiplexing it with other data that come from other peripherals, such as write status button (Write\_ST) associated with the pen head, to achieve the writing process, and one other switch in order to change the writing color on the PC program's work space. Low power small size PIC of "18f 2250" family will be used.

The communication with the sensor will be through two serial ports and through one other serial port to communicate with Bluetooth module.

### 3.2.5 Transmission system

Wireless connectivity between the pen and computer will be performed via Bluetooth. Bluetooth is a proprietary open wireless technology standard for exchanging data over short distances - using short-wavelength radio transmissions in the ISM (industrial, scientific and medical) band from 2400–2480 MHz - from fixed and mobile devices, creating personal area networks (PANs) with high levels of security, and more flexibility in communication range .

One other choice is to use Xbee modules, one of its advantages is that it is a low power device, although it is still not compatible with the wireless pen project since its size makes the pen unstructured, and that is not acceptable.

### 3.2.6 Software Program

This project is divided into two parts, hardware part, and the other part is the software on a computer to process the signal that is received from the pen in order to show the motion of that pen on the screen exactly as it is. There are many programs that could serve us especially C# and/or Java.

## 3.3 Project Design

The entirety of our project is broken into the following subsections:

3.3.1 Hardware structure.

3.3.2 Firmware and software.

### 3.3.1 Hardware structure

#### 3.3.1.1 Microchip PIC 18f 2550

The 18f 2550 is used mainly as an intermediary between the ADNS-2080 and the BC-4 Serial Bluetooth Transceiver Module so that it should contact with both the optical sensor and the Bluetooth module with two interfaces, (SPI) interface has been used to interface the PIC with

ADNS optical sensor using two serial connection wires one for clock in order to assure synchronization and the other for data flow between them.

Again On other side serial peripheral interface have been used between the pic and Serial Bluetooth Transceiver Module, such that the pic sends the data of movements and other data to BC-4 over one serial connection. So Serial connections in terms of this project is a three wire connection's two of them used for our Agilent ADNS2080 optical sensor (slave device) and one another for BC-4 Serial Bluetooth Transceiver Module.

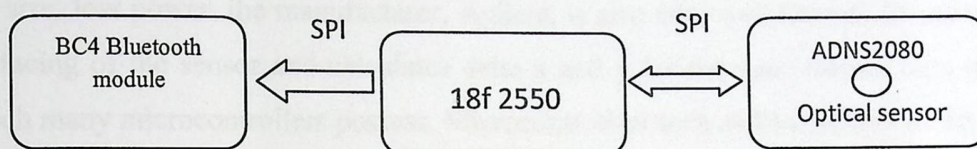


Figure 3.3: SPI connections

This PIC has mainly three ports these are port A, port B and port C each with 7 pins, VDD and Vss, more over it has the capapility for internal clock generation up to 4MHz , it is simple and easy in programming and eventually it is enough to verify its function [12].

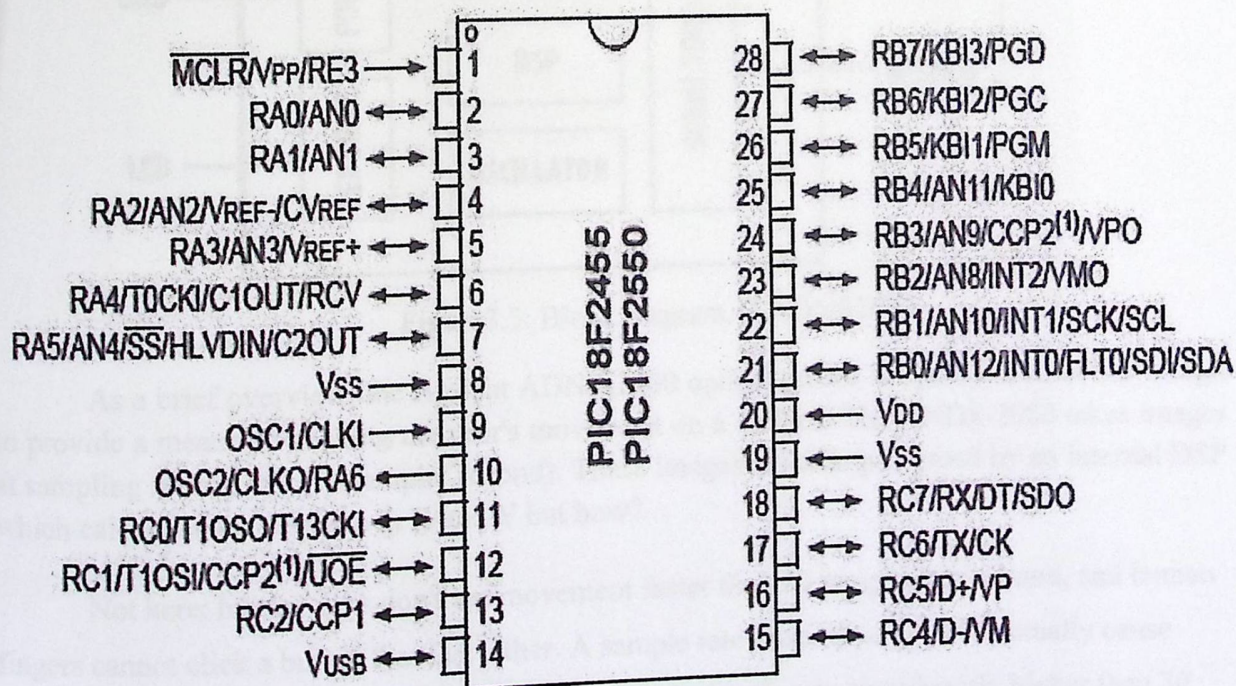


Figure 3.4: 18f 2550 Diagram.

There are several concepts that should be addressed for the sake of improvement and for future direction. These include: increased cost, potential that this microcontroller is not utilized in such projects, and the fact that this part can eventually be replaced by other type.

### 3.3.1.2 Agilent ADNS-2080 [6] [13]

There are several reasons to justify the use of this product. One of them, sheer performance; the sensor that is used in a pen must be highly accurate and responsive. To name a few, its small size, low power, the manufacturer, Agilent, is also very well known. Moreover the easy of interfacing of the sensor and calculates delta x and y for the user. Sensor uses an SPI interface which many microcontrollers possess. Microcontrollers such as Microchip PIC 18 series were on hand that could interface with it as shown in the figure.

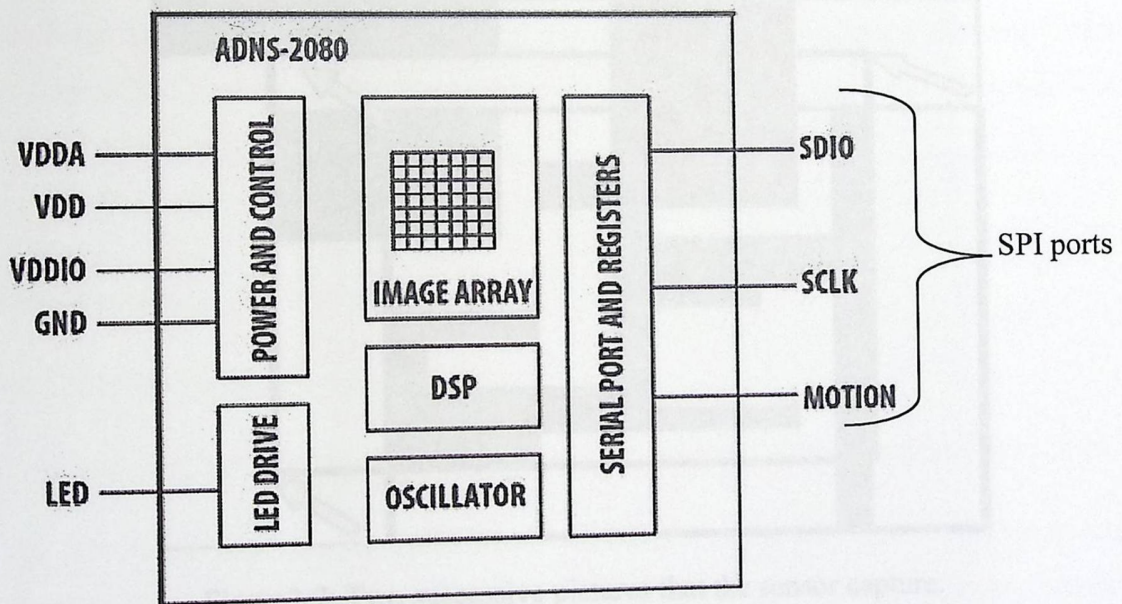


Figure3.5: Block diagram of ADNS2080.

As a brief overview, the Agilent ADNS-2080 optical sensor is mainly used in our design to provide a means of tracking the user's movement on a surface. The ANDS-2080 takes images at sampling rate up to 100 (sample/ second). These images are then processed by an internal DSP which calculates the distance in X and Y but how?

Not here: human eyes don't see movement faster than 30 samples per second, and human fingers cannot click a button that fast either. A sample rate lower than 30, will actually cause visibly delay and lower sensor movement response. A sample rate significantly higher than 30

will waste precious I/O bus bandwidth however sample rate at 100 sample/s to assure high accuracy. From the following figure if a user moves the pen from point A to point B .

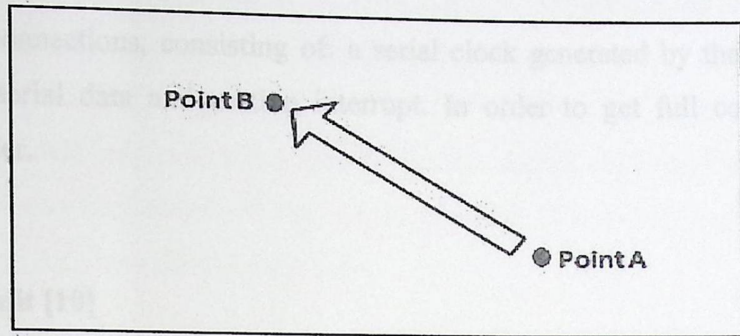


Figure3.6: Moves the pen from point A to point B.

Then sensor captures two successive pictures with sample rate of 100 sample/s

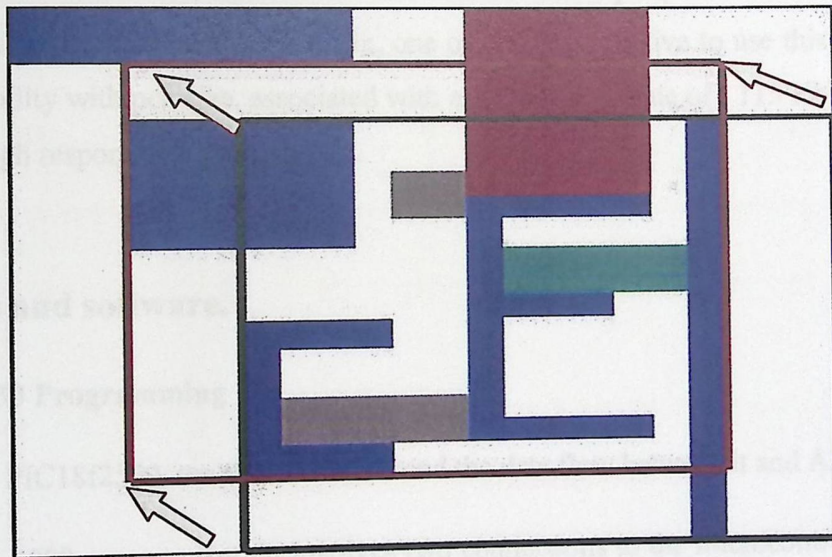


Figure3.7: Two successive pictures that the sensor capture.

At least 170 noticeable features should be picked up from each captured picture the number of noticed features are stored in SQUAL reg in the sensor which determines how much correct  $\Delta X$  &  $\Delta Y$  are, DSP unit within the sensor compare between these features and the features assigned with the next captured picture, then X and Y coordinates are output as a Delta X and Delta Y by means of reading a DX & DY registers. These are read by a single SPI port as shown in figure3.5. There are 31 addressable registers on the ADNS-2080 for reading or writing. These registers can be found in the Agilent ADNS-2080 datasheet. Each one

used for a special purpose, we want to use just a three of them as will describe in the next title of "PIC Programming".

A three wire connections, consisting of: a serial clock generated by the master device, Outgoing /Incoming serial data and motion interrupt. In order to get full contact with PIC 18f2550 microcontroller.

### 3.3.1.3 Transceiver unit [10]

USB Bluetooth adapters or "dongles" are available; more over modern laptops can connect with TRx Bluetooth adapters easily through a build in adapter with more reliable and multiple choices. In this project we will use "BC4 Class 1" Serial Bluetooth RF Transceiver Module.

This module connected with pic microcontroller via serial peripheral interface, and its feature are listed in its datasheet in the appendix, one of our Main motive to use this chip is the small size compatibility with pen size, associated with a transmission rate of 115 Kbps which is enough to assure high response for the system .

## 3.3.2 Firmware and software.

### 3.3.2.1 PIC 18f2550 Programming

To program PIC18f2550, we should understand the data flow between it and ADNS-2080.

The ADNS-2080 communication involves two connections to the microcontroller: a clock and a data in/out line. The ADNS-2080 -1184EN"datasheet describes the timing of communication well.

We can get several data items from the ADNS-2080, such as:

- Product ID register and it used for identify the sensor in the beginning or the start of communication. (Register 1).
- Movement along the X axis (register 3).
- Movement along the Y axis (register 4).
- Surface Quality (SQUAL) (register 5).
- The actual image seen by the sensor (register 8).

Each of these data items is stored in its own register. To access the register the PIC microcontroller clock in the register address, wait the required setup time for the ADNS-2080 to retrieve the data, and then clock out the data from the ADNS-2080 to our microcontroller (8 bits of data). The movement data for the X and Y axis is formatted assigned integers, meaning that 1 to 127 indicates a positive movement of that amount, while 128 to 255 indicate a negative movement of -128 to -1. As shown in the figure 3.6.

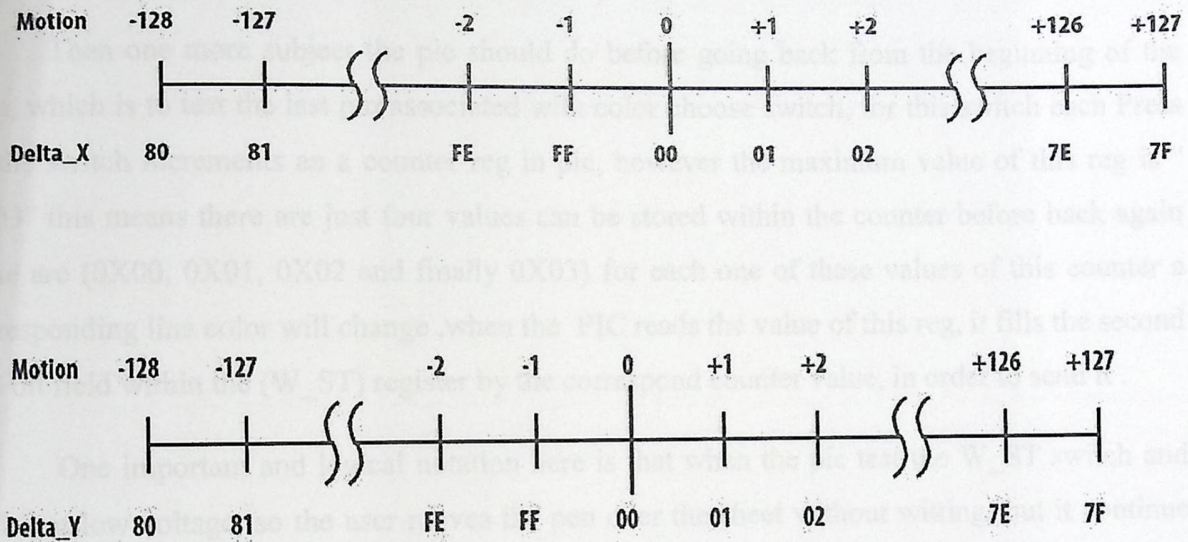


Figure 3.8: the different value of captured point and its relative hex value

The communication steps between the pic and sensor as following. When powers the system the pic take a while of 50 ms to start up and initialize the sensor and the Bluetooth module.

First of all the pic waits for motion interrupting signal from sensor to start reading the data, an interrupt signal come from sensor whenever delta\_x or delta\_y registers are updated with a new value, at the same time the pic store the direction of movement as two bit to indicate the sign of movement these two bits are stored within second and third bit field of W\_ST reg.

First register microcontroller will read is the value stored in Surface Quality register (SQUAL) at sensor, this value is a measure of the number of valid features visible by the sensor which according to the microcontroller can decide if the user holds the pen at a convenient

height. Max value of that register is "180", at reading of 170, the sensor still gives correct values for X and Y.

After finish the test on SQUAL register, a height level voltage output over RB4 to light a red light if the data is correct, then microcontroller tends to inspect the voltage level on pin RB0, which connected to a button associated with the top of the pen, to decide if what's happened writing or just pen movement, if it set, a bit of value "1" will be stored in the first field of write status (W\_ST) register in PIC to indicate there is a write process otherwise Zero value will be stored to indicates it is just motion and no write is happened.

Then one more subject the pic should do before going back from the beginning of the loop, which is to test the last pin associated with color choose switch, for this switch each Press on the switch increments an a counter reg in pic, however the maximum value of this reg is "0X03" this means there are just four values can be stored within the counter before back again these are (0X00, 0X01, 0X02 and finally 0X03) for each one of these values of this counter a corresponding line color will change ,when the PIC reads the value of this reg, it fills the second two bit field within the (W\_ST) register by the correspond counter value, in order to send it .

One important and logical notation here is that when the pic test the W\_ST switch and find it at low voltage, so the user moves the pen over the sheet without witting, but it continue the test for other switch of color!

Once finishing the collection of data from sources, then it will be assembled into a packet in the PIC. The arrangement inside the packet will be as Dx, guard bit, W\_ST, guard bit and DY sequentially by the way we don't utilize all W\_st register just 2 bits sor color and one other bit for W\_ST status and other two bits for sign for the sign of DX an DY, but still yet 3 bit not used to solve this we use tow gurde band bits at each side of byte and one last bit at the middle which always 1. As shown in the figure below this data is sent from the 18f2550 through the RX pin to Bluetooth transceiver module to be transmitted to the computer.

