CUWIN

5000/6000/CWV Series

Microsoft Windows Embedded CE Touch Controller

User's Manual

2014-10-01

"Everything for Embedded Control"

COMFILE TECHNOLOGY

Comfile Technology Inc.
www.cubloc.com

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Preface

This document was created to help our customers quickly explore and enjoy the CUWIN without having to spend much effort reading documentation and experimenting beforehand. This document will help users connect the CUWIN to a PC, transfer files to and from the CUWIN and a PC, program the CUWIN, and interface the CUWIN to other digital devices like the CUBLOC.

The exercises in this document will make use of Visual Studio 2008, the C# programming language, and the .Net Compact Framework, but the CUWIN can be programmed in any programming language and development environment that is compatible with Windows Embedded CE 6.0 and the CUWIN's processor. This includes, but is not limited to, Visual Basic and C++.

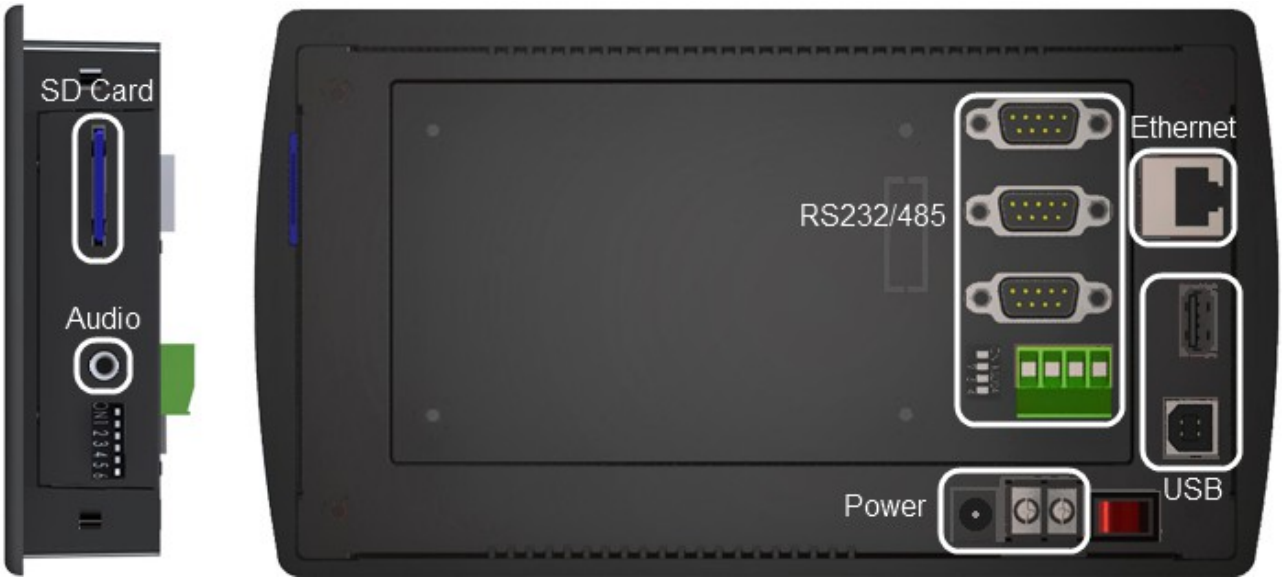
This document will make use of the CUWIN5200, but all examples can be easily adaptable to any CUWIN model with little or no modification.

We hope this document will reveal just how easy it is to quickly begin using the CUWIN, develop software, and interface the CUWIN to almost any digital device.

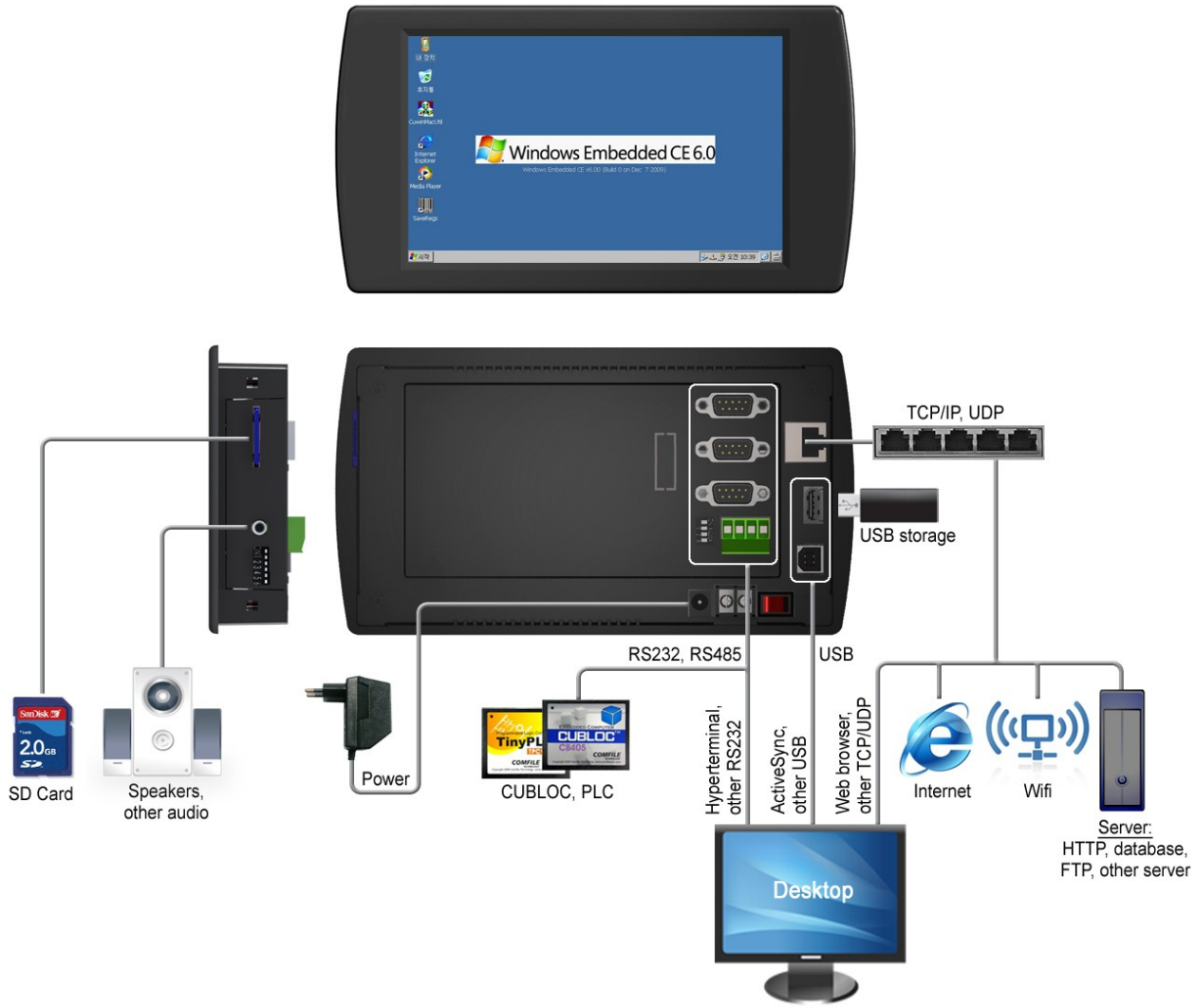
Overview

The CUWIN is a Windows Embedded CE touch controller primarily targeted for use as a Human Machine Interface(HMI).

The CUWIN's front panel features an 800x480 color touch screen capable of receiving input from a human user, by touching the screen, and displaying colorful information.



The CUWIN's rear and side panels feature several interfaces (RS232/485, USB, Ethernet, Audio, SD Card) for communicating with many different electronic devices.



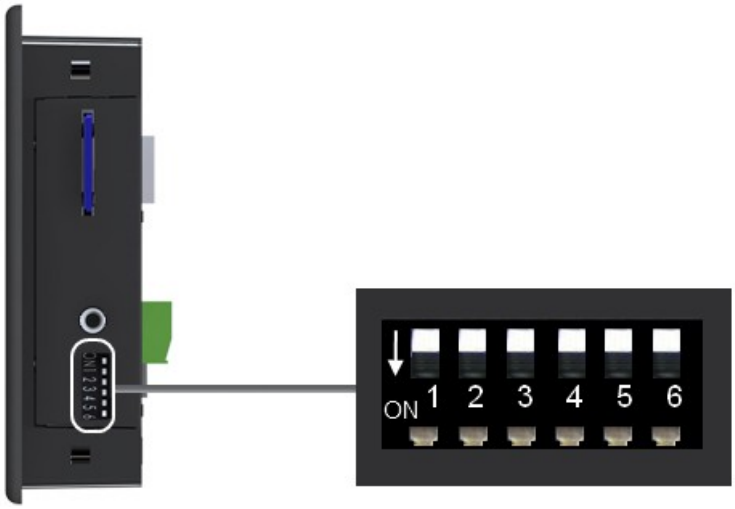
The CUWIN translates input from a human user to signals that electronic devices can understand, and receives signals from those electronic devices, translating them to colorful output that the user can understand. Thus, the CUWIN serves as a Human Machine Interface(HMI).

Using the CUBLOC, TinyPLC or other Programmable Logic Controllers(PLC), the CUWIN can provide a human interface to electronic and mechanical systems such as robots, monitoring systems, environment control systems, and automation equipment just to name a few. The CUWIN has been used in all kinds of applications from solar energy systems that track the sun to beauty appliances for styling hair. The possibilities are endless.

Powering On the CUWIN for the First Time

Setting the CUWIN's Operating Mode

The CUWIN is very flexible and can operate in many modes depending on the CUWIN's final purpose. The following table lists the CUWIN's different operating modes.



			Position					
Position	**Function**	**Mode**	**1**	**2**	**3**	**4**	**5**	**6**
1	Boot Device (5000/6000 Series)	Reserved	Off					
		NAND Flash	On					
	Boot Device (CWV Series)	NAND Flash	Off					
		Reserved	On					
2 and 3	Boot Mode	Reserved		On	On			
		Auto-Run Mode		On	Off			
		Development Mode		Off	Off			
		OS Image Download Mode		Off	On			
4, 5, and 6	Reserved	Reserved						

Development Mode

For the exercises in this document we need to set the CUWIN's operating mode to Development Mode.

5000/6000 Series: 1-On, the rest Off

CWV Series: All Off

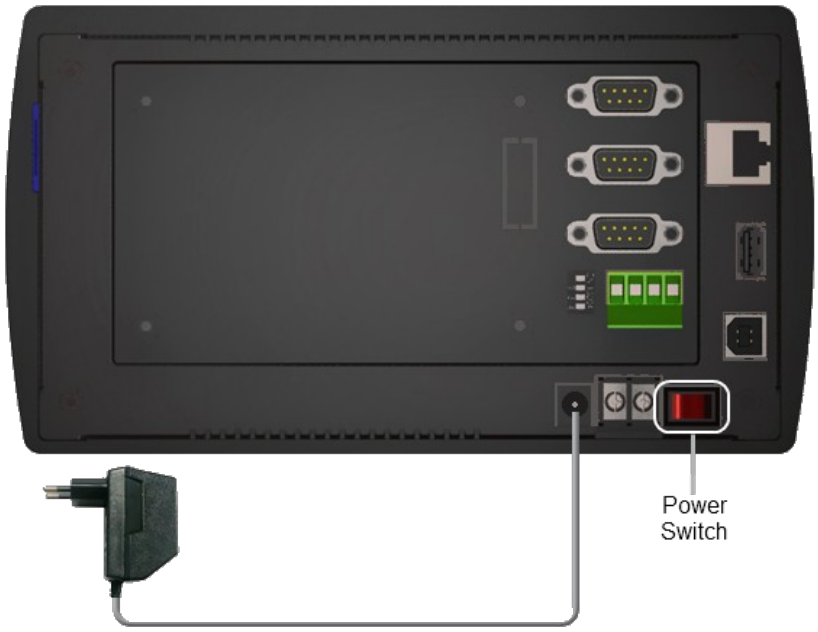
AutoRun Mode

To configure the CUWIN to automatically start when the system boots, create the folder "\Flash Disk\AutoRun" and copy the *.exe file to execute into that folder. Then configure the device for AutoRun mode.

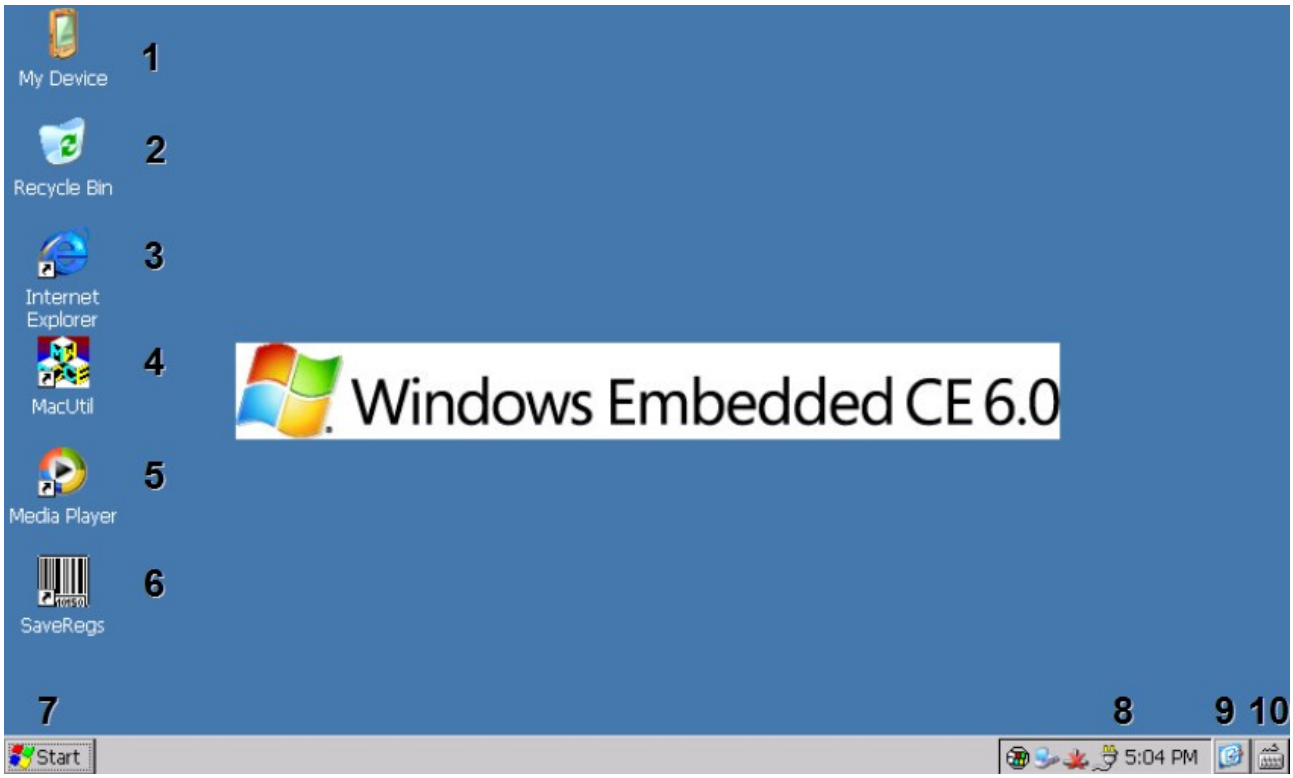
5000/6000 Series: 1-On, 2-On, the rest Off

CWV Series: 2-On, the rest Off

Powering On the CUWIN



Now that the CUWIN's operating mode has been set, we are ready to power on the CUWIN for the first time. It is not necessary to make any connections to the CUWIN except the power cable. Connect the power cable and power on the CUWIN by depressing the power switch.



After a few seconds the Windows Embedded CE desktop will appear. To complete the exercises in this document, it is not necessary to understand each of these features. For now, a simple overview will suffice.

	Item	Description
1	My Device	Opens the file explorer.
2	Recycle Bin	Storage for deleted files before permanent deletion.
3	Internet Explorer	Internet browser
4	MacUtil	Utility to change the Network Interface Card(NIC)'s Media Access Control(MAC) address. CUWIN 5000 & 6000 series only.
5	Media Player	Windows CE Media player for playing audio and video files.
6	SaveRegs	Utility to permanently save any changes to the device's registry.
7	Start Button	Opens the Windows CE Start Menu
8	System Tray	Windows CE System Tray
9	Show Desktop	Minimizes any open windows and shows the Windows CE desktop.
10	Input Panel	Opens the Windows CE Input Panel (onscreen keyboard)

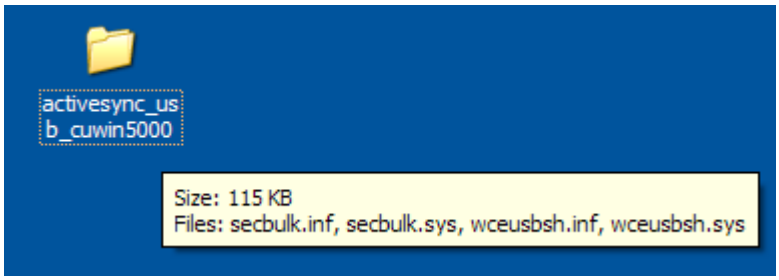
Connecting the CUWIN to a Personal Computer (PC)

In order to customize the CUWIN for your needs you will likely need to transfer data and programs to the CUWIN. Typically this is done by connecting the CUWIN to a Personal Computer (PC).

In order for a PC to communicate with the CUWIN, a USB device driver must be installed on the PC. Once the driver is installed, ActiveSync (Windows XP) or Windows Mobile Device Center (Windows Vista and Windows 7) can be used to copy data and programs to and from a PC and the CUWIN.

Installing the USB Driver

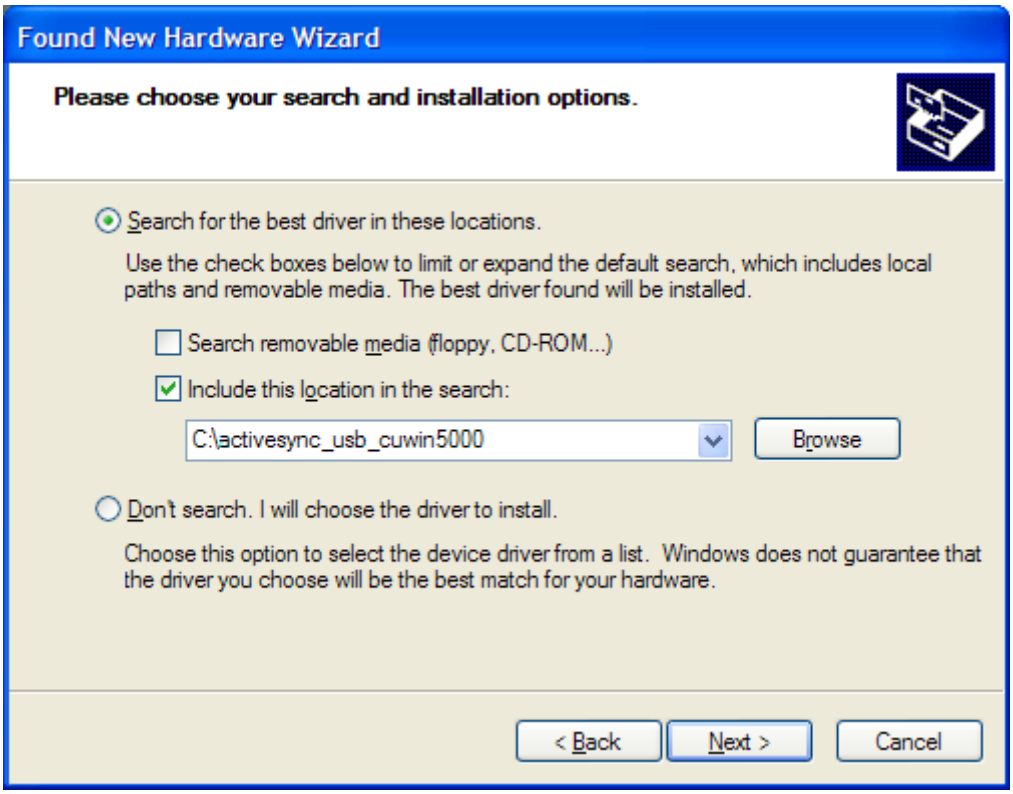
The following instructions describe how to install the CUWIN's USB driver on the PC. Although the instructions are illustrated using Windows XP, the same procedure should be followed for Windows Vista or Windows 7.



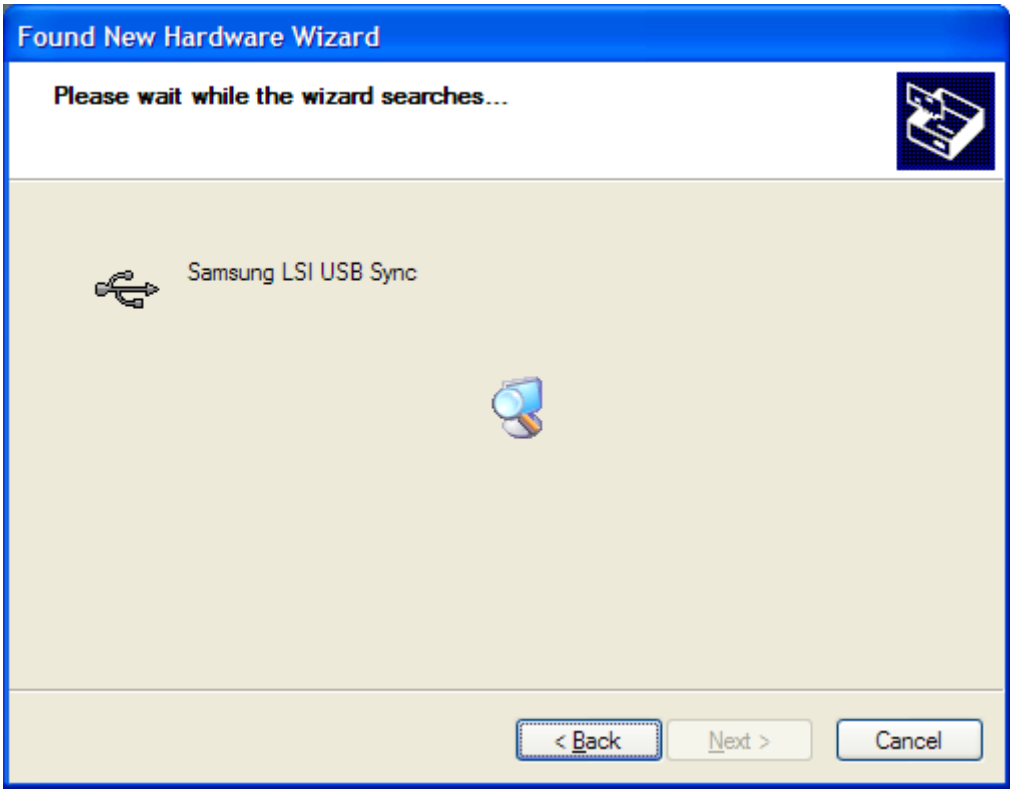
1. Download the "ActiveSync USB Driver [CUWIN5000 series]" file from the Comfile Technology website at http://www.cubloc.com/data/07.php, and unzip the file to a folder of your choosing.

2. Using a USB cable, connect the CUWIN to the PC.

3. After connecting the CUWIN to the PC, the "Found New Hardware Wizard" will appear. Select "Install from a list or specific location(Advanced)" and click the "Next" button.

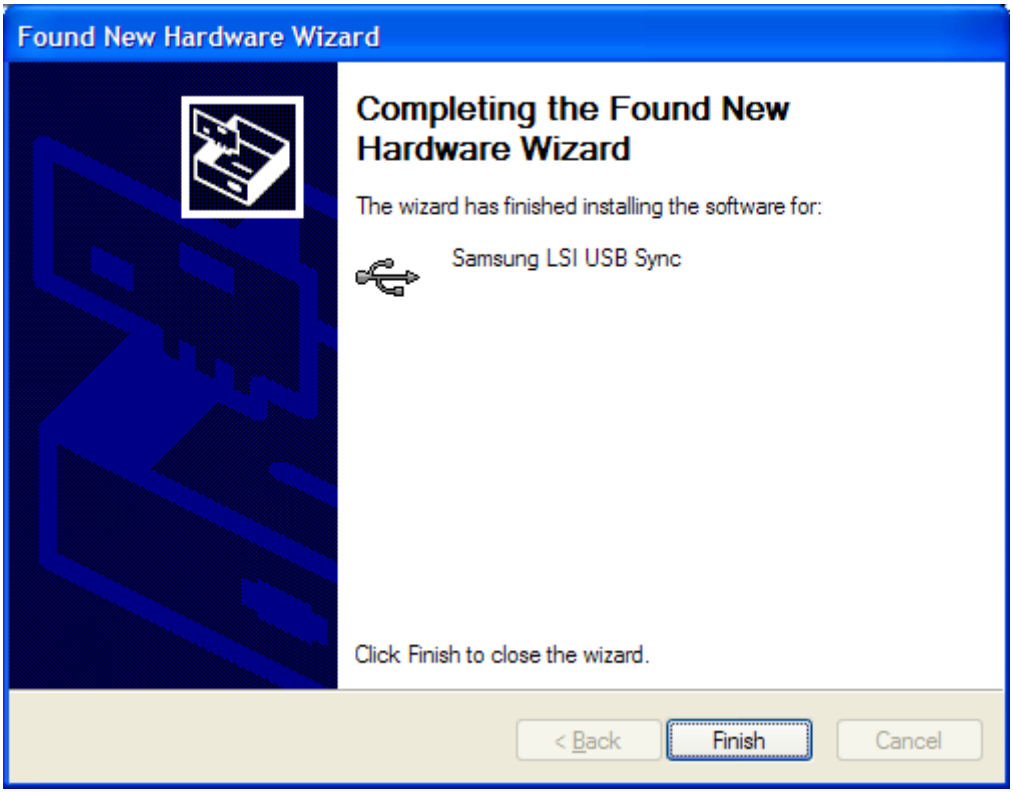


4. Select "Search for the best driver in these locations" radio button and the "Include this location in the search:" checkbox. Then, browse to the folder containing the drivers that were downloaded in step 1, and click the "Next" button.



5. The PC will begin searching for a suitable driver. Wait for it to finish.

6. When it locates the driver, it will display a dialog box as shown above. Click the "Continue Anyway" button.



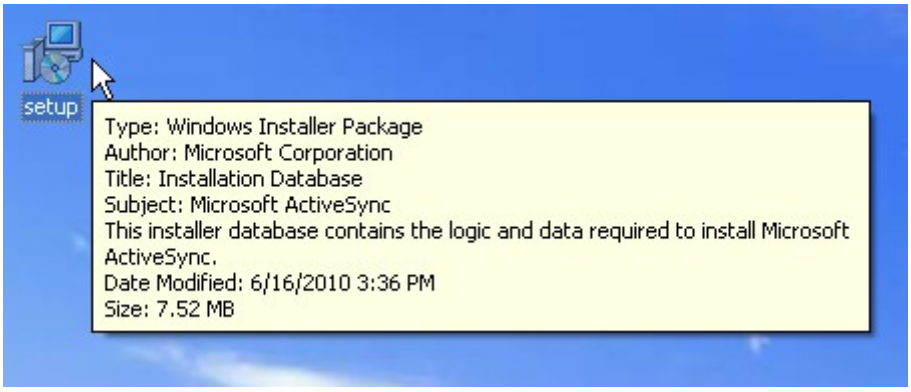
7. The driver will then install. When it is finished, the window above will appear. Click the "Finish" button.

