Tecmar

Captain

Installation Manual
Technical Reference

#934744 Rev. A Printed by Tecmar Presses

FCC Required Instructions

This equipment generates and uses radio frequency energy and if not installed and used properly, i.e., in strict accordance with the operating instructions, reference manuals, and the service manual, may cause interference to radio or television reception. It has been tested and found to comply with the limits for a Class B computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a residential installation.

If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna.
- Relocate the equipment with respect to the receiver.
- Move the equipment away from the receiver.
- Plug the equipment into a different outlet so that equipment and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful:

"How to Identify and Resolve Radio-TV Interference Problems".

This booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock No. 004-000-00345-4.

The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. It is the responsibility of the user to correct such interference.

Checklist

In addition to this manual, your carton should contain the following items. You should check to make sure they are all present before you install your Captain.

□ Captain

□ Treasure Chest of Software

□ Guide to Cover Removal and Replacement

□ Treasure Chest User's Guide

□ Treasure Chest Technical Reference

□ Plastic Card Edge Guide

If any items are missing or damaged, or if you encounter any problems with this product, contact your Tecmar dealer.

Contents

System Requirements

Compatible Computers

You can use the Captain with the IBM PC, XT, Portable and many IBM compatible computers, such as the Compaq, Columbia Desktop, and Columbia Portable computers.

If you have another IBM compatible, check with your dealer to see if you can install the Captain in your system.

Memory Required

In general, the memory on your system board must be fully expanded. For most computers this will require that you have 256K of memory on your system board.

Exceptions are:

- □ The IBM PC with a 64K system board: You can install the Captain in this situation.
- □ The Columbia Desktop model number 4210: Since this computer is limited to 128K on its system board, you must add an additional memory board (such as Tecmar's Dynamic Memory board) to upgrade to 256K before you install the Captain.

Expansion Slot

You must have at least one expansion slot available in your personal computer or Expansion Chassis to install the Captain.

Introduction

The Captain is a multifunction board that fits into any slot of your IBM Personal Computer, XT (full-size slots only), or other compatible computer. It can also be installed in the Tecmar Expansion Chassis.

Its features include:

- □ Easy memory expansion from zero to 348K Bytes in 64K Byte steps.
- □ An RS-232 port for controlling a modem, serial printer, or other serial device.
- □ A printer port which is compatible with the IBM parallel printer.
- □ A clock/calendar which includes a battery and applications software with automatic time-setting functions.
- □ Tecmar's Treasure Chest of Software, 24 programs that include business applications, games, a security system, and hardware tests.
- □ An optional Programmable Array Logic Chip (PAL). One of its uses can be to restrict access to certain software for security purposes.

Section 1

Installation

About this Section

This section gives instructions for installing Tecmar's Captain in your IBM Personal Computer, XT, PC2, or Tecmar's Expansion Chassis. You can also install Captain in many IBM look-alike computers such as the Compaq, Corona, or Columbia.

Organization

This section is divided into four chapters.

Chapter 1

Preparing Your Computer:
Shows you how to set the switches on the system board of your personal computer for memory expansion.

If your computer does not have a system switch block, you should skip this chapter.

Chapter 2

Preparing Your Captain:
Shows how to set the switches and jumpers on your Captain.

Chapter 3

Installing the Captain:
Shows how to install your Captain in your personal computer or Expansion Chassis.

Chapter 4

If Problems Occur:
Offers suggestions for solving problems which might occur.

Tools Required

You will need the following tools to install your Captain:

- ☐ Medium size, flat-blade screwdriver
- ☐ Ballpoint pen
- ☐ Tweezers or needle nose pliers
- ☐ Phillips head screwdriver (for Expansion Chassis)

Getting Started

■ If you have not yet read the *System Requirements* section at the front of this manual, please do so now.

Setting Switches

■ If you have never set switches, or if it has been some time since you have done so, see Appendix A for an explanation of setting switch modules.

Memory Size

■ You need to know how much total memory you currently have in your system to set the switches on the system board and the Captain.

Use the DOS CHKDSK command if you are not sure how much memory you have. See your DOS manual for an explanation of CHKDSK.