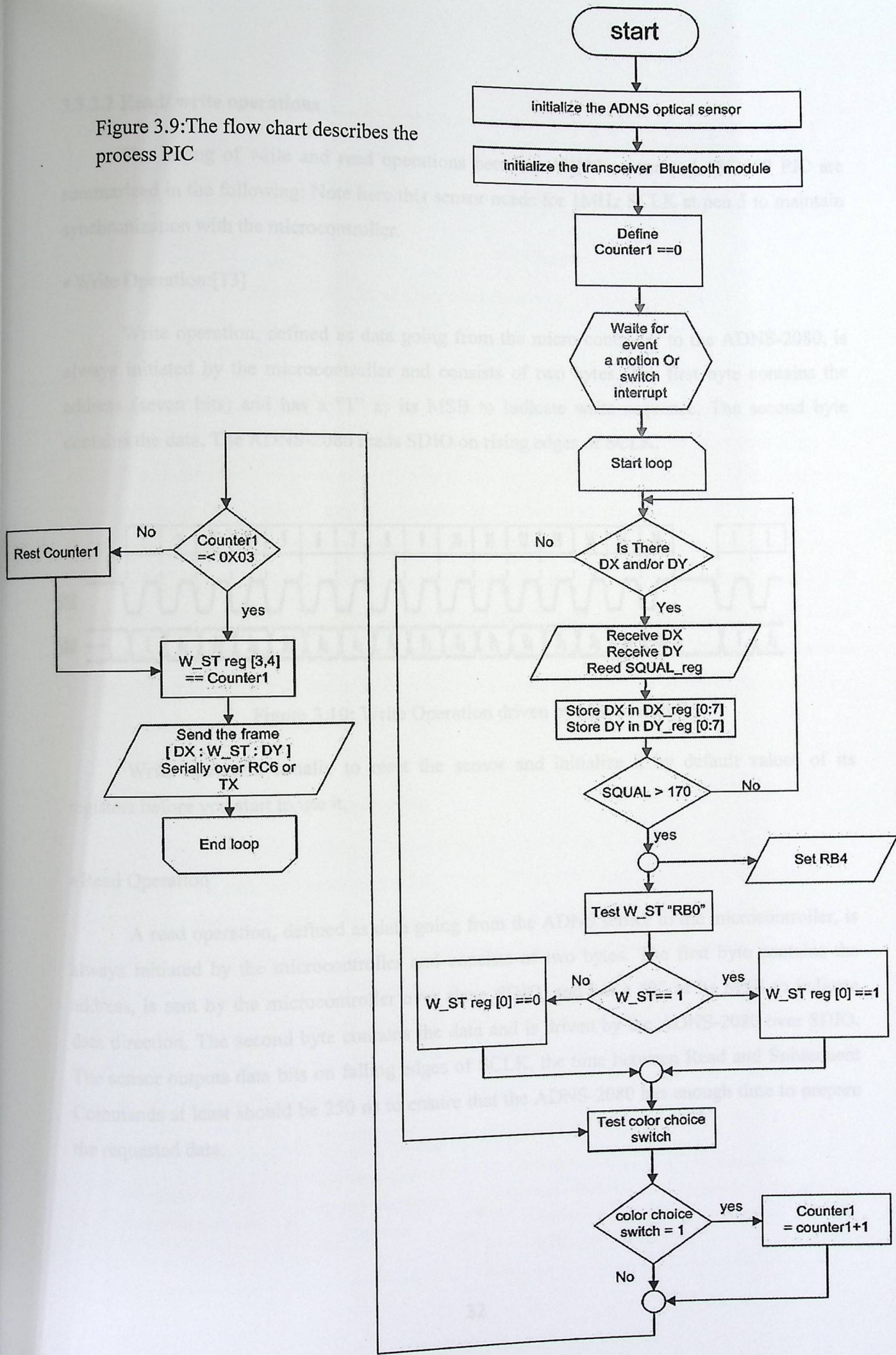


Table 3.1: Data packets.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 1	X movement							
Byte 2	Gurd bit=1	Write status	Color 0	Color 1	Always 1	Y sign bit	X sign bit	Gurd bit=1
Byte 3	Y movement							

We will use "Boot Loader 104" program to help us in programming PIC microcontroller at home. This program is associated with a circuit shown below to connect PIC microcontroller with computer, this method will give more flexibility in dealing with it.

Figure 3.9: The flow chart describes the process PIC



### 3.3.2.2 Read/ write operations

The timing of write and read operations between ADNS sensor and 18f2550 PIC are summarized in the following: Note here this sensor needs for 1MHz SCLK at pen 5 to maintain synchronization with the microcontroller.

- Write Operation:[13]

Write operation, defined as data going from the micro-controller to the ADNS-2080, is always initiated by the microcontroller and consists of two bytes. The first byte contains the address (seven bits) and has a "1" as its MSB to indicate write sequence. The second byte contains the data. The ADNS-2080 reads SDIO on rising edges of SCLK.

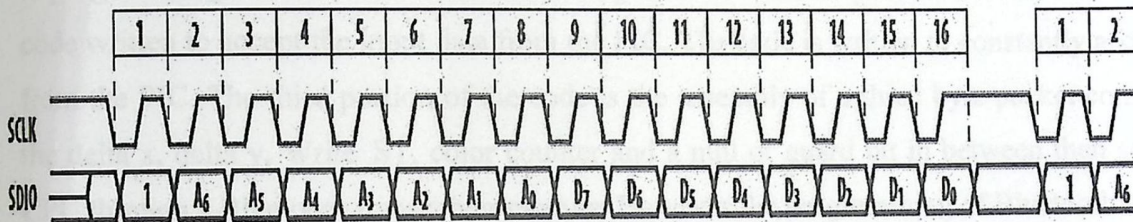


Figure 3.10: Write Operation driven by Microcontroller

Write operation usually to reset the sensor and initialize it by default values of its registers before you start to use it.

- Read Operation

A read operation, defined as data going from the ADNS sensor to the microcontroller, is always initiated by the microcontroller and consists of two bytes. The first byte contains the address, is sent by the microcontroller over slave SDIO, and has a "0" as its MSB to indicate data direction. The second byte contains the data and is driven by the ADNS-2080 over SDIO. The sensor outputs data bits on falling edges of SCLK, the time between Read and Subsequent Commands at least should be 250 ns to ensure that the ADNS-2080 has enough time to prepare the requested data.

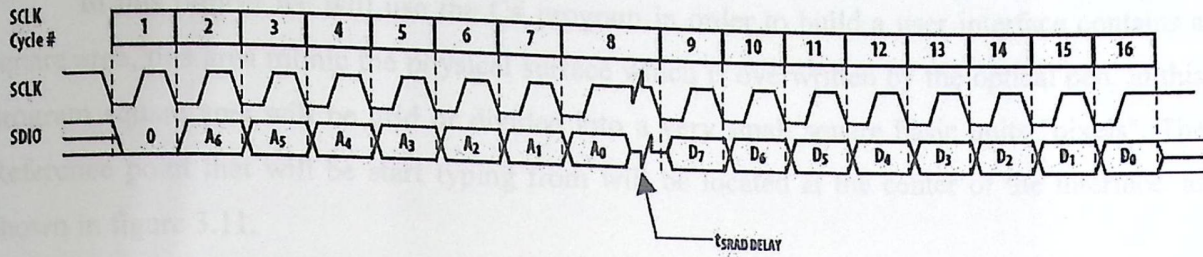


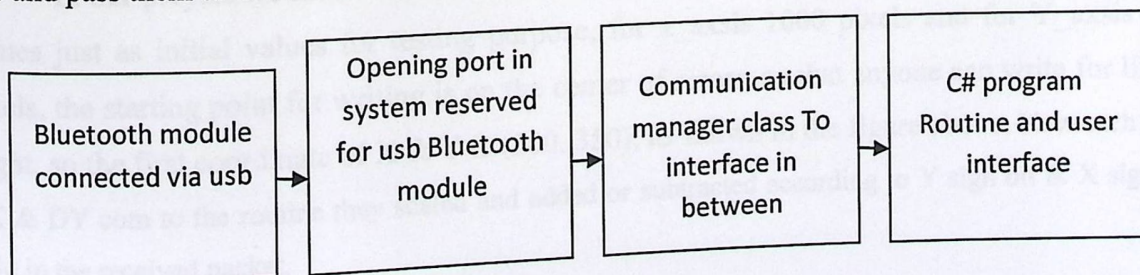
Figure 3.11: Read Operation driven by Microcontroller

### 3.3.2.4 Bluetooth Interface

An overview of the Bluetooth interface firmware is that it provides major necessities to the project. This includes hardware directive along with translation of data received from the 18f2550 and outputting movement wirelessly to the computer. The first element of the firmware is programming the Bluetooth unit to be recognized as wireless pen. The second element is the code written to accept the input data from the PIC. The code is written to constantly accept bytes from the PIC. The third portion of the code is the assembly of a three byte packet consisting of the delta x, delta y, Write\_ST, color counter and a null or guard bit in between then sent to the CPU through a Bluetooth transceiver module. However the programming of Bluetooth module to be recognized from the PIC not too much hard, AT command used for identify this module the above figure describe the process.

### 3.3.2.5 Computer software programming

At computer side a receiving Bluetooth module wherever it is internal or external connected to USB port, will receives the Dx, Write\_ST, and DY data. By using intermediate interfacing program it will pass these data to C# program in order to perform the correct processes on it, we replace this inter mediate program by a well known class which is communication manager class this class connect between the opened port and the C# program, communication manager based on Serial Port Profile (SpP) which receives data just serially from the com port connected with receiving Bluetooth module communication manager accept data as it is and pass them to C#.as shown in the figure below:



In this project we will use the C# program in order to build a user interface contains a square area, this area mimic the physical surface which is overwritten by the optical pen, in this program square area will be grid or divided into a very small square basic units "pixels". The Reference point that will be start typing from will be located at the center of the interface, as shown in figure 3.11.

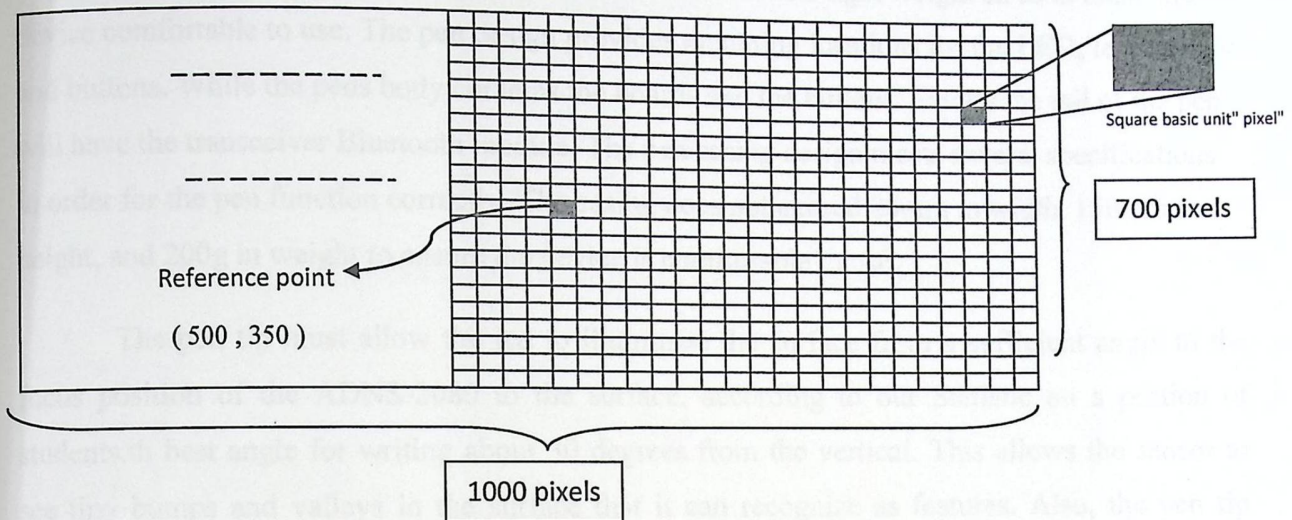


Figure 3.12: Program interface contains a square area

At the time C# receives both DX & DY actually it receive the difference between the coordinates and this difference basically defied as a counts each count defined as a number of pixels, DX & DY values in this project most likely between "1 and 2 " counts, this value to be displayed on the screen it should be scaled or mapped to another comparable value, in order to view the logical movement on the screen, and to make it easy for a user to see all the writing on the screen without having to re Thumbnail screen.

We will make scaling between the read values of DX displacement received at Bluetooth receiver, and the corresponding value of DX that will be written on the surface, at this stage we make it fixed scaling 1:1 so that the written will appear in its real diminutions. On the future we could make it adjustable according to user choice.

In our project we assume the work space of the program to be adjusted on the following values just as initial values for testing purpose, for x\_axis 1000 pixels and for Y\_axis 700 pixels, the starting point for writing is on the center of screen so that anyone can write for lift or Right, so the first coordinate of X & Y is (500, 350), as shown in the figure above. Now each time DX & DY com to the routine they scaled and added or subtracted according to Y sign bit & X sign bit field in the received packet.

Other addition such as, show the movement line and the line color are processed sequentially before showing the line.

### 3.3.3 Case Design

The function of the pen design is to provide a body for the electrical components to be mounted, and formed in the shape of a pen, and be slender and light weight so as to make the device comfortable to use. The pen design provides mounting locations for the LED, lens, sensor and buttons. While the pens body contains the boards and the buttons. Finally the tail of the pen will have the transceiver Bluetooth module. The pen casing design meets several specifications in order for the pen function correctly. The casing does not exceed 20mm in width, 150mm in height, and 200g in weight to ensure the device is comfortable to use.

The pen tip must allow the led to illuminate the surface from a sufficient angle to the focus position of the ADNS-2080 to the surface, according to our Statistic on a portion of students.th best angle for writing about 30 degrees from the vertical. This allows the sensor to see tiny bumps and valleys in the surface that it can recognize as features. Also, the pen tip allows an open path hole through the pen and goes out used for the blade. The body is chosen to provide enough room for the electronics and the batteries to be mounted inside.

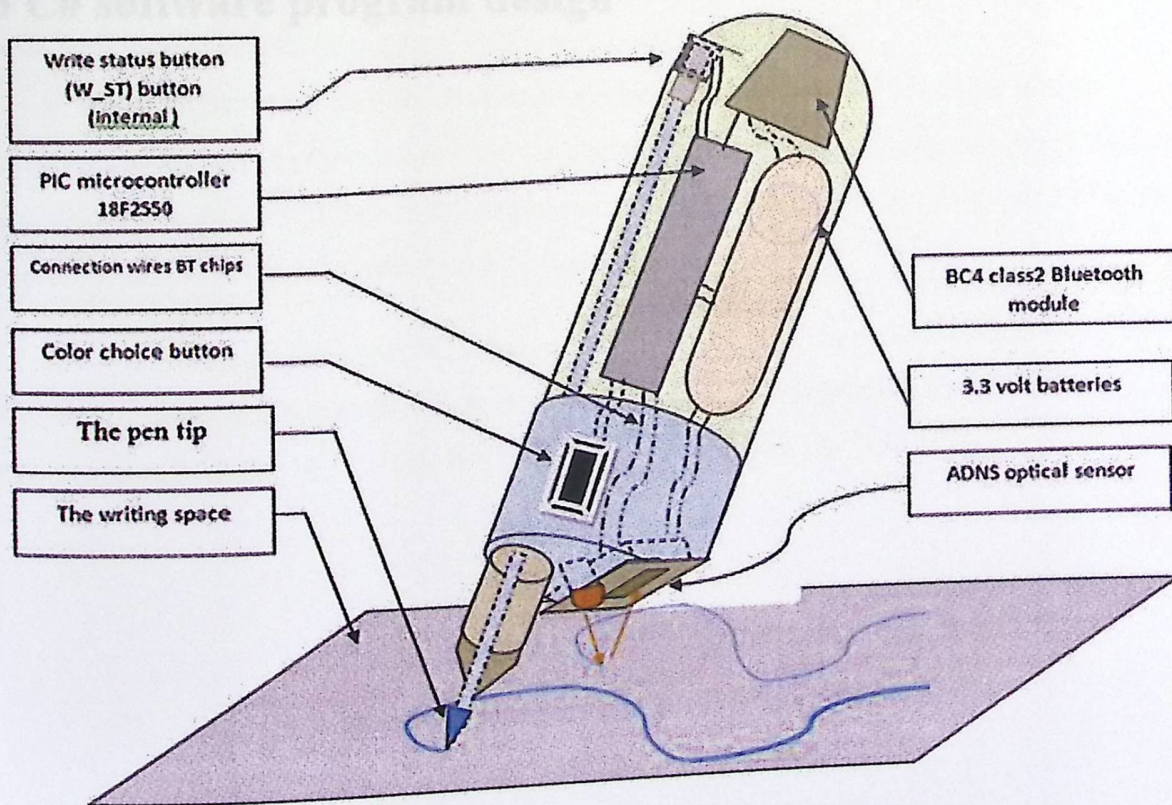


Figure 3.13:Final design of the Pen.

# 4

## Chapter Four System Implementation

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### 4.1 Introduction

### 4.2 Sensors and PIC interfacing and programming

### 4.3 C# software program design

## 4.1 Introduction

This chapter describes the hardware and software implementation of the system. The system can be divided into three main parts: PIC interfacing and sensor interfacing, (C#) software program part and Bluetooth communication part. Each one of these parts will be described in details in this chapter.

## 4.2 Sensor and PIC interfacing and programming

PIC 18F2550 is a 28 pin micro controller with three ports port A, P and C. It described as the main component and it used to process all movements' data and the other signals comes from peripheral switch. To make the PIC able read the input signals correctly. MicroC programming language is used to write the program for the PIC.

### 4.2.1 Interface PIC and optical sensor:

The pin "5" of optical sensor is connecting to the PIC 18F2550 to via pin "11", which is PORTC and used to clocks in sensor a 1NHZ for synchronization.

A bidirectional serial data I/O line connects between port C pin "12" of pic which programmed as serial communication path, as shown in the following figure, and pin "1" optical sensor witch related to serial data input output pin. The interrupt connection from pin 3 of sensor associated with pin "24" wich defined as interrupt pin.

The input voltage pens for PIC microcontroller 18F2550: It needs to voltage of +5 volt at pin "20" normally but it can also work in proper way at 3.3 voltage level we will use a constant voltage batteries of "5" volt. the ground connection with pin "19".



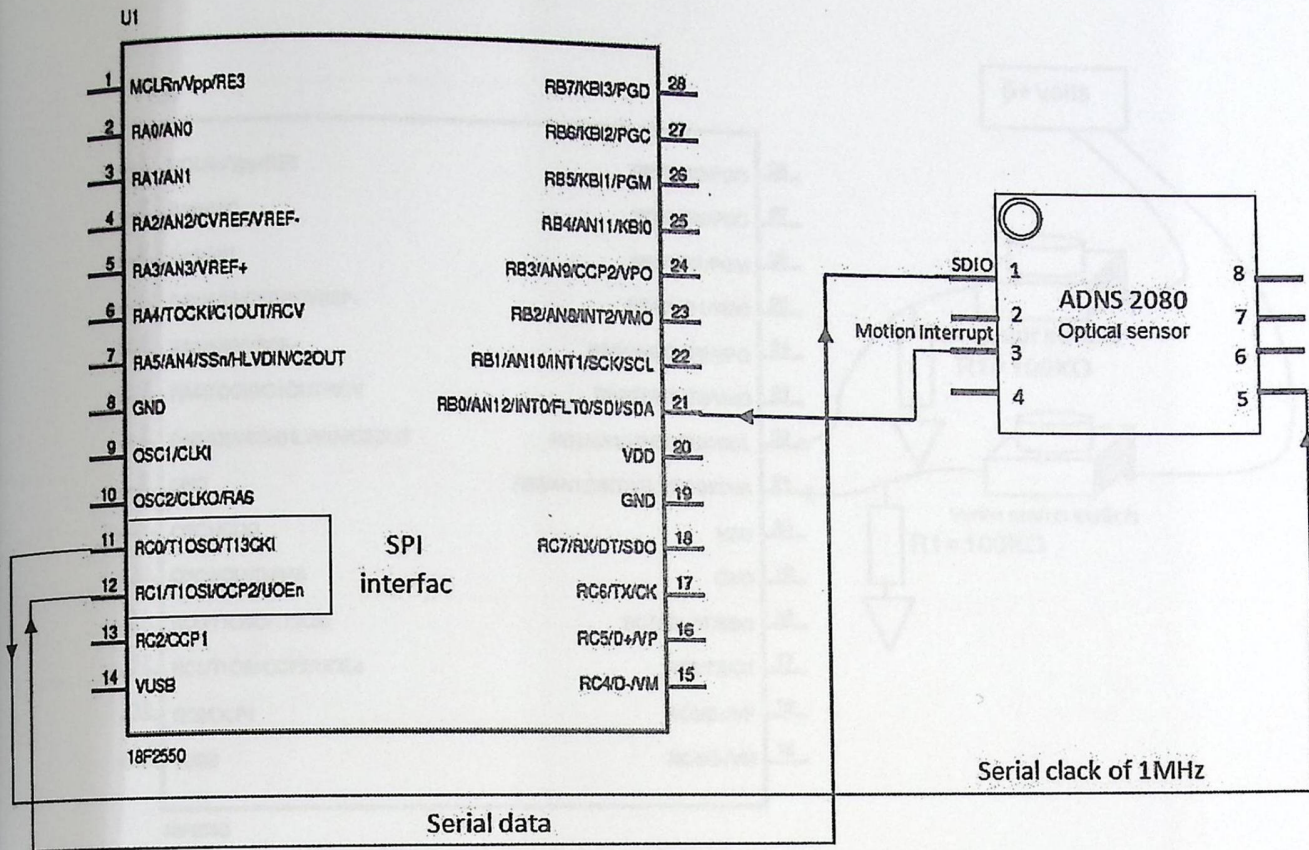


Figure 4.1: PIC with optical sensor connections.