ActiveSync (Windows XP)

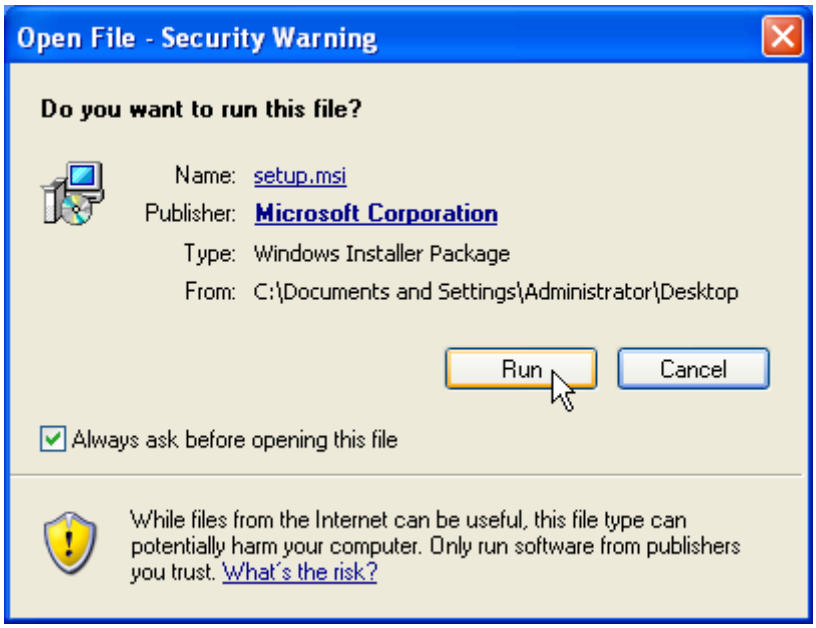
After the USB driver has been installed, ActiveSync (Windows XP) or Windows Mobile Device Center (Windows Vista, or Windows 7) can be installed.

If you are running Windows XP, please perform the following procedure to install ActiveSync.

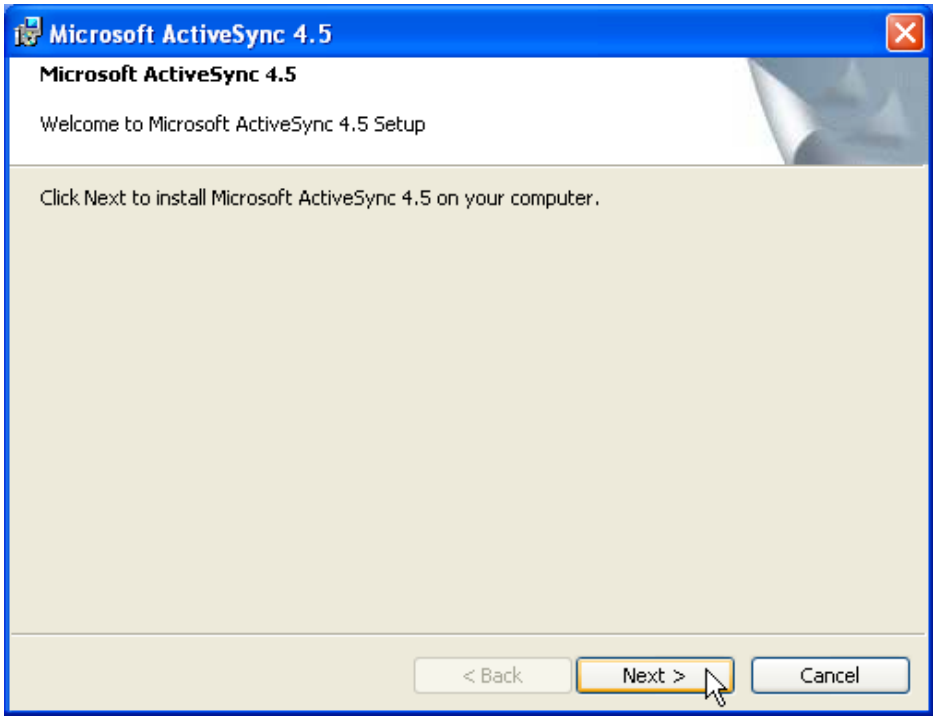
1. Download ActiveSync – At the time of this writing, the latest version was 4.5 and could be downloaded from http://www.microsoft.com/windowsmobile/en-us/downloads/microsoft/activesync-download.mspx



2. Run the downloaded file.

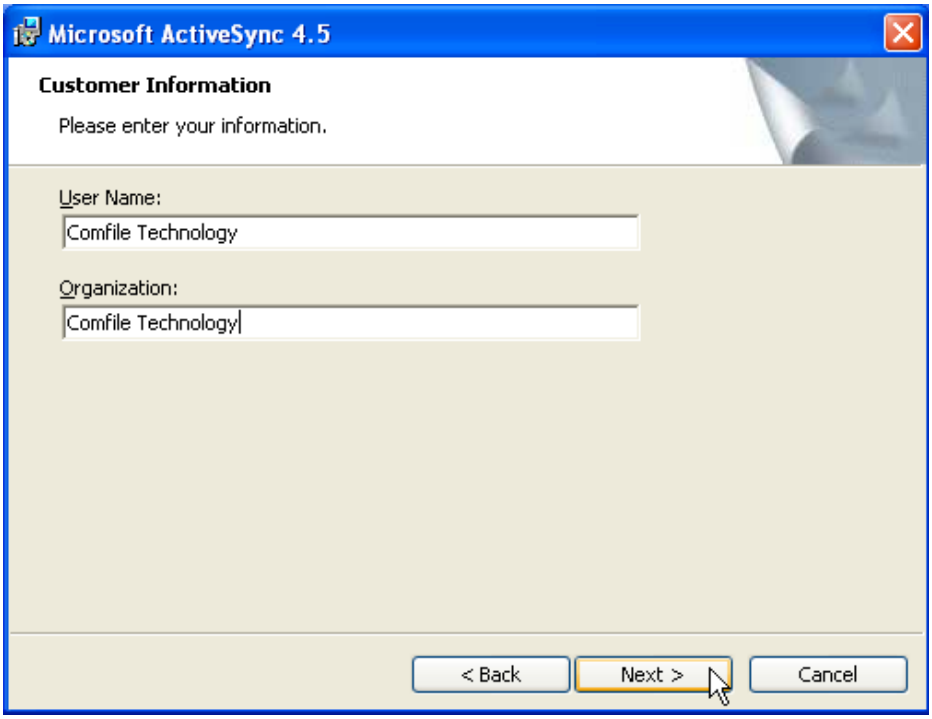


3. If a "Security Warning" dialog box appears, click the "Run" button.

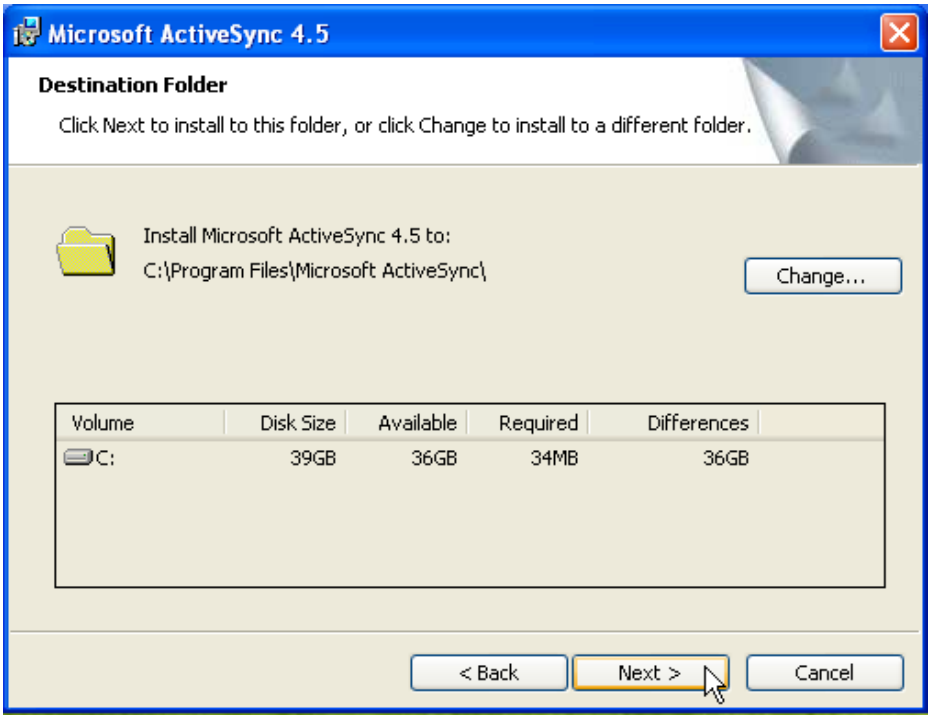


4. On the following screen, click the "Next" button.

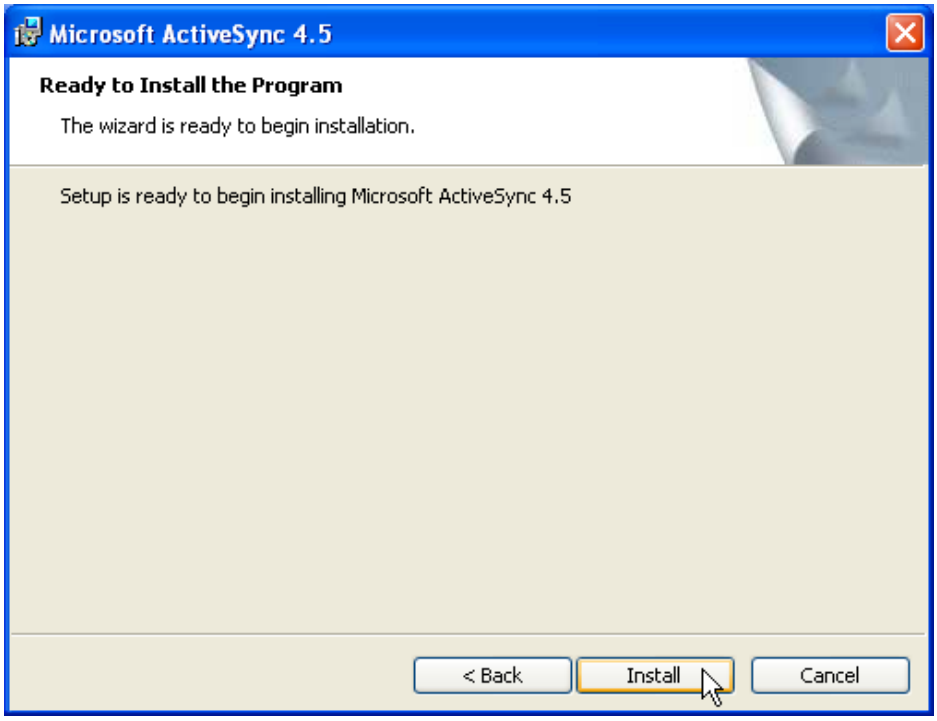
5. Read the license agreement and, if you agree, accept the license agreement and click the "Next" button.



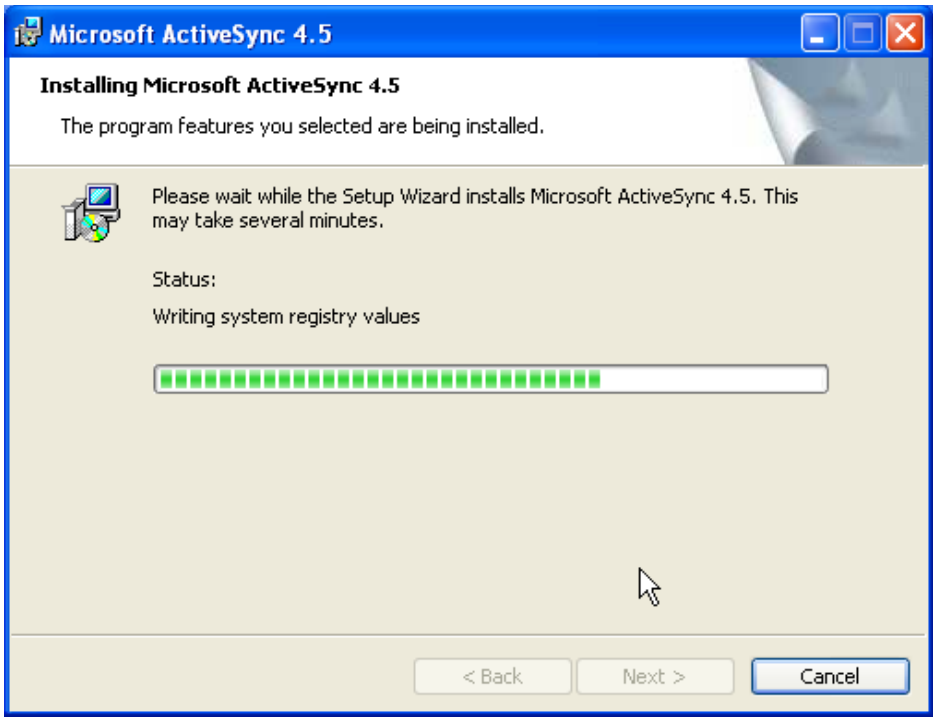
6. On the "Customer Information" dialog, enter the appropriate information in the "User Name" and "Organization" text boxes. Then click the "Next" button.



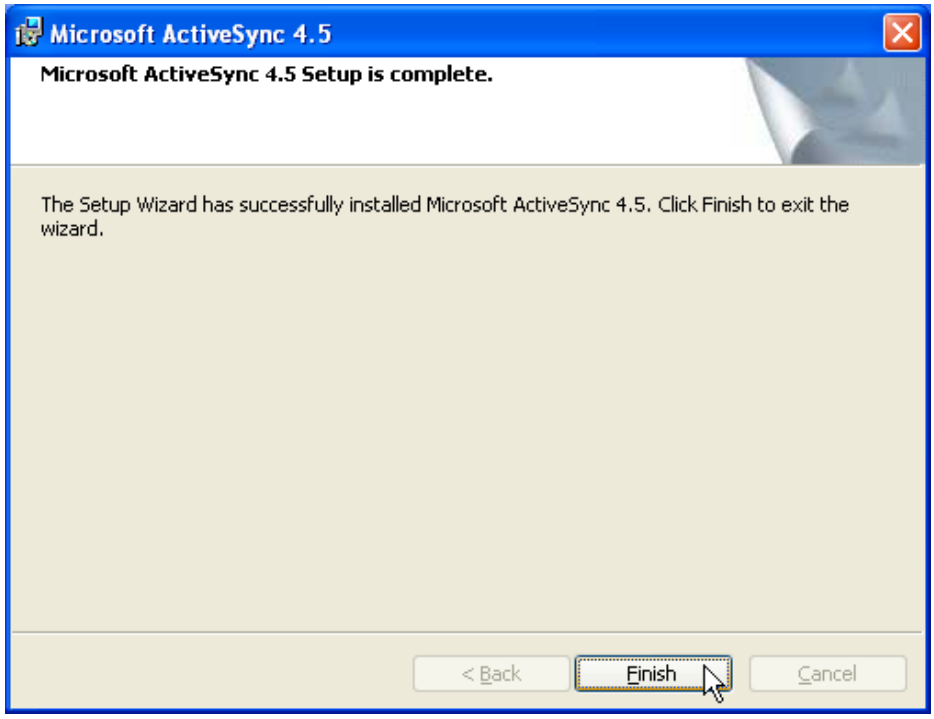
7. On the "Destination Folder" dialog, accept the default or change the destination folder. Then click the "Next" button.



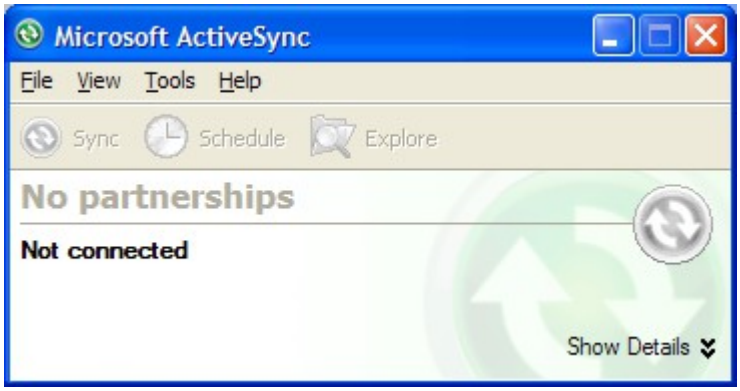
8. A dialog will appear telling you that you are ready to install the program. Click the "Install" button.



9. A new dialog with a progress bar will then appear showing the status of the installation. Wait for it to complete.



10. When installation is complete, a dialog will appear saying "Microsoft ActivSync 4.5 Setup is complete". Click the "Finish" button.

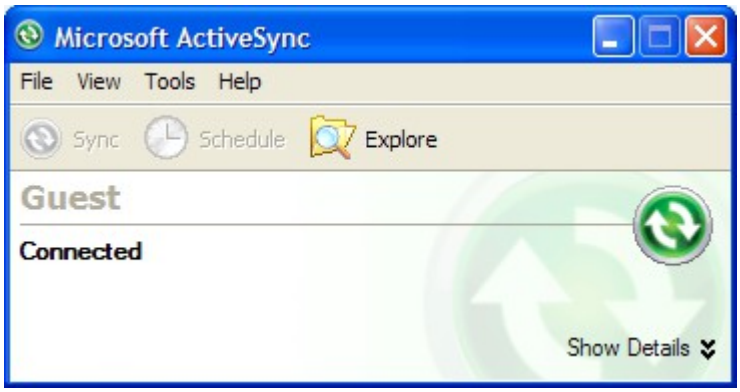


11. ActiveSync is now installed, and you should see the ActiveSync icon in your system tray. If you double-click the system tray icon, the ActiveSync window will display showing a status of "Not Connected."

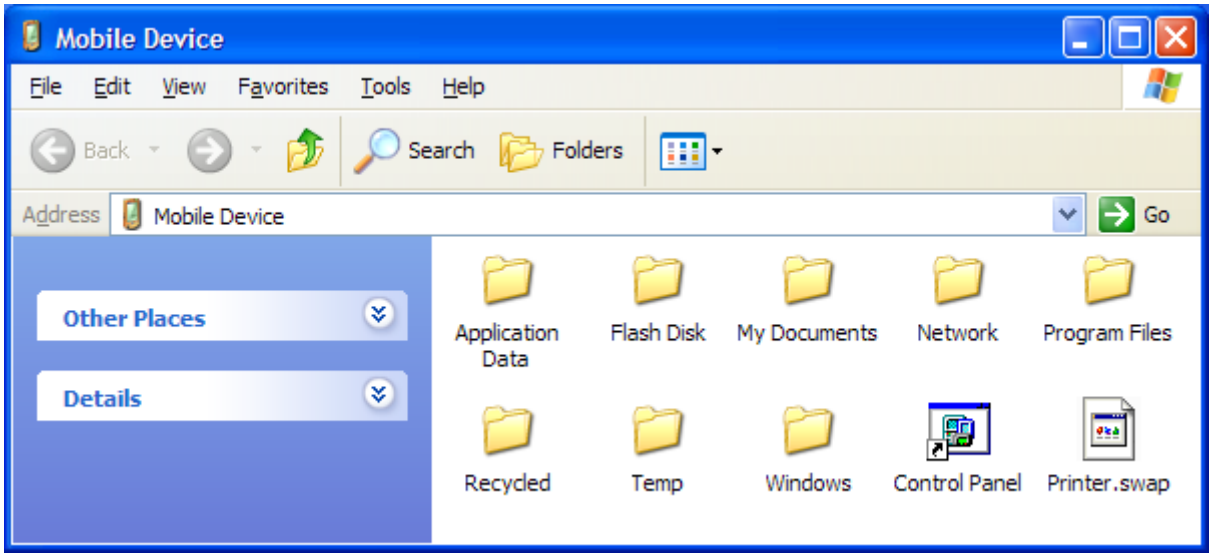
12. Using a USB cable, connect the CUWIN to the PC.

13. You will probably hear a few sounds from the PC and the CUWIN and a small dialog will briefly appear on the CUWIN.

14. ActiveSync will then prompt you to create a partnership between the PC and the CUWIN. Make your selection. If you're not sure, just choose "No". Then click the "Next" button.



15. ActiveSync will now show a status of "Connected", and the ActiveSync system tray icon will change indicating the CUWIN is connected to the PC. Click the "Explore" icon.

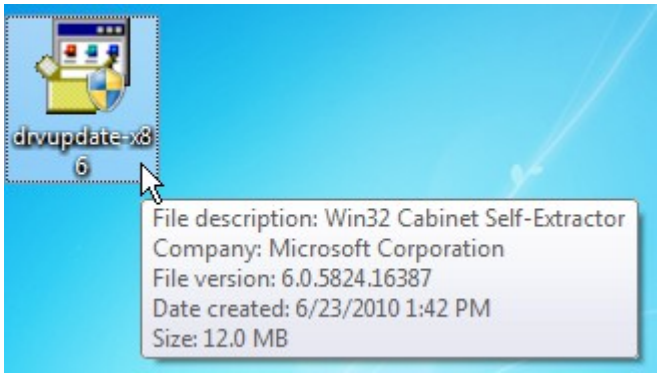


16. Using Windows Explorer, you will now be able to view the CUWIN's file system and transfer files to and from the CUWIN just as you would on the PC.

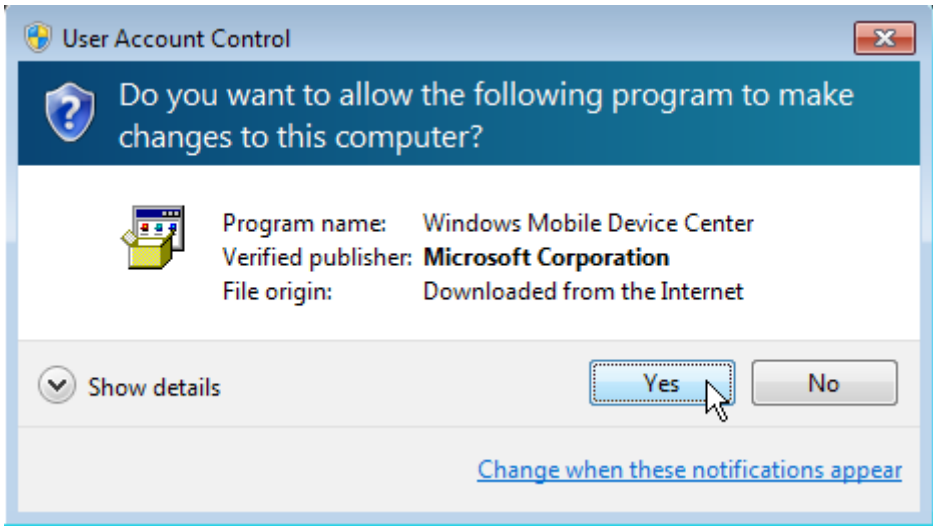
Windows Mobile Device Center (Windows Vista, 7)

If you are running Windows Vista or Windows 7, please perform the following procedure to install Windows Mobile Device Center.

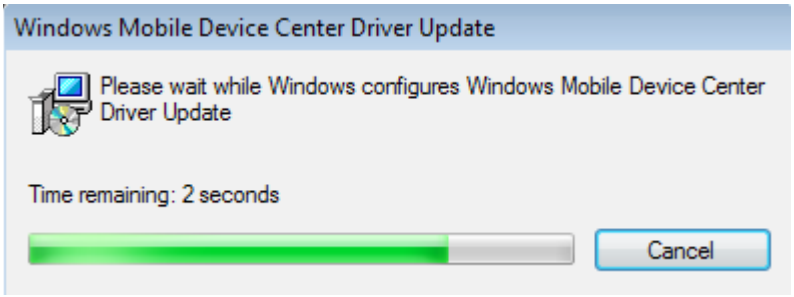
1. Download Windows Mobile Device Center. At the time of this writing, the latest version was 6.1 and could be downloaded from http://www.microsoft.com/downloads/details.aspx?FamilyId=46F72DF1-E46A-4A5F-A791-09F07AAA1914&displaylang=en



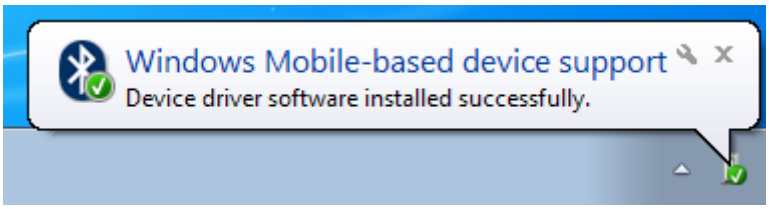
2. Run the downloaded file.



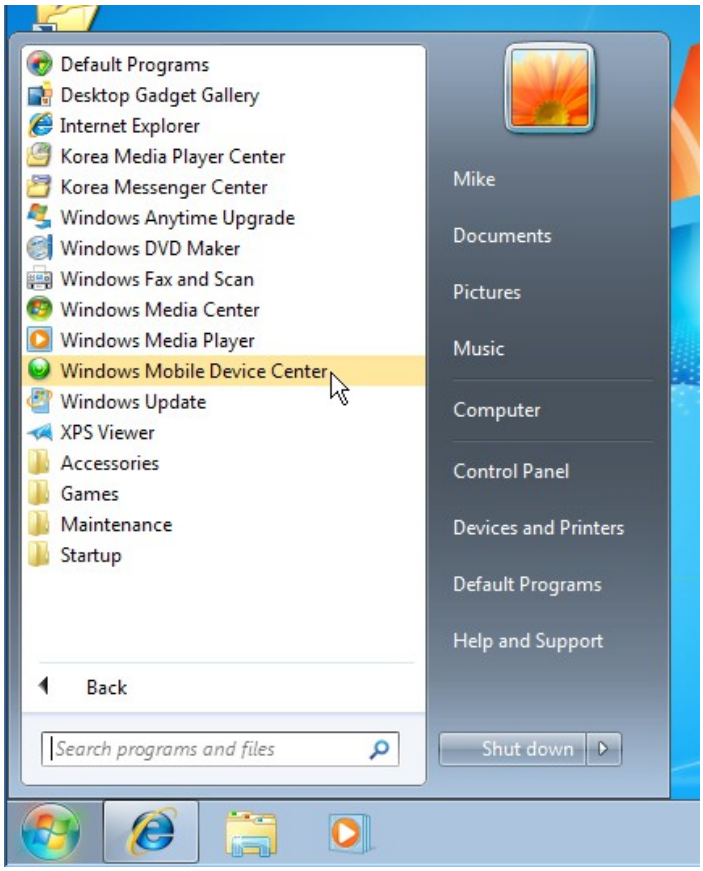
3. If you are presented with a "User Account Control" dialog, click the "Yes" button.



4. Windows Mobile Device Center will begin installing. Wait for it to finish.



5. When the installation is finished, a message will appear in the system tray telling you that the installation was successful.

