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WATER SENSOR SYSTEM (RECEIVER)

DIYANA BINTI MUHAMAD

**Project Report Submitted as Partial Fulfilment
of the Requirement for the
Degree in Bachelor of Electrical Engineering
(Telecommunication)**

**FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITI TEKNOLOGI MALAYSIA**

NOVEMBER 2006

"I hereby declared that this thesis entitled Water Sensor System (Receiver) is a result of my own research and idea, except for works that have been cited clearly in the references".

Signature : ____________________

Name : DIYANA BINTI MUHAMAD

Date : 30 NOVEMBER 2006

Specially Dedicated to

My beloved Mother; Nik Aeshah Nik Mustapha, Father; Muhamad Mat Salleh, Siblings and Friends

For their eternal support, motivation, encouragement and inspiration throughout my journey of education.

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ABSTRACT

Nowadays, Wireless Sensor Network (WSN) has become very popular. The availability of low-cost, high performance and practical usage of the embedded processor, radios and sensor has lead to the used of wireless sensor communication in humans life. The application of WSN is very wide. It can be used as habitat monitoring, health monitoring, and sensing others environmental data such as temperature, humidity, light, water and etc remotely at distance. The purpose of this project is to develop a sensor system which able to monitor increments of water level at computer. Water sensor system consists of two nodes which are transmitter and receiver. Transmitter will sense four levels increment of the water and sent to the receiver end wirelessly. Then the receiver will capture the signal, demodulate, process data, display on LEDs and send to PC. Water sensor system can be used as an early warning system to monitor flood. This report elaborates the development of receiver node that includes the hardware and software design. The receiver node is built using ATmega8535 as it processor, superheterodyne receiver module as it communication tool and computer to display the sensor value. This system implements the non-standard protocol for point to point communication between two nodes. All programming is written in C language. GUI is also developed as an additional feature to the system (using VB 6.0). The results obtained in this project are taken using USART terminal, oscilloscope and GUI interface. It is observed that the frame sent is successfully received and displayed at the receiver end with very small time interval between transmitted and receive frame.

ABSTRAK

Rangkaian pengesan tanpa wayar (RPTW) telah menjadi semakin popular pada masa kini. Dengan adanya pemproses terbenam, radio dan pengesan yang berharga rendah, pertasi tinggi dan juga praktikal untuk digunakan telah membawa kepada penggunaan sistem pengesan tanpa wayar dalam kehidupan manusia. Aplikasi RPTW adalah meluas. Ianya boleh digunakan sebagai pemerhati habitat, pemerhati kesihatan dan pengesan elemen persekitaran seperti suhu, kelembapan, cahaya, air dan sebagainya pada jarak jauh. Projek ini adalah bertujuan untuk membina sebuah sistem pengesan yang mampu mencerap takat kenaikan air di komputer. Sistem ini terdiri daripada dua nod iaitu stesen pemancar dan penerima. Stesen pemancar akan mengesan empat takat kenaikan air dan menghantarnya secara tanpa wayar ke stesen penerima. Kemudian stesen penerima akan menangkap isyarat, mengubah ke bentuk digital , memproses, memapar ke LED dan menghantar data ke komputer. Sistem ini sesuai digunakan sebagai sistem amaran awal untuk mengesan banjir. Laporan ini mengemukakan pembagunan nod penerima termasuk rekaan perkakasan dan rekaan perisian. Nod penerima dibina menggunakan ATmega8535 sebagai pemprosess, Modul frekuensi radio sebagai alat komunikasi dan komputer untuk paparan.Sistem ini menggunakan rekaan protokol bukan-standard untuk komunikasi nod ke nod. Semua atucara ditulis dalam bahasa pengatucaraan C. Selain itu, antaramuka- pengguna bergrafik turut dibangunkan sebagai ciri tambahan kepada sistem (menggunakan VB 6.0). Keputusan yang diperolehi diambil dengan menggunakan terminal USART, osiloskop dan antaramuka pengguna- bergrafik. Di dapati bingkai yang di hantar berjaya diterima oleh stesen penerima. Perbezaan masa diantara bingkai yang dihantar and bingkai yg diterima adalah sangat kecil .

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LIST OF ABBREVIATIONS

AM	Amplitude Modulation
AVRGCC	AVR-GNU Compiler Collection
AVR RISC	AVR Reduced Instruction Set Computer
COM	Serial Communication port
CPU	Central Processor Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
GUI	Graphical User Interface
IF	Intermediate Frequency
ISP	In-Circuit Serial Programmable
LED	Light Emitting Diode
MHz	Megahertz
OS	Operating System
OSI	Open System Interconnection
PC	Personal Computer
PCB	Printed Circuit Board
RF	Radio Frequency
RT-OS	Real Time Operating System
RX	Receiver
SRAM	Static Random Access Memory
TCP/IP	Transmission Control Protocol/ Internet protocol
TX	Transmitter
USART	Universal Synchronous Asynchronous Receiver Transmitter
VB	Visual Basic
WSN	Wireless Sensor Network

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Water sensor system is another application of Wireless Sensor Network (WSN). This system enable user to monitor four increment of water level remotely at PC or LEDs on receiver board. For a prototype, this project only develops two nodes which are transmitter node and receiver node. Transmitter node consists of water sensor board connected to processing board (contain microcontroller and RF module). Meanwhile, at the receiver end, there are processing board (contain microcontroller and RF module) connected to the computer.

The nonstandard communication protocol was implemented in the system. The error detection codes and addresses are attached to the data before transmitted. This application is using radio signal with frequency of 433MHz to transmit data wirelessly to the receiver. The type of communication implemented in the system is simplex communication where transmitter node continuously sends data to receiver without waiting for acknowledgement. While, at the other end a receiver is ready to receive data from transmitter.

Water sensor system is suitable to be used as an early warning system to detect flood. The sensor node is suitable to be setup near the river banks or drain to sense the increment of the water while the receiver node can be install at the resident house or police station so that whenever water exceed the critical level, police can alarm resident low lying area to be prepared.

1.1 Problem Statement

Malaysia is a tropical country. Generally, the country is frequently hits by heavy rain all year around cause by north- east monsoon and south-west monsoon which later lead to floods. Usually major floods occur at the east coast and north side of the country during the north-east monsoon.

However, nowadays the scenario is slightly different where flood can happened anytime and anywhere whenever heavy rains occur. Flash-flood is a new type of flood that strike urban area like Johor Bharu and Kuala Lumpur in a very short period. Without any warning, this catastrophic may cause a lot of negative impact such as damaged properties, public utilities, cultivation, loss of lives and also caused hindrance to social and economic activities. Average annual flood damage is reported as high as RM100 millions [3].

Figure 1.1 Flash Flood that strike Kuala Lumpur

The government of Malaysia has developed many strategies to reduce the impact and the negative effect of the floods. The floods control strategies include construction of multi purpose dam, properly plan and designed the urban drainage system, river bed deepening and widening, etc. The development of all above strategies is very costly and will take longer time to be finished. Therefore, at a mean time, flood forecasting and warning system is being considered as the most effective non-structural measure to minimize the losses of properties and human lives due to floods.

As mention before, water sensor system can be implement for this purpose. Beside it low costs, this system is also easy to be installed and maintained in a very short time.

1.2 Project Objectives

The objectives of this project include:

- To develop receiver node that will receive data from the sensor node using wireless transmission and processing.
- To implement nonstandard protocol for communication between sensor and receiver node at data link and physical layer.
- To display the level of the water level using LED on receiver board
- To monitor the changes of water level remotely on computer in a very small time interval.

1.3 Scope of Works

The works involve in this project includes Hardware and Software development. This project will developed receiver node using ATmega8535 as processor and RF receiver module with frequency range 433MHz as communication device. Since the computer will be used to display the data value, an interface circuit between receiver node and computer need to be built (RS-232 circuit).In addition; ISP cable is developed as a utility to load the hex file to the microcontroller.

The most important element of wireless sensor system is communication between nodes and data processing. This function can be implemented on the nodes through programming. Software developments involve some programmings which enable the receiver node to perform tasks such as receive data frame from transmitter, check header, address and checksum, extract data from the frame, display on LED and send data to the PC. Graphical User Interface is also developed as additional feature to the system. All programming are written in C language accept for GUI which written in Visual Basic 6.0.

CHAPTER 2

LITERATURE REVIEWS

There are many relevant and similar projects on wireless sensor system. In this section the discussion will be made on the wireless sensor network (WSN), OSI network modeling and OOK amplitude modulation scheme which are relevant to the project.

2.1 Introduction to Wireless Sensor Network

The advances in science and technology are deeply intertwined. This has lead to next evolutionary development of wireless sensor network application in building, utilities, industrial, and home, shipboard and transportation systems automation. The concept of wireless sensor networks is based on a simple equation:

Sensing + CPU + Radio = Thousands of potential applications

As soon as people understand the capabilities of a wireless sensor network, hundreds of applications spring to mind. It is a straightforward combination of modern technology [4].

The most important element in the WSN is sensory data from the real word. Sensory data comes from multiple sensors of different modalities in distributed locations. The application of WSN can divided into three classes which are environmental data collection, security monitoring, and sensor node tracking [4]. The majority of wireless sensor network application will fall into one of these classes.

The environment data collection is normally use by research scientist to collect several sensor readings from a set of points in an environment over a period of time in order to detect trends and interdependencies. The data need to be collect for analyzing is usually from hundreds of points spread throughout the area. Examples of environment sensory data are habitat monitoring, humidity, temperature, etc. The application of Water sensor system lies in this class.

The second class of sensor network application is security monitoring which composed of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect any variance. A main difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data. Each node has to frequently check the status of its sensors then transmit a data report when there is a security violation. Therefore, the latency of the data communication across the network to the base station has a critical impact on application performance [4].

A third class is the tracking of a tagged object through a region of space monitored by a sensor network. Example of applications include as distance sensor, velocity sensor, object tracking etc. Unlike sensing or security networks, node tracking applications will continually have topology changes as nodes move through the network. [4].

The second element of wireless sensor system is CPU. The purposes of CPU are for data processing and perform standard communication protocol. The TCP/IP, point to point or other non-standard protocol may be embedded into the processor to make the communication possible between nodes

The concept of wireless sensor system is to monitor the sensory data remotely from the actual observable area. Therefore, the radio frequency communication is required for data transmission in long range distance.

2.1 Network Modeling

The communication protocol is the key element in data transmission for Wireless Sensor System. It is the set of rules governing the exchange of data between 2 entities. It is used for communication between entities in the system [1]. In communication system, the task is broken up into modules. The services offered by the modules are grouped into layers where each layer provide/used service to/ provide by other layers. There are two types of standard layering model in data communication which are TCP/IP and OSI Model.

Open System Interconnection (OSI) model is a set of protocols that attempt to define and standardize the data communications process. The OSI model is set by the International Standards Organization (ISO). The OSI model has the support of most major computer and network vendors, many large customers, and most governments, including the United States [Definition of OSI Model from Wikipedia].

The concept is to describe how data communications should take place. It divides the process into seven groups, called layers. The layers in the OSI model are physical, data link, network, transport, session presentation and application. Each layer performs a related subset of the function required to communicate with another system (refer to figure 2.1). It relies on the next lower layer to perform more primitive functions and to conceal the details of those layers [1]. Each layer also provides service to the next higher layer. The function of each layer is well defined therefore any changes in one layer will not required changes in any other layer.

Application Provide access to the OSI environment for user and also provides distributed information services
Presentation Provide independence to the application process from difference in data representation (syntax)
Session Provide the control structure for communication between applications; establish, manage, terminate the connection between cooperating systems
Transport Provide reliable transparent transfer of data between end points; provide end to end error recovery and flow control
Network Provide upper layers with independence from the data transmission and switching technologies used to connect system; responsible for establishing, maintaining, and terminating connections.
Data Link Provide for the reliable transfer of information across the physical link; sends blocks (frame) with necessary synchronization, error control and flow control
Physical Concern with transmission of unstructured bit stream over physical medium; deals with mechanical, electrical, functional, and procedural characteristics to access the physical medium

Figure 2.1 The OSI layer

Water sensor system only deploys the two bottom layer of the model which is data link and physical. The non- standard protocol is implemented for the system for communication. The main task of the data link layer for this project is to take a raw transmission facility and transform it into a line that appears free of transmission errors in the network layer. The task is accomplished by input the data into data frames, insert the error detection sequence bit, and transmit the frames sequentially. Since the physical layer merely accepts and transmits a stream of bits without any regard to meaning of structure, it is up to the data link layer to create and recognize frame boundaries. This can be accomplished by attaching special bit patterns to the beginning and end of the frame.

On the other hand, the service offered by physical layer is to provide the electrical and mechanical interface to the network medium (wireless link). This layer gives the data-link layer (layer 2) its ability to transport a stream of serial data bits between two nodes in the system; it conveys the bits that move along the link. It is also responsible for making sure that the raw bits get from one place to another, by modulation technique, and deals with the electrical and mechanical characteristics of the wireless link such as frequency used, type of modulation, communication device, etc.

2.2 Introduction to Wireless and RF Communication System

The area of wireless communication is fairly broad especially in technological research and development. It is deal with transmitting data via some form of air waves. Wireless communication can de defined as any transfer of data from one point to another using no wires. Radios, cell phones, satellite TVs, and remote controls are just a few of the many technologies currently being used and developed in the area of wireless communication.

The Water Sensor System use Amplitude Modulation scheme to transmit data wirelessly to the receiver. It works by varying the strength of the transmitted signal in relation to the information being sent. Hence the amplitude demodulator is used at the receiver end to converse back the AM signal into digital output. Receiver node in system is using super heterodyne receiver.

The super heterodyne principle, as used in radio receivers, allows certain obstacles in high-performance radio design to be overcome [5]. All signal frequencies are converted typically to a constant lower frequency before detection. This constant frequency is called the intermediate frequency, or IF. In typical AM (Medium Wave) home receivers, that frequency is 455 kHz, for FM VHF receivers, it is usually 10.7 MHz.

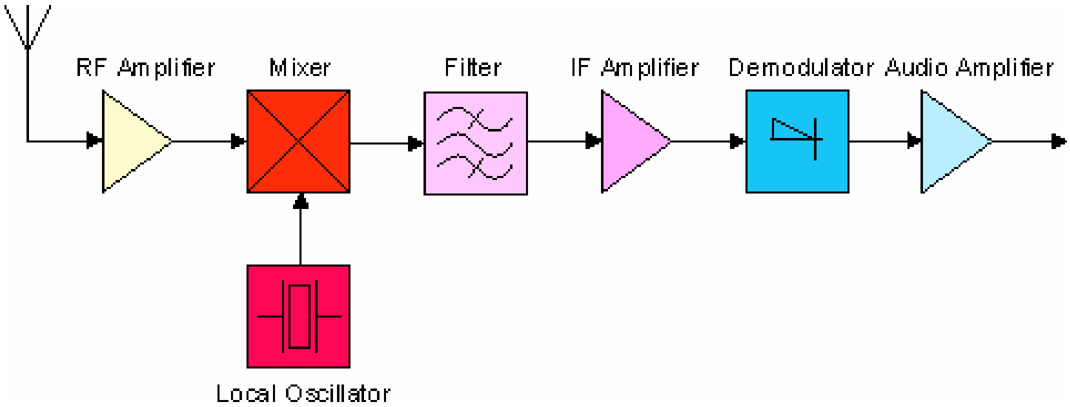


Figure 2.2 Block Diagram of Superheterodyne Receiver

Heterodyne receivers "beat" or heterodyne a frequency from a local oscillator (within the receiver) with all the incoming signals. In mixer, the local oscillator signal will multiplies with the incoming signal, producing beat frequencies both above and below the incoming signal. The mixer stage produces outputs at both the sum of the two input frequencies and at the difference. Either the higher or the lower (typically) is chosen as the IF, which is amplified and then demodulated [5].

