



NEAR EAST UNIVERSITY

**INSTITUTE OF APPLIED
AND SOCIAL SCIENCES**

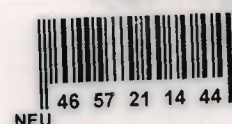
**DESIGN AND IMPLEMENTATION OF A USER
INTERFACE FOR PLC BASED SYSTEM
AUTOMATION**

Latif Nizipli

Master Thesis

**Department of Electrical and Electronic
Engineering**

Nicosia – 2002



**Latif Nizipli : Design And Implementation Of A User Interface
For PLC Based System Automation**



**Approval of the Graduate School of Applied and
Social Sciences**

**Prof. Dr. Fakhraddin Mamedov
Director**

**We certify that this thesis is satisfactory for the award of the
degree of Master of Science in Electrical Engineering**

Examining Committee in charge:

**Prof. Dr. Fakhraddin Mamedov, Chairman of committee, Dean of
Engineering Faculty, NEU**

**Assoc. Prof. Dr. Adnan Khashman, Chairman of Electrical and
Electronic Engineering
Department, NEU**

**Assoc. Prof. Dr. Rahib Abiyev, Committee Member, Computer
Engineering Department, NEU**

ACKNOWLEDGEMENT

I would like to thank my supervisor Assoc. Prof. Dr. Dogan Ibrahim for his valuable advice given throughout the duration of this project.

I am also thankful to my friend Mr. Yunus Kurtoglu for the help he has given me on the PC parallel port.

Finally, I wish to thank to both Prof. Dr. Senol Bektas , Prof. Dr. Fakhreddin Mamedov , Assoc. Prof. Dr. Adnan Khashman and Assoc. Prof. Dr Rahib Abiyev who gave me encouragement and support during my studies at the Near East University.

ABSTRACT

Automation is nowadays used in many factories, offices, and buildings. Conventionally, Programmable Logic Controllers (PLC) are used very frequently in many automation applications. These devices are flexible and they provide simple solutions to most automation projects. The major disadvantage of PLCs is their high cost and the rather long time required to train programmers and operators to use such systems.

In this thesis, a novel interface system to PLC based automation is described where a coder/decoder (CODEC) interface circuit has been designed to control very complex automation projects with large numbers of inputs and outputs. The system designed is low cost, and it also has the advantage that it is highly user friendly, requiring considerably less time to learn.

The aim of this thesis was to design a simple and friendly user interface system.

CONTENTS

ACKNOWLEDGEMENT	i
ABSTRACT	ii
CONTENTS	iii
LIST OF ABBREVIATIONS	v
LIST OF FIGURES	vi
LIST OF TABLES	vii
INTRODUCTION	1
1. PLC BASED AUTOMATION	2
1.1 What Are PLC's	2
1.1.1 Introduction To The Siemens S7-200 PLC	4
1.1.2 Input - Output	5
1.1.3 High-Speed Counters	5
1.1.4 High-Speed Pulse Output	6
1.1.5 Representation of Numbers	6
1.1.6 Downloading and Uploading The PLC Program	6
1.2 Advantages and Disadvantages of PLC's	7
1.3 Applications of PLC's	7
1.4 Summary	7
2. INTERFACING PCS TO PLC'S	8
2.1 Standard Interface	8
2.2 A Novel Interface System By using a CODEC	9
2.2.1 Overview of the New Interface System	9
2.2.1.1 Description of the New Interface System	9
2.2.1.2 Advantages of the New Interface :	24
2.2.1.3 Disadvantages of the New Interface :	25
2.2.2 Hardware of the CODEC	25
2.2.2.1 The Block Diagram	27
2.2.2.2 Operation of the Hardware	28
2.2.3 Software of the CODEC	32
2.2.3.1 The Algorithm of the Interface	33
3. EXAMPLE APPLICATION USING THE CODEC IN A HOSPITAL AUTOMATION	36
3.1 Description of the system	36
3.2 Requirements of the System	37
3.3 Designing the Automation System	37
3.3.1 The Hardware	37
3.3.2 The Software	40
3.3.2.1 Main Menu	40

3.3.2.2 Illumination Section	41
3.3.2.3 Indoor Illumination	42
3.3.2.4 Outdoor Illumination	42
3.3.2.5 Heat Sensors	43
3.3.2.6 Fire Alarm	44
3.3.2.7 Heating Room	44
3.3.2.8 Status Of The Tanks	45
3.3.2.9 Codec Interface Codes of the Automation Pro 2001	45
3.3.3 Advantages of the New System	49
4. SUGGESTIONS FOR FUTURE WORK	51
5. CONCLUSIONS	52
REFERENCES	53
APPENDIX I	54
APPENDIX II	64

List of Abbreviations

PC	Personal Computer
PLC	Programable Logic Controller
A/D	Analog to Digital
D/A	Digital to Analog
ADC	Analog to Digital converter
DAC	Digital to Analog converter
I/O	Input Output
CODEC	Coder Encoder Circuit
CPU	Central Processing Unit
ASCII	American Standardasation Code For International Interchange
SPP	Standard Parallel Port
EPP	Enhanced Parallel Port
ECP	Extended Capabilities Port
DMA	Direct Memory Access
IRQ	Interrupt request
RAM	Random Access Memory

List of Figures

	Page
Figure 1.1 S7-200 Micro PLC	4
Figure 1.2 Components Of An S7-200 Micro PLC System	5
Figure 2.1 System Configuration Example	8
Figure 2.2 Block Diagram Of The New System	10
Figure 2.3 In Windows 95-98 You Can Select A Port Configuration In The Device Manager's Resources Window. A Message Warns If Windows Detects Any System Conflicts With The Selected Configuration	19
Figure 2.4 In The Figure On The Left Shows The Back Panel Of An Expansion Card, With A Parallel Port's 25-Pin Female D-Sub Connector On The Left Side Of The Panel. (The Other Connector Is For A Video Monitor.) The Figure On The Right Shows The 36-Pin Female Centronics Connector Used On Most Printers.	21
Figure 2.5 Electrical Diagram Of The Circuit	26
Figure 2.6 Block Diagram Of The System	27
Figure 2.7 Electrical Diagram Of The Circuit	28
Figure 2.8 Address Decoding Part Of The Circuit	29
Figure 2.9 Input Buffers	30
Figure 2.10 D Flip-Flops (Output Part Of The Circuit)	31
Figure 2.11 The Connections Of OR Gates	32
Figure 2.12 IDE Sockets Which Are Used For Taking Inputs From PLC And Sending Outputs To The PLC	32
Figure 2.13 First alternative	34
Figure 2.14 Second Alternative	35
Figure 3.1 Representative Drawing Of The Hospital	36
Figure 3.2 Main Menu	40
Figure 3.3 Illumination Submenu	41
Figure 3.4 Form Of Indoor Illumination	42
Figure 3.5 Outdoor Illumination Form	42
Figure 3.6 Form Of Heat Sensors	43
Figure 3.7 Form Of Fire Alarm	44
Figure 3.8 Form Of The Heating Room	44
Figure 3.9 Form Of The Tanks	45
Figure 3.10 Third Level Outdoor Illumination Menu	46
Figure 3.11 Timing Diagram Of The System	50

List of Tables

		Pages
Table 1.1	Data Size Designations and Associated Integer Ranges	6
Table 2.1	Addresses of Parallel port	14
Table 2.2	Pin Assignment of Parallelport (Lpt1) Female DB-25 on PC	22
Table 2.3	Parallel Laplink Cable Pinouts	23
Table 2.4	DB-25 Connectors (Female and Male)	24
Table 3.1	IDE Soccet No 1 Connections	38
Table 3.2	IDE Soccet No 2 Connections	39
Table 3.3	Binary Codes Of All Command	47
Table 3.4	Addressing Codes And Data	49

INTRODUCTION

Computers are nowadays playing a big role to implement the automation in many factories. There are many software and hardware products in the market which help design computer based automation systems. One of the problems is that these products are either too expensive or complex to implement. Most of these automation products are nowadays PC based. The hardware is usually in the form of a card which is plugged into the back plane of a standard PC and special software is used or developed for this card. Some automation hardware can be plugged into the serial port of a PC and such products can usually be used with any kind of computer.

Programmable Logic Controllers (PLC) are special hardware designed for automation purposes. The hardware is a self-contained unit which is manufactured to work in noisy and dirty environments such as in factories. A PLC basically contains a microprocessor, memory, and input-output interface circuitry. The input-output capacity of PLCs are usually small and in complex automation applications it may be necessary to use a large number of PLCs. In this thesis, the design of a coder/decoder (CODEC) interface circuit is discussed.

Chapter 1 is an introduction to the PLC systems and it describes the basic principles of PLCs.

Chapter 2 describes the various PLC interface techniques and then describes the interface technique developed by the author.

Chapter 3 is an application of the method developed by the author. In this chapter, a hospital automation system is described where the input-output requirements are very large. A Visual Basic program was developed to control the new CODEC card and it is shown that by using the new technique it is possible to cut down the cost and also simplify the design considerably.

The aim of this thesis is designing a simple and friendly user interface system.

1. PLC BASED AUTOMATION

1.1 What Are PLC's

PLC stands for Programmable Logic Controller. PLCs were first introduced in late 1960s. The reason for designing such devices was to eliminate the bulky switches and relays used in factory automation and to have standard units which could be used in many different applications. Early PLCs were still heavily based on relay inputs and outputs and conventional logic circuits were used in the design of the processing unit. In mid 1970s, the processing power of the PLCs increased and microprocessor based products, such as bit-slice processors were used as the main processing units. As a result of this, it was possible to design very complex and programmable factory automation products which could be used in many different applications. Most of the PLCs were still purely digital devices and interface to the external world was by using relays. In late 1970s, there has been a major change in the PLC market when analog signal handling capability was added to PLCs. By using A/D and D/A converters it has been possible to interface the PLCs to analog sensors such as temperature and pressure sensors. By 1980s the complexity and the processing powers of PLCs increased and it has been possible to use floating-point arithmetic in PLCs. This enabled various controller algorithms to be implemented easily and the demand for PLCs has increased rapidly. In 1990s the size and the power consumption of PLCs reduced and it has been possible to purchase a PLC as small as a few square inches.

One of the advantages of PLCs is the ease of programming and visual display capabilities. They can be used to control all types of industrial plants in real-time. PLCs are also used to collect data for future analysis. For example, a PLC can be used to collect temperature data over a very long time.

PLCs are usually programmed using the ladder diagram techniques. The reason for this is historic since the early machine control equipment was also programmed using ladder diagrams and the engineers are usually familiar with such programming techniques. The programming can either be done by using a small hand-held unit, or the PLC can be connected to a PC via the serial or the parallel interface and the ladder

diagram program can be developed on the PC. This program can then be downloaded to the PLC.

There are several types of PLCs. Compact PLCs are manufactured such that all parts of the system are enclosed in a single unit. These systems are usually available for lower input-output capacities and are used in small automation applications. Modular PLCs are formed by combining separate modules together. These systems have much higher input-output capacities and also higher processing power. Modular PLCs are more expensive and they are usually used in complex automation applications where a large number of interface signals are required.

Input-output (I/O) from a PLC can be in several forms. The simplest I/O is digital I/O where a number of parallel lines are provided. PLCs usually have I/O drivers such as opto-couplers, relay outputs, and semiconductor switch outputs so that high drive components such as motors can directly be connected to the PLC. Some PLCs are equipped with A/D and D/A interfaces, enabling analog sensors to be connected directly to the PLC.

PLCs are usually equipped with different types of memories. Most PLCs have RAM, EPROM and EEPROM type memories. Temporary variables are usually stored in the RAM. The program steps are either stored in an EPROM or an EEPROM type non-volatile memories. The memory size requirement depends on the application but the memory can usually be increased from about 1Kbyte to 64Kbyte.

In this thesis, a Siemens S7-200 type PLC was used and the features of this PLC are described in the following sub-sections.

1.1.1 Introduction To The Siemens S7-200 PLC

The S7-200 series is a line of micro-programmable logic controllers (Micro PLCs) that can control a variety of automation applications. Figure 1.1 shows an S7-200 Micro PLC. The compact design, expandability, low cost, and powerful instruction set of the S7-200 Micro PLC make a perfect solution for controlling small applications. In addition, the wide variety of CPU sizes and voltages provides the flexibility needed to solve automation problems.

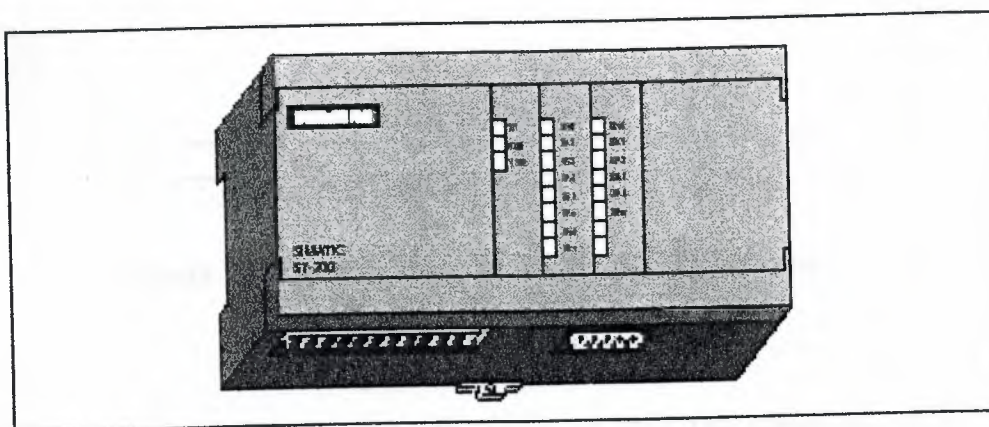


Figure 1.1 S7-200 micro PLC

Equipment Requirements of this PLC are shown in Figure 1.2 shows the basic S7-200 Micro PLC system, which includes an S7-200 CPU module, a personal computer, STEP 7-Micro/WIN programming software, and a PC/PPI type communications cable. In order to use a personal computer (PC), one must have one of the following sets of equipment:

- _ A PC/PPI cable
- _ A communications processor (CP) card and multipoint interface (MPI) cable
- _ A multipoint interface (MPI) card. A communications cable is provided with the MPI card.

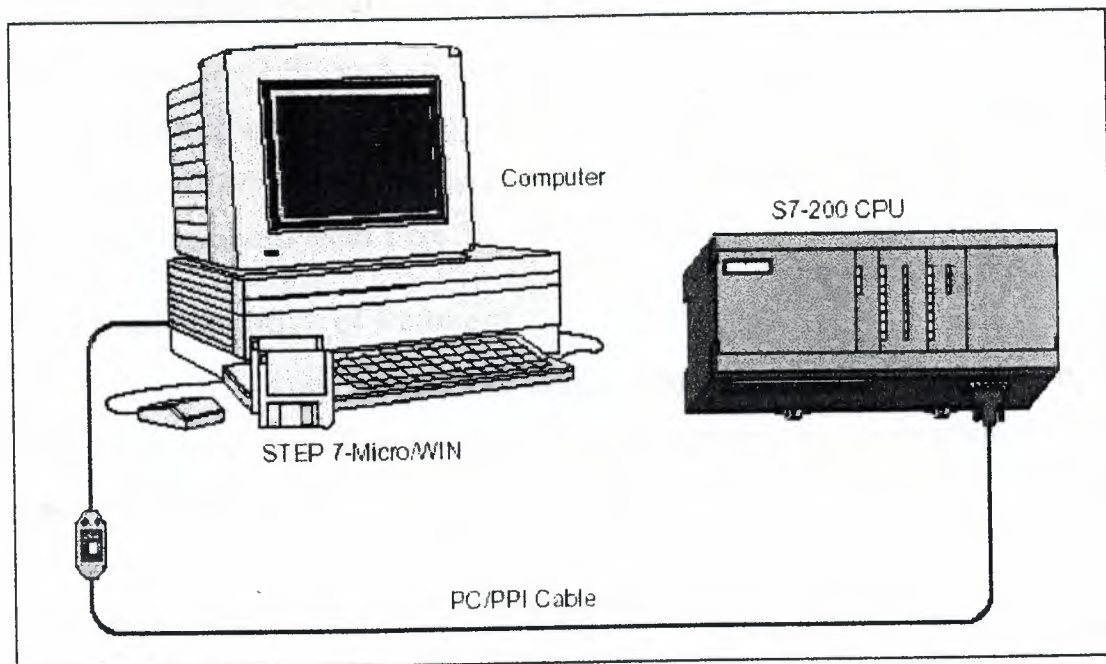


Figure 1.2 Components of an S7-200 micro PLC system

The S7-200 family includes a wide variety of CPUs. This variety provides a range of features to aid in designing a cost-effective automation solution.

1.1.2 Input - Output

The inputs and outputs are the system control points: the inputs monitor the signals from the field devices (such as sensors and switches), and the outputs control pumps, motors, or other devices in your process. The PLC also provides high-speed I/O for controlling events where a higher speed is required.

1.1.3 High-Speed Counters

High-speed counters count high-speed events that cannot be controlled at the scan rates of the S7-200 CPU modules. The S7-200 CPU module provides one software high-speed counter and up to two hardware high-speed counters. Each counter has dedicated inputs for clocks, direction control, reset, and start, where these functions are supported. In quadrature modes, an option is provided to select one or four times the maximum counting rates.

1.1.4 High-Speed Pulse Output

The S7-200 CPU supports high-speed pulse outputs where a square wave output can be generated with varying duty cycle. The number of pulses can be specified from 1 to 4,294,967,295 pulses. The cycle time can be specified in either microsecond or millisecond increments either from 250 s to 65,535 s or from 2 ms to 65,535 ms.

1.1.5 Representation of Numbers

Table 1.1 shows the range of integer values that can be represented by the different sizes of data. Real (or floating-point) numbers are represented as 32-bit, single-precision numbers.

Table 1.1 Data Size Designations and Associated Integer Ranges

Data Size	Unsigned Integer Range		Signed Integer Range	
	Decimal	Hexadecimal	Decimal	Hexadecimal
B (Byte): 8-bit value	0 to 255	0 to FF	-128 to 127	80 to 7F
W (Word): 16-bit value	0 to 65,535	0 to FFFF	-32,768 to 32,767	8000 to 7FFF
D (Double word, Dword): 32-bit value	0 to 4,294,967,295	0 to FFFF FFFF	-2,147,483,648 to 2,147,483,647	8000 0000 to 7FFF FFFF

1.1.6 Downloading and Uploading The PLC Program

The program consists of three elements: the user program, the data block (optional), and the CPU configuration (optional). Downloading the program stores these elements in the RAM area of the CPU memory. The CPU also automatically copies the user program, data block (DB1), and the CPU configuration to the EEPROM for permanent storage.

When you upload a program from the CPU, the user program and the CPU configuration are uploaded from the RAM to your computer. When you upload the data block, the permanent area of the data block (stored in the EEPROM) is merged with the remainder of the data block (if any) that is stored in RAM. The complete data block is then transferred to the computer. The size of the permanent V memory area depends on the CPU.

1.2 Advantages and Disadvantages of PLC's

PLC's have several advantages and disadvantages as listed below:

Advantages

- Easy to setup
- Easy to program
- Easy to test
- Easy to interrupt the current operation
- Easy to adapt to different automation applications
- Compact

Disadvantages

- Limited input and output numbers
- Limited programming memory (it can not accept huge programs)
- Usually expensive
- Ladder diagrams are limited in capability

1.3 Applications of PLC's

PLC's have huge application area. They are used mainly in automation systems in factories, in security systems, air conditioning systems, robotic systems, and so on. PLCs are ideal in small production systems where a task is repeated continuously, such as in bottling applications, conveyor belt applications, and packaging systems.

1.4 Summary

In this chapter description of the PLC , history of the PLC , types of PLCs and applications of PLCs was described deeply. At the end of the this chapter advantages and disadvantages of the PLC system are listed.

2. INTERFACING PCs TO PLC's

2.1 Standard Interface

There are different PLC interface modules for connecting them to a computer. Usually all of these modules are connected to the serial port of PCs. RS232C connection is commonly used, although some PLCs used the RS485 connection for multi-drop operations where more than one PLC can share the same serial line. RS485 uses a twisted cable with three or more cables used to transmit and receive data. Figure 2.1 shows a typical connection of RS485 type devices. In the upper part of the figure the operator interface is connected to one device only. The lower part of the figure shows how many devices can share the same line.

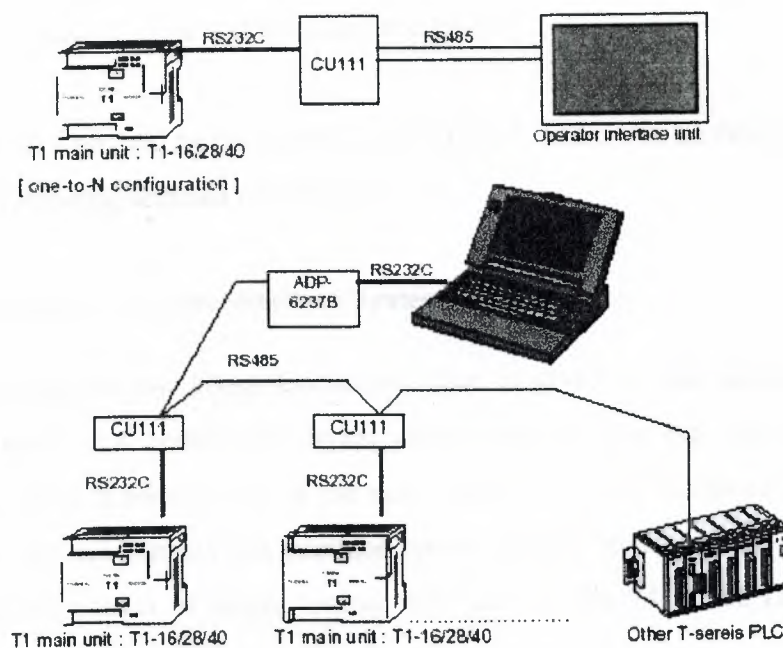


Figure 2.1 System configuration example

2.2 A Novel Interface System By using a CODEC

2.2.1 Overview of the New Interface System

The novel interface system designed by the author can be used with any PLC based automation system easily. The interface system is connected to the parallel port of a standard PC. There is no need to have a special PC and any kind of PC can be used as long as it has a parallel interface. The speed or the memory capacity of the PC is not important.

By using the new interface system the cost of the overall automation system goes down considerably, resulting in huge savings.

This novel system consist of three main elements:

A Personal Computer (PC)

A Programmable Logic Controller (PLC)

A CODEC interface (Coder and Decoder interface)

The part designed by the author is the CODEC and it will be described in more detail in the following sections of the thesis.