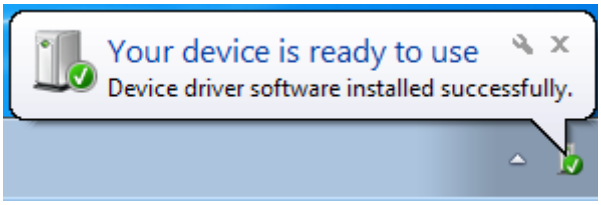


6. Run “Windows Media Device Center” from the Windows Start Menu.

7. Read the license agreement and, if you agree, click the "Accept" button.

8. Windows Mobile Device Center will open, and will indicate a status of "Not Connected".

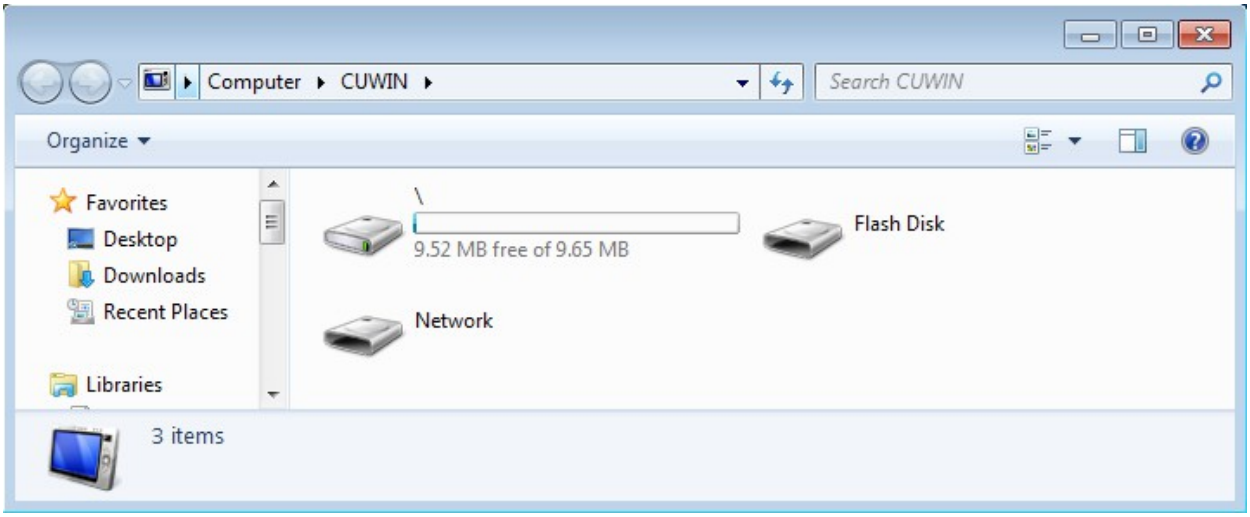
9. Using a USB cable, connect the CUWIN to the PC.



10. Windows will begin installing a driver for the CUWIN. When it is finished, a message will display in the system tray saying "Your device is ready to use."

11. Windows Mobile Device Center will begin connecting with the CUWIN. When it is finished, it will display a status of connected. At this time you can use Windows Mobile Device Center to do many things with the CUWIN. You are encouraged to read the Windows Mobile Device Center documentation for more information. For this exercise, however, we just want to transfer files, so click "Connect without setting up your device".

12. Under "File Management" click "Browse the contents of your device."

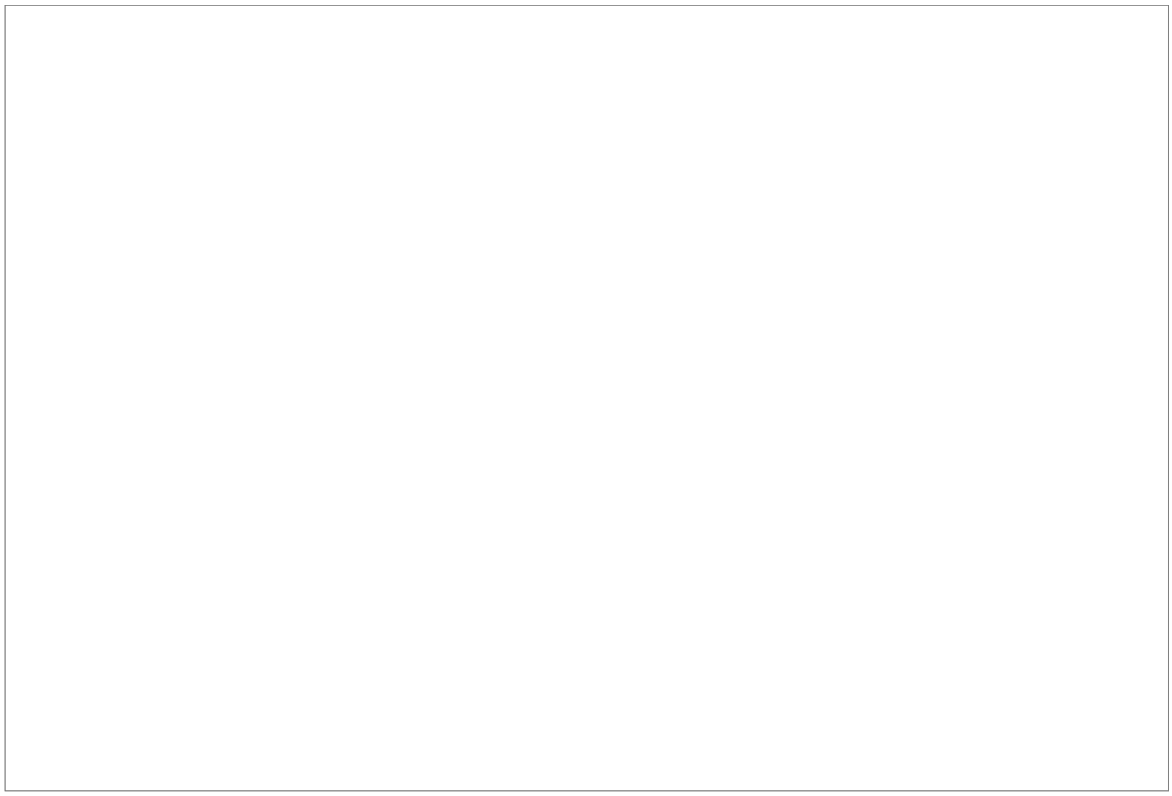


13. Using Windows Explorer you will be able to view the CUWIN's file system and transfer files to and from the CUWIN just as you would on the PC.

Setting the CUWIN's Ethernet MAC Address

CUWIN 5xxx & 6xxx

For the CUWIN 5000 and 6000 series, you can set the CUWIN's MAC address by running the MacUtil program from the Windows CE Desktop.

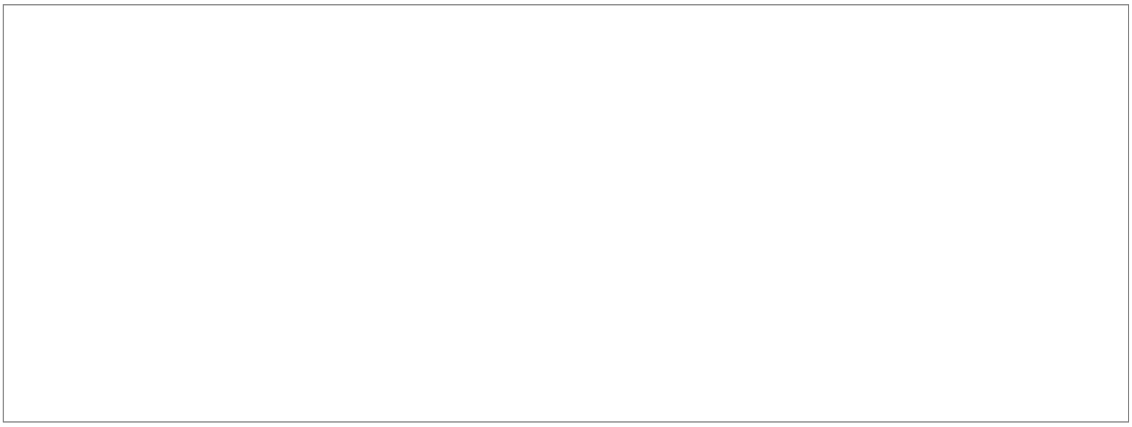


1. Select "2450" and use the buttons to set the last two bytes of the MAC address. The first four bytes are fixed.
2. Press the "Save" button and the new value will be committed to the devices registry.
3. Press the "Close" button when finished.

CUWIN CWV Series

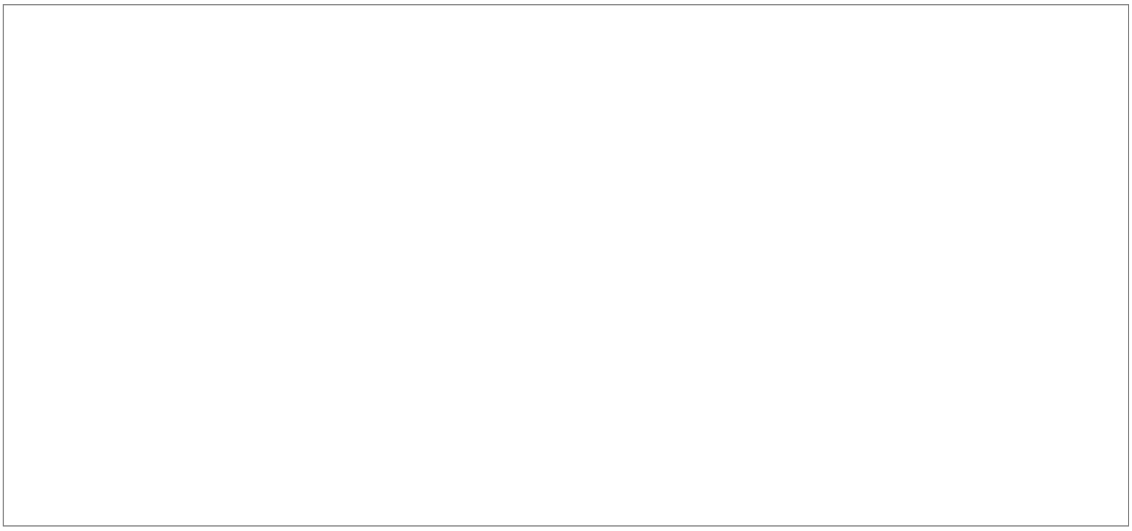
For the CUWIN CWV series, you must boot the device in a special mode to bring up the configuration console.

1. Connect a serial cable from a PC to the CUWIN's Com 3 Serial port.
2. Use your favorite terminal program (in this case PuTTY) to establish a serial connection at 115200 baud, 8 data bits, 1 stop bit, no parity, and no flow control.
3. On the right side of the CUWIN set dip switch 3 to ON and the rest OFF.



4. Reboot the CUWIN and a configuration menu will appear.

5. Type “C” to bring up the “Bootloader Configurations” menu.



6. Type “7” to configure the MAC address. Enter a hexadecimal MAC address of your choice. In this example “00.00.12.34.ab.cd”.

7. Reset the dip switch on the right side of the CUWIN and reboot.

Developing Software for the CUWIN

In order to develop software for the CUWIN a software development environment must be installed. This document will make use of Microsoft's Visual Studio 2008 as a development environment, but any software development environment capable of producing Windows Embedded CE programs compatible with the CUWIN's processor can be used.

Visual Studio supports several programming languages; primarily Visual C++, C#, and Visual Basic.Net, and can produce two kinds of programs: managed and unmanaged(native) programs. Managed programs rely on the .Net Framework while unmanaged programs do not. Visual C++ can produce either managed or unmanaged programs, but C# and Visual Basic.Net are primarily used to produce managed programs. For this document we will be programming in C# so our programs will be managed and will thus rely on the .Net Framework.

The .Net Framework is an extremely large collection of libraries and application programming interfaces (APIs) for Windows operating systems. It is much too large for embedded systems that are intended to be small and light, like the CUWIN. Therefore, Microsoft has created the .Net Compact Framework to suit the small and light needs of the embedded systems market. The CUWIN comes with the .Net Compact Framework 3.5 pre-installed and the example programs produced in this document will be built to make use of it.

Installing Visual Studio 2008

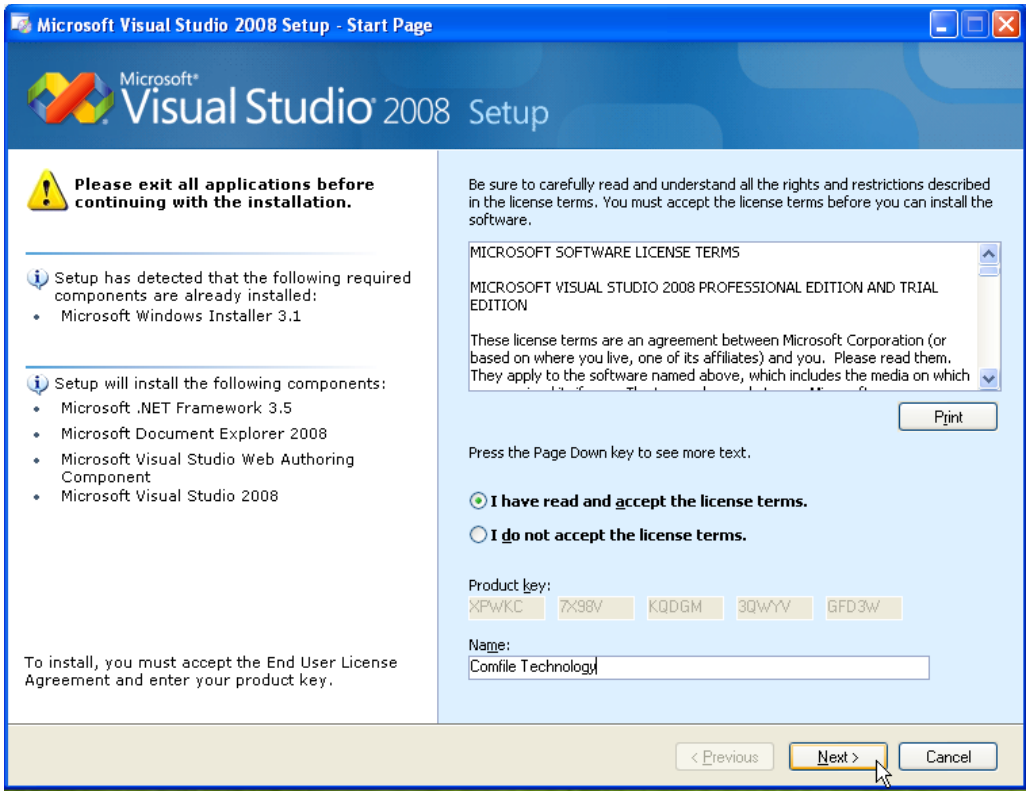
At the time of writing this document, Visual Studio Express editions didn't support smart device development. Also, at the time of writing this document, Visual Studio 2010 didn't yet support smart device development. Therefore, Visual Studio 2008 will be our development environment of choice for this document.

This document will only show the installation process for Windows XP, the but installation process for Windows Vista and Windows 7 is quite similar.

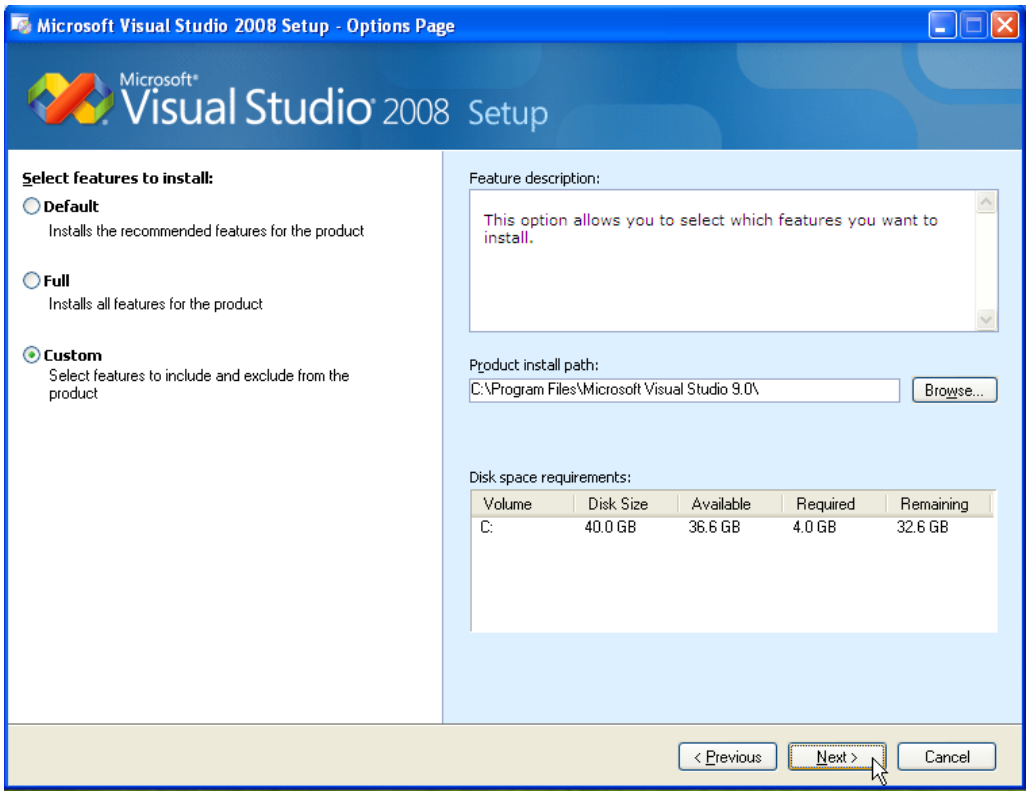
1. If you don't yet own Visual Studio 2008, you can download a 90-day trial version at http://www.microsoft.com/downloads/details.aspx?FamilyID=83c3a1ec-ed72-4a79-8961-25635db0192b. The downloaded file must be burned to a DVD. Use a DVD burner to burn the *.iso image to a DVD disc.
2. Insert your Visual Studio 2008 DVD into your DVD drive to begin the installation.

3. Click the "Install Visual Studio 2008" link to begin the installation.

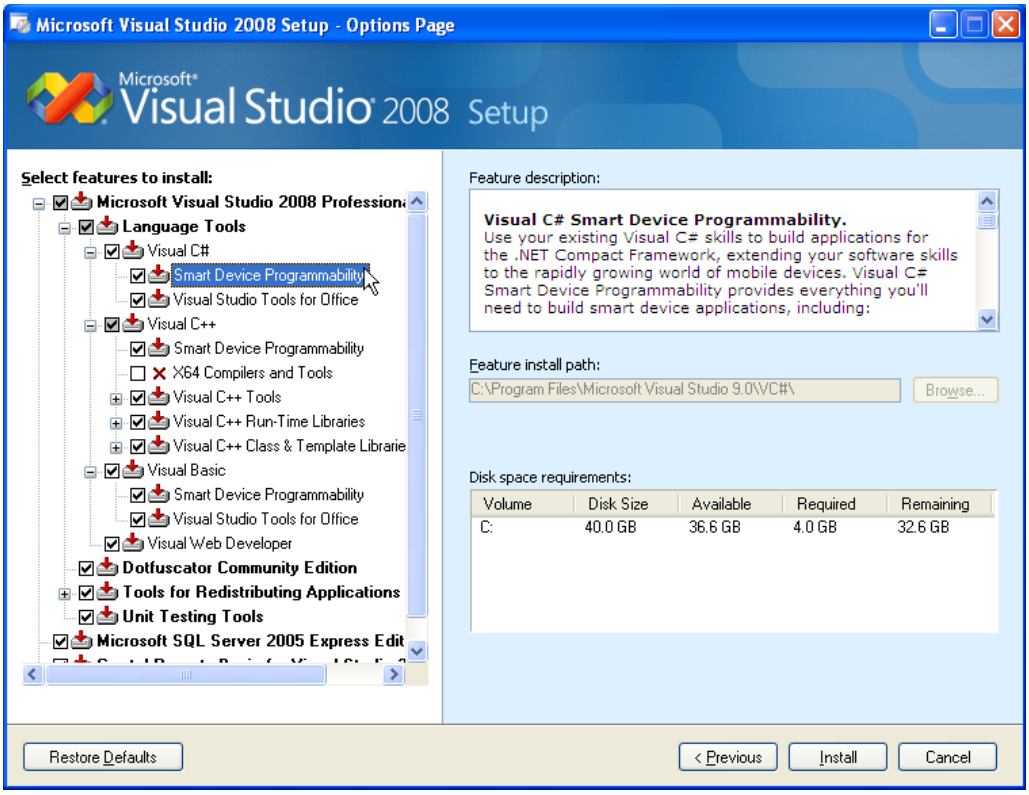
4. A welcome screen will appear. Click "Next" to continue.



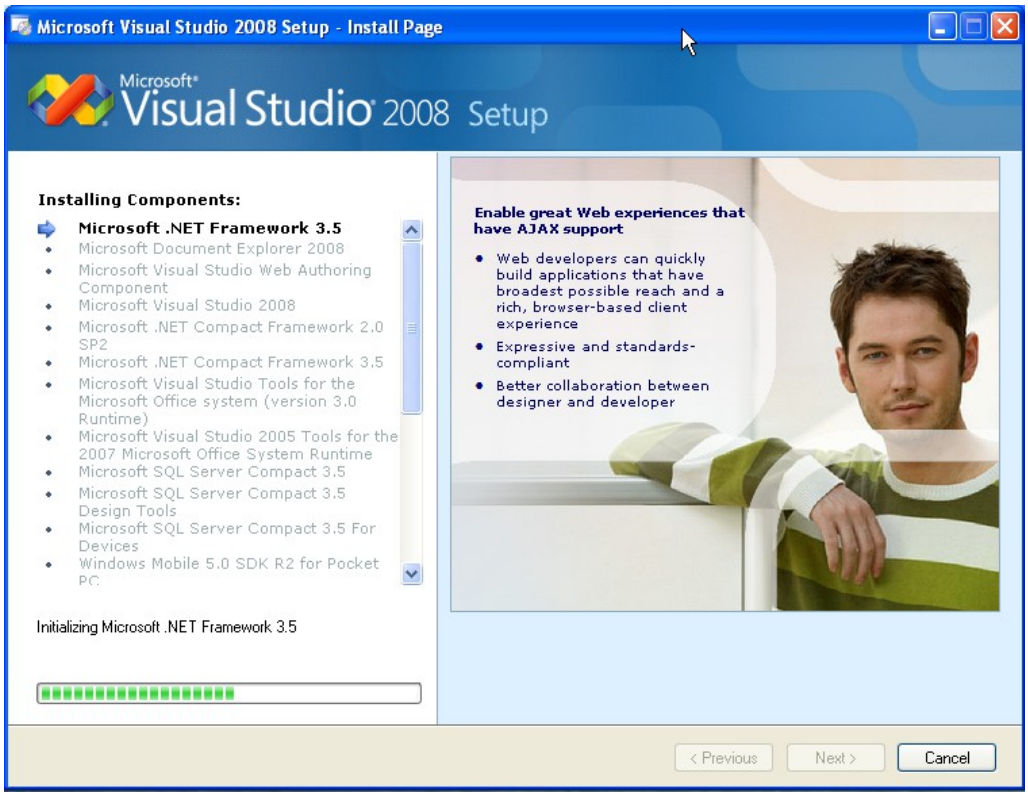
5. Read the license agreement and, if you agree, check the "I have read and accept the license terms." Enter an appropriate name in the "Name" text box and click the "Next" button.



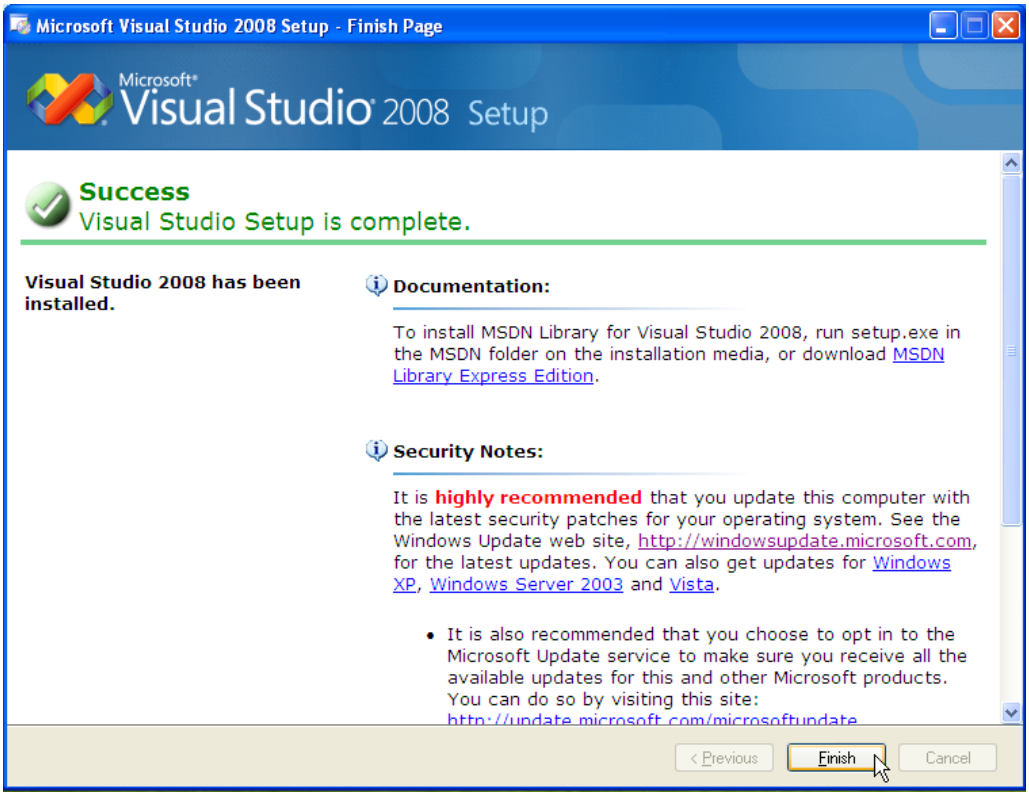
6. Choose an appropriate setup option for your needs. "Default" and "Full" will both install the necessary components for this document, but we will use "Custom" so you can see exactly what we will need.



7. In order to program for the .Net Compact Framework, you must choose the "Smart Device Programmability" option. And, since we will be programming in C#, be sure to check the Visual C# option. Then click the "Install" button.



8. Visual Studio 2008 will begin installing. Wait for the installation to complete. It may take some time.



9. When the installation is complete, the above screen will appear. No further action is necessary, but if you wish, you can download and install MSDN documentation and other updates from this screen. Make your choice or click the "Finish" button.

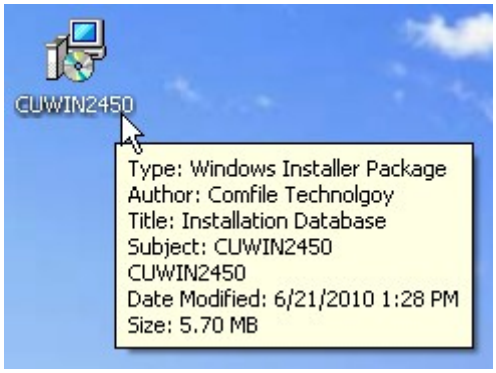
10. The above screen will then appear. From this screen you can modify your Visual Studio installation, install MSDN documentation, and/or check for updates. At this time it is recommended that you update your computer by clicking the "Check for Service Releases" link, or by using Windows Update. Make your choice or click the "Exit" button.

Installing the CUWIN Software Development Kit (SDK)

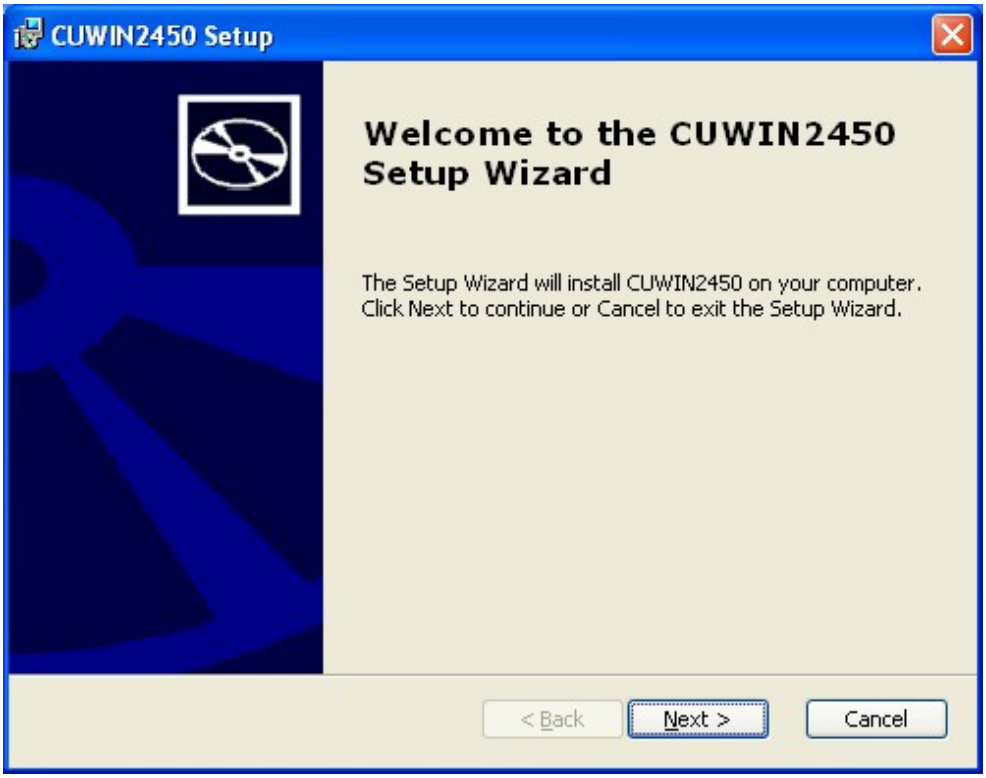
IMPORTANT: You must install Visual Studio before installing the SDK or the installation may fail.