The advantage of Superheterodyne receiver is that most of the radio's signal path has to be sensitive to only a narrow range of frequencies. Only the front end (the part before the frequency converter stage) needs to be sensitive to a wide frequency range. For example, the front end might need to be sensitive to 30 MHz, while the rest of the radio might need to be sensitive only to 455 kHz, a typical IF frequency. Other than that it also has superior characteristics to simpler receiver types in frequency stability and selectivity [5].

CHAPTER 3

RECEIVER NODE DEVELOPMENT

3.1 Introduction

The purpose of water sensor system is to sense the increment of water remotely at distance. In order to do so, block diagram for the whole system is developed and the function for each block is clarified. Figure 3.1 shows the block diagram of the overall system. For this project, water sensor can only sense four increment of the water level. Then, this level is send to the microcontroller at transmitter board for processing. The processor of transmitter end will process the data by creating a data frame to be transmitted to the receiver node through USART. This data frame represent in form of digital signal (0 and 1). In order to be transmitted wirelessly, the data must be transformed into analog signal. RF Module will modulate the data to analog signal using Amplitude modulation. Afterwards, this signal will be

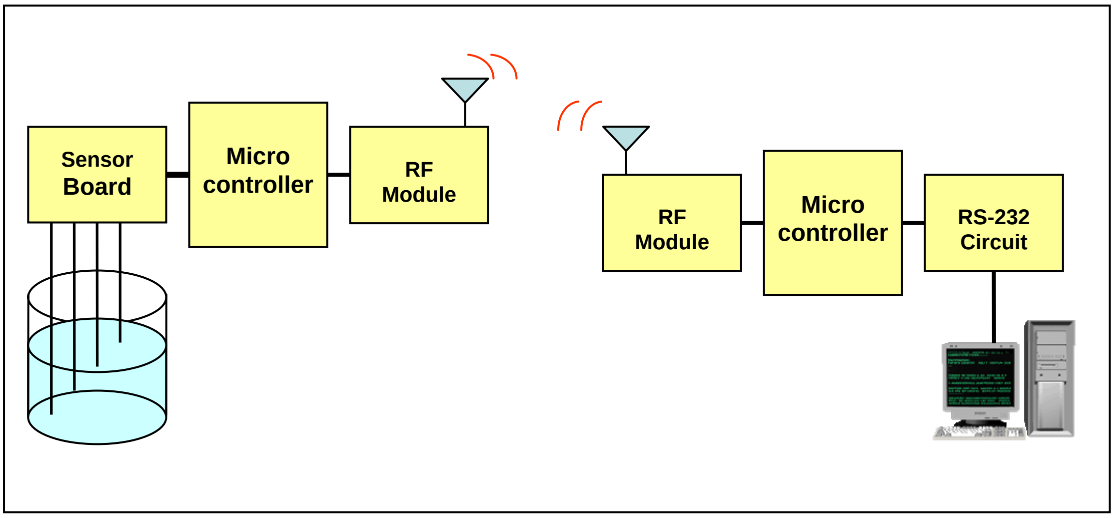


Figure 3.1 Block Diagram of Water sensors System

At the receiver end, RF Module will capture the signal and demodulate into the original data. This data then will be passed to the microcontroller for further process. The process that involve in receiver includes checking whether the data is free from error then send to the PC and display on LED. If the data contained any error, the data will be discarded and alert user through PC. Whenever the water exceeds the forth level, an alarm will be on.

The thesis describes in details the methodology that is used to develop the receiver node in term of hardware and software. The development processes are based on the objective of the project which is to produce receiver node that has an ability to receive data, do some processing and display on LEDs and Computer. Figure 3.2 has shown the works flow in developing the hardware and the software of receiver node. It start by choosing the right component to used for node’s processor, RF module and other components that will used to indicate the water level such as LEDs and Buzzer. The receiver node block diagram was constructed to simplify the schematic drawing. After finished designing the schematic, the hardware was implemented. This hardware will encounter several tests to ensure the reliability of the system

The nonstandard protocol that will be embedded to the system is clarified. Software developments mostly concentrate in codes writing. Then those programs is burned and run test. The programming and correction is continued until successful result is obtained.

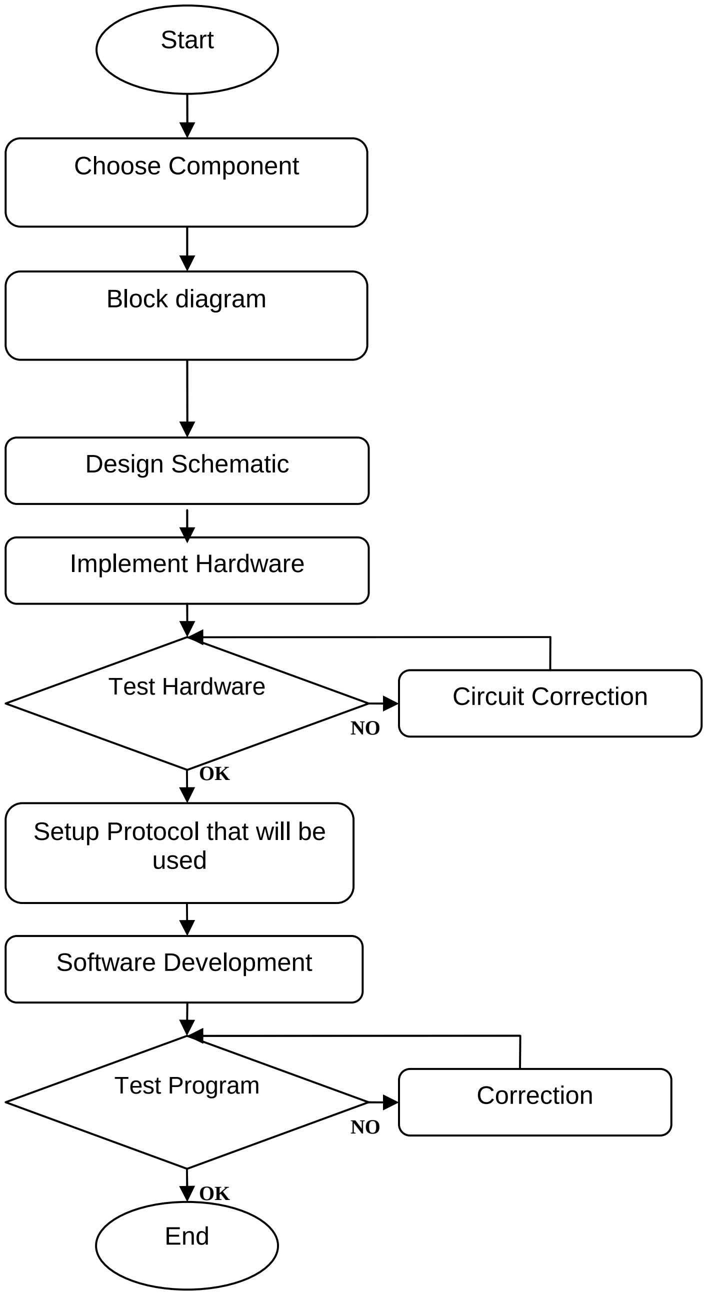


Figure 3.2 Flow chart of developing the receiver node.

3.1 Hardware Development

Choosing components are very important element in implementing the hardware for every system. The components are chosen based on the function and suitability for the system. The components used for the receiver node are AVR Microcontroller (ATmega8535), RF receiver module with 433MHz operating frequency, and RS-232 Interface Circuit.

Figure 3.3 shows the block diagram of the receiver node.ATmega8535 has four I/O ports. Port A is connected to the LEDs and Buzzer. Port B is connected to ISP cable for uploading the hex file. While RF receiver module and RS-232 are connected to the Rx and Tx pin respectively at Port C.

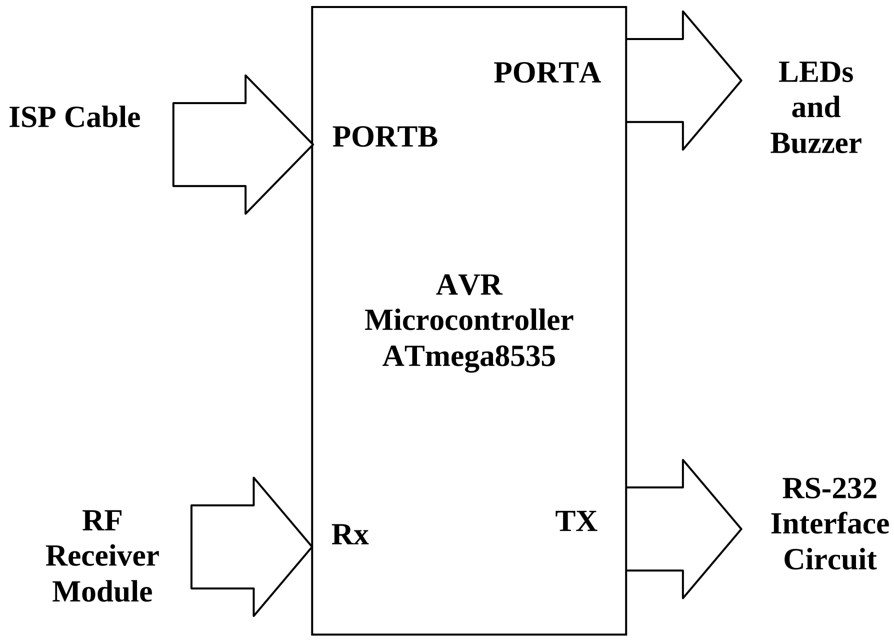


Figure 3.3 Block Diagram for Receiver node

3.1.1 Processor

Microcontroller plays important role in water sensor system. It is the main unit of the node device. Basically all programs will be run in this unit. Microcontroller responsible for receiving data and check whether the data is free from error. Other than that, it also responsible to on and off the LEDs according to the data and pass to the PC.

Choosing a microcontroller is very important. Nowadays, there are many types of microcontroller available in the market such as PIC from microchip, microcontroller from Motorola, Intel, Rabbit 2000 and etc. In Wireless Sensor System, power consumption and memory utilization is the significant element when deciding the right processor [7].

Many WSN applications used 8-bit AVR RISC microcontroller as it processor. ATmega8535 is one of the AVR- microcontroller families with 8K bytes Flash Memory. It also has 512 bytes EEPROM, 512 bytes SRAM, 32 I/O line, and six sleep mode and can operate in 4.5 to 5.5 Volts. This microcontroller is very suitable to be used for embedded system.

3.1.2 RF Module

The data that is send from transmitter node is not critical like sending the text message or picture or video file where the data must be accurate and error free. If those data are spoiled, retransmission will be needed. However for this application the data send to receiver end is fixed to only five values which are below level 1, level 1, level 2, level 3 and level 4 of the water. Therefore the type of communication that is suitable to be implemented for water sensor system is simplex communication. This type of communication is where transmitter node will continuously send data to the receiver without any concern whether the data is safely received at the receiver node.

On the other hand, the receiver accepts data without sending any response to the transmitter.

Hence, in this project, RF transmitter and receiver module is use to transfer data from sensor node to receiver node wirelessly. Both RF modules are operating in free licensed frequency which is 433MHz. The modulation scheme use for the system is OOK-AM modulation. The receiver uses Superheterodyne receiver. The maximum distance that can be implemented for the system is 100 meter. While the operating voltage range for the receiver module is 4.5 to 5.5 Volts. Therefore, this module is compatible to be connected directly to the AVR Microcontroller.

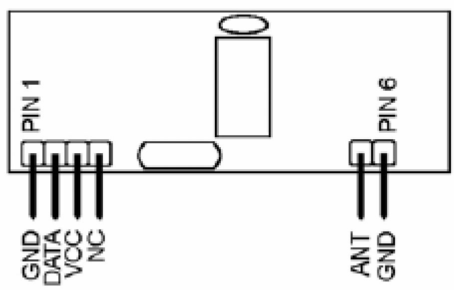


Figure 3.4 Pin Connection of RF Receiver Module

3.1.3 Circuit Designed

The circuit is designed based on the block diagram. Figure 3.5 shows the schematic for Receiver Node. The microcontroller used 8 MHz external crystal oscillator. Since the voltage range of ATmega 8535 is 4.5Volts to 5.5Volts. Therefore the circuit cannot get direct supply from the Battery. In order to avoid any harm to the microcontroller, Voltage Regulator is used to step down the voltage to appropriate value.

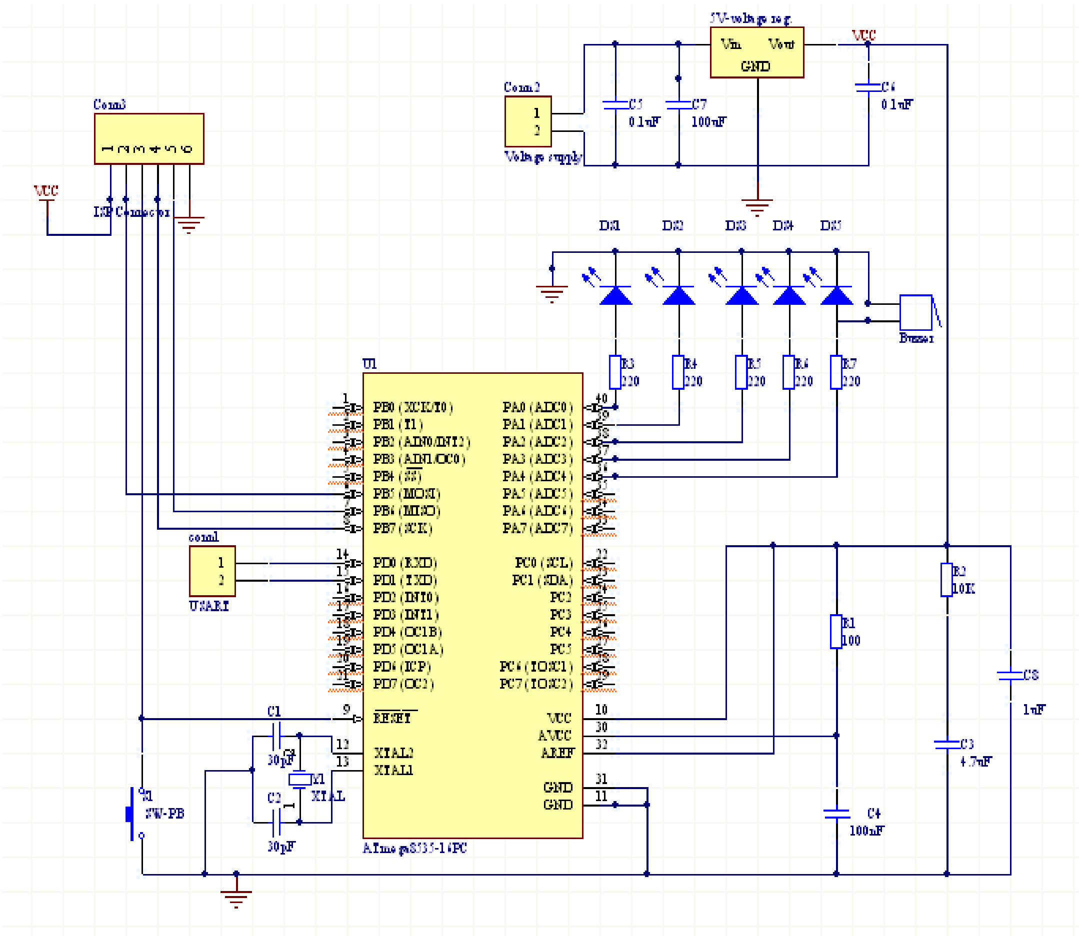


Figure 3.5 Receiver Node Schematic diagram

PortA0 until PortA4 of microcontroller is connected to the LED which indicates the level of the water. LED0 specify water below all level. While LED1 for level 1, LED2 for level 2 and so on. PORTA4 is also connected to the Buzzer so that when the water level exceeds level 4 the LED 4 and the buzzer will on. The circuit was implemented using the strip board (figure 3.6)