#### 4.2.2 Interface PIC with switches

The pic connected with two main switches write state (w\_st ) switch, and color switch. W\_st switch which detects if you hands the pen and writs, or just moving it over on space, if a user button it an active low voltage level will go through pin "25" to inform the pic the user write. Note here this pen does not interrupt the pic any way if the user doesn't write put the pen still get coordinates from the sensor. But color switch will ill interrupt the pic whenever you push it to change the color an active high voltage level will go through pen "21" of pic. Note here a 100KΩ resistors used for protection

Pin	Function	Value	Color
21	Motion Interrupt	100KΩ	Blue
20	VDD	5V	Red
19	GND	0V	Black
15	RC4/D-/M	5V	Red
16	RC5/D+/VP	5V	Red
17	RC6/TX/CK	5V	Red
18	RC7/RX/DT/SDO	5V	Red

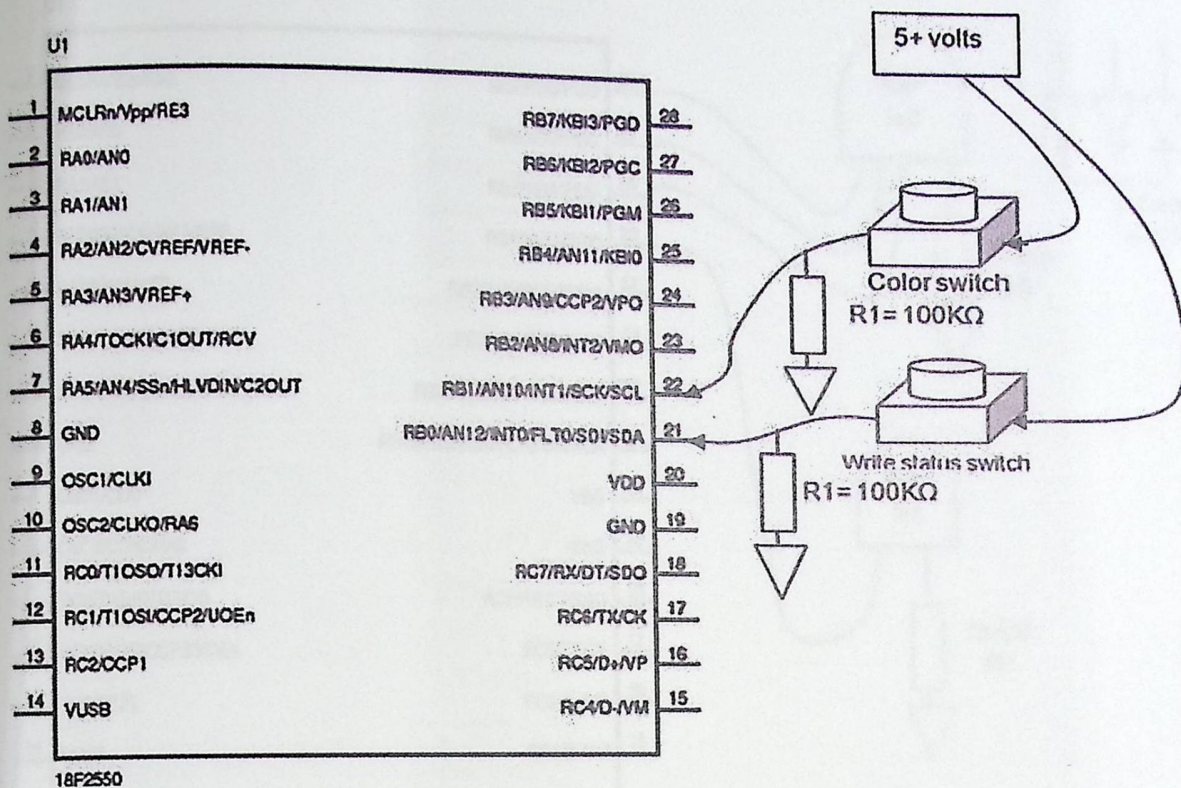


Figure4.2: The PIC connection with switches.

### 4.2.3 Interface PIC with LEDs

LEDs here are used to inform the user about the current state of his writing, this led is common cathode led and this type has "4" pens the first one connected with pic by pin "28", the second connected to pin "27", the third one connected to pin 3, the last one connected directly to a 100KΩ resistor for protection as shown in the figure and then to ground the led color determined by the value of color counter in the pic, which connected by the way to color switch, now for each button over the switch the counter incremented by "1" and so the pic switches the high voltage level from pen to another, so you can notes the color's change, as shown in the table, note here the corresponding counter value for white color is 0X00 so the user will actually erase the written.

Table4.1 : The counter values and corresponding LED color and pins states.

The color field in value xy_st register	0X00	0X01	0X02	0X03
Corresponding light of RGP led	white	green	red	blue
The pic's pins state in order(28 ,27 ,26)	0 0 0	1 0 0	0 1 0	0 0 1

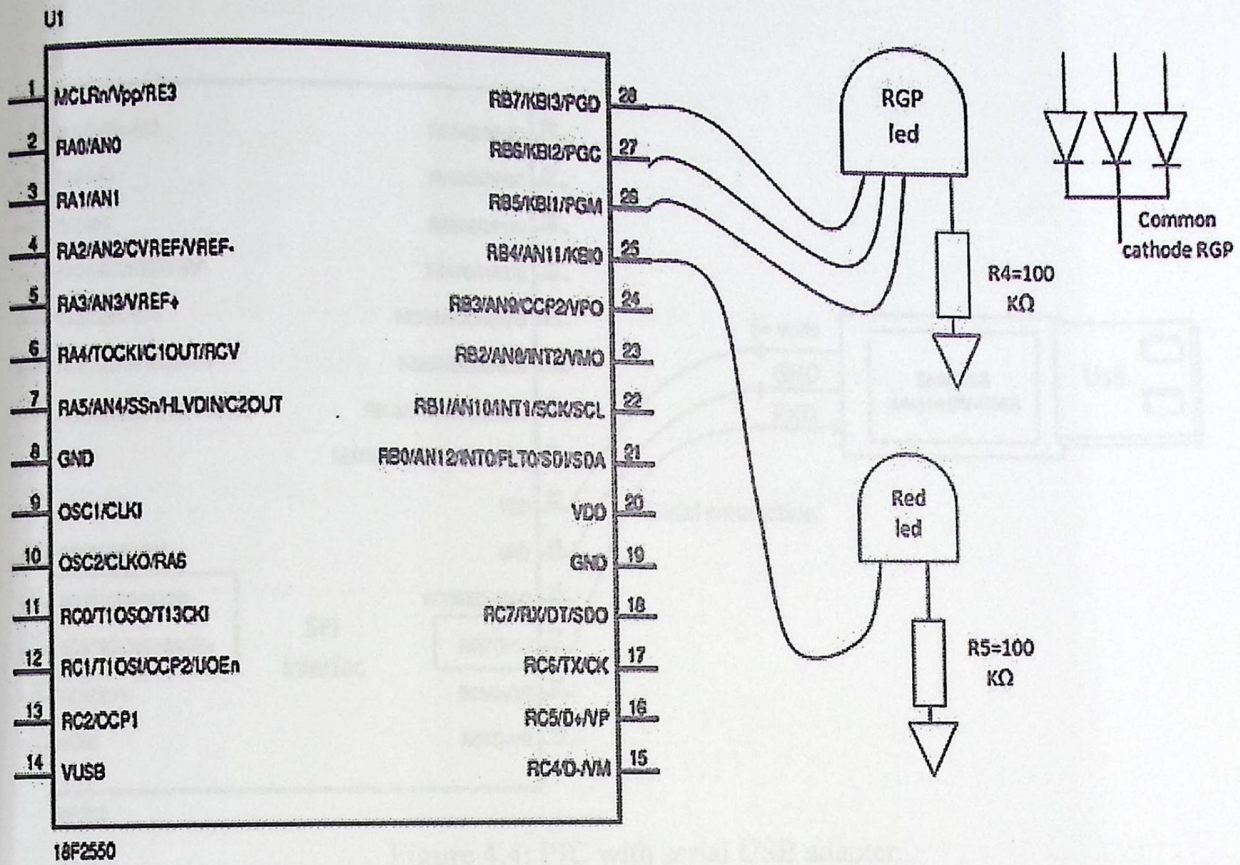


Figure 4.3: The PIC interface with LEDs.

#### 4.2.4 Interface the PIC with Serial USB dongle "JY-US03"

Serial USB adapter used at test purpose, to connect the pic with computer via USB port to in order to, power up the pic and peripherals, moreover while testing to ensure that signal or data correctly passed to the computer, after ensuring access data correctly to the computer, the serial USB adapter will be replaced by the Bluetooth module. The serial USB adapter has been connected to the PIC as shown in the following figure:

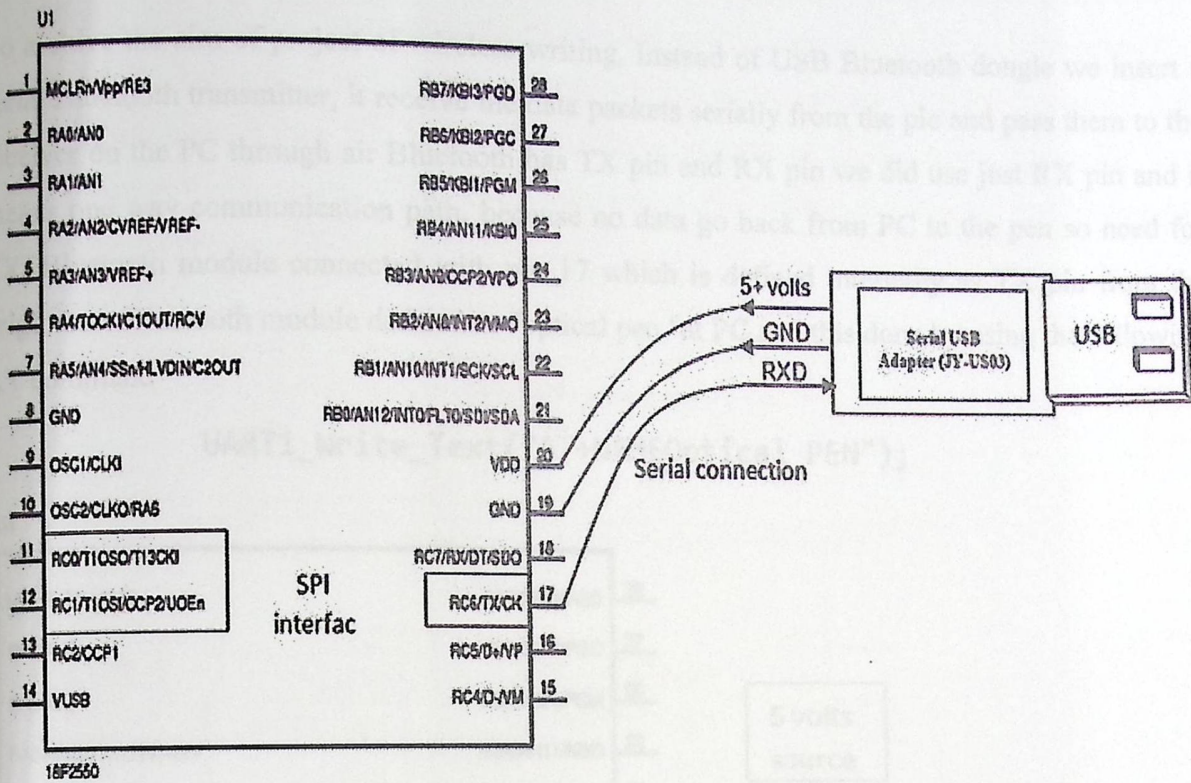


Figure 4.4: PIC with serial USB adapter.

The real connection while testing

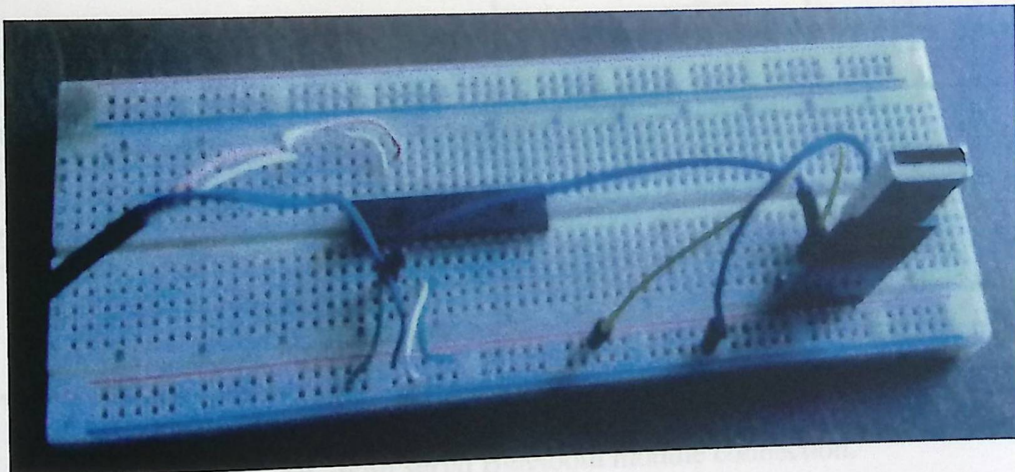


Figure 4.5: The real connection while testing.

When the PIC18F2550 is used for USB connectivity, it must have either a 6 MHz or 48 MHz clock for USB operation, depending on whether Low-Speed or Full-Speed mode is being used. This may require some forethought in selecting an oscillator frequency and programming the device. This section is important in the test operation which is discussed in chapter five.

## 4.2.5 PIC with Bluetooth module

To achieve the aim of project of wireless writing, Instead of USB Bluetooth dongle we insert a serial Bluetooth transmitter, it receive the data packets serially from the pic and pass them to the receiver on the PC through air Bluetooth. The TX pin and RX pin we did use just RX pin and it means one way communication path, because no data go back from PC to the pen so need for TX. Bluetooth module connected with pin 17 which is defined internally as TX pin from the originators Bluetooth module defined as "optical pen" at PC and this done by using the following AT command

```
UART1_Write_Text("AT+NAMEOptical PEN");
```

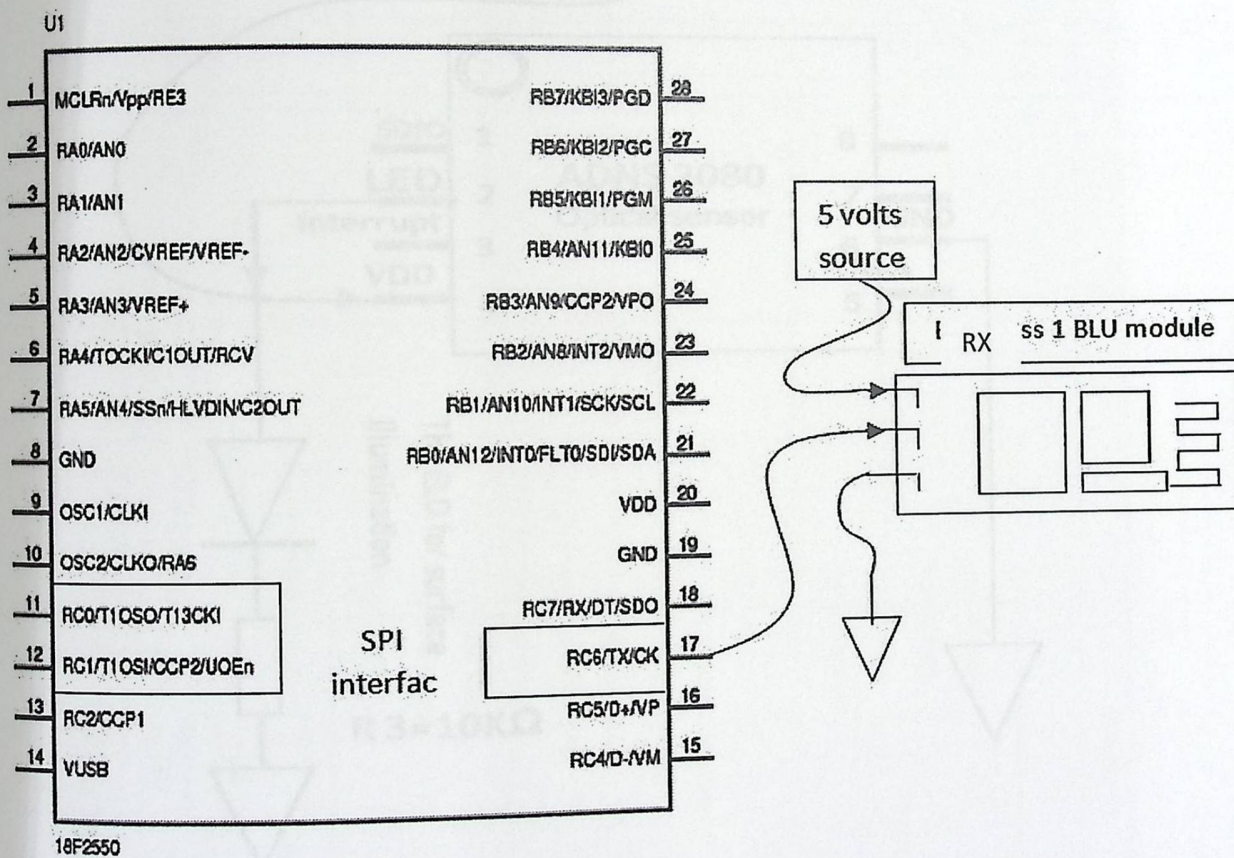


Figure 4.6: PIC with serial Bluetooth module connection.