2.2.1.1 Description of the New Interface System

More information about Codec interface is given in this section. The Codec interface system is a completely digital circuit and it does not contain any analog element in it. This is perhaps one of the most important things in this project because of this property we can connect this interface system directly to the parallel port of any PC. Also, the circuit consist of simple logical chips such as the 74HC138 (3 to 8 decoder) chip (See Appendix II)

The working principle of this novel interface system is very simple and the block diagram is given below

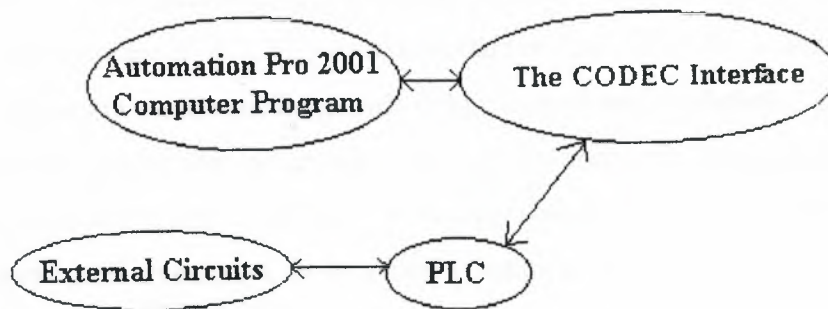


Figure 2.2 Block diagram of the new system

A program on the PC (called the Automation Pro 2001 which wrote by using Visual Basic programming language) controls everything in the system. When the operator wishes to send commands to the system, the computer program will convert the commands into specific bit patterns and then these bit patterns will be sent to the CODEC interface circuit via the parallel port of the PC. The CODEC circuit makes necessary address decoding processes to connect data with the necessary connection points on the PLC. The PLC then drives other devices in the system such as sensors, motors, shafts etc. We call all of these as external circuit. Also, opposite direction of action is available where the external circuits sends their signals to the PLC and the PLC sends these signals to the CODEC interface to tell the operator what is happening in the system. Up to this point all communications can be done by using full duplex techniques. After this point, communication goes on half duplex channel. The Automation Pro 2001 computer program will take the signals from CODEC interface and then show the operator what is going on in the automation system. More detailed information is given in the next chapter. The PC parallel port is an important part of the overall system and it is described next in detail.

2.3 The PC Parallel Port

Defining the Port :

What is the “parallel port”? In the computer world, a port is a set of signal lines that the microprocessor, or CPU, uses to exchange data with other components. Typical uses for ports are communicating with printers, modems, keyboards, and displays, or just about any component or device except system memory. Most computer ports are digital, where each signal, or bit, is 0 or 1. A parallel port transfers multiple bits at once, while a serial port transfers a bit at a time (though it may transfer in both directions at once). There are other ports such as SCSI, USB, and IrDA, but the parallel port remains popular because it's capable, flexible, and every PC has one. The term PC-compatible, or PC for short refers to the IBM PC and any of the many, many personal computers derived from it. From another angle, a PC is any computer that can run Microsoft's MS-DOS or WINDOWS operating system and whose expansion bus is compatible with the ISA or PCI bus in the original IBM PC. The category includes the PC, XT, AT, PS/2, and most computers with 80x86, Pentium, and compatible CPUs. It does not include the Macintosh, Amiga, or IBM mainframes, though these and other computer types may have ports that are similar to the parallel port on the PC.

The original PC's parallel port had eight outputs, five inputs, and four bi-directional lines. These are enough for communicating with many types of peripherals. On many newer PCs, the eight outputs can also serve as inputs, for faster communications with scanners, drives, and other devices that send data to the PC. The parallel port was designed as a printer port, and many of the original names for the port's signals (PaperEnd, AutoLineFeed) reflect that use. But these days, you can find all kinds of things besides printers connected to the port. The term peripheral, or peripheral device is a catchall category that includes printers, scanners, modems, and other devices that connect to a PC.

Port Types :

As the design of the PC evolved, several manufacturers introduced improved versions of the parallel port. The new port types are compatible with the original design, but add new abilities, mainly for increased speed. Speed is important because as computers and peripherals have gotten faster, the jobs they do have become more complicated, and the amount of information they need to exchange has increased. The original parallel port was plenty fast enough for sending bytes representing ASCII text characters to a dot matrix or daisy wheel printer. But modern printers need to receive much more information to print a page with multiple fonts and detailed graphics, often in color. The faster the computer can transmit the information, the faster the printer can begin processing and printing the result.

A fast interface also makes it feasible to use portable, external versions of peripherals that you would otherwise have to install inside the computer. A parallel-port tape or disk drive is easy to move from system to system, and for occasional use, such as making back-ups, you can use one unit for several systems. Because a backup may involve copying hundreds of Megabytes, the interface has to be fast to be worthwhile;

Original (SPP) :

The parallel port in the original IBM PC, and any port that emulates the original port's design, is sometimes called the SPP, for standard parallel port, even though the original port had no written standard beyond the schematic diagrams and documentation for the IBM PC. Other names used are AT-type or ISA-compatible. The port in the original PC was based on an existing Centronics printer interface.

However, the PC introduced a few differences, which other systems have continued. SPPs can transfer eight bits at once to a peripheral, using a protocol similar to that used by the original Centronics interface. The SPP doesn't have a byte-wide input port, but for PC-to-peripheral transfers, SPPs can use a Nibble mode that transfers each byte 4 bits at a time. Nibble mode is slow, but has become popular as a way to use the parallel port for input.

PS/2-type (Simple Bi-directional) :

An early improvement to the parallel port was the bi-directional data port introduced on IBM's model PS/2. The bi-directional port enables a peripheral to transfer eight bits at once to a PC. The term PS/2-type has come to refer to any parallel port that has a bi-directional data port but doesn't support the EPP or ECP modes described below. Byte mode is an 8-bit data-transfer protocol that PS/2-type ports can use to transfer data from the peripheral to the PC.

Epp :

The EPP (enhanced parallel port) was originally developed by chipmaker Intel, PC manufacturer Zenith, and Xircom, a maker of parallel-port networking products. As on the PS/2-type port, the data lines are bi-directional. An EPP can read or write a byte of data in one cycle of the ISA expansion bus, or about 1 microsecond, including handshaking, compared to four cycles for an SPP or PS/2-type port. An EPP can switch directions quickly, so it's very efficient when used with disk and tape drives and other devices that transfer data in both directions. An EPP can also emulate an SPP, and some EPPs can emulate a PS/2-type port.

Ecp :

The ECP (extended capabilities port) was first proposed by Hewlett Packard and Microsoft. Like the EPP, the ECP is bi-directional and can transfer data at ISA-bus speeds. ECPs have buffers and support for DMA (direct memory access) transfers. And data compression. ECP transfers are useful for printers, scanners, and other peripherals that transfer large blocks of data. An ECP can also emulate an SPP or PS/2-type port, and many ECPs can emulate an EPP as well.

Multi-mode Ports :

Many newer ports are multi-mode ports that can emulate some or all of the above types. They often include configuration options that can make all of the port types available, or allow certain modes while locking out the others.

System Resources :

The parallel port uses a variety of the computer's resources. Every port uses a range of addresses, though the number and location of addresses varies. Many ports have an assigned IRQ (interrupt request) level, and ECPs may have an assigned DMA channel. The resources assigned to a port can't conflict with those used by other system components, including other parallel ports

Addressing:

The standard parallel port uses three contiguous addresses, usually in one of these ranges:

Table 2.1 Addresses of Parallel port

Base0	Base1	Base2
378h	278h	3BCh
379h	279h	3BDh
37Ah	27Ah	3BEh

The first address in the range is the port's base address, also called the Data register or just the port address. The second address is the port's Status register, and the third is the Control register. EPPs and ECPs reserve additional addresses for each port. An EPP adds five registers at base address + 3 through base address + 7, and an ECP adds three registers at base address + 400h through base address + 402h. For a base address of 378h, the EPP registers are at 37Bh through 37Fh, and the ECP registers are at 778h through 77Fh.

On early PCs, the parallel port had a base address of 3BCh. On newer systems, the parallel port is most often at 378h. But all three addresses are reserved for parallel ports, and if the port's hardware allows it, you can configure a port at any of the addresses. However, we normally can't have an EPP at base address 3BCh, because the added EPP registers at this address may be used by the video display. IBM's Type 3

PS/2 port also had three additional registers, at base address +3 through base address + 5, and allowed a base address of 1278h or 1378h. Most often, DOS and Windows refer to the first port in numerical order as LPT1, the second, LPT2, and the third, LPT3. So on bootup, LPT1 is most often at 378h, but it may be at any of the three addresses. LPT2, if it exists, may be at 378h or 278h, and LPT3 can only be at 278h. Various configuration techniques can change these assignments, however, so not all systems will follow this convention. LPT stands for line printer, reflecting the port's original intended use. If your port's hardware allows it, you can add a port at any unused port address in the system. Not all software will recognize these non-standard ports as LPT ports, but you can access them with software that writes directly to the port registers.

Interrupts :

Most parallel ports are capable of detecting interrupt signals from a peripheral. The peripheral may use an interrupt to announce that it's ready to receive a byte, or that it has a byte to send. To use interrupts, a parallel port must have an assigned interrupt-request level (IRQ).

Conventionally, LPT1 uses IRQ7 and LPT2 uses IRQ5. But many sound cards use IRQ5, and because free IRQ levels can be scarce on a system, even IRQ7 may be reserved by another device. Some ports allow choosing other IRQ levels besides these two.

Many printer drivers and many other applications and drivers that access the parallel port don't require parallel-port interrupts. If you select no IRQ level for a port, the port will still work in most cases, though sometimes not as efficiently, and you can use the IRQ level for something else.

DMA Channels :

ECPs can use direct memory access (DMA) for data transfers at the parallel port. During the DMA transfers, the CPU is free to do other things, so DMA transfers can result in faster performance overall. In order to use DMA, the port must have an assigned DMA channel, in the range 0 to 3.

Finding Existing Ports :

DOS and Windows include utilities for finding existing ports and examining other system resources. In Windows 95, click on Control Panel, System, Devices, Ports, and click on a port to see its assigned address and (optional) IRQ level and DMA channel. In Windows 98 you can use Microsoft's Diagnostic (msd.exe) to view ports, assigned IRQ levels, and other system details.

Configuring :

The parallel port that comes with a PC will have an assigned address and possibly an IRQ level and DMA channel. Multi-mode ports may also be configured with specific modes enabled. You can change some or all of these assignments to match your needs. If you're adding a new port, you need to configure it, making sure that it doesn't conflict with existing ports and other resources.

Port Options :

There is no standard method for configuring a port. Some ports, especially older ones, use jumper blocks or switches to select different options. Others allow configuring in software, using a utility provided on disk. A port on a system motherboard may have configuration options in the system setup screens (the CMOS setup) that you can access on bootup. On ports that meet Microsoft's Plug and Play standard, Windows 95 can automatically assign an available port address and IRQ level to a port.

Some ports allow a choice of just one or two of the three conventional base addresses. A few allow you to choose any uncommitted address, including non-standard ones. On some boards, the jumpers or switches are labeled, which is extremely handy when you don't have other documentation (or can't find it). If your port supports ECP transfers, assign it an IRQ level and DMA channel if possible. Most ECP drivers do use these, and if they're not available, the driver will revert to a slower mode.

Multi-mode Ports :

Configuring a multi-mode port needs special consideration. A multi-mode port's controller chip supports a variety of modes that emulate different port types. In addition to the configuration options described above, on most multi-mode ports, you also have to select a port type to emulate.

The problem is that there is no single standard for the basic setup on the controller chips, and there are many different chips! Usually the setup involves writing to configuration registers in the chip, but the location and means of accessing the registers varies.

For this reason, every port should come with a simple way to configure the port. If the port is on the motherboard, look in the CMOS setup screens that you can access on bootup. Other ports may use jumpers to enable the modes, or have configuration software on disk.

The provided setup routines don't always offer all of the available options or explain the meaning of each option clearly. The PS/2 option actually configures the port as an ECP, with the ECP's PS/2 mode selected, but there is no documentation explaining this. The only way to find out what mode is actually selected is to read the chip's configuration registers. And although the port also supports EPP, the CMOS setup includes no way to enable it; so again, accessing the configuration registers is the only option.

If the port is EPP- or ECP-capable but the setup utility doesn't offer these as choices, a last resort is to identify the controller chip, obtain and study its data sheet, and write a program to configure the port. The exact terminology and the number of available options can vary, but these are typical configuration options:

Multi-Mode Port

SPP : Emulates the original port. Also called AT-type or ISA-compatible.

PS/2 : Complex or simple bidirectional. Like an SPP, except that the data port is bidirectional.

EPP : Can do EPP transfers. Also emulates an SPP. Some EPPs can emulate a PS/2-type port.

ECP : Can do ECP transfers. The ECP's internal modes enable the port to emulate an SPP or PS/2-type port. An additional internal mode, Fast Centronics, or Parallel Port FIFO, uses the ECP's buffer for faster data transfers with many old-style (SPP) peripherals.

ECP + EPP : An ECP that supports the ECP's internal mode 100, which emulates an EPP. The most flexible port type, because it can emulate all of the others.

Drivers :

After setting up the port's hardware, there may be a need to configure the operating system and applications to use the new port.

For DOS and Windows 98 systems, on bootup the operating system looks for ports at the three conventional addresses and assigns each an LPT number. In Windows 98, to assign a printer to an LPT port, click on Control Panel, then if the printer model isn't displayed, click Add and follow the prompts.

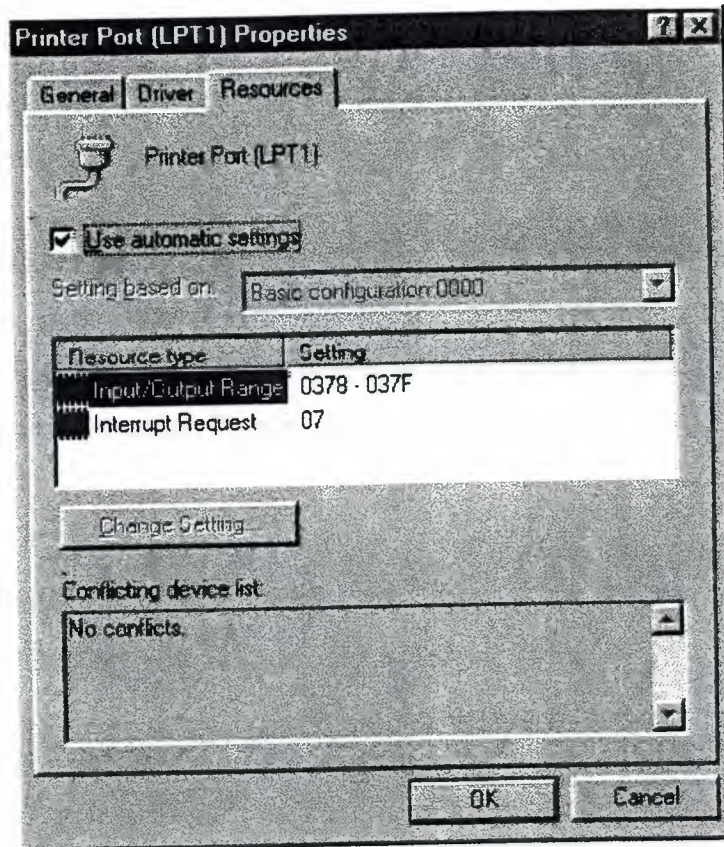


Figure 2.3 In Windows 95-98 you can select a port configuration in the Device Manager's Resources Window. A message warns if Windows detects any system conflicts with the selected configuration.

Select the desired printer model, then click Connect to view the available ports. Select a port and click OK, or Cancel to make no changes. In Windows 95, the Control Panel lists available ports under System Properties, Device Manager, Ports. There's also a brief description of the port. Printer Port means that Windows treats the port as an ordinary SPP, while ECP Printer Port means that Windows will use the abilities of an ECP if possible. To change the driver, select the port, then Properties, Driver, and Show All Drivers. Select the driver and click OK. If an ECP doesn't have an IRQ and DMA channel, the Windows 95 printer driver will use the ECP's Fast Centronics mode, which transfers data faster than an SPP, but not as fast as ECP.

The Device Manager also shows the port's configuration. Select the port, then click Resources. Windows attempts to detect these settings automatically. If the configuration shown doesn't match your hardware setup, de-select the Use Automatic Settings check box and select a different configuration.

If none matches, the setting can be changed by double-clicking on the source type and entering a new value. Windows displays a message if it detects any conflicts with the selected settings. To assign a printer to a port, click on Control Panel, Printers, and select the printer to assign Parallel port devices that don't use the Windows printer drivers.

DOS programs generally have their own printer drivers and methods for selecting a port.

Adding a Port :

Most PCs come with one parallel port. If there's a spare expansion slot, it's easy to add one or two more. Expansion cards with parallel ports are widely available. Cards with support for bi-directional, EPP, and ECP modes are the best choice unless you're sure that you won't need the new modes, or you want to spend as little as possible. Cards with just an SPP are available for as little as \$15. A card salvaged from an old computer may cost nothing at all.

We can get more use from a slot by buying a card with more than a parallel port. Because the port circuits are quite simple, many multi-function cards include a parallel port. Some have serial and game ports, while others combine a disk controller or other circuits with the parallel port. On older systems, the parallel port is on an expansion card with the video adapter. These should include a way to disable the video adapter, so you can use the parallel port in any system. When buying a multi-mode port, it's especially important to be sure the port comes with utilities or documentation that shows you how to configure the port in all of its modes. Some multi-mode ports default to an SPP configuration, where all of the advanced modes are locked out. Before you can use the advanced modes, you have to enable them. Because the configuration methods vary from port to port, you need documentation. Also, because the

configuration procedures and other port details vary from chip to chip, manufacturers of ECP and EPP devices may guarantee compatibility with specific chips, computers, or expansion cards.

Port Hardware :

The parallel port's hardware includes the back-panel connector and the circuits and cabling between the connector and the system's expansion bus. The PC's microprocessor uses the expansion bus's data, address, and control lines to transfer information between the parallel port and the CPU, memory, and other system components.

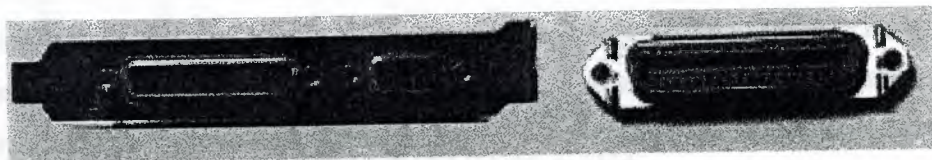


Figure 2.4 In the Figure on the left shows the back panel of an expansion card, with a parallel port's 25-pin female D-sub connector on the left side of the panel. (The other connector is for a video monitor.) The figure on the right shows the 36-pin Female Centronics connector used on most printers.

Basic Concepts of Computer Cabling :

A PARALLEL port consist of a 25 pin port adapter called a DB-25. Each adapter can be a male type connector with pins or a female type adapter with tiny holes. Generally a PRINTER port (called LPT1) on the back of a computer is female type adapter and we need to use MALE DB-25 pin cable on it for PRINTER connection or for parallel data transfers.

IBM Parallel port Pin Descriptions (Wire name) for each pin number :

Following is a table which shows the pin assignments of the parallel port.

Table 2.2 Pin Assignment of Parallel port (Lpt1) Female DB-25 on PC.

<= in or => out	DB25 Pin	Cent Pin	Name of Signal	Reg Bit	Function Notes
=> out	1	1	-Strobe	C0-	Set Low pulse >0.5 us to send
=> out	2	2	Data 0	D0	Set to least significant data
=> out	3	3	Data 1	D1	...
=> out	4	4	Data 2	D2	...
=> out	5	5	Data 3	D3	...
=> out	6	6	Data 4	D4	...
=> out	7	7	Data 5	D5	...
=> out	8	8	Data 6	D6	...
=> out	9	9	Data 7	D7	Set to most significant data
<= in	10	10	-Ack	S6+	IRQ; Low Pulse ~ 5 US, after accept
<= in	11	11	+Busy	S7-	High for Busy/Offline/Error
<= in	12	12	+PaperEnd	S5+	High for out of paper
<= in	13	13	+SelectIn	S4+	High for printer selected
=> out	14	14	-AutoFeed	C1-	Set Low to autofeed one line
<= in	15	32	-Error	S3+	Low for Error/Offline/PaperEnd
=> out	16	31	-Init	C2+	Set Low pulse > 50 US to init
=> out	17	36	-Select	C3-	Set Low to select printer
==	18-25	19-30, 33,17,1 6	Ground	-	Do not connect any of these grounds to a shield

Note : "<= In" and ">= Out" are defined from the viewpoint of the PC, not the printer.
The IRQ line (-Ack/S6+) is positive edge triggered, but only enabled if C4 is 1.

Parallel Port Laplink Cable Pinout :

The second kind of parallel port cable is Laplink Cable .Below is a table showing pin connections. Only 18 pins are used in a Laplink Cable, therefore only these pins are shown here.

To make this cable we need :

1. Two DB-25 type male sockets.
2. Shielded cable with 18 cores (lines of wires).

Table 2.3 Parallel Laplink Cable Pinouts

Male DB-25	==>>	Male DB-25
1		Both Not used
2	To	15
3	To	13
4	To	12
5	To	10
6	To	11
7		Both Not used
8		Both Not used
9		Both Not used
10	To	5
11	To	6
12	To	4
13	To	3
14		Both Not used
15	To	2
16		Both Not used
17	To	19
18	To	18
19	To	17
20		Both Not used
21	To	21
22	To	22
23	To	23
24		Both Not used
25	To	25
Pinbody*	To	Pinbody

*In this project, one wire was attached to the metal body of the Male pins on both sides. Total 18 wired cable is necessary for this cable including one wire for body of the pin too.

IMP: DCC users to troubleshoot and test DCC connection and cable on both the computers. It also provides detailed information about the connection, the cable being used for the connection, the I/O mode (4-bit, 8-bit, ECP), the parallel port types, I/O address, and IRQ. The company, Parallel Technologies, is associated with the Microsoft

for DCC and can be seen listed in Win9x Help (Index+Direct Cable Connection + ordering cables).

SPEED: Parallel port Laplink cable is always faster than Serial port cable because of more numbers of cores of wires used in Parallel port cable (25 pin) than Serial port cable (9 pins). The expected speed is 300kb/second but it is extremely dependent on the different quality chipset structure of Parallel Ports on different makes of the Motherboards. Some even reported the lowest speed of 60kb/sec even though all other settings are correct. It is recommended that you setup LPT1 mode as only "ECP/EPP" or "ECP" mode in bios to get better speed, and not the "Normal" (4bit/8bit) modes.

IBM DB-25 numbering scheme. (Pin numbers) :

Each pin has a number assigned to it. When connecting null modem, for example, it is important to know these numbers in order to select the correct cables, or when making your own cables.

Table 2.4 DB-25 Connectors (Female and Male)

Female	Male
13 <----- 1	1 -----> 13
\ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /	\ /
\ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 /	\ /
25 <----- 14	14 -----> 25

2.2.1.2 Advantages of the New Interface :

This new interface system has more advantages than the others, these are

- Data transmission is fast, it is approximately 300 Kbps which means that when you send a command to the system, system execute that operation within the same second.
- The cost of this system is more less than others

- This interface system can be applicable for all PC's model newer than 386 based
- This interface system can be used with any kind of PLC
- This interface system does not use much power, it's power dissipation is approximately 0.5 Watts.

2.2.1.3 Disadvantages of the New Interface :

This system has only one disadvantage and this is the number of controlled bits in the automation system. In other words, one can control at most 1024 bits, all of these bits can be carry information inside the CODEC from PLC (inside) or it can carry information from PC to the PLC (outside) or these can worked as multi way some of them could be inside and others could outside.

2.2.2 Hardware of the CODEC

The electrical drawing of the CODEC circuit is shown in next figure. As you can see this circuit consists of simple logical chips so that the cost of this interface is probably the cheapest one with respect to other interfaces in the market.