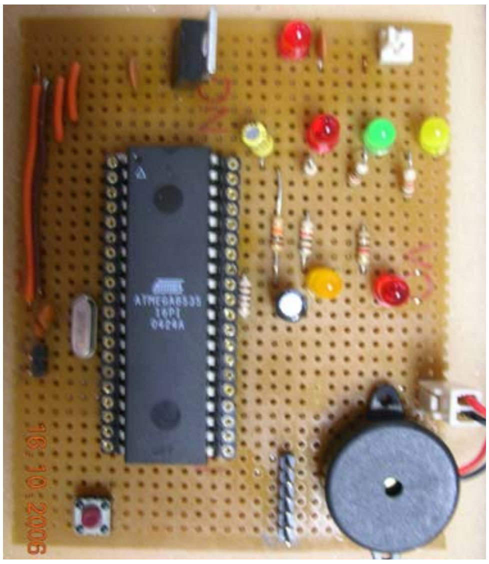


Figure 3.6 Receiver Node Prototypes (Finishing Product)

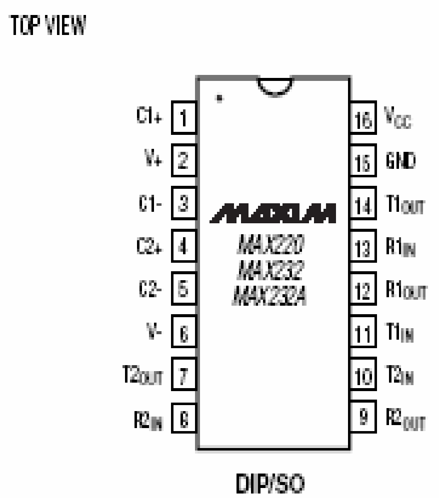
3.1.4 Additional Tools

Additional tools needed to be developed for supporting the system application. Those tools include RS-232 Circuit and ISP Cable.

3.1.4.1 RS-232 Circuit

The receiver node is connected to the PC for displaying purpose. The data is sent in serial due to its simplicity and low hardware overhead compared to parallel communication. Rs-232 is an IEA/TIA-232-E specification standard for serial binary data interconnection between a DTE Data Terminal Equipment and DCE [Definition of RS-232 from Wikipedia]. Unlike many standards, RS-232 specifies electrical, functional and mechanical characteristic of three criteria which are common voltage and signal levels, common pin-wiring configurations and a minimal amount of control information between the host and peripheral systems.

RS-232 connector was originally developed to use 25 pins. The original MAX232 Driver/Receiver and its related parts simply doubled and inverted the input voltage to supply the RS-232 driver circuitry. This design enabled much more voltage than actually required; it wasted power. The EIA-232 levels are defined as ±5V into 5k. With a new low-dropout output stage, Maxim introduced RS-232 transceivers with internal charge pumps that provided regulated ±5.5V outputs. This design allows the transmitter outputs to maintain RS-232-compatible levels with a minimum amount of supply current [8]. MAX232 has two TTL/CMOS inputs, RS-232 inputs, two TTL/CMOS outputs and RS-232 outputs (figure 3.7). One of the TTL/CMOS input (pin 10 or 11) is connected to the Rx pin of AVR microcontroller. While one of the RS232 input and output is connected to the RS232 connector (refer to figure 3.8). Four 1uF capacitances are required to be connected (table in figure 3.7). The overall schematic is shown in figure 3.8. This circuit is then implemented using strip board (figure3.9)



CAPACITANCE (μF)					
DEVICE	C1	C2	C3	C4	C5
MAX220	4.7	4.7	10	10	4.7
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1

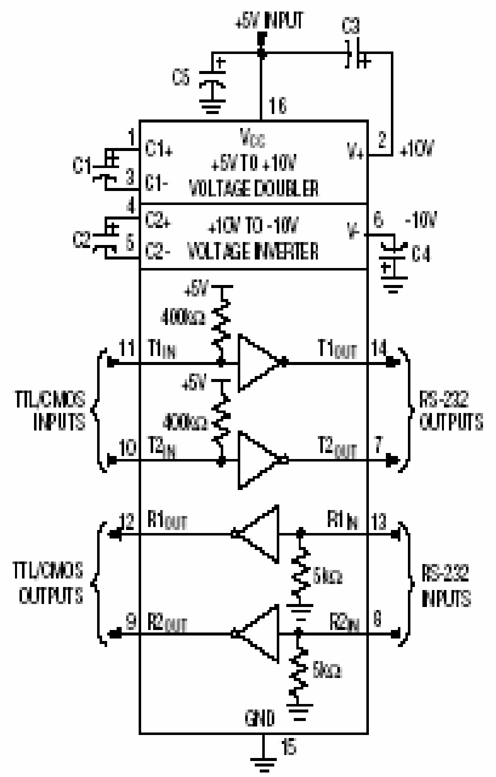


Figure 3.7 Pin Configuration and Block Diagram of Max232

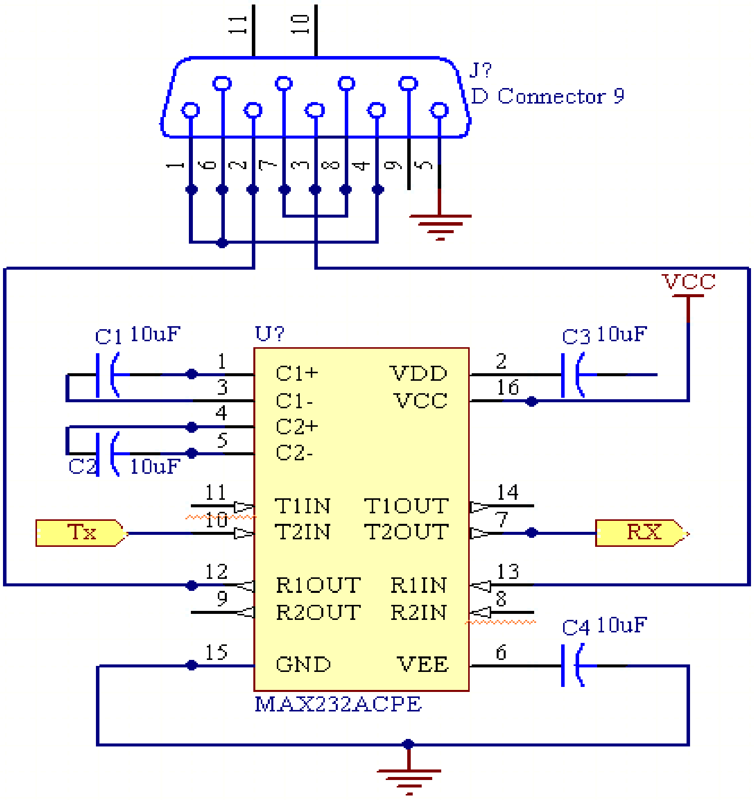


Figure 3.8 RS-232 Schematic

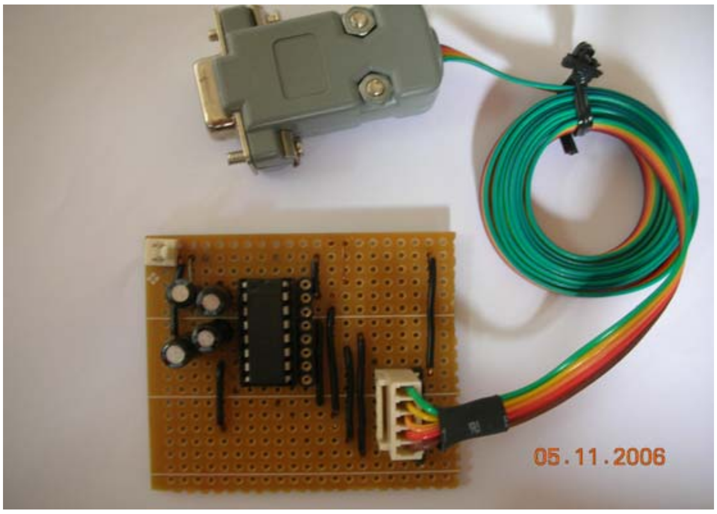


Figure 3.9 RS-232 Interface Cable

3.1.4.2 ISP (In-System Programmer) Cable

One of the advantages using AVR microcontroller the available software package called the Atmel AVRISP. This software enable user to upload the source code into microcontroller directly on board. Figure 3.10 show the ISP cable developed using donut board.

Figure 3.10 ISP Cable

There are many types of AVRISP schematic diagrams available in the Internet. However, figure 3.11 shows the simplest ISP schematic that used for this project. This ISP cable is suitable for ATmega8535. 74LS245 is an octal tristate buffer which used to provide the float state after the hex code has been written into the AVR chip. Using LED is for indicating the PC start up and code is written into the chip.

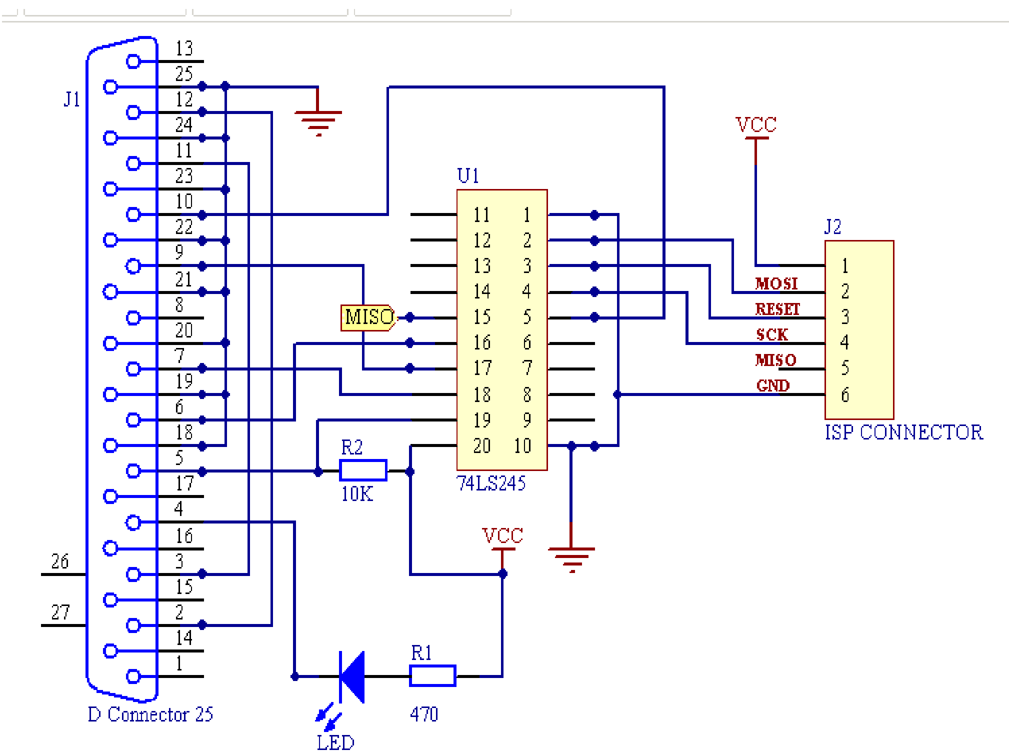


Figure 3.11 ISP Schematic

There are four signals from AVR microcontroller need to be connected which are MOSI, MISO, SCK and RESET. MISO/MOSI pins are used for all the CPUs except ATmega103 which uses TXD/RXD pin instead [Warsuzarina Binti Mat Jubadi; Nov, 2005]. Table 3.1 has shown the function of ISP Connector Pin Header.

Table 3.1 Function of ISP Connector Pin Header

Name	Function	Description
MOSI	Master Out- Slave In	Data being transmitted to the part being programmed is sent on this pin
RESET	Target MCU Reset	Connect to target AVR. Target AVR is programmed while in Reset State.
SCK	Shift Clock	Serial Clock generated by the Programmer
MISO	Master In Slave Out	Data received from the part being programmed is sent on this pin
VCC	ISP Power	5Volts Power supply for ISP. ISP header must supply power to the dongle
GND	Ground	Common Ground

3.2 Software Development

Software development is referring to development process in embedded the application into the microcontroller and writing codes to display the data on the computer. Figure 3.12 shows the flow chart of software development. All source code was developed in C language except for GUI.

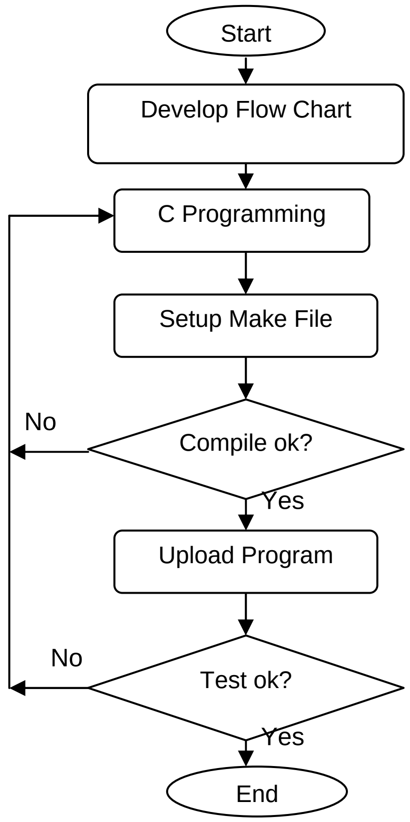


Figure 3.12 Flow of Software development

C code is the high- level programming language which is easy to understand and suitable for many systems-programming applications that had traditionally been implemented in assembly language. The design goal are it could be compiled in a straightforward manner using a relatively simple compiler, provide low-level access to memory, generate only a few machine language instructions for each of its core language elements, and not require extensive run-time support [9]. The language can be used widely from embedded microcontrollers to supercomputers.

The source code is composed of the flow chart of the system. Then those code need to be verified and compiled which can be download from ATMEL distributor websites or others. AVR-GCC is one of the compiler which available in DOS and Windows version. Others compiler existed such as WINAVR, AVRLib, CodeVision AVR and etc. Next, the hex file produce is uploaded into the microcontroller. The application is considered success when the target device works according to the plan.

3.2.1 Software Tools

There are many software tools needed to support the development of water sensor system starting from writing the source code to upload the hex file to the microcontroller. Those soft wares are free and can be downloaded from internet accept for software to develop GUI. The soft wares that utilized in this project includes Programmer Notepad (WINAVR), PONY PROG and Microsoft Visual Basic 6.0

3.2.1.1 Programmer Notepad (WINAVR)

Programmer Notepad (WINAVAR) is an open source window based platform to write the source code for the ATMEL series of RICS microcontroller. It is operate in user-friendly environment which make the application easy to use. The WINAVR are supported only in DOS command line platform [10]. The user needs to setup the Makefile before compiling the program. Figure 3.13 shows the programmer Notepad window in WINAVR. The most right window is the source codes while the left window is output file generated after compiling the program.

