REMOTE PROCESS CONTROL AND MONITORING BY USING TCP/IP

NURUL IZYAN BINTI AHMAD TARMIZI

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **REMOTE PROCESS CONTROL AND MONITORING BY USING TCP/IP**

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Saya **NURUL IZYAN BINTI AHMAD TARMIZI (860401-33-5136)**
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Alamat Tetap:

LOT 4431 JLN KG CHENGAL LEMPONG,
BALOK, 26100 KUANTAN,
PAHANG DARUL MAKMUR.

ROSMADI BIN ABDULLAH
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Date : 17 NOVEMBER 2008

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NURUL IZYAN BINTI AHMAD TARMIZI

This report is submitted as partial fulfillment of the requirements for the award of the Degree of Bachelor of Electrical Engineering (Electronics)

Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

NOVEMBER 2008

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Date : 17 NOVEMBER 2008

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ABSTRACT

This project presents a practical approach to monitor and control the process in industries by computer using TCP/IP connection. Transmission Control Protocol (TCP) and the Internet Protocol (IP) are the protocols for communication on the Internet where a stream of data that is sent over the Internet is first broken down into packets by the TCP and IP is responsible for sending the packet to its destination along a route. The system contains two main parts that is a local digital controller and graphical user interface (GUI) application. The local digital controller which controls the system is implemented on a PIC18F4620 microcontroller. The graphical user interface (GUI) application by using visual basic makes the users easier to monitor and control the system when uses TCP/IP protocol. The user can monitor and control the process by using computer. Programming software also will be used to program this microcontroller. By using this TCP/IP on this project, a lot of advantages we can get such as the user can be at any place to monitor and control the system as long as they have computer along with the internet connection. It also can maintain the productivity and prevent losses of the product in industries.

ABSTRAK

Projek ini merupakan salah satu cara praktikal untuk mengawal dan memerhati proses yang dijalankan di dalam industri dengan menggunakan TCP/IP sebagai alat perhubungan. Protokol kawalan pindahan (TCP) dan protokol internet (IP) merupakan protokol komunikasi dimana data akan dihantar melalui TCP dalam bentuk paket dan IP akan menghantar paket data itu ke destinasi yang dikehendaki. Sistem ini mengandungi dua bahagian iaitu pengawal digital setempat dan antaramuka pengguna bergrafik (GUI). Pengawal digital setempat digunakan untuk mengawal system yang diaplikasikan kepada pengawal mikro PIC18F4620. Antaramuka pengguna bergrafik yang menggunakan visual basic memudahkan pengguna untuk memerhati dan mengawal proses apabila protokol TCP/IP digunakan. Pengguna boleh mengawal dan memerhati proses dengan hanya menggunakan komputer sahaja. Perisian pengaturcara akan digunakan untuk mengaturcara pengawal mikro ini. Terdapat pelbagai faedah yang kita boleh perolehi dengan menggunakan TCP/IP ini seperti pengguna boleh berada dimana sahaja untuk memerhati dan mengawal system selagi mereka mempunyai komputer dan internet. TCP/IP ini boleh mengekalkan produktiviti dan mengurangkan pengeluaran produk yang tidak elok di industri.

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LIST OF ABBREVIATIONS

LED	-	Light-Emitting Diode
PIC	-	Peripheral Interface Controller
PCB	-	Printed Circuit Board
LCD	-	Liquid Crystal Display
VCC	-	Supply voltage

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CHAPTER 1

INTRODUCTION

1.1 Background

The name TCP/IP refers to a suite of data communication protocols. The name is misleading because TCP and IP are only two of dozens of protocols that compose the suite. Its name comes from two of the more important protocols in the suite that is the Transmission Control Protocol (TCP) and the Internet Protocol (IP). They are the protocols for communication on the Internet. A stream of data that is sent over the Internet is first broken down into packets by the TCP. Data packets include the receiving computer's address, a sequence number, error correction information, and a small piece of data. IP is responsible for sending the packet to its destination along a route.

In 1969, Department of Defense (DoD) was initialized that TCP/IP originated out from the investigation research into networking protocols. Before that in 1968, the DoD Advanced Research Projects Agency (ARPA) began researching the network technology that is called packet switching. The TCP/IP protocols played an important role in the development of internet. In the early 1980s, the TCP/IP protocols were developed and became standard protocols for ARPANET in 1983.

1.1 Introduction to the project

Normally in a process plant, flows, pressures, levels and temperatures during a process need to be monitored so that there are no errors occurred to maintain productivity and prevent losses but it is dangerous for a worker to monitor these parameters directly from the process room. So, the TCP/IP is one way to avoid the hazardous for the workers and increase safety for them.

We also can maintain the desired state such processes that we need to keep constant at prescribed values such variables as flows, pressures, levels, temperatures and others which demands the design of automatic control systems for them.

The important aspects during this project are theoretical and practical aspects. The theoretical part gives scientific knowledge about the topic. The practical part allows the student to gain more understanding of the theoretical concept with develop a hardware.

This project is purposely designed to easier the users to monitor and control the process in industries by computer using TCP/IP connection. The users can be at any place to monitor and control the process as long as they have computer along with the internet connection. Besides that, it can save the cost from taking many employees and save time because the system can be monitored and control by one person only.

1.2 Objective

The objective of this project is to design and fabricate a system that can monitor and simultaneously can control devices in a system remotely using TCP/IP.

1.3 Scope of the project

i. To design a process control system in industry by using Peripheral Interface Controller (PIC).

ii. To design the graphical user interface (GUI) using Visual Basic.

iii. To integrate the GUI and hardware by using TCP/IP connection.

1.3 Report contents

In chapter 1, an introduction briefly describe preface of the project. It will clearly elaborate on how to remote process control and monitoring by using TCP/IP. This chapter generally described the main idea of project including objective and scope as guidance along manage the project.

In chapter 2, a literature review will elaborate early finding about the project. All information about past study and related equipments were analyzed and discussed carefully. Equipment on development this project is described in theory and technically.

In chapter 3, a methodology briefly describe the methods will use to run the project. All the method and tools used for run this project has been mention clearly here. This chapter also stated the whole project planning from the beginning till it has been completed. The project planning has been represented by a flow chart.

In chapter 4, the result and discussion of the project will be described. This is the important chapter, the results obtain from the PCB board whether it can run the device or not. The elaboration about whole project will discuss clearly and complete from early step to the end. The result gain and procedure the test conduct will be discuss either it achieve the objective or not.

In chapter 5, a conclusion briefly described all the works and act that have been done before and summarized the finding and result.. In addition, suggestion that have value for future improvement or extension will list.

CHAPTER 2

LITERATURE REVIEW

2.1 TCP/IP

The name TCP/IP refers to a suite of data communication protocols. The protocols that make up the internet protocol suite know as TCP (Transmission Control Protocol) and IP (Internet Protocol). TCP/IP is design to hides the function of this layer from users. It is concerned with getting data across a specific type of physical network such as Ethernet.

The TCP/IP protocol suite consists of several interacting pieces of software including a data layer IP, ICMP, TCP, SNMP and others. The TCP/IP uses a layered networking structure. At the data layer, adjacent hosts and routers exchange link packets. At the IP layer, nodes decode IP packets within the link packet. Hosts use the protocol field to forward the encapsulated packet to an upper-layer protocol where the routers use the destination address and a routing algorithm to determine which interface to forward each packet on.

At the transport layer, TCP use the port and address fields to communicate with separate processes on one or more hosts. It also uses several mechanisms to ensure that the data is transferred reliably and efficiently. The application layer communicates with other application layers using TCP.

2.2 PIC18F4620 Microcontroller

Figure 2.1: PIC18F4620 Microcontroller

2.2.1 Function Description

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "Programmable Interface Controller" but shortly thereafter was renamed "Peripheral Interface Controller".

PICs are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

Special Microcontroller Features for PIC18F4620 are:

- C Compiler Optimized Architecture where it has optional extended instruction set designed to optimize re-entrant code.
- 100,000 Erase/Write Cycle Enhanced Flash Program Memory Typical
- 1,000,000 Erase/Write Cycle Data EEPROM Memory Typical

- Flash/Data EEPROM Retention: 100 Years Typical
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8x8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer(WDT): Programmable period from 4 ms to 131s
- Single-supply 5V In-Circuit Serial Programming™ (ICSP™) via Two Pins
- Wide Operating Voltage Range: 2.0V to 5.5V

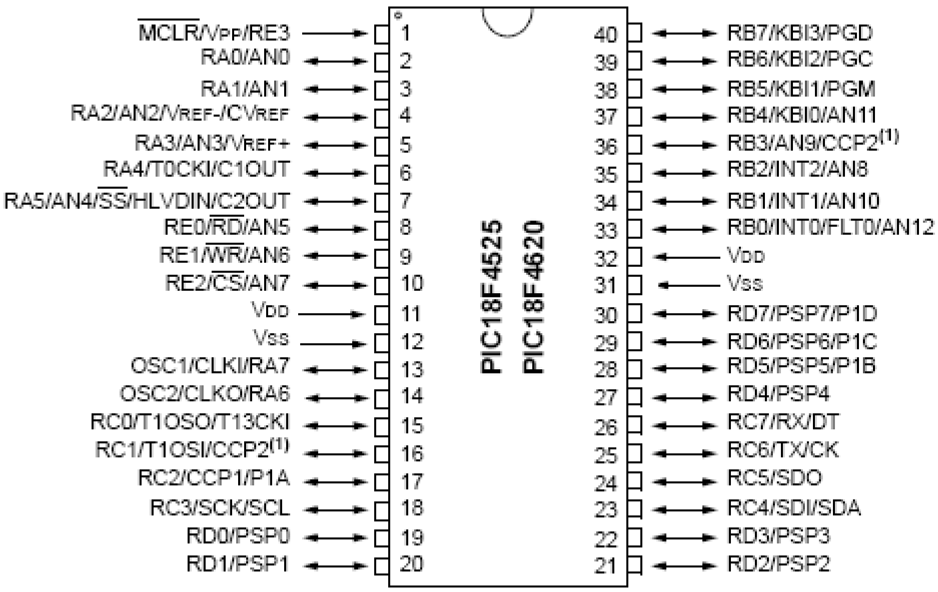


Figure 2.2: Pin Diagram of PIC18F4620

2.3 Graphical User Interface (GUI)

A graphical user interface or GUI is a type of user interface which allows people to interact with a computer and computer controlled devices. It presents graphical icons and visual indicator. The graphical icons usually used in conjunction with text, labels or text navigation to fully represent the information and actions available to a user. GUI does not apply to other high-resolution types of interfaces that are non-generic such as video games or not restricted to flat screens like volumetric displays.

Designing the visual composition and temporal behavior of GUI is an important part of software application programming. Its goal is to enhance the efficiency and ease of use for the underlying logical design of a stored program, a design discipline known as usability. Techniques of user-centered design are used to ensure that the visual language introduced in the design is well tailored to the tasks it must perform.

The visible graphical interface features of an application are sometimes referred to as chrome. Larger visual indicator such as windows usually provides a frame or container for the main presentation content such as a web page, email message or drawing. Smaller ones usually act as a user-input tool.

A GUI may be designed for the rigorous requirements of a vertical market. This is known as an application specific graphical user interface. Examples of an application specific GUI are:

- Touch screen point of sale software used by wait staff in a busy restaurant
- Self-service checkouts used in a retail store
- Automated teller machines (ATM)
- Airline self-ticketing and check-in
- Information kiosks in a public space, like a train station or a museum
- Monitors or control screens in an embedded industrial application which employ a real time operating system (RTOS).

2.3.1 Visual Basic 6

Visual Basic 6 was used as GUI in this project. It designed to be easy to learn and use. The language not only allows programmers to create simple GUI applications but can also develop complex applications as well. Programming in visual basic 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. Performance problems were experienced by earlier versions but with faster computers and native code compilation this has become less of an issue

2.4 ENC28J60 Ethernet Controller

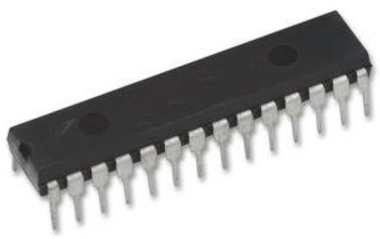


Figure 2.3: ENC28J60 Ethernet Controller

2.4.1 Function Description

ENC28J60 Ethernet controller is a standalone Ethernet controller with an industry standard peripheral interface (SPI). It is designed to serve as an Ethernet network interface for any microcontroller equipped with SPI. It meets all the specifications for IEEE 802.3 and incorporates a number of packet filtering schemes to limit incoming packets. Also provides internal DMA for fast data throughput and support for hardware assisted IP checksum calculation. Communication with the microcontroller is implemented via SPI with data rates up to 10bit/s. Figure 3 show the pin diagram of this IC.

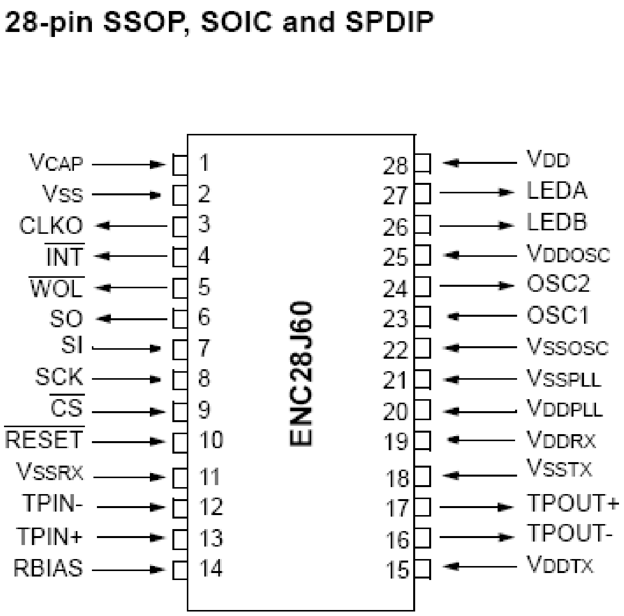


Figure 2.4: Pin Diagram for ENC28J60

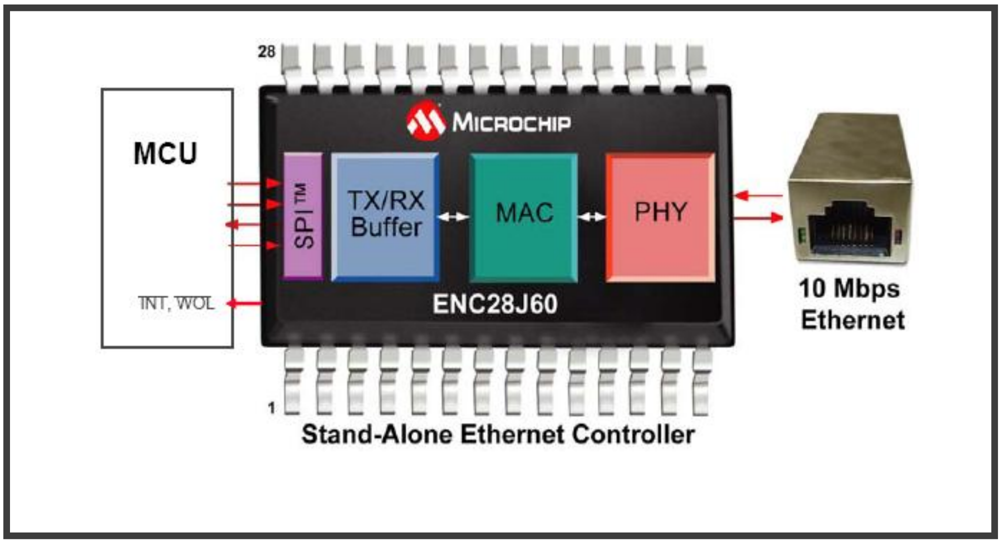


Figure 2.5: Block diagram of Ethernet controller

Referencing the block diagram above,

The device comes with an on-chip 10 Mbps Ethernet Physical Layer Device (PHY) and Medium Access Controller (MAC), providing reliable packet-data transmission/reception based on an industry-standard Ethernet protocol. The PHY contains analog circuitry to encode and decode the data on the twisted pair interface while the MAC contains digital circuitry to control when to transmit, handle automatic retransmission when a collision occurs, calculate and validate CRCs (Cyclical Redundancy Check), and do other necessary tasks.