In order for Visual Studio to build and debug applications specific to the CUWIN, you must download and install the CUWIN Software Development Kit (SDK).

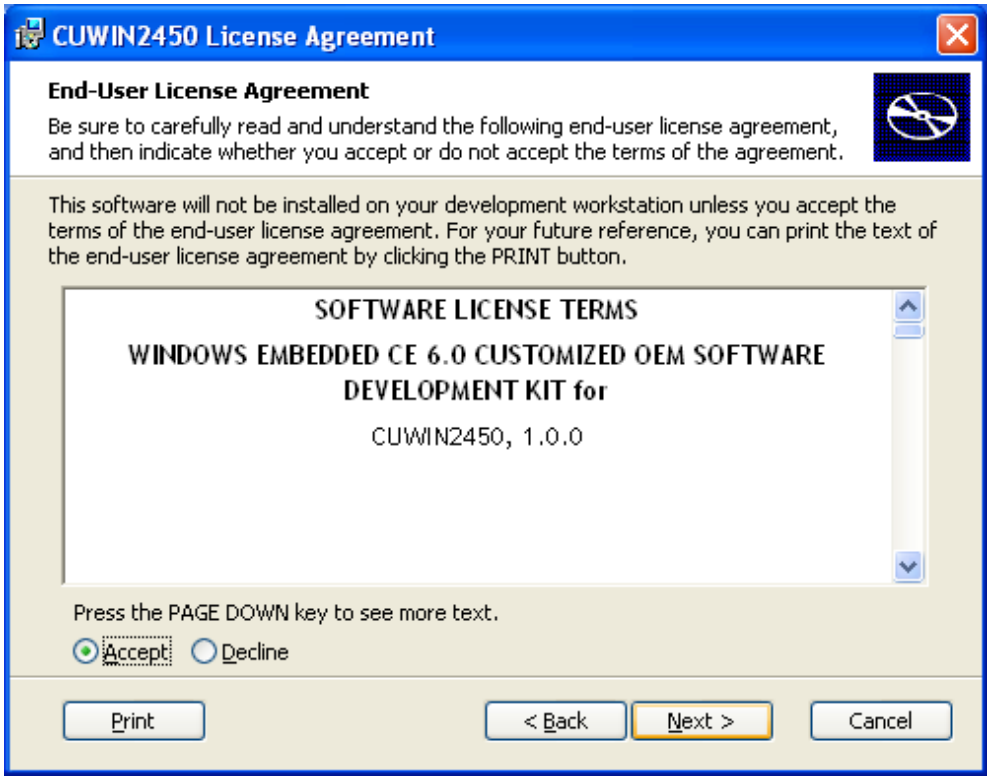
1. Download the SDK from http://www.cubloc.com/data/07.php



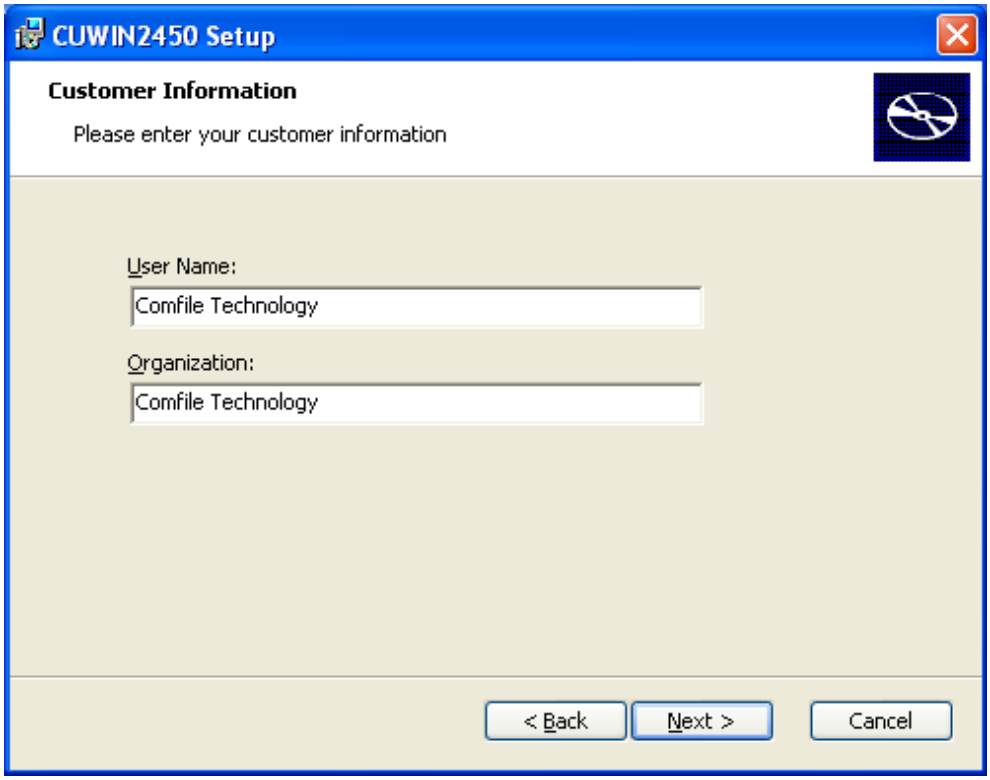
2. Execute the downloaded file to begin the installation.



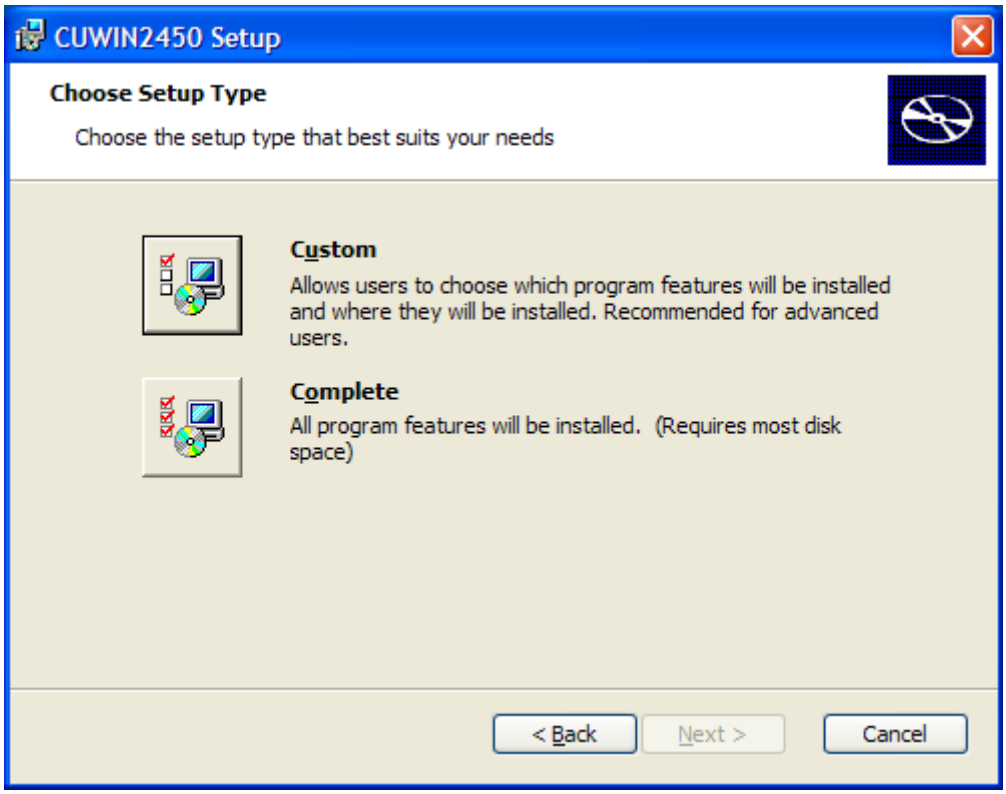
3. When the welcome screen appears, click the "Next" button.



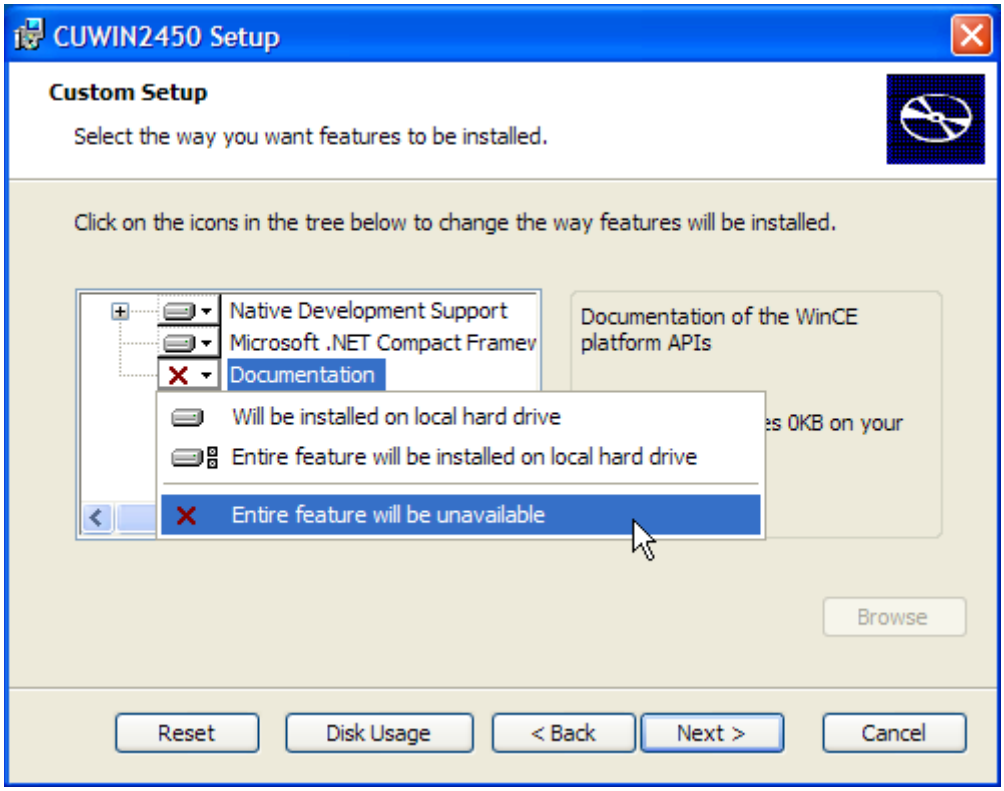
4. Read the license agreement and, if you agree, choose "Accept" and click the "Next" button.



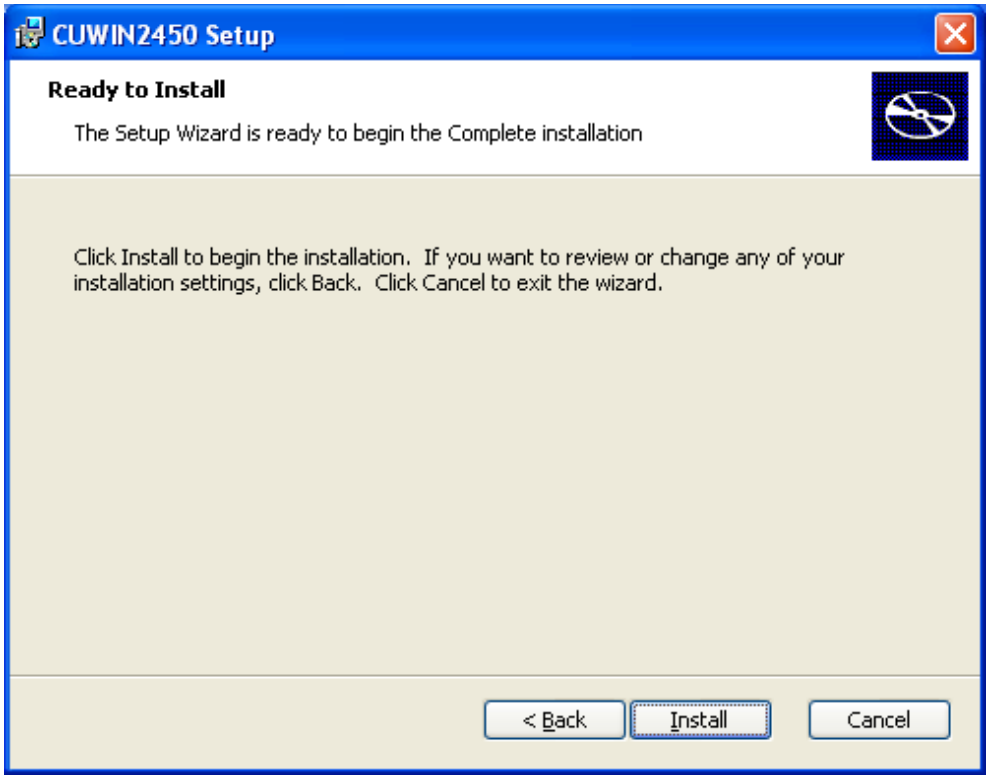
5. On the "Customer Information" dialog, enter the appropriate information the in "User Name" and "Organization" text boxes. Then click the "Next" button.



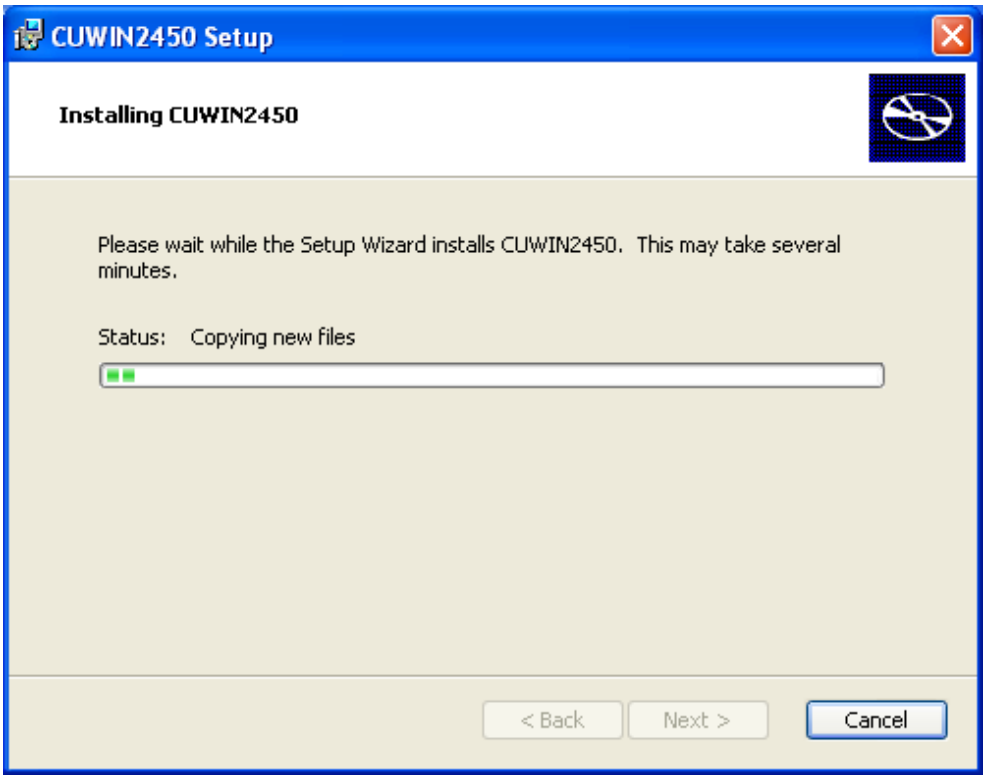
6. Choose "Custom". If you choose "Complete" the installation may fail.



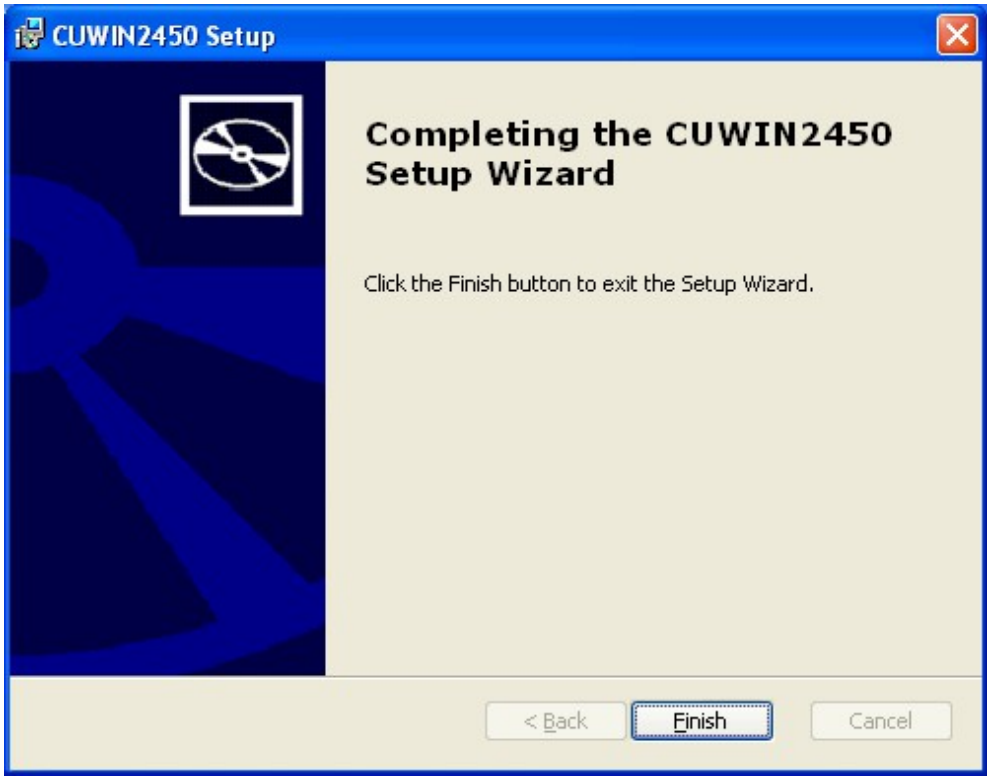
7. Remove the "Documentation" feature from the installation. If you don't do this, the installation may fail.



8. We are now ready to begin the installation. Click the "Install" button to begin.



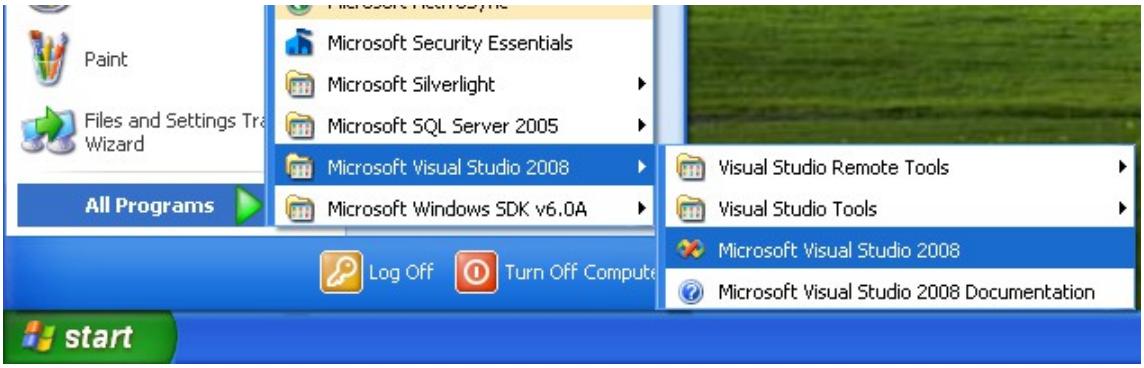
9. The SDK will begin installing. Wait for it to finish.



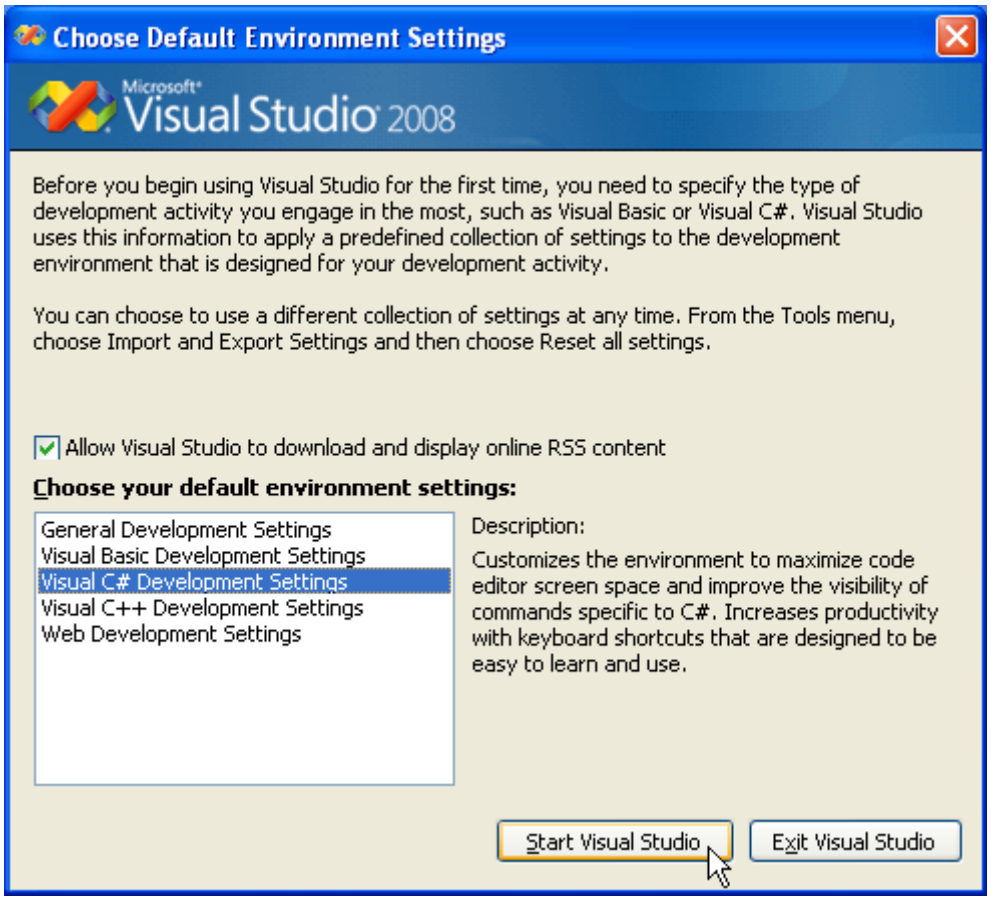
10. When the installation is finished a dialog will display saying "Completing the CUWIN2450 Setup Wizard". Click the "Finish" button.

Creating Our First CUWIN Program

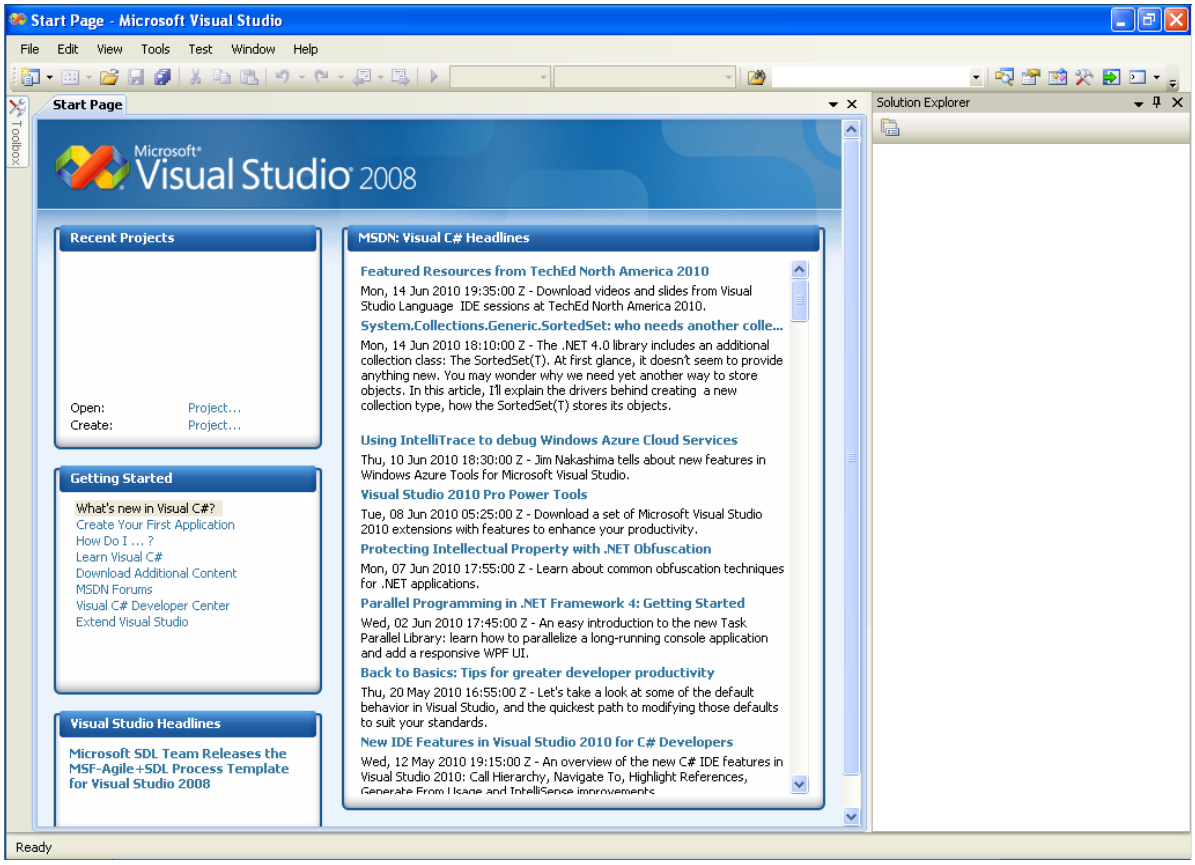
Now that the development environment is installed, we are ready to develop programs for the CUWIN. In this section, we will create a very simple "Hello World" program. Although this program is very simple, it will illustrate the process that we must go through to develop, deploy and debug any CUWIN program.