## 4.2.6 Optical sensor Interferences

Here we will not show the connection between the sensor and the pic because it shown in the section of "4.2.2 Interface PIC and optical sensor" here we will describe the connections between the sensor's led and sensor and power source the first connection between the sensor an its LDE, the LED actually used in order to maximize the reflected illumination

back from the surface of writing so that the sensor can easily detects the noticeable features of that surface, this results to more accurate coordinates and less errors, the LED;s light controlled actually be the sensor DSP unit directly according to the surface nature . The led connected with pin "2" of sensor and then to a 10K $\Omega$  resistor for protection as shown in the figure. Pin 4 of sensor connected with power, VDD, This is the main CPU voltage, and this pin provides power to the internal structures of the chip.

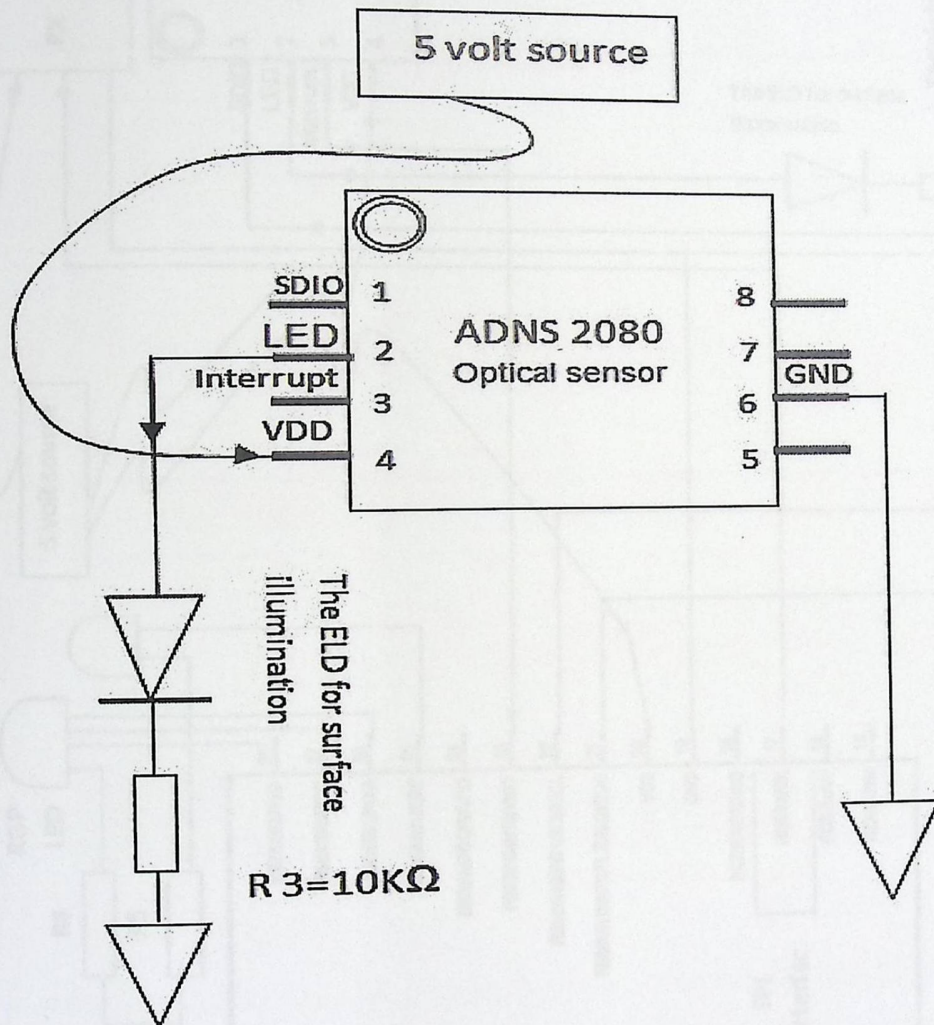


Figure4.7 : the connection between sensor and its LED.

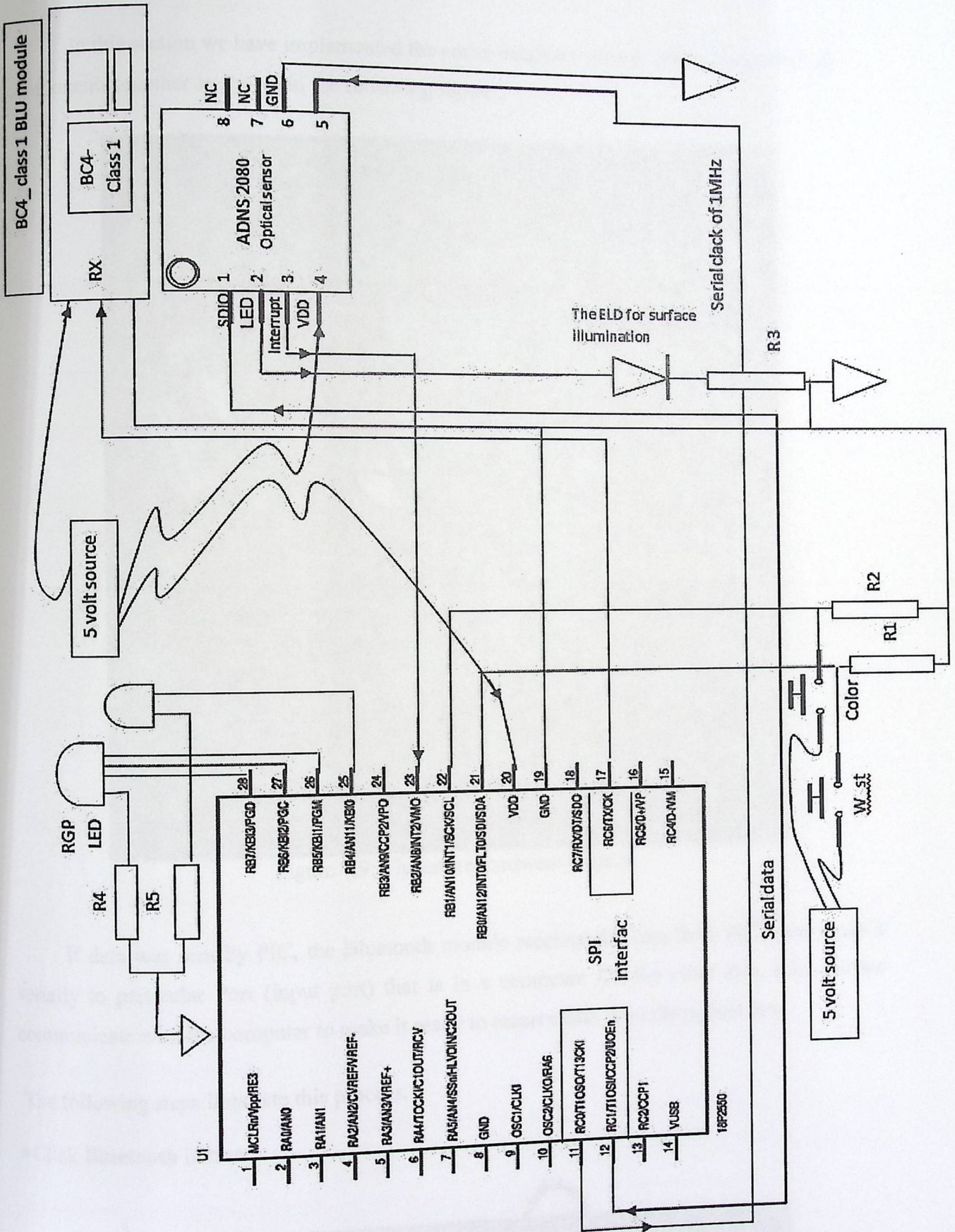


Figure 4.8: The overall diagram.

#### 4.2.7 Complete project implementation.

In this section we have implemented the entire hardware system which is to collect all components together as shown in the following figure :

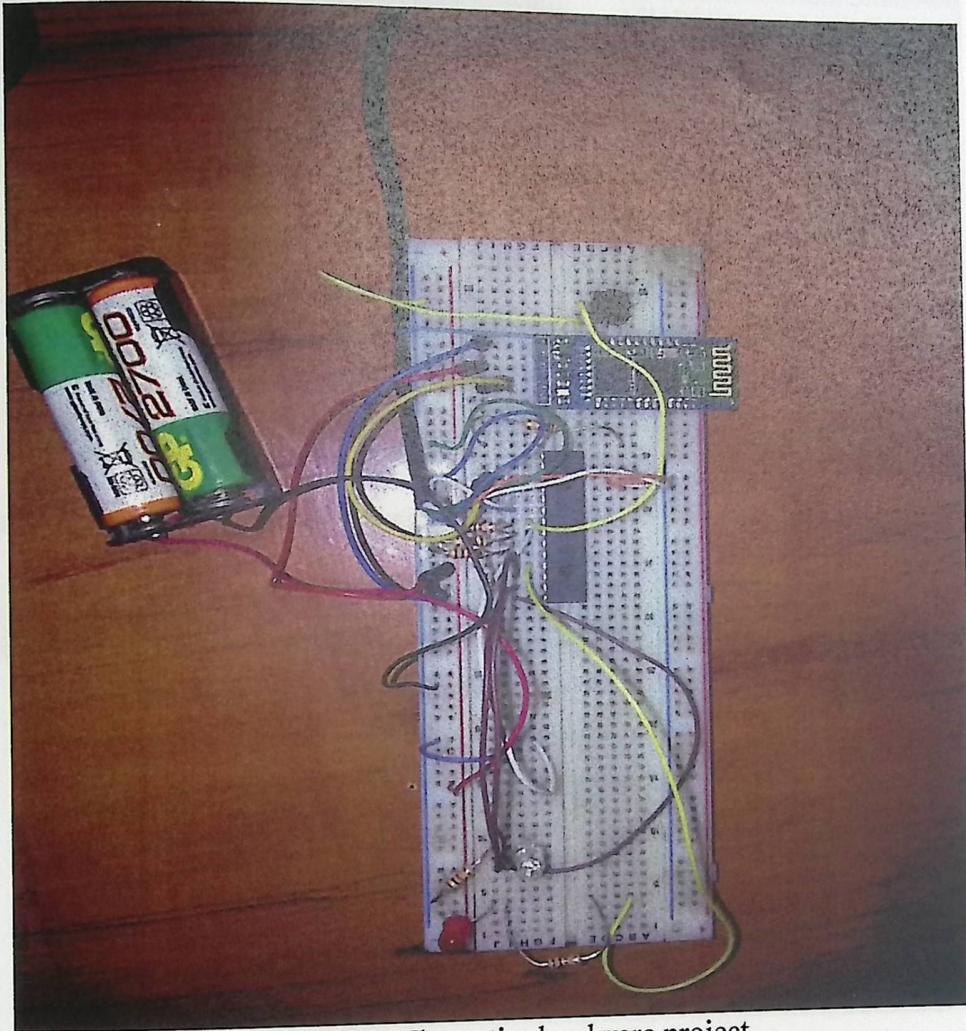


Figure 4.9: The entire hardware project.

If data was sent by PIC, the Bluetooth module receives the data from PIC, then sends it serially to particular Port (input port) that is in a computer. On the other side, how can we communicate with the computer to make it ready to receive data from the optical pen.

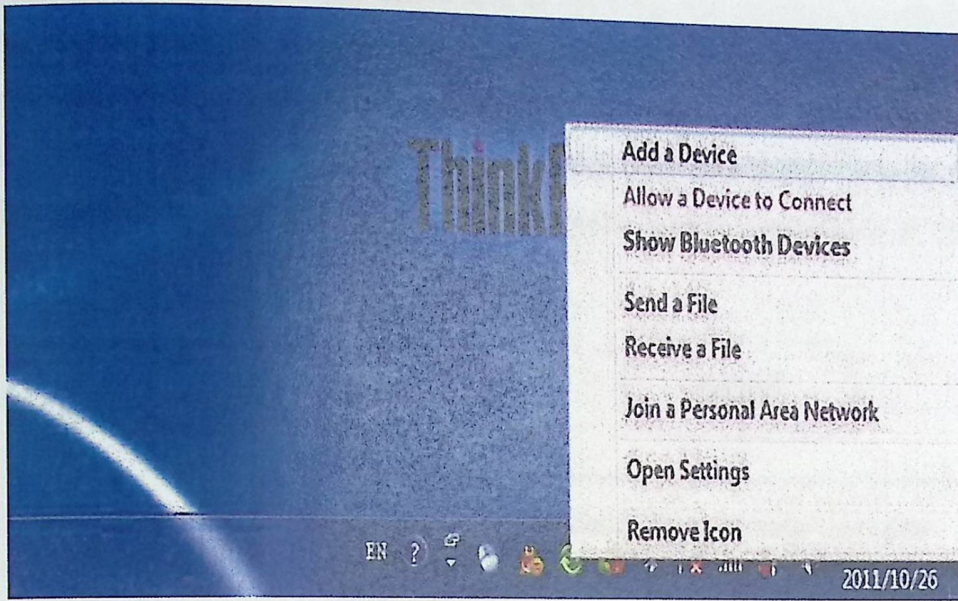
The following steps illustrate this process.

- Click **Bluetooth** button.

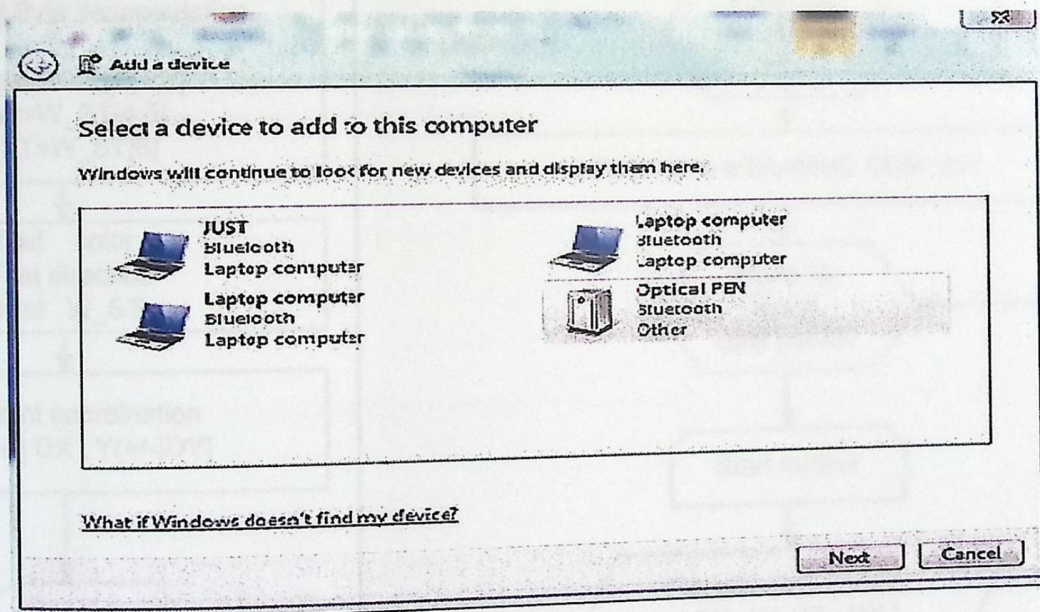




- Click Add a Device button.



- Select the "Optical PEN" device and click Next.



### 4.3 Software interface.

We use the communication manager which is a code program library to interface the transmission data that comes to the input serial port in the computer (COMxx) by the Bluetooth module and the software program.

### 4.3.1 C# Software Program Design

The C# program in the central office acts as the brain that controls the whole system. It receives the signals from the sensor' microcontroller via the Bluetooth module. From the received information, the program gets the delta X ,delta Y and the status of buttons then adds them to the corresponding data base in order to process them and make the necessary actions. The algorithm which will be implemented in computer program explained in the following flowchart.

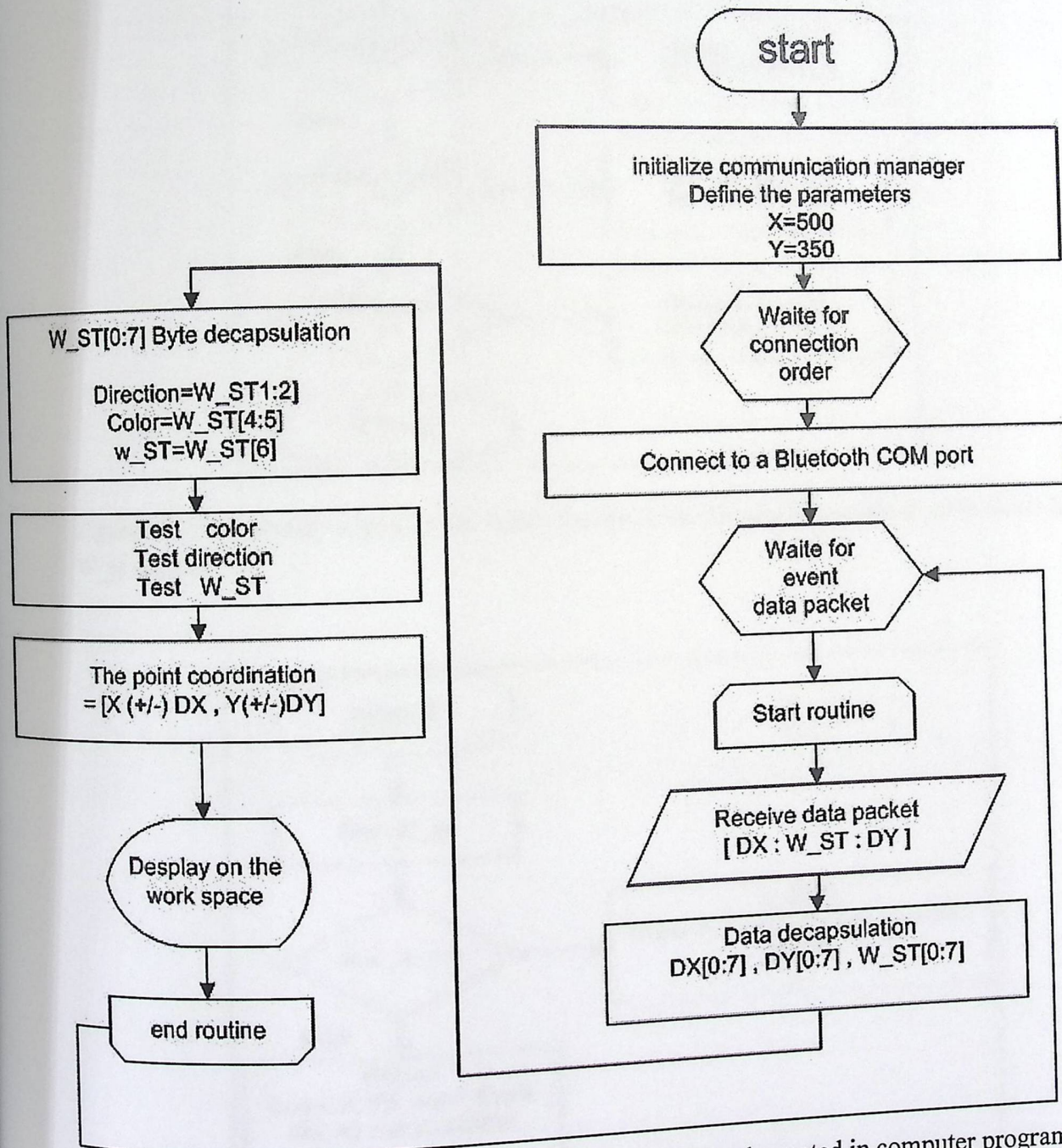


Figure 4.10: The algorithm which will be implemented in computer program.