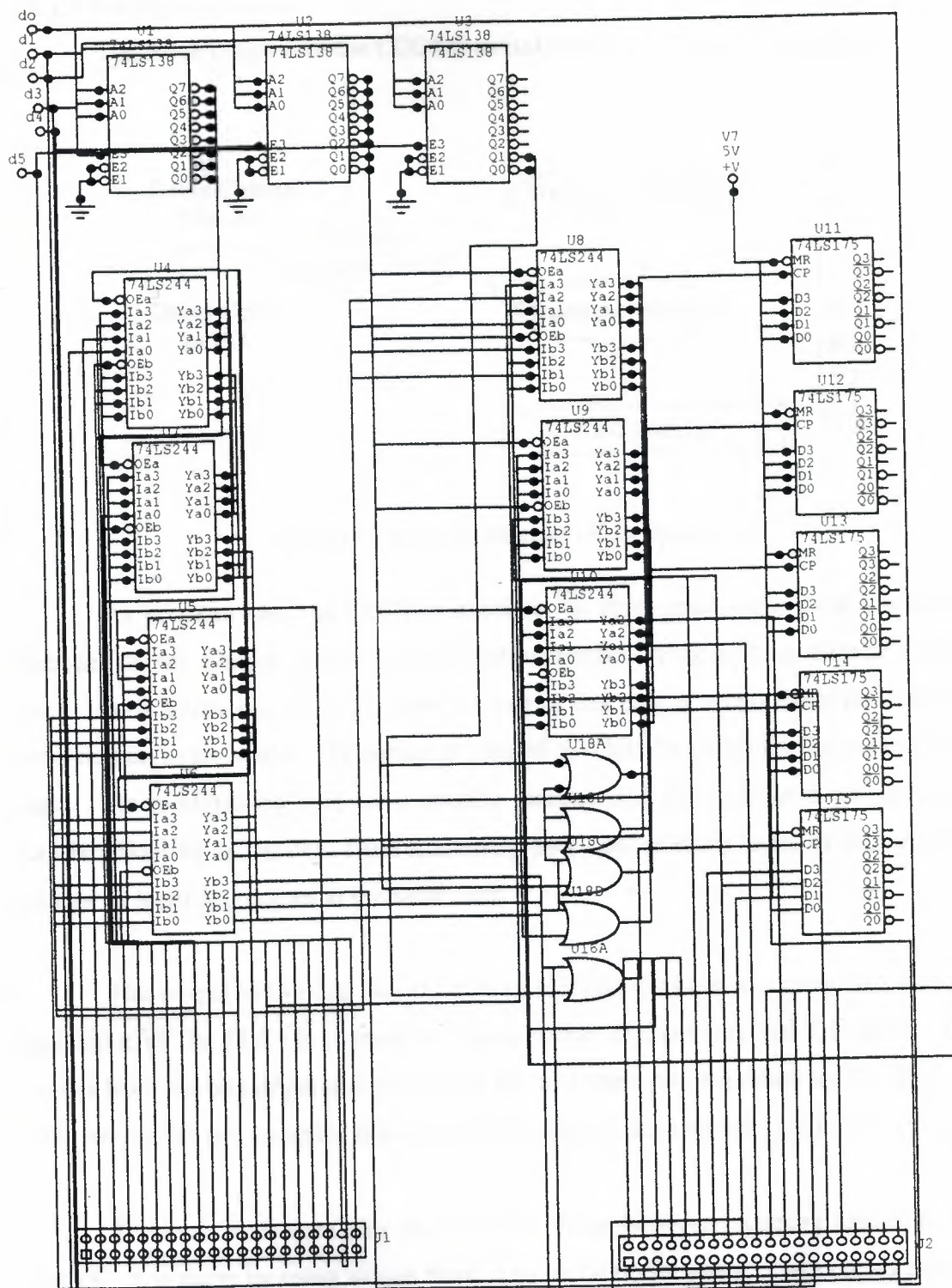


Figure 2.5 Electrical Diagram of the Circuit

2.2.2.1 The Block Diagram

The block diagram of the CODEC circuit is given in the next figure below.

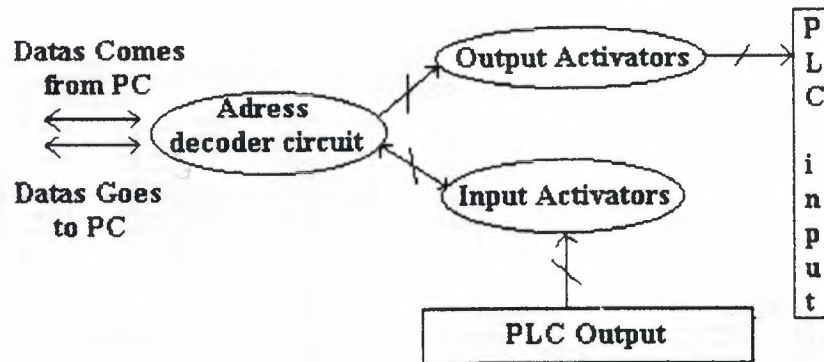


Figure 2.6 Block diagram of the system

As you can see, the CODEC interface has three main parts these are address decoder circuit, Output activators and input activators. In the address decoder circuit I used 3-to-8 active low decoder chips the role of this part is simply drive the activators with respect to its inputs. The output of parallel port bits D_0 D_1 D_2 D_3 D_4 D_5 D_6 D_7 were used. Each addressing byte has a specific function and this function is not constant it can be allocated as desired. Each addressing byte can be either input or output, but it cannot be input and output at the same time.

The output activators play the role of a bridge between incoming data from PC and input of the PLC. It is made by using simple D flip-Flops and OR gates. Data comes from the bits of parallel port of the PC and these bits are called as S_3 S_4 S_5 S_6 . This sub-circuit will be active if and only if the address decoder sub-circuit will drive it.

The input activators play the role of a bridge between incoming data from PLC and PC. It is made by using simple three stage octal buffer gates. Data comes from the PLC's output and it is resent to the input bits of parallel port of PC and these bits are called as C_0 C_1 C_2 C_3 . This sub-circuit will be active if and only if the address decoder sub-circuit will drive it. But bits C_0 C_1 C_3 of the parallel port are logically inverted. To eliminate this logical NOT operation, the Automation Pro 2001 Computer interface program will take again reverse of these bits.

2.2.2.2 Operation of the Hardware

In this part you will see the operation of the hardware, what is its job and how it is working? Let's start by analyzing the elements which are used in the codec.

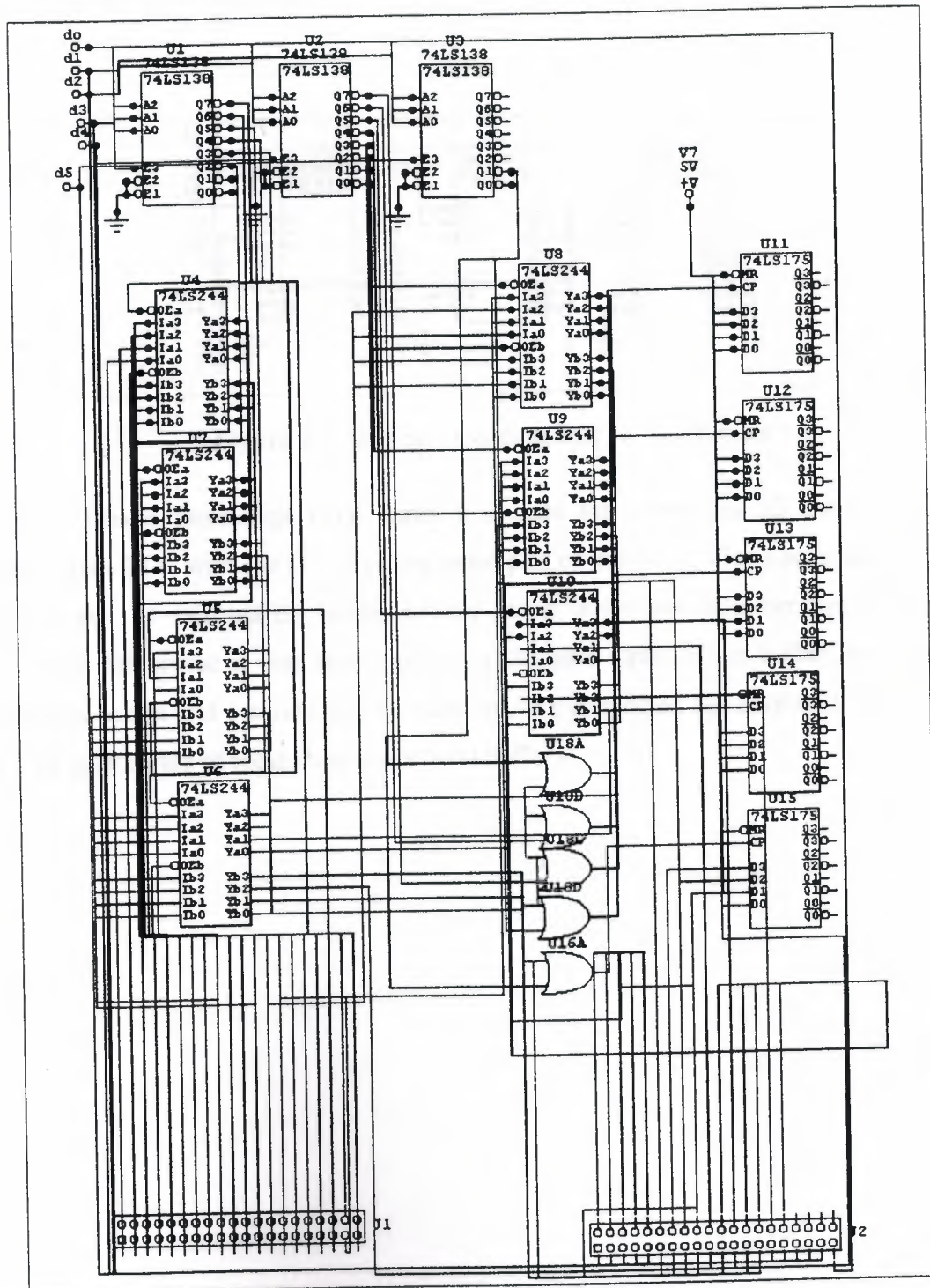


Figure 2.7 Electrical Diagram of the Circuit

This Codec circuit consists of three 3 to 8 active low decoder. It is used for addressing the incoming and outgoing bits. I used six addressing bits in my circuit this means that we can control $24 \times 4 = 96$ bits. But also we can control at most 1024 bits by using parallel port of any PC

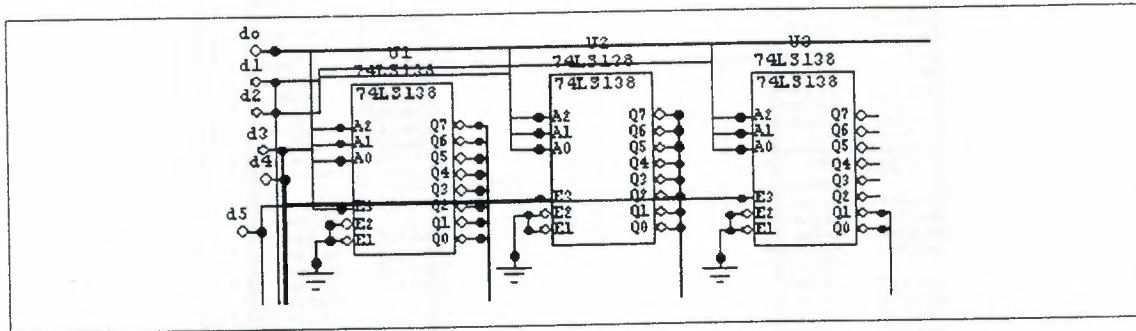


Figure 2.8 Address Decoding Part Of The Circuit

This is three-stage octal buffer it is used for connecting all inputs which are came from PLC with the PC. Working principles of this IC is; if you send logic 1 to the gate input of this buffer, buffer directly make interconnection between anode and cathode. Otherwise if you send logic 0 to the gate input of the buffer the resistance between anode and cathode will be infinitive. We connected the output of the decoders to the gate inputs of these three stage octal buffers.

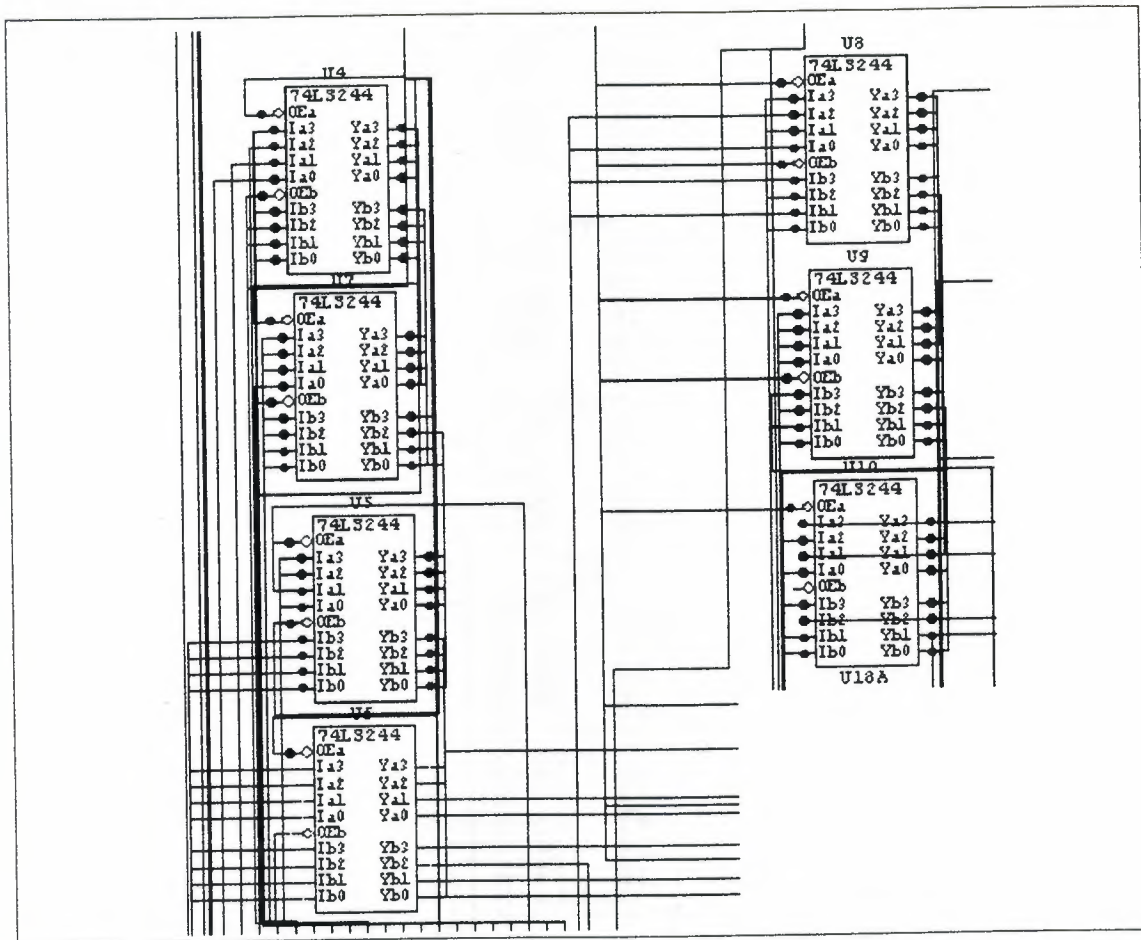


Figure 2.9 Input Buffers

The quad D flip-flops with clock input. We have to send our outputs every time to the PLC not to effect the system. Because of this reason, I used 74LS175 in this circuit. The circuit sends outputs to PLC through the D flip-flop. By using this IC we can send our outputs all the time. I used five IC in this circuit. This means that we have twenty output bits. The inputs of these D flip-flops are connected to the status bits of the parallel port of PC; the Clock pulse input are connected an OR gate also this OR gate inputs are connected a clock pulser and the output of the address decoder sub-circuit.

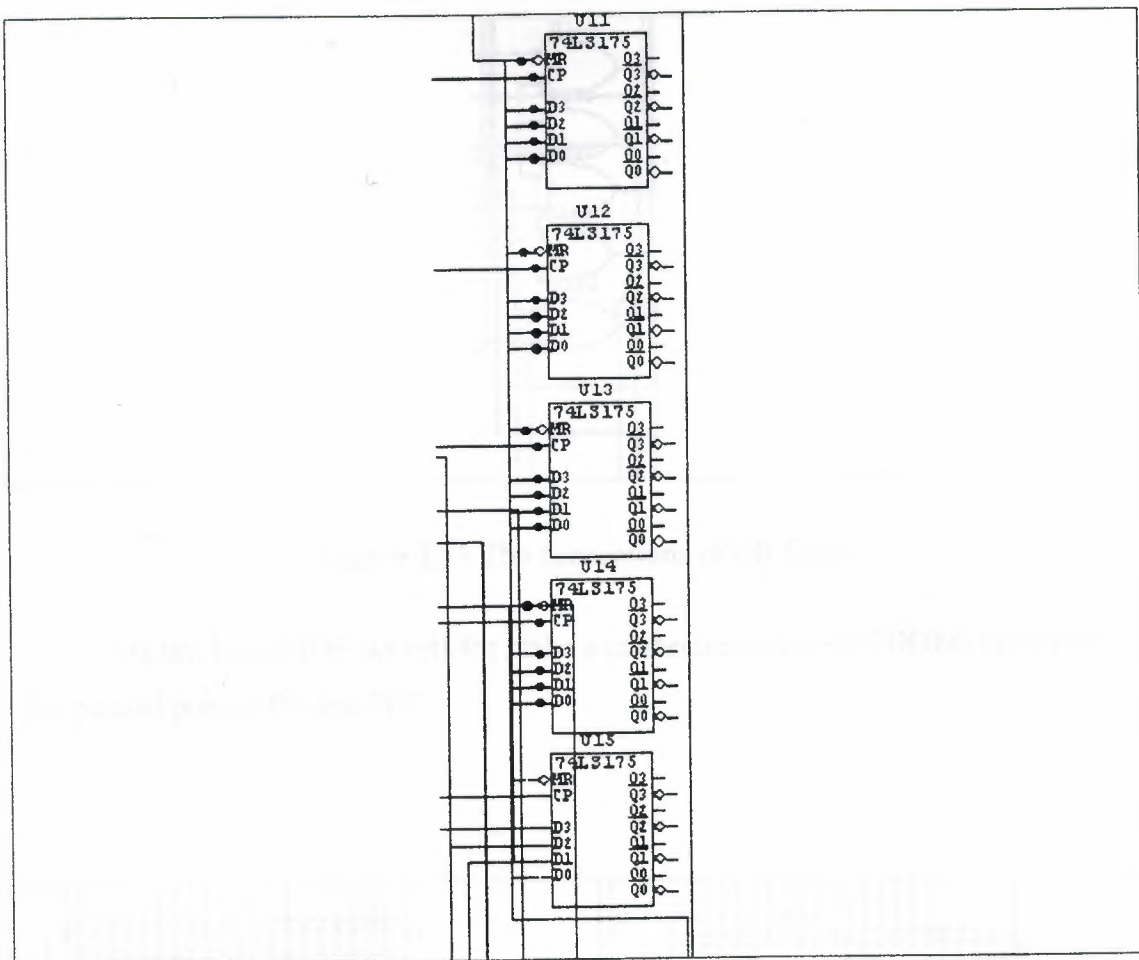


Figure 2.10 D flip-flops (output part of the circuit)

I used 74LS32 chips because sending clock pulses to the D flip-flops when data sending to outside direction so that these D flip-flops could not loaded when data came from PLC or any other unwanted time.

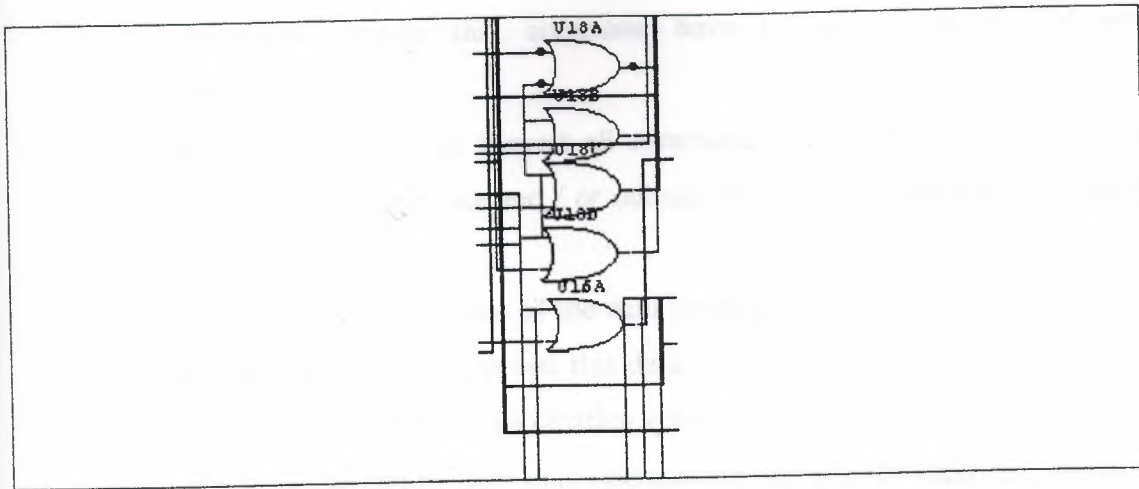


Figure 2.11 The connections of OR Gates

At last I used IDE sockets for make a connection between CODEC circuit and the parallel port of PC and PLC.

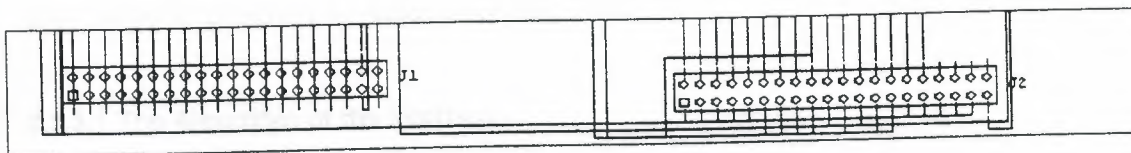


Figure 2.12 IDE sockets which are used for taking inputs from PLC and sending outputs to the PLC

2.2.3 Software of the CODEC

As it was described earlier, an operator can control everything in the automation system by using a computer program. But this computer program should have some properties; these are

- It should be easy to use and the operator should not need to attend any training to learn how he / she can use the computer program
- This computer program must contain less code for sending data to the parallel port of computer. Because when operator sends a command to the

automation system that command have to go to the parallel port immediately.

- This program have to convert all commands to their specific binary codes (such as addressing byte and / or output data) before sending to the parallel port of that PC
- This program can be take all the data coming from CODEC interface circuit and also it has to be convert this data to real values to show the operator what is happening in the automation system.
- This program can be used only operator no one else for security purpose so that it have a password protection.
- The operator could be fast when making changes in the system so that the menus must be easy to reach.

To do all these jobs, I used Visual Basic Programming Language. I prefer this language because it has all properties to do this job and it is easy to program. I called this computer program as Automation Pro 2001.

2.2.3.1 The Algorithm of the Interface

We can analyze the algorithm of this software in two groups because there are two alternatives. One of these is, operator sends a command to the system and the other one is, a status data comes from the system to the computer. These algorithms are described below.