Note: If you have more memory than 256K, you must readdress the memory above 256K to start where your Captain memory ends.

Power Off

■ **TURN OFF THE POWER TO YOUR PERSONAL COMPUTER OR EXPANSION CHASSIS** and unplug it from its source of power. It is important that there be no power applied to the unit while system switches are being set or while the board is being installed. Failure to do so may result in serious damage to the computer.

Cover Removal

■ Remove the cover of your computer. See the **Guide to Cover Removal and Replacement** for step by step instructions.

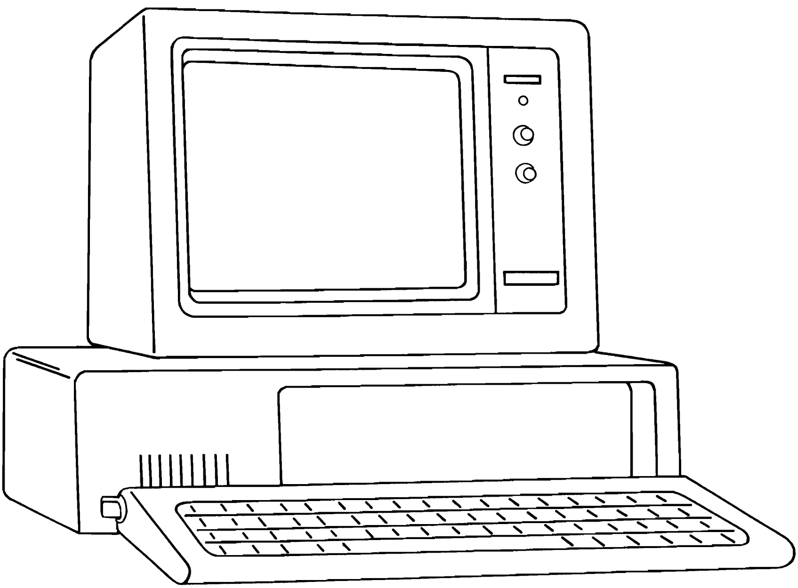
Chapter 1

Preparing Your Computer

This chapter should be used by people who are installing the Captain in most computers, including the IBM Personal Computer, the PC2, the XT, or the Compaq Computer.

The Columbia Desktop and some other IBM "look-alike"computers do not use a system switch block to recognize memory. If this is your case, go directly to Chapter 2.

This chapter shows you how to set the switches on the system board of your personal computer for memory expansion.



System Board Switch Modules

In order for the computer system to recognize the Captain's memory as system memory, the computer's switches must be set.

- Locate the switch modules on your system board. They are just beyond the back left corner of Drive A. (The system board is the bottom board on the computer system chassis.)

IBM PC

In the IBM Personal Computer or PC2, the switches consist of switch modules labeled SW1 and SW2.

IBM XT IBM Portable

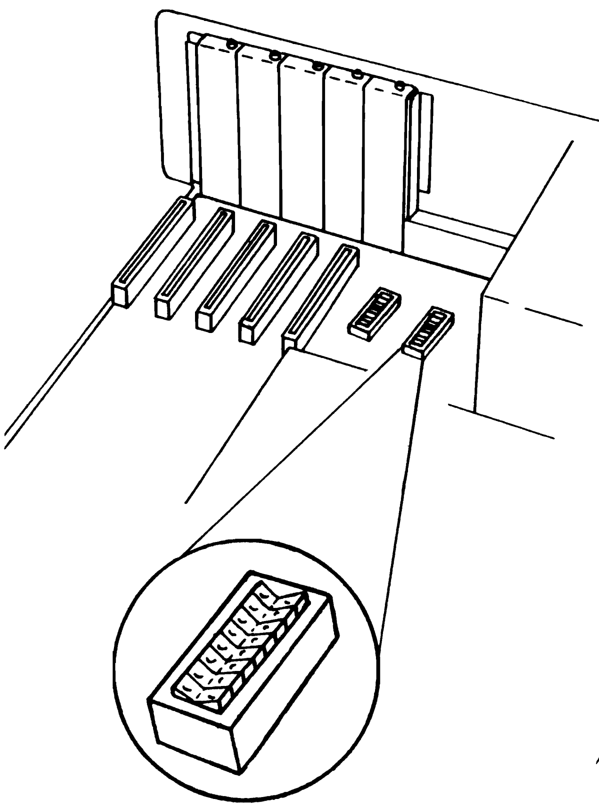
If you have an IBM XT or IBM Portable Computer, SW1 is your only switch module.