A total of 8 kilobytes of RAM is present on the device. The microcontroller can configure how much of the 8KB is allocated to the receive hardware. The unallocated space remains useful as a transmit buffer. The Buffer memory enables an efficient method for packet storage, retrieval and modification, eliminating memory requirements for the host microcontroller. This buffer memory provides a flexible, reliable data-management system.

Once of the quite unique features for this Ethernet controller is that it interfaces to the host MCU over a Serial peripheral interface. (SPI) With only 4 wires, a MCU can be network enabled.

Has two interrupts. One is general INT, and the other, WOL (Wake on LAN), allows the network administrator to send a packet and wake the device up from its sleep state.

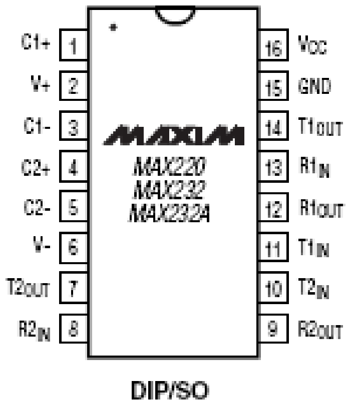
For internet communication over Ethernet, a Transmission Control protocol/Internet protocol (TCP/IP) software stack is necessary. This stack resides on the Host MCU. Microchip offers a free TCP/IP stack that includes the entire major protocols necessary from the physical Ethernet layer up to and including the presentation or application layer:

- Stack version 2.20: proven in the industry
- Royalty-free, No license cost
- Can be download from the microchip web site today
- Is about 25 Kb of code
- Is modular in design so that the user can pick and choose the protocols according to the application need.
- Is portable to all PIC18 micros
- Has supporting documentation for more information regarding the stack.

2.5 MAX232

2.5.1 Function Description

The MAX232 transceivers have a proprietary low-dropout transmitter output stage enabling true RS-232 performance from a 3.0V to 5.5V supply with a dual charge pump. The devices require only four small 1.0μF external charge-pump capacitors. The MAX232 are guaranteed to run at data rates of 120kbps while maintaining RS-232 output levels. The MAX232 have 2 receivers and 2 drivers.



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 2.6: Pin Configuration of MAX232

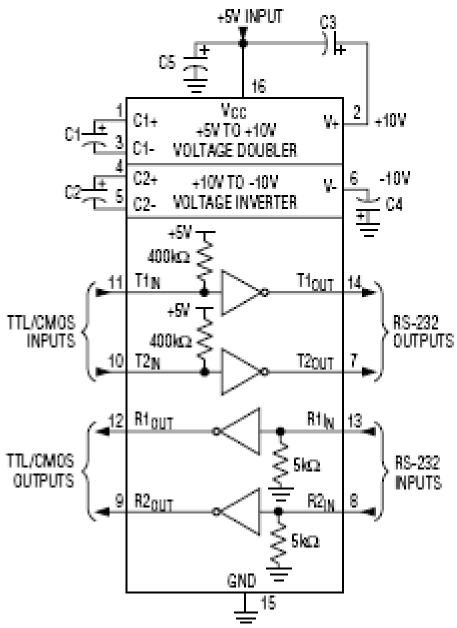


Figure 2.7: Typical Operating Circuit

2.6 TYCO ELECTRONICS-JACK, 10/100 BASE T

Figure 2.8: Electronics jack 10/100 base T

2.6.1 Function Description

Jack, 10/100 Base T has connector type modular Jack RJ45 with integrated Magnetics (MAG 45). It material and plating contact are Phosphor Bronze and Gold. It use ports no 1 and connection type is 10/100 Base-T Ethernet. Temperature output for minimum and maximum are 0°C and 70°C.

Electrical Performance Summary:

- Meets IEEE 802.3 specification

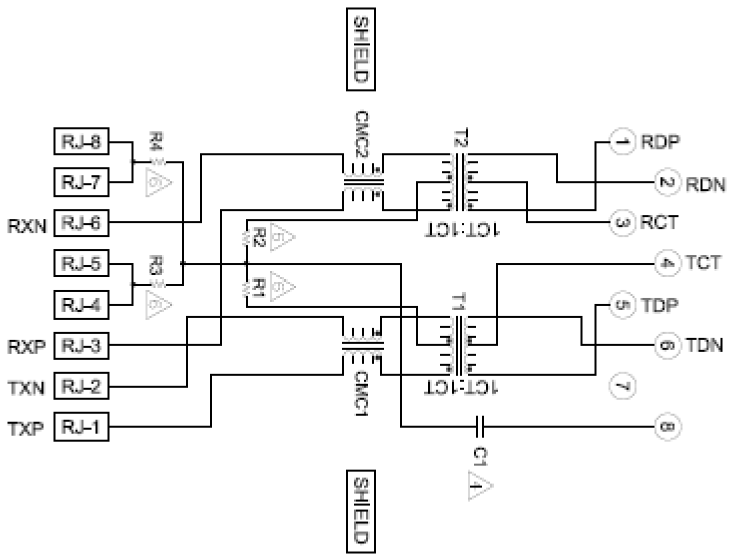


Figure 2.9: 726 Series Magnetic Circuit

2.7 Example project that use similar method to control and monitor the system.

2.7.1 Remote monitor and control application for thermal process using TCP/IP [2]

This paper presents a practical approach for remote monitor and control of the electrically heated oven temperature. The digital system contains two main parts that is a local digital controller and a server-client application. The digital controller which controls the temperature of the electrically heated oven was implemented on a PIC16F628 microcontroller. The server-client application is realized in Lab Windows/CVI language and uses TCP/IP protocol for monitoring and controlling the parameters of the temperature local digital controller.

The special practical approach is design to monitor and to control the electrically heated oven temperature locally and remotely from a personal computer. The application developed has two main parts that are local digital controller built around the PIC16F628 microcontroller (on microcontroller board) and the server client application realized in Lab Windows/CVI language that uses the TCP/IP protocol for network communication and remotely temperature monitor and control. The server interacts with client using TCP/IP socket and the communication is made on a single thread.

2.7.2 Process Control and Supervision through Internet [3]

In this paper the control and supervision through Internet of a process managed by PLCs (Programmable Logic Controller) was presented. The proposed software architecture allows remote users to know the sensors state and to send control signals to process actuators by means of a graphical interface that is accessible via a web browser. The remote user also can download control programs to PCL. It has been used the client or server architecture where the PLC and the server PC are connected by a Visual Basic application and the server PC and the client PC exchange data using the TCP/IP protocol. This architecture has been applied to a real system that consists in an electro pneumatic manipulator. This manipulator together the PLC and the server PC form the virtual laboratory.

A PLC can be programmed locally or remotely to sense, activate and control industrial equipment and therefore, incorporates a number of input or output terminals that are used to interface the PLC to the environment or process. Each input and output connection point on a PLC module has a unique address that identifies it.

Using the TCP/IP protocol, the IP address of the PLC, command type and the address of the item (I/O point) that is referenced are all contained in the IP packet. The IP address of the PLC is included in the header field. The payload field of the IP packet is allocated to carry various PLC related parameters and commands.

2.7.3 Web Based Home Security System [4]

In this paper, the web based home security system was applied. It was use a computer to control almost appliances in the house via the internet from any place in the world. The security system deals with primarily three components that is centralized database, a remote application and web based application. The remote application is customized for clients and gives visual representation of various parts and appliances in the house. The database wills stores invaluable information regarding the status of various appliances in the house and the web based part incorporated the above in a web application.

The web based GUI makes it possible for users to log in remotely from practically anywhere in the world and be able to control various appliances and parts of a house. The interface will be a very self explanatory interface which anyone with even the most trivial knowledge of the internet will be able to understand and use. This interface has been developed using the HTML, VBScript and ASP based technologies. All data regarding the client's houses is stored in a robust and relational SQL Server database. The hardware part of the house is controlled using a digital board via Visual Basic. To control various components in the house one could make a request using the ASP program or the Visual Basic interface. This request eventually talks to the Visual Basic program which performs the action and sends a record of this change to the ASP program which updates the database.

2.8 Summary

We have seen there was many way to control and monitor the devices. The examples have shown that by using RS232, PLC, Web Based and others can used to control and monitor devices. Some of them also use TCP/IP to transmit and receive data. So for my project, I also will use the TCP/IP method to monitor and control the devices in industries from the long distance.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains about the methodology to design and fabricate a system that can be monitor and control devices simultaneously in a system remotely using TCP/IP.

The methodology has two parts that is software and hardware. For the software, VB6 will be used to design the graphical user interface and meanwhile for the hardware the Programmable Interface Controller (PIC) will used to control the devices.

3.2 Research and study tool

3.2.1 Articles and magazines

Development of this project needs lot of study to gathered information especially to keep in touch with the latest technology. This tool is the first source used to understand the characteristic of TCP/IP connection where it can control and monitor by using computer. New trends of equipment used that related to project can be finds with using this tool especially Jack, 10/100 Base T and microcontroller that been manufactured.

3.2.2 Internet

Internet is the world without limitation. Information related to this project can be obtained here. From the advantage, all data from around the world can be search and access but cannot fully trust. Trusted information from certain website was used to gain information and latest trend about this project.

3.3 Project Planning

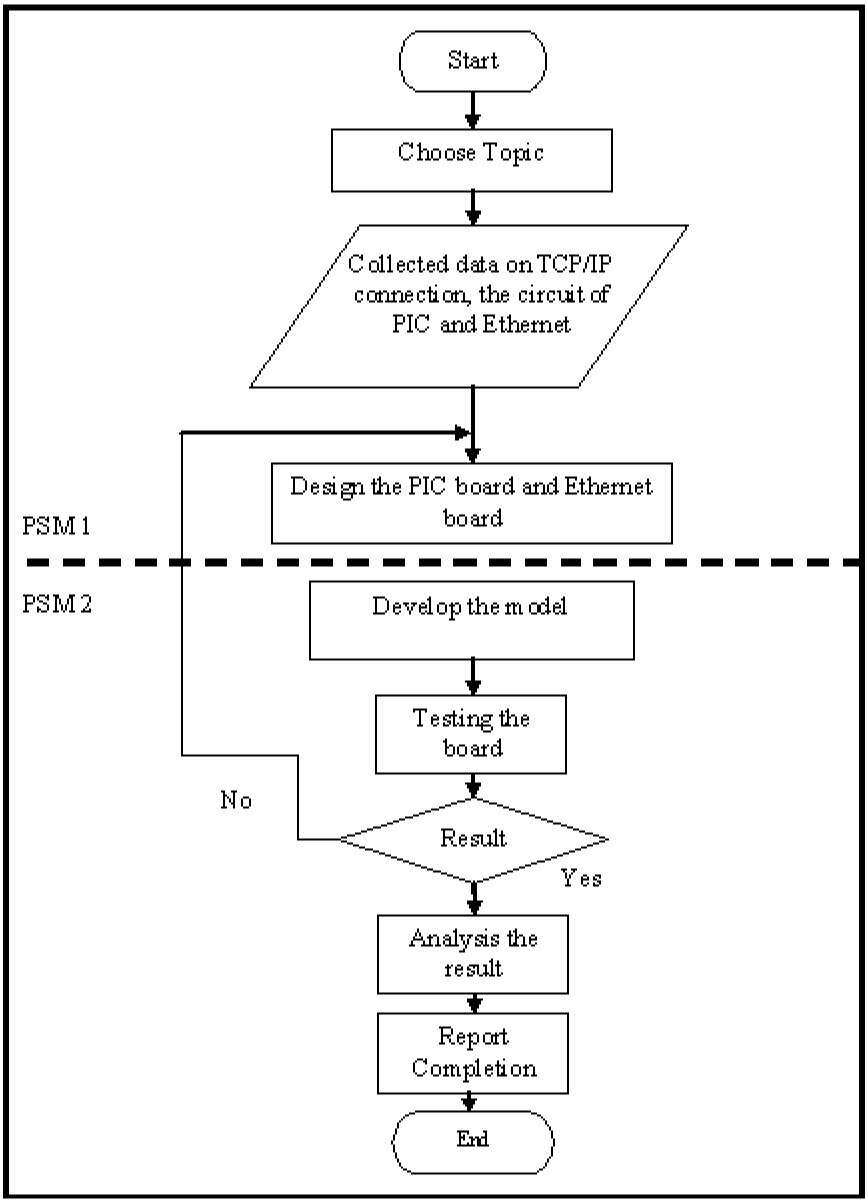


Figure 3.1: Project Flowchart

From Figure 3.1, it shows the project flowchart that was divided into two parts. In first phase, it is briefly showed that the process from topic selection to design the PIC board and Ethernet board. In early stage after topic has been selected, the data related to the project likes the TCP/IP connection, the circuit of PIC and Ethernet.

The source from the journals, magazines, books, papers and internets were used. After the data has been collected, suitable design was draw with the aid of drawing software. In second phase, the model develops follow the design proposed before. After completion, several tests will be doing to analysis the board. If the result obtains as expected to achieve the objective, the result will analyze and complete the report writing. In other hand, the prototype will be redesign and tested until the objective achieve.

3.4 Project flow diagram

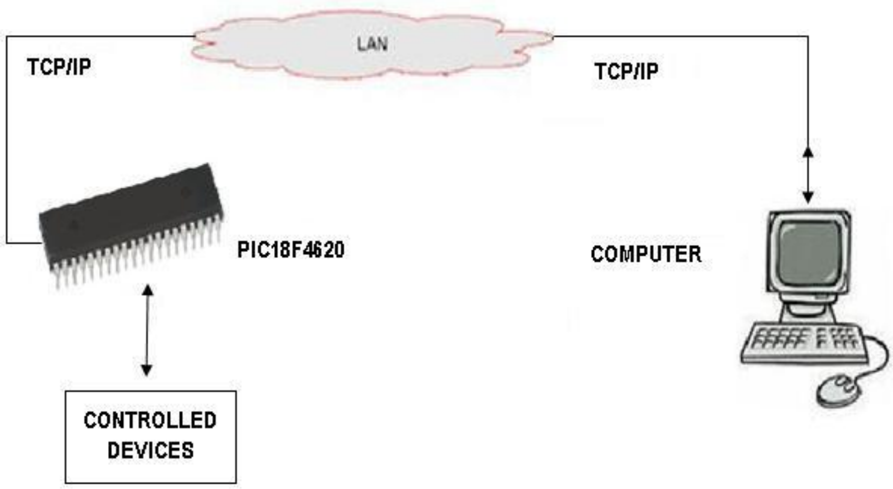


Figure 3.2: Block diagram of the system

The block diagram showed the flow diagram of the system. The user can monitor and control the process by using computer. To monitor the process variable such as temperature, level, flow and pressure, the transducer will be used to measure the variable value. Then the value will be send to PIC and convert it to a stream of data. The computer will be used to capture the data and display it. While in process control, control signal will be send to devices from the computer to PIC through the twisted pair cable that has been used in monitoring process above.

3.5 Tool and Equipment Selection

3.5.1 Software

In development of project, software used can be dividing into two. That is design tool and programming tool.

3.5.1.1 Design Software

Design software was used to create the drawing of the prototype. All part that used in development is draw by using DXP 2004.

3.5.1.2 Programming

Programming software was used to program the programmable interface controller. Movement of the prototype will follow the instruction given. The software used is Microcode and WinPIC 8000 as a program to transfer the file produce by Microcode to programmable interface.