First alternative: (operator will send a command to the system)

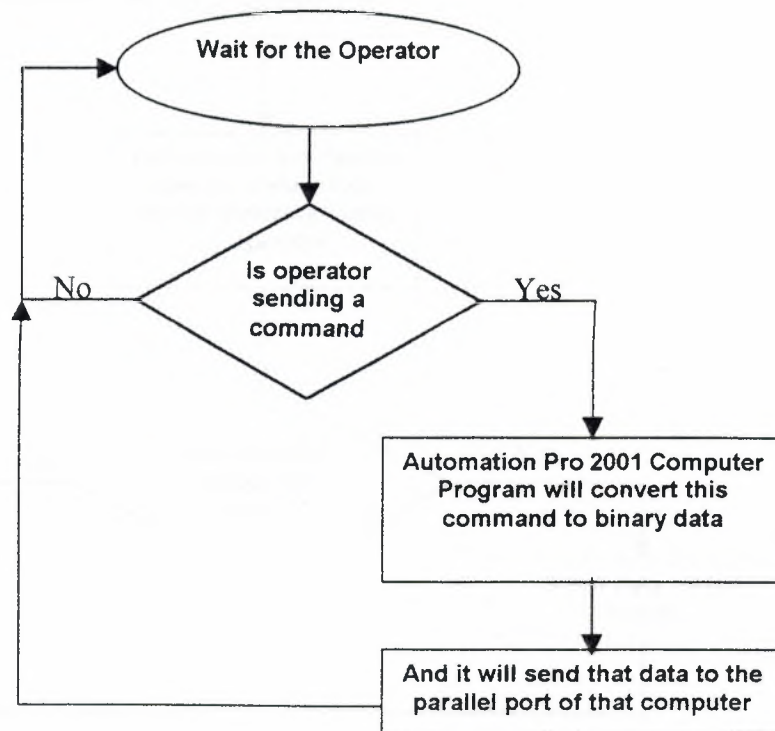


Figure 2.13 First alternative

Second alternative: (A status data came to the parallel port from CODEC interface)

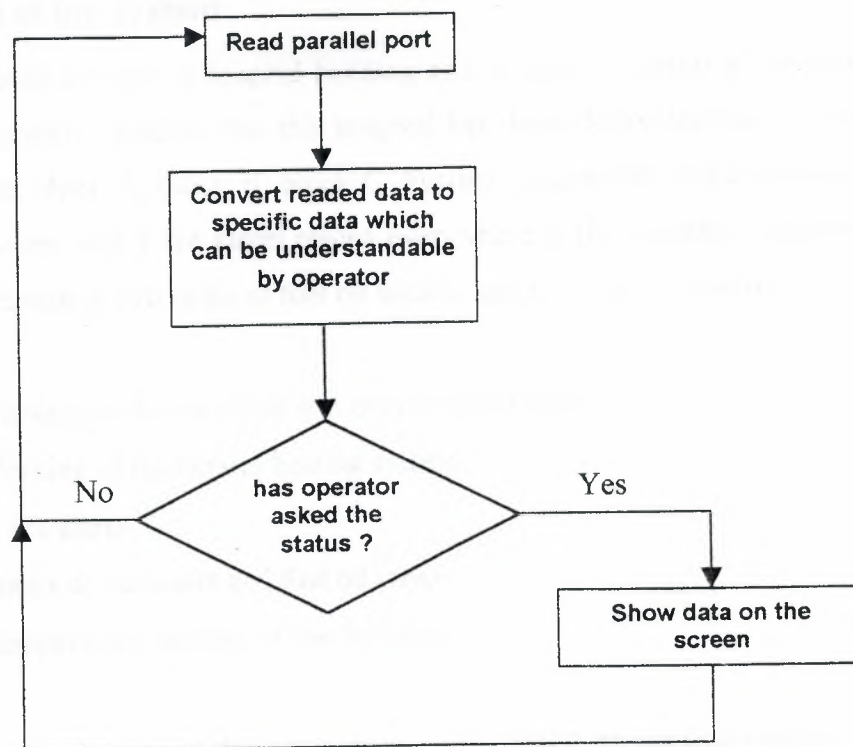


Figure 2.14 Second alternative

3. EXAMPLE APPLICATION USING THE CODEC IN A HOSPITAL AUTOMATION

3.1 Description of the system

Now suppose we have a hospital building and we want to setup an automation system in this hospital. Assume that this hospital has three floors and each floor has three blocks called block A, block B, block C. Further assume that this building has a central heating system and a fire alarm placed everywhere in the building. Also assume that this building contains two tanks of fuel oil liquids, and we want to control

- Illumination levels inside and outside the building
- Working of the central heating system
- A fire alarm
- Status of the water and fuel oil tanks
- Temperature readings in the building

We want to control all of these factors by using central automation system. The representative drawing of this building is shown in Figure 3.1.

	Block A	Block B	Block C
Floor 3	Sector 7	Sector 8	Sector 9
Floor 2	Sector 4	Sector 5	Sector 6
Floor 1	Sector 1	Sector 2	Sector 3

Figure 3.1 Representative drawing of the hospital

3.2 Requirements of the System

To make this automation system we need these elements.

- A CODEC interface circuit.
- A PC, which can be:
 - At least 486 based microprocessor
 - 16 Mbytes RAM
 - 2 Mbytes of free disk space
- Any kind of PLC (I used Siemens S7 - 200)

3.3 Designing the Automation System

3.3.1 The Hardware

We can use exactly the same CODEC interface circuit that we described in section 2.2.2. In this section, we will look at the connection between CODEC interface and the PLC.

As I said before to make this automation we have such a PLC which has 50 bits output and 20 bits input. Now we have two alternatives to get this PLC. One of these is to use a PLC such as Siemens S5 series PLC, or connect 5 Siemens S7-200 type PLCs to our system. I selected a Siemens S7-200 type PLC for this Project. This has got 80 inputs and 50 bits outputs.

The output and input pins of CODEC interface and its connection points with the PLC are given in next table. To make this connection, I used the IDE sockets on the CODEC interface. As I said before there are two IDE sockets on the CODEC interface to make connections between the CODEC and PLC and each of these IDE sockets has 40 pins.

Table 3.1 IDE Soccet No 1 Connections

Soccet Bit No	Connection point of PLC	Description
1,2,3,4,5,6,7,8	Q0-Q7	Fire alarm input
9,10	Q8,Q9	Lights position information of sector 1
11,12	Q10,Q11	Lights position information of sector 2
13,14	Q12,Q13	Lights position information of sector 3
15,16	Q14,Q15	Lights position information of sector 4
17,18	Q16,Q17	Lights position information of sector 5
19,20	Q18,Q19	Lights position information of sector 6
21,22	Q20,Q21	Lights position information of sector 7
23,24	Q22,Q23	Lights position information of sector 8
25,26	Q24,Q25	Lights position information of sector 9
27,28	Q26,Q27	Liquid position information of tank 1
29,30	Q28,Q29	Liquid position information of tank 2
31,32	Q30,Q31	Working Status of the heater
33,34,35,36,37,38,39,40	Q32-Q39	Temperature readings of inside the building

Table 3.2 IDE Soccet No 2 Connections

Soccet Bit No	Connection point of PLC	Description
1,2,3,4,5,6,7,8	Q40-Q47	Temperature readings of outside the building
38,39	Q48-Q49	Lights position information of Outside the building
9,10	I1-I2	Sector1 activation Lights codes
11,12	I3-I4	Sector2 activation Lights codes
13,14	I5-I6	Sector3 activation Lights codes
15,16	I7-I8	Sector4 activation Lights codes
17,18	I9-I10	Sector5 activation Lights codes
19,20	I11-I12	Sector6 activation Lights codes
21,22	I13-I14	Sector7 activation Lights codes
23,24	I15-I16	Sector8 activation Lights codes
25,26	I17-I18	Sector9 activation Lights codes
27,28	I19-I20	Outside of the building activation ligths codes
40	To external Pulser	To activate the circuit it should be at least 66 MHz.

3.3.2 The Software

In this section more detailed description of the Automation Pro 2001 computer program , including the submenus it consist of and what they do , can be found. Let us analyze this software by starting with the main menu.

3.3.2.1 Main Menu

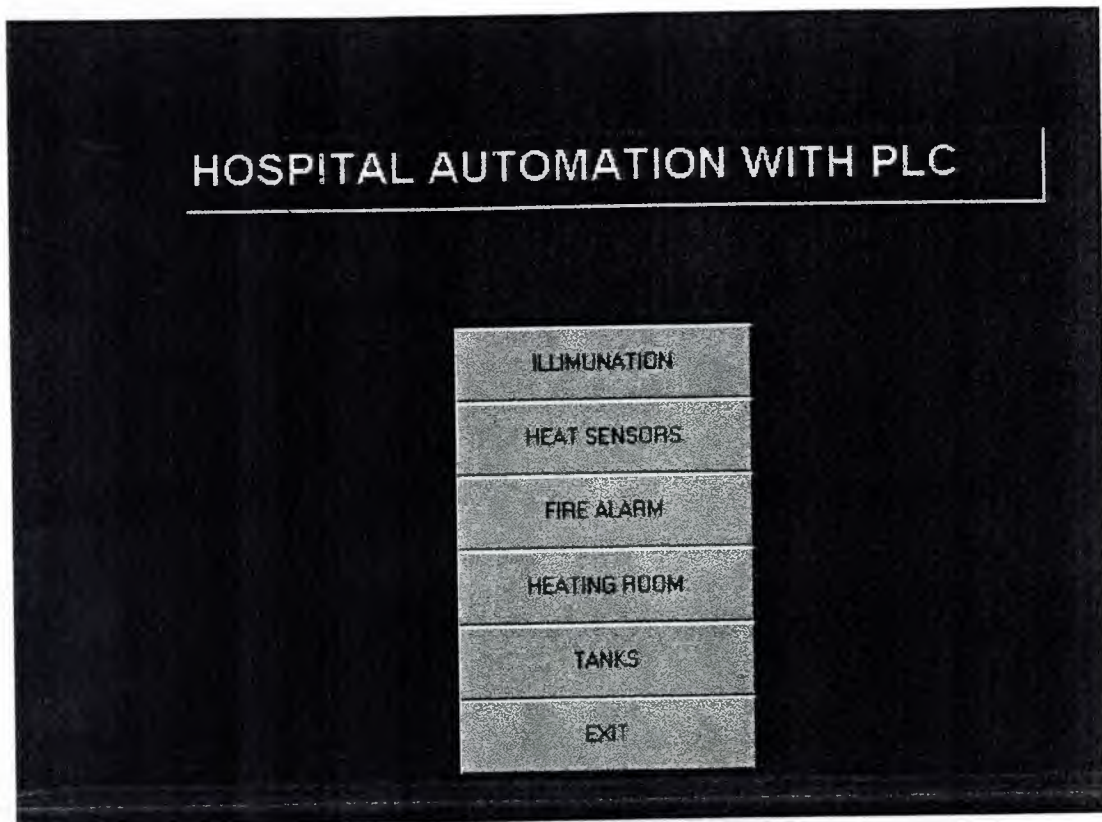


Figure 3.2 Main menu

This menu consists of five submenus. The user can select the section which is controlled by the user. First submenu is ILLUMINATION when user select this menu the software will open another menu to give a selection to the user which is "indoor" or "outdoor" illumination. Second menu is the heat sensors menu. If user will select this submenu program will open directly open heat sensors form. Third one is for "fire alarm" section. Fourth one is "Heating room", Fifth one is "TANKS" section and last one is EXIT button if the user select this button program automatically closed. If the user will close the program, the output of the LPT port will be send randomly data to

the CODEC this action will occur unwanted operations of the PLC so that user must not close the program when the PLC is working.

Another properties of this form is, When a fire alarm signal come form automatically closed and program will open directly fire alarm form and show the place of fire in the building to the user.

3.3.2.2 Illumination Section

When the user selects illumination section another menu will come to the screen figure 3.3. User will select which part's illumination He / She will control here.

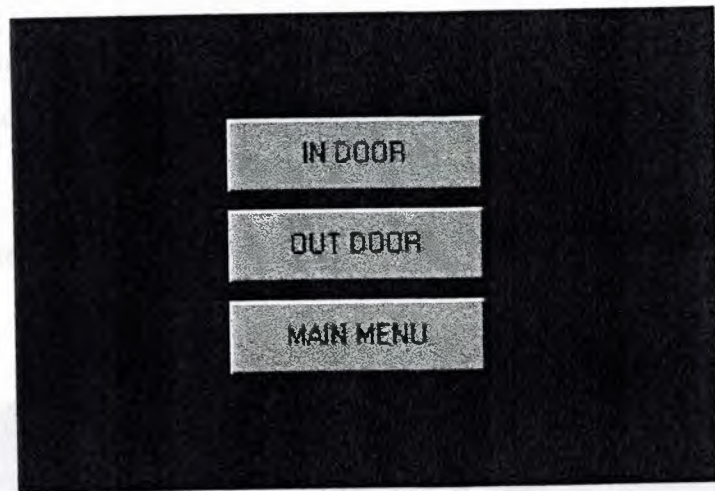


Figure 3.3 Illumination Submenu

3.3.2.3 Indoor Illumination

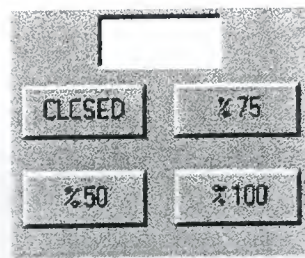


Figure 3.4 Form of indoor illumination

In this form user can easily observe the illumination level in the building each flat and each block can controlled separately. For each part, there are 4 different alternative either the level of the illumination can be closed or %50 or % 75 or it should be %100 .If the user push the BACK button program reopen the illumination submenu.

3.3.2.4 Outdoor Illumination

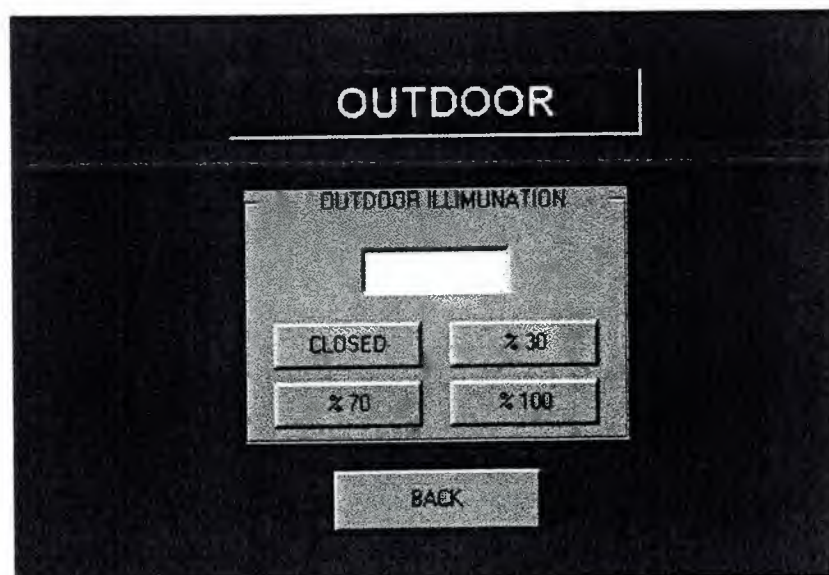


Figure 3.5 Outdoor illumination form

In this form everthing is same as the indoor form but here user can manipulate the illumination level of the outside of the building.

3.3.2.5 Heat Sensors

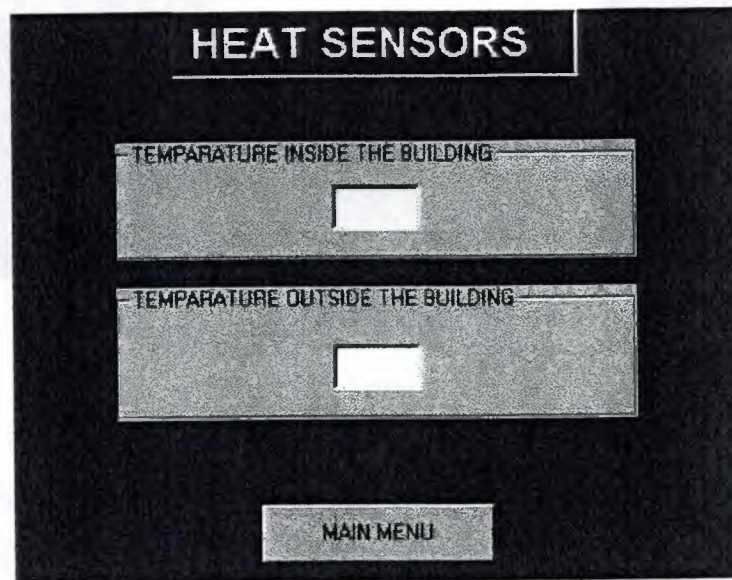


Figure 3.6 Form of heat sensors

In this section user can observe the temperature both inside and outside the building.

3.3.2.6 Fire Alarm



Figure 3.7 Form of fire alarm

If a fire signal comes to the Codec, Codec directly send this signal to the PC by using the LPT port. The program will find the location of the fire and show the user place of the fire alarm as flat, as block and also as room number.

3.3.2.7 Heating Room

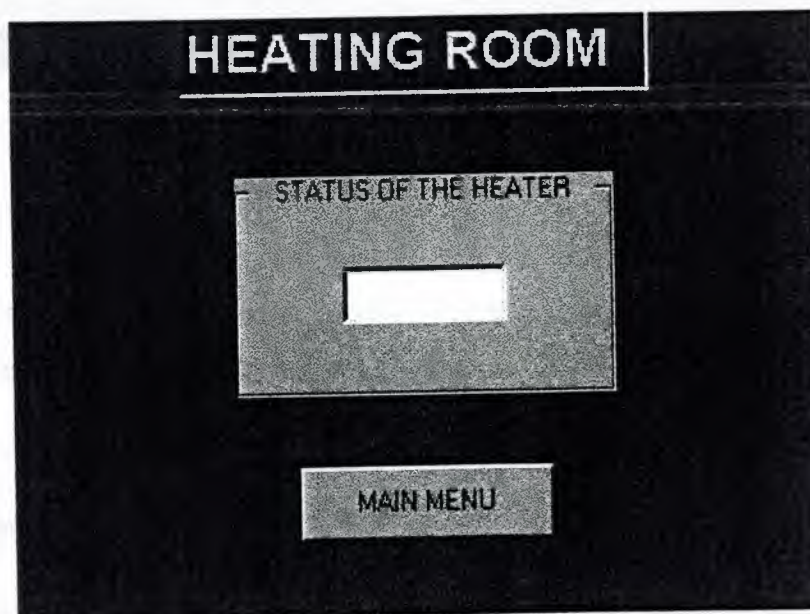


Figure 3.8 Form of the heating room

In this form the user only see the position of the heater, is it working or not. If the user select “ main menu “ button this form directly closed and main menu will open.

3.3.2.8 Status Of The Tanks

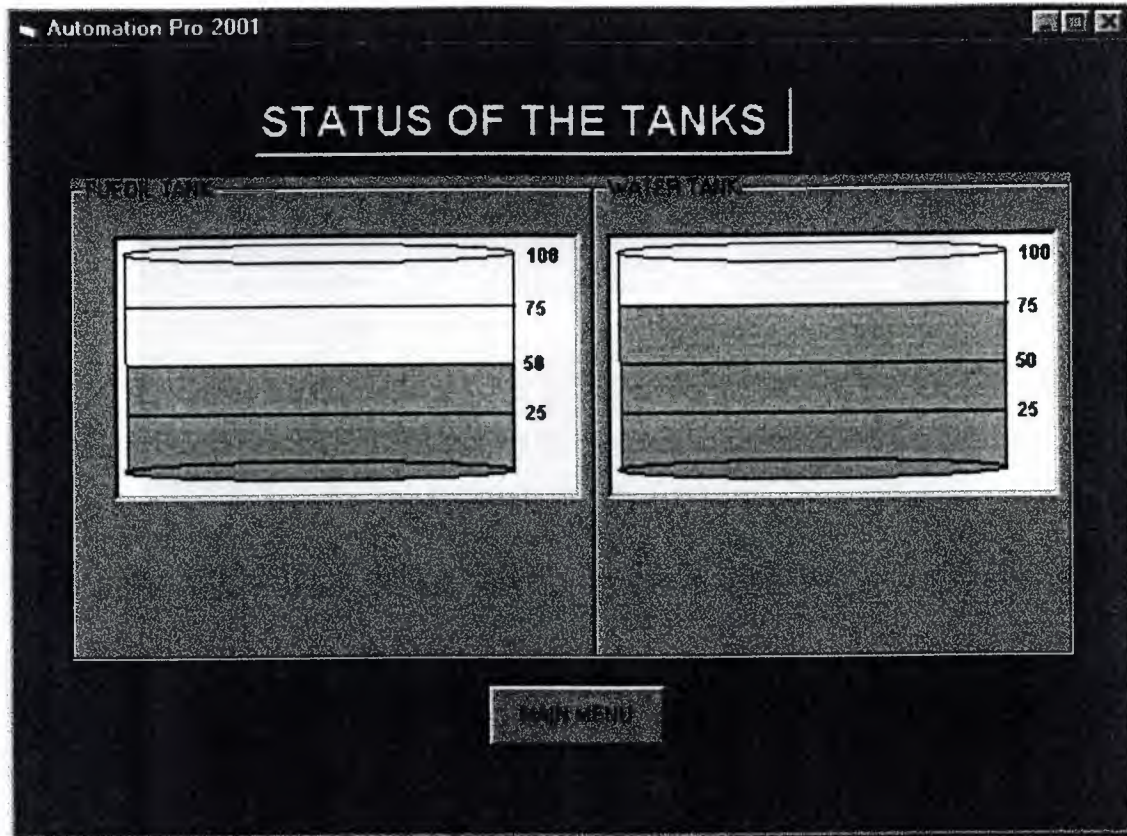


Figure 3.9 Form of the tanks

There are two tanks in our building one is used for fuel oil other is for water. User can see the level of these tanks by using this form. If user wants to exit this form he/she can select “ main menu “ button.

3.3.2.9 Codec Interface Codes of the Automation Pro 2001

As we said before the Automation Pro 2001 computer software takes command from an operator and it converts this command to pre-designed binary codes and then

sends the codes to the CODEC interface via the parallel port of the PC. In this section you can find a whole list of commands and codes.

Suppose the operator will enter the submenu of the illumination then he / she enters third level submenu of outdoor illumination. As shown in figure 3.10

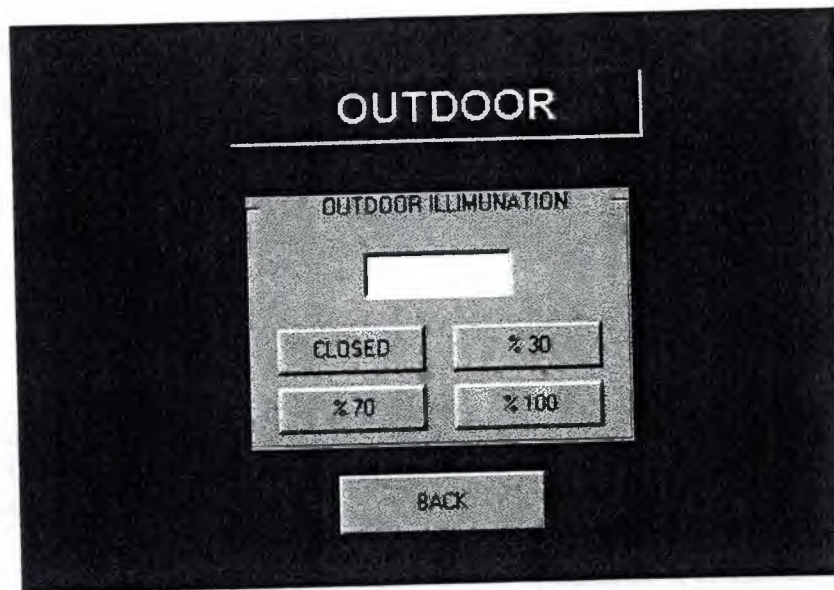


Figure 3.10 Third level outdoor illumination menu

After this second the computer program will keep waiting a command from the operator. Operator can send four different commands to the program these are

- Close all the lights outside (CLOSED)
- Open predesigned 30 % of the lights which are placed outside of the building (% 30)
- Open predesigned 70 % of the lights which are placed outside of the building (% 70)
- Open predesigned 100 % of the lights which are placed outside of the building (% 100)

Each command has specific binary codes these codes are

Commands Codes

CLOSED	00
30 %	01
70 %	10
100 %	11

So that if the operator send a CLOSED command to the system the Automation Pro 2001 computer program will directly send (binary 00) to the status bits of the parallel port of the PC with required address decoding codes. Next table is showing us the whole binary codes of each command.