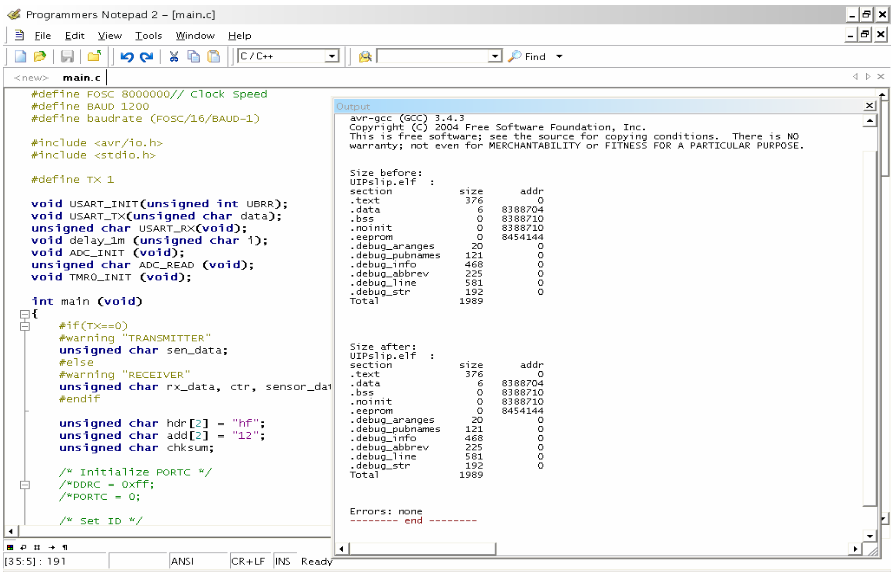


Figure 3.13 Window of Programmer Notepad (WINAVR)

The development tools for WINAVR includes the GNU GCC compiler for C and C++, Assembler, Linker, Librarian, File Converter, other file utilities, C Library, Programmer software, Debugger, In- circuit Emulator software, Editor/IDE, and others support utilities. The compiler provided by this software is flexible and can be hosted on many platforms where it can target many different processor or operating systems (back-end), and can be configured in different languages (front-end).This features is ideal for execute the User's Makefile which in turn calls the compiler, linker and other utilities used to develop software. Programmer Notepad then will capture the output and display on window. If there is any error, user can simply clicked on the error or warning and programmer notepad will automatically open file and go to the error or warning line of the program.

3.2.1.2 PonyProg2000

After the source code is successfully compiled, the next step is to upload the program to the AVR microcontroller. As mention earlier, AVR family allow programmer to upload the source code directly to the microcontroller (on board). Hence, this facility can be done by using AVRISP cable with PonyProg2000 software. PonyProg is serial device programmer software with a user friendly GUI framework available for Windows95, 98, 2000 & NT and Intel Linux. Its purpose is reading and writing every serial device. At the moment it supports I^2C Bus, Microwire, SPI eeprom, the Atmel AVR and PIC micro[11].

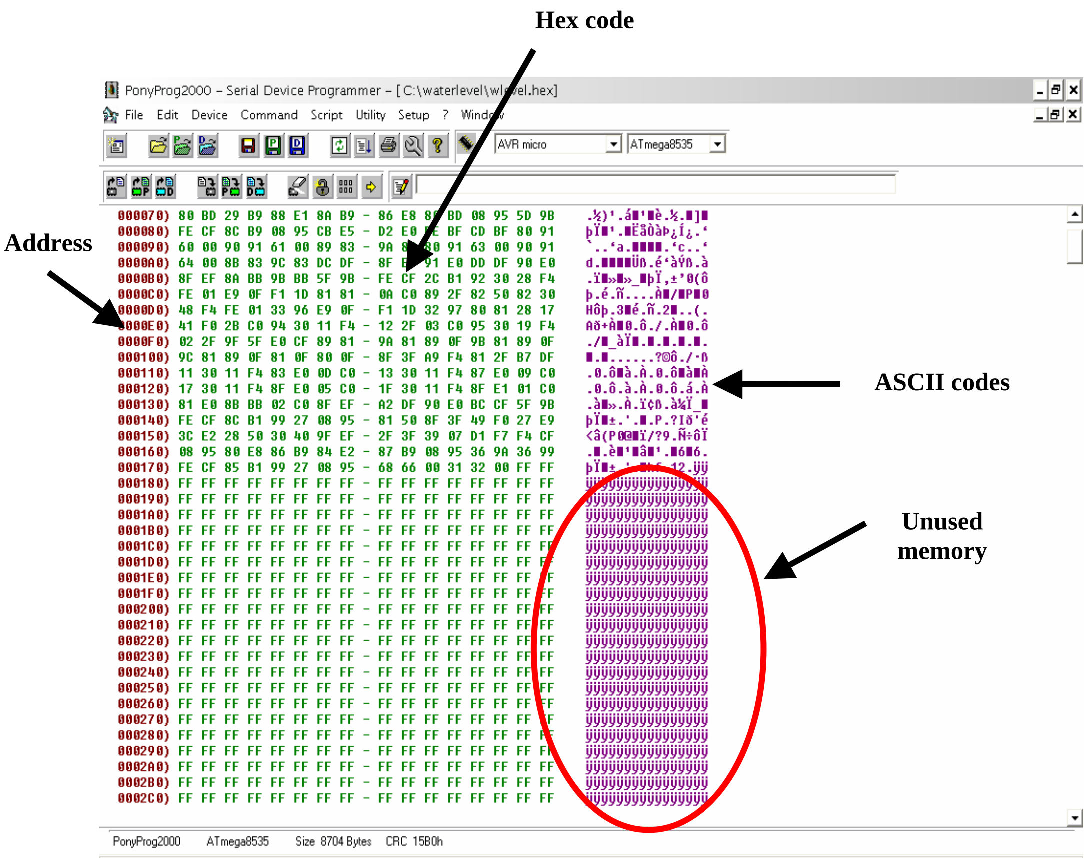


Figure 3.14 PonyProg2000 Window Application

Figure 3.14 shows the machine codes (hex file) resulting from compiling the source code. Some configuration need to be done before using the software to uploading the codes. At the beginning, user need to setup the interface by specify the connector used (serial or parallel) between microcontroller and PC. Next, calibrate the bus timing, define the device used (e.g. ATmega8535, PIC16xx83, etc) and setup the configuration and security bits. Then, the hex file is opened and programmed to the target device. The hex file consist of memory address, machine code presented in the form of hexadecimal and ASCII. PonyProg also verify filled”0XFF” in the unused memory.

3.2.1.3 Microsoft Visual Basic 6.0

Visual Basic (VB) is an event driven programming language and associated development environment from Microsoft. The language is rather very simple and easy to understand where the codes are written using simple English-like words and syntax. Its not only allows programmers to easily create simple GUI applications, but also has the flexibility to develop fairly complex applications [Definition of Visual Basic from Wikipedia].

Programming in VB is a combination of visually arranging components or controls on a form, specifying attributes and actions of those components, and writing additional lines of code for more functionality. Since default attributes and actions are defined for the components, a simple program can be created without the programmer having to write many lines of code [12].

3.2.2 Main Program

Generally, there are three significant tasks need to be performed by receiver node which are receive data from transmitter, error detection and display.

The flowchart is constructed based on the task before writing the codes. This is important in order to ease the code writing and can ensure that the program is not away from main system application.

Refer to the figure 3.15; the program starts with initializing the USART interrupt function. Those codes can be found in the ATmega8535 Datasheet. Water Sensor System use Serial Communication to transfer between two microcontrollers and PC. The sensor data is sent in a form of frame as shown in figure 3.16. Header is used for frame synchronization. When receiver node receives first 2bytes data, it will check whether it is a header or not.

Then it will obtain the next coming data if the header is found.

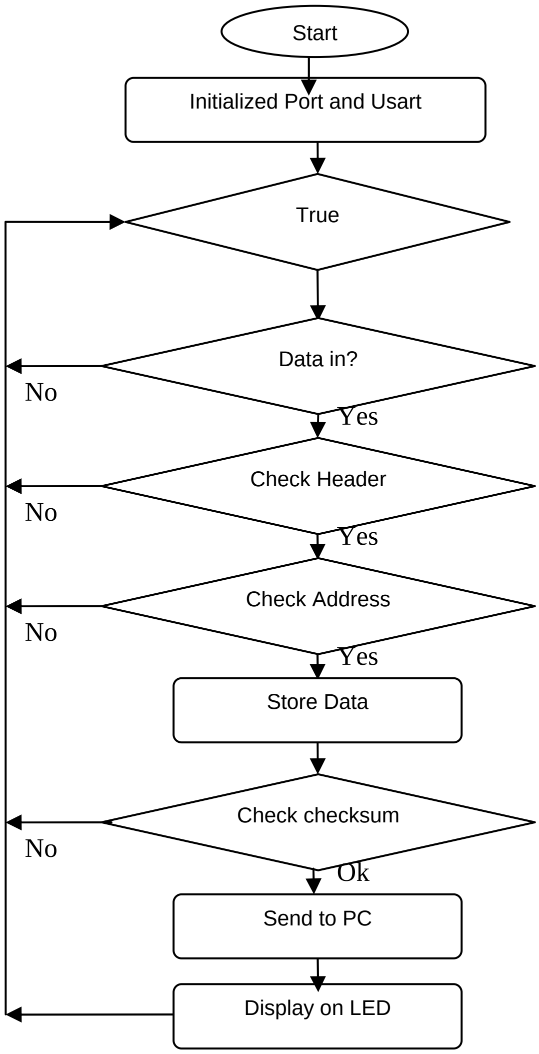


Figure 3.15 Flowchart for Receiver Node

Header	Address	Data	Checksum
2 Bytes	2Bytes	1Byte	1Bytes

Figure 3.16 Frame Format

The second element in the frame is Address. It indicates the receiver port name. Since this project only have two nodes with one sensor application. Therefore the source port address will be less important.

However, for many nodes and sensor application, the source address will be significant to differentiate which sensor and node are the data refer to.

Error detection is another important aspect in data communication. Wireless system application are likely interferes by noise. Regardless of the transmission system designed, there will be errors, resulting in the change of one or more bits in a transmitted frame. There are two types of error detection scheme existed in data communication. The simplest approach is Parity check where parity bit is appended to the end of the block of data. However when there are two or any even number of bits are inverted due to error, an undetected error occurs [1].

Another most common and powerful method is the Cyclic Redundancy Check (CRC). For a *k*-bit block of bits or message, the transmitter will generate a (*n*-*k*)-bit sequence known as a frame check sequence (FCS) which is used later for receiver to detect error. Nevertheless, this error detection scheme require complex program to be implemented.

The easiest way to employ error detection which is used in Water Sensor System is Checksum. It is an error- detecting code based on a summation operation performed on the bits to be check. The formula to generate Checksum Code is:

Checksum = ~ (Header1 + Header2 +Address1 + Address2 + Data)

This sequence code is then will be add up to the frame and transmit to the other end. At the receiver, some calculation will be made to detect error. Processor will Sum up all bytes including the Checksum value. For free- error transmission, the expected summation result should be 0x1FF. If there is an error occurs, the data will be discarded. Figure below shows the flowchart for error detection

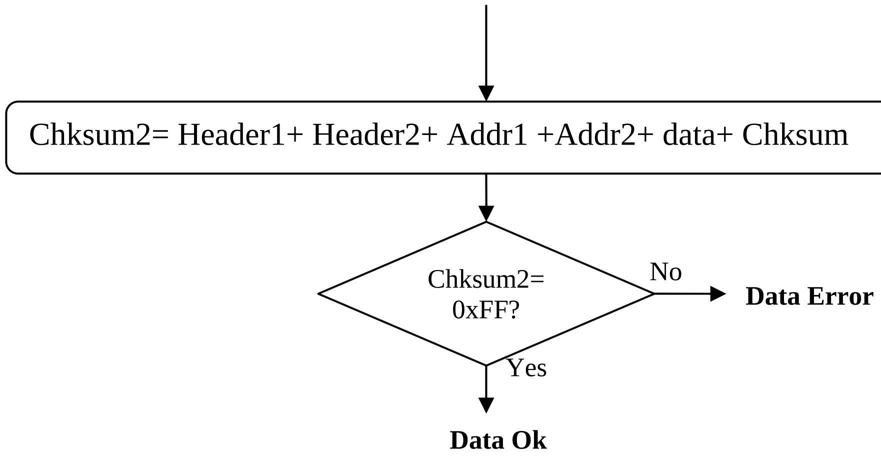


Figure 3.17 Flow chart to detect error at Receiver End

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3.2.3 Graphical User Interface

GUI is used to display the water level at computer. It was developed using Microsoft visual Basic 6.0. This software provide user friendly-environment platform which simplify the development process.

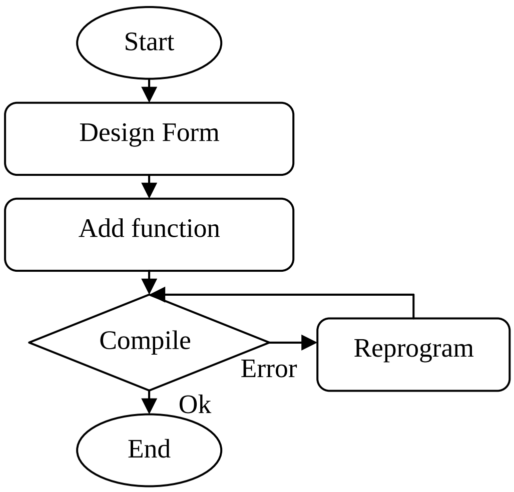


Figure 3.18 Flowchart for GUI development

Figure 3.18 shows the flow processes of developing the GUI. First step, the form is designed accordingly to the need of the system as shown in figure 3.20. It is created using drag and drop techniques. A tool is used to place controls (e.g., text boxes, buttons, etc.) on the window form (refer to figure 3.18). Controls used for this GUI are labels; frame, Mscomm and timer. All controls have attributes and event handlers associated with them. The values provided for each control is changed to the suitable value (e.g. high, width, font, background color, caption, etc).This value can be changed at the window properties (figure 3.18) The main control in the GUI is Mscomm which allowed the reading function from PC com port. The control timer is used to generate the current time when the application is run. There are nine labels on the window form. One label used to display message indicating the water level, three of the label is used to display day, date and time and others for animated graph.

Afterward, function is added for each of the control component on the window form through coding. Since VB 6.0 is widely used software, hence the source code for certain functions are available from Internet. However some modification need to be done depend on application. The program for this GUI is presented in the Appendix-Next, the source codes are compiled. Whenever error occurs, Visual basic will automatically highlight the line in the program which contained error.