3.5.2 Electronic components

Table 3.1: Electronic equipment

No	Circuit	
	PIC Board	**ENC28J60 Board**
1	PIC18F4620	ENC2860 IC
2	25LC256P EEPROM	Pulse jack
3	MAX 232	74ACT125 IC
4	5V voltage regulator	3.3V voltage regulator
5	Crystal 25Mhz	Crystal 25Mhz
6	Capacitor 15ρF	Capacitor 18ρF
7	Capacitor 1µF	Capacitor 0.1µF
8	Capacitor 0.1µF	Capacitor 0.47µF
9	Capacitor 100µF	Capacitor 47µF
10	Resistor 10kΩ	Capacitor 10µF
11	Diode 1N5818	Resistor 330Ω
12	Reset button	Resistor 49.9Ω 1%
13	PIC based	Resistor 2.7kΩ
14	LED (Light emitting diode)	LED (Light emitting diode)
15	Terminal block	Inductor ferrite bead
16	Header	
17	Printed circuit board (PCB)	
18	PIC Programmer	
19	Connector	
20	LCD	

The equipment used in development of circuits was showed by the Table 1. All part will be used and placed follow the schematic diagram that has been shown. The PCB machine will be used to make the PCB board.

CHAPTER 4

RESULT AND ANALYSIS

This chapter reviews about the result and analysis for the whole project.

4.1 Hardware & software design

4.1.1 Peripheral Interface Controller (PIC) board

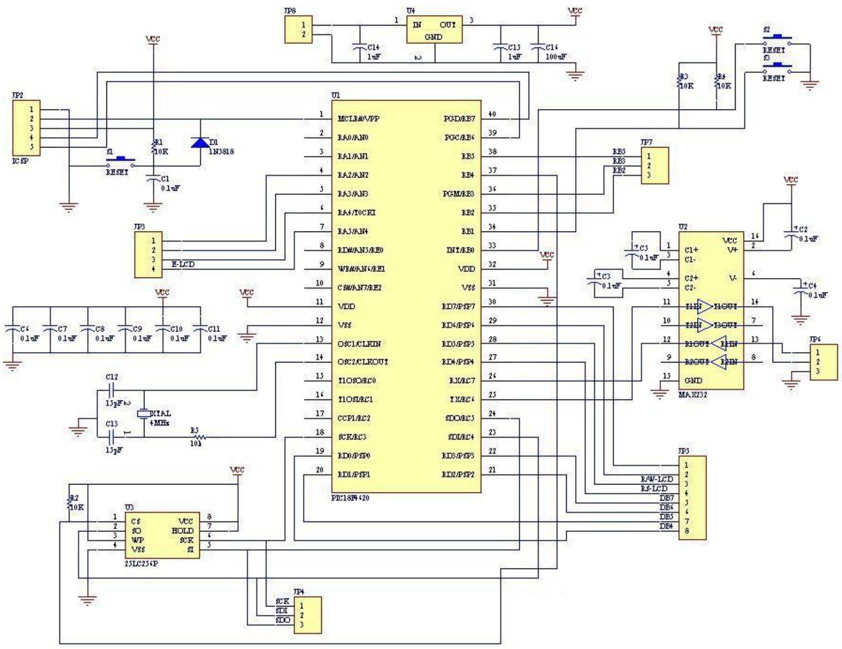


Figure 4.1: Schematic diagram for PIC board

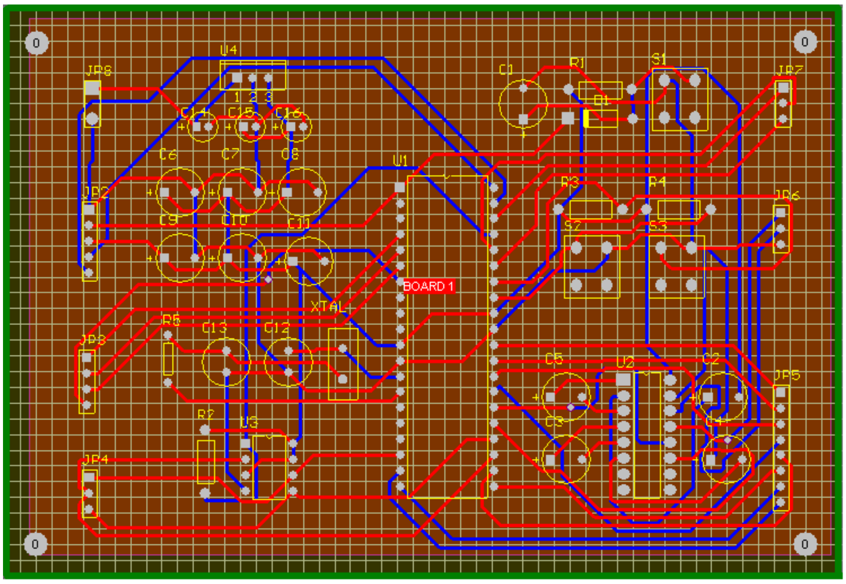


Figure 4.2: PCB layout for PIC board

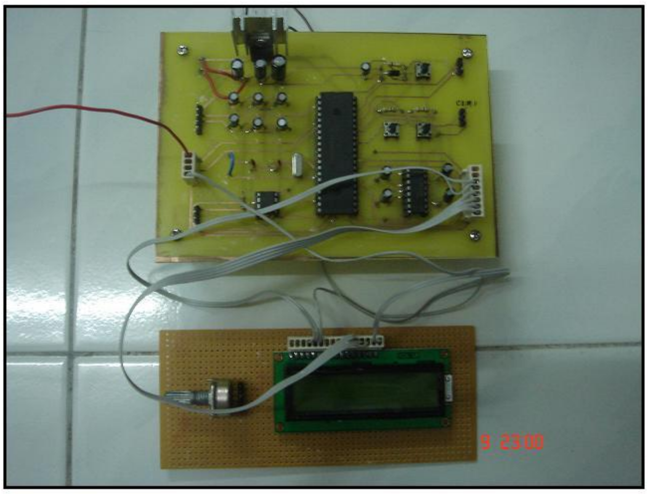


Figure 4.3: Prototype of PIC board

Peripheral interface controller circuit has been developed following the schematic diagram that show in figure 4.1. The figure 4.3 shows that the prototype of PIC circuit that produce with PCB board. The function of this circuit was tested with supply the 9VDC voltage. Multimeter was used to check the continuity of circuit or connection between components. The 9VDC voltage was step down to 5VDC using voltage regulator because PIC only can operate in range 5VDC voltage only. By using the microcontrollers PIC 18F4620, there is no limited amount of program memory space to fit all stack modules and leave available space for the application.

The PIC 18F4620 has been programmed using the MPLAB IDE version 8.0 to program the PIC. This software is using the C language, which is easy for human to understand compare to assembly language. MPLAB also have been choosing because the PIC used is produced by same company that is Microchip. PIC Microcontroller programmer L4128D from Cytron Technologies has been used with helps of software WinPic800 as shown in figure 4.3 to program and transfer the file (.hex) produced by MPLAB to microcontroller. WinPic800 software has been used because it comes with the programmer.

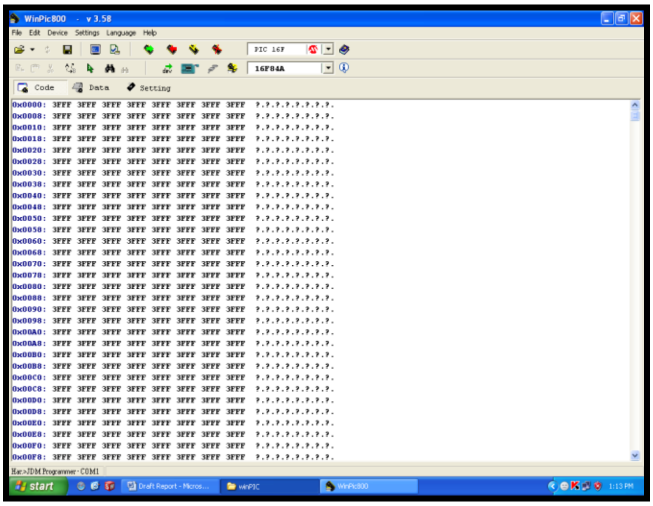


Figure 1.4: WinPIC 800 Software

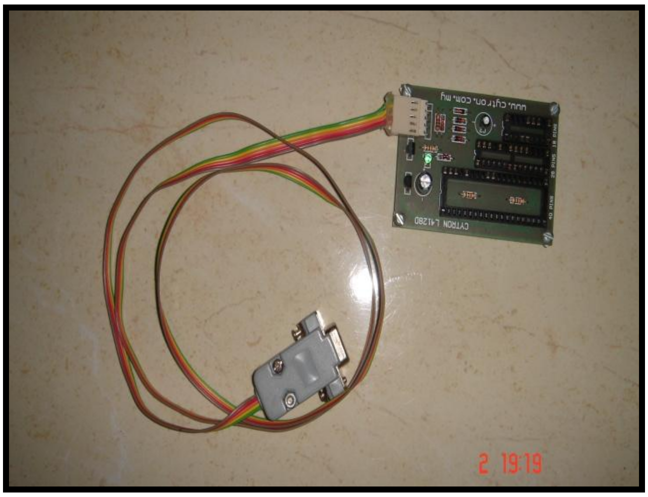


Figure 4.5: PIC Programmer

4.1.1.2 Analysis 1: LED blinking

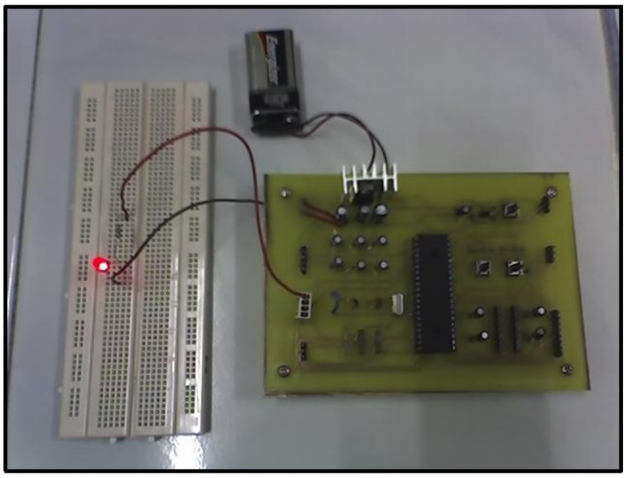


Figure 4.6: LED blinking

Light emitter diode (LED) has been used to check whether the circuit can operate or not based on the program given. This is the simple test where the LED will turn on for 0.2 second and then turn off for 0.2 second.

The program and the board are tested in first test. The test is success when the LED is blinking. This means that the program and the board are in good condition because the components and the connection of the board are all right.

4.1.1.3 Source code for blinking test

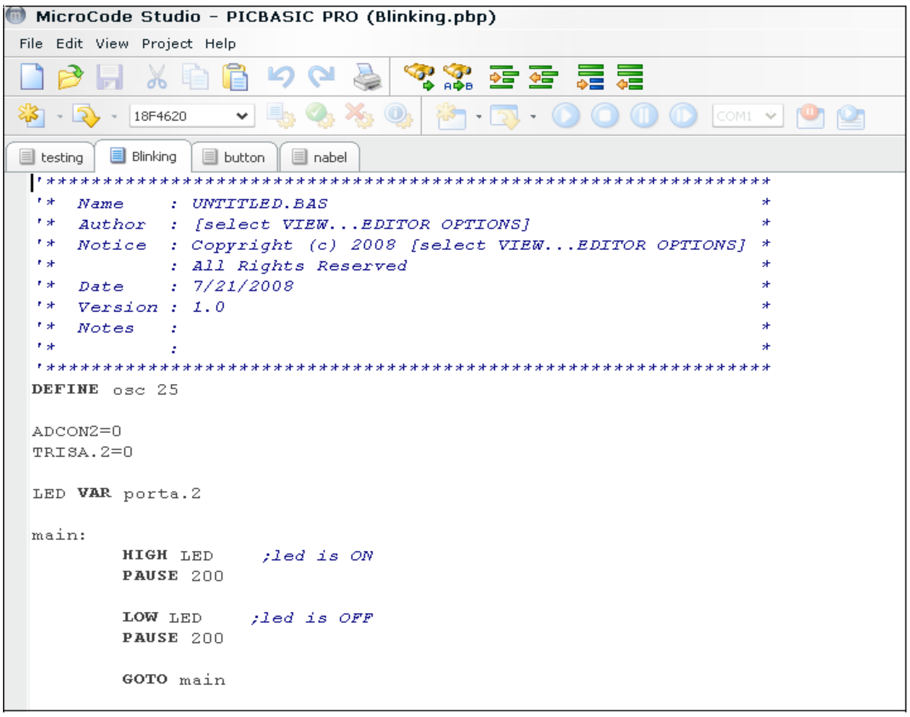


Figure 4.7: Source code for blinking test

The code as figure 4.6 only used for port A as output. From the program, LED should blink on port A for 0.2 second. After that, the LED will turn off 0.2 second and will blinking until will stop it. Program above can be check at the leg of PIC using multimeter, the multimeter will give reading range in 5V when the LED turn on and 0V when turn off.

4.1.1.4 Analysis 2: LCD display

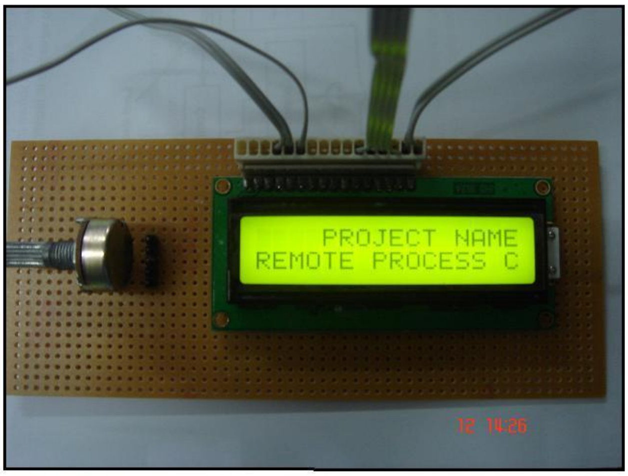


Figure 4.8: LCD display

The program for LCD was tested in second test. The test is success when the LCD displays the word 'PROJECT NAME REMOTE PROCESS CONTROL AND MONITORING'. This means that the LCD can function with the PIC board.

4.1.1.5 Source code for LCD display

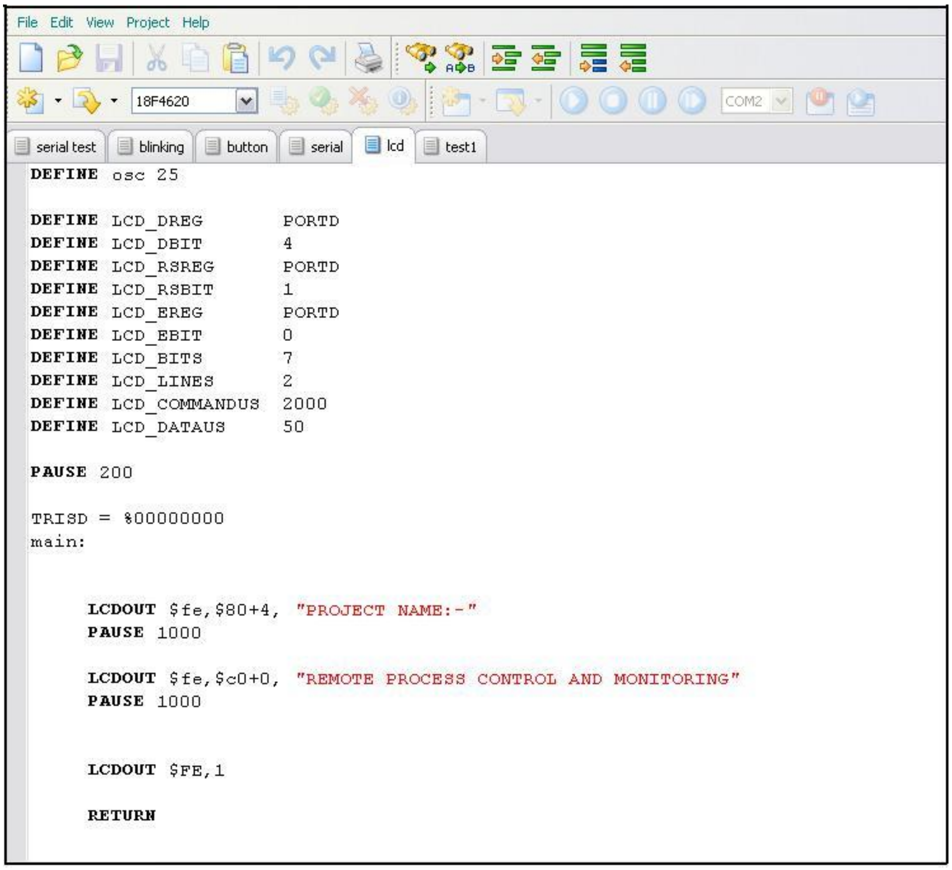


Figure 4.9: Source code for LCD display

The code as figure 4.8 is only used port D as output. From the program, the LCD will display the word PROJECT NAME first. After 0.2 second it will display the word REMOTE PROCESS CONTROL AND MONITORING.