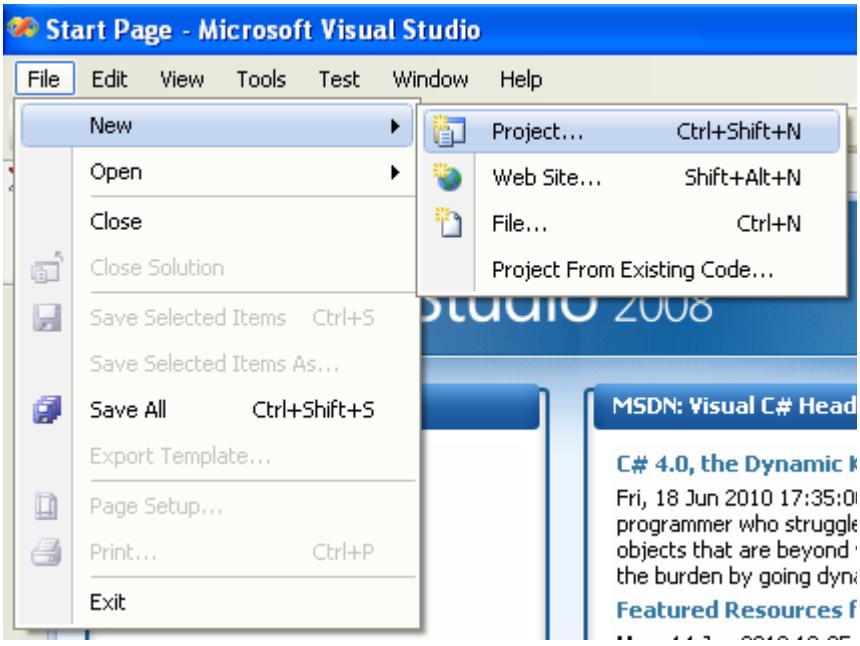
1. Start Visual Studio 2008 by selecting it from the Start Menu.



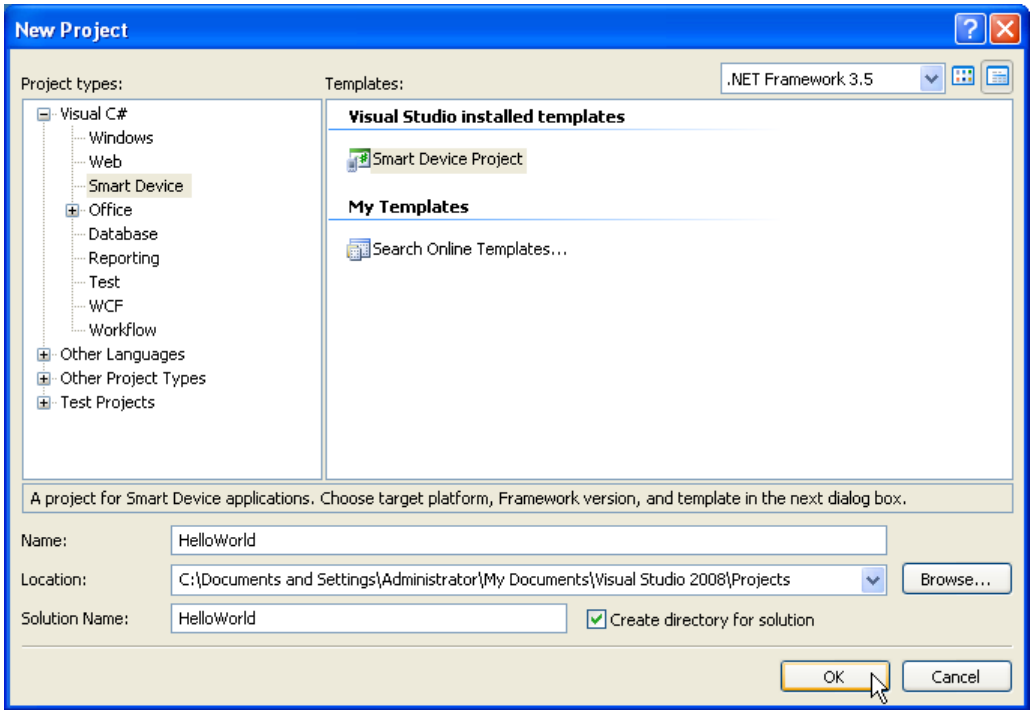
2. If this is your first time to run Visual Studio, it will ask you to choose your primary development environment. For the exercises in this document, it is recommended that you choose "Visual C# Development Settings". Then click the "Start Visual Studio" button.



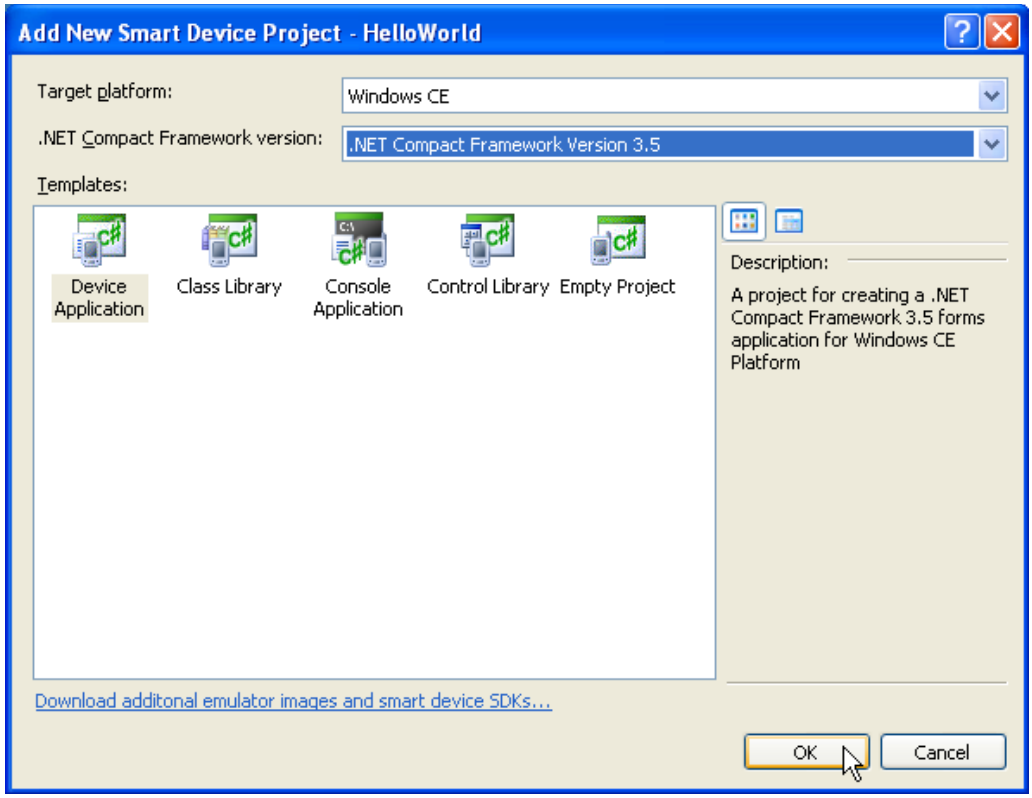
3. Visual Studio will open to the "Start Page". Now we need to create a project.



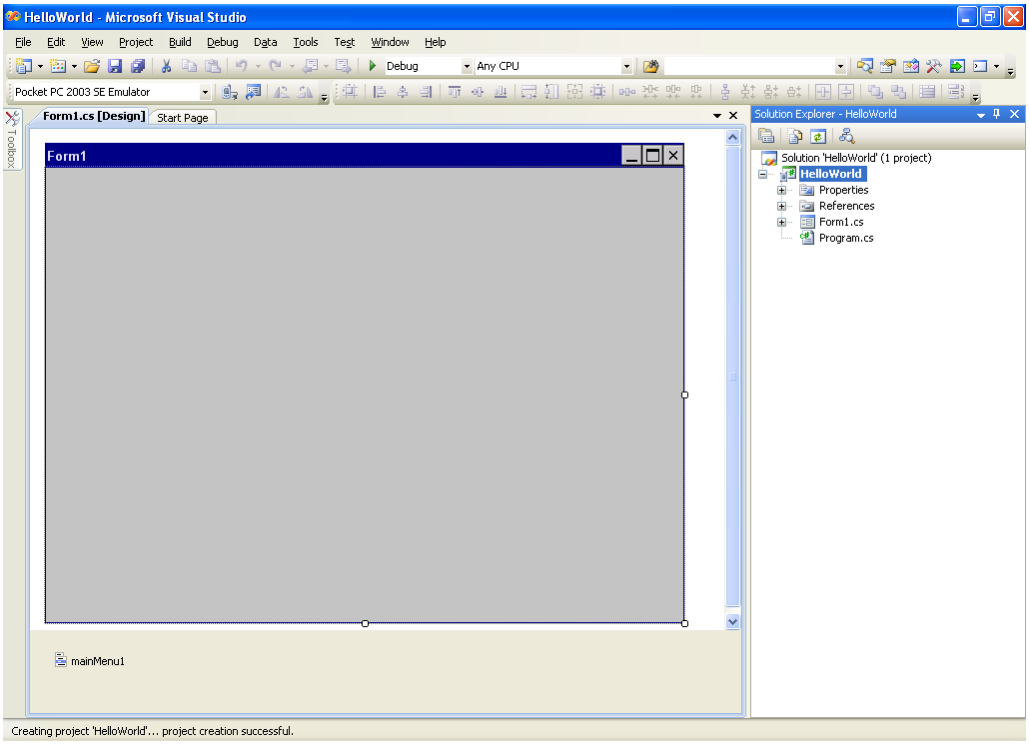
4. Select "File"->"New..."->"Project..." from the menu.



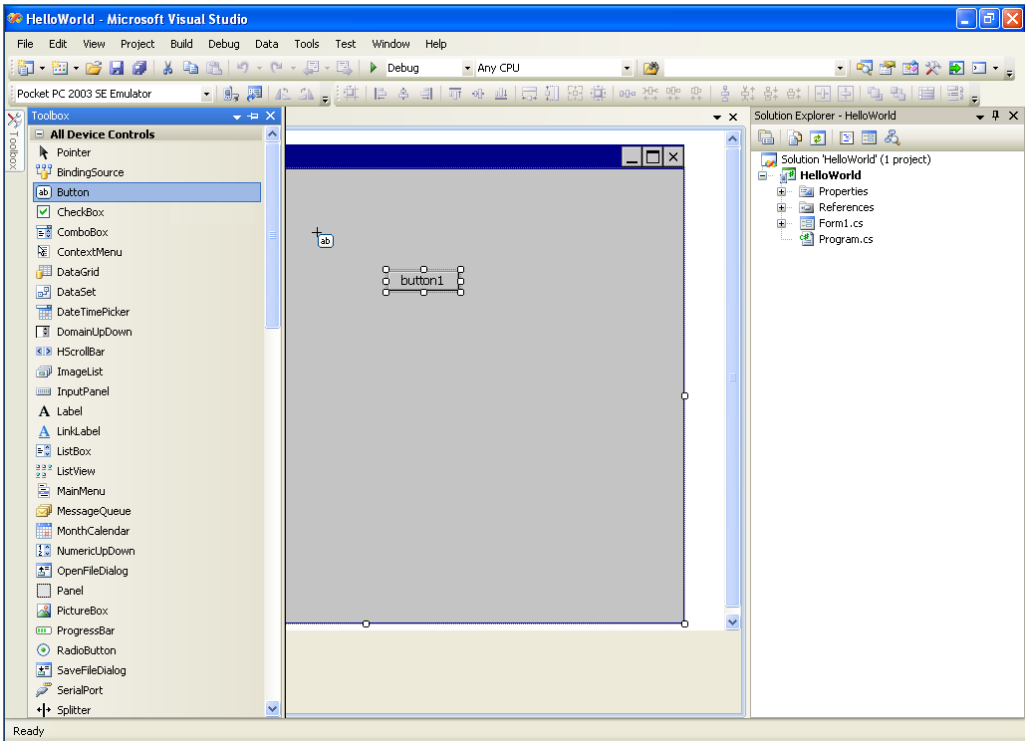
5. Select "Visual C#"->"Smart Device" from the "Project Types" tree, and "Smart Device Project" from the "Templates" list. Makes sure ".Net Framework 3.5" is selected from the top, right-hand corner, and change the "Name" of the project to "HelloWorld". Then click the "OK" button.



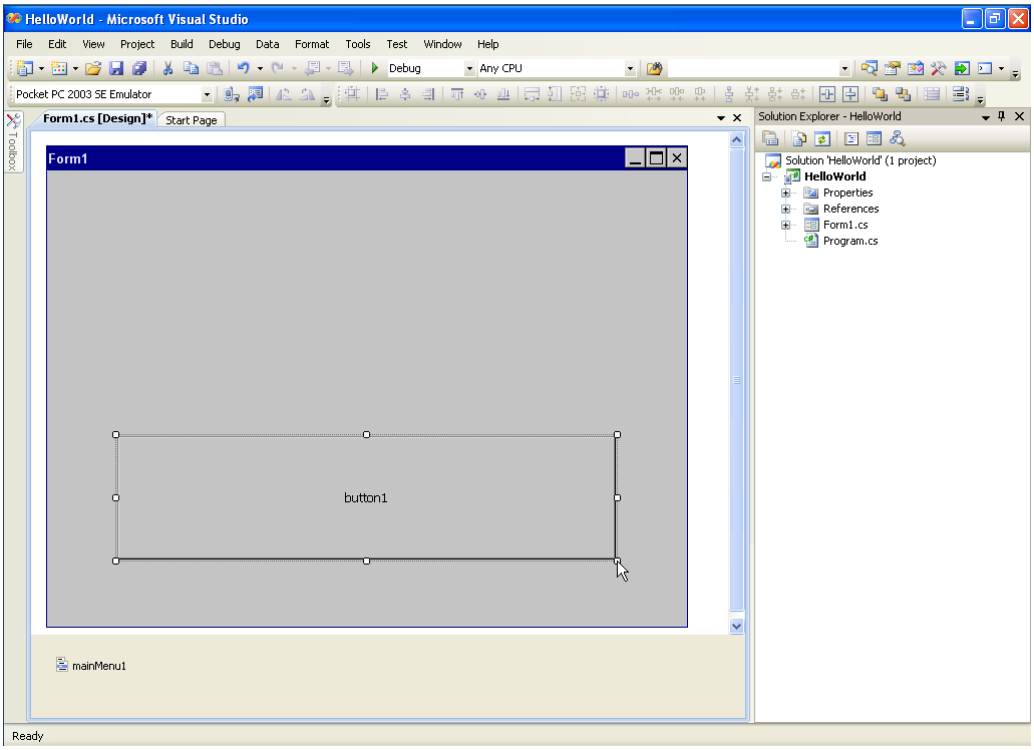
6. Another dialog will display asking for more project configuration. Select "Windows CE" from the "Target Platform" list, and ".Net Compact Framework 3.5" from the ".Net Compact Framework Version" list. Then, select "Device Application" from the "Templates" list, and click the "OK" button.



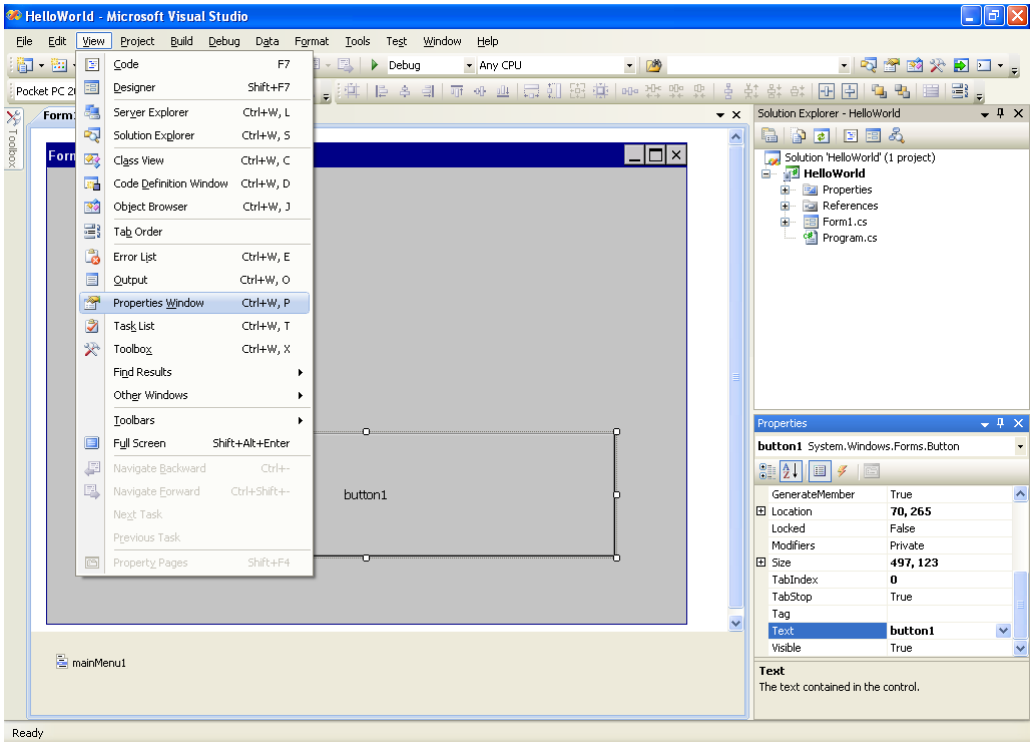
7. Finally, the project will open, and we are ready to start programming.



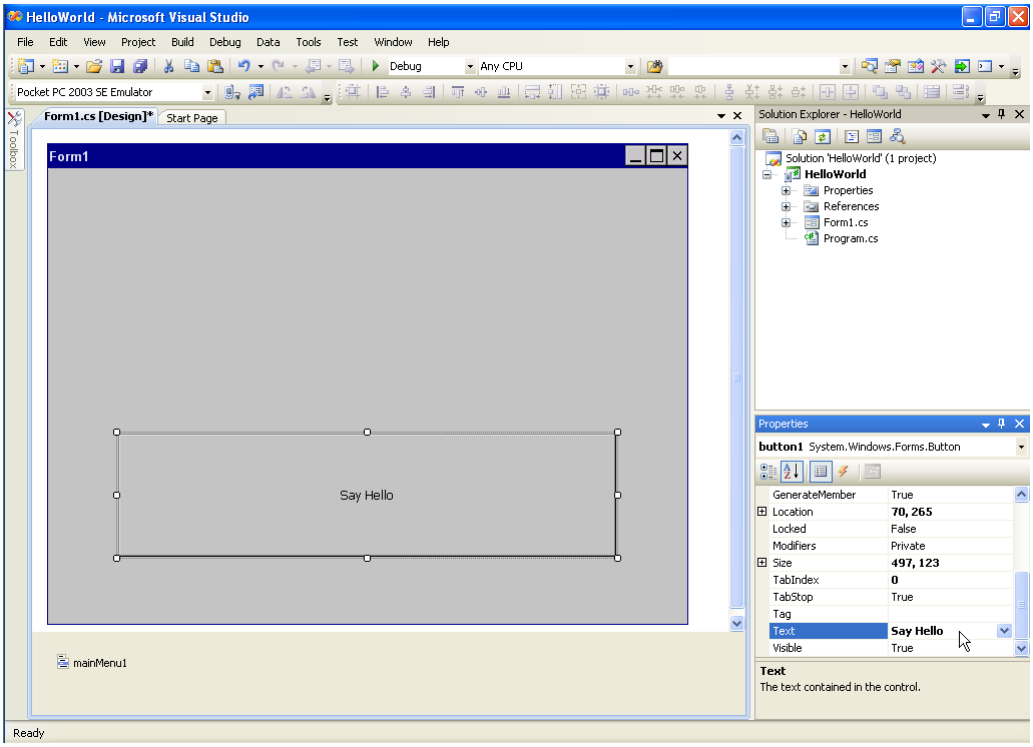
8. Move your mouse over the "Toolbox" tab on the left side of the screen, and the "Toolbox" menu will open. Select or drag a "Button" to the form. A new button labeled "button1" will appear on the form.



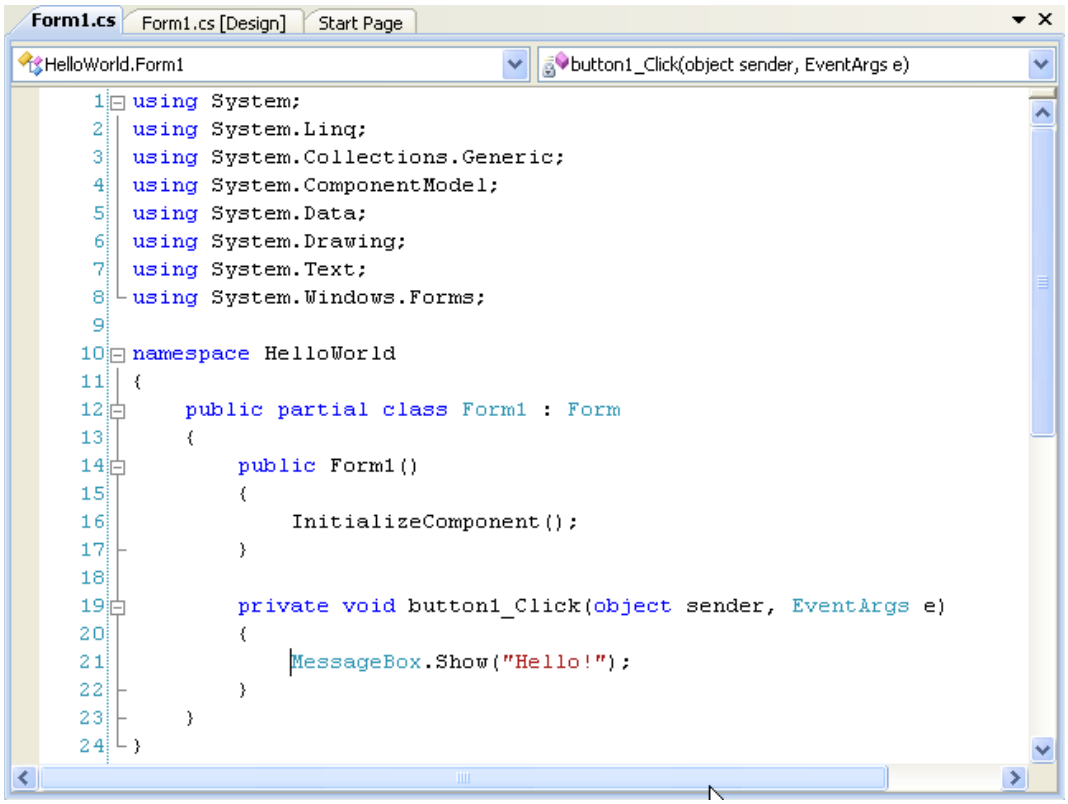
9. Position the button to the bottom of the form, and resize the button so it is easy to *touch* on the touch screen.



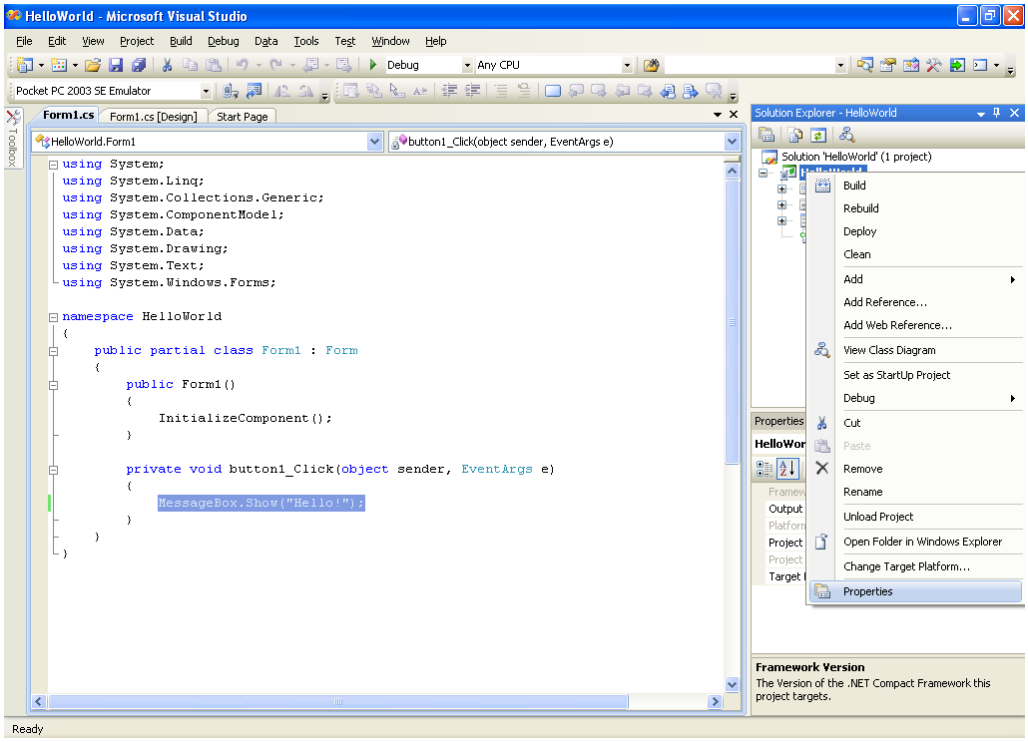
10. If the "Properties" window is not yet displayed, select "View"->"Properties Window" from the menu, and it should appear in the bottom, right-hand corner of the screen.



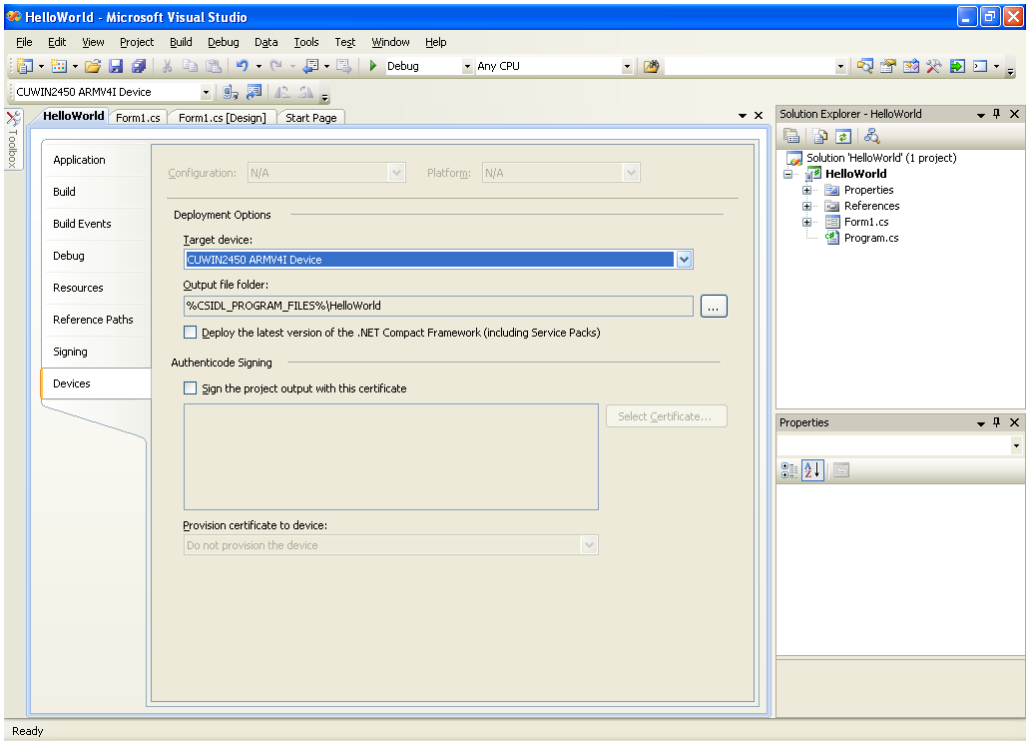
11. In the "Properties" Window change the "Text" property to "Say Hello" and press the "Enter" key. You'll see the button's label change to "Say Hello"



12. Now, double-click on the button and you will be taken to the button's event handler. It is here you you tell the program what to do when the button is clicked. Add the line `MessageBox.Show("Say Hello!");`

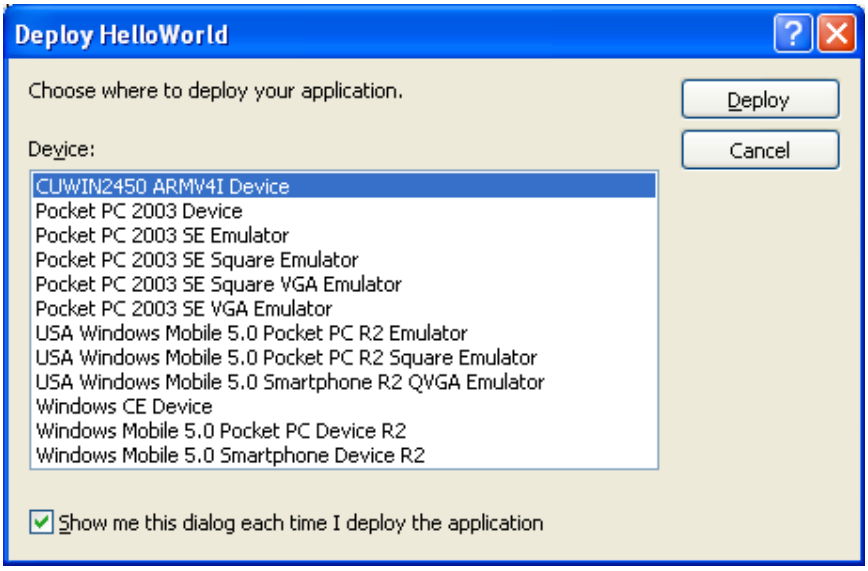


13. We are finished editing the code necessary to build this program. Now, we need to make some project configuration changes in order to build the program for the CUWIN. Right-click the "Hello World" project node in the "Solution Explorer" window, and choose "Properties".