IBM Compatibles

Hard disk versions of the Compaq and some other IBM compatible computers have only one switch module.

■ Skip the instructions for SW2 if your computer has only one system board switch module.

The diagram below shows a switch module "exploded" out of a system board.



System Board Switch Module

Record Current Settings

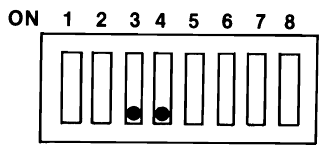
■ Make a note of how the switches are presently set before you change any switches on your computer. Then if you get unusual errors after installing the board, you can check to see if you moved another switch accidentally.

SW1 Switch Settings

■ The black dots on the diagram below represent the way switches 3 and 4 are to be set. (See Appendix A for an explanation of setting switches.)

Set switches 3 and 4 on SW1 of the system board switch module to the OFF position as shown.

Use a ballpoint pen to push the switches into the desired positions. DO NOT USE A PENCIL. Double check the settings. They must exactly match the diagram.



Do not change any other switches on SW1.

SW2 Switch Settings

Switch module SW2 must be set for computers that have two switch blocks on their system board.

The settings shown in Table 1 are correct for IBM PC computers. If you have an IBM compatible, see your computer manual for instructions.

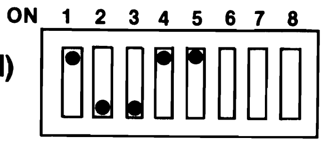
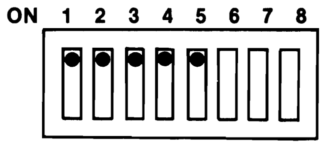
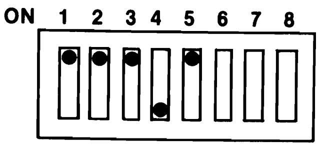
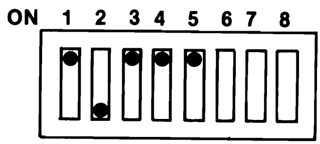
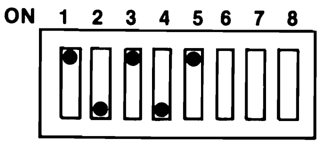
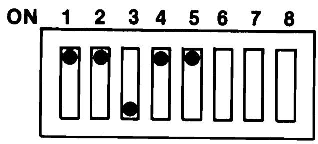
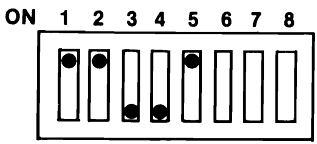
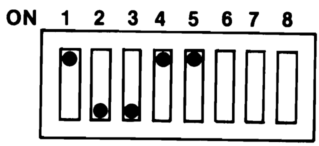
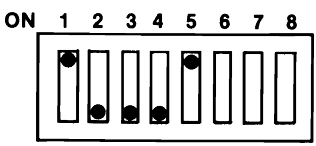
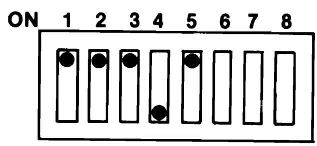
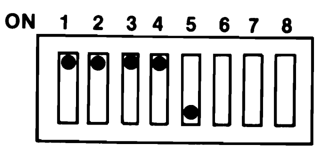
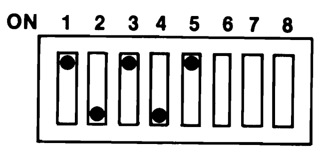
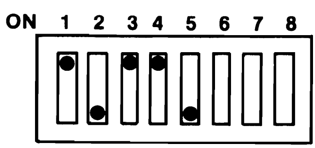
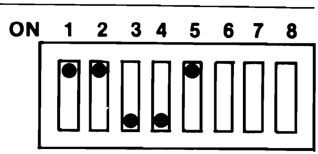
Table 1 shows the correct settings for switches one through five on SW2. The black dots represent the selected choices.