4.1.1.6 Analysis 3: Serial connection

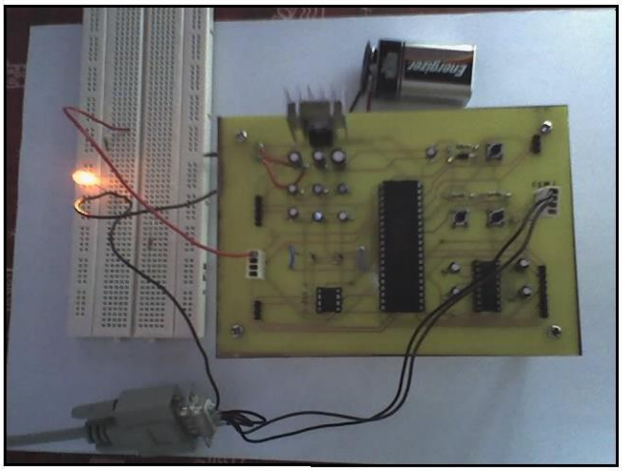


Figure 4.10: LED ON when test using serial connection

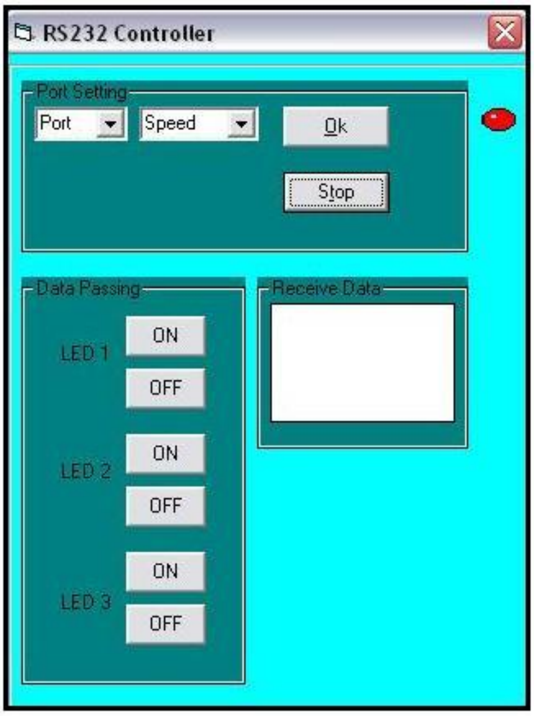


Figure 4.11: Graphical User Interface (GUI) using Visual basic 6

Figure 4.10 is the graphical user interface (GUI) that is design using visual basic 6. In that GUI, there are 3 boxes that are port setting, data passing and receive data.

In the port setting box, the port must be setting at com 1 and the speed at 9600 baud rate. After that click button OK to on the serial port. In data passing box, there are button ON and OFF for each LED. For LED 1, when click button ON, the box receive data will display the word command 1 OK where it shows that the LED is on as in figure 4.9. When click button OFF, the box receive data will display the word command 2 OK where it shows the LED is off. This process will continue until the last LED is ON and OFF.

4.1.1.7 Source code for serial test

```
#include <18F4620.h>
#fuses HS,NOWDT,NOPROTECT,NOLVP
#use delay(clock=25000000)
#use rs232(baud=9600 ,xmit=PIN_C6,rcv=PIN_C7)

unsigned int command;

#define LED1 PIN_A2
#define LED2 PIN_A3
#define LED3 PIN_A4

void print_help(){

   puts("command  function");
   puts("    1      set LED1");
   puts("    2      clr LED1");
   puts("    3      set LED2");
   puts("    4      clr LED2");
   puts("    5      clr LED3");
   puts("    6      clr LED3");
   puts("    ?     help");
}

void send_ok(){
   putc(7);  // send bell back
   printf("\n\rcommand %c ok",command);
}
```

Figure 4.12: Source code for serial test

The code is used port A as output to ON and OFF the LED meanwhile the transmit data and received data used port C. The baud rate is setting at 9600. The transmit data, received data and the baud rate is very important to make sure the connection between the board and the computer is operate for serial port.

4.1.2 Ethernet board

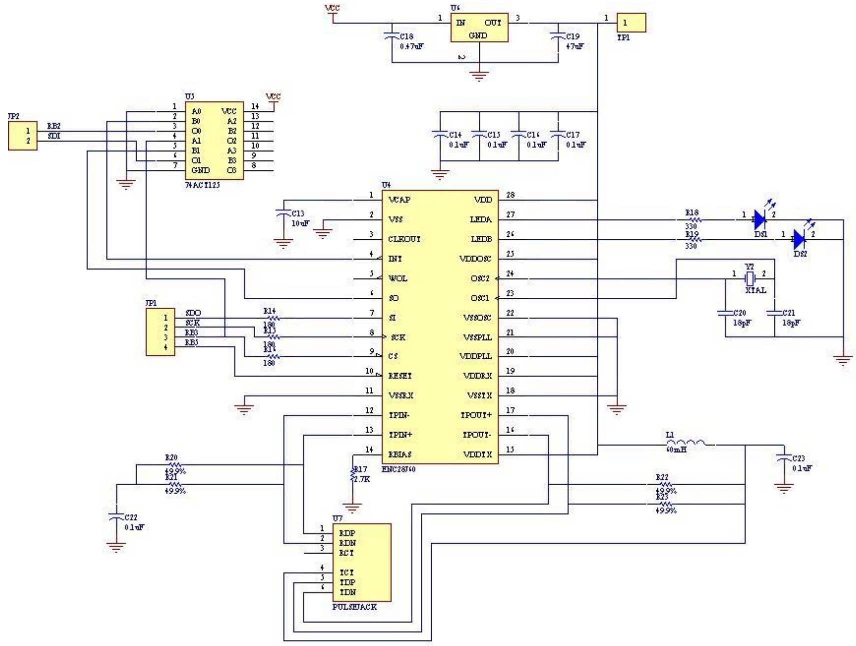


Figure 4.13: Schematic diagram for Ethernet board

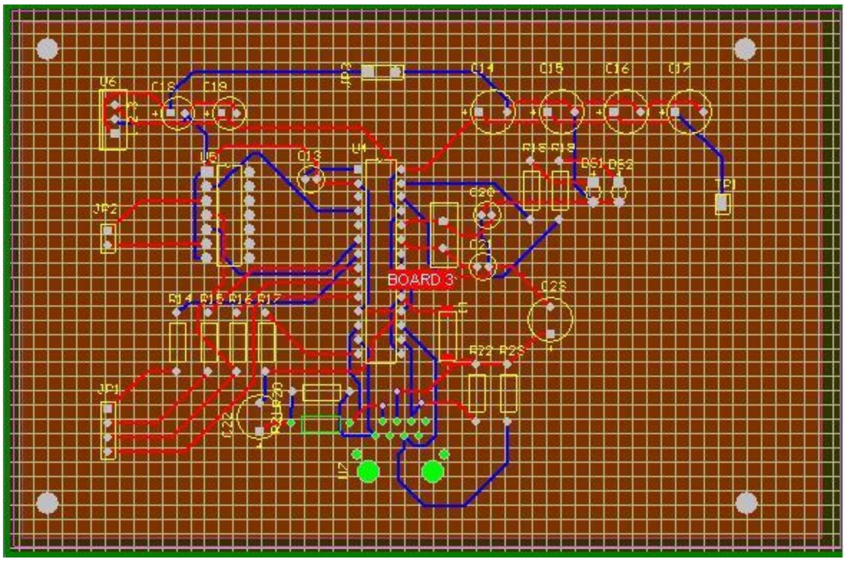


Figure 4.14: PCB layout for Ethernet board

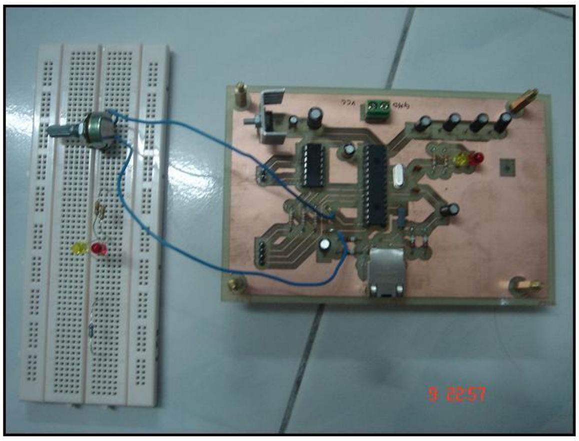


Figure 4.15: Prototype of Ethernet board

Ethernet circuit has been developed following the schematic diagram in figure 4.13. The figure 4.12 shows that the prototype of Ethernet circuit that produce with PCB board. The function of this circuit was tested with supply the 5VDC voltage where the power supply comes from the PIC board. Multimeter was used to check the continuity of circuit or connection between components. The 5VDC voltage was step down to 3.3VDC using voltage regulator because the ENC28J60 chip only can operate in range 3.3VDC voltage only.

4.1.2.1 Analysis 4: Direct local area network (LAN)

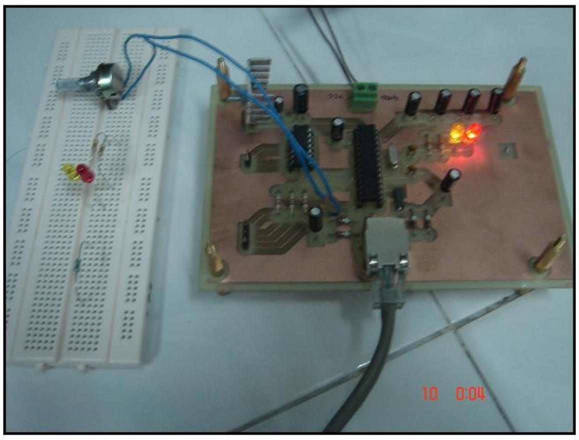


Figure 4.16: LED blinking when test with direct LAN

The analysis shows that the Ethernet board is function when it is been test with direct connection with local area network (LAN) and the LED is blinking. This means that the circuit around ENC28J60 is working.

4.1.3 Combination of PIC board and Ethernet board

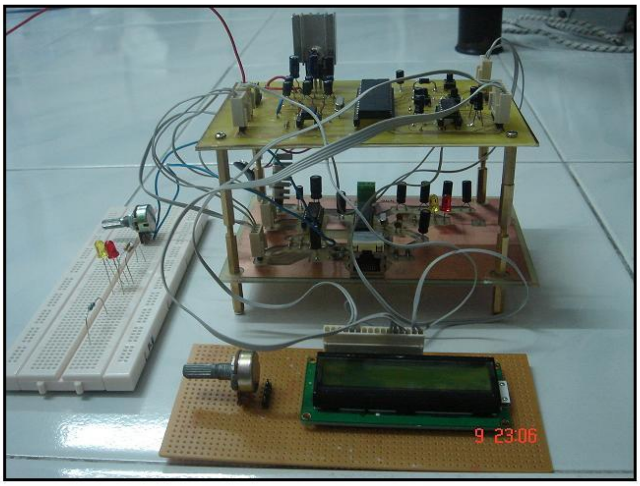


Figure 4.17: PIC board and Ethernet board

The figure 4.14 shows the PIC board and the Ethernet board after combine. The output that we can see are the LED on the Ethernet board will blink about once a second and the LCD will display the word ‘Microchip TCP v3.75.6.’

The Ethernet controller is interface with the PIC over a serial peripheral interface (SPI) with only 4 wires only and then the PIC can be network enable. The four wires that connected between the both boards are:

- SO – data out pin for SPI interface
- SI – data in pin for SPI interface
- SCK – clock in pin for SPI interface
- CS – chip select pin for SPI interface

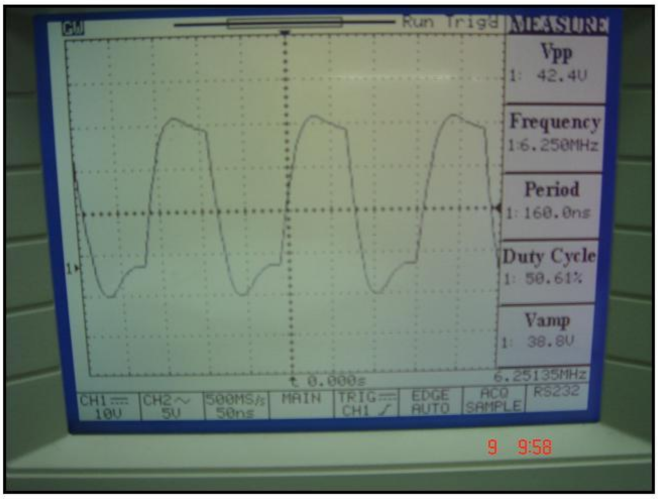


Figure 4.18: CLKOUT for Ethernet board

The figure 4.15 show the default signal on CLKOUT for Ethernet board is 6.25MHz. This means that the ENC28J60 oscillator is working. By using the multimeter, the value for Vcap is 2.62V. It is been in range 2.5V until 2.7V. On the Tx+ and Tx-, the value should be 3.3V. For the RBIAS, the value should be around 2.0V.

CHAPTER 5

CONCLUSION AND FUTURE DEVELOPMENT

5.1 Conclusion

In this project, the analysis will be done by test the board part by part. The analysis that has been done showed that the PIC board is function as well as for the Ethernet board too. The development of this project involves the PCB method to make the prototype. The DXP 2004 software also been used to design the prototype and produce the PCB layout for each board. MPLAB software has been choose to programmed the PIC because it is software that provided by the Microchip and suitable with the peripheral interface controller used (PIC18F4620). The advantage using this TCP/IP on this project that is it can control the system as far as we want but we must have computer along with the internet connection to control it. In industries, it also can maintain the productivity and prevent losses of the product.

5.2 Recommendation

For the future improvement, this project can control and monitored a lot of things. One of the things that it can do is maintain the desired state of such processes we need to keep constant at prescribed values such variables as flows, pressures, levels, temperature, concentrations and others.

5.3 Cost and Commercialization

This part will describe the parts and overall cost fabrication of remote process control and monitoring by using TCP/IP. This part also will explain the commercialization of project.