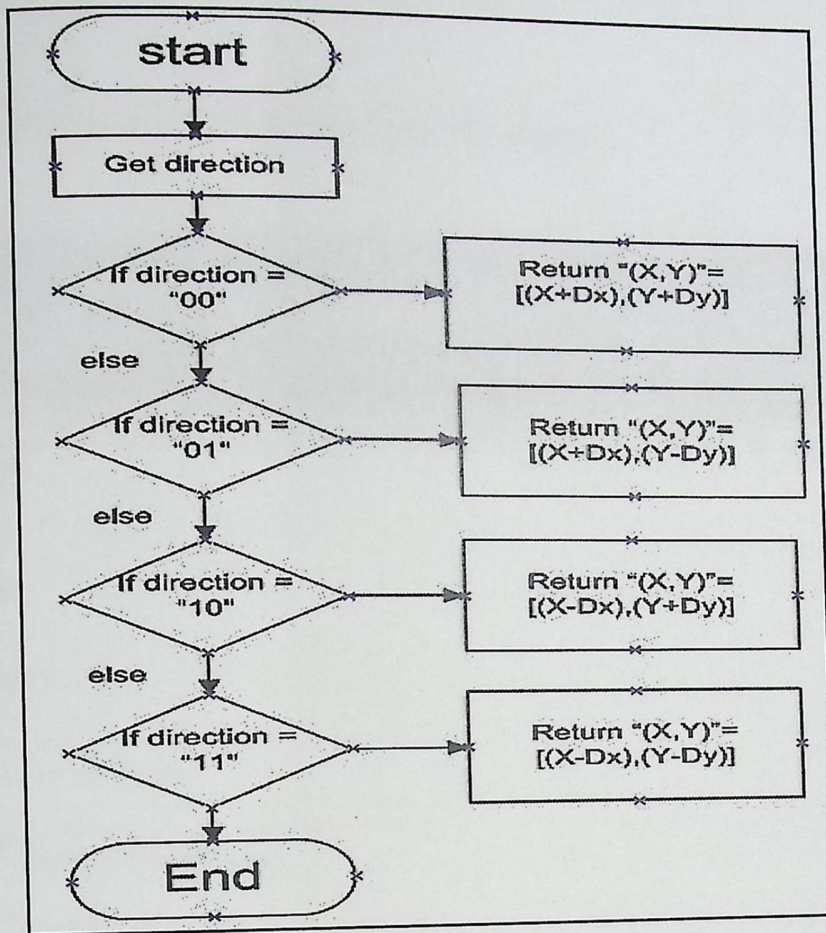


Figure 4.11: The routine algorithm to detect the direction. Depending on the sign bit fields in  $W\_st$  register.

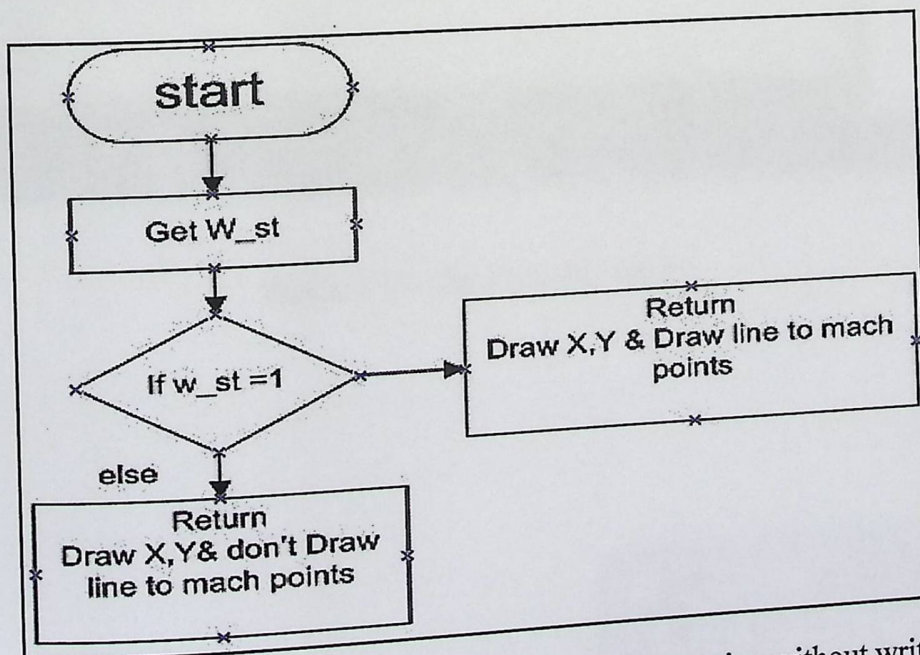


Figure 4.12: The routine algorithm to detect wither a writing or moving without writing.

A graphical user interface has been designed to enable the systems users to deal with the program in an easy way.

After opening the program the following screen will appear.

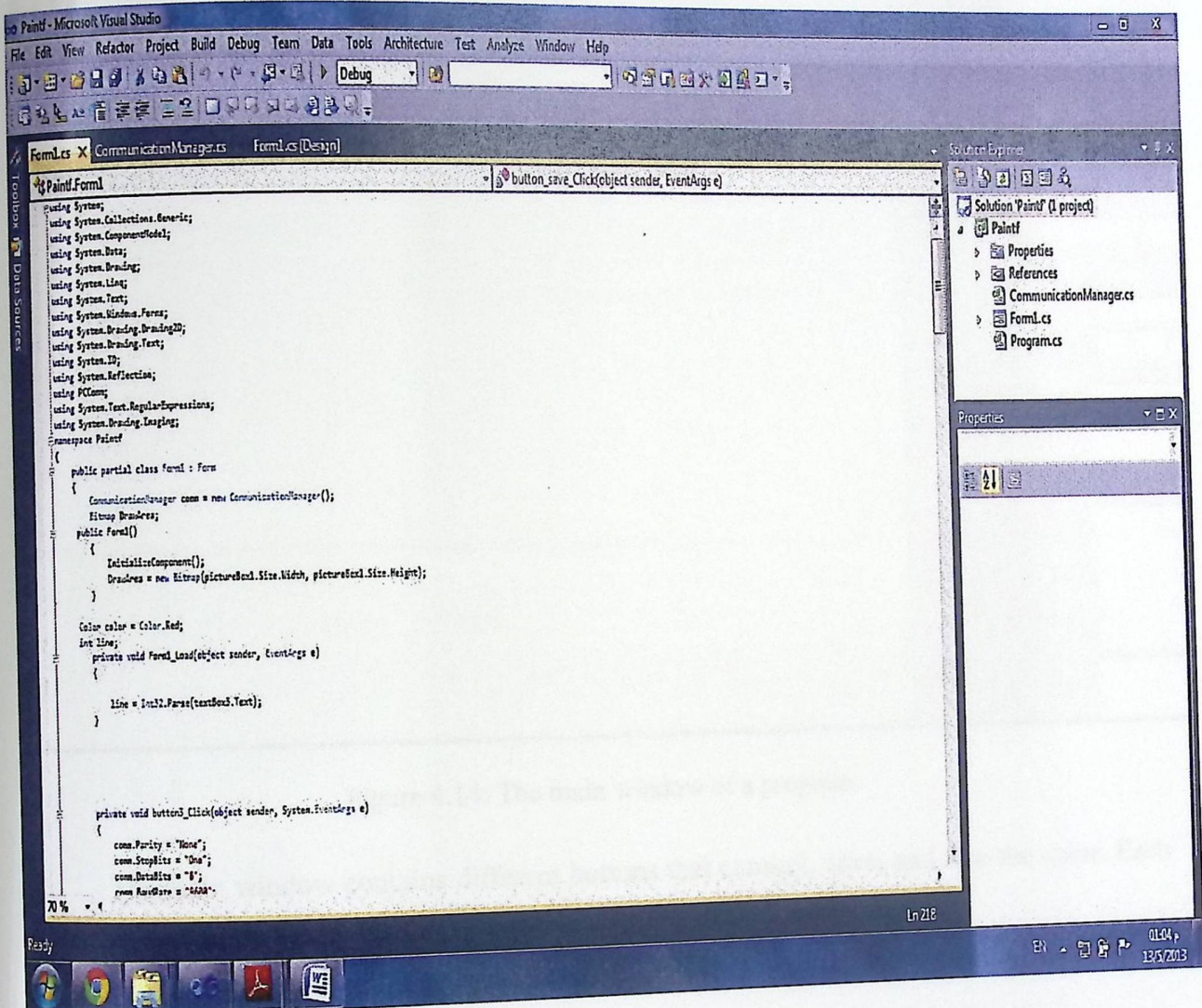
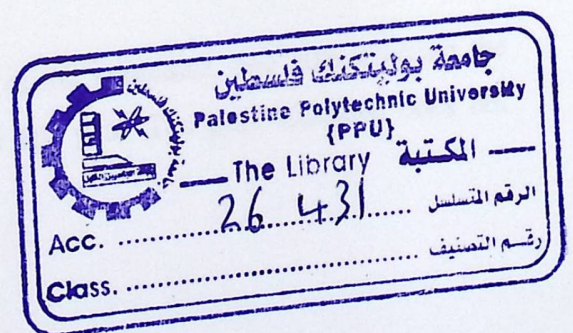


Figure 4.13: The C# code screen.



After running the program, the following screen will appear:

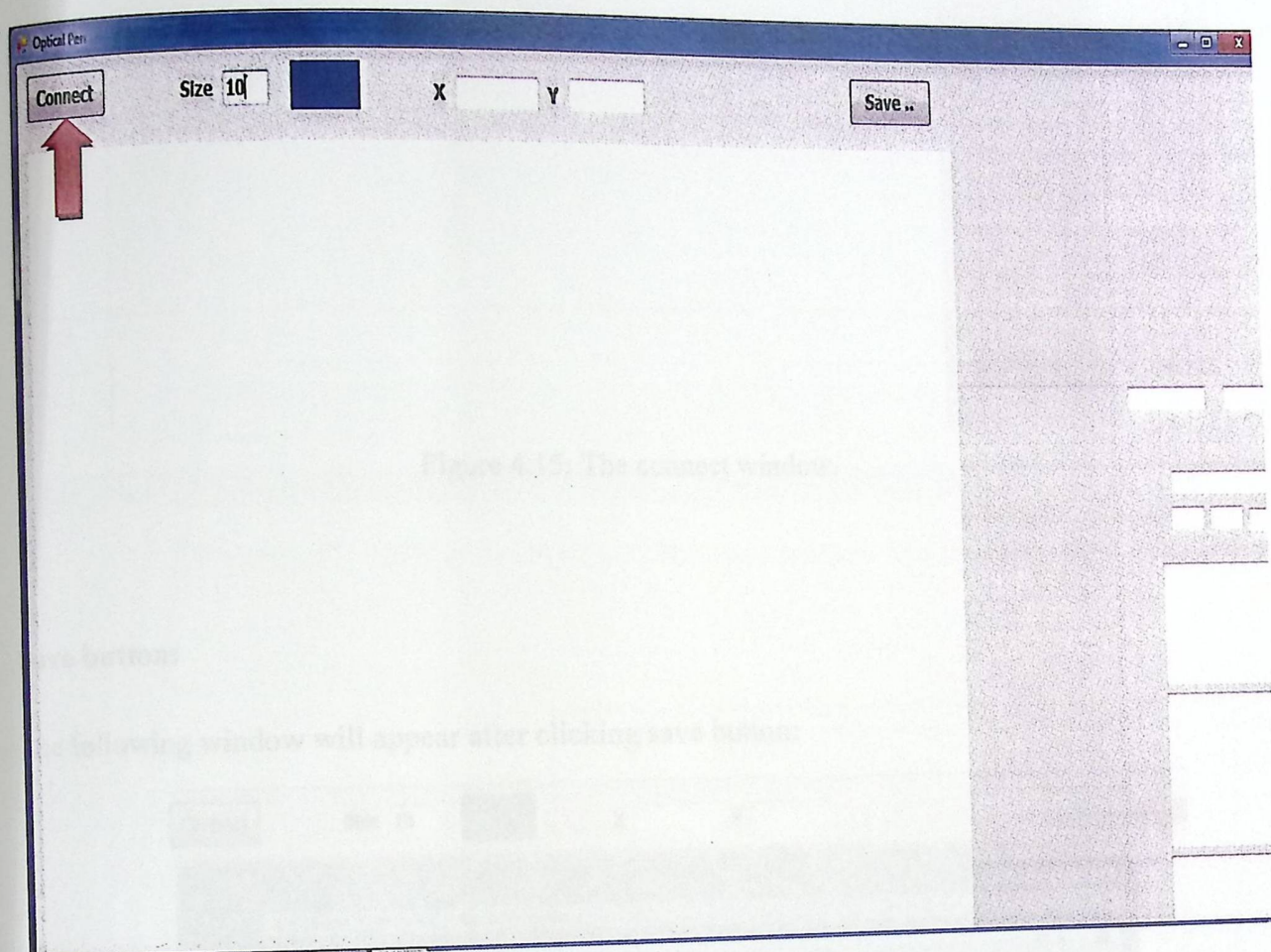


Figure 4.14: The main window of a program.

The main window contains different buttons that connect, save, and size the color. Each one of these buttons will be explained in details below.

### 4.3.2 The main window buttons

#### Connect button:

If a project is connected to the Bluetooth of the computer, the program will connect directly if the user presses on connect icon on the left of the above side so it will display any received data onto the screen.

If a project is not connected to the Bluetooth of the computer, and after clicking the connect button, the following window will appear to tell you "The port 'COM34' does not connect":

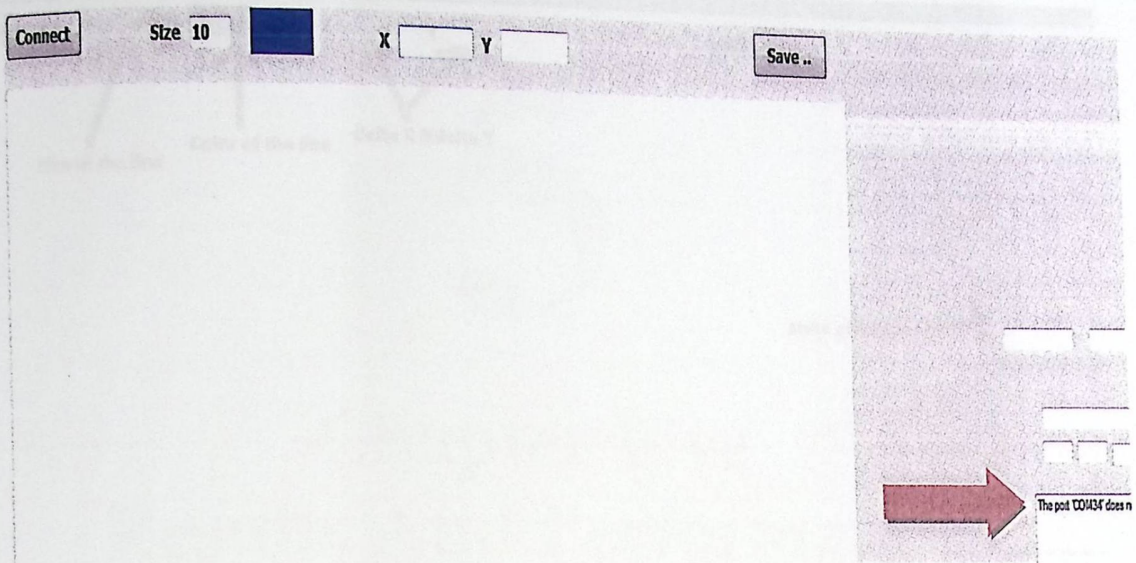


Figure 4.15: The connect window.

**Save button:**

The following window will appear after clicking save button:

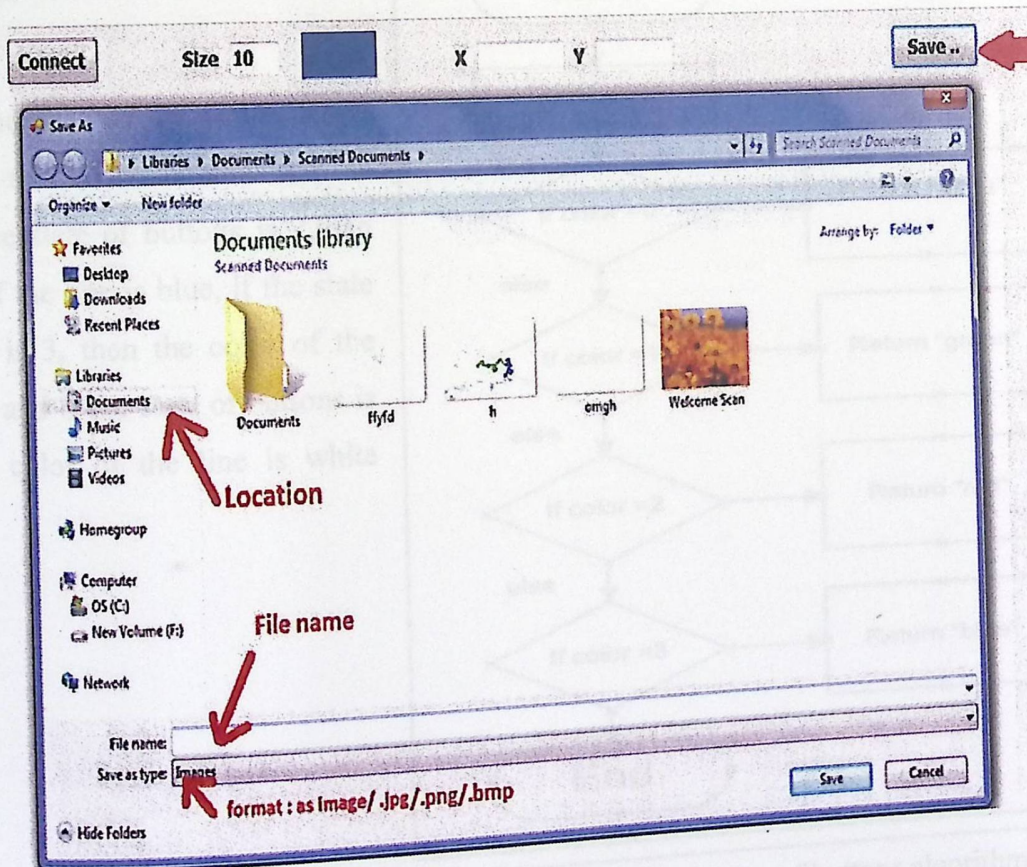


Figure 4.16: The Save window.