Table 3.3 Binary Codes Of All Command.

Address Decoding Codes (D4-D3-D2-D1)	Command Codes (C3-C2-C1-C0)	Description
10101	00	Close all lights in sector 1
	01	Open 50 % of lights in sector 1
	10	Open 75 % of lights in sector 1
	11	Open 100 % of lights in sector 1
* 10101	00	Close all lights in sector 2
	01	Open 50 % of lights in sector 2
	10	Open 75 % of lights in sector 2
	11	Open 100 % of lights in sector 2
10110	00	Close all lights in sector 3
	01	Open 50 % of lights in sector 3
	10	Open 75 % of lights in sector 3
	11	Open 100 % of lights in sector 3
* 10110	00	Close all lights in sector 4
	01	Open 50 % of lights in sector 4
	10	Open 75 % of lights in sector 4
	11	Open 100 % of lights in sector 4
10111	00	Close all lights in sector 5
	01	Open 50 % of lights in sector 5
	10	Open 75 % of lights in sector 5
	11	Open 100 % of lights in sector 5

* 10111	00	Close all lights in sector 6
	01	Open 50 % of lights in sector 6
	10	Open 75 % of lights in sector 6
	11	Open 100 % of lights in sector 6
11000	00	Close all lights in sector 7
	01	Open 50 % of lights in sector 7
	10	Open 75 % of lights in sector 7
	11	Open 100 % of lights in sector 7
* 11000	00	Close all lights in sector 8
	01	Open 50 % of lights in sector 8
	10	Open 75 % of lights in sector 8
	11	Open 100 % of lights in sector 8
11001	00	Close all lights in sector 9
	01	Open 50 % of lights in sector 9
	10	Open 75 % of lights in sector 9
	11	Open 100 % of lights in sector 9
* 11001	00	Close all lights in outside
	01	Open 50 % of lights in outside
	10	Open 75 % of lights in outside
	11	Open 100 % of lights in outside

: The Codes sent by using C3 and C2 bits of parallel port in the lines with ""

The Automation Pro 2001 Computer Program takes the data from codec interface continuously when the operator is not sending any command. This process is working in form of this; Automation pro 2001 computer program will send some range of address decoder data continuously to the codec interface to read comes data to it. Then for each address it takes codes and convert this codes to the visible data to show the operator when he / she ask it. In next table you can find these addressing codes and data.

Table 3.4 Addressing Codes And Data

Address Decoding Codes (D4-D3-D2-D1)	Command Codes (S3-S2-S1-S0)	Description
001000 and 001001	From 00000000 to 11111111	Show the Place of the fire if it is exists
001010 and 001011	From 00000000 to 11111111	Temperature readings at inside of the building
001100 and 001101	From 00000000 to 11111111	Temperature readings at outside of the building
001110	00,10,01,11	Lighting level of the sector 1
* 001110	00,10,01,11	Lighting level of the sector 2
001111	00,10,01,11	Lighting level of the sector 3
* 001111	00,10,01,11	Lighting level of the sector 4
010000	00,10,01,11	Lighting level of the sector 5
* 010000	00,10,01,11	Lighting level of the sector 6
010001	00,10,01,11	Lighting level of the sector 7
* 010001	00,10,01,11	Lighting level of the sector 8
010010	00,10,01,11	Lighting level of the sector 9
* 010010	00,10,01,11	Lighting level of the outside
010011	00,10,01,11	Liquid level of the tank 1
* 010011	00,10,01,11	Liquid level of the tank 2
010100	00,10,01,11	Heater status

* : The codes are taken by using S3 and S2 bits of parallel port in the lines with “*”

3.3.3 Advantages of the New System

To see the advantages of this system I will give an example to the old system. Sani Konukoğlu Hospital has an automation system which has same ability with the system described in chapter four. This old system was designed and installed by Siemens. In their automation systems they used a special computer. This computer has more than 1 parallel port and it is not a PC. To connect this PC to PLC they didn't use any kind of computer interface so that they connected the computer directly to the PLC's inputs or outputs. To this reason that PLC group has a different input and output bit for each connection bit of the computer so that this PLC group has thousands of inputs and outputs. This is automatically increasing the cost of the system. Now this is the most important advantage of this new kind automation system. It is the cheapest

Complex Automation system in the world. It decreases the cost of all system by factor of 10.

To setup this new system you don't have to a large area as much as other systems because this system is used less PLC modules.

Another important advantages of this new system is processing time if the operator send a command to the system, that command will execute at that time and that command will be delivered to activators, sensors, motors, sensors etc. etc which are used in the system at most 1 second later for this application. This time is depends to the used elements in the automation system. Next figure is for pentium based computer.

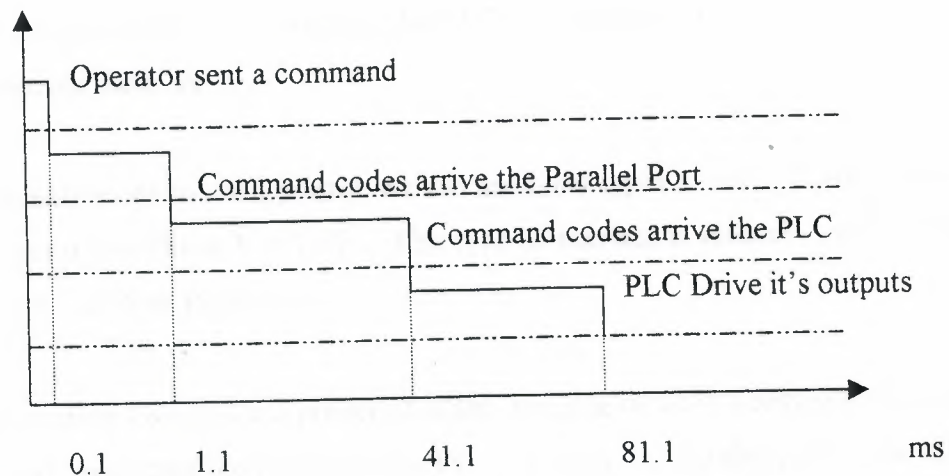


Figure 3.11 Timing Diagram Of The System

The operator does not have to enter a course to learn this system because the operator interface of this system is very simple it likes using any version of Windows operating system. The Automation Pro 2001 Computer Program can be used by anyone who had some knowledge of PC's.

If an error occurs in the system the operator can control the system easily before that error will not effect the building or people inside the building. And last advantage of this system is that, this system will setup one time at anywhere and it does not need any service periodically.

4. SUGGESTIONS FOR FUTURE WORK

The new system described can be used to automate medium scale plants. Because the system is based on the parallel port, the input-output capacity is currently limited to 1024. Although this may seem to be a limitation, it is possible to expand the I/O limit by using special design techniques in the CODEC circuit. It may also be possible to setup a network-based system for large automation applications. The I/O capacity will then not be a problem.

The second suggestion is to use a printer with this system to print important changes in the system. Standard printers use the parallel port of the PC's but each PC has only and only one parallel port and as a result of this we can not use a printer in this automation system at the same time as the CODEC interface. To do this job we have three alternatives these are:

Alternative one to use a printer, we can use other types of printers, which have different types of interfaces. E.g. USB. This type of interface is generally available on higher end PCs, such as Pentiums.

Alternative Two to use a printer, it is also possible to setup a network by using a cheap PC and connecting the printer to this PC. This way, the parallel port of the main PC will be available for the CODEC use. Using a second PC will increase the cost of the system slightly.

Alternative three to use a printer, my last suggestion for the using a printer is design a new interface system by using serial port of the PC's. This new interface will connect printer to PC by using PC's serial port. This will also increase the cost of the system slightly.



5. CONCLUSIONS

The design of a coder/decoder (CODEC) interface circuit has been described. The circuit is between a PC and a PLC and it enables large number of inputs and outputs to be controlled from a standard PC.

The aim of this thesis was to design a simple and friendly user interface system.

Chapter 1 has described the basic principles of PLCs and PLC based automation systems.

The conventional methods of interfacing PLCs to PCs have been described in detail in Chapter 2. Also, the novel system developed by the author has been described in this chapter.

Chapter 3 has described a practical application of the new system developed by the author. It is shown that the new system offers many advantages. First of all, the cost of the new system is considerably lower compared to standard systems. Also, the new system is interfaced to a PC using the standard parallel port type interface. All PCs are equipped with at least one parallel port, and as a result of this, it should be possible to use any kind of PC in the new design. This is a big advantage because the user can keep the costs down by choosing a low cost PC.

There is a hospital automation system in Gaziantep, at the Sani Konukoglu Hospital. This system is based on PLCs and the specifications of this system are very close to the example system given in Chapter 3. The system at Gaziantep is based on conventional design techniques, resulting in a large number of inputs and outputs and the use of complex dedicated hardware and software. The same hospital could have been controlled using the new interface system described in this thesis at the fraction of the cost involved.

REFERENCES

- [1]. Yagimli, M .; Akar, F .(1999). Dijital Elektronik , İstanbul : Beta Yayınevi .
- [2]. Karagülle , I .; Pala, Z (2000). Visual Basic 6.0 , İstanbul : Türkmen yayınevi.
- [3]. Tatar, H. (1998). VISUAL BASIC , İstanbul : Seçkin yayınevi.
- [4]. Akın , C. (1996). VISUAL BASIC 3.0 , İstanbul : Evrim Yayınevi.
- [5]. Karagülle , I .; Pala, Z (1998). Basic Bilmeyenler için Visual Basic , İstanbul : Türkmen yayınevi.
- [6]. Tanyeri , F. M . (1999). İleri Düzey Visual Basic, İstanbul : International kitabevi.
- [7]. Mamedov , F . (2000). Telecommunications , Nicosia :NEU press.
- [8]. Serçe, S . (1996). Analog & Dijital Elektronik , İstanbul :Birsen yayınevi.
- [9]. Ismailow , K . (2000). Principles Of Measurement And Instrumentation , Nicosia : NEU press.
- [10]. Bektaş , Ş .; Mamedov , F.; Khashman ,A (2001) .Graduate Studies A Complete Reference , Nicosia : NEU press
- [11]. Yağımlı , M .; Akar , F (1998) .Programlanabilir Logic Denetleyiciler , İstanbul : Beta Yayınevi
- [12]. Teközgen , E . (1998). PLC Uygulamaları ve Programlanabilir Logic Denetliyeciler , İstanbul : Birsen Yayınevi.

APPENDIX 1

PLC PROGRAM OF THE HOSPITAL AUTOMATION SYSTEM

PROGRAM TITLE COMMENTS

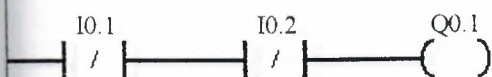
Press F1 for help and example program

Network 1 FIRE ALARAM

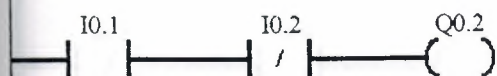
NETWORK COMMENTS



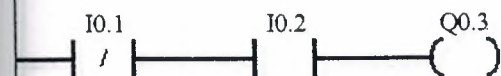
Network 2 SECTOR 1



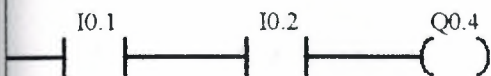
Network 3 SECTOR 1



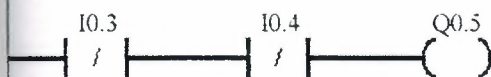
Network 4 SECTOR1



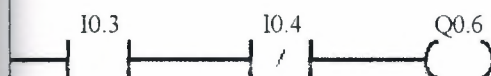
Network 5 SECTOR 1



Network 6 SECTOR 2



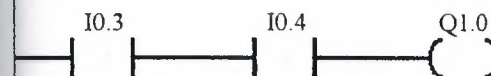
Network 7 SECTOR 2



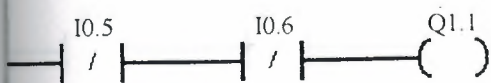
Network 8 SECTOR 2



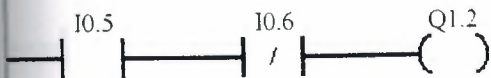
Network 9 SECTOR 2



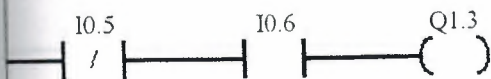
Network 10 SECTOR 3



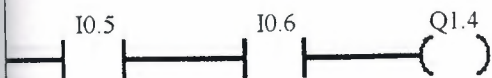
Network 11 SECTOR 3



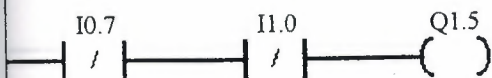
Network 12 SECTOR 3



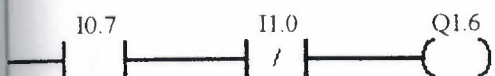
Network 13 SECTOR 3



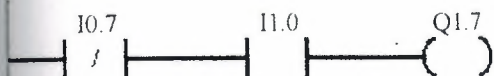
Network 14 SECTOR 4



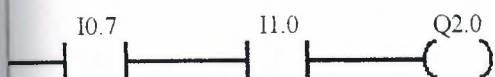
Network 15 SECTOR 4



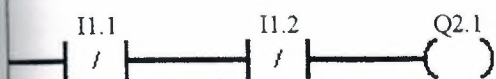
Network 16 SECTOR 4



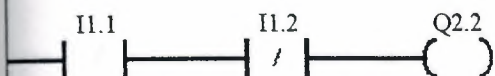
Network 17 SECTOR 4



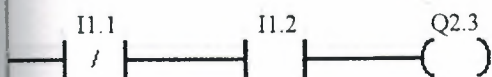
Network 18 SECTOR 5



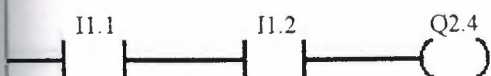
Network 19 SECTOR 5



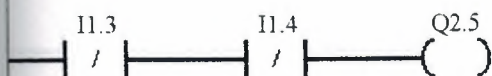
Network 20 SECTOR 5



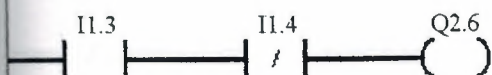
Network 21 SECTOR 5



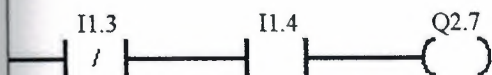
Network 22 SECTOR 6



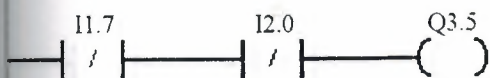
Network 23 SECTOR 6



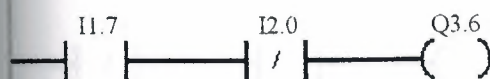
Network 24 SECTOR 6



Network 30 SECTOR 8



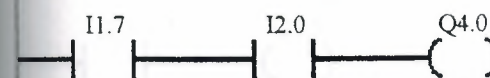
Network 31 SECTOR 8



Network 32 SECTOR 8



Network 33 SECTOR 8



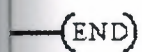
Network 34 SECTOR 9



Network 40



Network 41



APPENDIX 2

DATA SHEETS OF USED IC'S IN CODEC CIRCUIT

For a complete data sheet, please refer to the following:

- The ICSE 74HC/HCT173 and 74HC/HCT174 data sheets
- The SEU 74HC/HCT173 and 74HC/HCT174 data sheets
- The ICSE 74HC/HCT173 and 74HC/HCT174 data sheets

74HC/HCT173

Quad D-type flip-flop; positive-edge
trigger; 3-state

Product specification

File number: Integrated Circuits, IC36

December 1990

Philips
Semiconductor Division



PHILIPS

DATA SHEET

For a complete data sheet, please also download:

- The IC06 74HC/HCT/HCU/HCMOS Logic Family Specifications
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Information
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Outlines

74HC/HCT173

Quad D-type flip-flop; positive-edge trigger; 3-state

Product specification
File under Integrated Circuits, IC06

December 1990



Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

FEATURES

- Gated input enable for hold (do nothing) mode
- Gated output enable control
- Edge-triggered D-type register
- Asynchronous master reset
- Output capability: bus driver
- I_{CC} category: MSI

GENERAL DESCRIPTION

The 74HC/HCT173 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT173 are 4-bit parallel load registers with clock enable control, 3-state buffered outputs (Q_0 to Q_3) and master reset (MR).

When the two data enable inputs (\bar{E}_1 and \bar{E}_2) are LOW, the data on the D_n inputs is loaded into the register

synchronously with the LOW-to-HIGH clock (CP) transition. When one or both \bar{E}_n inputs are HIGH one set-up time prior to the LOW-to-HIGH clock transition, the register will retain the previous data. Data inputs and clock enable inputs are fully edge-triggered and must be stable only one set-up time prior to the LOW-to-HIGH clock transition.

The master reset input (MR) is an active HIGH asynchronous input. When MR is HIGH, all four flip-flops are reset (cleared) independently of any other input condition.

The 3-state output buffers are controlled by a 2-input NOR gate. When both output enable inputs (\overline{OE}_1 and \overline{OE}_2) are LOW, the data in the register is presented to the Q_n outputs. When one or both \overline{OE}_n inputs are HIGH, the outputs are forced to a high impedance OFF-state. The 3-state output buffers are completely independent of the register operation; the \overline{OE}_n transition does not affect the clock and reset operations.

QUICK REFERENCE DATA

GND = 0 V; $T_{amb} = 25^\circ\text{C}$; $t_r = t_f = 6\text{ ns}$

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PHL}/t_{PLH}	propagation delay CP to Q_n MR to Q_n	$C_L = 15\text{ pF}$; $V_{CC} = 5\text{ V}$	17	17	ns
			13	17	ns
f_{max}	maximum clock frequency		88	88	MHz
C_i	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per flip-flop	notes 1 and 2	20	20	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

$$P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o) \text{ where:}$$

f_i = input frequency in MHz

f_o = output frequency in MHz

$\sum (C_L \times V_{CC}^2 \times f_o)$ = sum of outputs

C_L = output load capacitance in pF

V_{CC} = supply voltage in V

2. For HC the condition is $V_i = \text{GND to } V_{CC}$
For HCT the condition is $V_i = \text{GND to } V_{CC} - 1.5\text{ V}$

ORDERING INFORMATION

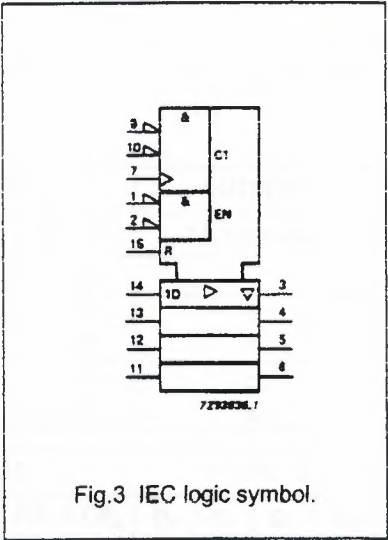
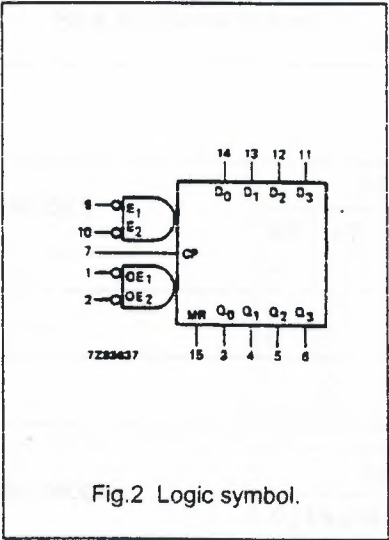
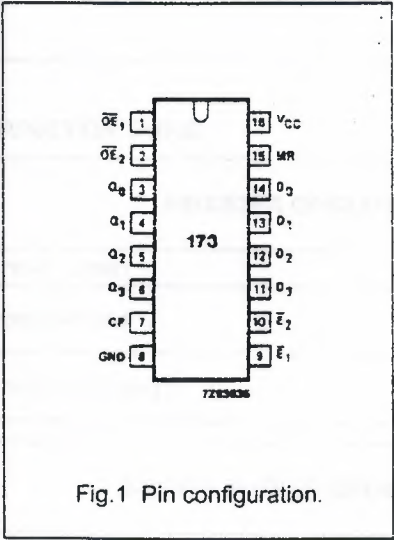
See "74HC/HCT/HCU/HCMOS Logic Package Information".

Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1, 2	$\overline{OE}_1, \overline{OE}_2$	output enable input (active LOW)
3, 4, 5, 6	Q_0 to Q_3	3-state flip-flop outputs
7	CP	clock input (LOW-to-HIGH, edge-triggered)
8	GND	ground (0 V)
9, 10	$\overline{E}_1, \overline{E}_2$	data enable inputs (active LOW)
14, 13, 12, 11	D_0 to D_3	data inputs
15	MR	asynchronous master reset (active HIGH)
16	V_{CC}	positive supply voltage



Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

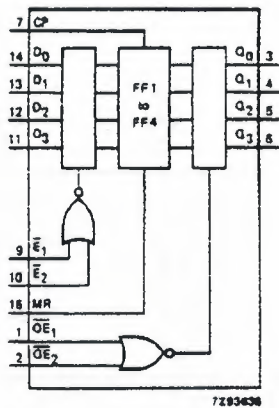


Fig.4 Functional diagram.

FUNCTION TABLE

REGISTER OPERATING MODES	INPUTS					OUTPUTS			
	MR	CP	\overline{E}_1	\overline{E}_2	D_n	Q_n (register)			
reset (clear)	H	X	X	X	X	L			
parallel load	L	\uparrow	L	L	L	L			
	L	\uparrow	L	L	h	H			
hold (no change)	L	X	h	X	X	q_n			
	L	X	X	h	X	q_n			

3-STATE BUFFER OPERATING MODES	INPUTS			OUTPUTS			
	Q_n (register)	\overline{OE}_1	\overline{OE}_2	Q_0	Q_1	Q_2	Q_3
read	L	L	L	L	L	L	L
	H	L	L	H	H	H	H
disabled	X	H	X	Z	Z	Z	Z
	X	X	H	Z	Z	Z	Z

Notes

1. H = HIGH voltage level
- h = HIGH voltage level one set-up time prior to the LOW-to-HIGH CP transition
- L = LOW voltage level
- L = LOW voltage level one set-up time prior to the LOW-to-HIGH CP transition
- q = lower case letters indicate the state of the referenced input (or output)
- one set-up time prior to the LOW-to-HIGH CP transition
- X = don't care
- Z = high impedance OFF-state
- \uparrow = LOW-to-HIGH CP transition

Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

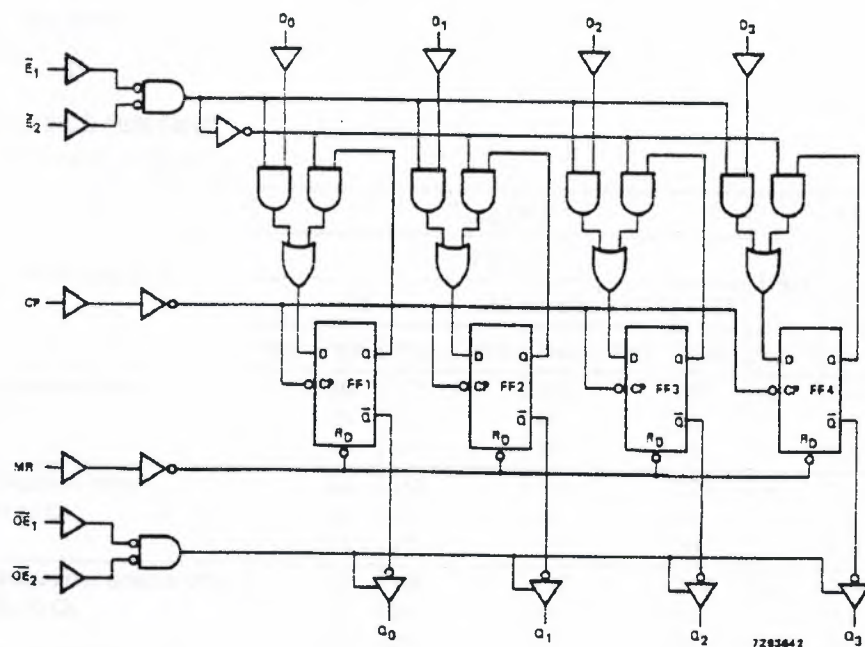


Fig.5 Logic diagram.

Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

DC CHARACTERISTICS FOR 74HC

For the DC characteristics see "74HC/HCT/HCU/HCMOS Logic Family Specifications".

Output capability: bus driver

I_{CC} category: MSI

AC CHARACTERISTICS FOR 74HC

GND = 0 V; t_r = t_f = 6 ns; C_L = 50 pF

SYMBOL	PARAMETER	T _{amb} (°C)								UNIT	TEST CONDITIONS	
		74HC									V _{CC} (V)	WAVEFORMS
		+25			-40 to +85		-40 to +125					
		min.	typ.	max.	min.	max.	min.	max.				
t _{PHL} / t _{PLH}	propagation delay CP to Q _n		55 20 16	175 35 30		220 44 37		265 53 45	ns	2.0 4.5 6.0	Fig.6	
t _{PHL}	propagation delay MR to Q _n		44 16 13	150 30 26		190 38 33		225 45 38	ns	2.0 4.5 6.0	Fig.7	
t _{PZH} / t _{PZL}	3-state output enable time \overline{OE}_n to Q _n		52 19 15	150 30 26		190 38 33		225 45 38	ns	2.0 4.5 6.0	Fig.8	
t _{PHZ} / t _{PLZ}	3-state output disable time \overline{OE}_n to Q _n		52 19 15	150 30 26		190 38 33		225 45 38	ns	2.0 4.5 6.0	Fig.8	
t _{THL} / t _{TLH}	output transition time		14 5 4	60 12 10		75 15 13		90 18 15	ns	2.0 4.5 6.0	Fig.6	
t _w	clock pulse width HIGH or LOW	80 16 14	14 5 4		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig.6	
t _w	master reset pulse width; HIGH	80 16 14	14 5 4		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig.7	
t _{rem}	removal time MR to CP	60 12 10	-8 -3 -2		75 15 13		90 18 15		ns	2.0 4.5 6.0	Fig.7	
t _{su}	set-up time \overline{E}_n to CP	100 20 17	33 12 10		125 25 21		150 30 26		ns	2.0 4.5 6.0	Fig.9	
t _{su}	set-up time D _n to CP	60 12 10	17 6 5		75 15 13		90 18 15		ns	2.0 4.5 6.0	Fig.9	

Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

SYMBOL	PARAMETER	T _{amb} (°C)							UNIT	TEST CONDITIONS	
		74HC								V _{CC} (V)	WAVEFORMS
		+25			-40 to +85		-40 to +125				
		min.	typ.	max.	min.	max.	min.	max.			
t _h	hold time E _n to CP	0	-17		0		0		ns	2.0	Fig.9
		0	-6		0		0			4.5	
		0	-5		0		0			6.0	
t _h	hold time D _n to CP	1	-11		1		1		ns	2.0	Fig.9
		1	-4		1		1			4.5	
		1	-3		1		1			6.0	
f _{max}	maximum clock pulse frequency	6.0	26		4.8		4.0		MHz	2.0	Fig.6
		30	80		24		20			4.5	
		35	95		28		24			6.0	

Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

DC CHARACTERISTICS FOR 74HCT

For the DC characteristics see "74HC/HCT/HCU/HCMOS Logic Family Specifications".

Output capability: bus driver

I_{CC} category: MSI

Note to HCT types

The value of additional quiescent supply current (ΔI_{CC}) for a unit load of 1 is given in the family specifications. To determine ΔI_{CC} per input, multiply this value by the unit load coefficient shown in the table below.

INPUT	UNIT LOAD COEFFICIENT
$\overline{OE}_1, \overline{OE}_2$	0.50
MR	0.60
$\overline{E}_1, \overline{E}_2$	0.40
D _n	0.25
CP	1.00

Quad D-type flip-flop; positive-edge trigger; 3-state

74HC/HCT173

AC CHARACTERISTICS FOR 74HCT

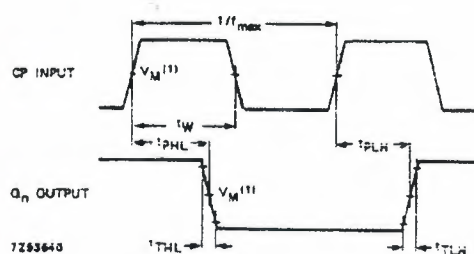
GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T _{amb} (°C)							UNIT	TEST CONDITIONS	
		74HCT								V _{CC} (V)	WAVEFORMS
		+25			−40 to +85		−40 to +125				
		min.	typ.	max.	min.	max.	min.	max.			
t _{PHL} / t _{PLH}	propagation delay CP to Q _n		20	40		50		60	ns	4.5	Fig.6
t _{PHL}	propagation delay MR to Q _n		20	37		46		56	ns	4.5	Fig.7
t _{PZH} / t _{PZL}	3-state output enable time OE _n to Q _n		20	35		44		53	ns	4.5	Fig.8
t _{PHZ} / t _{PLZ}	3-state output disable time OE _n to Q _n		19	30		38		45	ns	4.5	Fig.8
t _{THL} / t _{TLH}	output transition time		5	12		15		19	ns	4.5	Fig.6
t _w	clock pulse width HIGH or LOW	16	7		20		24		ns	4.5	Fig.6
t _w	master reset pulse width; HIGH	15	6		19		22		ns	4.5	Fig.7
t _{rem}	removal time MR to CP	12	−2		15		18		ns	4.5	Fig.7
t _{su}	set-up time E _n to CP	22	13		28		33		ns	4.5	Fig.9
t _{su}	set-up time D _n to CP	12	7		15		18		ns	4.5	Fig.9
t _h	hold time E _n to CP	0	−6		0		0		ns	4.5	Fig.9
t _h	hold time D _n to CP	0	−3		0		0		ns	4.5	Fig.9
f _{max}	maximum clock pulse frequency	30	80		24		20		MHz	4.5	Fig.6

Quad D-type flip-flop; positive-edge trigger; 3-state

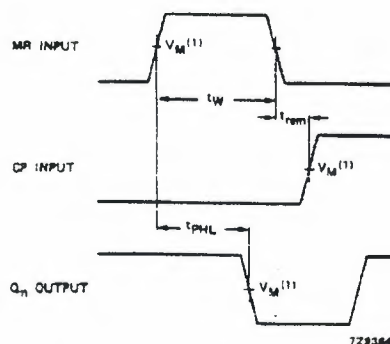
74HC/HCT173

AC WAVEFORMS



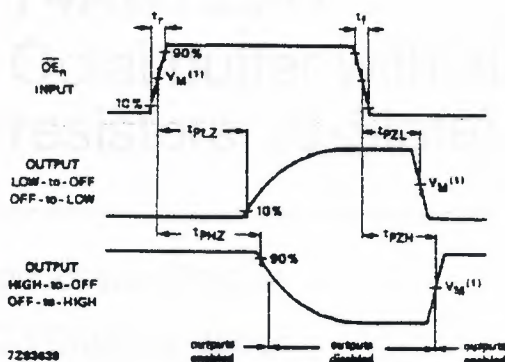
- (1) HC : $V_M = 50\%$; $V_I = \text{GND to } V_{CC}$.
HCT: $V_M = 1.3 \text{ V}$; $V_I = \text{GND to } 3 \text{ V}$.

Fig.6 Waveforms showing the clock (CP) to output (Q_n) propagation delays, the clock pulse width, the output transition times and the maximum clock pulse frequency.



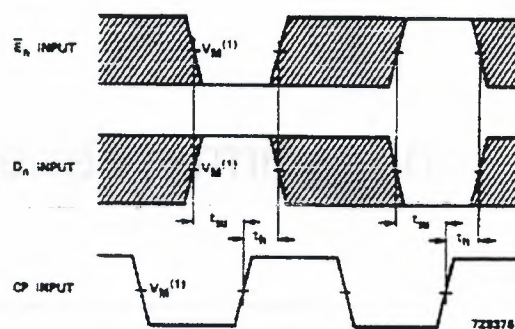
- (1) HC : $V_M = 50\%$; $V_I = \text{GND to } V_{CC}$.
HCT: $V_M = 1.3 \text{ V}$; $V_I = \text{GND to } 3 \text{ V}$.

Fig.7 Waveforms showing the master reset (MR) pulse width, the master reset to output (Q_n) propagation delays and the master reset to clock (CP) removal time.



- (1) HC : $V_M = 50\%$; $V_I = \text{GND to } V_{CC}$.
HCT: $V_M = 1.3 \text{ V}$; $V_I = \text{GND to } 3 \text{ V}$.

Fig.8 Waveforms showing the 3-state enable and disable times.



The shaded areas indicate when the input is permitted to change for predictable output performance.

- (1) HC : $V_M = 50\%$; $V_I = \text{GND to } V_{CC}$.
HCT: $V_M = 1.3 \text{ V}$; $V_I = \text{GND to } 3 \text{ V}$.

Fig.9 Waveforms showing the data set-up and hold times from input (\bar{E}_n , D_n) to clock (CP).

PACKAGE OUTLINES

See "74HC/HCT/HCU/HCMOS Logic Package Outlines".

DATA SHEET

74ABT2241

Octal buffer with 30Ω series termination resistors; (3-State)

Product specification

1996 Sep 30

IC23 Data Handbook



Octal buffer with 30Ω series termination resistors
(3-State)

74ABT2241

FEATURES

- Octal bus interface
- 3-State buffers
- Power-up 3-State
- Output capability: +12mA/-32mA
- Latch-up protection exceeds 500mA per Jedec Std 17
- ESD protection exceeds 2000 V per MIL STD 883 Method 3015 and 200 V per Machine Model

DESCRIPTION

The 74ABT2241 high-performance BiCMOS device combines low static and dynamic power dissipation with high speed and high output drive.

The 74ABT2241 device is an octal buffer that is ideal for driving bus lines. The device features two Output Enables (1OE, 2OE), each controlling four of the 3-State outputs.

The 74ABT2241 is designed with 30Ω series resistance in both the High and Low states of the output. The design reduces line noise in applications such as memory address drivers, clock drivers, and bus receivers/transceivers.

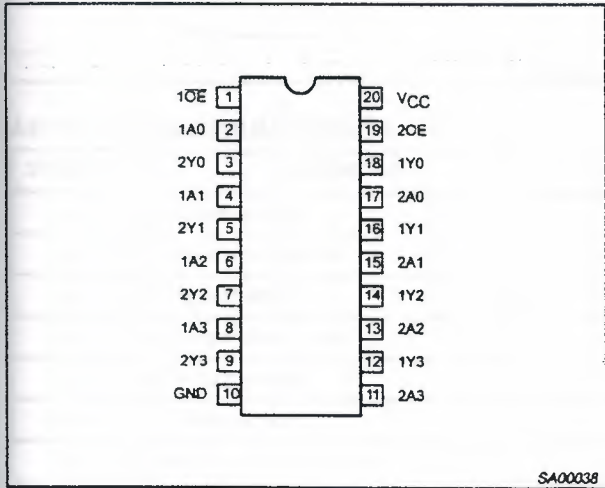
QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS $T_{amb} = 25^{\circ}\text{C}$; GND = 0V	TYPICAL	UNIT
t_{PLH} t_{PHL}	Propagation delay An to Yn	$C_L = 50\text{pF}$; $V_{CC} = 5\text{V}$	2.9	ns
C_{IN}	Input capacitance	$V_I = 0\text{V}$ or V_{CC}	3	pF
C_{OUT}	Output capacitance	Outputs disabled; $V_O = 0\text{V}$ or V_{CC}	7	pF
I_{CCZ}	Total supply current	Outputs disabled; $V_{CC} = 5.5\text{V}$	50	μA

ORDERING INFORMATION

PACKAGES	TEMPERATURE RANGE	OUTSIDE NORTH AMERICA	NORTH AMERICA	DWG NUMBER
20-Pin Plastic DIP	-40°C to +85°C	74ABT2241 N	74ABT2241 N	SOT146-1
20-Pin plastic SO	-40°C to +85°C	74ABT2241 D	74ABT2241 D	SOT163-1
20-Pin Plastic SSOP Type II	-40°C to +85°C	74ABT2241 DB	74ABT2241 DB	SOT339-1
20-Pin Plastic TSSOP Type I	-40°C to +85°C	74ABT2241 PW	74ABT2241PW DH	SOT360-1

PIN CONFIGURATION



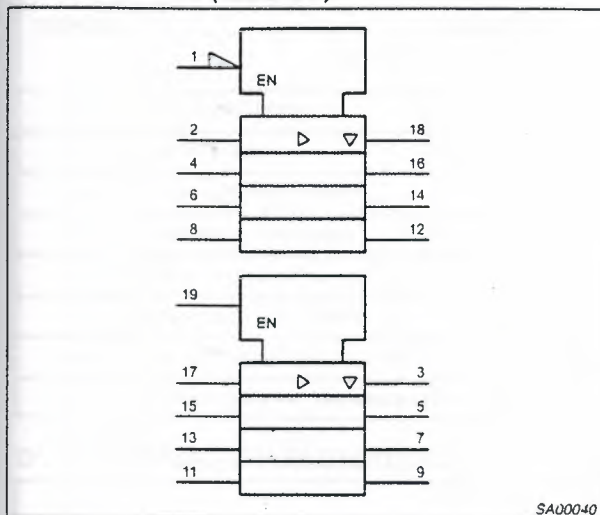
PIN DESCRIPTION

PIN NUMBER	SYMBOL	NAME AND FUNCTION
2, 4, 6, 8	1A0 – 1A3	Data inputs
17, 15, 13, 11	2A0 – 2A3	Data inputs
18, 16, 14, 12	1Y0 – 1Y3	Data outputs
3, 5, 7, 9	2Y0 – 2Y3	Data outputs
1, 19	1OE, 2OE	Output enables
10	GND	Ground (0V)
20	VCC	Positive supply voltage

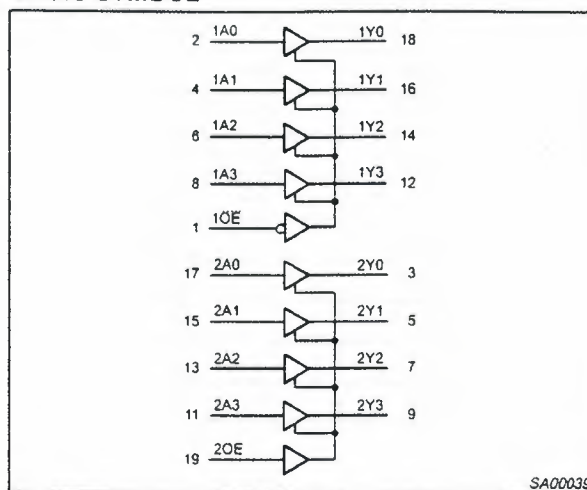
Octal buffer with 30Ω series termination resistors (3-State)

74ABT2241

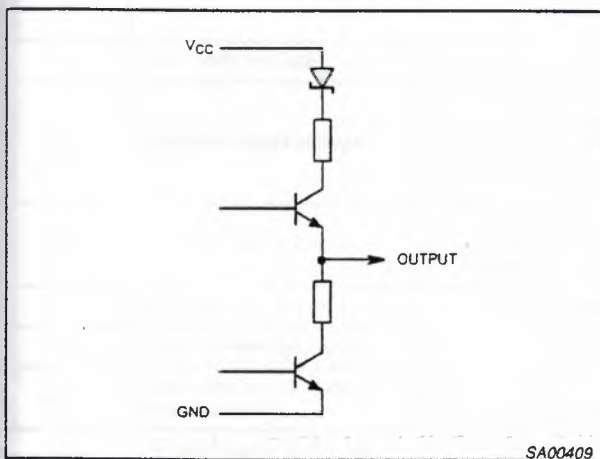
LOGIC SYMBOL (IEEE/IEC)



LOGIC SYMBOL



SCHEMATIC OF EACH OUTPUT



FUNCTION TABLE

INPUTS				OUTPUTS	
1OE	1An	2OE	2An	1Yn	2Yn
L	L	H	L	L	L
L	H	H	H	H	H
H	X	L	X	Z	Z

H = High voltage level
 L = Low voltage level
 X = Don't care
 Z = High impedance "off" state

ABSOLUTE MAXIMUM RATINGS^{1, 2}

SYMBOL	PARAMETER	CONDITIONS	RATING	UNIT
V _{CC}	DC supply voltage		-0.5 to +7.0	V
I _{IK}	DC input diode current	V _I < 0	-18	mA
V _I	DC input voltage ³		-1.2 to +7.0	V
I _{OK}	DC output diode current	V _O < 0	-50	mA
V _{OUT}	DC output voltage ³	output in Off or High state	-0.5 to +5.5	V
I _{OUT}	DC output current	output in Low state	128	mA
T _{stg}	Storage temperature range		-65 to 150	°C

NOTES:

- Stresses beyond those listed may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- The performance capability of a high-performance integrated circuit in conjunction with its thermal environment can create junction temperatures which are detrimental to reliability. The maximum junction temperature of this integrated circuit should not exceed 150°C.
- The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

Octal buffer with 30Ω series termination resistors (3-State)

74ABT2241

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	LIMITS		UNIT
		Min	Max	
V_{CC}	DC supply voltage	4.5	5.5	V
V_I	Input voltage	0	V_{CC}	V
V_{IH}	High-level input voltage	2.0		V
V_{IL}	Low-level input voltage		0.8	V
I_{OH}	High-level output current		-32	mA
I_{OL}	Low-level output current		12	mA
$\Delta t/\Delta v$	Input transition rise or fall rate	0	5	ns/V
T_{amb}	Operating free-air temperature range	-40	+85	°C

DC ELECTRICAL CHARACTERISTICS

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS					UNIT
			T _{amb} = +25°C			T _{amb} = -40°C to +85°C		
			Min	Typ	Max	Min	Max	
V _{IK}	Input clamp voltage	V _{CC} = 4.5V; I _{IK} = -18mA		-0.9	-1.2		-1.2	V
V _{OH}	High-level output voltage	V _{CC} = 4.5V; I _{OH} = -3mA; V _I = V _{IL} or V _{IH}	2.5	2.9		2.5		V
		V _{CC} = 5.0V; I _{OH} = -3mA; V _I = V _{IL} or V _{IH}	3.0	3.4		3.0		V
		V _{CC} = 4.5V; I _{OH} = -32mA; V _I = V _{IL} or V _{IH}	2.0	2.4		2.0		V
V _{OL}	Low-level output voltage	V _{CC} = 4.5V; I _{OL} = 5mA; V _I = V _{IL} or V _{IH}		0.32	0.55		0.55	V
		V _{CC} = 4.5V; I _{OL} = 12mA; V _I = V _{IL} or V _{IH}			0.8		0.8	V
I _I	Input leakage current	V _{CC} = 5.5V; V _I = GND or 5.5V		±0.01	±1.0		±1.0	μA
I _{OFF}	Power-off leakage current	V _{CC} = 0.0V; V _I or V _O ≤ 4.5V		±5.0	±100		±100	μA
I _{PU} /I _{PD}	Power-up/down 3-State output current ³	V _{CC} = 2.0V; V _O = 0.5V; V _I = GND or V _{CC} ; V _{OE} = V _{CC} ; V _{OE} = GND		±5.0	±50		±50	μA
I _{OZH}	3-State output High current	V _{CC} = 5.5V; V _O = 2.7V; V _I = V _{IL} or V _{IH}		5.0	50		50	μA
I _{OZL}	3-State output Low current	V _{CC} = 5.5V; V _O = 0.5V; V _I = V _{IL} or V _{IH}		-5.0	-50		-50	μA
I _{CEX}	Output High leakage current	V _{CC} = 5.5V; V _O = 5.5V; V _I = GND or V _{CC}		5.0	50		50	μA
I _O	Output current ¹	V _{CC} = 5.5V; V _O = 2.5V	-50	-100	-180	-50	-180	mA
I _{CCH}	Quiescent supply current	V _{CC} = 5.5V; Outputs High, V _I = GND or V _{CC}		50	250		250	μA
I _{CCL}		V _{CC} = 5.5V; Outputs Low, V _I = GND or V _{CC}		24	30		30	mA
I _{CCZ}		V _{CC} = 5.5V; Outputs 3-State; V _I = GND or V _{CC}		50	250		250	μA
ΔI _{CC}	Additional supply current per input pin ²	Outputs enabled, one input at 3.4V, other inputs at V _{CC} or GND; V _{CC} = 5.5V		0.5	1.5		1.5	mA
		Outputs 3-State, one data input at 3.4V, other inputs at V _{CC} or GND; V _{CC} = 5.5V		50	250		250	μA
		Outputs 3-State, one enable input at 3.4V, other inputs at V _{CC} or GND; V _{CC} = 5.5V		0.5	1.5		1.5	mA

NOTES:

Octal buffer with 30Ω series termination resistors
(3-State)

74ABT2241

1. Not more than one output should be tested at a time, and the duration of the test should not exceed one second.
2. This is the increase in supply current for each input at 3.4V.
3. This parameter is valid for any V_{CC} between 0V and 2.1V with a transition time of up to 10msec. For $V_{CC} = 2.1V$ to $V_{CC} = 5V \pm 10\%$, a transition time of up to 100 μsec is permitted.