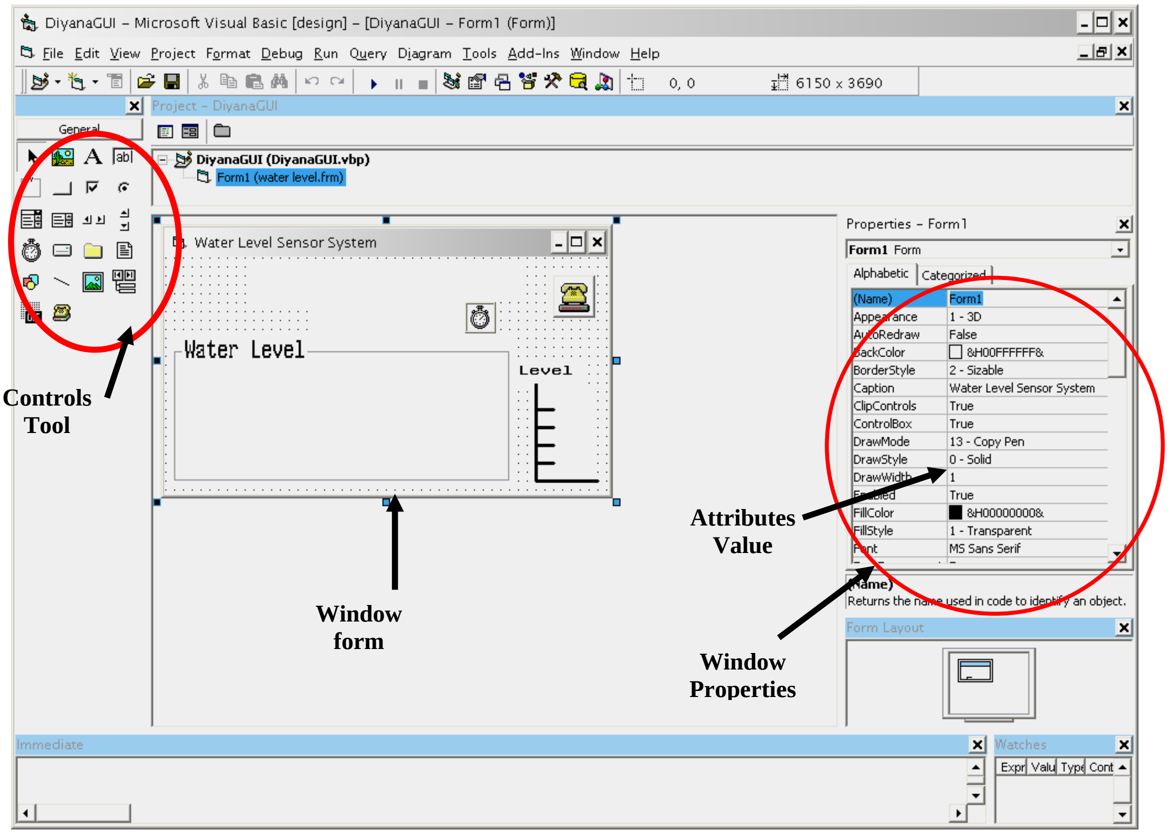


Figure 3.19 Visual Basic 6.0 window environment

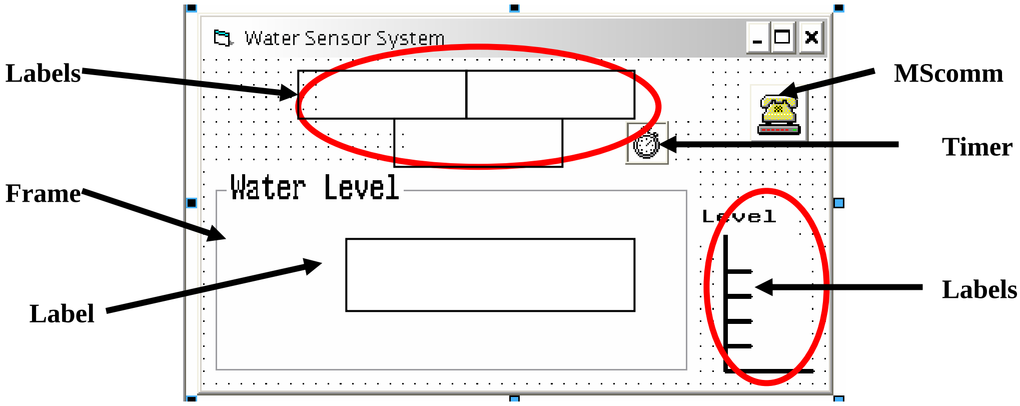


Figure 3.20 Form designed for Water Sensor System

CHAPTER 4

RESULTS AND ANALYSIS

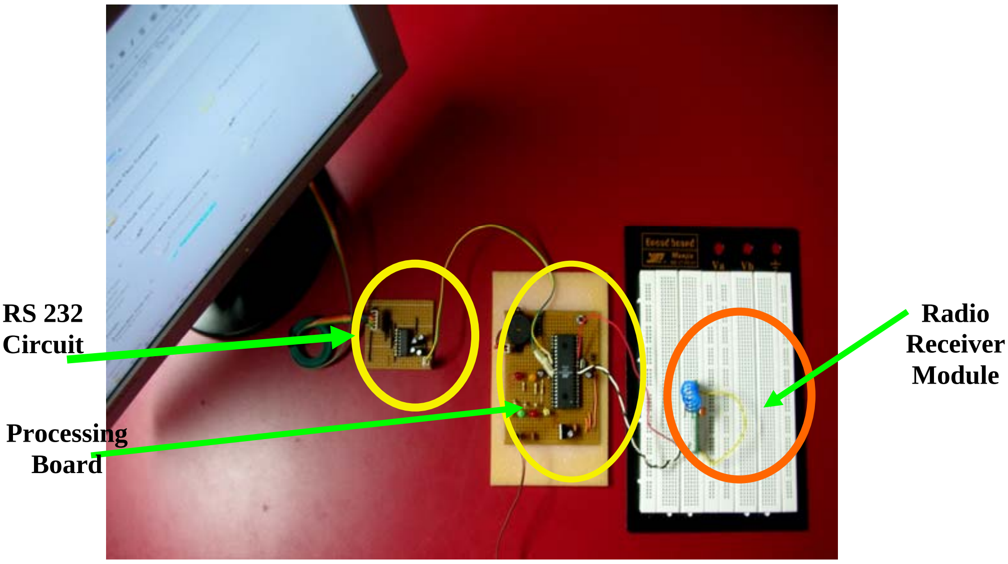
4.1 Overview

This chapter analyses the simulation result attained for overall system. The performance of data transmission between nodes for both wired and wireless transmission is compared. The result are taken from the Oscilloscope, USART terminal and GUI Interfaced.

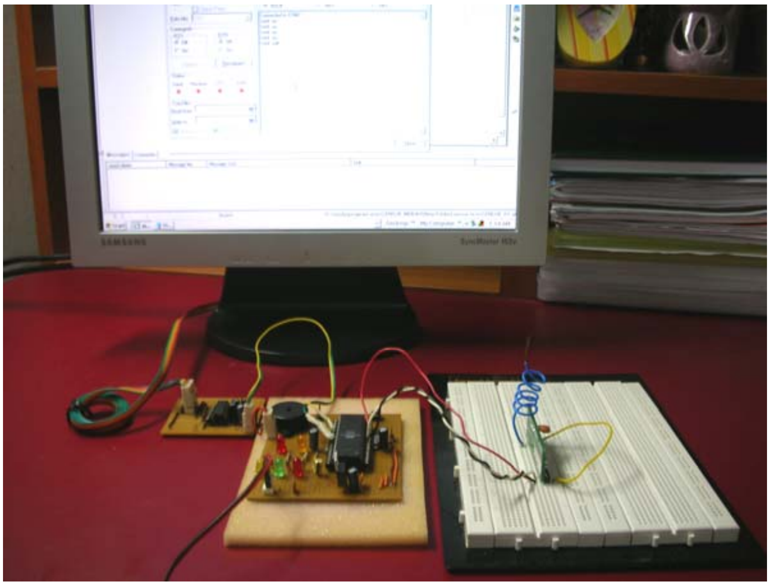
4.2 System Hardware

Water Sensor System consists of two parts which are transmitter and receiver end**.** The transmitter end comprises of sensor circuit, processing board and radio transmitter module.

While, on the other end, the receiver part consists of Processing board, RS-232 Interface Circuit and the computer. All hardware develops using stripe board (Refer to following figure 4.1). Hard wares are build base on the function of receiver node al already discussed in previous chapter.



(a)



(b)

Figure 4.1 The receiver end prototype: (a) Top view, (b) Side view

The Radio receiver module is connected to the processing board through receive USART terminal. While the RS-232 interfaces circuit is connected to the board through Transmit USART Terminal. The RS-232 circuit is then connected to the computer.

4.1 System Software

After completing developing the hardware module, the next stage is software development where the communication and data processing function is embedded in the microcontrollers. The source code is written in the Programmer Notepad (WIN AVR). Then the code was compiled to produce the hex file, list file and object file .However only hex file will be used to be uploaded. Figure 4.2 shows the successful compiled result on WINAVR window. The left window shows the source code while the right shows the output window. The total memory size used for this system is 1989 bytes.

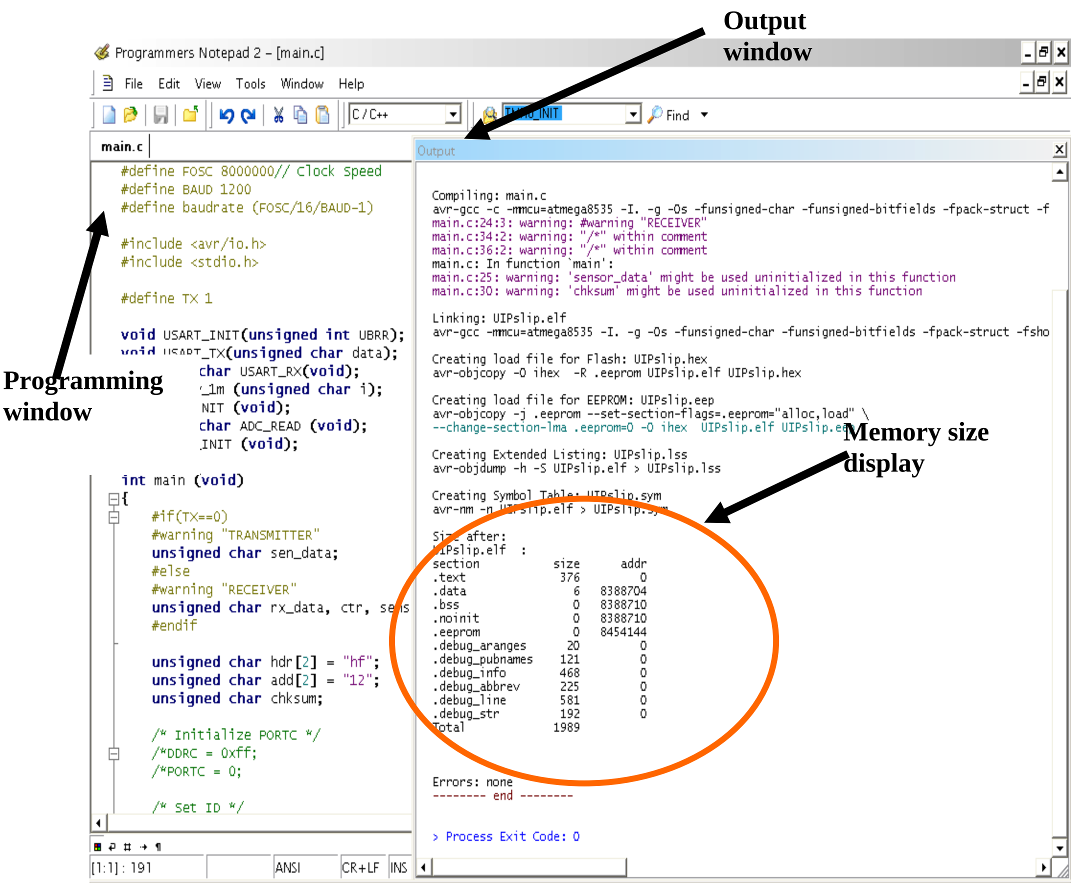


Figure 4.2 Output Window resulting from compilation

Then, the hex file produced is uploaded into the AVR-microcontroller using PonyProg 2000. Figure 4.3 proved the hex code is successfully embedded into the microcontroller. It would be better to erase the microcontroller’s memory before writing the codes to the target device (especially if device is already contained any program). The notice window will pop-up to indicate that the uploading process is completed and successful.

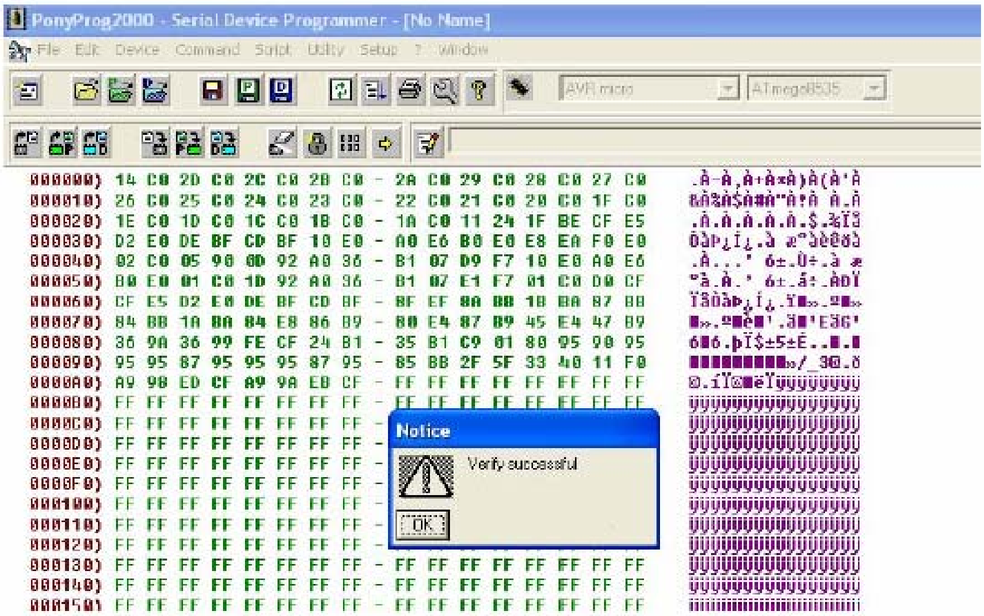


Figure 4.3 Porting Hex code using Ponyprog200 software.

4.2 Measured Voltage

The supply voltage, VCC which is connected to the AVR microcontroller must be stable. The stability of the supply will affect the performance of the system especially for wireless communication. The DC power supply unit was used for testing, where the value can be easily verified. Figure 4.4 shows the signal taken from VCC pin of ATmega8535 at oscilloscope. The value is 5.35Volts which still in the range of microcontroller’s operating voltages. Although there are little spikes existed, it is tolerable since the spiking voltage are below 5.5Volts.

Figure 4.4 Measured Supply voltage for input processor board

4.3 Data Transmission

This section will elaborate the result obtained for data communication for the system. The data transmission for this system uses the USART, with 8 bit frame format, Big Indian byte order and baud rate of 1200 bps. The same baud rates are set for both nodes for synchronization. The result is taken in two different system layouts which are wired and wireless connection.

4.3.1 Wired Connection

The data sent from the transmitter node is in the form of frame which includes 2 bytes header, 2 bytes address, 1 byte data and 1 byte checksum as discussed in previous chapter. The following figures show the result taken from USART terminal for both nodes using Usart terminal and Oscilloscope.