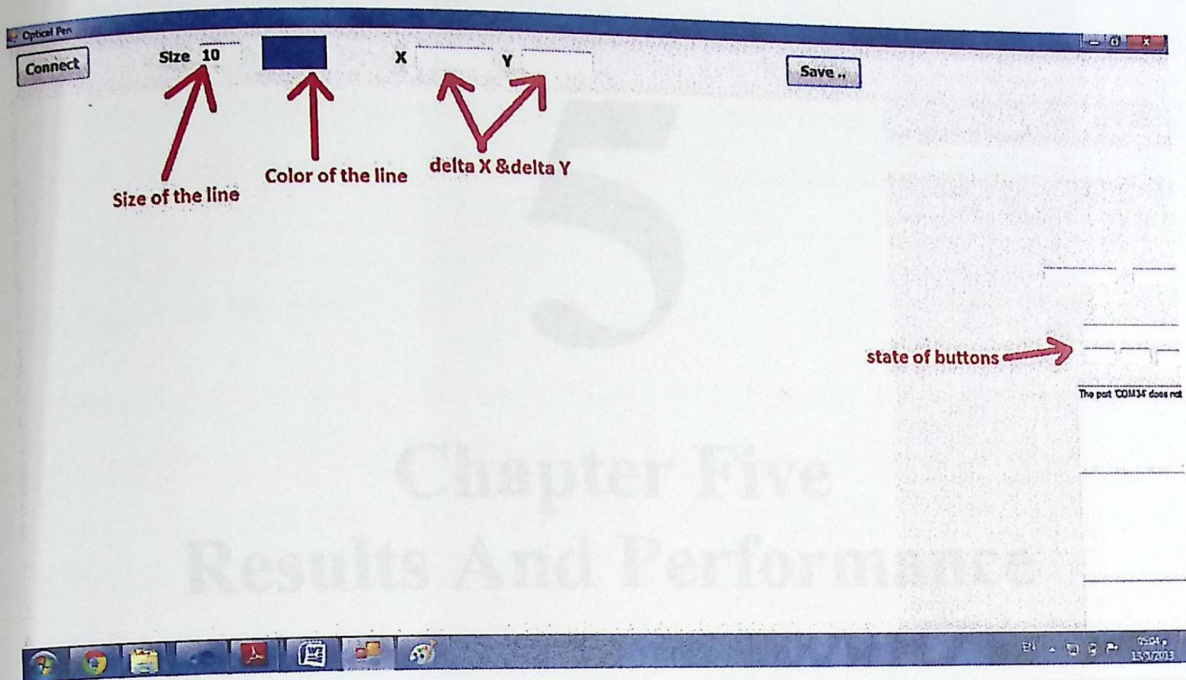


Figure 4.17: General description of the main window of a program.

### Status of buttons

If the state of buttons is 1 (one click), then the color of the line is green, if the state of buttons is 2, then the color of the line is blue, if the state of buttons is 3, then the color of the line is red, and if the state of buttons is 0, then the color of the line is white (clear).

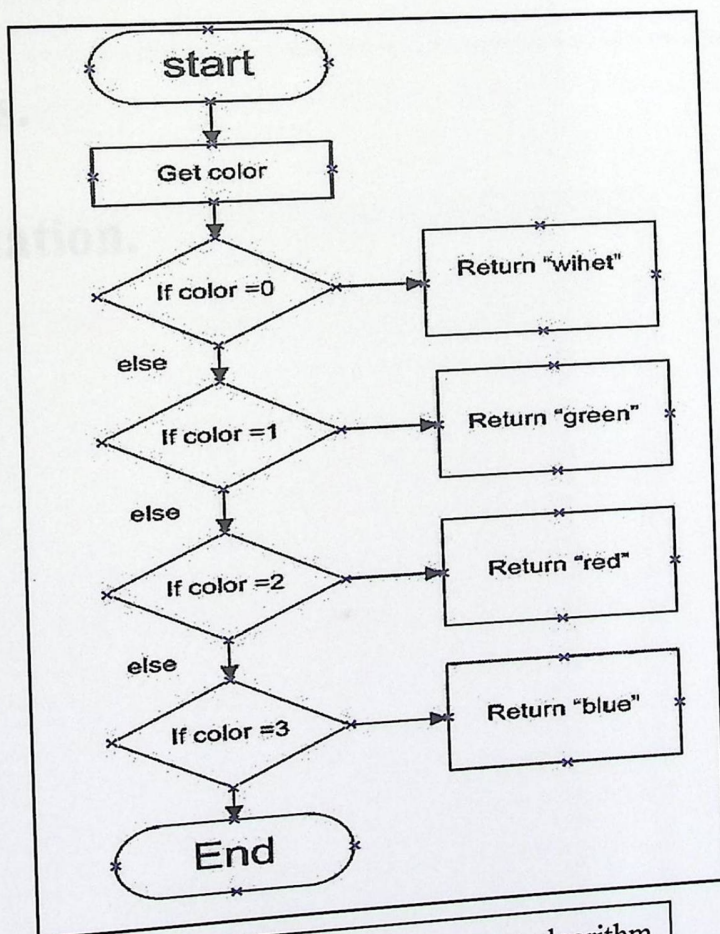


Figure 4.18: Status of buttons algorithm

# 5

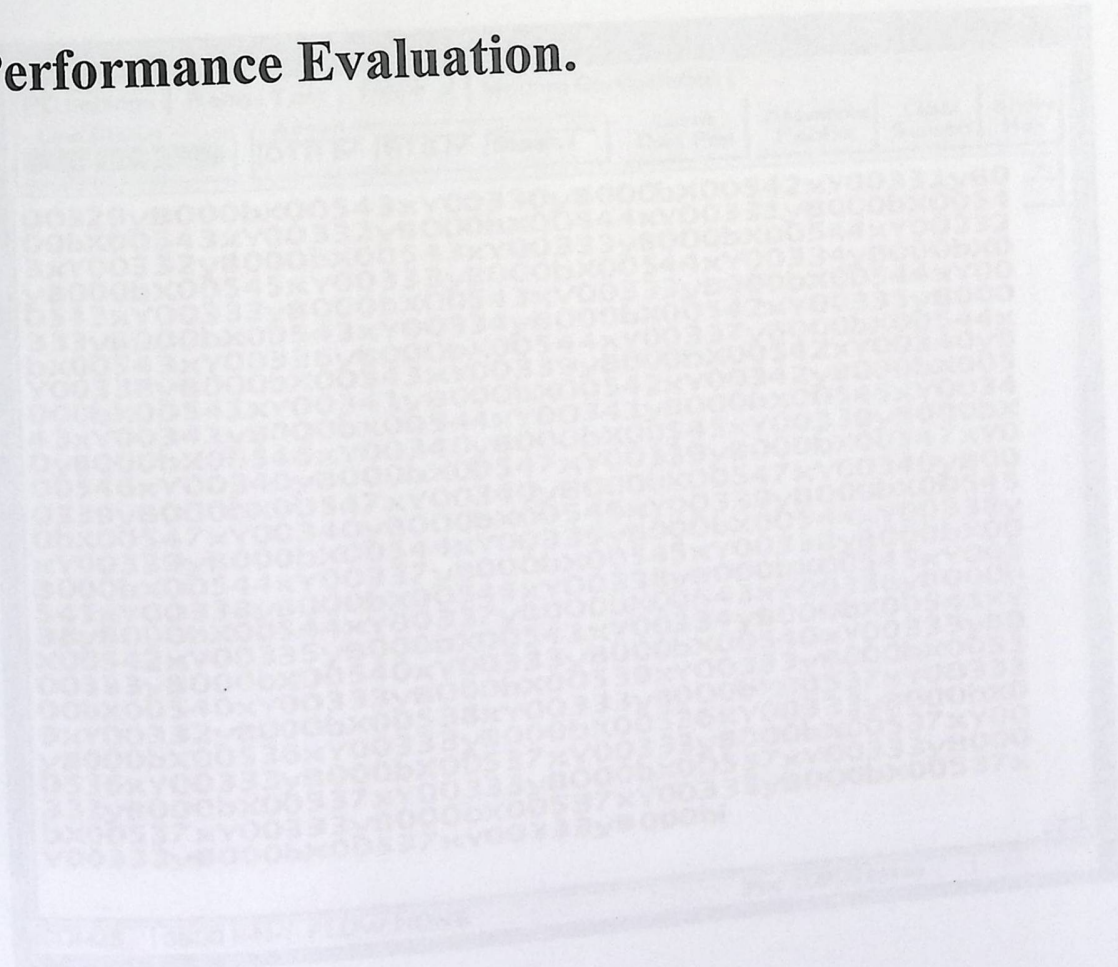
## Chapter Five Results And Performance

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### 5.1 Introduction.

### 5.2 Testing And Results.

### 5.3 Performance Evaluation.





## 5.1 Introduction

Measuring and testing the performance of the system is the final stage to complete the project. And this chapter gives a detailed description of the project testing performance.

## 5.2 Testing And Results

Checking of and testing the results of the project sensor, PIC microcontrollers, serial Bluetooth module, and software are illustrated in this section, the testing performed as one unit since it is so hard to test each part independently, because we deals with DSP sensor and it so hard to simulate the input and output data frames of this sensor , so .

### 5.2.1 Sensor and PIC Testing

When the optical sensor is connected to the PIC, and connected the PIC to the serial USB adapter to transfer data to the computer side to assure if data access to the computer or not. By using the X-CTU program (to show the data),the data is shown as in figure (5.1).

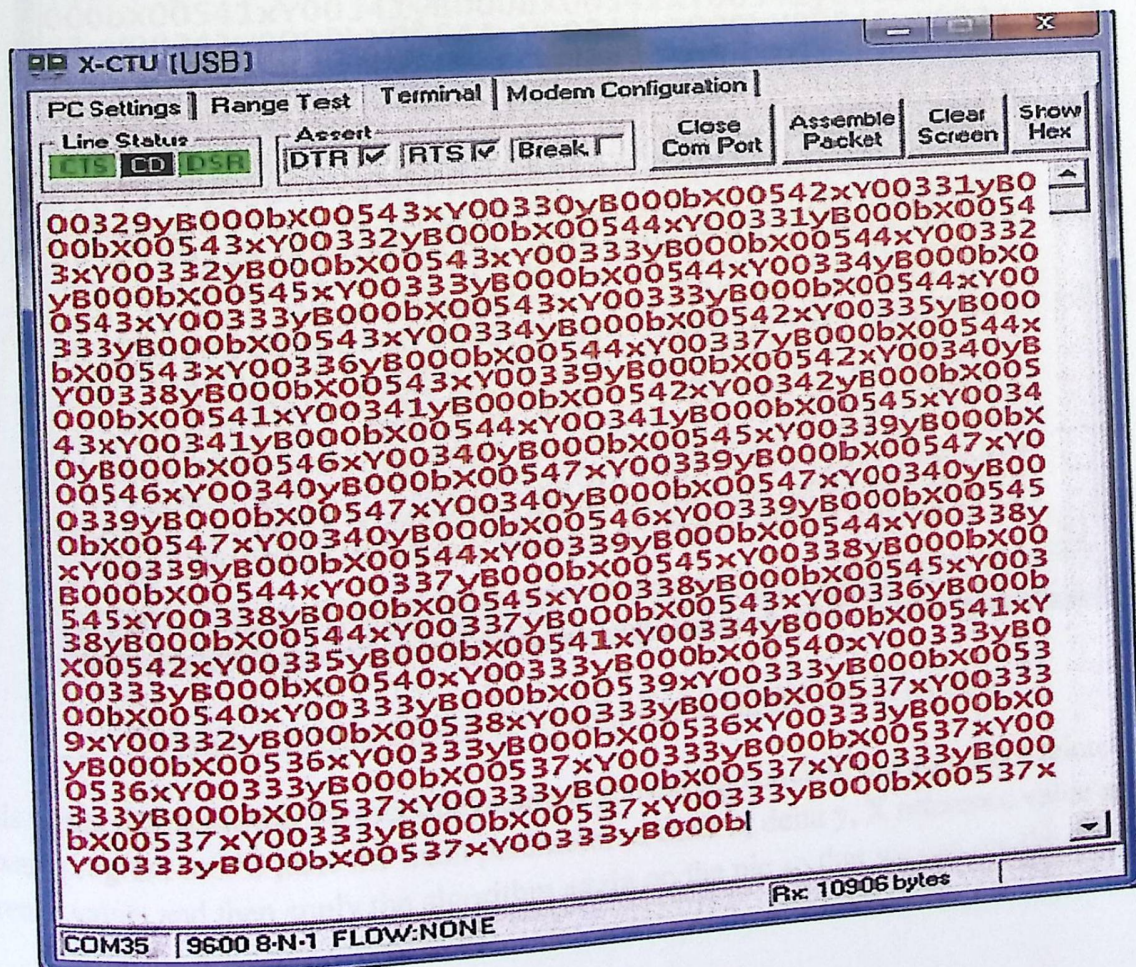


Figure 5.1: Data appear at computer side via USB adapter.

In the previous figure shows the values of delta X (X), delta Y (Y) and status of button (W\_st).

### 5.2.2 Serial Bluetooth module Testing

When we connected the Bluetooth module we test it by the same program (X-CTU) to assure access data to the computer wirelessly by Bluetooth, the data appear as the following figure.

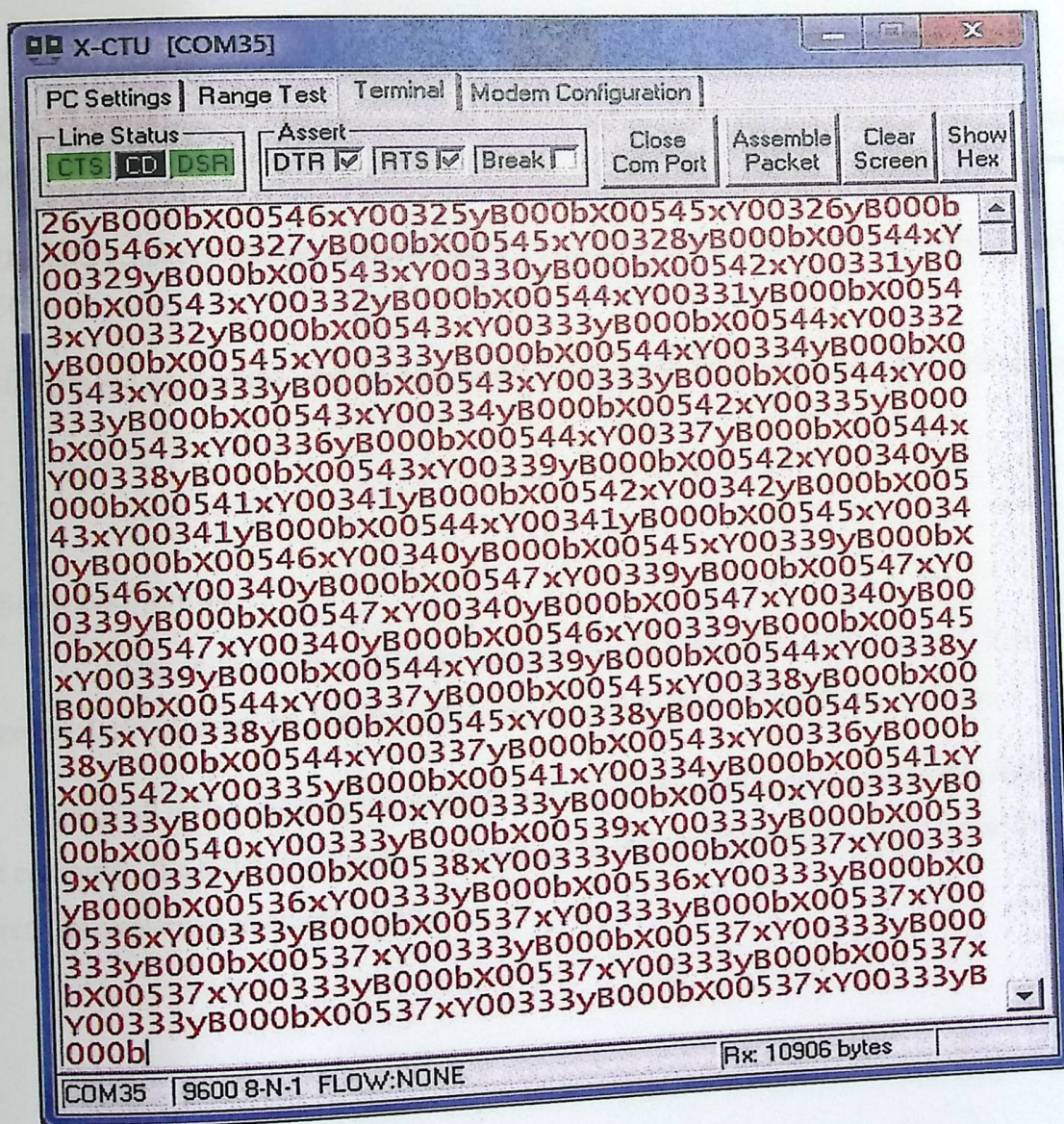


Figure 5.2: Data appear at computer side via Bluetooth module.

In this figure the result was correct one hundred percent, go back to the algorithm related to the software program on PC, take the main parameter of delta x, delta y, X reference value and Y reference value, and then apply the algorithm again on the pic so that we can see the desired

point on the program work space as it is, by comparing the resulted point coordinates with direction of motion we find it in the same direction .

More analysis on the result if we for example take a sample from the previous data screen let be

**X00537xY00333yB000b**

Here the pic transfers this point coordinate to the Bluetooth module in a form of integers and then the Bluetooth module transmits it in character form by using XCTU program we can show this coordinates data points and compare them with the direction of motion , we did use X,xY,y,B,b, characters to show the start and the end of x coordinates and so for y and switches state .

Now :

**X00537x**, means that the user moves "37 " pixel to the right because X reference value is "500" .

**Y00333y**, means that the user moves "37 " pixel to the left because Y reference value is "350".

**B000b** means that the user moves over the sheet and don't write , and the color is white.

### 5.2.3 Software Testing

The ability of the software is tested to send data by moving the pen, to receive and analyze the data collected by PIC from the sensor, and to show this data as writing.

First of all, after clicking the connect button , if a project is not connected to the Bluetooth of the computer, the following window will appear to tell you "The port 'COMxxx' does not connect", as explained in chapter four.

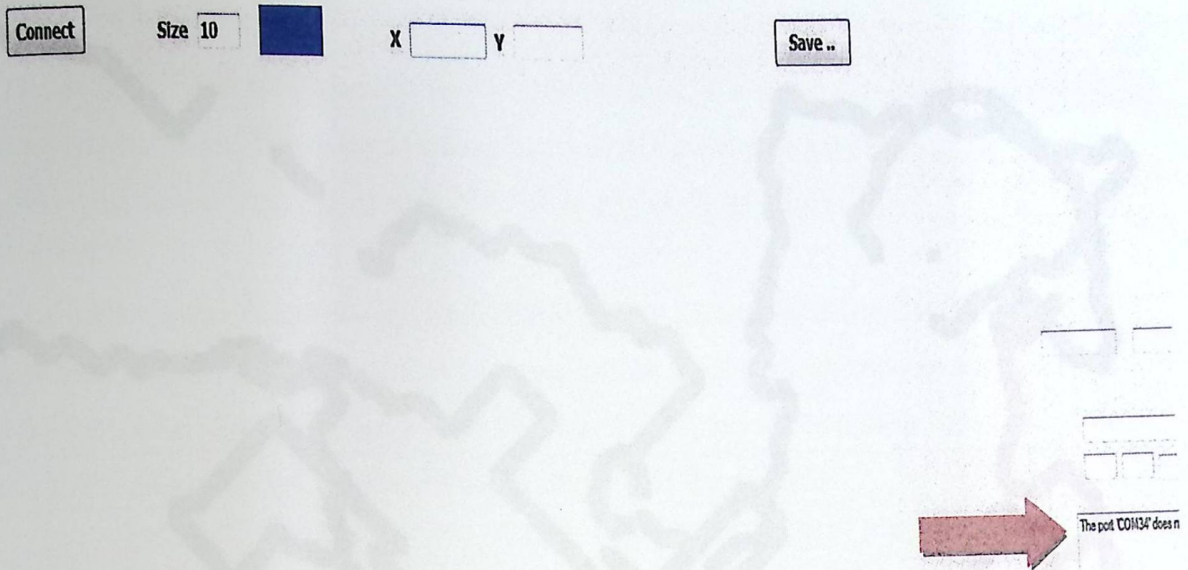


Figure 5.3: A message stating that "The port 'COMxx' does not connect".