Use the table by looking down the column with the amount of memory in your system (256K or 64K) until you reach the row with the amount of memory on your Captain.

Use a ballpoint pen to push the switches into the positions indicated in the diagram you circled. DO NOT USE A PENCIL. Double check the settings. They must exactly match the diagram.

Do not change any other switches on SW2.

Table 1. System Board Switch Settings - SW2

Amount of Captain Memory to Activate	Systems With 256K RAM	IBM PC Models With 64K RAM
0 (all disabled)		
64K		
128K		
192K		
256K		
320K		
384K		

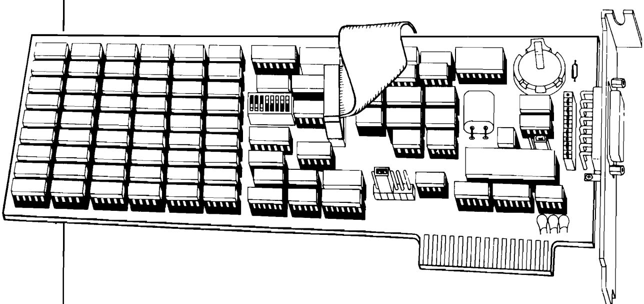
Double check your settings. **ONLY DESIGNATED SWITCHES SHOULD BE CHANGED.** Follow the diagrams and make no other changes.

Chapter 2

Preparing the Captain

This chapter of the manual shows you how to set the switch modules and jumper blocks on your Captain.

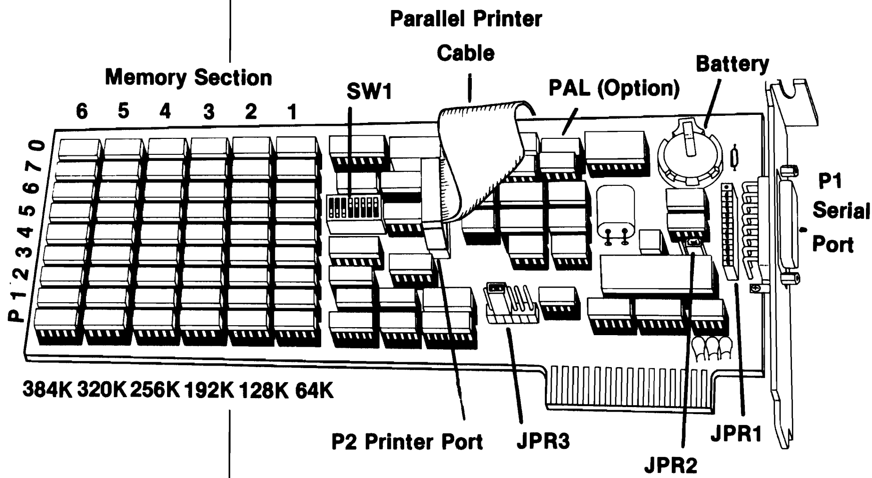
See Appendix A for an explanation of setting switch modules and connecting jumper block positions.



The Captain Board

- Unpack the Captain and place it component side up on a clean, static-free, flat surface. The surface should be non-metallic to prevent shorting of the battery.

- Find Switch 1 (SW1), jumper blocks 1-3 (JPR1, JPR2, JPR3), and the printer (P2) and serial (P1) ports.



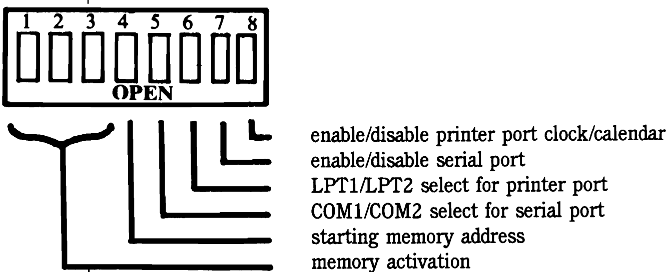
Note: The Captain clock/calendar backup battery must be replaced by a factory trained technician.