5.3.1 Project Costing

Table 5.1: The cost of components

Devices	Qty	Model	Unit	Manufacturer	Unit Cost (RM)	Extended Cost (RM)
PIC	1	18F4620		Microchip	RM 44.67	RM 44.67
EEPROM	1	25LC256P		Microchip	RM 11.16	RM 11.16
MAX 232	1				RM 4.00	RM 4.00
Ethernet controller	1	ENC2860		Microchip	RM 24.63	RM 24.63
Quad Bus Buffer	1	74ACT125		Microchip	RM 0.55	RM 0.55
Pulse jack	1	6605759			RM 21.23	RM 21.23
5Vvoltage regulator	1				RM 1.20	RM 1.20
3.3V voltage regulator	1				RM 6.82	RM 6.82
Crystal	2		25Mhz		RM 1.50	RM 3.00
Capacitor	2		18ρF		RM 0.08	RM 0.16
Capacitor	1		0.47μF		RM 0.15	RM 0.15
Capacitor	1		47μF		RM 0.15	RM 0.15
Capacitor	2		15ρF		RM 0.08	RM 0.16
Capacitor	2		1μF		RM 0.08	RM 0.16

Capacitor	17		0.1µF		RM 0.10	RM 1.70
Capacitor	1		100µF		RM 0.15	RM 0.15
Capacitor	1		10µF		RM 0.12	RM 0.12
Resistor	2		330Ω		RM 0.06	RM 0.12
Resistor	4		49.9Ω 1%		RM 0.06	RM 0.24
Resistor	1		2.7kΩ		RM 0.06	RM 0.06
Resistor	1		10kΩ		RM 0.06	RM 0.06
Inductor ferrite bead	1				RM 2.19	RM 2.19
Diode	1		1N5818		RM 0.10	RM 0.10
LCD	1	2X16 JHD16A			RM 15.00	RM 15.00
LED	4				RM 0.15	RM 0.60
Reset button	2				RM 1.00	RM 2.00
Terminal block	2				RM 0.50	RM 1.00
Header	10				RM 0.50	RM 5.00
Connector	8				RM 3.04	RM 24.32
DB9	1		Female		RM 0.50	RM 0.50
					Total	**RM 171.20**

5.3.2 Commercialization

The overall cost of the whole project is based on the hardware development. As discussed in previous chapter, the hardware development consists of two boards. Therefore the whole project cost is depends on the cost of electronic devices.

From the project costing, the overall cost to fabricate this remote process control and monitoring by using TCP/IP is about RM 171.20. The cost is not very expensive even though there are some components that we need to order outside from Malaysia.

This project can be upgraded as mentioned in future developments by using the others device to control but the price may be increase a little bit because we use different devices. Furthermore, the system can be redesigned to compatible with the system that we want to control. So, the product has highly potential to be commercialized.

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Accessed on: 4 April 2008

APPENDIX A

Schematic Diagram for PIC board

APPENDIX B

Schematic Diagram for Ethernet board

APPENDIX C

Main program for TCP/IP stack

```
#if defined(__C30__)
int main(void)
#else
void main(void)
#endif
{
#if defined(USE_LCD) && (LCD_ROWS == 2)
   BYTE lcd_cycle = 0;
#endif

#if defined(USE_TIME)
   time_t time;
   tm tm_time;
#endif

   char buffer[30];
   static TICK t = 0;

   InitializeBoard();          // Initialize hardware

#if defined(USE_LCD)
   LCDInit();                  // Initialize LCD module
   DelayMs(50);

   // Load in some custom chars on the LCD character generation RAM
   LCDLoadCGRAM(1,(ROM char *) &CGCHAR01);
   LCDLoadCGRAM(2,(ROM char *) &CGCHAR02);
   LCDLoadCGRAM(3,(ROM char *) &CGCHAR03);
   LCDLoadCGRAM(4,(ROM char *) &CGCHAR04);
   LCDLoadCGRAM(5,(ROM char *) &CGCHAR05);
   LCDLoadCGRAM(6,(ROM char *) &CGCHAR06);

   // Display software version and current IP address
   strcpypgm2ram((char *)&LCDBuffer[0][0],(ROM char *)"\001\002\003Microchip
TCP");
   strcpypgm2ram((char *)&LCDBuffer[1][0],(ROM char *)"\004\005\006 v"
VERSION);

   LCDRefresh();
   DelayMs(250);
#endif

#if defined(USE_TIME)
   SetTimeTick(220924800ul);  // Jan 1 2007, 00:00:00 UTC
#endif

   TickInit();                 // Initialize tick manager
```

```
#if defined(USE_TIME) && defined(TIME_SOURCE_32KTIMER)
   Init32KTimer();
#endif

#if defined(MPFS_USE_EEPROM) || defined(MPFS_USE_PGRM)
   MPFSInit();              // Initialize file system
#endif

   // Load the default NetBIOS Host Name
   memcpypgm2ram( AppConfig.NetBIOSName, DEFAULT_NETBIOS_NAME, 16);
   FormatNetBIOSName((char *)&AppConfig.NetBIOSName);

   InitAppConfig();         // Load configuration vector

#if defined(ENABLE_BUTTON0_CONFIG)
   if(BUTTON0_IO == 0)
   {
      // If BUTTON0 is pressed during startup initiate the
      // configuration menu via the serial interface
      SetConfig();
   }
#endif

   StackInit();             // Initialize TCP/IP stack

#if defined(STACK_USE_HTTP_SERVER)
   HTTPInit();              // Start HTTP server
#endif

#if defined(STACK_USE_FTP_SERVER)
   FTPInit();               // Start FTP server
#endif

#if defined(STACK_USE_DHCP) || defined(STACK_USE_IP_GLEANING)
   if(!AppConfig.Flags.bIsDHCPEnabled)
   {
      // Force IP address display update.
      myDHCPBindCount = 1;

#if defined(STACK_USE_DHCP)
      DHCPDisable();
#endif
   }

#endif
```

```
    while(1)
    {
        if ( TickGetDiff(TickGet(), t) >= TICK_SECOND/2 )
        {
            t = TickGet();
            LED0_IO ^= 1;           // Blink system LED

#if defined(USE_LCD)
            UpdateLCD();
#endif
        }

        StackTask();

#if defined(STACK_USE_HTTP_SERVER)
        HTTPServer();          // Execute HTTP server FSM
#endif

#if defined(STACK_USE_FTP_SERVER)
        FTPServer();           // Execute FTP server FSM
#endif

#if defined(STACK_USE_ANNOUNCE)
        DiscoveryTask();       // Execute announce function
#endif

#if defined(STACK_USE_TCP_EXAMPLE1)
        GenericTCPClient();    // Execute client example
#endif

#if defined(STACK_USE_UDPTEST)
        UDPTest();             // Execute UDP Test routine
#endif

#if defined(ENABLE_USER_PROCESS)
        ProcessIO();           // Execute analog I/O process

        // ADD YOUR SPECIFIC TASKS HERE //
#endif


        if ( DHCPBindCount != myDHCPBindCount )
        {
            myDHCPBindCount = DHCPBindCount;
            putrsUART(NewIP);
            IPAddressToString(&AppConfig.MyIPAddr, buffer);
            putsUART(buffer);
```

```
            putrsUART(CRLF);

#if defined(STACK_USE_ANNOUNCE)
            AnnounceIP();
#endif

        }
    }
}
```

APPENDIX D

Visual Basic program for serial connection

```
Option Explicit
Dim baudrate$, Port%


Private Sub CboPort_Change()

End Sub

Private Sub CmdOK_Click()
On Error GoTo salah:


  If (CboPort.Text = "Port" And CboSpeed.Text = "Speed") Then
     MsgBox "Please Select Your Port and Speed!"
  Exit Sub

  End If



     If CboPort.ListIndex = 0 Then
          Port = 1
        ElseIf CboPort.ListIndex = 1 Then
           Port = 2
        ElseIf CboPort.ListIndex = 2 Then
           Port = 3
        ElseIf CboPort.ListIndex = 3 Then
           Port = 4
        ElseIf CboPort.ListIndex = 4 Then
           Port = 5
        End If

     If CboSpeed.ListIndex = 0 Then
        baudrate = "110"
           ElseIf CboSpeed.ListIndex = 1 Then
              baudrate = "300"
           ElseIf CboSpeed.ListIndex = 2 Then
              baudrate = "600"
           ElseIf CboSpeed.ListIndex = 3 Then
              baudrate = "1200"
           ElseIf CboSpeed.ListIndex = 4 Then
              baudrate = "2400"
           ElseIf CboSpeed.ListIndex = 5 Then
              baudrate = "4800"
           ElseIf CboSpeed.ListIndex = 6 Then
              baudrate = "9600"
           ElseIf CboSpeed.ListIndex = 7 Then
```

```
            baudrate = "14400"
          ElseIf CboSpeed.ListIndex = 8 Then
            baudrate = "19200"
          ElseIf CboSpeed.ListIndex = 9 Then
            baudrate = "28800"
          ElseIf CboSpeed.ListIndex = 10 Then
            baudrate = "38400"
          ElseIf CboSpeed.ListIndex = 11 Then
            baudrate = "56000"
          ElseIf CboSpeed.ListIndex = 12 Then
            baudrate = "57600"
          ElseIf CboSpeed.ListIndex = 13 Then
            baudrate = "115200"
    End If


OpenCommPort
imgConnected.ZOrder

salah:

    If Err Then MsgBox Err.Description

End Sub



Private Sub CmdStop_Click()
If (MSComm1.PortOpen = True) Then
MSComm1.PortOpen = False
imgNotConnected.ZOrder
Else
MsgBox " Port Already Closed"
End If
End Sub

Private Sub Command1_Click()
On Error GoTo salah:

  MSComm1.Output = Trim$(1)


salah:

  If Err Then MsgBox Err.Description

End Sub
```

```
Private Sub Command2_Click()
On Error GoTo salah:

   MSComm1.Output = Trim$(2)


salah:

   If Err Then MsgBox Err.Description
End Sub

Private Sub Command3_Click()
On Error GoTo salah:

   MSComm1.Output = Trim$(3)


salah:

   If Err Then MsgBox Err.Description
End Sub

Private Sub Command4_Click()
On Error GoTo salah:

   MSComm1.Output = Trim$(4)


salah:

   If Err Then MsgBox Err.Description
End Sub

Private Sub Command5_Click()
On Error GoTo salah:

   MSComm1.Output = Trim$(5)


salah:

   If Err Then MsgBox Err.Description
End Sub

Private Sub Command6_Click()
On Error GoTo salah:
```

```
   MSComm1.Output = Trim$(6)


salah:

   If Err Then MsgBox Err.Description
End Sub

Private Sub Form_Load()

'Setting the connection

CboPort.AddItem "COM" & "1"
CboPort.AddItem "COM" & "2"
CboPort.AddItem "COM" & "3"
CboPort.AddItem "COM" & "4"
CboPort.AddItem "COM" & "5"

' Load Speed Settings 1st Port
CboSpeed.AddItem "110"
CboSpeed.AddItem "300"
CboSpeed.AddItem "600"
CboSpeed.AddItem "1200"
CboSpeed.AddItem "2400"
CboSpeed.AddItem "4800"
CboSpeed.AddItem "9600"
CboSpeed.AddItem "14400"
CboSpeed.AddItem "19200"
CboSpeed.AddItem "28800"
CboSpeed.AddItem "38400"
CboSpeed.AddItem "56000"
CboSpeed.AddItem "57600"
CboSpeed.AddItem "115200"


End Sub




Public Sub OpenCommPort()
On Error GoTo salah3:

MSComm1.Settings = baudrate & "n,8,1"

If MSComm1.PortOpen = False Then
  MSComm1.CommPort = Port
```

```
  MSComm1.PortOpen = True

End If
      FrmController.MSComm1.Handshaking = comNone
      FrmController.MSComm1.RTSEnable = True
      FrmController.MSComm1.DTREnable = True
      FrmController.MSComm1.RThreshold = 0
      FrmController.MSComm1.SThreshold = 0

salah3:

   If Err Then MsgBox Err.Description
   Exit Sub

End Sub

Private Sub TimerClearTxt_Timer()

   TxtReceiveData.Text = ""


End Sub

Private Sub TimerReceive_Timer()
Dim InString As String

If MSComm1.InBufferCount > 0 Then
   InString = MSComm1.Input

   TxtReceiveData.SelText = InString & vbCrLf


End If

End Sub
```

APPENDIX E

PIC18F4620 Datasheet

PIC18F2525/2620/4525/4620

28/40/44-Pin Enhanced Flash Microcontrollers with 10-Bit A/D and nanoWatt Technology

Power Management Features:

- Run: CPU on, Peripherals on
- Idle: CPU off, Peripherals on
- Sleep: CPU off, Peripherals off
- Ultra Low 50nA Input Leakage
- Run mode Currents Down to 11 µA Typical
- Idle mode Currents Down to 2.5 µA Typical
- Sleep mode Current Down to 100 nA Typical
- Timer1 Oscillator: 900 nA, 32 kHz, 2V
- Watchdog Timer: 1.4 µA, 2V Typical
- Two-Speed Oscillator Start-up

Flexible Oscillator Structure:

- Four Crystal modes, up to 40 MHz
- 4x Phase Lock Loop (PLL) – Available for Crystal and Internal Oscillators
- Two External RC modes, up to 4 MHz
- Two External Clock modes, up to 40 MHz
- Internal Oscillator Block:
  - Fast wake from Sleep and Idle, 1 µs typical
  - 8 use-selectable frequencies, from 31 kHz to 8 MHz
  - Provides a complete range of clock speeds from 31 kHz to 32 MHz when used with PLL
  - User-tunable to compensate for frequency drift
- Secondary Oscillator using Timer1 @ 32 kHz
- Fail-Safe Clock Monitor:
  - Allows for safe shutdown if peripheral clock stops

Peripheral Highlights:

- High-Current Sink/Source 25 mA/25 mA
- Three Programmable External Interrupts
- Four Input Change Interrupts
- Up to 2 Capture/Compare/PWM (CCP) modules, one with Auto-Shutdown (28-pin devices)
- Enhanced Capture/Compare/PWM (ECCP) module (40/44-pin devices only):
  - One, two or four PWM outputs
  - Selectable polarity
  - Programmable dead time
  - Auto-shutdown and auto-restart

Peripheral Highlights (Continued):

- Master Synchronous Serial Port (MSSP) module Supporting 3-Wire SPI (all 4 modes) and I²C™ Master and Slave modes
- Enhanced Addressable USART module:
  - Supports RS-485, RS-232 and LIN/J2602
  - RS-232 operation using internal oscillator block (no external crystal required)
  - Auto-wake-up on Start bit
  - Auto-Baud Detect
- 10-Bit, up to 13-Channel Analog-to-Digital (A/D) Converter module:
  - Auto-acquisition capability
  - Conversion available during Sleep
- Dual Analog Comparators with Input Multiplexing
- Programmable 16-Level High/Low-Voltage Detection (HLVD) module:
  - Supports interrupt on High/Low-Voltage Detection

Special Microcontroller Features:

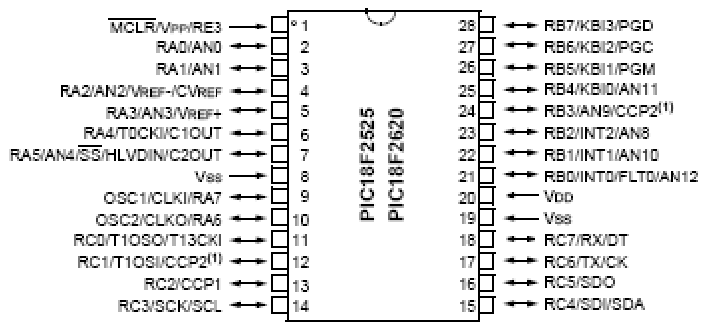
- C Compiler Optimized Architecture:
  - Optional extended instruction set designed to optimize re-entrant code
- 100,000 Erase/Write Cycle Enhanced Flash Program Memory Typical
- 1,000,000 Erase/Write Cycle Data EEPROM Memory Typical
- Flash/Data EEPROM Retention: 100 Years Typical
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
  - Programmable period from 4 ms to 131s
- Single-Supply 5V In-Circuit Serial Programming™ (ICSP™) via Two Pins
- In-Circuit Debug (ICD) via Two Pins
- Wide Operating Voltage Range: 2.0V to 5.5V
- Programmable Brown-out Reset (BOR) with Software Enable Option

Device	Program Memory		Data Memory		I/O	10-Bit A/D (ch)	CCP/ ECCP (PWM)	MSSP		EUSART	Comp.	Timers 8/16-Bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)				SPI	Master I²C™			
PIC18F2525	48K	24576	3968	1024	25	10	2/0	Y	Y	1	2	1/3
PIC18F2620	64K	32768	3968	1024	25	10	2/0	Y	Y	1	2	1/3
PIC18F4525	48K	24576	3968	1024	36	13	1/1	Y	Y	1	2	1/3
PIC18F4620	64K	32768	3968	1024	36	13	1/1	Y	Y	1	2	1/3