After clicking the connect button If a project is not connected to the Bluetooth of the computer, the software will show data and writing.

### 5.2.4 The final system Testing

After confirming the work of each unit in the project correctly, we examined the system first and the results were reassuring, where the results showed, as in the following figure:

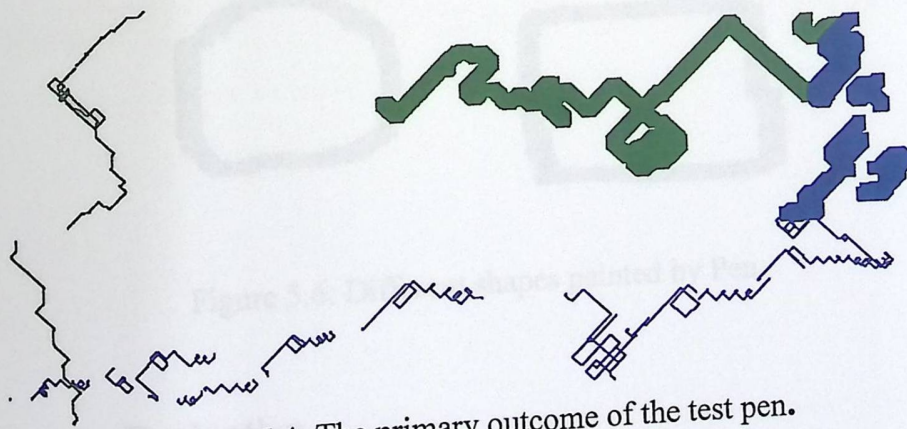


Figure 5.4: The primary outcome of the test pen.

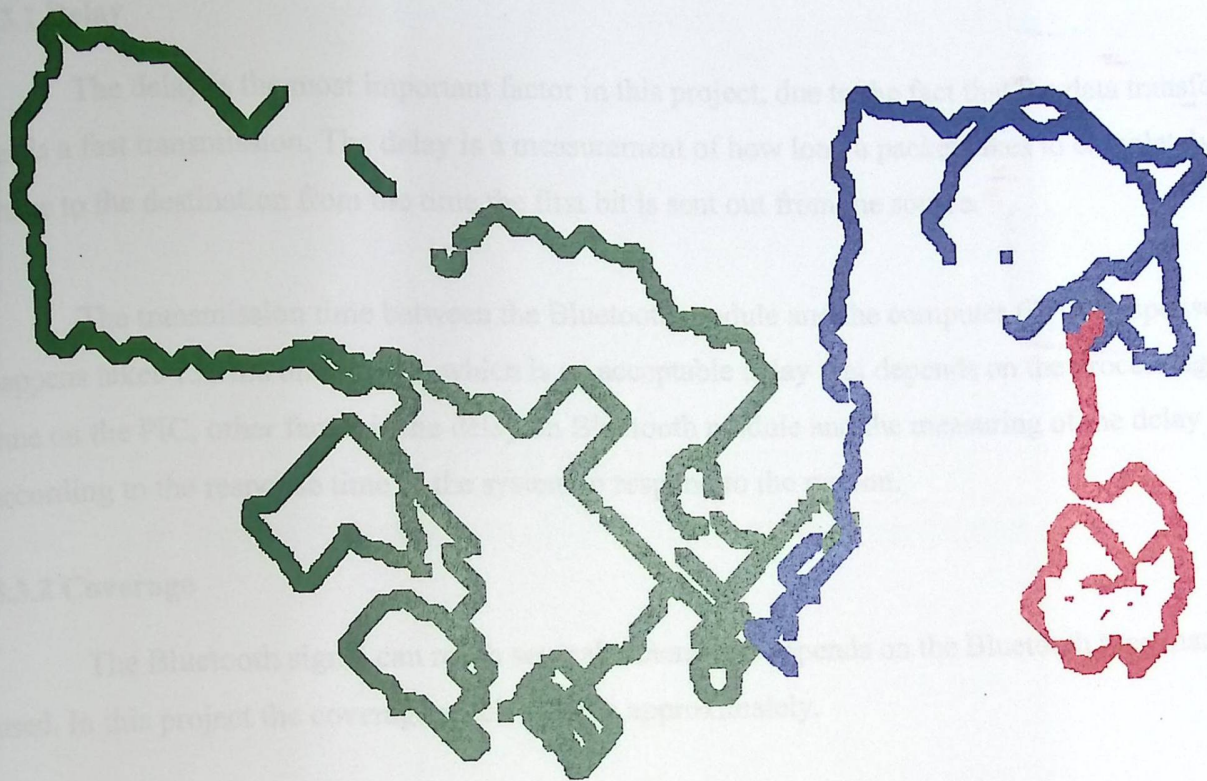


Figure 5.5: The second phase of testing for writing and cleaning.

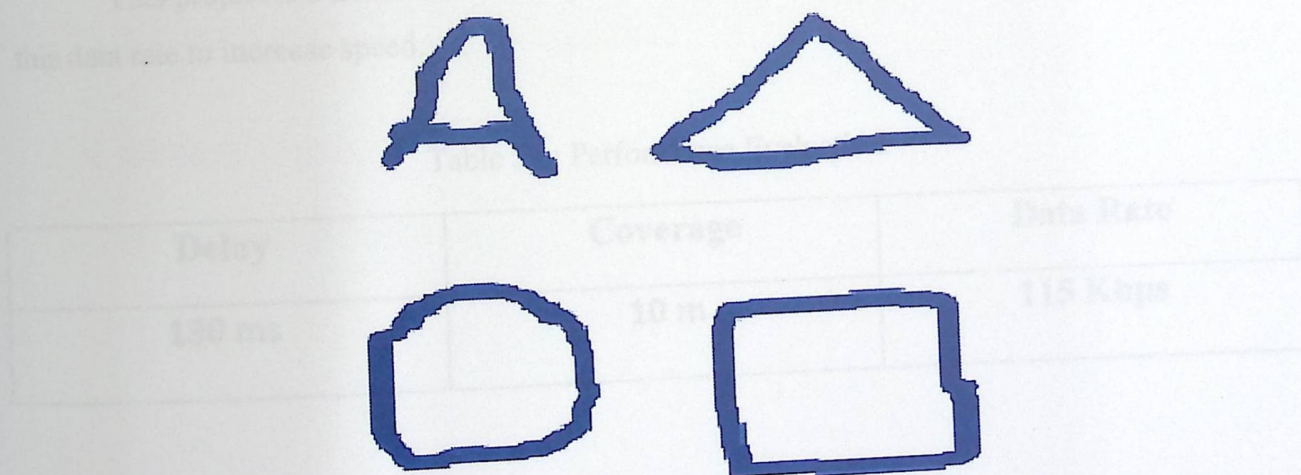


Figure 5.6: Different shapes painted by Pen.

### 5.3 Performance Evaluation

The performance evaluation in the project can be made by measuring the delay, data rate, and the coverage of the Bluetooth signal.

### 5.3.1 Delay

The delay is the most important factor in this project, due to the fact that the data transfer needs a fast transmission. The delay is a measurement of how long a packet takes to completely arrive to the destination from the time the first bit is sent out from the source.

The transmission time between the Bluetooth module and the computer till the response happens takes 130 ms on average, which is an acceptable delay that depends on the processing time on the PIC, other factor is the delay on Bluetooth module and the measuring of the delay according to the response time to the system to respond to the motion.

### 5.3.2 Coverage

The Bluetooth signal can reach several meters as it depends on the Bluetooth type that used. In this project the coverage reach to 10 m approximately.

### 5.3.3 Data Rate

This project is a Bluetooth based system with 115 Kbps, which is we needed to increase this data rate to increase speed.

Table 5.1: Performance Evaluation.

Delay	Coverage	Data Rate
130 ms	10 m	115 Kbps

# 6

## Chapter Six Conclusion and Recommendations

**6.1 Introduction**

**6.2 Problems**

**6.3 Acquired Learning Outcomes**

**6.4 Future works**

**6.5 Recommendations**

## 6.1 Introduction

This chapter describes the real learning outcomes have been acquired during the work on the project, and recommendations and suggestions for future work and development.

## 6.2 Problems

Many problems, challenges, and issues have been raised during the work on the project. Many experiments, suggestions, ideas and researches have been carried out to deal with the different situations. Some of these problems are:

1. The Availability of the quantity and the quality of some of the Project's equipment.
2. Slow response in the system and because of the treatment process.
3. Big time spent in the programming process and learn the appropriate programming language.
4. Size of the project may be large relative to the size of the appropriate pen.

## 6.3 Acquired Learning Outcomes

After accomplishing the project tasks many talents and abilities have been achieved as:

1. We have learnt MicroC programming language that is used to program the microcontroller.
2. We have learnt C# programming language.
3. We have developed our abilities in troubleshooting and problem solving.



## 6.4 Future works

1. We look for using Matlab library to use ORC tool box to convert the hand written in the saved images to text.
2. Work to increase the responsiveness and speed as much as possible, as well as increase the coverage.
3. Work to reduce the size as much as possible, as well as increase functions for pen.
4. Work on the development of the software interface so that it becomes the most beautiful.
5. Linking this project with smart phone devices that used android and others.

## 6.5 Recommendations

At the end, some ideas can be given to develop the system or extend its duties and functions, and some recommendations can be given to avoid the problems that may happen in the future as:

1. If the project has a hardware part, try to get all the components of the project at the preparation stage not to postpone it to the last moment.
2. To be a group of students to serve parts of the project, each one according to his specialty.
3. Distribute a group of students to serve parts of the project, each one according to his specialty.

# Appendix A

## PIC18F2550 Data Sheet

### 1.0 DEVICE OVERVIEW

This document contains device-specific information for the following devices:

This family of devices offers the advantages of all PIC18 microcontrollers – namely, high computational performance at an economical price – with the addition of high endurance, Enhanced Flash program memory. In addition to these features, the PIC18F2455/2550/4455/4550 family introduces design enhancements that make these microcontrollers a logical choice for many high-performance, power sensitive applications.

#### 1.1 New Core Features

**1.1.1 nanoWatt TECHNOLOGY** All of the devices in the PIC18F2455/2550/4455/4550 family incorporate a range of features that can significantly reduce power consumption during operation.

Key items include:

- **Alternate Run Modes:** By clocking the controller from the Timer1 source or the internal oscillator block, power consumption during code execution can be reduced by as much as 90%.
- **Multiple Idle Modes:** The controller can also run with its CPU core disabled but the peripherals still active. In these states, power consumption can be reduced even further, to as little as 4% of normal operation requirements.
- **On-the-Fly Mode Switching:** The power-managed modes are invoked by user code during operation, allowing the user to incorporate power-saving ideas into their application's software design.
- **Low Consumption in Key Modules:** The power requirements for both Timer1 and the Watchdog Timer are minimized. See **Section 28.0**

“**Electrical Characteristics**” for values.

**1.1.2 UNIVERSAL SERIAL BUS (USB)** Devices in the PIC18F2455/2550/4455/4550 family incorporate a fully featured Universal Serial Bus

communications module that is compliant with the USB Specification Revision 2.0. The module supports both low-speed and full-speed communication for all supported data transfer types. It also incorporates its own on-chip transceiver and 3.3V regulator and supports the use of external transceivers and voltage regulators.

### 1.1.3 MULTIPLE OSCILLATOR OPTIONS AND FEATURES

All of the devices in the PIC18F2455/2550/4455/4550 family offer twelve different oscillator options, allowing users a wide range of choices in developing application hardware. These include:

- Four Crystal modes using crystals or ceramic resonators.
- Four External Clock modes, offering the option of using two pins (oscillator input and a divide-by-4 clock output) or one pin (oscillator input, with the second pin reassigned as general I/O).
- An internal oscillator block which provides an 8 MHz clock ( $\pm 2\%$  accuracy) and an INTRC source (approximately 31 kHz, stable over temperature and VDD), as well as a range of 6 user-selectable clock frequencies, between 125 kHz to 4 MHz, for a total of 8 clock frequencies. This option frees an oscillator pin for use as an additional general purpose I/O.
- A Phase Lock Loop (PLL) frequency multiplier, available to both the High-Speed Crystal and External Oscillator modes, which allows a wide range of clock speeds from 4 MHz to 48 MHz.
- Asynchronous dual clock operation, allowing the USB module to run from a high-frequency oscillator while the rest of the microcontroller is clocked from an internal low-power oscillator. Besides its availability as a clock source, the internal oscillator block provides a stable reference source that gives the family additional features for robust operation:
  - **Fail-Safe Clock Monitor:** This option constantly monitors the main clock source against a reference signal provided by the internal oscillator. If a clock failure occurs, the controller is switched to the internal oscillator block, allowing for continued low-speed operation or a safe application shutdown.
  - **Two-Speed Start-up:** This option allows the internal oscillator to serve as the clock source from Power-on Reset, or wake-up from Sleep mode, until the primary clock source is available.

### 1.2 Other Special Features

- **Memory Endurance:** The Enhanced Flash cells for both program memory and data EEPROM are rated to last for many thousands of erase/write cycles – up to 100,000 for program memory

and 1,000,000 for EEPROM. Data retention without refresh is conservatively estimated to be greater than 40 years.

- **Self-Programmability:** These devices can write to their own program memory spaces under internal software control. By using a boot loader routine, located in the protected Boot Block at the top of program memory, it becomes possible to create an application that can update itself in the field.

- **Extended Instruction Set:** The PIC18F2455/2550/4455/4550 family introduces an optional extension to the PIC18 instruction set, which adds 8 new instructions and an Indexed Literal Offset Addressing mode. This extension, enabled as a device configuration option, has been specifically designed to optimize re-entrant application code originally developed in high-level languages such as C.

- **Enhanced CCP Module:** In PWM mode, this module provides 1, 2 or 4 modulated outputs for controlling half-bridge and full-bridge drivers. Other features include auto-shutdown for disabling PWM outputs on interrupt or other select conditions and auto-restart to reactivate outputs once the condition has cleared.

- **Enhanced Addressable USART:** This serial communication module is capable of standard RS-232 operation and provides support for the LIN bus protocol. Other enhancements include Automatic Baud Rate Detection and a 16-bit Baud Rate Generator for improved resolution. When the microcontroller is using the internal oscillator block, the USART provides stable operation for applications that talk to the outside world without using an external crystal (or its accompanying power requirement).

- **10-Bit A/D Converter:** This module incorporates programmable acquisition time, allowing for a channel to be selected and a conversion to be initiated, without waiting for a sampling period and thus, reducing code overhead.

- **Dedicated ICD/ICSP Port:** These devices introduce the use of debugger and programming pins that are not multiplexed with other microcontroller features. Offered as an option in select packages, this feature allows users to develop I/O intensive applications while retaining the ability to program and debug in the circuit.

### 1.3 Details on Individual Family Members

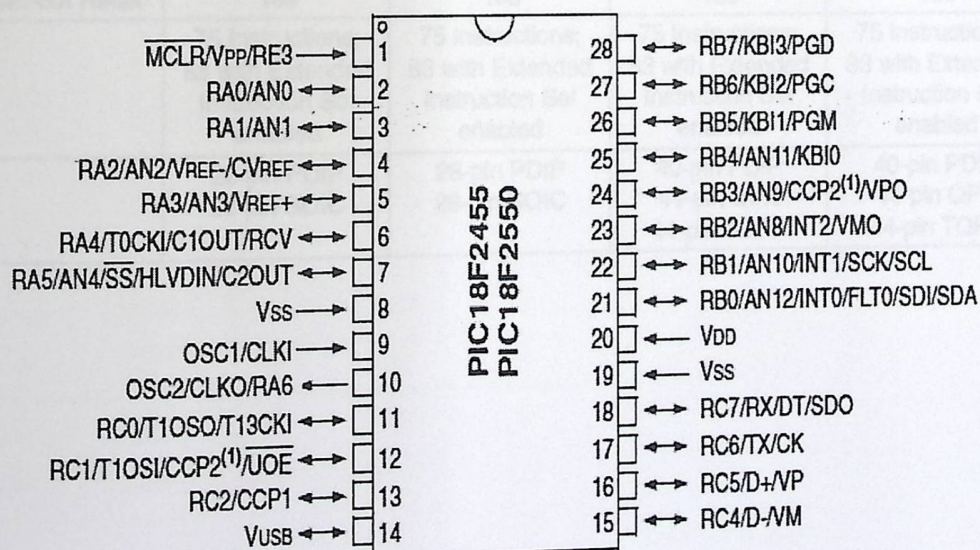
Devices in the PIC18F2455/2550/4455/4550 family are available in 28-pin and 40/44 pin packages. Block diagrams for the two groups are shown in Figure 1-1 and Figure 1-2.

The devices are differentiated from each other in six ways:

1. Flash program memory (24 Kbytes for PIC18FX455 devices, 32 Kbytes for PIC18FX550).
2. A/D channels (10 for 28-pin devices, 13 for 40/44-pin devices).
3. I/O ports (3 bidirectional ports and 1 input only port on 28-pin devices, 5 bidirectional ports on 40/44-pin devices).
4. CCP and Enhanced CCP implementation (28-pin devices have two standard CCP modules, 40/44-pin devices have one standard CCP module and one ECCP module).
5. Streaming Parallel Port (present only on 40/44-pin devices). All other features for devices in this family are identical. These are summarized in Table 1-1. The pinouts for all devices are listed in Table 1-2 and Table 1-3. Like all Microchip PIC18 devices, members of the PIC18F2455/2550/4455/4550 family are available as both standard and low-voltage devices. Standard devices with Enhanced Flash memory, designated with an "F" in the part number (such as PIC18F2550), accommodate an operating VDD range of 4.2V to 5.5V. Low-voltage parts, designated by "LF" (such as PIC18LF2550), function over an extended VDD range of 2.0V to 5.5V.