A saftey fuse is also provided to prevent high voltages from entering the battery. If this fuse blows, contact Tecmar. Do not simply replace the fuse; it can only burn out as a result of some other hardware malfunction.

SW1 Functions

Switch module SW1 on the Captain board has eight numbered switches.

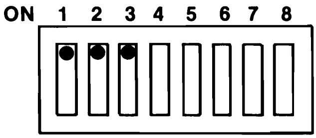
The diagram below shows the functions of the SW1 switch positions.



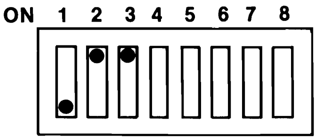
Captain Memory Settings

Switches 1, 2, and 3 of switch module SW1 control the amount of memory on the Captain board.

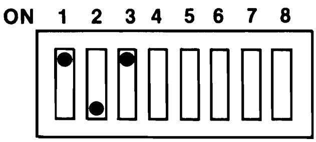
- To find the correct SW1 switch settings, find the example below that shows the amount of memory on your Captain. Circle the diagram that matches.



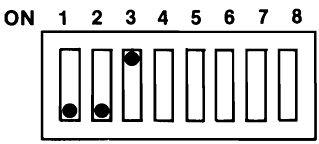
0 bytes activated



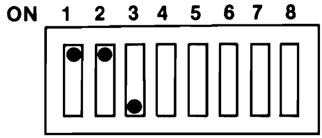
64K activated



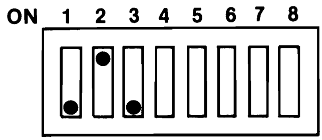
128K activated



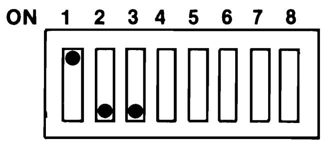
192K activated



256K activated



320K activated



384K activated

Captain Board Memory Settings

The black dots show the correct settings for switches 1, 2, 3.

Use a ballpoint pen to push the switches into the positions indicated in the diagram you circled. DO NOT USE A PENCIL.

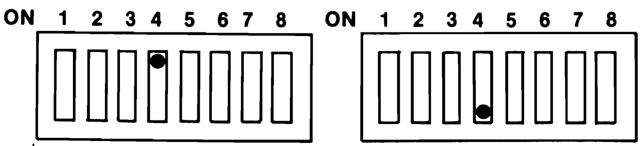
Double check the settings. They must match the diagram precisely.

Do not change any other switches on SW1. (See pages 52-53 for error messages that could occur.)

Starting Memory Address

■ To set the correct starting address for Captain memory, you will need to set Switch 4 on switch module SW1.

To find the correct Switch 4 setting, select the diagram below that matches your personal computer system and circle it.



Start at 64K (Original IBM PC)

Start at 256K (XT, IBM Portable, PC2, Columbia, Compaq, and other computers)

SW1 Switch 4 Settings

Use a ballpoint pen to slide the switch into the position indicated. **Double check the setting.** It must match the diagram exactly.

Do not change any other switches on SW1.

Port Setups

Switches 5, 6, 7, and 8 on the Captain switch module SW1 allow you to select COM1/COM2, LPT1/Time1 and LPT2/Time2 I/O locations.

Serial Ports

DOS uses the labels COM1 and COM2 to represent the serial ports. These labels represent addresses in the computer's memory.

The first serial port in the system is designated COM1, while the second serial port is designated COM2.

Printer Ports and Addresses

DOS uses the labels LPT1, LPT2, and LPT3 to represent the first, second, and third printer ports.

Three different addresses are used for the printer ports. The first starting address, 3BC (hexadecimal), is used for the IBM Monochrome Display Adapter.

The second starting address is 378 (hexadecimal), and it is used for the IBM Printer Adapter, if you have one. Otherwise it is available for non-IBM boards, such as the Captain.

DOS Procedure

When you first turn on your computer, DOS searches for the first printer port in the system and designates it LPT1. If DOS finds a second printer port, it gets the label LPT2, and the third (if there is one) becomes LPT3.

IBM's power up procedures will assign the name LPT2 to the Captain port, if it and the IBM Monochrome board or the IBM Printer Adapter are the only printer ports in the system.