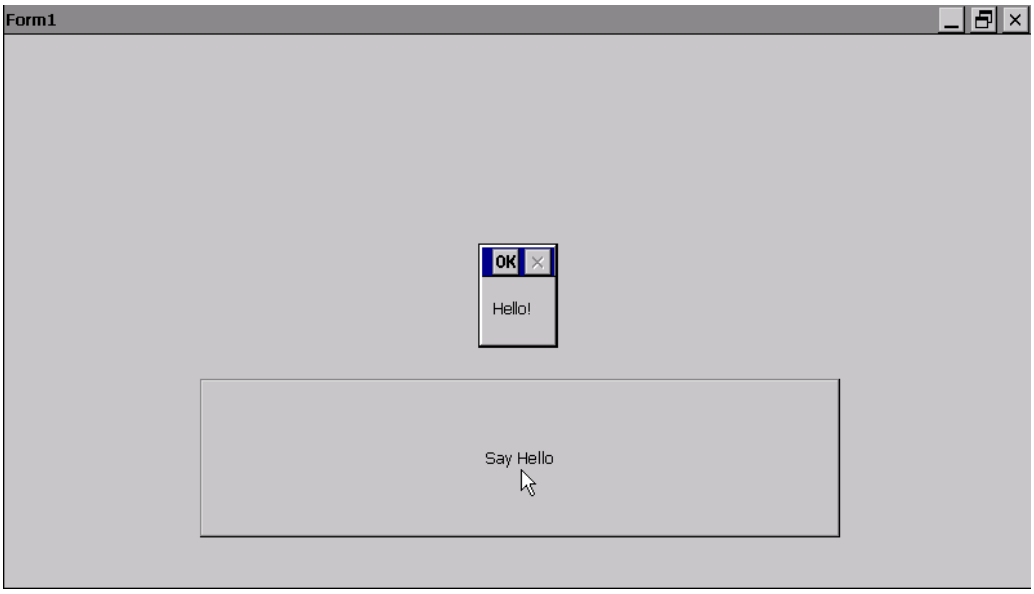


14. Choose the "Devices" tab on the left-hand side of the screen. Under "Deployment Options" change the "Target Device" to "CUWIN2450 ARMV4I Device". The CUWIN comes with the .Net Compact Framework 3.5 pre-installed, so if you don't have any updates, uncheck the "Deploy the latest version of the .Net Compact Framework (including Service Packs)" checkbox.

15. To execute the program, ensure the CUWIN in powered on and is connected to the PC, and click the "Start Debugging" button on the toolbar.



16. If a "Deploy HelloWorld" dialog is displayed, choose "CUWIN2450 ARMV4I Device" from the "Device" options, and click the "Deploy" button. The program will compile, upload to the CUWIN, and begin executing.



17. The program's main window will then appear on the CUWIN. Touch the "Say Hello" button and a message box will appear saying "Hello!".

Interfacing the CUWIN to Other Devices

The CUWIN has several different interfaces with which it can interface to other devices. In the exercises to follow we will make use of the Recommended Standard 232 (RS-232) interface, also known as a serial port or com port. We will use RS-232 to have the CUWIN communicate with a PC and the CUBLOC.

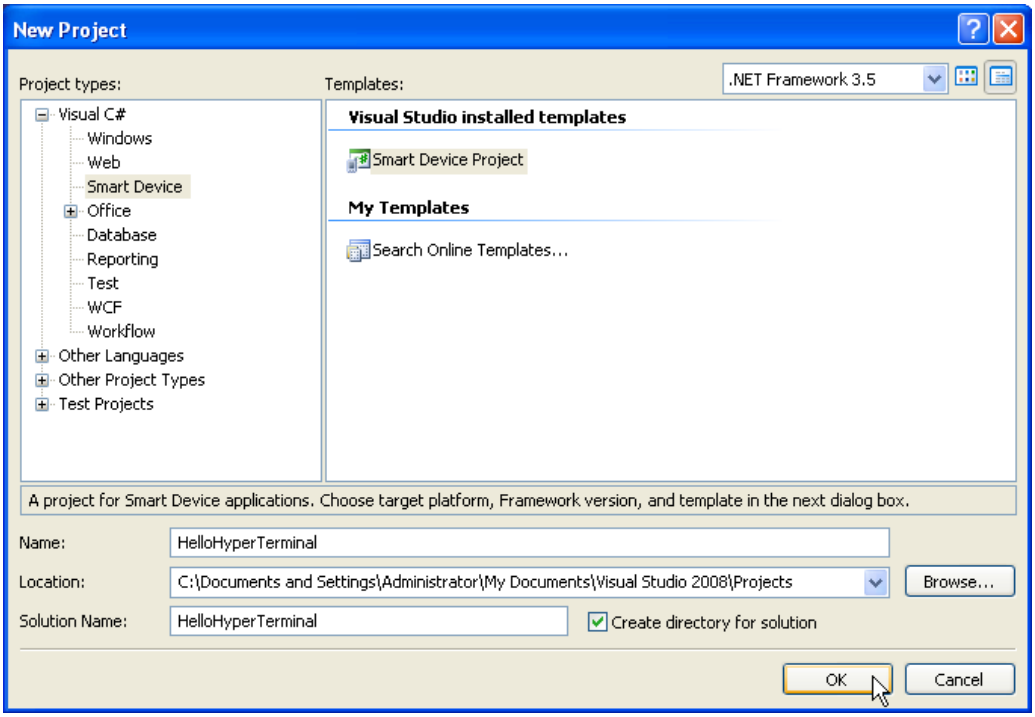
RS-232

RS-232 has been around for many years and is commonly used in the HMI industry as a way for devices to communicate with one another. To illustrate how the CUWIN can use RS-232 to communicate with other devices, we will program the CUWIN to send messages to a PC. The PC will display the received messages in HyperTerminal. HyperTerminal is an application included in all the latest versions of Windows, and is well-suited for RS-232 communication. Finally we will modify this program to read keystrokes in HyperTerminal and display them on the CUWIN.

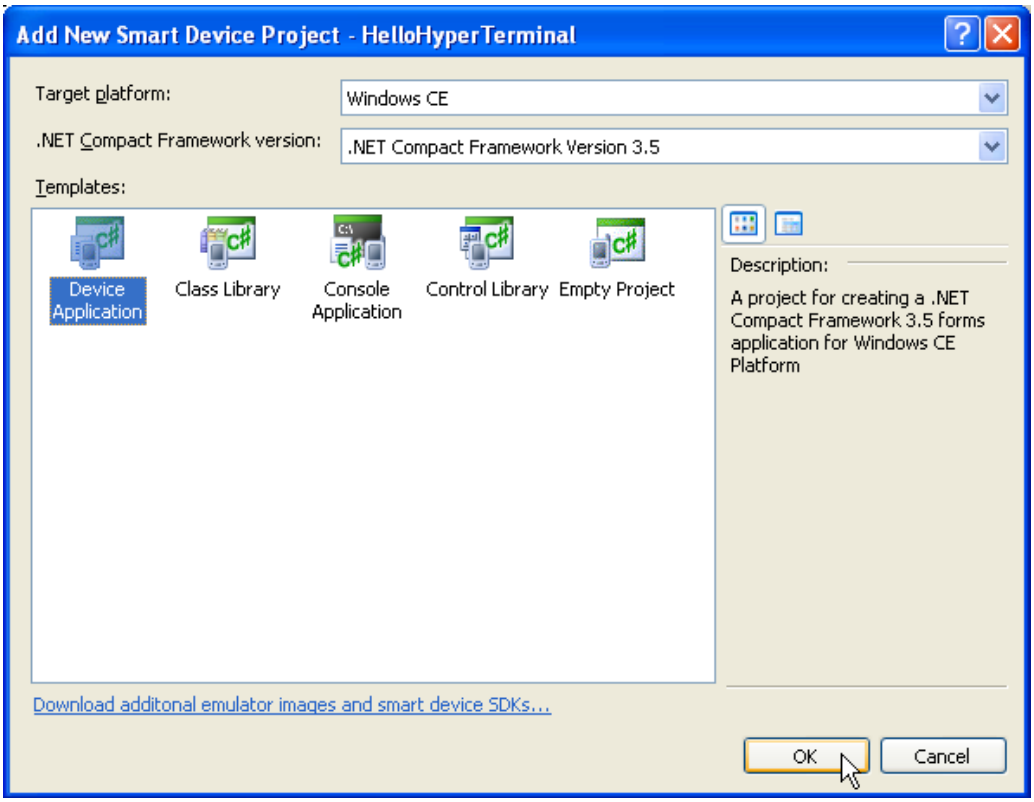
Writing to the CUWIN's Serial Port

For this exercise, you will need to connect an RS-232 cable from CUWIN's COM1 serial port to a PC's serial port. The CUWIN and most PCs have more than one serial port, so be aware which serial port you are using. For this exercise, we will assume that both the CUWIN and the PC will use their COM1 serial port.

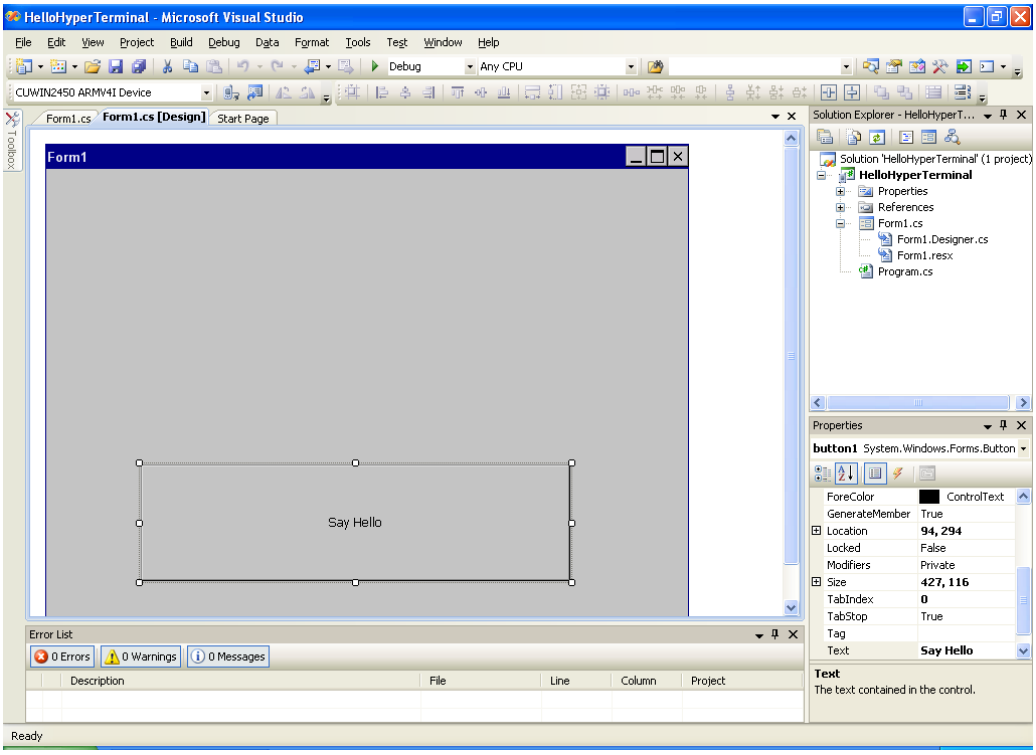
You should now have two connections between the CUWIN and the PC: USB and RS-232.



1. Create a new smart device project as we did for HelloWorld, and name it HelloHyperTerminal.



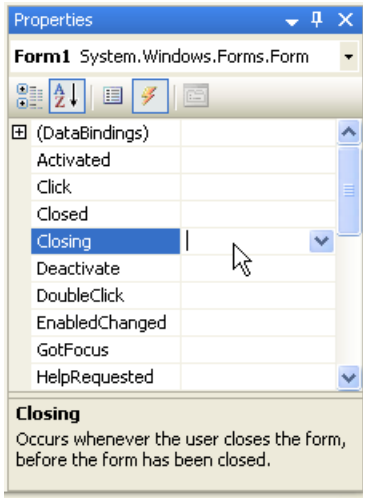
2. Make the project a "Device Application" just as we did for the HelloWorld project.



3. Add a large button to the form and label it "Say Hello" just as we did for the HelloWorld project.

```
using System;
using System.ComponentModel;
using System.Windows.Forms;
using System.IO.Ports;

namespace HelloHyperTerminal
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
        }

        private SerialPort _port;

        private void Form1_Load(object sender, EventArgs e)
        {
            _port = new SerialPort("Com1", //Com port
                19200,          //Baud Rate
                Parity.None,    //Parity
                8,              //Data Bits
                StopBits.One);  //Stop Bits

            _port.Open();
        }
    }
}
```

4. Double-click in any blank space on the form, and Visual Studio will create a `Form1_OnLoad` event handler for you. Add code to this event handler exactly as pictured above.



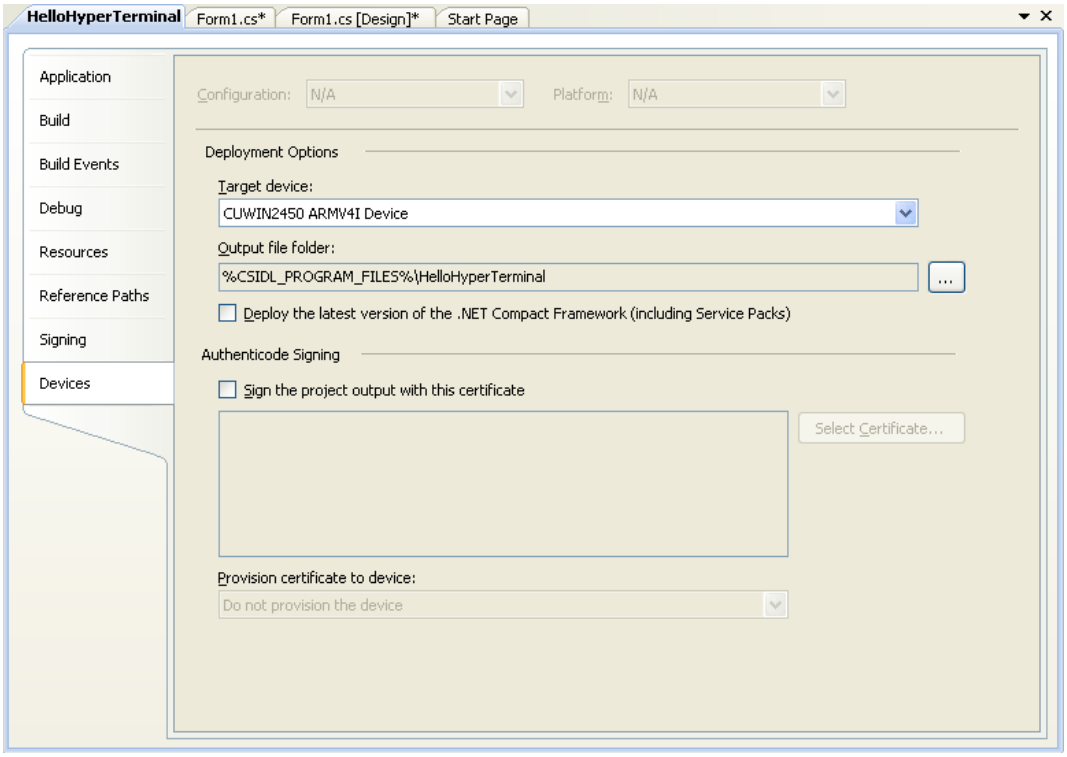
5. Go back to the "Form1.cs [Design]" tab. Select the form, and in the "Properties" window click the lightning bolt icon . This will display all of the events that you can attach event handlers to. Double-click the "Closing" event and a `Form1_Closing` event handler will be created.

```
28          private void Form1_Closing(object sender, CancelEventArgs e)
29          {
30              //Close the serial port
31              _port.Close();
32          }
```

6. Add code to this event handler exactly as pictured above.

```
34          private void button1_Click(object sender, EventArgs e)
35          {
36              //Send "Hello!" to HyperTerminal
37              _port.Write("Hello!\r\n");
38          }
```

7. Go back to the "Form1.cs [Design]" tab, and double-click the "Say Hello" button. This will add a `button1_Click` event handler. Add code to this event handler exactly as pictured above.



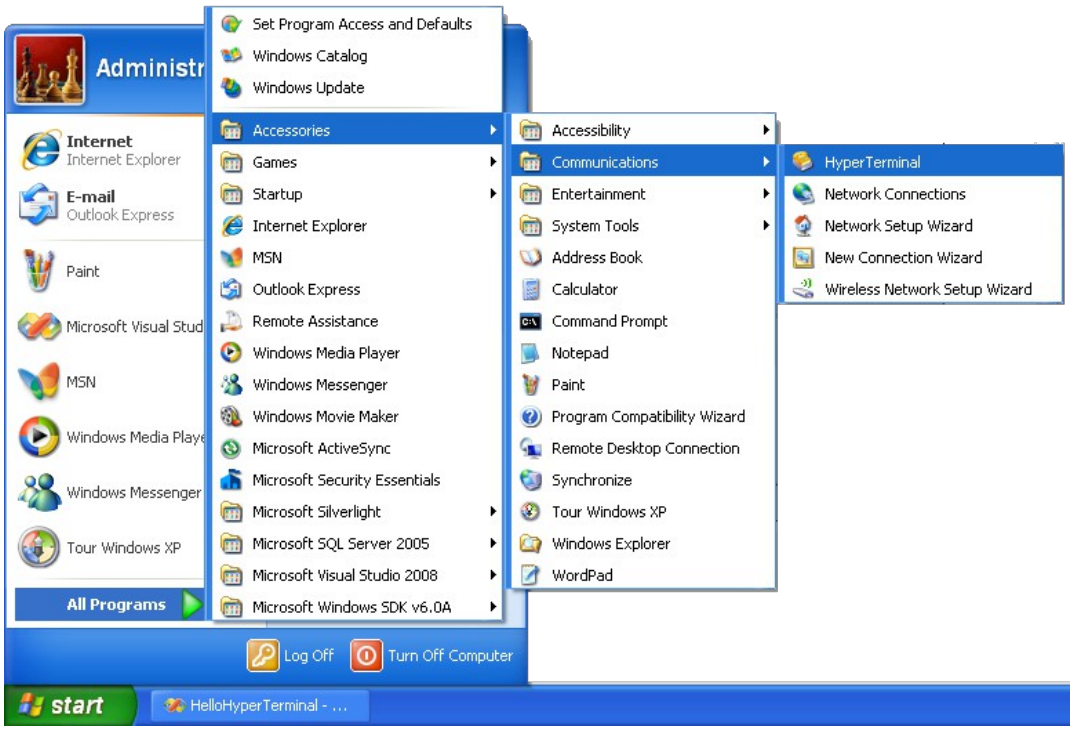
8. Finally adjust the project properties just as we did in the HelloWorld project.

How the Code Works:

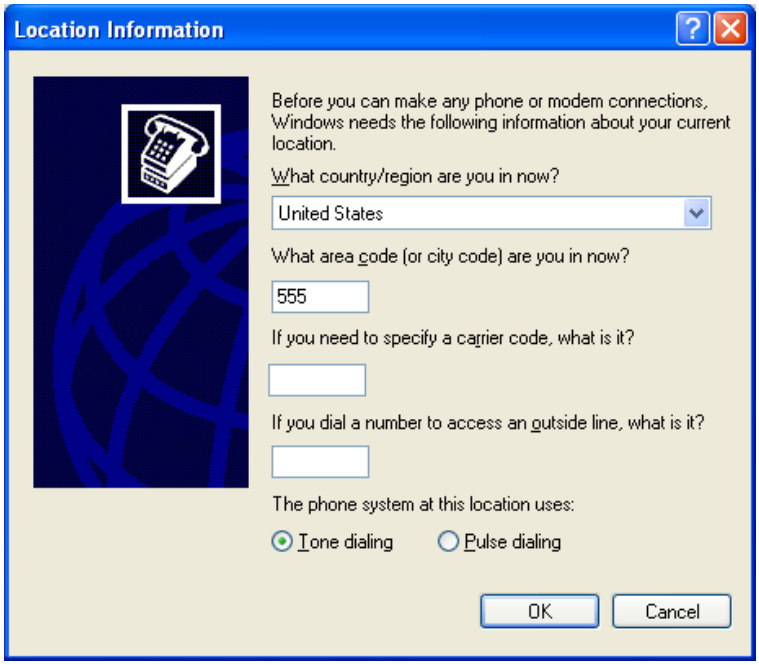
1. When the form opens, the form's `Load` event fires executing the `Form1_Load` event handler. This event handler configures the COM1 serial port and opens it so we can write to it.
2. When we close the form, the form's `Closing` event fires calling the `Form1_Closing` event handler. This event handler closes the COM1 serial port.
3. When we touch the "Say Hello" button, the button's `Click` event fires calling the `button1_Click` event handler. This event handler writes "Hello!" to the serial port. The "`\r`" and "`\n`" characters are a carriage return and line feed, so each "Hello!" we send appears on a new line.

Displaying our "Hello!" Message on the PC

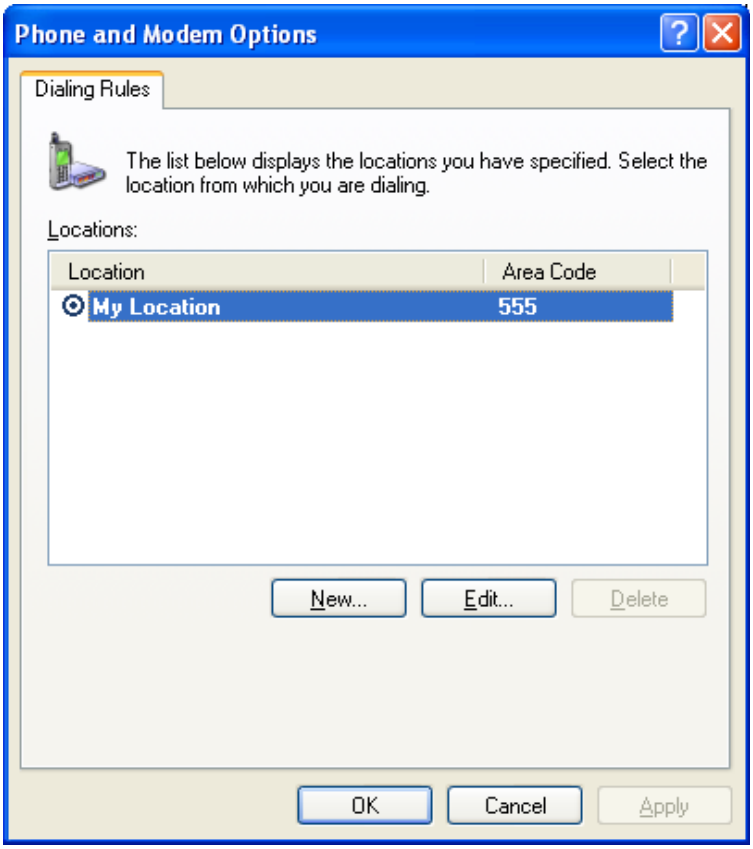
We now need some device to read and display the "Hello!" being sent from the CUWIN. For this we will use the program HyperTerminal which is included in all recent versions of Windows.



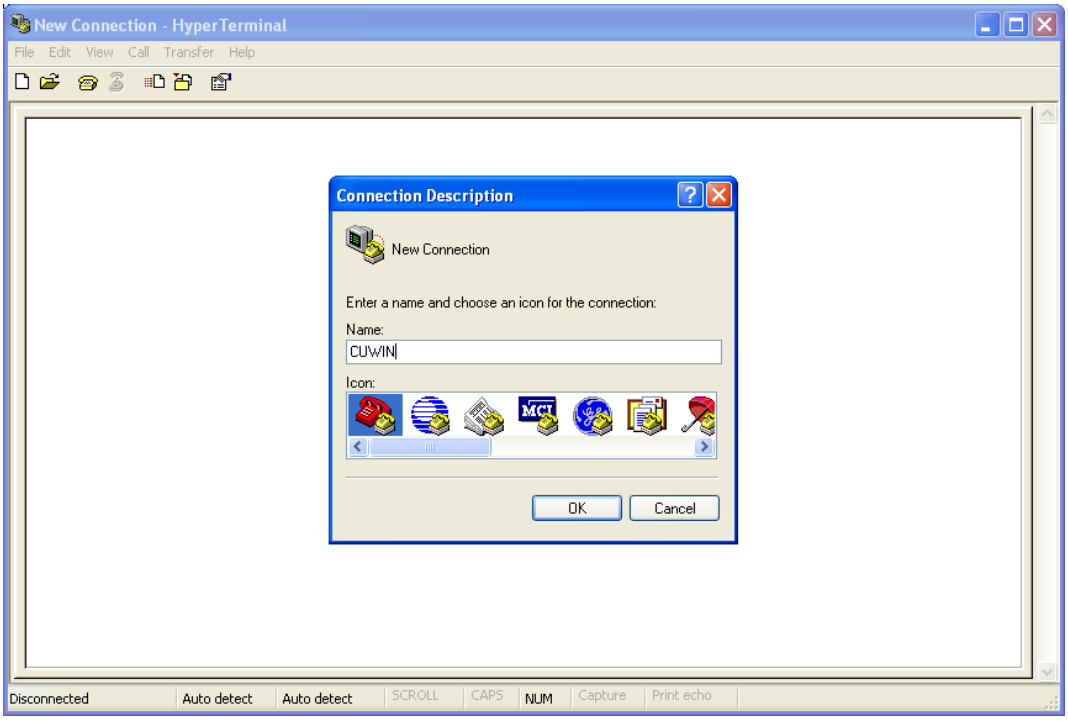
1. Start HyperTerminal by selecting Start-->All Programs-->Accessories-->Communications-->HyperTerminal in the Windows start menu.



2. You may be prompted to configure your Location information. You only need to select your country/region and enter you area code. This settings are not necessary for this experiment, but HyperTerminal requires it. After you are finished, click the "OK" button.