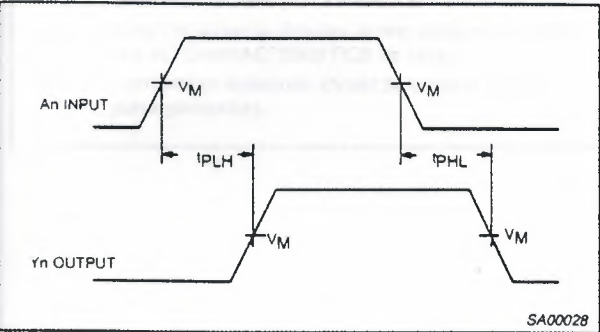
AC CHARACTERISTICS

GND = 0V; $t_R = t_F = 2.5ns$; $C_L = 50pF$, $R_L = 500\Omega$

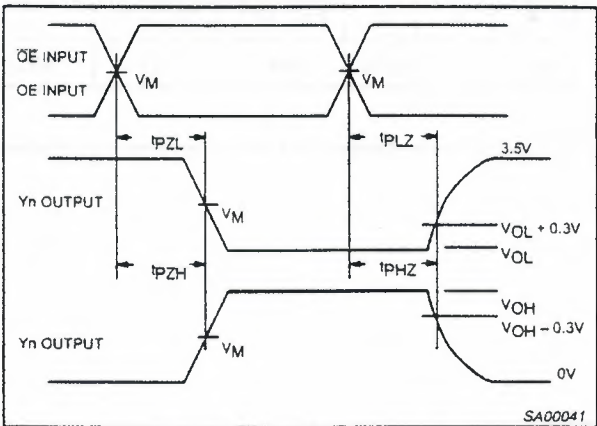
SYMBOL	PARAMETER	WAVEFORM	LIMITS						UNIT
			T _{amb} = +25°C V _{CC} = +5.0V			T _{amb} = -40°C to +85°C V _{CC} = +5.0V ±0.5V			
			Min	Typ	Max	Min	Max		
t _{PLH} t _{PHL}	Propagation delay An to Y _n	1	1.0 1.0	2.7 3.9	4.3 5.3	1.0 1.0	4.7 5.6	ns	
t _{PZH} t _{PZL}	Output enable time to High and Low level	2	1.1 2.1	3.3 5.4	4.8 7.6	1.1 2.1	5.8 8.4	ns	
t _{PHZ} t _{PLZ}	Output disable time from High and Low level	2	1.7 1.7	3.8 3.4	5.6 5.8	1.7 1.7	6.6 6.4	ns	

AC WAVEFORMS

$V_M = 1.5V$, $V_{IN} = GND$ to 3.0V



Waveform 1. Waveforms Showing the Input (An) to Output (Yn) Propagation Delays

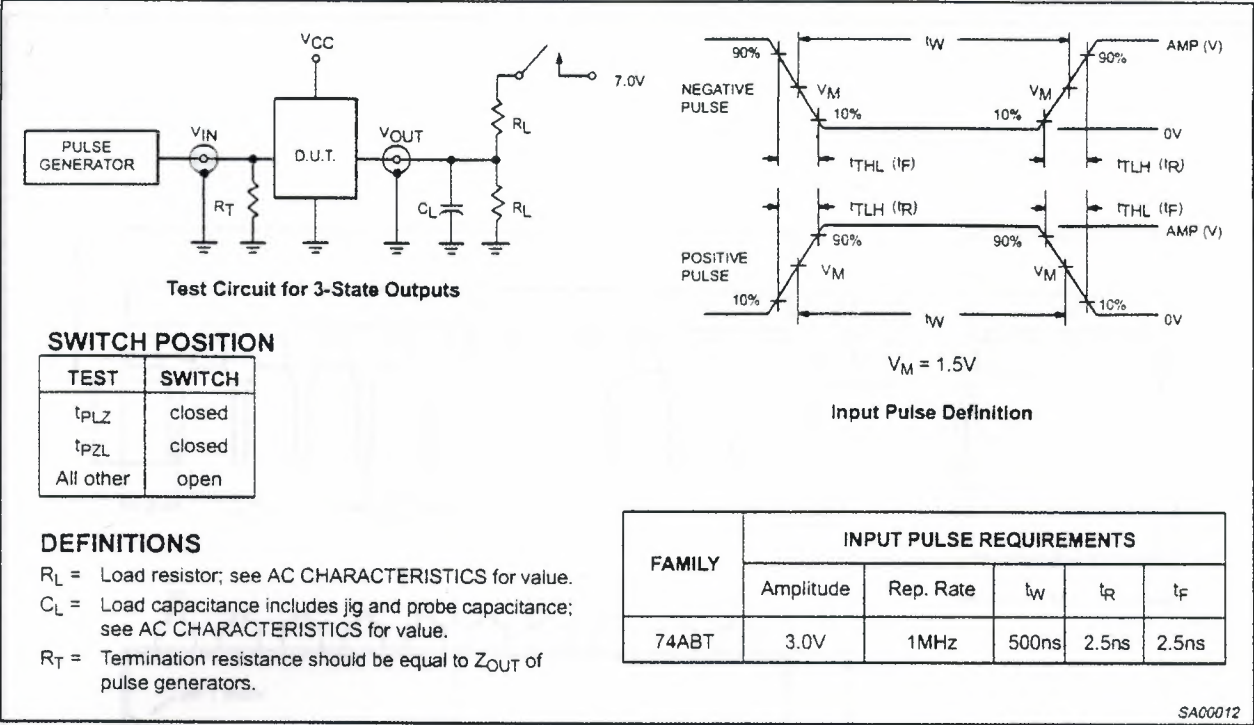


Waveform 2. Waveforms Showing the 3-State Output Enable and Disable Times

Octal buffer with 30Ω series termination resistors
(3-State)

74ABT2241

TEST CIRCUIT AND WAVEFORMS

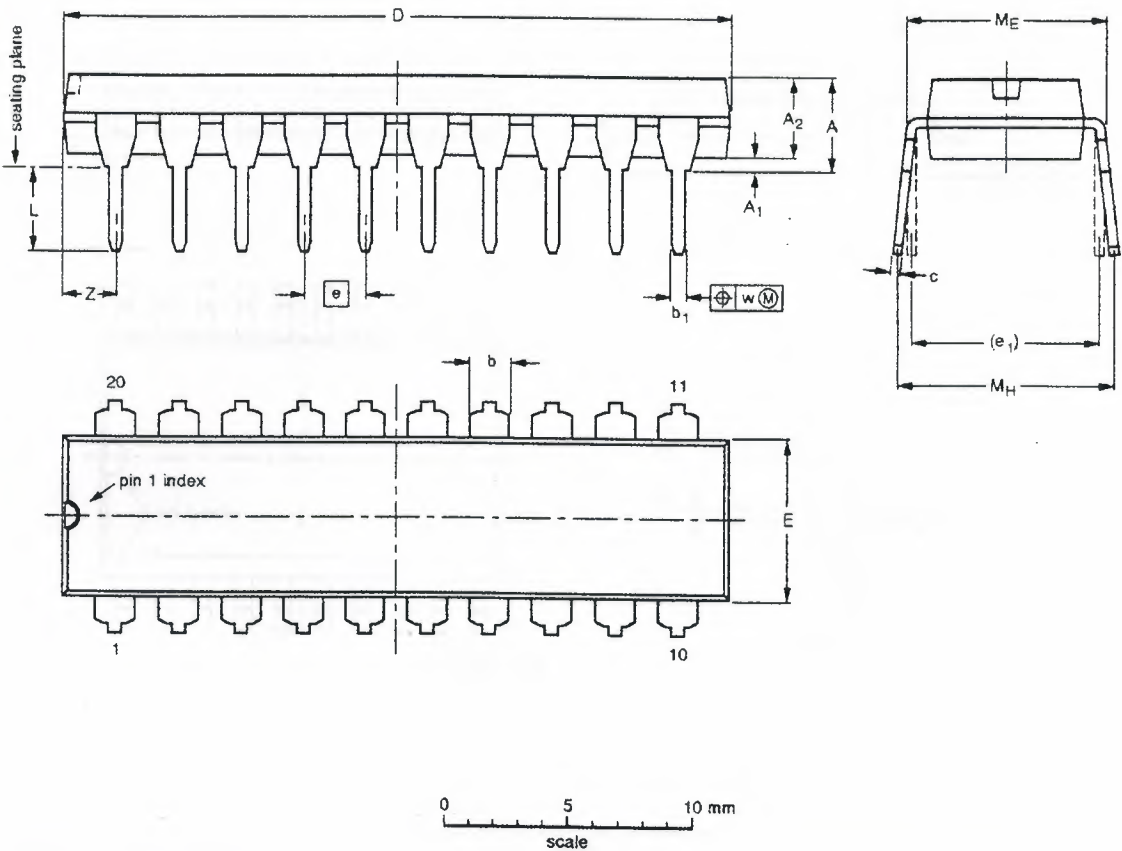


Octal buffer with 30Ω series termination resistors
(3-State)

74ABT2241

DIP20: plastic dual in-line package; 20 leads (300 mil)

SOT146-1



DIMENSIONS (Inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A ₁ min.	A ₂ max.	b	b ₁	c	D ⁽¹⁾	E ⁽¹⁾	e	e ₁	L	M _E	M _H	w	Z ⁽¹⁾ max.
mm	4.2	0.51	3.2	1.73 1.30	0.53 0.38	0.36 0.23	26.92 26.54	6.40 6.22	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	2.0
inches	0.17	0.020	0.13	0.068 0.051	0.021 0.015	0.014 0.009	1.060 1.045	0.25 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.078

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

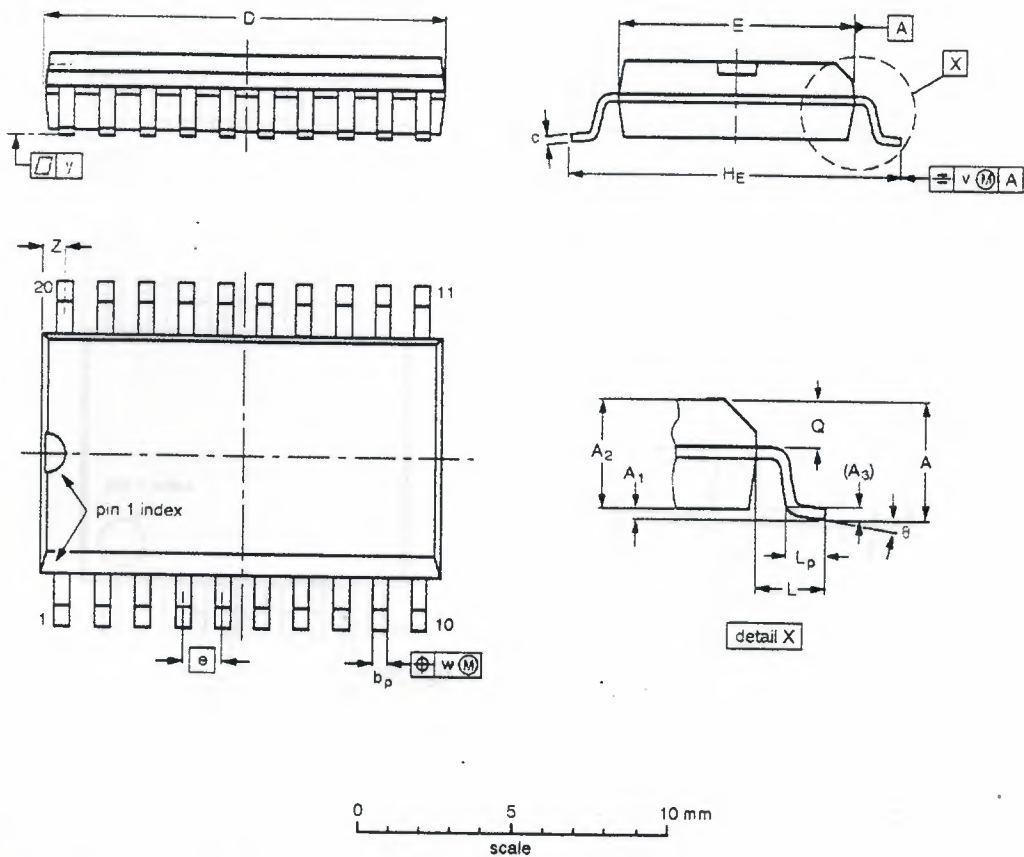
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT146-1			SC603			92-11-17 95-05-24

Octal buffer with 30Ω series termination resistors
(3-State)

74ABT2241

SO20: plastic small outline package; 20 leads; body width 7.5 mm

SOT163-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽¹⁾	e	H _E	L	L _p	Q	v	w	y	Z ⁽¹⁾	θ
mm	2.65	0.30 0.10	2.45 2.25	0.25	0.49 0.36	0.32 0.23	13.0 12.6	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8° 0°
inches	0.10	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.51 0.49	0.30 0.29	0.050	0.42 0.39	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

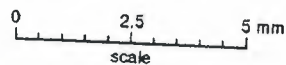
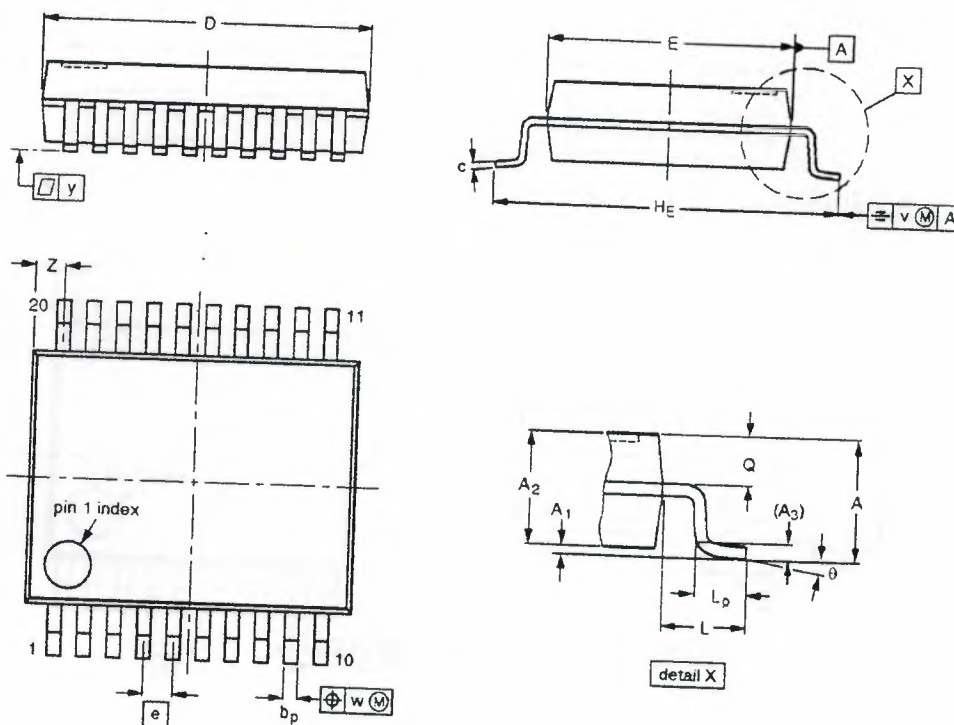
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT163-1	075E04	MS-013AC				92-11-17 95-01-24

Octal buffer with 30Ω series termination resistors
(3-State)

74ABT2241

SSOP20: plastic shrink small outline package; 20 leads; body width 5.3 mm

SOT339-1




DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽¹⁾	e	H _E	L	L _p	Q	v	w	y	Z ⁽¹⁾	θ
mm	2.0	0.21 0.05	1.80 1.65	0.25	0.38 0.25	0.20 0.09	7.4 7.0	5.4 5.2	0.65	7.9 7.6	1.25	1.03 0.63	0.9 0.7	0.2	0.13	0.1	0.9 0.5	8° 0°

Note

1. Plastic or metal protrusions of 0.20 mm maximum per side are not included.

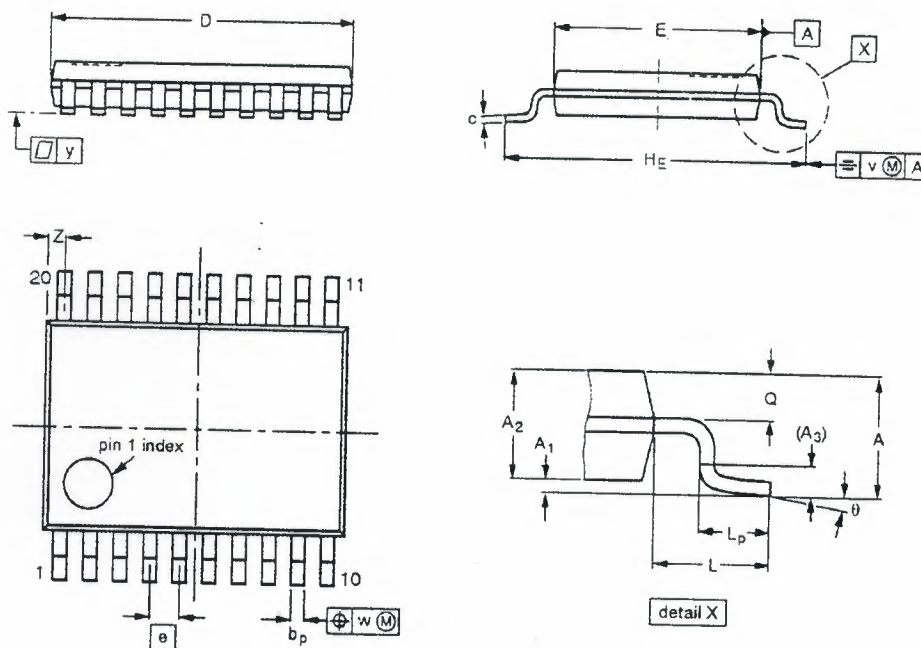
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT339-1		MO-150AE				93-09-00 95-02-04

Octal buffer with 30Ω series termination resistors (3-State)

74ABT2241

TSSOP20: plastic thin shrink small outline package; 20 leads; body width 4.4 mm

SOT360-1




DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽²⁾	e	H _E	L	L _p	Q	v	w	y	Z ⁽¹⁾	θ
mm	1.10	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	6.6 6.4	4.5 4.3	0.65	6.6 6.2	1.0	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.5 0.2	8° 0°

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT360-1		MO-153AC				93-06-16 95-02-04

Octal buffer with 30 Ω series termination resistors (3-State)

74ABT2241

NOTES

Octal buffer with 30Ω series termination resistors (3-State)

74ABT2241

DEFINITIONS

Data Sheet Identification	Product Status	Definition
<i>Objective Specification</i>	Formative or In Design	This data sheet contains the design target or goal specifications for product development. Specifications may change in any manner without notice.
<i>Preliminary Specification</i>	Preproduction Product	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
<i>Product Specification</i>	Full Production	This data sheet contains Final Specifications. Philips Semiconductors reserves the right to make changes at any time without notice, in order to improve design and supply the best possible product.

Philips Semiconductors and Philips Electronics North America Corporation reserve the right to make changes, without notice, in the products, including circuits, standard cells, and/or software, described or contained herein in order to improve design and/or performance. Philips Semiconductors assumes no responsibility or liability for the use of any of these products, conveys no license or title under any patent, copyright, or mask work right to these products, and makes no representations or warranties that these products are free from patent, copyright, or mask work right infringement, unless otherwise specified. Applications that are described herein for any of these products are for illustrative purposes only. Philips Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

LIFE SUPPORT APPLICATIONS

Philips Semiconductors and Philips Electronics North America Corporation Products are not designed for use in life support appliances, devices, or systems where malfunction of a Philips Semiconductors and Philips Electronics North America Corporation Product can reasonably be expected to result in a personal injury. Philips Semiconductors and Philips Electronics North America Corporation customers using or selling Philips Semiconductors and Philips Electronics North America Corporation Products for use in such applications do so at their own risk and agree to fully indemnify Philips Semiconductors and Philips Electronics North America Corporation for any damages resulting from such improper use or sale.

Philips Semiconductors
811 East Arques Avenue
P.O. Box 3409
Sunnyvale, California 94088-3409
Telephone 800-234-7381

Philips Semiconductors and Philips Electronics North America Corporation
register eligible circuits under the Semiconductor Chip Protection Act.
© Copyright Philips Electronics North America Corporation 1996
All rights reserved. Printed in U.S.A.

DATA SHEET

For a complete data sheet, please also download:

- The IC06 74HC/HCT/HCU/HCMOS Logic Family Specifications
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Information
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Outlines

74HC/HCT32 Quad 2-input OR gate

Product specification
File under Integrated Circuits, IC06

December 1990



Quad 2-input OR gate

74HC/HCT32

FEATURES

- Output capability: standard
- I_{CC} category: SSI

GENERAL DESCRIPTION

The 74HC/HCT32 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT32 provide the 2-input OR function.

QUICK REFERENCE DATA

GND = 0 V; $T_{amb} = 25\text{ }^{\circ}\text{C}$; $t_r = t_f = 6\text{ ns}$

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PHL}/t_{PLH}	propagation delay nA, nB to nY	$C_L = 15\text{ pF}$; $V_{CC} = 5\text{ V}$	6	9	ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per gate	notes 1 and 2	16	28	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

$$P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o) \text{ where:}$$

f_i = input frequency in MHz

f_o = output frequency in MHz

$\sum (C_L \times V_{CC}^2 \times f_o)$ = sum of outputs

C_L = output load capacitance in pF

V_{CC} = supply voltage in V

2. For HC the condition is $V_I = \text{GND to } V_{CC}$
For HCT the condition is $V_I = \text{GND to } V_{CC} - 1.5\text{ V}$

ORDERING INFORMATION

See "74HC/HCT/HCU/HCMOS Logic Package Information".

Quad 2-input OR gate

74HC/HCT32

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1, 4, 9, 12	1A to 4A	data inputs
2, 5, 10, 13	1B to 4B	data inputs
3, 6, 8, 11	1Y to 4Y	data outputs
7	GND	ground (0 V)
14	V _{CC}	positive supply voltage

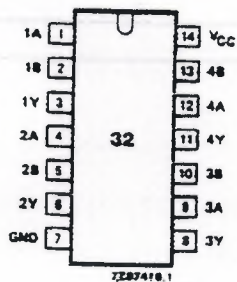


Fig.1 Pin configuration.

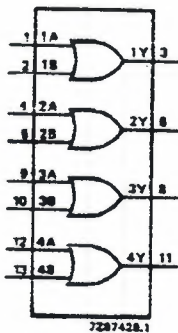


Fig.2 Logic symbol.

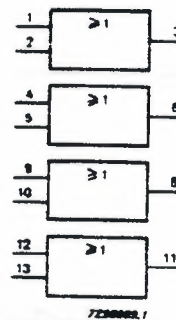


Fig.3 IEC logic symbol.

Quad 2-input OR gate

74HC/HCT32

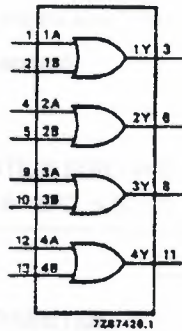


Fig.4 Functional diagram.

FUNCTION TABLE

INPUTS		OUTPUT
nA	nB	nY
L	L	L
L	H	H
H	L	H
H	H	H

Notes

- 1. H = HIGH voltage level
- L = LOW voltage level

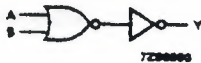


Fig.5 Logic diagram 74HC (one gate).

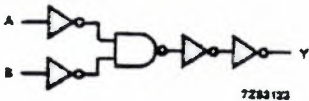


Fig.6 Logic diagram 74HCT (one gate).

Quad 2-input OR gate

74HC/HCT32

DC CHARACTERISTICS FOR 74HC

For the DC characteristics see "74HC/HCT/HCU/HCMOS Logic Family Specifications".

Output capability: standard

 I_{CC} category: SSI

AC CHARACTERISTICS FOR 74HC

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T _{amb} (°C)							UNIT	TEST CONDITIONS	
		74HC								V _{CC} (V)	WAVEFORMS
		+25			-40 to +85		-40 to +125				
		min.	typ.	max.	min.	max.	min.	max.			
t _{PHL} / t _{PLH}	propagation delay nA, nB to nY		22 8 6	90 18 15		115 23 20		135 27 23	ns	2.0 4.5 6.0	Fig.7
t _{THL} / t _{TLH}	output transition time		19 7 6	75 15 13		95 19 16		110 22 19	ns	2.0 4.5 6.0	Fig.7

DC CHARACTERISTICS FOR 74HCT

For the DC characteristics see "74HC/HCT/HCU/HCMOS Logic Family Specifications".

Output capability: standard

 I_{CC} category: SSI

Note to HCT types

The value of additional quiescent supply current (ΔI_{CC}) for a unit load of 1 is given in the family specifications. To determine ΔI_{CC} per input, multiply this value by the unit load coefficient shown in the table below.