With IBM Monochrome Display

If you have an IBM Monochrome Display Adapter, DOS automatically labels it LPT1, because its address is found first (3BC).

Therefore, when you have the Captain and an IBM Monochrome Display Adapter, you should set the Captain as LPT1 (starting address 378).

In this situation, the Captain's address does not conflict with the one for the IBM Monochrome Display Adapter.

With IBM Printer Adapter

When you have an IBM Printer Adapter, you should set the Captain port as LPT2 (starting address 278).

Third Printer Port

If the Captain is the third printer port in your system, you must select the switch settings for the second printer port (LPT2), but the system will assign it the default name LPT3.

Time of Day

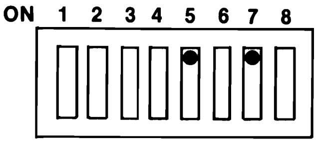
The names Time1 and Time2 represent addresses in the computer for the Time of Day chip. Time1 must be selected if the Captain printer port is LPT1, and Time2 must be used if the Captain port is LPT2.

SW1 Settings

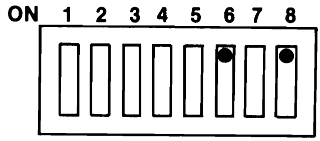
The diagrams below show the possible settings for switches five through eight on SW1. You need to select one example from each column.

- Unless your system has special requirements, you should select the setting labeled "COM1 selected"in the first column below and the setting labeled "LPT1 and Time 1 selected" in the second column below. (Most IBM PC's and PC2's will use this setting.)

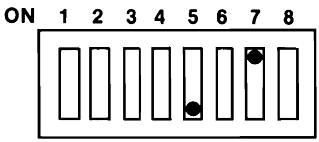
- See page 31 for more on systems with special requirements.



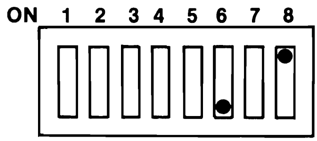
COM1 selected



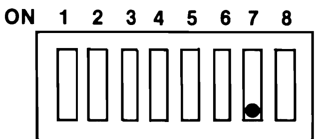
LPT1 and Time 1 selected



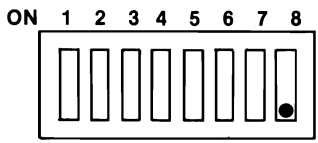
COM2 selected



LPT2 and Time 2 selected



Serial Port disabled



Printer Port and Clock/Calendar disabled

SW1 Settings for Ports

Use a ballpoint pen to push the switches into the positions indicated in the diagrams you circled. Do not use a pencil. **Double check the settings.** They must exactly match the diagrams.

For Second Serial Port

- If you already have a serial port in your system (as in an XT), you must set the serial port on the Captain to COM2. This is done to prevent I/O address conflicts between the ports. You will also need to change JPR3, the interrupt jumper (see Table 2 on page 37).

With IBM Compatibles

- If you will be installing Captain in an IBM look alike computer with one serial port, such as the Columbia Portable, your Captain serial port must be set as COM2 and your printer port can be set either as LPT1/Time1 or as LPT2/Time2.

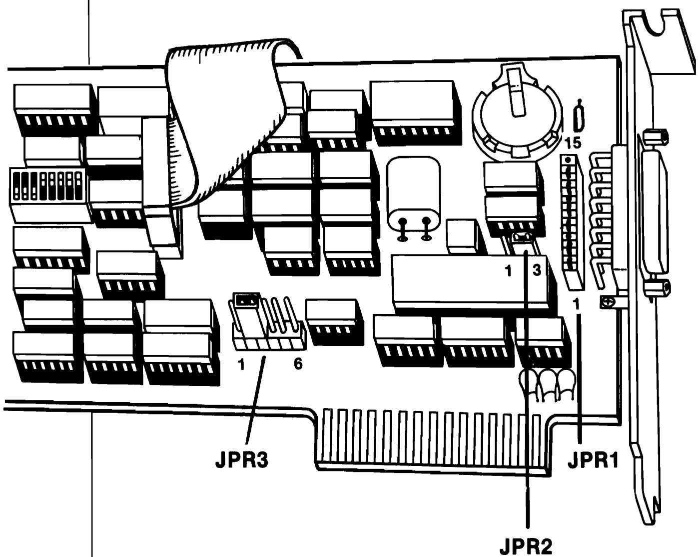
  If you have a computer with two serial ports, such as the Columbia Desktop, disable the serial port on the Captain.