## Pin Diagrams

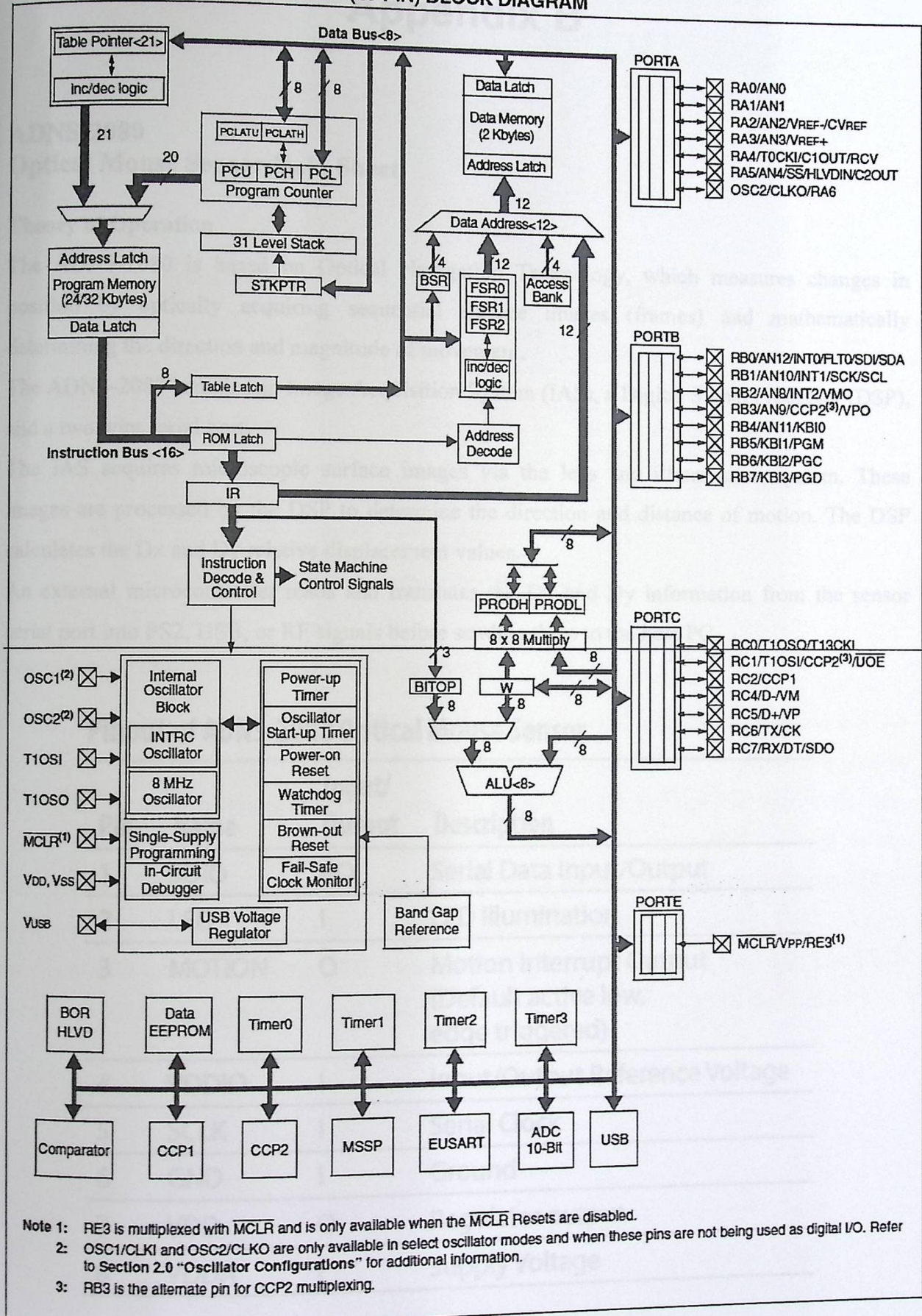
### 28-Pin PDIP, SOIC



**TABLE 1-1: DEVICE FEATURES**

Features	PIC18F2455	PIC18F2550	PIC18F4455	PIC18F4550
Operating Frequency	DC – 48 MHz	DC – 48 MHz	DC – 48 MHz	DC – 48 MHz
Program Memory (Bytes)	24576	32768	24576	32768
Program Memory (Instructions)	12288	16384	12288	16384
Data Memory (Bytes)	2048	2048	2048	2048
Data EEPROM Memory (Bytes)	256	256	256	256
Interrupt Sources	19	19	20	20
I/O Ports	Ports A, B, C, (E)	Ports A, B, C, (E)	Ports A, B, C, D, E	Ports A, B, C, D, E
Timers	4	4	4	4
Capture/Compare/PWM Modules	2	2	1	1
Enhanced Capture/ Compare/PWM Modules	0	0	1	1
Serial Communications	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART
Universal Serial Bus (USB) Module	1	1	1	1
Streaming Parallel Port (SPP)	No	No	Yes	Yes
10-Bit Analog-to-Digital Module	10 Input Channels	10 Input Channels	13 Input Channels	13 Input Channels
Comparators	2	2	2	2
Resets (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT
Programmable Low-Voltage Detect	Yes	Yes	Yes	Yes
Programmable Brown-out Reset	Yes	Yes	Yes	Yes
Instruction Set	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled
Packages	28-pin PDIP 28-pin SOIC	28-pin PDIP 28-pin SOIC	40-pin PDIP 44-pin QFN 44-pin TQFP	40-pin PDIP 44-pin QFN 44-pin TQFP

**FIGURE 1-1: PIC18F2455/2550 (28-PIN) BLOCK DIAGRAM**



**Note 1:** RE3 is multiplexed with  $\overline{\text{MCLR}}$  and is only available when the  $\overline{\text{MCLR}}$  Resets are disabled.  
**Note 2:** OSC1/CLKI and OSC2/CLKO are only available in select oscillator modes and when these pins are not being used as digital I/O. Refer to Section 2.0 "Oscillator Configurations" for additional information.  
**Note 3:** RB3 is the alternate pin for CCP2 multiplexing.

# Appendix B

## ADNS-2080

### Optical Mouse Sensor Data Sheet

#### Theory of Operation

The ADNS-2080 is based on Optical Navigation Technology, which measures changes in position by optically acquiring sequential surface images (frames) and mathematically determining the direction and magnitude of movement.

The ADNS-2080 contains an Image Acquisition System (IAS), a Digital Signal Processor (DSP), and a two wire serial port.

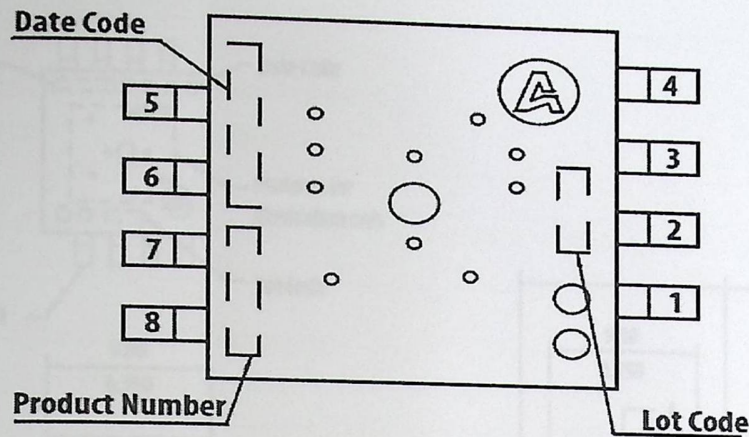
The IAS acquires microscopic surface images via the lens and illumination system. These images are processed by the DSP to determine the direction and distance of motion. The DSP calculates the Dx and Dy relative displacement values.

An external microcontroller reads and translates the Dx and Dy information from the sensor serial port into PS2, USB, or RF signals before sending them to the host PC.

#### Pinout of ADNS-2080 Optical Mouse Sensor

Pin	Name	Input/ Output	Description
1	SDIO	I/O	Serial Data Input/Output
2	LED	I	LED Illumination
3	MOTION	O	Motion Interrupt Output (Default active low, edge triggered)
4	VDDIO	I	Input/Output Reference Voltage
5	SCLK	I	Serial Clock
6	GND	I	Ground
7	VDD	O	Regulator output
8	VDDA	I	Supply Voltage





Item	Marking	Remarks
Product Number	A2080	
Date Code	XYWWZ	X = Subcon Code YYWW = Date Code Z = Sensor Die Source
Lot Code	VVV	Numeric

Figure 1. Package Outline Drawing (Top View)

### Overview of Optical Mouse Sensor Assembly

Avago Technologies provides an IGES file drawing describing the base plate molding features for lens and PCB alignment. The ADNS-2080 sensor is designed for mounting on a through-hole PCB, looking down. There is an aperture stop and features on the package that align to the lens. The ADNS-5110-001 lens provides optics for the imaging of the surface as well as the illumination of the surface at the optimum angle. Features on the lens align it to the sensor, base plate, and clip with the LED. The LED clip holds the LED in relation to the lens. The LED must be inserted into the clip and the LED's leads formed prior to loading on the PCB. The LEDs recommended for illumination include HSDL-4261 IR LED and HLMP-EG3E Red LED.

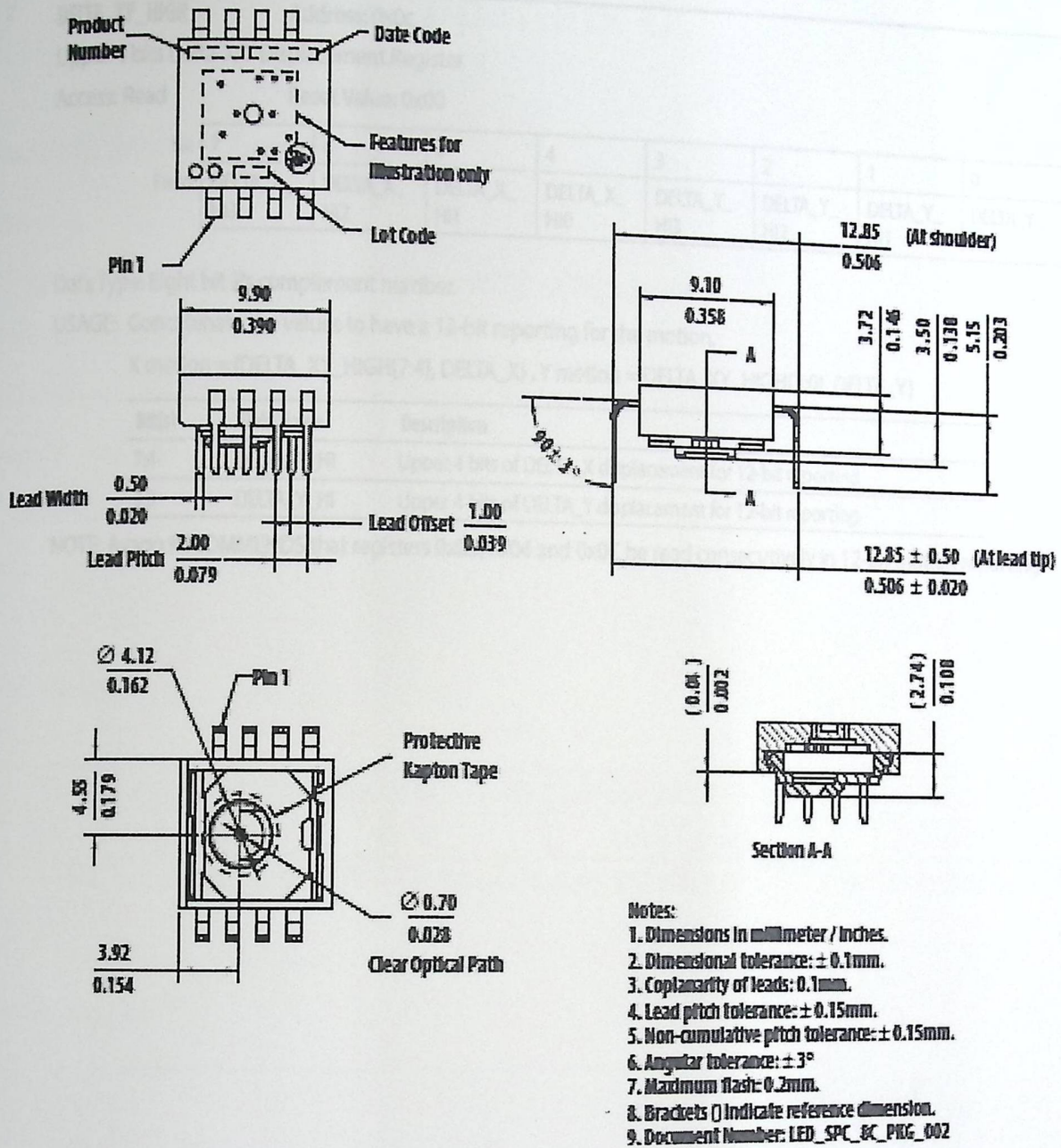


Figure 2. Package Outline Drawing

**CAUTION:** It is advised that normal static precautions be taken in handling and assembling of this component to prevent damage and/or degradation which may be induced by ESD.

**DELTA\_XY\_HIGH** Address: 0x0c

Upper 4 bits Delta-X/Y Displacement Register

Access: Read Reset Value: 0x00

Bit	7	6	5	4	3	2	1	0
Field	DELTA_X_HI3	DELTA_X_HI2	DELTA_X_HI1	DELTA_X_HI0	DELTA_Y_HI3	DELTA_Y_HI2	DELTA_Y_HI1	DELTA_Y_HI0

Data Type: Eight bit 2's complement number.

USAGE: Concatenate the values to have a 12-bit reporting for the motion.

X motion = {DELTA\_XY\_HIGH[7:4], DELTA\_X}, Y motion = DELTA\_XY\_HIGH[3:0], DELTA\_Y

Bit(s)	Field Name	Description
7:4	DELTA_X_HI	Upper 4 bits of DELTA_X displacement for 12-bit reporting
3:0	DELTA_Y_HI	Upper 4 bits of DELTA_Y displacement for 12-bit reporting

NOTE: Avago RECOMMENDS that registers 0x03, 0x04 and 0x0C be read consecutively in 12-bit motion reporting.

# Appendix C

## Bluetooth Module Data Sheet

### 1. Scope

This specification is applied to the Bluetooth 2.0+EDR module

Interface: USB/UART(H4)/BCSP

IC/Firmware: BC4-ROM Ver. 21e (Support 3wire co-existence )

Weight : 0.125g

Reference clock: internal (26MHz)

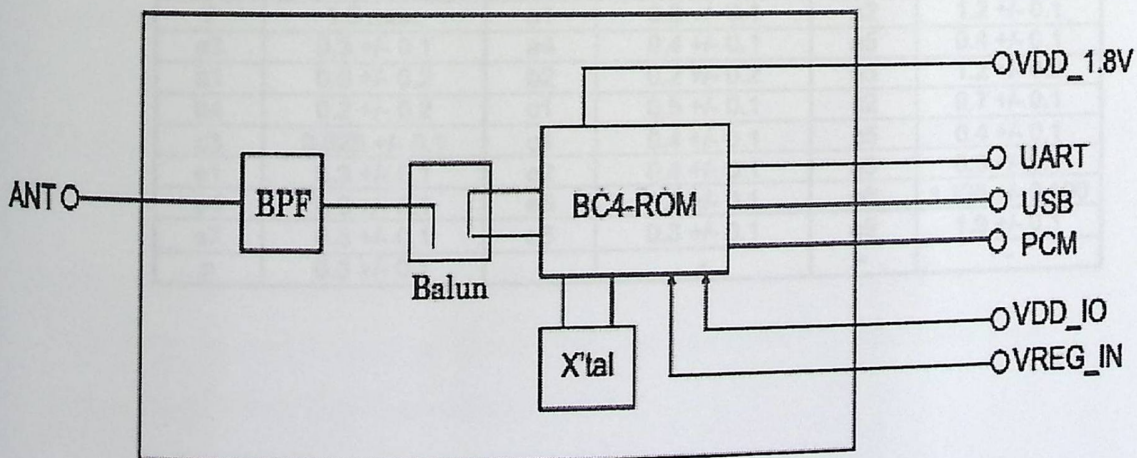
MSL : 1

### 2. Part Number

Part Number	LBMA465HG1-TEMP	LBMA465HG2-TEMP	LBMA465HG3-TEMP
HCI Interface	USB	UART (H4)	BCSP *

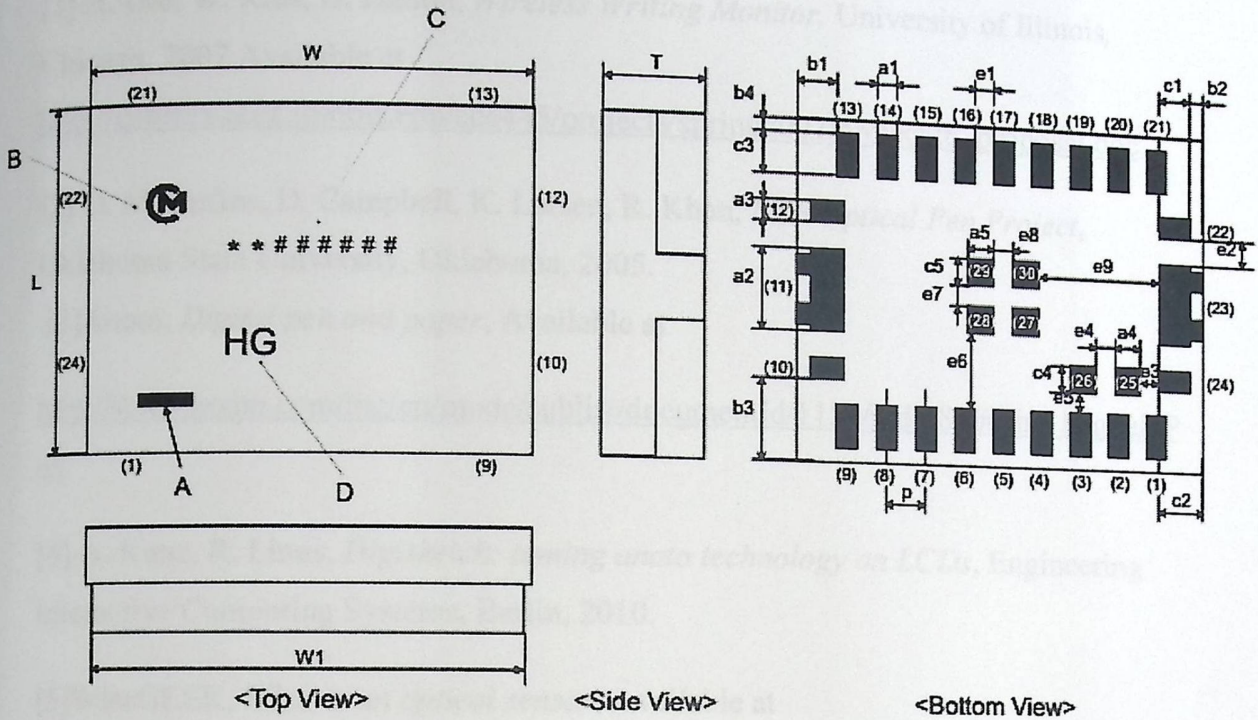
\* BCSP (Blue Core Serial Protocol) is a proprietary of CSR's serial protocol.

### 3. Block Diagram



Terminal	3.0 Power Supply	1.8V Power Supply
VDD_1.8V	Bypass capacitor	1.7 to 1.9V
VDD_IO	1.7 to 3.6V	1.7 to 1.9V
VREG_IN	2.6 to 4.2V	NC

#### 4. Dimensions, Marking and Terminal Configurations



Marking	Meaning
A	Pin 1 Marking
B	Murata Logo
C	BD Address
D	Module Type

#### Dimensions

(Unit : mm)

Mark	Dimension	Mark	Dimension	Mark	Dimension
L	5.0 +/- 0.3	W	6.4 +/- 0.3	W1	6.3 +/- 0.3
T	1.5 max.	a1	0.3 +/- 0.1	a2	1.2 +/- 0.1
a3	0.3 +/- 0.1	a4	0.4 +/- 0.1	a5	0.4 +/- 0.1
b1	0.6 +/- 0.2	b2	0.2 +/- 0.2	b3	1.2 +/- 0.2
b4	0.2 +/- 0.2	c1	0.5 +/- 0.1	c2	0.7 +/- 0.1
c3	0.625 +/- 0.1	c4	0.4 +/- 0.1	c5	0.4 +/- 0.1
e1	0.3 +/- 0.1	e2	0.4 +/- 0.1	e3	0.3 +/- 0.1
e4	0.3 +/- 0.1	e5	0.3 +/- 0.1	e6	1.125 +/- 0.100
e7	0.3 +/- 0.1	e8	0.3 +/- 0.1	e9	1.9 +/- 0.1
p	0.6 +/- 0.1	-	-	-	-

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