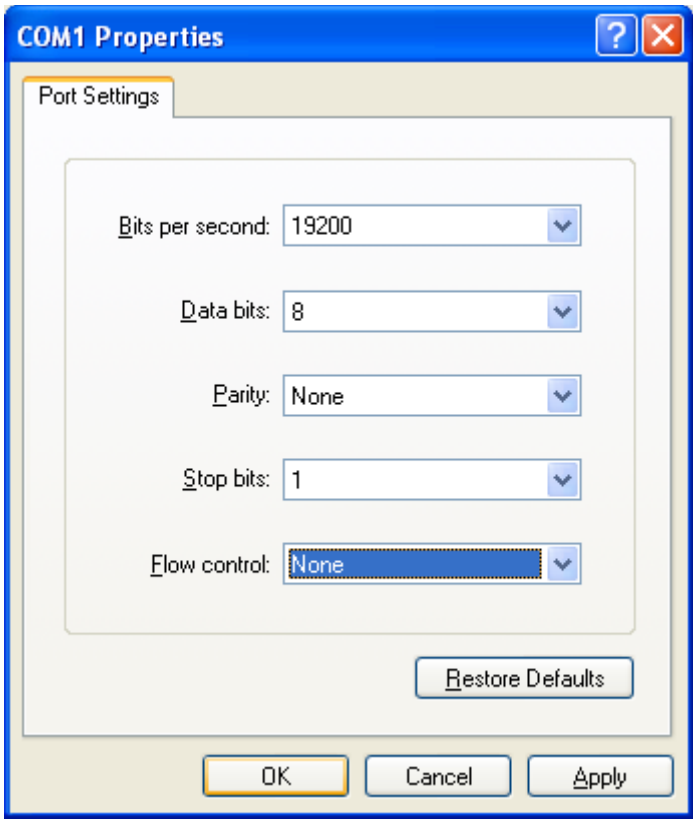


3. You may then be prompted to edit dialing rules. Again, this is not necessary for this experiment. Just click the "OK" button.



4. HyperTerminal will open and display a "Connection Description" dialog. It is here we need to configure the PC's serial port. Enter "CUWIN" in the "Name" textbox and click the "OK" button.

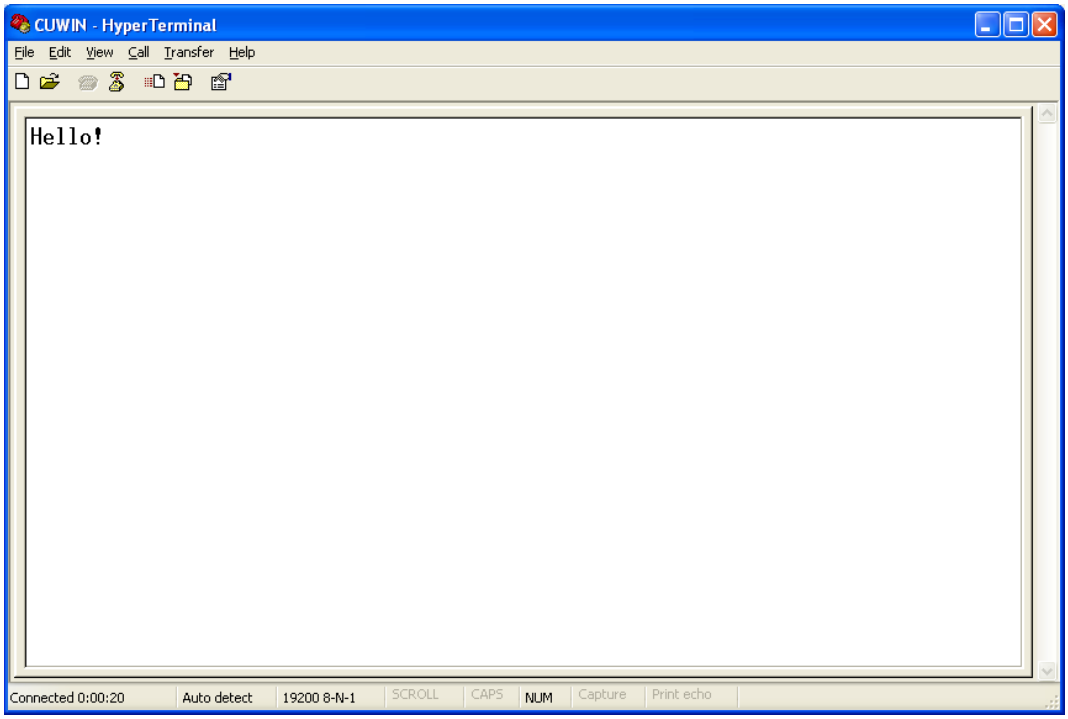
5. In the "Connect Using" drop-down list, select the serial port you wish to use. Note that this is the PC's serial port, not the CUWIN's serial port; they may be different. Then, click the "OK" button.



6. A new dialog will appear asking for your port settings. These settings must match those settings made in the `Form1_Load` event handler of the CUWIN program or the PC and the CUWIN will not be able to communicate with one another. Adjust the settings appropriately, then click the "OK" button.

7. Execute the CUWIN program from Visual Studio.

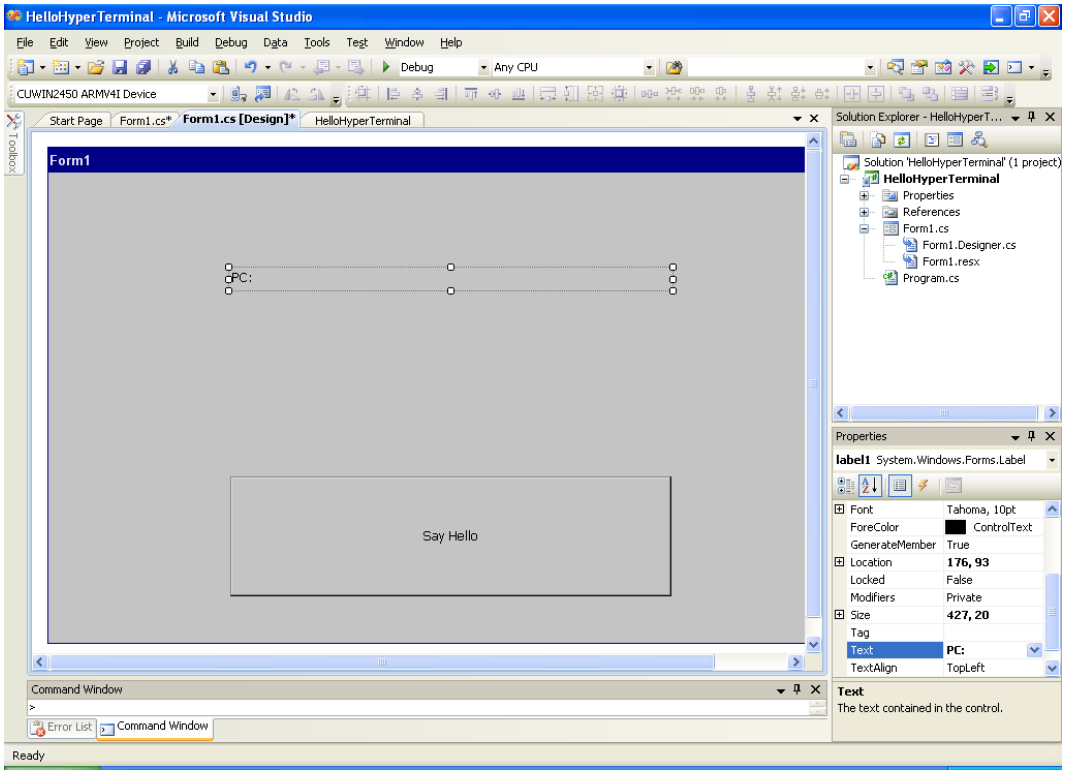
8. The form will display on the CUWIN. Click the "Say Hello" button.



9. Take a look at the PC's HyperTerminal window. You will see the "Hello!" message sent from the CUWIN.

Reading from the CUWIN's Serial Port

We have successfully built an program that writes data to the CUWIN's serial port, sending it to HyperTerminal on the PC, but communication is usually bi-directional. We will now modify this program to read input from HyperTerminal, and send it to the CUWIN.



1. Add a "Label" from the Toolbox to the form, and label it "PC: " by changing its `Text` property.

```
17          private void Form1_Load(object sender, EventArgs e)
18          {
19              _port = new SerialPort("Com1", //Com port
20                  19200,          //Baud Rate
21                  Parity.None,    //Parity
22                  8,              //Data Bits
23                  StopBits.One);  //Stop Bits
24
25              //Listen for incoming data
26              _port.DataReceived += new SerialDataReceivedEventHandler(
27                  _port_DataReceived);
28
29              _port.Open();
30          }
31
32          void _port_DataReceived(object sender, SerialDataReceivedEventArgs e)
33          {
34              //Update label1 with the data read
35              string dataRead = _port.ReadExisting();
36              label1.Invoke(new Action(() => label1.Text += dataRead));
37          }
```

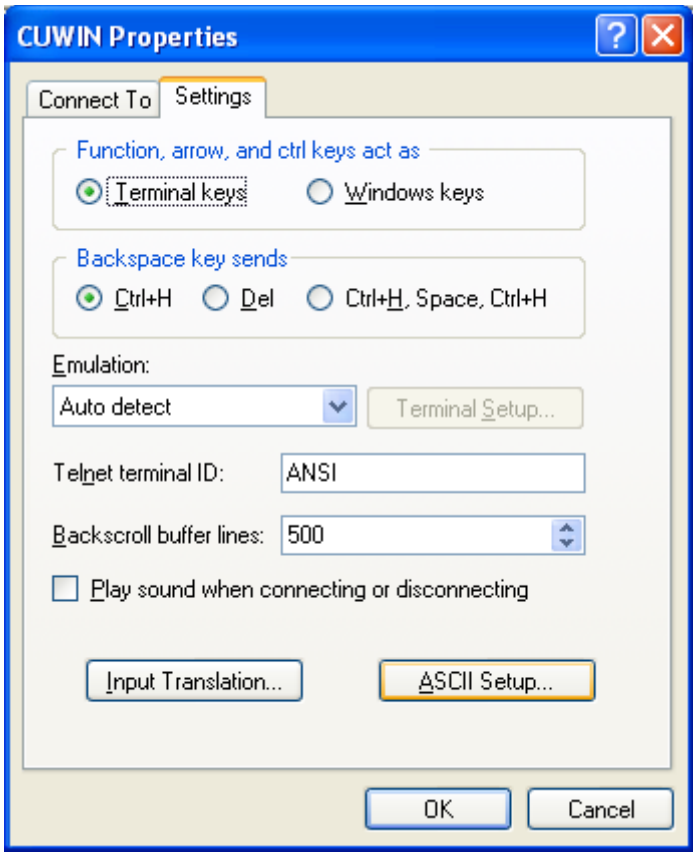
2. Go to the Form.cs tab, and add the `_port_DataReceived` event handler exactly as pictured above.

How the Code Works:

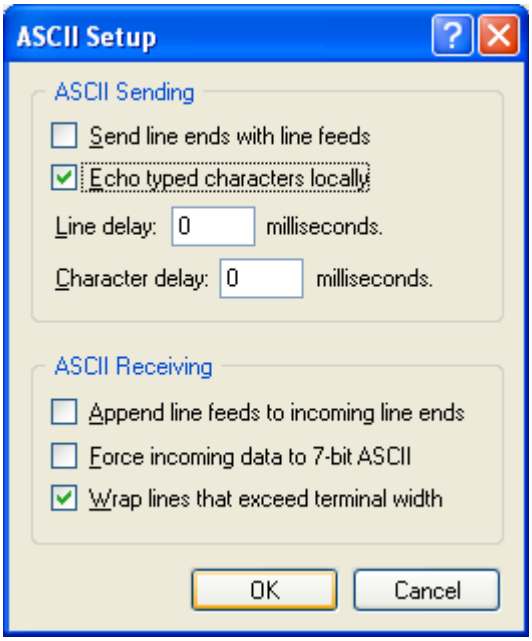
1. When data is received on the CUWIN's serial port, the `DataReceived` event is fired, which executes the `_port_DataRecieved` event handler.
2. In the `_port_DataRecieved` event handler, we read the data from the CUWIN's serial port, and append the data to the "PC:" label. NOTE: The `Invoke` method is necessary because the `_port_DataRecieved` event handler will be running on a different thread than the one used to create the label. Also, the code inside the Invoke method is a lambda expression which is new to C# 3.0. See the Microsoft Development Network (MSDN) documentation for Control.Invoke and Lambda Expressions for more information.

Configuring HyperTerminal to Accept Keystrokes

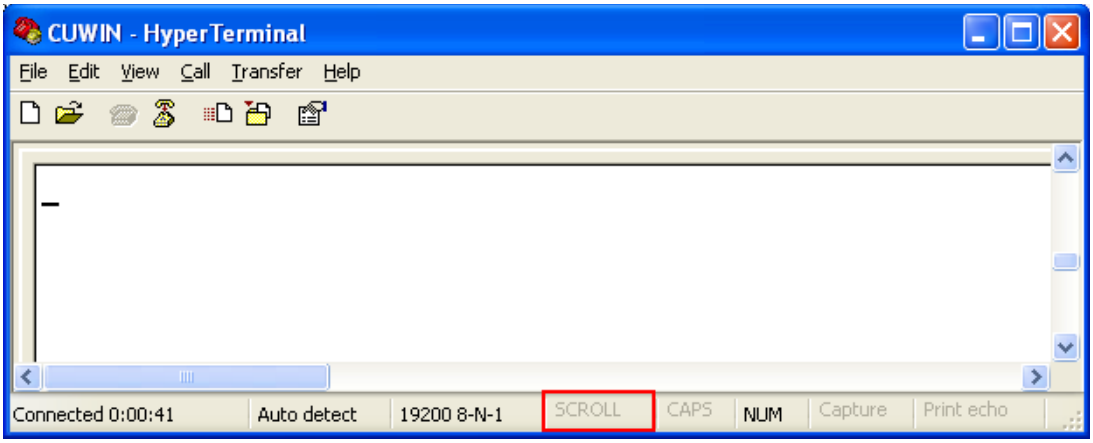
Now we must configure HyperTerminal to accept keystrokes, show them on the screen, and send them to the CUWIN.



1. In HyperTerminal with the CUWIN connection open, select File->Properties from the menu. The "CUWIN Properties" dialog will appear. On the "Settngs" tab, click the "ASCII Settup..." button.



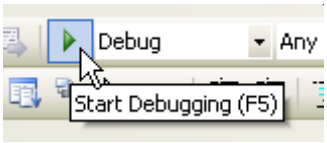
2. Check the "Echo typed characters locally" checkbox. This will ensure that as we type in HyperTerminal, our keystrokes will appear on the screen. Click the "OK" button, then click the "OK" button on the "CUWIN Properties" dialog.



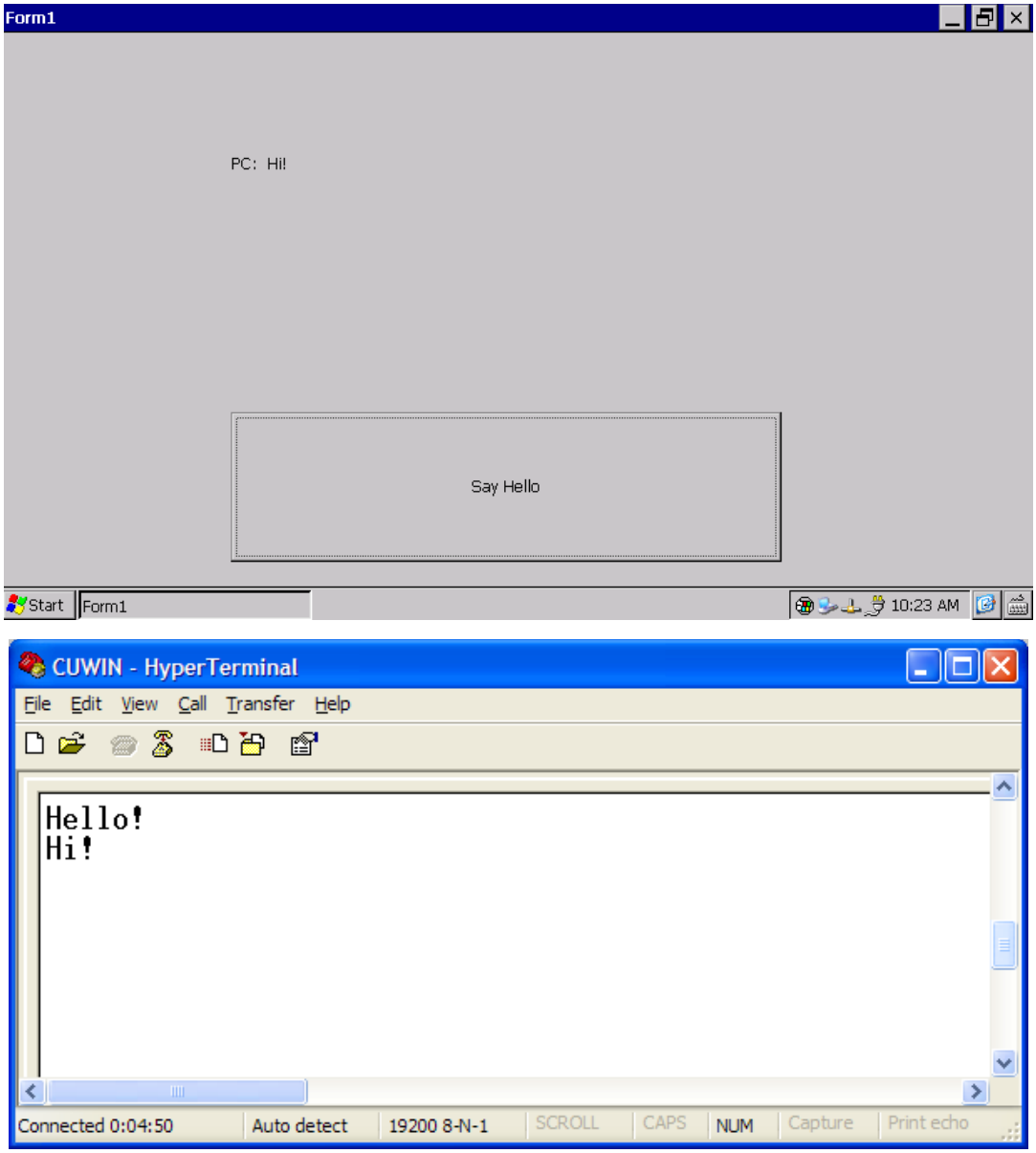
3. Hyperterminal will not accept keyboard input until the Scroll Lock is turned off. Press the "Scroll Lock" key on your keyboard until the status bar shows "Scroll" in gray (disabled). Now if we type in HyperTerminal, what we type will display on the screen and will be sent to the CUWIN.

Running the Program

We are now ready to run the program.



1. Once again, execute the CUWIN program from Visual Studio.



2. When the form appears on the CUWIN, touch the "Say Hello" button and "Hello!" will appear in HyperTerminal. Then type "Hi!" in HyperTerminal and the CUWIN will display "Hi!" in the "PC:" label.

Modbus

We've now seen how we can program the CUWIN to send and receive data over the its serial port using RS-232. However, in that program we transmitted only human readable character data. Most digital devices probably don't know what "Hello!" and "Hi!" mean. If we want to communicate with electronic devices we must speak their language.

Enter Modbus. Modbus is a protocol created by Modicon in 1979 to communicate with industrial electronic devices, and has proliferated to become the de facto standard in the industry.

Modbus uses a request/reply protocol with a single master device and one or more slave devices. The master sends a request to a single slave, and that slave replies with a response to the master's request. A slave can only respond to requests from the master; it cannot initiate communication on its own. These requests and replies are called Protocol Data Units (PDUs).

Modbus supports two PDU formats: Remote Terminal Unit (RTU) and American Standard Code for Information Interchange (ASCII). The RTU format encodes each PDU in a compact, binary form and uses a Cyclic Redundancy Check (CRC) to verify the integrity of the transmission. The ASCII format encodes each PDU as a set of ASCII characters and uses a Longitudinal Redundancy Check (LRC) to verify the integrity of the transmission.

Modubus request PDUs vary, but typically they contain the following:

1. Slave Address – The address of the slave device the request is intended for
2. Function Code – The function to performed on the slave device (read, write, etc...)
3. Data – Information needed to perform the given function
4. Error Code – CRC for RTU, or LRC for ASCII to verify the transmission integrity

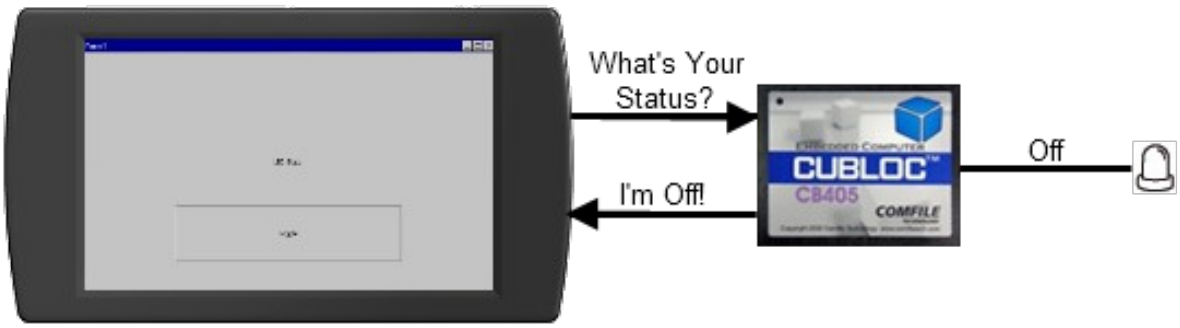
Modbus reply PDUs also vary, but typically they contain the following:

1. Slave Address – The address of slave device the reply is from
2. Function Code – The function performed by the slave device
3. Data – Information about the function performed
4. Error Code – CRC for RTU, or LRC for ASCII to verify the transmission integrity

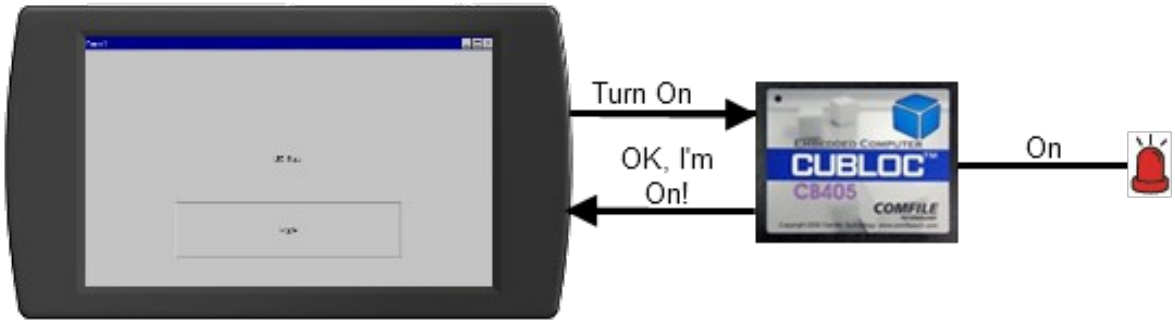
This very brief introduction to Modbus is all that is needed to understand the exercises to follow. It is out of the scope of this document to explain Modbus in detail so, to learn more, please see The Modbus Organization.

Using Modbus to Interface the CUWIN to the CUBLOC

In this exercise, we will interface the CUWIN to a CUBLOC to toggle an LED on and off.



First the CUWIN must ask the CUBLOC if the LED is on or off.



Then, the CUWIN will tell the CUBLOC to turn the LED on (if the LED was off), or off (if the LED was on).

The following Modbus PDUs are listed here to help you understand the exercise to follow. To keep this exercise simple for the purpose of learning, we will hard-code these PDUs in our program.

Reading the State of the LED

To ask the CUBLOC what the state of the LED is, we issue the following Modbus PDU.

Request	
Value	**Description**
0x01	Slave Address 1
0x02	Read Bit
0x0000	Register Address 0 (Port 0)
0x0001	Read only 1 bit
0xB9CA	CRC

If the LED is off, the CUBLOC will respond with the following Modbus PDU:

Reply	
Value	**Description**
0x01	Slave Address 1
0x02	Read Bit
0x01	1 Bit Read
0x00	LED is off
0xA188	CRC

If the LED is on, the CUBLOC will respond with the following Modbus PDU:

Reply	
Value	**Description**
0x01	Slave Address 1
0x02	Read Bit
0x00	1 Bit Read
0x01	LED is on
0x6048	CRC

Turning the LED On:

To have the CUBLOC turn the LED on, we issue the following Modbus PDU.

Request	
Value	**Description**
0x01	Slave Address 1
0x05	Write bit
0x0000	Register Address 0 (Port 0)
0xFF00	Turn the LED on
0x8C3A	CRC

The CUBLOC will respond with the following Modbus PDU (an echo of the request):

Reply	
Value	**Description**
0x01	Slave Address 1
0x05	Read Bit
0x0000	Register Address 0 (Port 0)
0xFF00	The LED was turned on
0x8C3A	CRC

Turning the LED Off

To have the CUBLOC turn the LED off, we issue the following Modbus PDU.