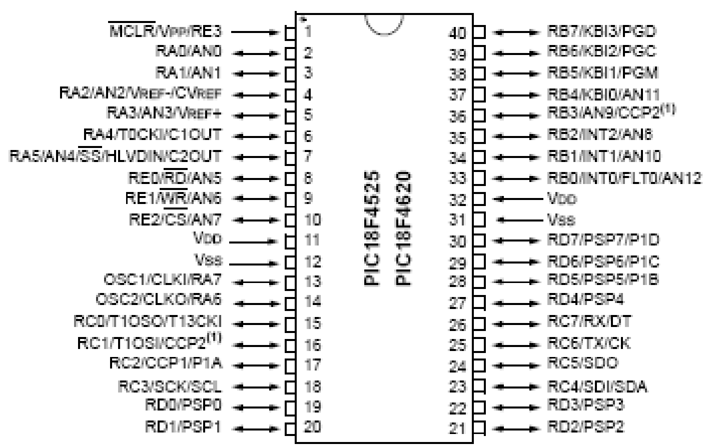
PIC18F2525/2620/4525/4620

Pin Diagrams

28-Pin SPDIP, SOIC



40-Pin PDIP



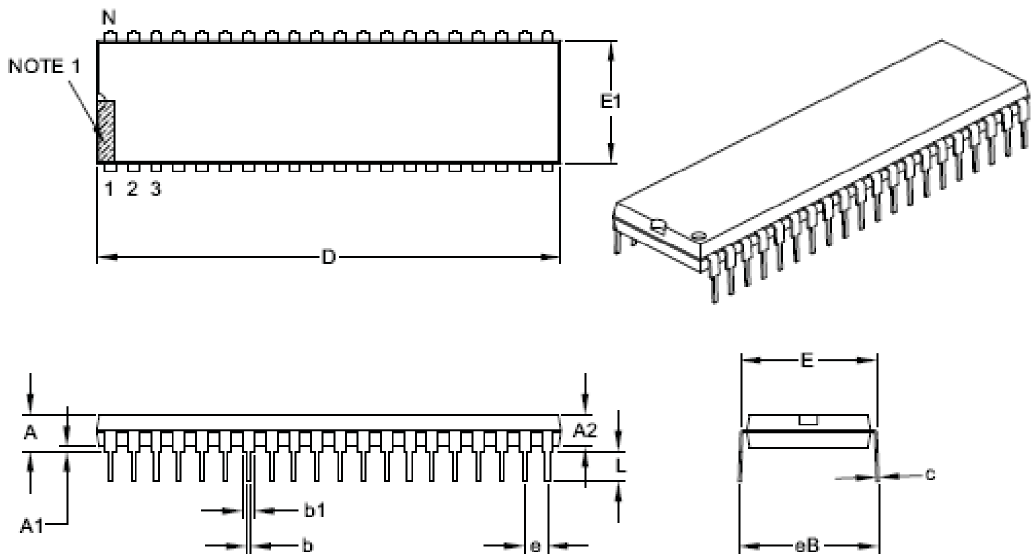
Note 1: RB3 is the alternate pin for CCP2 multiplexing.

TABLE 1-1: DEVICE FEATURES

Features	PIC18F2525	PIC18F2620	PIC18F4525	PIC18F4620
Operating Frequency	DC – 40 MHz	DC – 40 MHz	DC – 40 MHz	DC – 40 MHz
Program Memory (Bytes)	49152	65536	49152	65536
Program Memory (Instructions)	24576	32768	24576	32768
Data Memory (Bytes)	3968	3968	3968	3968
Data EEPROM Memory (Bytes)	1024	1024	1024	1024
Interrupt Sources	19	19	20	20
I/O Ports	Ports A, B, C, (E)	Ports A, B, C, (E)	Ports A, B, C, D, E	Ports A, B, C, D, E
Timers	4	4	4	4
Capture/Compare/PWM Modules	2	2	1	1
Enhanced Capture/Compare/ PWM Modules	0	0	1	1
Serial Communications	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART
Parallel Communications (PSP)	No	No	Yes	Yes
10-Bit Analog-to-Digital Module	10 Input Channels	10 Input Channels	13 Input Channels	13 Input Channels
Resets (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), MCLR (optional), WDT
Programmable Low-Voltage Detect	Yes	Yes	Yes	Yes
Programmable Brown-out Reset	Yes	Yes	Yes	Yes
Instruction Set	75 Instructions; 83 with Extended Instruction Set Enabled	75 Instructions; 83 with Extended Instruction Set Enabled	75 Instructions; 83 with Extended Instruction Set Enabled	75 Instructions; 83 with Extended Instruction Set Enabled
Packages	28-Pin SPDIP 28-Pin SOIC	28-Pin SPDIP 28-Pin SOIC	40-Pin PDIP 44-Pin QFN 44-Pin TQFP	40-Pin PDIP 44-Pin QFN 44-Pin TQFP

40-Lead Plastic Dual In-Line (P) – 600 mil Body [PDIP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		INCHES		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		40	
Pitch	e		.100 BSC	
Top to Seating Plane	A	–	–	.250
Molded Package Thickness	A2	.125	–	.195
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.590	–	.625
Molded Package Width	E1	.485	–	.580
Overall Length	D	1.980	–	2.095
Tip to Seating Plane	L	.115	–	.200
Lead Thickness	c	.008	–	.015
Upper Lead Width	b1	.030	–	.070
Lower Lead Width	b	.014	–	.023
Overall Row Spacing §	eB	–	–	.700

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic.
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-016B

APPENDIX F

ENC29J60 Datasheet

MICROCHIP

ENC28J60

Stand-Alone Ethernet Controller with SPI™ Interface

Ethernet Controller Features

- IEEE 802.3 compatible Ethernet controller
- Integrated MAC and 10BASE-T PHY
- Receiver and collision squelch circuit
- Supports one 10BASE-T port with automatic polarity detection and correction
- Supports Full and Half-Duplex modes
- Programmable automatic retransmit on collision
- Programmable padding and CRC generation
- Programmable automatic rejection of erroneous packets
- SPI™ Interface with speeds up to 10 Mb/s

Buffer

- 8-Kbyte transmit/receive packet dual port SRAM
- Configurable transmit/receive buffer size
- Hardware-managed circular receive FIFO
- Byte-wide random and sequential access with auto-increment
- Internal DMA for fast data movement
- Hardware assisted IP checksum calculation

Medium Access Controller (MAC) Features

- Supports Unicast, Multicast and Broadcast packets
- Programmable receive packet filtering and wake-up host on logical AND or OR of the following:
  - Unicast destination address
  - Multicast address
  - Broadcast address
  - Magic Packet™
  - Group destination addresses as defined by 64-bit hash table
  - Programmable pattern matching of up to 64 bytes at user-defined offset
- Loopback mode

Physical Layer (PHY) Features

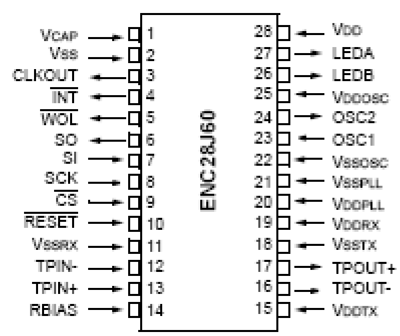
- Wave shaping output filter
- Loopback mode

Operational

- Two programmable LED outputs for LINK, TX, RX, collision and full/half-duplex status
- Seven interrupt sources with two interrupt pins
- 25 MHz clock
- Clock out pin with programmable prescaler
- Operating voltage range of 3.14V to 3.45V
- TTL level inputs
- Temperature range: -40°C to +85°C Industrial, 0°C to +70°C Commercial (SSOP only)
- 28-pin SPDIP, SSOP, SOIC, QFN packages

Package Types

28-Pin SPDIP, SSOP, SOIC



28-pin QFN

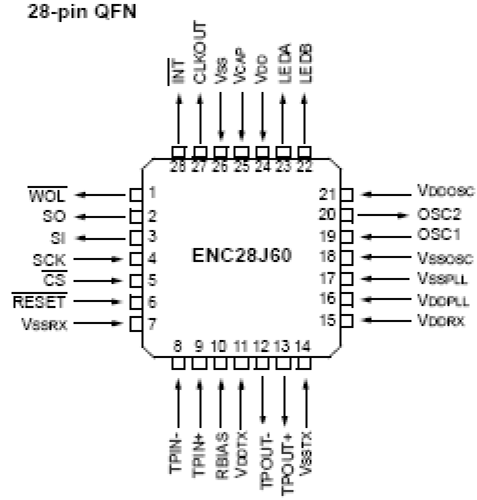


FIGURE 1-2: TYPICAL ENC28J60-BASED INTERFACE

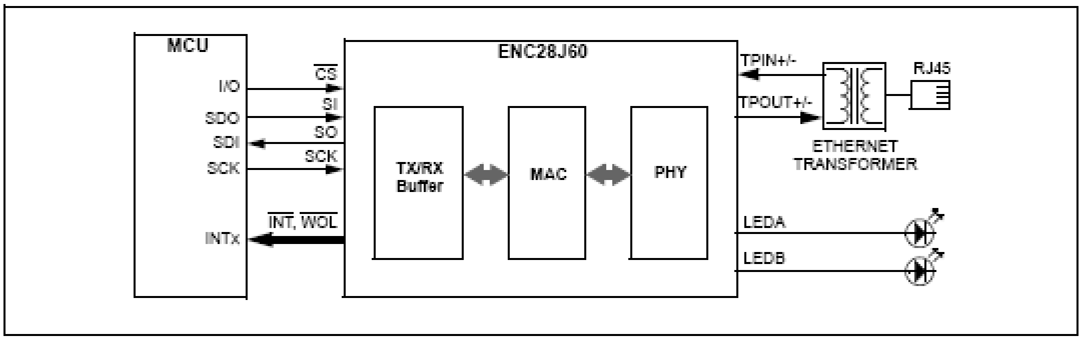


TABLE 1-1: PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number		Pin Type	Buffer Type	Description
	SPDIP, SOIC, SSOP	QFN			
V_{CAP}	1	25	P	—	2.5V output from internal regulator. A 10 μF capacitor to V_{SSTX} must be placed on this pin.
V_{SS}	2	26	P	—	Ground reference.
CLKOUT	3	27	O	—	Programmable clock output pin.[1]
$\overline{INT}$	4	28	O	—	INT interrupt output pin.[2]
$\overline{WOL}$	5	1	O	—	Wake-up on LAN interrupt out pin.[2]
SO	6	2	O	—	Data out pin for SPI™ interface.[2]
SI	7	3	I	ST	Data in pin for SPI interface.[3]
SCK	8	4	I	ST	Clock in pin for SPI interface.[3]
$\overline{CS}$	9	5	I	ST	Chip select input pin for SPI interface.[3,4]
$\overline{RESET}$	10	6	I	ST	Active-low device Reset input.[3, 4]
V_{SSRX}	11	7	P	—	Ground reference for PHY RX.
TPIN-	12	8	I	ANA	Differential signal input.
TPIN+	13	9	I	ANA	Differential signal input.
RBIAS	14	10	I	ANA	Bias current pin for PHY. Must be tied to V_{SSRX} through a 2 kΩ, 1% resistor.
V_{DDTX}	15	11	P	—	Positive supply for PHY TX.
TPOUT-	16	12	O	—	Differential signal output.
TPOUT+	17	13	O	—	Differential signal output.
V_{SSTX}	18	14	P	—	Ground reference for PHY TX.
V_{DDRX}	19	15	P	—	Positive 3.3V supply for PHY RX.
V_{DDPLL}	20	16	P	—	Positive 3.3V supply for PHY PLL.
V_{SSPLL}	21	17	P	—	Ground reference for PHY PLL.
V_{SSOSC}	22	18	P	—	Ground reference for oscillator.
OSC1	23	19	I	DIG	Oscillator input.
OSC2	24	20	O	—	Oscillator output.
V_{DDOSC}	25	21	P	—	Positive 3.3V supply for oscillator.
LEDB	26	22	O	—	LEDB driver pin.[6]
LEDA	27	23	O	—	LEDA driver pin.[6]
V_{DD}	28	24	P	—	Positive 3.3V supply.

Legend: I = Input, O = Output, P = Power, DIG = Digital input, ANA = Analog signal input, ST = Schmitt Trigger

Note 1: Pins have a maximum current capacity of 8 mA.
2: Pins have a maximum current capacity of 4 mA.
3: Pins are 5V tolerant.
4: Pins have an internal weak pull-up to V_{DD}.
5: Pins have a maximum current capacity of 12 mA.

2.4 Magnetics, Termination and Other External Components

To complete the Ethernet interface, the ENC28J60 requires several standard components to be installed externally. These components should be connected as shown in Figure 2-4.

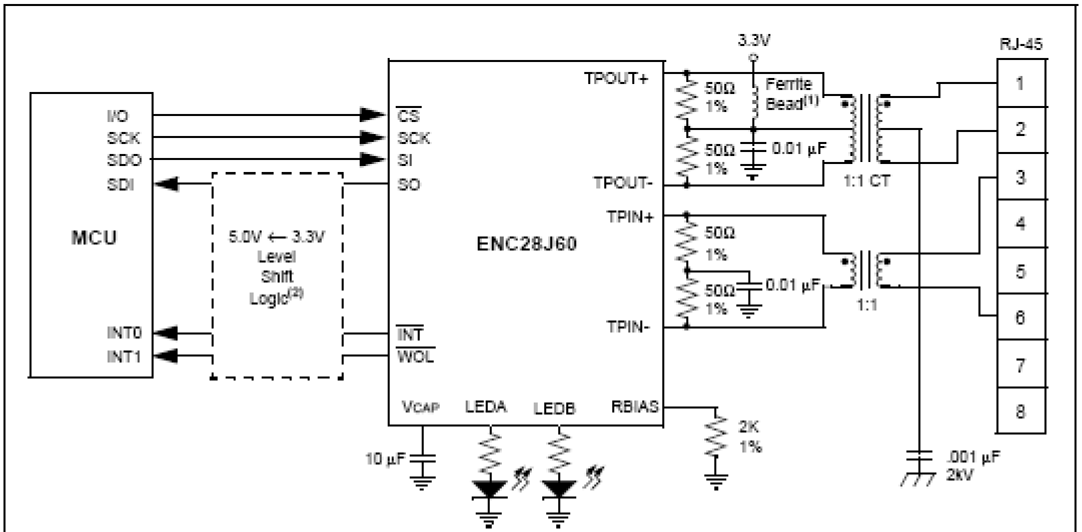
On the differential receive pins (TPIN+/TPIN-), a 1:1 pulse transformer rated for 10BASE-T operation is required. On the differential transmit pins (TPOUT+/TPOUT-), a 1:1 pulse transformer with a center tap is required. The transformers should be rated for isolation of 2 kV or more to protect against static voltages. See **Section 16.0 "Electrical Characteristics"** for specific transformer requirements. Both portions additionally require two 50Ω, 1% resistors and a 0.01 µF capacitor for proper termination.

The internal analog circuitry in the ENC28J60 requires that an external 2 kΩ, 1% resistor be attached from RBIAS to ground.

Some of the digital circuitry in the ENC28J60 operates at a nominal 2.5V to reduce power consumption. A 2.5V regulator is incorporated internally to generate the necessary voltage. The only external component required is a 10 µF capacitor for stability purposes. This capacitor should be attached from VCAP to ground. The internal regulator was not designed to drive external loads.

All power supply pins must be externally connected to the same 3.3V power source. Similarly, all ground references should be externally connected to the same ground node. Each VDD and VSS pin pair should have a 0.1 µF ceramic bypass capacitor placed as close to the pins as possible. Relatively high currents are necessary to operate the twisted pair interface, so all wires should be kept as short as possible and reasonable wire widths should be used on power wires to reduce resistive loss.