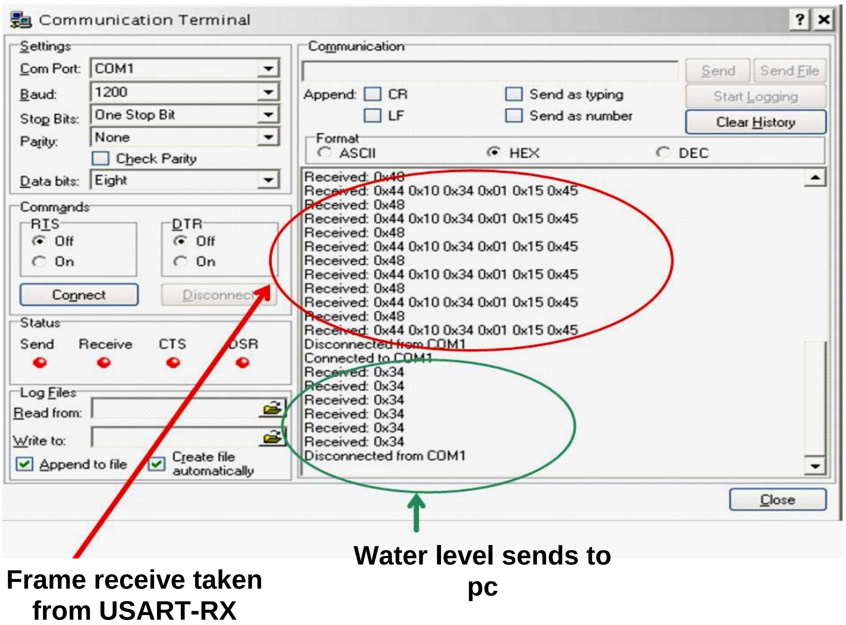


Figure 4.5 Result taken from Usart Terminal (wired connection)

Referring to figure 4.5, the red circle indicates the frame received at the receiver end (pin USART RX). Then this frame is processed by checking the error. If the frame is free from error, processor will then extracts data from the frame. Afterward, this data will be send to the PC through pin USART –TX (green circle).

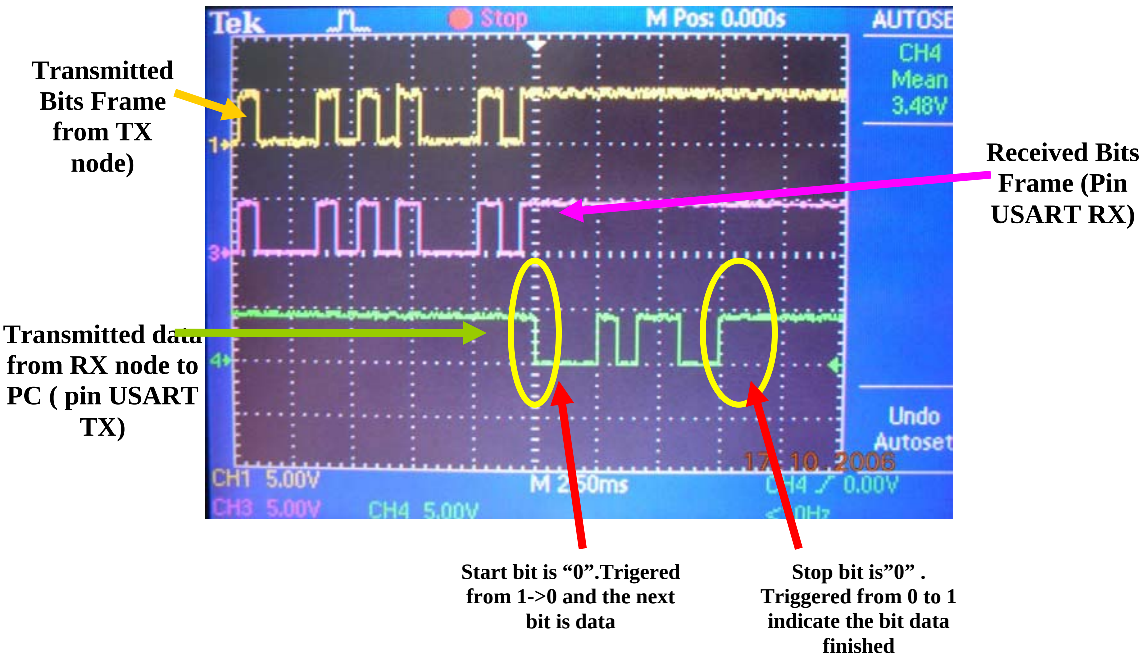


Figure 4.6 Result taken from Oscilloscope (Wired connection)

The result taken from oscilloscope has shown three different output which are from transmitter node USART transmit pin, Receiver node USART receive and transmit pin (refer to figure 4.6). The ATmega8535 has USART function which automatically generates the start and the stop bit for every byte transmitted. The start Bit and the stop bit is “0”. The bit will remain “1” when the line is idle. This is clearly proven at the generated green signal. It is nearly impossible to observe the start bit of the data frame (yellow and pink signal) because the oscilloscope shows the continuous display.

4.3.2 Wireless Connection

After the wired transmission has been successfully implemented, the test for wireless connection was made. Fortunately, the result obtained using wireless is actually same as wired. This has been proven in the following figure.

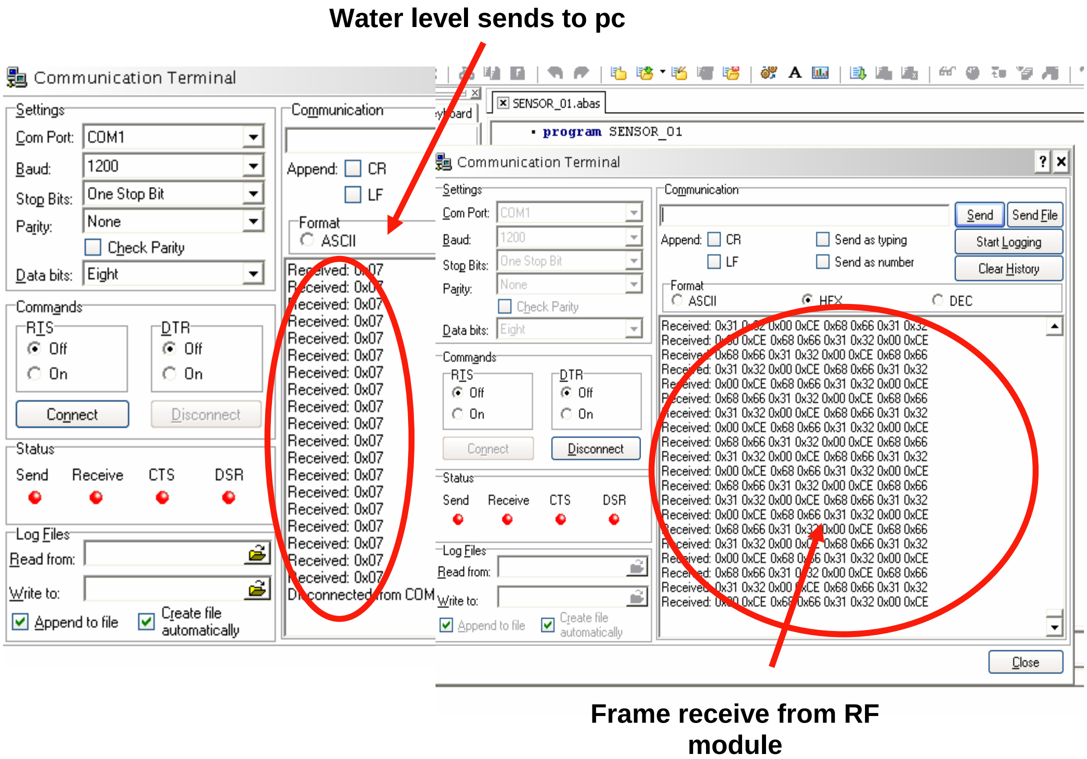


Figure 4.7 Result taken from Usart Terminal (wireless connection)

Result from USART terminal shows two windows (figure 4.7). The right window illustrate the receive frame taken from data out pin of RF module. The frame consists of 6 bytes data which are 0x68, 0x66, 0x31, 0x32, 0x00 and 0xCE. The first two byte is the frame header (ASCII code =“hf”). While the next two bytes data are the address (ASCII=”12”) followed by water level (0x00). This value indicates that there is no water sensed by water sensor. Finally, the last byte is the checksum (~(0x68 +0x66+0x31+0x32+0x00) = 0xCE).

The left window show the data sent to the PC (taken from TX-Usart pin). This time the data is sent without a frame. Please note that both windows are captured at different time. That is why the data in the frame (right window) is not the same as data sent to PC (left window). The 0x07 signify that water is now at level 3.

More clear result can be obtained by using oscilloscope. Referring to figure 4.8, there are three signals taken which are from transmitter node (USART-TX), receiver node (USART-RX) and receiver node (USART-TX). It is observed that transmitted bits frame is exactly the same as received bits frame. Also, notice that the time interval between transmit and receive frame is very small which nearly 0sec. The purple signal indicates the water level value. This data will be used by the PC to display the real value.

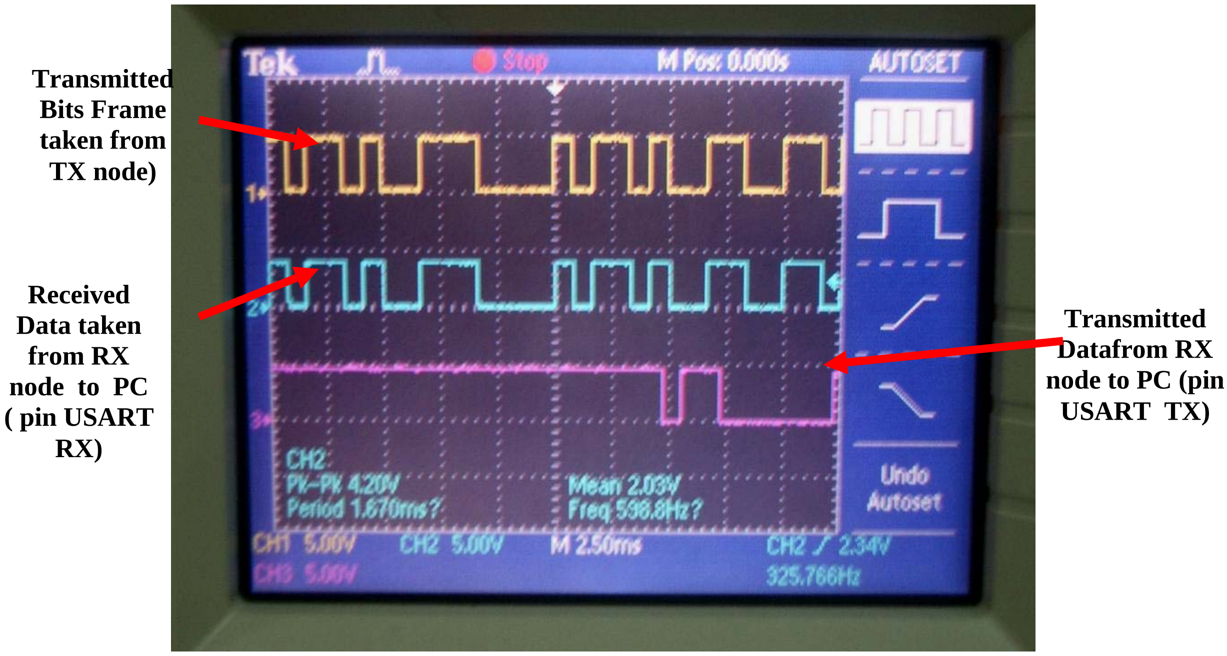
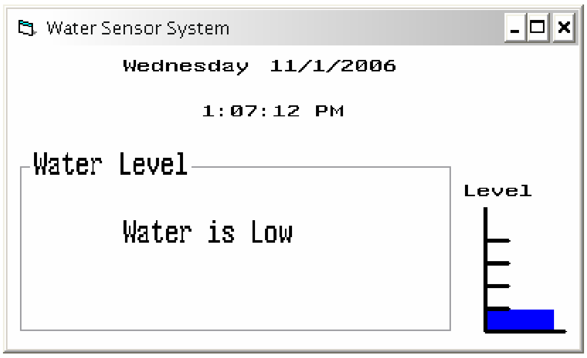


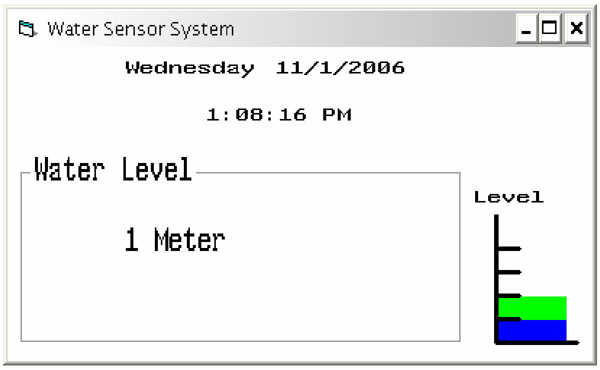
Figure 4.8 Result taken from Oscilloscope (Wireless connection)

4.4 Result from Graphical User Interface

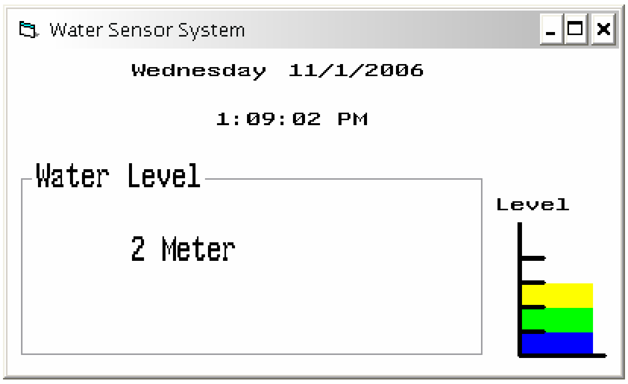
The Graphical User Interface was developed as additional features to the system. When the sensor did not sense any water, it considers as low water level. Therefore the first level is assigned with blue color (figure 4.9(a)). The message also wills popup in the “water level” section. Then when the sensor sense the first level of the water, the second level in GUI will assigns green color. This process will continue until the water reached the highest level where the message “4 meter (critical)” will appear on screen (figure 4.9(e)). The following figures have summarized the operation of GUI for this system.


Water Sensor System
Wednesday 11/1/2006
1:07:12 PM
Water Level
Water is Low
Level

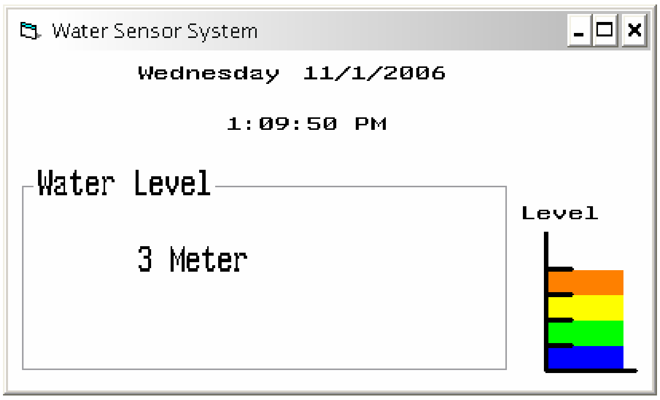
(a)


Water Sensor System
Wednesday 11/1/2006
1:08:16 PM
Water Level
1 Meter
Level

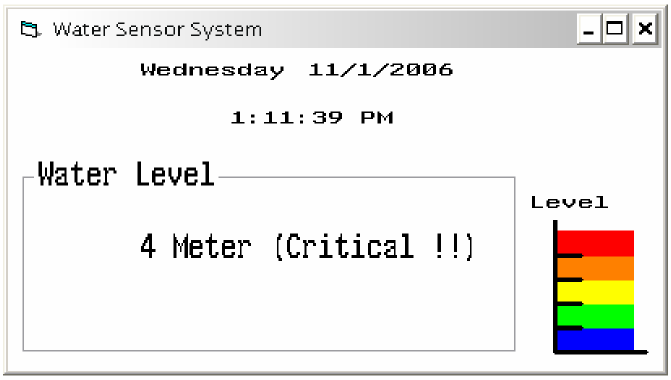
(b)


Water Sensor System
Wednesday 11/1/2006
1:09:02 PM
Water Level
2 Meter
Level

(c)



(d)



(e)

Figure 4.9 GUI result: (a) No level, (b) Level 1, (c) level 2, (d) level 3 and (e) level 4

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 Conclusions

The main purpose of this project is to implement the application of wireless sensor system. This project was designed based on ideas and theory of wireless sensor network. Water detector has been chosen as a sensor detecting flood. In general, this project is has successful in achieving all the objectives. The communication between nodes using non-standard protocol is met. It is shown that the receiver node can receive data from transmitter and display on LED and PC.