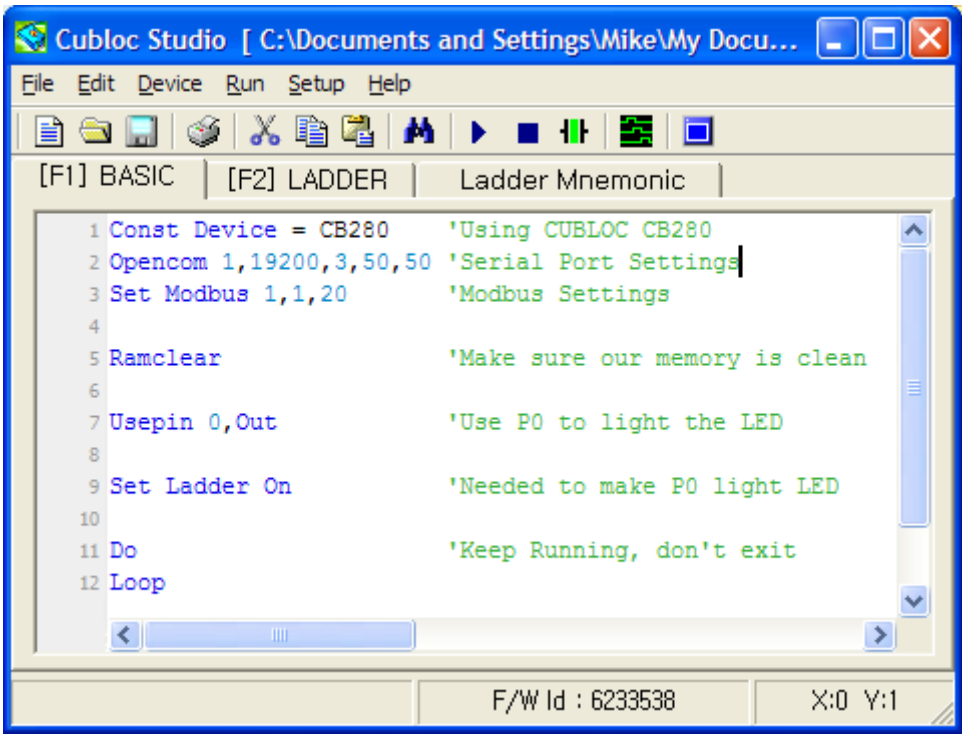
Request	
Value	**Description**
0x01	Slave Address 1
0x05	Write bit
0x0000	Register Address 0 (Port 0)
0x0000	Turn the LED off
0xCDCA	CRC

The CUBLOC will respond with the following Modbus PDU (an echo of the request):

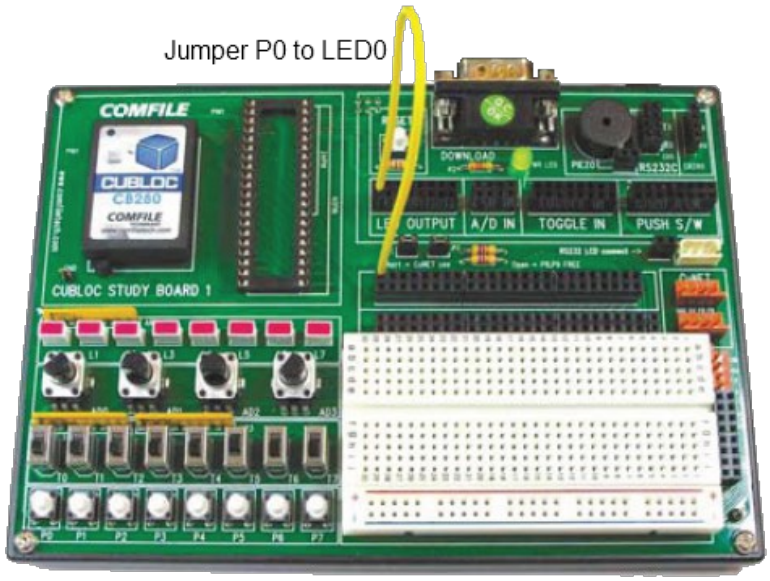
Reply	
Value	**Description**
0x01	Slave Address 1
0x05	Read Bit
0x0000	Register Address 0 (Port 0)
0x0000	The LED was turned off
0xCDCA	CRC

Setting Up the CUBLOC

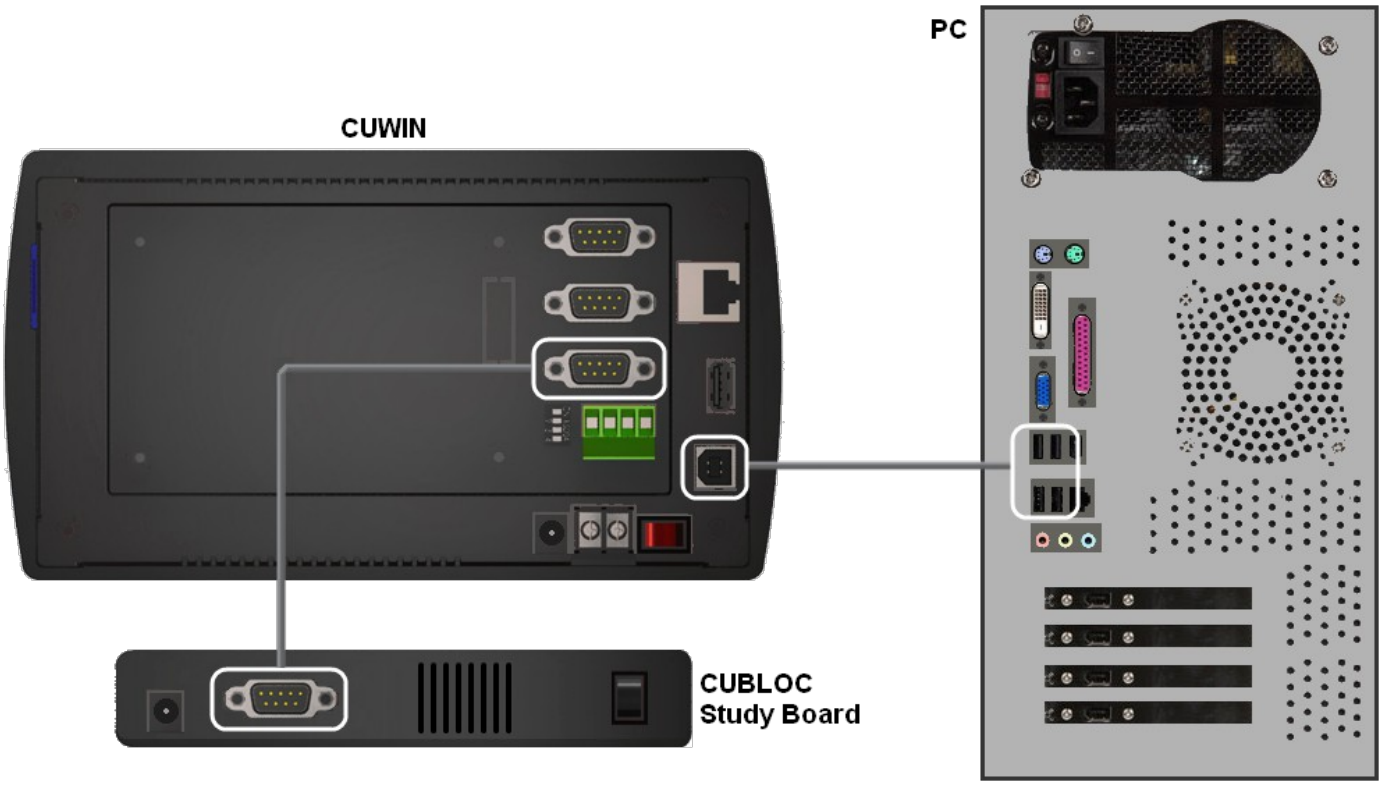
Now that we have a general idea what Modbus is, we need to set up the CUBLOC to perform the task at hand. Follow the following procedures to program the CUBLOC, connect one of its I/O ports to an LED, and connect it to the CUWIN.



1. Using Cubloc Studio, program the CUBLOC as shown above. This will configure the CUBLOC to communicate via Modbus over its serial port, and enable port 0 to apply voltage to an LED. It is not necessary to fully understand this program. If you want to learn more about programming the CUBLOC, see the CUBLOC's user manual.



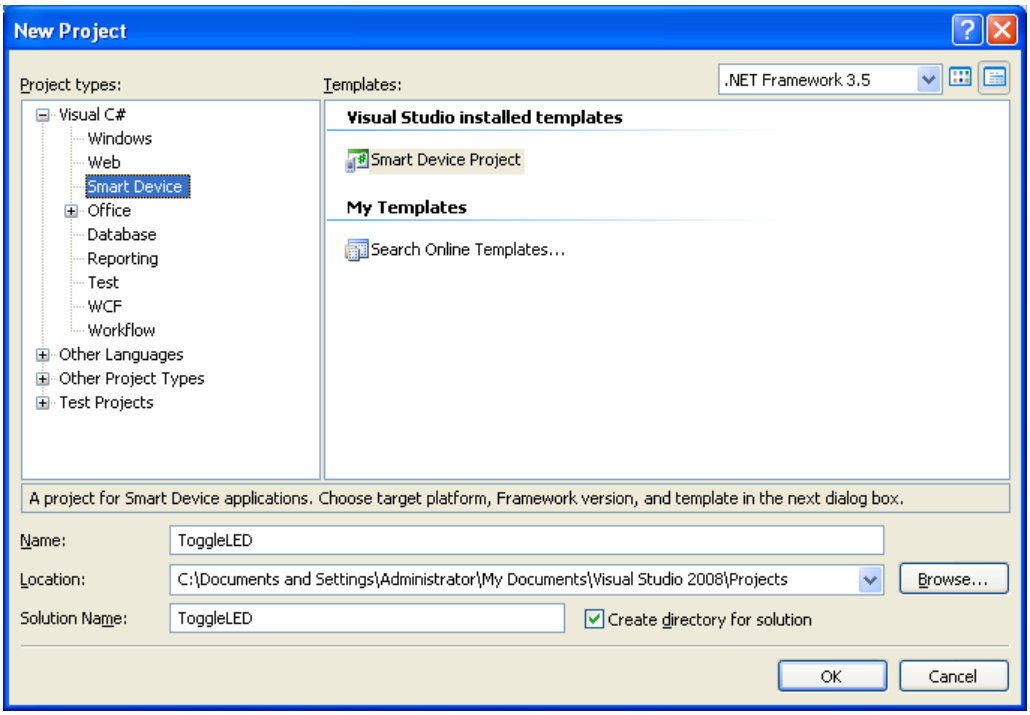
2. Connect the CUBLOC's I/O port 0 to an LED. The image above illustrates how to accomplish this using the CUBLOC Study Board.



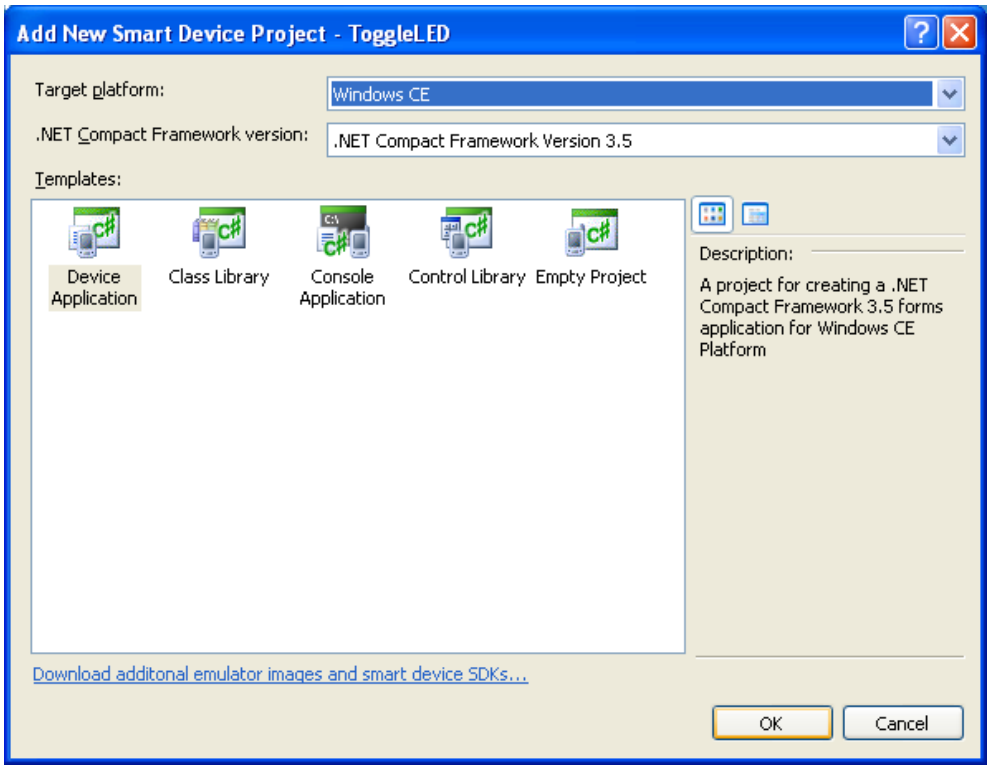
3. Connect the CUBLOC's serial port to the CUWIN's COM1 serial port. The image above illustrates how to accomplish this using the CUBLOC Study Board. There will now be two connections to the CUWIN: a USB connection to the PC, and an RS-232 connection to the CUBLOC Study Board.

Programming the CUWIN

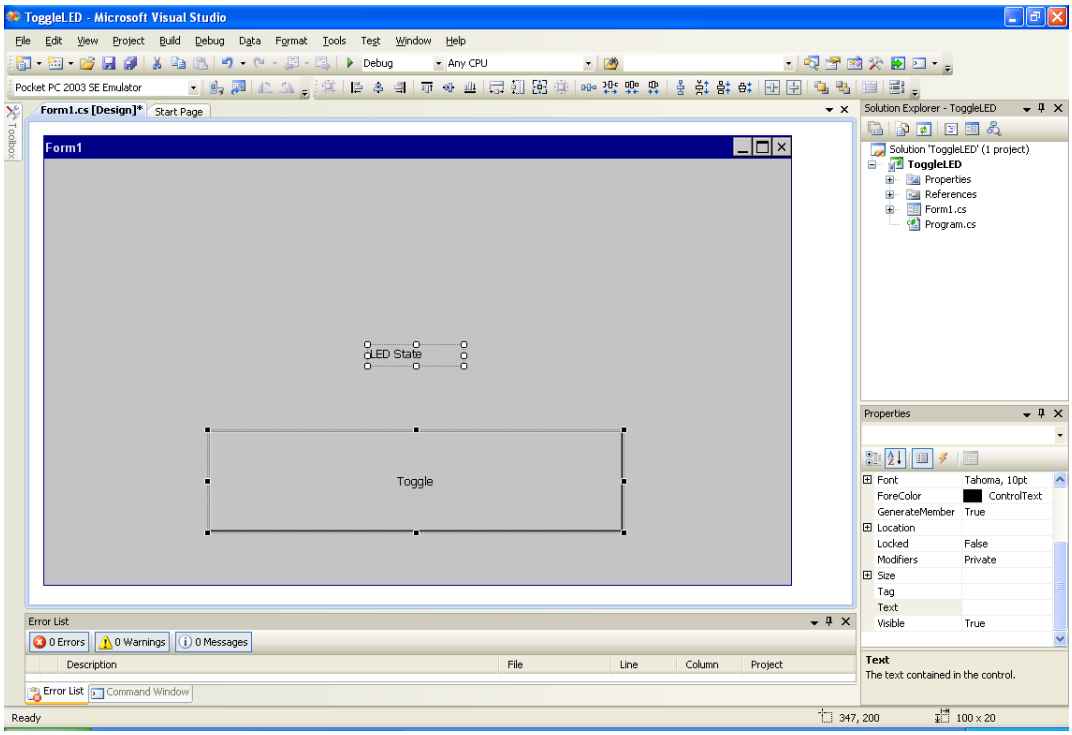
Now that the CUBLOC has been programmed to process Modbus PDUs, configured to light an LED, and connected to the CUWIN, we need to program the CUWIN to send Modbus PDUs to the CUBLOC.



1. Create a new smart device project just as we did in the previous exercises, and name it "ToggleLED".



2. Make the project a "Device Application" project just as we did in the previous exercises.



3. Add a label and a button to the form. Label the button “Toggle” and the label “LED State”.

```
using System;
using System.ComponentModel;
using System.Windows.Forms;
using System.IO.Ports;

namespace ToggleLED
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
        }

        private SerialPort _port;

        private void Form1_Load(object sender, EventArgs e)
        {
            //Configure the serial port
            _port = new SerialPort();
            _port.BaudRate = 19200;
            _port.DataBits = 8;
            _port.Parity = Parity.None;
            _port.StopBits = StopBits.One;

            //Open the serial port
            _port.Open();
        }

        private void Form1_Closing(object sender, CancelEventArgs e)
        {
            //Close the serial port
            _port.Close();
        }
    }
}
```

4. Add the code above to the form's `Load` and `Closing` event handlers. This will configure the CUWIN's serial port and open it when the form loads. When the form closes, the the serial port will be closed.

```
using System;
using System.ComponentModel;
using System.Windows.Forms;
using System.IO.Ports;
using System.Threading;

namespace ToggleLED
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
        }

        private SerialPort _port;
        private byte[] _response = new byte[8];
        private ManualResetEvent _evt = new ManualResetEvent(false);

        private void Form1_Load(object sender, EventArgs e)
        {
            //Configure the serial port
            _port = new SerialPort();
            _port.BaudRate = 19200;
            _port.DataBits = 8;
            _port.Parity = Parity.None;
            _port.StopBits = StopBits.One;

            //Listen for data arriving on the serial port
            _port.DataReceived += new
                   SerialDataReceivedEventHandler(_port_DataReceived);

            //Open the serial port
            _port.Open();
        }

        private void Form1_Closing(object sender, CancelEventArgs e)
        {
            //Close the serial port
            _port.Close();
        }

        void _port_DataReceived(object sender, SerialDataReceivedEventArgs e)
        {
            //Read data into _response buffer
            _port.Read(_response, 0, _port.BytesToRead);

            //Notify that a response was received
            _evt.Set();
        }
    }
}
```

5. Attach an event handler to the serial ports `DataReceived` event. This event handler will store the PDU received from the CUBLOC in the `_response` buffer, and notify the the form's thread (See ManualResetEvent for more information) that the PDU was received.

```
52          //Returns true if LED is on, false if LED is off
53          private bool ReadLEDState()
54          {
55              //slave address = 0x01
56              //function code = 0x02 - read bit
57              //register address = 0x00, 0x00
58              //read only 1 bit = 0x00, 0x01
59              //crc = 0xB9, 0xCA
60              byte[] request = { 0x01, 0x02, 0x00, 0x00, 0x00, 0x01, 0xB9, 0xCA };
61
62              //send request
63              _port.Write(request, 0, request.Length);
64
65              //Wait for a response
66              _evt.WaitOne();
67              _evt.Reset();
68
69              //byte[3] contains the LED's status
70              if (_response[3] == 0)
71                  return false;
72              else
73                  return true;
74          }
```

6. Add a function called `ReadLEDState` that sends a Modbus PDU to the CUBLOC to read the state of the LED. This function will wait for a response PDU from the CUBLOC (`_evt.WaitOne()`), and examine the response. If the response PDU's data is 0, then the LED is off and this method will return false. Otherwise, the LED is on and this method will return true.

```
76          //If turnOn is true, turn on LED.  Otherwise turn off LED
77          private void ChangeLEDState(bool turnOn)
78          {
79              //slave address = 0x01
80              //function code = 0x05 - write bit
81              //register address = 0x00, 0x00
82              //On or Off = OxFF 0x00 (on), 0x00 0x00 (0ff)
83              //crc = 0x8C 0x3A (on), 0xCD 0xCA (off)
84              byte[] request;
85              if (turnOn)
86              {
87                  request = new byte[]
88                      { 0x01, 0x05, 0x00, 0x00, 0xFF, 0x00, 0x8C, 0x3A };
89              }
90              else
91              {
92                  request = new byte[]
93                      { 0x01, 0x05, 0x00, 0x00, 0x00, 0x00, 0xCD, 0xCA };
94              }
95
96              //send request
97              _port.Write(request, 0, request.Length);
98
99              //Wait for a response
100             _evt.WaitOne();
101             _evt.Reset();
102         }
```

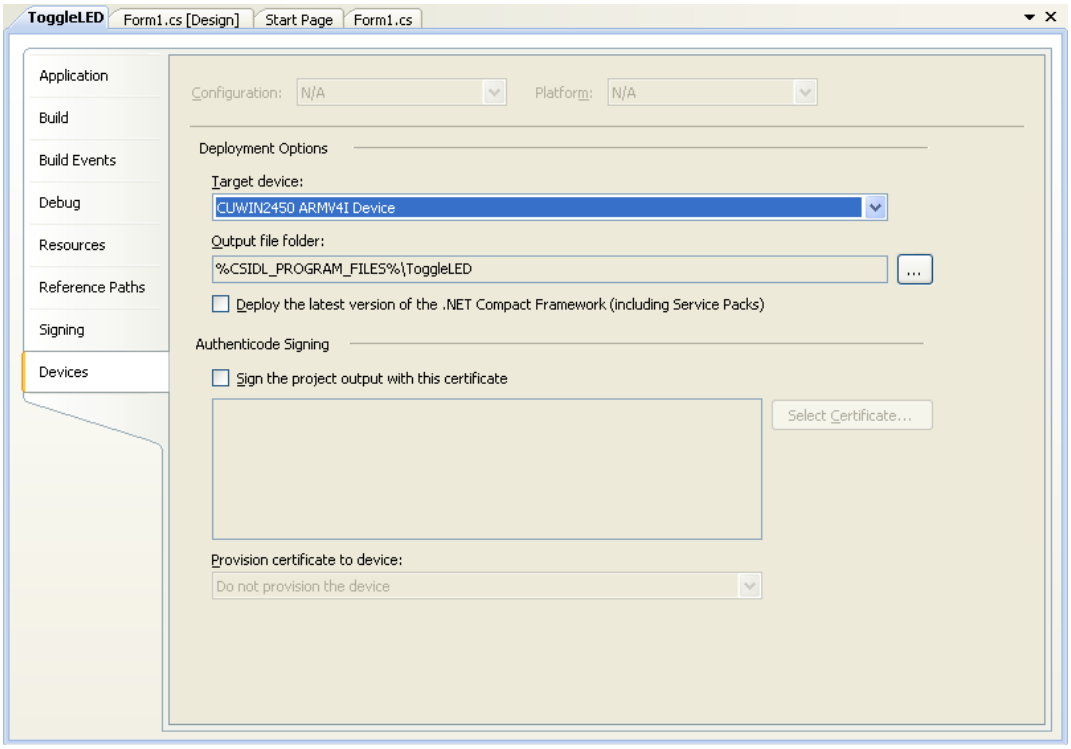
7. Add a function called `ChangeLEDState` that sends a Modbus PDU to the CUBLOC to turn the LED on or off, and waits for a response PDU from the CUBLOC (`_evt.WaitOne()`). The response PDU from the CUBLOC is not needed, so it is ignored.

```
104         private void button1_Click(object sender, EventArgs e)
105         {
106             //Is LED on or off?
107             bool isOn = ReadLEDState();
108 
109             //Toggle LED
110             ChangeLEDState(!isOn);
111 
112             //Confirm: Is LED on or off?
113             isOn = ReadLEDState();
114 
115             //Update label
116             if (isOn)
117                 label1.Text = "On";
118             else
119                 label1.Text = "Off";
120         }
```

8. We now have functions for reading and changing the state of the LED. We now need to add attach an event handler to the button's `Click` event to toggle the state of the LED. After the state is changed, the program will read the state of the LED and update the "LED State" label.

```
20          private void Form1_Load(object sender, EventArgs e)
21          {
22              //Configure the serial port
23              _port = new SerialPort();
24              _port.BaudRate = 19200;
25              _port.DataBits = 8;
26              _port.Parity = Parity.None;
27              _port.StopBits = StopBits.One;
28 
29              //Listen for data arriving on the serial port
30              _port.DataReceived += new
31                  SerialDataReceivedEventHandler(_port_DataReceived);
32 
33              //Open the serial port
34              _port.Open();
35 
36              //Is LED on or off?
37              bool isOn = ReadLEDState();
38 
39              //Update label
40              if (isOn)
41                  label1.Text = "On";
42              else
43                  label1.Text = "Off";
44          }
```

9. When the form loads, we should update the "LED State" label with the LED's initial state. To do this, modify the `Form1_Load` event handler as shown above.



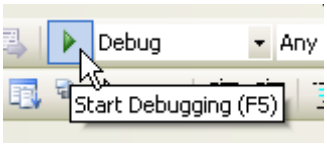
10. Finally, adjust the project properties as we did in the previous exercises.

How the Code Works:

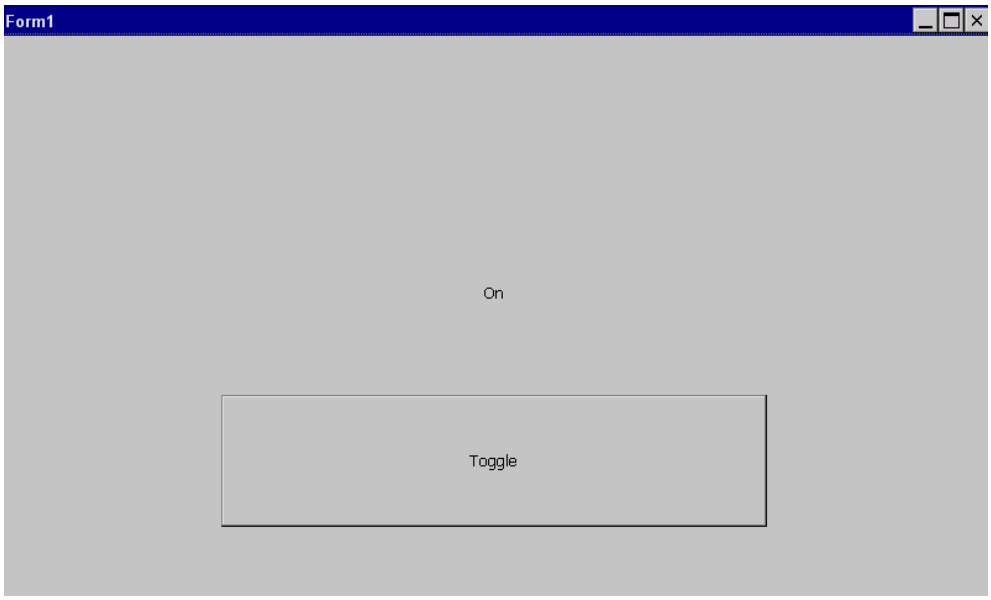
1. When the form loads, the form's `Load` event fires, calling the `Form1_Load` event handler. This event handler configures the CUWIN's serial port, attaches the `_port_DataReceived` event handler, opens the port, and initializes the "LED State" label with the current state of the LED: "On" or "Off".
2. When the "Toggle" button is clicked, the button's `Click` event fires, calling the `button1_Click` event handler. This event handler reads the state of the LED, reverses the LED's state, confirms the new state of the LED, and updates the "LED State" label with the LED's new state.
   - ✔ The `ReadLEDStatus` function sends a Modbus PDU to the CUBLOC asking for the value in register 0x0000 (the value of port 0), then waits for a response from the CUBLOC.
   - ✔ The `ChangeLEDStatus` function sends a Modbus PDU to either set the value in register 0x0000 to 1 (turn on the LED), or set the value in register 0x0000 to 0 (turn off the LED) depending on the value of the `turnOn` parameter. NOTE: The Modbus protocol requires us to send a value of 0x00FF to change register 0x0000's value to 1.
   - ✔ The `_port_DataReceived` event handler receives a Modbus response PDU from the CUBLOC, stores the PDU in the `_response` buffer, then notifies the form that the response has been received.
3. Finally when the form closes, the form's `Close` event fires, calling the `Form1_Closing` event handler. This event handler closes the CUWIN's serial port.

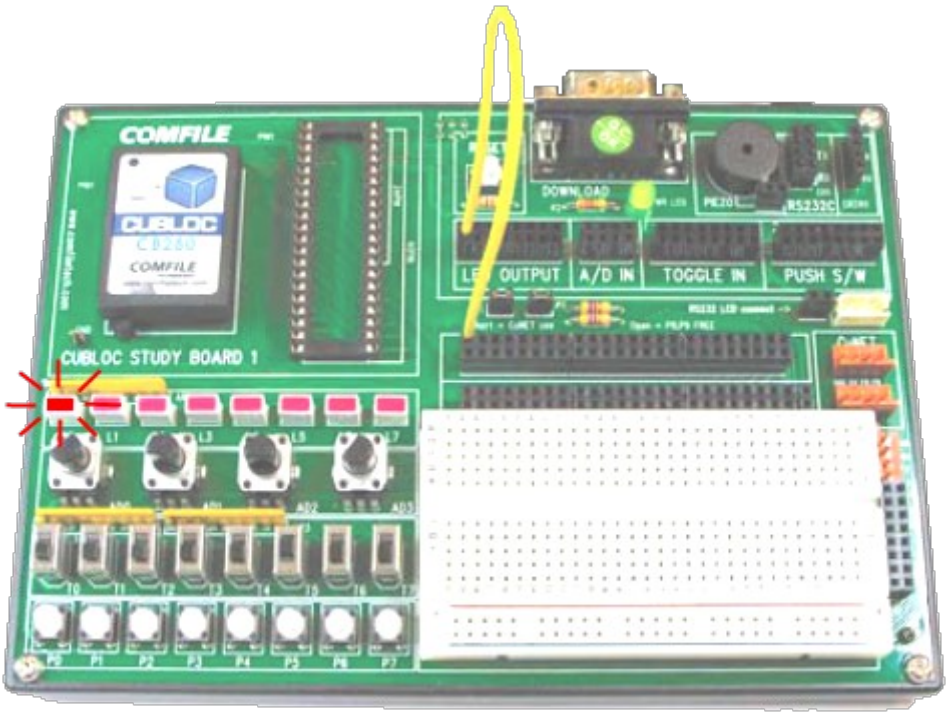
Running the Program

We are now ready to run the program.



1. Execute the CUWIN program from Visual Studio.





2. When the form loads, you will see the "LED State" label update to the current state of the LED. When you click the "Toggle" button, the LED's state will change and the "LED State" label will update accordingly.

Final Thoughts

In an effort to keep this exercise simple for the purpose of learning, we have made several concessions. To name a few, we are not generating the request PDU's CRC dynamically, we are not checking the response PDU's CRC for transmission integrity, and we are waiting indefinitely for a response after issuing a request. Please keep this in mind as you explore the design of your own programs.