FIGURE 2-4: EXTERNAL CONNECTIONS



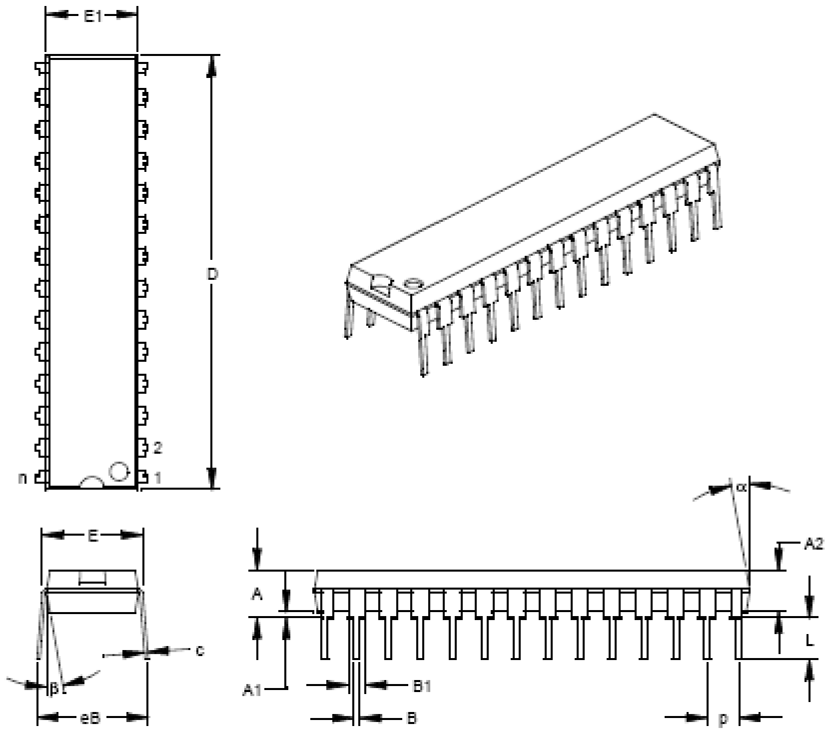
Note 1: Ferrite Bead should be rated for at least 100 mA.
2: Required only if the microcontroller is operating at 5V.

ENC28J60

17.2 Package Details

The following sections give the technical details of the packages.

28-Lead Skinny Plastic Dual In-line (SP) – 300 mil Body (PDIP)



	Units	INCHES*			MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		28			28	
Pitch	p		.100			2.54	
Top to Seating Plane	A	.140	.150	.160	3.56	3.81	4.06
Molded Package Thickness	A2	.125	.130	.135	3.18	3.30	3.43
Base to Seating Plane	A1	.015			0.38		
Shoulder to Shoulder Width	E	.300	.310	.325	7.62	7.87	8.26
Molded Package Width	E1	.275	.285	.295	6.99	7.24	7.49
Overall Length	D	1.345	1.365	1.385	34.16	34.67	35.18
Tip to Seating Plane	L	.125	.130	.135	3.18	3.30	3.43
Lead Thickness	c	.008	.012	.015	0.20	0.29	0.38
Upper Lead Width	B1	.040	.053	.065	1.02	1.33	1.65
Lower Lead Width	B	.016	.019	.022	0.41	0.48	0.56
Overall Row Spacing §	eB	.320	.350	.430	8.13	8.89	10.92
Mold Draft Angle Top	α	5	10	15	5	10	15
Mold Draft Angle Bottom	β	5	10	15	5	10	15

* Controlling Parameter
§ Significant Characteristic
Notes:
Dimension D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.
JEDEC Equivalent: MO-095
Drawing No. C04-070

APPENDIX G

25LC256P EEPROM Datasheet

25AA256/25LC256

256K SPI™ Bus Serial EEPROM

Device Selection Table

Part Number	Vcc Range	Page Size	Temp. Ranges	Packages
25LC256	2.5-5.5V	64 Byte	I, E	P, SN, ST, MF
25AA256	1.8-5.5V	64 Byte	I	P, SN, ST, MF

Features

- Max. clock 10 MHz
- Low-power CMOS technology
  - Max. Write Current: 5 mA at 5.5V, 10 MHz
  - Read Current: 5 mA at 5.5V, 10 MHz
  - Standby Current: 1 µA at 5.5V
- 32,768 x 8-bit organization
- 64 byte page
- Self-timed ERASE and WRITE cycles (5 ms max.)
- Block write protection
  - Protect none, 1/4, 1/2 or all of array
- Built-in write protection
  - Power-on/off data protection circuitry
  - Write enable latch
  - Write-protect pin
- Sequential read
- High reliability
  - Endurance: 1,000,000 erase/write cycles
  - Data retention: > 200 years
  - ESD protection: > 4000V
- Temperature ranges supported;
  - Industrial (I): -40°C to +85°C
  - Automotive (E): -40°C to +125°C
- Standard and Pb-free packages available

Pin Function Table

Name	Function
$\overline{CS}$	Chip Select Input
SO	Serial Data Output
$\overline{WP}$	Write-Protect
Vss	Ground
SI	Serial Data Input
SCK	Serial Clock Input
$\overline{HOLD}$	Hold Input
Vcc	Supply Voltage

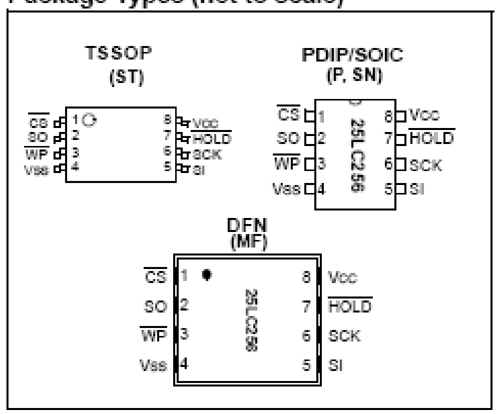
Description

The Microchip Technology Inc. 25AA256/25LC256 (25XX256*) are 256k-bit Serial Electrically Erasable PROMs. The memory is accessed via a simple Serial Peripheral Interface™ (SPI™) compatible serial bus. The bus signals required are a clock input (SCK) plus separate data in (SI) and data out (SO) lines. Access to the device is controlled through a Chip Select ($\overline{CS}$) input.

Communication to the device can be paused via the hold pin ($\overline{HOLD}$). While the device is paused, transitions on its inputs will be ignored, with the exception of Chip Select, allowing the host to service higher priority interrupts.

The 25XX256 is available in standard packages including 8-lead PDIP and SOIC, and advanced packaging including 8-lead DFN and 8-lead TSSOP. Pb-free (Pure Sn) finish is also available.

Package Types (not to scale)



SPI is a registered trademark of Motorola Corporation.

* 25XX256 is used in this document as a generic part number for the 25AA256, 25LC256 devices.

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Name	Pin Number	Function
$\overline{CS}$	1	Chip Select Input
SO	2	Serial Data Output
$\overline{WP}$	3	Write-Protect Pin
Vss	4	Ground
SI	5	Serial Data Input
SCK	6	Serial Clock Input
$\overline{HOLD}$	7	Hold Input
Vcc	8	Supply Voltage

3.1 Chip Select ($\overline{CS}$)

A low level on this pin selects the device. A high level deselects the device and forces it into Standby mode. However, a programming cycle which is already initiated or in progress will be completed, regardless of the $\overline{CS}$ input signal. If $\overline{CS}$ is brought high during a program cycle, the device will go into Standby mode as soon as the programming cycle is complete. When the device is deselected, SO goes to the high-impedance state, allowing multiple parts to share the same SPI bus. A low-to-high transition on $\overline{CS}$ after a valid write sequence initiates an internal write cycle. After power-up, a low level on $\overline{CS}$ is required prior to any sequence being initiated.

3.2 Serial Output (SO)

The SO pin is used to transfer data out of the 25XX256. During a read cycle, data is shifted out on this pin after the falling edge of the serial clock.

3.3 Write-Protect ($\overline{WP}$)

This pin is used in conjunction with the WPEN bit in the Status register to prohibit writes to the nonvolatile bits in the Status register. When $\overline{WP}$ is low and WPEN is high, writing to the nonvolatile bits in the Status register is disabled. All other operations function normally. When $\overline{WP}$ is high, all functions, including writes to the nonvolatile bits in the Status register, operate normally. If the WPEN bit is set, $\overline{WP}$ low during a Status register write sequence will disable writing to the Status register. If an internal write cycle has already begun, $\overline{WP}$ going low will have no effect on the write.

The $\overline{WP}$ pin function is blocked when the WPEN bit in the Status register is low. This allows the user to install the 25XX256 in a system with $\overline{WP}$ pin grounded and still be able to write to the Status register. The $\overline{WP}$ pin functions will be enabled when the WPEN bit is set high.

3.4 Serial Input (SI)

The SI pin is used to transfer data into the device. It receives instructions, addresses and data. Data is latched on the rising edge of the serial clock.

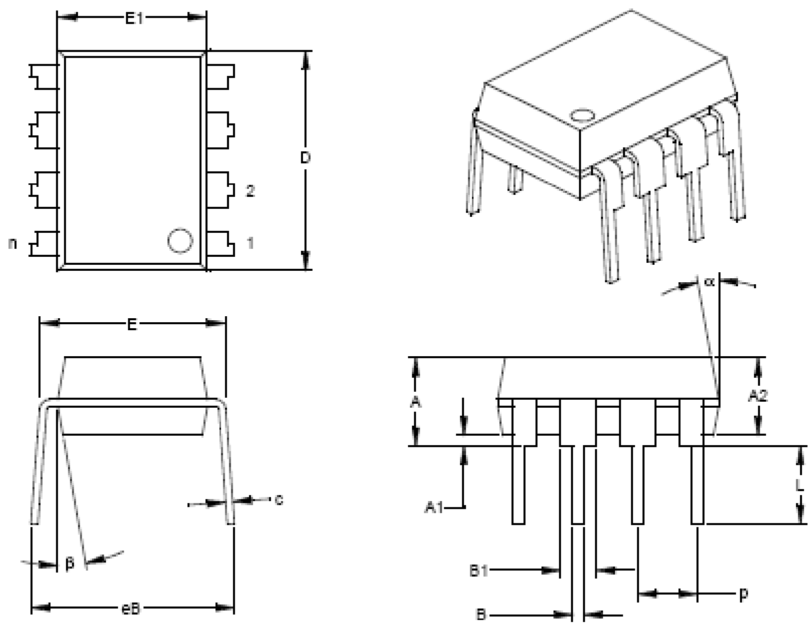
3.5 Serial Clock (SCK)

The SCK is used to synchronize the communication between a master and the 25XX256. Instructions, addresses or data present on the SI pin are latched on the rising edge of the clock input, while data on the SO pin is updated after the falling edge of the clock input.

3.6 Hold ($\overline{HOLD}$)

The $\overline{HOLD}$ pin is used to suspend transmission to the 25XX256 while in the middle of a serial sequence without having to retransmit the entire sequence again. It must be held high any time this function is not being used. Once the device is selected and a serial sequence is underway, the $\overline{HOLD}$ pin may be pulled low to pause further serial communication without resetting the serial sequence. The $\overline{HOLD}$ pin must be brought low while SCK is low, otherwise the HOLD function will not be invoked until the next SCK high-to-low transition. The 25XX256 must remain selected during this sequence. The SI, SCK and SO pins are in a high-impedance state during the time the device is paused and transitions on these pins will be ignored. To resume serial communication, $\overline{HOLD}$ must be brought high while the SCK pin is low, otherwise serial communication will not resume. Lowering the HOLD line at any time will tri-state the SO line.

8-Lead Plastic Dual In-line (P) – 300 mil (PDIP)



	Units	INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.100			2.54	
Top to Seating Plane	A	.140	.155	.170	3.56	3.94	4.32
Molded Package Thickness	A2	.115	.130	.145	2.92	3.30	3.68
Base to Seating Plane	A1	.015			0.38		
Shoulder to Shoulder Width	E	.300	.313	.325	7.62	7.94	8.26
Molded Package Width	E1	.240	.250	.260	6.10	6.35	6.60
Overall Length	D	.360	.373	.385	9.14	9.46	9.78
Tip to Seating Plane	L	.125	.130	.135	3.18	3.30	3.43
Lead Thickness	c	.008	.012	.015	0.20	0.29	0.38
Upper Lead Width	B1	.045	.058	.070	1.14	1.46	1.78
Lower Lead Width	B	.014	.018	.022	0.36	0.46	0.56
Overall Row Spacing §	eB	.310	.370	.430	7.87	9.40	10.92
Mold Draft Angle Top	α	5	10	15	5	10	15
Mold Draft Angle Bottom	β	5	10	15	5	10	15

* Controlling Parameter
§ Significant Characteristic

Notes:
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.
JEDEC Equivalent: MS-001
Drawing No. C04-018

APPENDIX H

MAX232 Datasheet

19-4323; Rev 11; 2/03

MAXIM

+5V-Powered, Multichannel RS-232 Drivers/Receivers

MAX220–MAX249

General Description

The MAX220–MAX249 family of line drivers/receivers is intended for all EIA/TIA-232E and V.28/V.24 communications interfaces, particularly applications where ±12V is not available.

These parts are especially useful in battery-powered systems, since their low-power shutdown mode reduces power dissipation to less than 5μW. The MAX225, MAX233, MAX235, and MAX245/MAX246/MAX247 use no external components and are recommended for applications where printed circuit board space is critical.

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multidrop RS-232 Networks

Features

Superior to Bipolar

- ♦ **Operate from Single +5V Power Supply (+5V and +12V—MAX231/MAX239)**
- ♦ **Low-Power Receive Mode in Shutdown (MAX223/MAX242)**
- ♦ **Meet All EIA/TIA-232E and V.28 Specifications**
- ♦ **Multiple Drivers and Receivers**
- ♦ **3-State Driver and Receiver Outputs**
- ♦ **Open-Line Detection (MAX243)**

Ordering Information

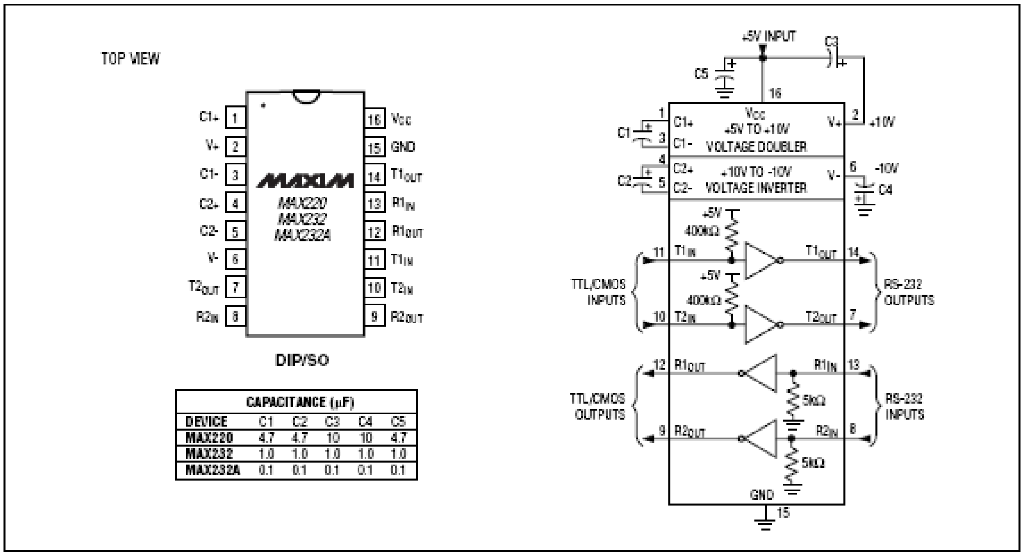
PART	TEMP RANGE	PIN-PACKAGE
MAX220CPE	0°C to +70°C	16 Plastic DIP
MAX220CSE	0°C to +70°C	16 Narrow SO
MAX220CWE	0°C to +70°C	16 Wide SO
MAX220C/D	0°C to +70°C	Dice*
MAX220EPE	-40°C to +85°C	16 Plastic DIP
MAX220ESE	-40°C to +85°C	16 Narrow SO
MAX220EWE	-40°C to +85°C	16 Wide SO
MAX220EJE	-40°C to +85°C	16 CERDIP
MAX220MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.