Besides early warning flood detection, water sensor system is also suitable to be use for measuring water level in the dam. Klang valley always has a problem related to water supply shortage due to decrement of water in the dam during drought. Sometimes there is no notice or any warning from responsible body to the residence. Resulting, resident has no opportunity to take a precaution action (Stack up water supply).

5.1 Future work

Event though water sensor system is considered success, however, it is only a prototype and there are still has some weaknesses that need to be improved. In future, few modifications can be done for real implementation. It is suggested that instead of using transmitter and receiver module, transceiver also can be used so that communication both ways can be applied.

This Water sensor system use non-standard protocol. Hence, the application is limited for that system network only. This system can be improved by using common standard protocol such as point to point or TCP/IP so that the system can be deployed in real network application. For TCP/IP, MicroIP can be used along with operating system application such as TinyOS or RT-OS.

The hardware designed in this project used strip board resulting large module size. This size of module can be reduced by using PCB. The PCB designed can be done via many tools and one of widely used tool is DXP Protel. Figure 5.1 shows the receiver node design.

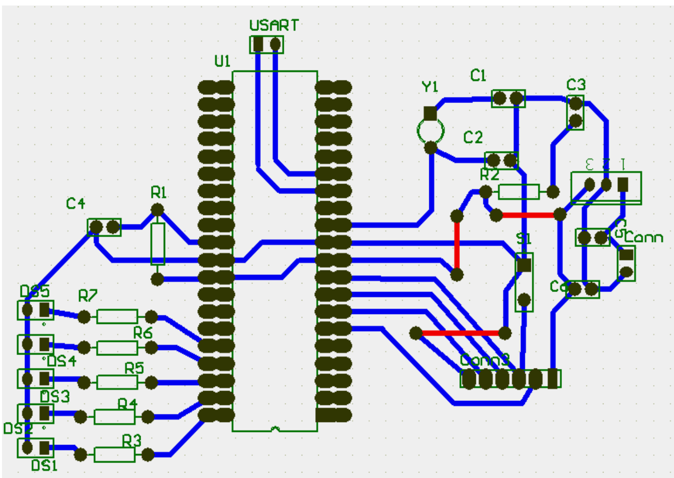


Figure 5.1 The PCB Design for Receiver module

Other than that, water sensor used in this project is rather simple and cheap. It has the ability to measure only four level of water. This feature can be improved by using water sensor with better features.

Lastly, since this project has only two nodes. It is suggested that more then two nodes is used to create a network. Function of the receiver node is to receive and display the water level. These features can be enhanced by form a database system so that interested parties can have access to the system through the Internet.

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16. VB Forums. Web page. URL: http://www.vbforums.com/

APPENDIX A

SOURCE CODE OF WATER SENSOR SYSTEM

```
/*********************************************************************/
/**Title            : Water Sensor System with Non-standart Protocol

   Description      :Basically this protocol only involve datalink layer.
                          The purpose of this protocol is to ensure the
                          reliability of datatransmission between 2
entities
                          ( point to point).Below are the details used in
                          this protocol:

             Error detection: Checksum
             Frame Structure:

             |------|---------|------|---------|
             |Flag  | Address | Data | Chcksum |
             |----- |---------|------|---------|
                2       2        1           1   -----> Bytes


             where,       Flag: hf
                          Address: 12
/********************************************************************/


#define FOSC 8000000// Clock Speed
#define BAUD 1200
#define baudrate (FOSC/16/BAUD-1)

#include <avr/io.h>
#include <stdio.h>

#define TX 1        // set tx=1:Receiver while tx-0: receiver


/*****************************************************/
/**********  Declaration  for Subroutine *************/
/*****************************************************/
void USART_INIT(unsigned int UBRR);
void USART_TX(unsigned char data);
unsigned char USART_RX(void);
void delay_1m (unsigned char i);




/*******************************************************/
/********     Main Program ****************************/
/*****************************************************/
int main (void)
{
       #if(TX==0)
       #warning "TRANSMITTER"
       unsigned char sen_data;
       #else
       #warning "RECEIVER"
       unsigned char rx_data, ctr, sensor_data, chksum_;
       #endif

       unsigned char hdr[2] = "hf";
       unsigned char add[2] = "12";
       unsigned char chksum;

/**************************************/
/***** Initialize Timer0 & USART *****/
/*************************************/

       USART_INIT(baudrate);
```

```
/***************************************/
/***** Program for Transmitter *********/
/**************************************/

       #if(TX==0)
       /* Initialize ADC */
       DDRA = 0xF0;

    while (1) {
              /*read port a*/
              sen_data = PINA;
       /*calculate checksum: sum up all bytes in dataframe then  invert (
1'scomplement)*/
              chksum = sen_data + hdr[0] + hdr[1] + add[0] + add[1];
              chksum = ~chksum;

              /*Send 2 bytes header*/
              USART_TX(hdr[0]);
              USART_TX(hdr[1]);
              /*send 2 bytes address*/
              USART_TX(add[0]);
              USART_TX(add[1]);
              /*send data*/
              USART_TX(sen_data);
              /*send checksum*/
              USART_TX(chksum);
       }
/**************************************/
/****** Program for Receiver***********/
/************************************/
       #else
       ctr = 0;

       /* Set PortA as output (connected to LED)*/
       DDRA = 0xff;
       PORTA = 0;

       while (1) {
              /* wait for incoming data*/
              if (UCSRA & (1<<RXC)) {
                     rx_data = UDR;

                     /* Check 2 bytes header*/
                     if (ctr < 2) {
                            if (rx_data == hdr[ctr]) {
                                ctr++;
                            } else {
                                   ctr = 0;
                            }
                            /* Check 2 byte Address*/
                     } else if ((ctr > 1) && (ctr < 4)) {
                            if (rx_data == add[ctr - 2]) {
                                   ctr++;
                            } else {
                                   ctr = 0;
                            }
                            /*copy and save data */
                     } else if (ctr == 4) {
                         sensor_data = rx_data;
                            ctr++;
                            /* copy check sum*/
                     } else if (ctr == 5) {
                            chksum = rx_data;
                            ctr++;
                            /* Check  wheter data contained any error?*/
                     } else {
                            chksum_ =  (hdr[0] + hdr[1] + add[0] + add[1] +
sensor_data + chksum);
```

```
                        /*If data is error free display on LED and send
to pC*/
                        if (chksum_ == 0xff) {
                              USART_TX(sensor_data);

                              if (sensor_data == 0x1) {
                                    PORTA = 0x3;
                              } else if (sensor_data == 0x3) {
                                    PORTA = 0x7;
                              } else if (sensor_data == 0x7) {
                                    PORTA = 0xf;
                              } else if (sensor_data == 0xf) {
                                    PORTA = 0x1f;
                              } else {
                                    PORTA = 0x1;
                              }
                        /*If data error send ff to pc alert user*/
                        } else {
                              USART_TX(0xff);
                        }
                        ctr = 0;
                  }
            }

      }

      #endif
}


/****************************************/
/*** Subroutine for Initialized USART**/
/***************************************/

void USART_INIT(unsigned int UBRR)
{

/* Set baud rate */
UCSRA &= 0xfd;
UBRRH = (unsigned char)((UBRR)>>8);
UBRRL = (unsigned char)(UBRR);

/* Enable receiver and transmitter */
UCSRB = (1<<RXEN)|(1<<TXEN);

/* Set frame format: 8data, no parity, 1 stop bit */
UCSRC = (1<< URSEL) | (1<< UCSZ1) |  (1<< UCSZ0);
}

/******************************************************/
/****  Subroutine for Transmit data through USART*****/
/*****************************************************/

void USART_TX(unsigned char data)
{
   /* Wait for empty transmit buffer */
   while ( !(UCSRA & (1<<UDRE)) ) ;

   /* Start transmission */
   UDR = data;  // send least significant byte
}

/****************************************************/
/***Subrounite for  Receive data through USART******/
/***************************************************/

unsigned char USART_RX(void) {
```

```
   /* Wait for data to be received */
   while (!(UCSRA & (1<<RXC))) ;

   /* Get and return received data from buffer */
   return UDR;
}


/*****************************************/
/****** Subroutine Delay 1 ms************/
/****************************************/

void delay_1m (unsigned char i)
{
    int j;
      while(i--)
      {
            j=11415;   // 8Mhz Exteranl Crystal(CKSEL3..0 = 1,1,1,1)
            while(j--);
      }
}


}
```

APPENDIX B

MAKE FILE FOR AVR MICROCONTROLLER

```
# WinAVR Sample makefile written by Eric B. Weddington, Jörg Wunsch, et
al.
# Released to the Public Domain
# Please read the make user manual!
#
# Additional material for this makefile was submitted by:
#  Tim Henigan
#  Peter Fleury
#  Reiner Patommel
#  Sander Pool
#  Frederik Rouleau
#  Markus Pfaff
#
# On command line:
#
# make all = Make software.
#
# make clean = Clean out built project files.
#
# make coff = Convert ELF to AVR COFF (for use with AVR Studio 3.x or
VMLAB).
#
# make extcoff = Convert ELF to AVR Extended COFF (for use with AVR
Studio
#                4.07 or greater).
#
# make program = Download the hex file to the device, using avrdude.
Please
#                customize the avrdude settings below first!
#
# make filename.s = Just compile filename.c into the assembler code
only
#
# To rebuild project do "make clean" then "make all".
#


# MCU name
MCU = atmega8535

# Output format. (can be srec, ihex, binary)
FORMAT = ihex

# Target file name (without extension).
TARGET = wlevel

# Optimization level, can be [0, 1, 2, 3, s]. 0 turns off optimization.
# (Note: 3 is not always the best optimization level. See avr-libc
FAQ.)
OPT = s


# List C source files here. (C dependencies are automatically
generated.)

SRC   = main.c
#delay.c usart_tr_vadib_sairi.c ruzaini.c
```

```
#usart_tr.c init.c blink.c usart_rx.c    adc_adibsairi.c

# If there is more than one source file, append them above, or modify
and
# uncomment the following:
#SRC += foo.c bar.c

# You can also wrap lines by appending a backslash to the end of the
line:
#SRC += baz.c \
#xyzzy.c



# List Assembler source files here.
# Make them always end in a capital .S.  Files ending in a lowercase .s
# will not be considered source files but generated files (assembler
# output from the compiler), and will be deleted upon "make clean"!
# Even though the DOS/Win* filesystem matches both .s and .S the same,
# it will preserve the spelling of the filenames, and gcc itself does
# care about how the name is spelled on its command-line.
ASRC =


# List any extra directories to look for include files here.
#     Each directory must be seperated by a space.
EXTRAINCDIRS =


# Optional compiler flags.
#  -g:        generate debugging information (for GDB, or for COFF
conversion)
#  -O*:       optimization level
#  -f...:     tuning, see gcc manual and avr-libc documentation
#  -Wall...:  warning level
#  -Wa,...:   tell GCC to pass this to the assembler.
#    -ahlms:  create assembler listing
CFLAGS = -g -O$(OPT) \
-funsigned-char -funsigned-bitfields -fpack-struct -fshort-enums \
-Wall -Wstrict-prototypes \
-Wa,-adhlns=$(<:.c=.lst) \
$(patsubst %,-I%,$(EXTRAINCDIRS))


# Set a "language standard" compiler flag.
#   Unremark just one line below to set the language standard to use.
#   gnu99 = C99 + GNU extensions. See GCC manual for more information.
#CFLAGS += -std=c89
#CFLAGS += -std=gnu89
#CFLAGS += -std=c99
CFLAGS += -std=gnu99



# Optional assembler flags.
#  -Wa,...:   tell GCC to pass this to the assembler.
#  -ahlms:    create listing
```

```
#  -gstabs:   have the assembler create line number information; note
that
#             for use in COFF files, additional information about
filenames
#             and function names needs to be present in the assembler
source
#             files -- see avr-libc docs [FIXME: not yet described
there]
ASFLAGS = -Wa,-adhlns=$(<:.S=.lst),-gstabs



# Optional linker flags.
#  -Wl,...:   tell GCC to pass this to linker.
#  -Map:      create map file
#  --cref:    add cross reference to  map file
LDFLAGS = -Wl,-Map=$(TARGET).map,--cref



# Additional libraries

# Minimalistic printf version
#LDFLAGS += -Wl,-u,vfprintf -lprintf_min

# Floating point printf version (requires -lm below)
#LDFLAGS += -Wl,-u,vfprintf -lprintf_flt

# -lm = math library
LDFLAGS += -lm




# Programming support using avrdude. Settings and variables.

# Programming hardware: alf avr910 avrisp bascom bsd
# dt006 pavr picoweb pony-stk200 sp12 stk200 stk500
#
# Type: avrdude -c ?
# to get a full listing.
#
AVRDUDE_PROGRAMMER = stk500


AVRDUDE_PORT = com1        # programmer connected to serial device
#AVRDUDE_PORT = lpt1    # programmer connected to parallel port

AVRDUDE_WRITE_FLASH = -U flash:w:$(TARGET).hex
#AVRDUDE_WRITE_EEPROM = -U eeprom:w:$(TARGET).eep

AVRDUDE_FLAGS = -p $(MCU) -P $(AVRDUDE_PORT) -c $(AVRDUDE_PROGRAMMER)

# Uncomment the following if you want avrdude's erase cycle counter.
# Note that this counter needs to be initialized first using -Yn,
# see avrdude manual.
#AVRDUDE_ERASE += -y
```

```
# Uncomment the following if you do /not/ wish a verification to be
# performed after programming the device.
#AVRDUDE_FLAGS += -V

# Increase verbosity level.  Please use this when submitting bug
# reports about avrdude. See
<http://savannah.nongnu.org/projects/avrdude>
# to submit bug reports.
#AVRDUDE_FLAGS += -v -v




# ---------------------------------------------------------------------
------

# Define directories, if needed.
DIRAVR = c:/winavr
DIRAVRBIN = $(DIRAVR)/bin
DIRAVRUTILS = $(DIRAVR)/utils/bin
DIRINC = .
DIRLIB = $(DIRAVR)/avr/lib


# Define programs and commands.
SHELL = sh

CC = avr-gcc

OBJCOPY = avr-objcopy
OBJDUMP = avr-objdump
SIZE = avr-size


# Programming support using avrdude.
AVRDUDE = avrdude


REMOVE = rm -f
COPY = cp

HEXSIZE = $(SIZE) --target=$(FORMAT) $(TARGET).hex
ELFSIZE = $(SIZE) -A $(TARGET).elf



# Define Messages
# English
MSG_ERRORS_NONE = Errors: none
MSG_BEGIN = -------- begin --------
MSG_END = --------  end  --------
MSG_SIZE_BEFORE = Size before:
MSG_SIZE_AFTER = Size after:
MSG_COFF = Converting to AVR COFF:
MSG_EXTENDED_COFF = Converting to AVR Extended COFF:
MSG_FLASH = Creating load file for Flash:
```

```
MSG_EEPROM = Creating load file for EEPROM:
MSG_EXTENDED_LISTING = Creating Extended Listing:
MSG_SYMBOL_TABLE = Creating Symbol Table:
MSG_LINKING = Linking:
MSG_COMPILING = Compiling:
MSG_ASSEMBLING = Assembling:
MSG_CLEANING = Cleaning project:




# Define all object files.
OBJ = $(SRC:.c=.o) $(ASRC:.S=.o)

# Define all listing files.
LST = $(ASRC:.S=.lst) $(SRC:.c=.lst)

# Combine all necessary flags and optional flags.
# Add target processor to flags.
ALL_CFLAGS = -mmcu=$(MCU) -I. $(CFLAGS)
ALL_ASFLAGS = -mmcu=$(MCU) -I. -x assembler-with-cpp $(ASFLAGS)



# Default target.
all: begin gccversion sizebefore $(TARGET).elf $(TARGET).hex
$(TARGET).eep \
	$(TARGET).lss $(TARGET).sym sizeafter finished end


# Eye candy.
# AVR Studio 3.x does not check make's exit code but relies on
# the following magic strings to be generated by the compile job.
begin:
	@echo
	@echo $(MSG_BEGIN)

finished:
	@echo $(MSG_ERRORS_NONE)

end:
	@echo $(MSG_END)
	@echo


# Display size of file.
sizebefore:
	@if [ -f $(TARGET).elf ]; then echo; echo $(MSG_SIZE_BEFORE);
$(ELFSIZE); echo; fi

sizeafter:
	@if [ -f $(TARGET).elf ]; then echo; echo $(MSG_SIZE_AFTER);
$(ELFSIZE); echo; fi



# Display compiler version information.
```

```
gccversion :
	@$(CC) --version



# Convert ELF to COFF for use in debugging / simulating in
# AVR Studio or VMLAB.
COFFCONVERT=$(OBJCOPY) --debugging \
	--change-section-address .data-0x800000 \
	--change-section-address .bss-0x800000 \
	--change-section-address .noinit-0x800000 \
	--change-section-address .eeprom-0x810000


coff: $(TARGET).elf
	@echo
	@echo $(MSG_COFF) $(TARGET).cof
	$(COFFCONVERT) -O coff-avr $< $(TARGET).cof


extcoff: $(TARGET).elf
	@echo
	@echo $(MSG_EXTENDED_COFF) $(TARGET).cof
	$(COFFCONVERT) -O coff-ext-avr $< $(TARGET).cof



# Program the device.
program: $(TARGET).hex $(TARGET).eep
	$(AVRDUDE) $(AVRDUDE_FLAGS) $(AVRDUDE_WRITE_FLASH)
$(AVRDUDE_WRITE_EEPROM)



# Create final output files (.hex, .eep) from ELF output file.
%.hex: %.elf
	@echo
	@echo $(MSG_FLASH) $@
	$(OBJCOPY) -O $(FORMAT) -R .eeprom $< $@

%.eep: %.elf
	@echo
	@echo $(MSG_EEPROM) $@
	-$(OBJCOPY) -j .eeprom --set-section-flags=.eeprom="alloc,load" \
	--change-section-lma .eeprom=0 -O $(FORMAT) $< $@

# Create extended listing file from ELF output file.
%.lss: %.elf
	@echo
	@echo $(MSG_EXTENDED_LISTING) $@
	$(OBJDUMP) -h -S $< > $@

# Create a symbol table from ELF output file.
%.sym: %.elf
```

```
	@echo
	@echo $(MSG_SYMBOL_TABLE) $@
	avr-nm -n $< > $@



# Link: create ELF output file from object files.
.SECONDARY : $(TARGET).elf
.PRECIOUS : $(OBJ)
%.elf: $(OBJ)
	@echo
	@echo $(MSG_LINKING) $@
	$(CC) $(ALL_CFLAGS) $(OBJ) --output $@ $(LDFLAGS)


# Compile: create object files from C source files.
%.o : %.c
	@echo
	@echo $(MSG_COMPILING) $<
	$(CC) -c $(ALL_CFLAGS) $< -o $@


# Compile: create assembler files from C source files.
%.s : %.c
	$(CC) -S $(ALL_CFLAGS) $< -o $@


# Assemble: create object files from assembler source files.
%.o : %.S
	@echo
	@echo $(MSG_ASSEMBLING) $<
	$(CC) -c $(ALL_ASFLAGS) $< -o $@






# Target: clean project.
clean: begin clean_list finished end

clean_list :
	@echo
	@echo $(MSG_CLEANING)
	$(REMOVE) $(TARGET).hex
	$(REMOVE) $(TARGET).eep
	$(REMOVE) $(TARGET).obj
	$(REMOVE) $(TARGET).cof
	$(REMOVE) $(TARGET).elf
	$(REMOVE) $(TARGET).map
	$(REMOVE) $(TARGET).obj
	$(REMOVE) $(TARGET).a90
	$(REMOVE) $(TARGET).sym
	$(REMOVE) $(TARGET).lnk
	$(REMOVE) $(TARGET).lss
	$(REMOVE) $(OBJ)
	$(REMOVE) $(LST)
```

```
	$(REMOVE) $(SRC:.c=.s)
	$(REMOVE) $(SRC:.c=.d)


# Automatically generate C source code dependencies.
# (Code originally taken from the GNU make user manual and modified
# (See README.txt Credits).)
#
# Note that this will work with sh (bash) and sed that is shipped with
WinAVR
# (see the SHELL variable defined above).
# This may not work with other shells or other seds.
#
%.d: %.c
	set -e; $(CC) -MM $(ALL_CFLAGS) $< \
	| sed 's,\(.*\)\.o[ :]*,\1.o \1.d : ,g' > $@; \
	[ -s $@ ] || rm -f $@


# Remove the '-' if you want to see the dependency files generated.
-include $(SRC:.c=.d)



# Listing of phony targets.
.PHONY : all begin finish end sizebefore sizeafter gccversion coff
extcoff \
	clean clean_list program
```