INPUT	UNIT LOAD COEFFICIENT
nA, nB	1.20

AC CHARACTERISTICS FOR 74HCT

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T _{amb} (°C)							UNIT	TEST CONDITIONS	
		74HCT								V _{CC} (V)	WAVEFORMS
		+25			-40 to +85		-40 to +125				
		min.	typ.	max.	min.	max.	min.	max.			
t _{PHL} / t _{PLH}	propagation delay nA, nB to nY		11	24		30		36	ns	4.5	Fig.7
t _{THL} / t _{TLH}	output transition time		7	15		19		22	ns	4.5	Fig.7

Quad 2-input OR gate

74HC/HCT32

AC WAVEFORMS

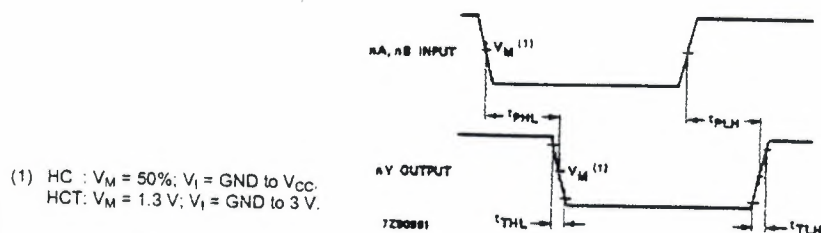


Fig.7 Waveforms showing the input (nA, nB) to output (nY) propagation delays and the output transition times.

PACKAGE OUTLINES

See "74HC/HCT/HCU/HCMOS Logic Package Outlines".

74ALS138

1-of-8 decoder/default 3-to-8 decoder

DATA SHEET

74ALS138

1-of-8 decoder/demultiplexer

Product specification

1996 Jul 03

IC05 Data Handbook

1-of-8 decoder/demultiplexer

74ALS138

FEATURES

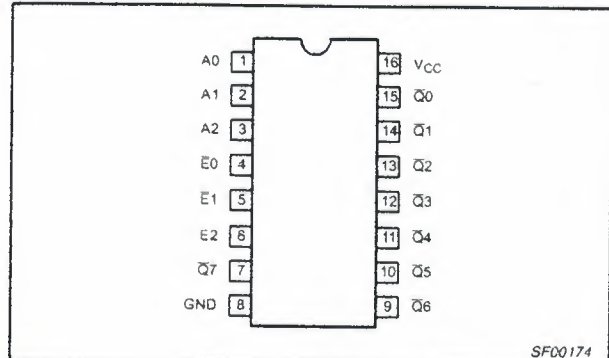
- Demultiplexing capability
- Multiple input enable for easy expansion
- Ideal for memory chip select decoding

DESCRIPTION

The 74ALS138 decoder accepts three binary weighted inputs (A0, A1, A2) and when enabled, provides eight mutually exclusive, active-Low outputs ($\bar{Q}0 - \bar{Q}7$). The device features three Enable inputs; two active-Low ($\bar{E}0, \bar{E}1$) and one active-High (E2). Every output will be High unless $\bar{E}0$ and $\bar{E}1$ are Low and E2 is High. This multiple enable function allows easy parallel expansion of the device to 1-of-32 (5 lines to 32 lines) decoder with just four 74ALS138s and one inverter. The device can be used as an eight output demultiplexer by using one of the active-Low Enable inputs as the data input and the remaining Enable inputs as strobes. Enable inputs not used must be permanently tied to their appropriate active-High or active-Low state.

TYPE	TYPICAL PROPAGATION DELAY	TYPICAL SUPPLY CURRENT (TOTAL)
74ALS138	12.0ns	4.0mA

PIN CONFIGURATION



ORDERING INFORMATION

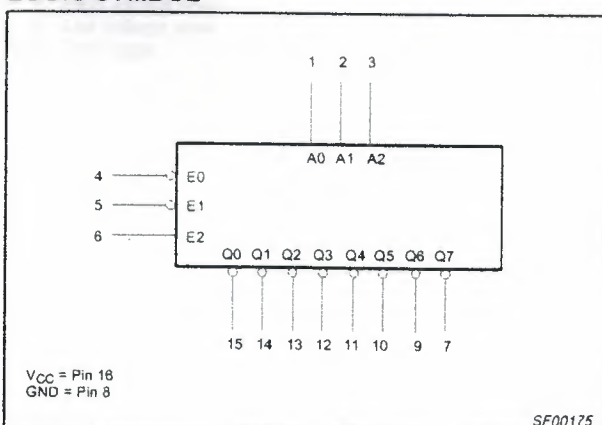
DESCRIPTION	ORDER CODE	DRAWING NUMBER
	COMMERCIAL RANGE $V_{CC} = 5V \pm 10\%$, $T_{amb} = 0^\circ C \text{ to } +70^\circ C$	
16-pin plastic DIP	74ALS138N	SOT38-4
16-pin plastic SO	74ALS138D	SOT109-1

INPUT AND OUTPUT LOADING AND FAN-OUT TABLE

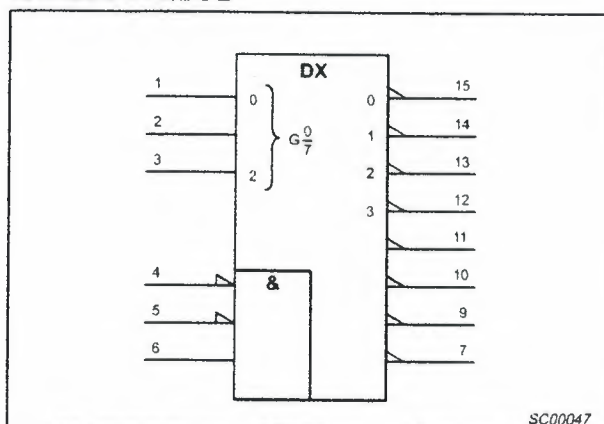
PINS	DESCRIPTION	74ALS (U.L.) HIGH/LOW	LOAD VALUE HIGH/LOW
A0 - A2	Address inputs	1.0/1.0	20 μ A/0.1mA
$\bar{E}0, \bar{E}1$	Enable inputs (active-Low)	1.0/1.0	20 μ A/0.1mA
E2	Enable input (active-High)	1.0/1.0	20 μ A/0.1mA
$\bar{Q}0 - \bar{Q}7$	Data outputs (active-Low)	50/33	1.0mA/20mA

NOTE: One (1.0) ALS unit load is defined as: 20 μ A in the High state and 0.1mA in the Low state.

LOGIC SYMBOL



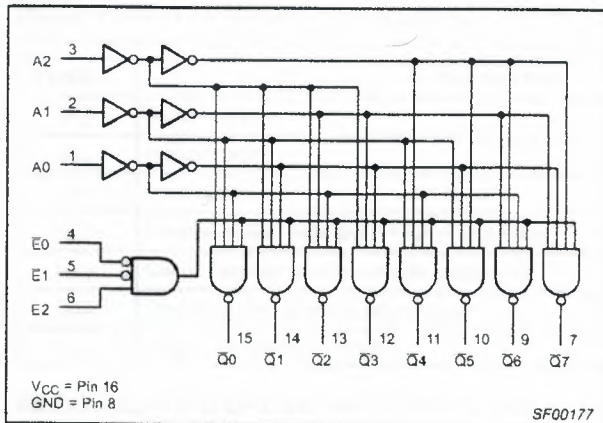
IEC/IEEE SYMBOL



1-of-8 decoder/demultiplexer

74ALS138

LOGIC DIAGRAM



FUNCTION TABLE

INPUTS						OUTPUTS							
$\bar{E}0$	$\bar{E}1$	$\bar{E}2$	A0	A1	A2	$\bar{Q}0$	$\bar{Q}1$	$\bar{Q}2$	$\bar{Q}3$	$\bar{Q}4$	$\bar{Q}5$	$\bar{Q}6$	$\bar{Q}7$
H	X	X	X	X	X	H	H	H	H	H	H	H	H
X	H	X	X	X	X	H	H	H	H	H	H	H	H
X	X	L	X	X	X	H	H	H	H	H	H	H	H
L	L	H	L	L	L	L	H	H	H	H	H	H	H
L	L	H	H	L	L	H	L	H	H	H	H	H	H
L	L	H	L	H	L	H	H	L	H	H	H	H	H
L	L	H	H	H	L	H	H	H	L	H	H	H	H
L	L	H	L	L	H	H	H	H	H	L	H	H	H
L	L	H	H	L	H	H	H	H	H	H	L	H	H
L	L	H	L	H	H	H	H	H	H	H	H	L	H
L	L	H	H	H	H	H	H	H	H	H	H	H	L

H = High voltage level

L = Low voltage level

X = Don't care

1-of-8 decoder/demultiplexer

74ALS138

ABSOLUTE MAXIMUM RATINGS

(Operation beyond the limit set forth in this table may impair the useful life of the device.
Unless otherwise noted these limits are over the operating free-air temperature range.)

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Supply voltage	-0.5 to +7.0	V
V_{IN}	Input voltage	-0.5 to +7.0	V
I_{IN}	Input current	-30 to +5	mA
V_{OUT}	Voltage applied to output in High output state	-0.5 to V_{CC}	V
I_{OUT}	Current applied to output in Low output state	16	mA
T_{amb}	Operating free-air temperature range	0 to +70	°C
T_{stg}	Storage temperature range	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	LIMITS			UNIT
		MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5.0	5.5	V
V_{IH}	High-level input voltage	2.0			V
V_{IL}	Low-level input voltage			0.8	V
I_{IK}	Input clamp current			-18	mA
I_{OH}	High-level output current			-0.4	mA
I_{OL}	Low-level output current			8	mA
T_{amb}	Operating free-air temperature range	0		+70	°C

DC ELECTRICAL CHARACTERISTICS

(Over recommended operating free-air temperature range unless otherwise noted.)

SYMBOL	PARAMETER	TEST CONDITIONS ¹	LIMITS			UNIT
			MIN	TYP ²	MAX	
V_{OH}	High-level output voltage	$V_{CC} = \pm 10\%$, $V_{IL} = \text{MAX}$, $V_{IH} = \text{MIN}$, $I_{OH} = -0.4\text{mA}$	$V_{CC} - 2$			V
V_{OL}	Low-level output voltage	$V_{CC} = \text{MIN}$, $V_{IL} = \text{MAX}$, $V_{IH} = \text{MIN}$, $I_{OL} = 4\text{mA}$		0.25	0.40	V
		$I_{OL} = 8\text{mA}$		0.35	0.50	V
V_{IK}	Input clamp voltage	$V_{CC} = \text{MIN}$, $I_I = I_{IK}$		-0.73	-1.5	V
I_I	Input current at maximum input voltage	$V_{CC} = \text{MAX}$, $V_I = 7.0\text{V}$			0.1	mA
I_{IH}	High-level input current	$V_{CC} = \text{MAX}$, $V_I = 2.7\text{V}$			20	μA
I_{IL}	Low-level input current	$V_{CC} = \text{MAX}$, $V_I = 0.4\text{V}$			-0.1	mA
I_O	Output current ³	$V_{CC} = \text{MAX}$, $V_O = 2.25\text{V}$	-30		-112	mA
I_{CC}	Supply current (total)	$V_{CC} = \text{MAX}$		4	7	mA

NOTES:

- For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable type.
- All typical values are at $V_{CC} = 5\text{V}$, $T_{amb} = 25^\circ\text{C}$.
- The output conditions have been chosen to produce a current that closely approximates one half of the true short-circuit output current, I_{OS} .

1-of-8 decoder/demultiplexer

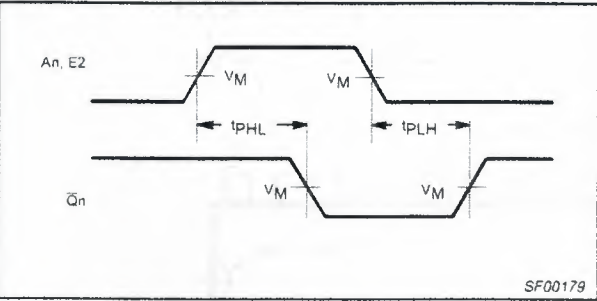
74ALS138

AC ELECTRICAL CHARACTERISTICS

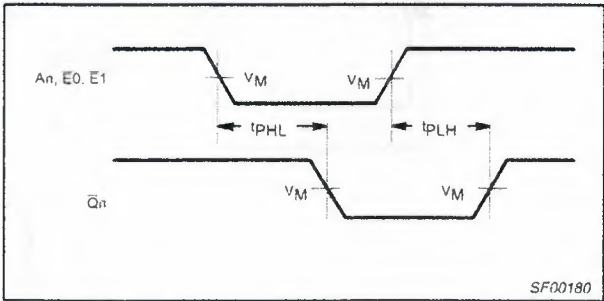
SYMBOL	PARAMETER	TEST CONDITION	LIMITS		UNIT
			$T_{amb} = 0^{\circ}C \text{ to } +70^{\circ}C$ $V_{CC} = +5.0V \pm 10\%$ $C_L = 50pF, R_L = 500\Omega$		
			MIN	MAX	
t_{PLH} t_{PHL}	Propagation delay An to \bar{Q}_n	Waveform 1, 2	3.0 3.0	22.0 18.0	ns
t_{PLH} t_{PHL}	Propagation delay E1, E2 to \bar{Q}_n	Waveform 2	3.0 3.0	17.0 17.0	ns
t_{PLH} t_{PHL}	Propagation delay E2 to \bar{Q}_n	Waveform 1	3.0 3.0	17.0 17.0	ns

AC WAVEFORMS

For all waveforms, $V_M = 1.3V$.

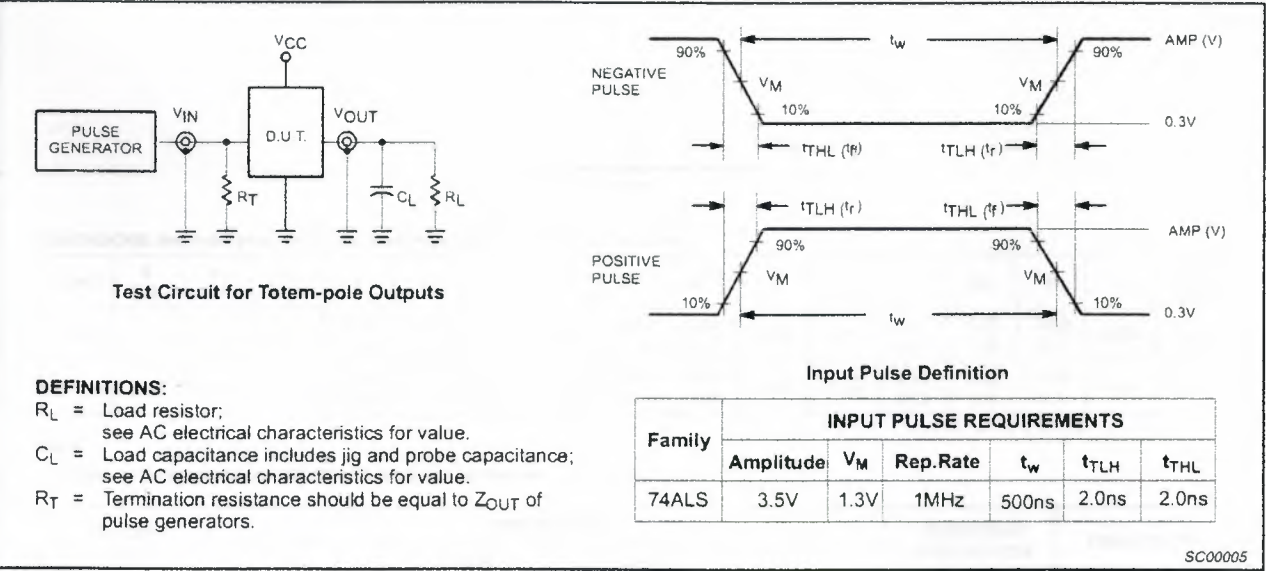


Waveform 1. Propagation Delay for Inverting Outputs



Waveform 2. Propagation Delay for Non-inverting Outputs

TEST CIRCUIT AND WAVEFORMS

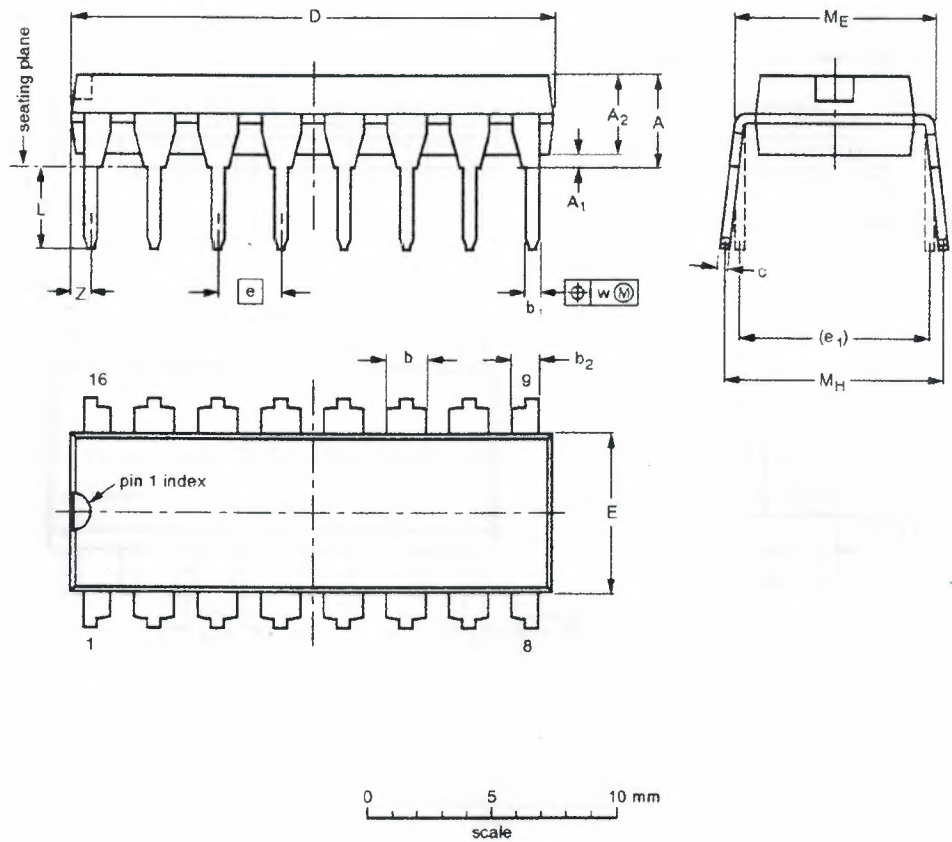


1-of-8 decoder/demultiplexer

74ALS138

DIP16: plastic dual in-line package; 16 leads (300 mil)

SOT38-4

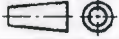


DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A ₁ min.	A ₂ max.	b	b ₁	b ₂	c	D ⁽¹⁾	E ⁽¹⁾	e	e ₁	L	M _E	M _H	w	Z ⁽¹⁾ max.
mm	4.2	0.51	3.2	1.73 1.30	0.53 0.38	1.25 0.85	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	0.76
inches	0.17	0.020	0.13	0.068 0.051	0.021 0.015	0.049 0.033	0.014 0.009	0.77 0.73	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.030

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

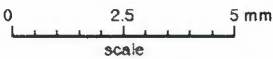
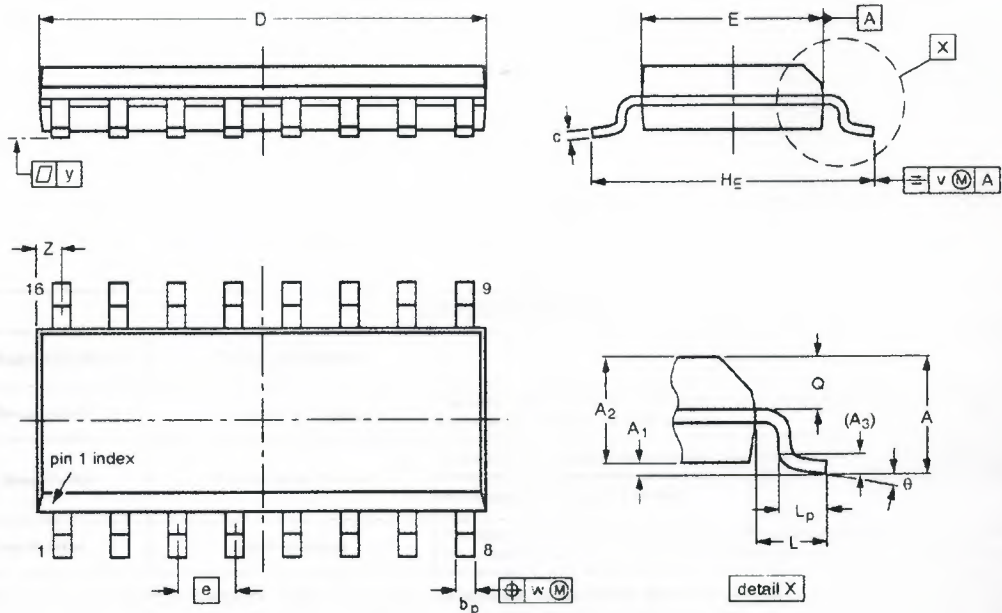
OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT38-4						92-11-17 95-01-14

1-of-8 decoder/demultiplexer

74ALS138

SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽¹⁾	e	H _E	L	L _p	Q	v	w	y	Z ⁽¹⁾	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8° 0°
inches	0.069	0.0098 0.0039	0.057 0.049	0.01	0.019 0.014	0.0098 0.0075	0.39 0.38	0.16 0.15	0.050	0.24 0.23	0.041	0.039 0.016	0.028 0.020	0.01	0.01	0.004	0.028 0.012	

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT109-1	076E07S	MS-012AC				91-08-13 95-01-23

1-of-8 decoder/demultiplexer

74ALS138

DEFINITIONS

Data Sheet Identification	Product Status	Definition
<i>Objective Specification</i>	<i>Formative or in Design</i>	This data sheet contains the design target or goal specifications for product development. Specifications may change in any manner without notice.
<i>Preliminary Specification</i>	<i>Preproduction Product</i>	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
<i>Product Specification</i>	<i>Full Production</i>	This data sheet contains Final Specifications. Philips Semiconductors reserves the right to make changes at any time without notice, in order to improve design and supply the best possible product.

Philips Semiconductors and Philips Electronics North America Corporation reserve the right to make changes, without notice, in the products, including circuits, standard cells, and/or software, described or contained herein in order to improve design and/or performance. Philips Semiconductors assumes no responsibility or liability for the use of any of these products, conveys no license or title under any patent, copyright, or mask work right to these products, and makes no representations or warranties that these products are free from patent, copyright, or mask work right infringement, unless otherwise specified. Applications that are described herein for any of these products are for illustrative purposes only. Philips Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

LIFE SUPPORT APPLICATIONS

Philips Semiconductors and Philips Electronics North America Corporation Products are not designed for use in life support appliances, devices, or systems where malfunction of a Philips Semiconductors and Philips Electronics North America Corporation Product can reasonably be expected to result in a personal injury. Philips Semiconductors and Philips Electronics North America Corporation customers using or selling Philips Semiconductors and Philips Electronics North America Corporation Products for use in such applications do so at their own risk and agree to fully indemnify Philips Semiconductors and Philips Electronics North America Corporation for any damages resulting from such improper use or sale.

Philips Semiconductors
811 East Arques Avenue
P.O. Box 3409
Sunnyvale, California 94088-3409
Telephone 800-234-7381

© Copyright Philips Electronics North America Corporation 1997
All rights reserved. Printed in U.S.A.

Let's make things better.

Philips
Semiconductors



PHILIPS