**Contact factory for dice specifications.*

Selection Table

Part Number	Power Supply (V)	No. of RS-232 Drivers/Rx	No. of Ext. Caps	Nominal Cap. Value (μF)	SHDN & Three-State	Rx Active in SHDN	Data Rate (kbps)	Features
MAX220	+5	2/2	4	0.1	No	—	120	Ultra-low-power, industry-standard pinout
MAX222	+5	2/2	4	0.1	Yes	—	200	Low-power shutdown
MAX223 (MAX213)	+5	4/5	4	1.0 (0.1)	Yes	✔	120	MAX241 and receivers active in shutdown
MAX225	+5	5/5	0	—	Yes	✔	120	Available in SO
MAX230 (MAX200)	+5	5/0	4	1.0 (0.1)	Yes	—	120	5 drivers with shutdown
MAX231 (MAX201)	+5 and +7.5 to +13.2	2/2	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; same functions as MAX232
MAX232 (MAX202)	+5	2/2	4	1.0 (0.1)	No	—	120 (64)	Industry standard
MAX232A	+5	2/2	4	0.1	No	—	200	Higher slew rate, small caps
MAX233 (MAX203)	+5	2/2	0	—	No	—	120	No external caps
MAX233A	+5	2/2	0	—	No	—	200	No external caps, high slew rate
MAX234 (MAX204)	+5	4/0	4	1.0 (0.1)	No	—	120	Replaces 1488
MAX235 (MAX205)	+5	5/5	0	—	Yes	—	120	No external caps
MAX236 (MAX206)	+5	4/3	4	1.0 (0.1)	Yes	—	120	Shutdown, three state
MAX237 (MAX207)	+5	5/3	4	1.0 (0.1)	No	—	120	Complements IBM PC serial port
MAX238 (MAX208)	+5	4/4	4	1.0 (0.1)	No	—	120	Replaces 1488 and 1489
MAX239 (MAX209)	+5 and +7.5 to +13.2	3/5	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; single-package solution for IBM PC serial port
MAX240	+5	5/5	4	1.0	Yes	—	120	DIP or flatpack package
MAX241 (MAX211)	+5	4/5	4	1.0 (0.1)	Yes	—	120	Complete IBM PC serial port
MAX242	+5	2/2	4	0.1	Yes	✔	200	Separate shutdown and enable
MAX243	+5	2/2	4	0.1	No	—	200	Open-line detection simplifies cabling
MAX244	+5	8/10	4	1.0	No	—	120	High slew rate
MAX245	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, two shutdown modes
MAX246	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, three shutdown modes
MAX247	+5	8/9	0	—	Yes	✔	120	High slew rate, int. caps, nine operating modes
MAX248	+5	8/8	4	1.0	Yes	✔	120	High slew rate, selective half-chip enables
MAX249	+5	6/10	4	1.0	Yes	✔	120	Available in quad flatpack package



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 5. MAX220/MAX232/MAX232A Pin Configuration and Typical Operating Circuit

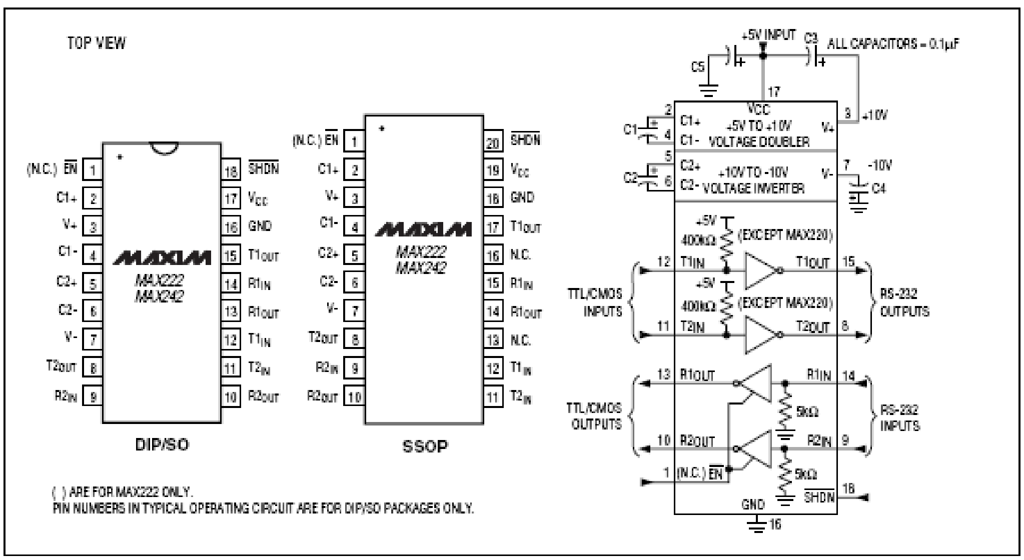


Figure 6. MAX222/MAX242 Pin Configurations and Typical Operating Circuit

APPENDIX I

LM3940 Datasheet

National Semiconductor

May 1999

LM3940
1A Low Dropout Regulator for 5V to 3.3V Conversion

General Description

The LM3940 is a 1A low dropout regulator designed to provide 3.3V from a 5V supply.

The LM3940 is ideally suited for systems which contain both 5V and 3.3V logic, with prime power provided from a 5V bus.

Because the LM3940 is a true low dropout regulator, it can hold its 3.3V output in regulation with input voltages as low as 4.5V.

The T0-220 package of the LM3940 means that in most applications the full 1A of load current can be delivered without using an additional heatsink.

The surface mount TO-263 package uses minimum board space, and gives excellent power dissipation capability when soldered to a copper plane on the PC board.

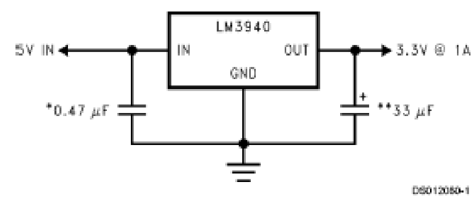
Features

- Output voltage specified over temperature
- Excellent load regulation
- Guaranteed 1A output current
- Requires only one external component
- Built-in protection against excess temperature
- Short circuit protected

Applications

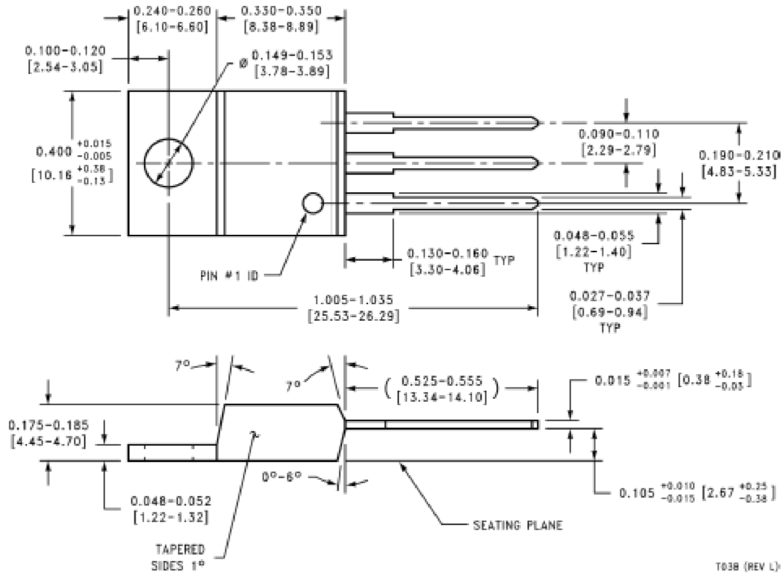
- Laptop/Desktop Computers
- Logic Systems

Typical Application



*Required if regulator is located more than 1" from the power supply filter capacitor or if battery power is used.
**See Application Hints.

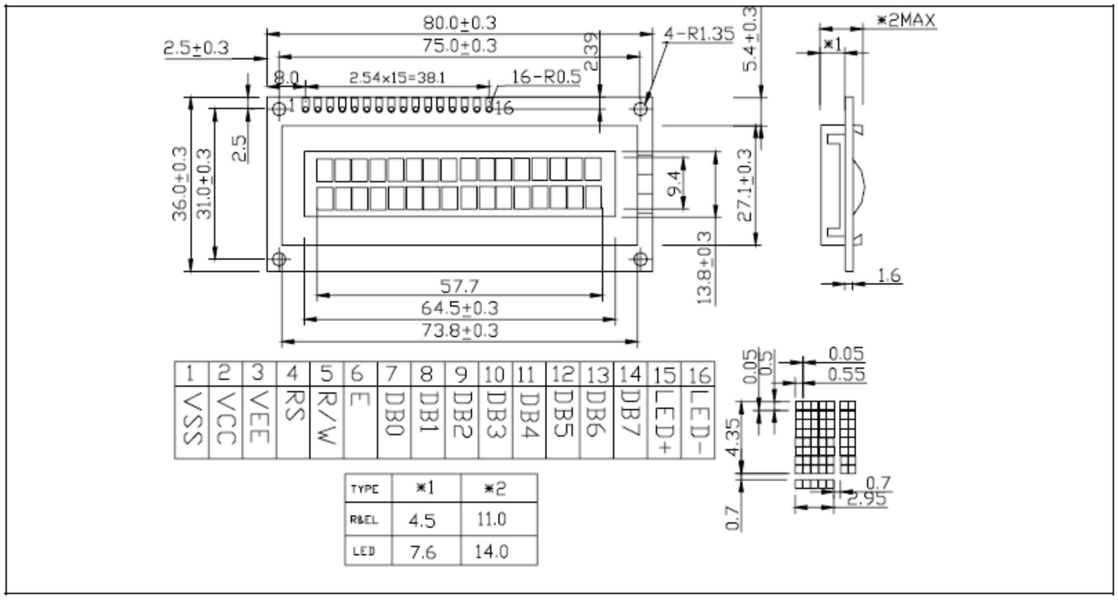
Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



3-Lead TO-220 Package
Order Part Number LM3940IT-3.3
NSC Package Number TO3B

APPENDIX J

LCD JHD162A Datasheet



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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
VSS	VCC	VEE	RS	R/W	E	DB0	DB1	DB2	DB3	DB4	DB5	DB6	DB7	LED+	LED-

■ **AC Characteristics Read Mode Timing Diagram**

APPENDIX K

74ACT125 QUAD BUFFER Datasheet

National Semiconductor

March 1993

54AC/74AC125 • 74ACT125 Quad Buffer with TRI-STATE® Outputs

General Description

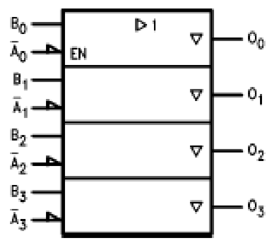
The 'AC/'ACT125 contains four independent non-inverting buffers with TRI-STATE outputs.

Features

- I_{CC} reduced by 50%
- Outputs source/sink 24 mA
- 'ACT125 has TTL-compatible outputs

Logic Symbol

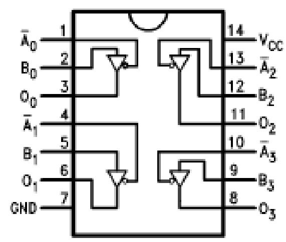
IEEE/IEC



TL/F/10692–1

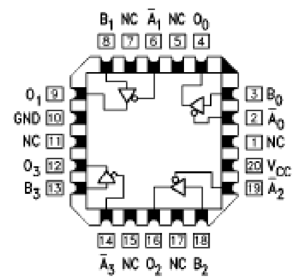
Connection Diagrams

Pin Assignment for DIP, SOIC and Flatpak



TL/F/10692–2

Pin Assignment for LCC



TL/F/10692–3

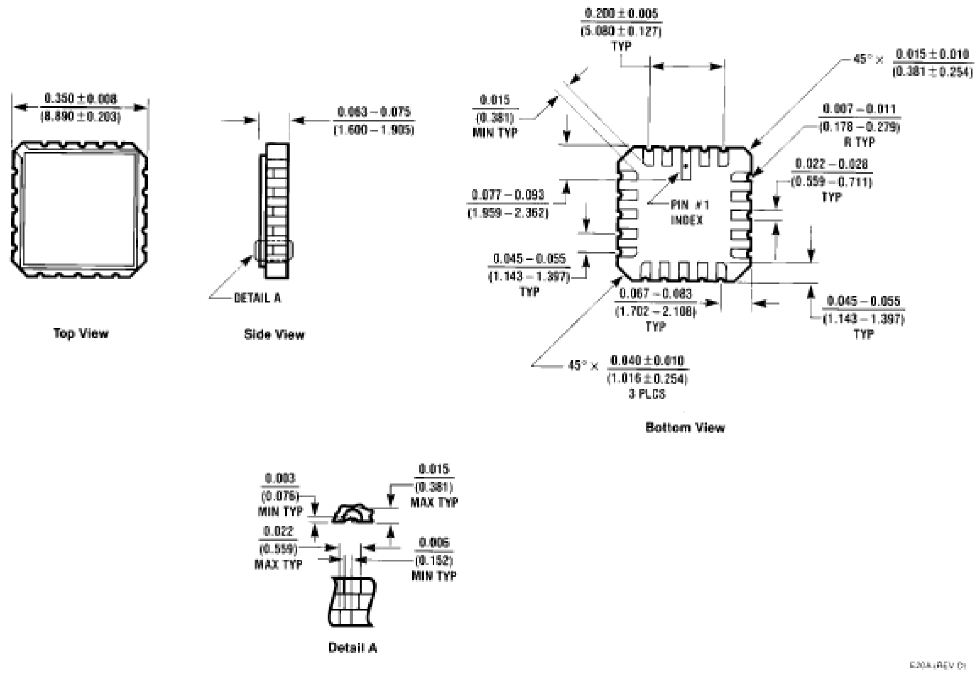
Pin Names	Description
$\overline{A}_n$, B_n	Inputs
O_n	Outputs

Function Table

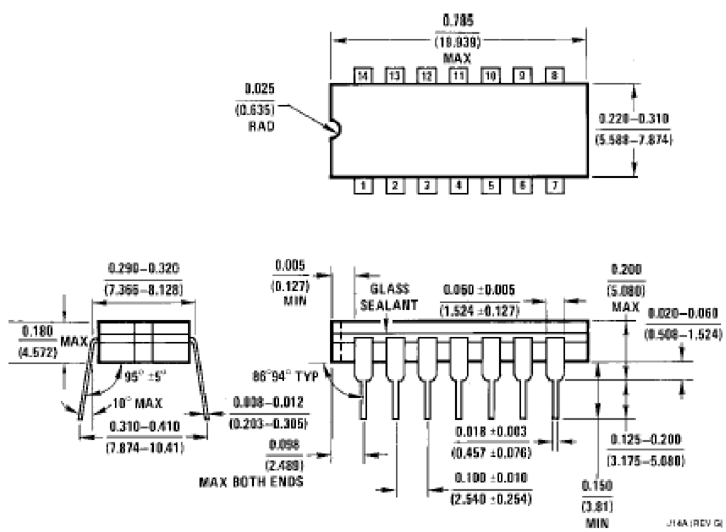
Inputs		Output
A_n	B_n	O_n
L	L	L
L	H	H
H	X	Z

H = HIGH Voltage Level
L = LOW Voltage Level
Z = HIGH Impedance
X = Immaterial

Physical Dimensions inches (millimeters)



20 Terminal Ceramic Leadless Chip Carrier (L)
NS Package Number E20A



14-Lead Ceramic Dual-In-Line Package (D)
NS Package Number J14A