APPENDIX C

SOURCE CODES FOR GRAPHICAL USER INTERFACE

```
Private Sub Timer1_Timer()
masa.Refresh
masa.Caption = Time
End Sub
Private Sub Form_Load()

MSComm1.RThreshold = 1
MSComm1.InputLen = 2
MSComm1.CommPort = 1
MSComm1.Settings = "1200,N,8,1"
MSComm1.DTREnable = False
MSComm1.PortOpen = True
Tarikh = Date
masa = Time
Hari = WeekdayName(Weekday(Date, vbSunday))
End Sub


Private Sub Form_Unload(Cancel As Integer)

        MSComm1.PortOpen = False
End Sub

Private Sub MSComm1_OnComm()
Dim x As Long
Dim y As Long
Dim r As Long
        Dim sData As String                         ' Holds our
incoming data
        Dim lHighByte As Integer
        Dim Word1 As Long                           ' Holds the Word
result

        If MSComm1.CommEvent = comEvReceive Then    ' If
comEvReceive Event then get data and display
        sData = MSComm1.Input
        lHighByte = Asc(Mid$(sData, 1, 1))          ' get 1st byte
        Word1 = lHighByte
        End If
        x = lHighByte

     If lHighByte = 46 & lHighByte = 57 Then
        MsgBox "THIS FRAME IS NOT FOR US!!"

      End If

       If x = &H1 Then
            Label3.Caption = "1 meter"
            Label1.BackColor = &HFF0000
            Label2.BackColor = &HFF00&
            Label4.BackColor = &HFFFFFF
            Label5.BackColor = &HFFFFFF
            Label6.BackColor = &HFFFFFF

        ElseIf x = &H3 Then
            Label3.Caption = "2 meter"
            Label1.BackColor = &HFF0000
            Label2.BackColor = &HFF00&
            Label4.BackColor = &HFFFF&
            Label5.BackColor = &HFFFFFF
            Label6.BackColor = &HFFFFFF
```

```
        ElseIf x = &H7 Then
            Label3.Caption = "3 meter"
            Label1.BackColor = &HFF0000
            Label2.BackColor = &HFF00&
            Label4.BackColor = &HFFFF&
            Label5.BackColor = &H80FF&
            Label6.BackColor = &HFFFFFF

        ElseIf x = &HF Then
            Label3.Caption = "4 meter"
           Label1.BackColor = &HFF0000
            Label2.BackColor = &HFF00&
            Label4.BackColor = &HFFFF&
            Label5.BackColor = &H80FF&
            Label6.BackColor = &HFF&
        Else
            Label3.Caption = "WATER LOW"
            Label1.BackColor = &HFF0000
            Label2.BackColor = &HFFFFFF
            Label4.BackColor = &HFFFFFF
            Label5.BackColor = &HFFFFFF
            Label6.BackColor = &HFFFFFF

        End If



End Sub
```

APPENDIX D

PONYPROG2000 USER MANUAL

How to use PonyProg2000 for the Microrobot AVR Products(Rev 0.3)

Contents

What is PonyProg2000?

PonyProg is a serial device programmer software with a user-friendly GUI framework available for Windows95, 98, 2000 & NT and Intel Linux. Its purpose is reading and writing every serial device. At the moment it supports I²C Bus, Microwire, SPI EEPROM, the Atmel AVR and Microchip PIC micro.

For more details, visit http://www.lancos.com/e2p/ponyprog2000.html

How to install?

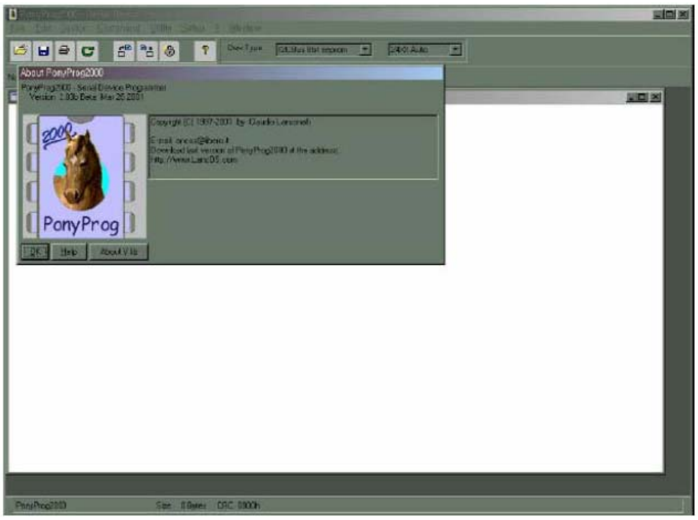
Run the setup.exe file.

Preparation

1. Supply proper power to the (CPU) board.
2. Connect the downloading adapter to the PC printer port. Then connect the downloading adapter and the board with the flat cable.
3. Turn on the power switch on the board. Power LED turns on (when applicable).
4. Compile the source file you want to download.

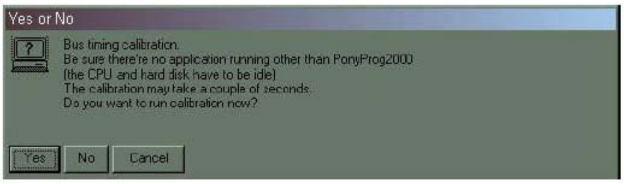
How to download a program using PonyProg2000

Run the PonyPorg2000 program.



Click on OK. The following window appears.

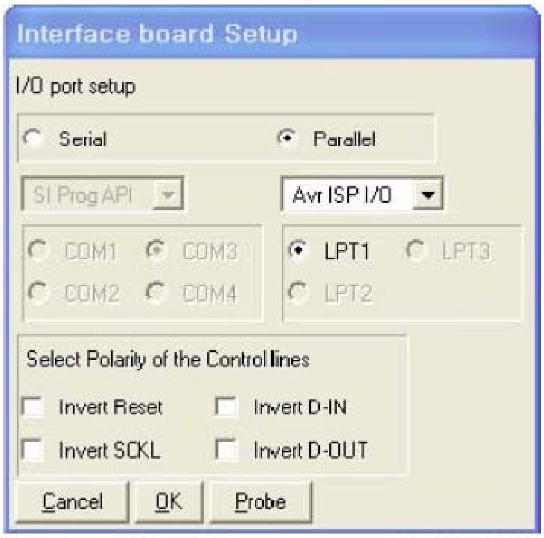
Click on OK. Select ‘Setup → Calibration’.



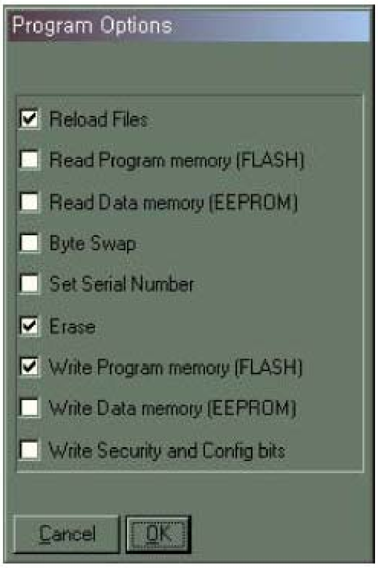
Click on Yes button. The following window appears.

Click on OK.

Select ‘Setup → interface Setup’ and set up as shown below (Parallel, Avr ISP I/O, LPT1) and click on Probe. ‘Test Ok’ message appears. Click on OK. Click on OK.



Select the device you want. ('Device → AVR micro → XXX', XXX is the device you want)
Select 'Command → Program Options' and check as shown below. (Reload Files, Erase, Write Program memory)
Click on OK.

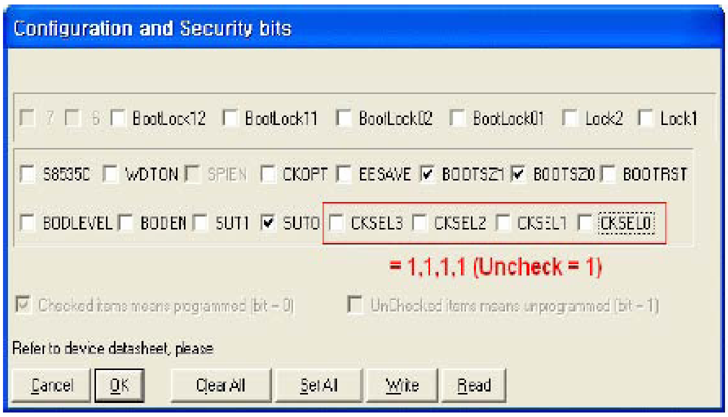


Some devices require 'Flash Fuse Bits Setting' for the desired clock source setting. For example, CKSEL3..0 bits of the ATmega8535 and Atmega8515 devices need to be set 1 to select the External Crystal clock source mode. Refer to 'Clock Options' of the device sheet for the detailed bit setting.

If you need to set the bits, select 'Command → Security and Configuration Bits…'.

Click on Read button, uncheck the CKSEL3..0 bits and then click on Write button.

Fig 1.6 shows a 'Security and Configuration Bits' dialog box as an example.



Note: If the board has an AT90S-type CPU instead of ATmega-type, the setting is not required.

Select 'File → Open Program File' and load the *.rom(or *.hex) file.

Select 'Command → Program' or press 'Ctrl + P' to start the downloading. If no 'Program Failed' message appears, the downloading has been completed successfully.

www.microrobot.com