For Second or Third Printer Port

- If you have a parallel printer adapter already in your system, you must set the printer port on the Captain to LPT2/Time2. If the Captain is the third printer port in your system, the Captain port will be assigned the default name LPT3 by the system.

Jumper Setups

Compare your Captain with the diagram below. The symbols labeled JPR1, JPR2, and JPR3 represent jumper blocks on the board. The numbers at each end of the jumper blocks represent the first and last jumper positions of each jumper block.



Right End of Captain

JPR1 Serial Port

The jumper block JPR1 is used to set the serial port as either Data Terminal Equipment (DTE) or Data Communication Equipment (DCE). Some peripherals such as modems, are set as DCE. Others, such as printers, are set as DTE.

Note: DTE ports only communicate with DCE devices, and DCE ports must communicate with DTE devices.

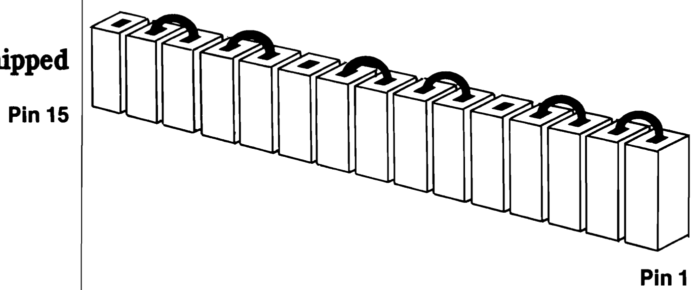
The setups differ only in the pin location of the signals on the pins of the serial port. The purpose of block JPR1 is to change the pin location of the signals. This allows two different ports to be connected without any special wiring in the cable.

The Captain is set up for DTE when shipped by Tecmar. Therefore, you do not have to change the jumper block if you will be connecting your serial port to a device configured as DCE, such as a modem.

DTE Settings

Check the manual included with the device you will be connecting to the serial port for its setup (DCE or DTE). The diagram below shows the connections for DTE.

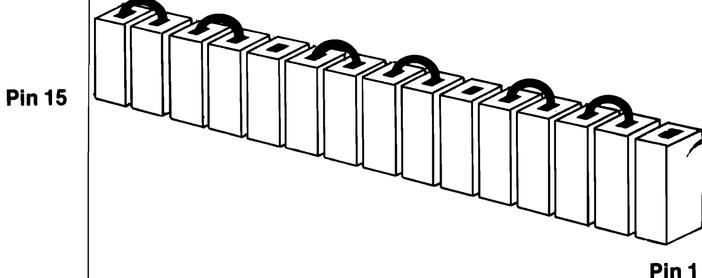
As Shipped



DTE Factory Setting of JPR1

DCE Settings

If you are connecting your serial port to a serial printer or another IBM-compatible serial port, change the jumper block to DCE. The diagram below shows the connections for DCE.



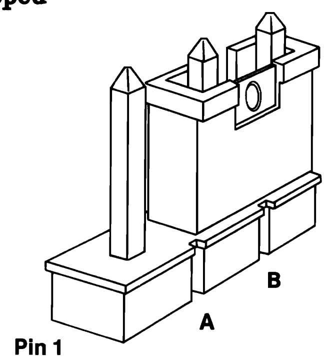
DCE Setting of JPR1

JPR2 Serial Port

Jumper block JPR2 allows you to choose between two types of data input.

- Connect position B to select the standard RS-232 data input, which is good for communication within 100 feet.
- If you have a terminal that requires current loop output, connect position A to select the current loop data input. It is good for communications up to 1000 feet.
- The board is shipped jumpered in position B as illustrated below.

As Shipped



Factory Setting
Jumper Block JPR2

JPR3 Interrupts

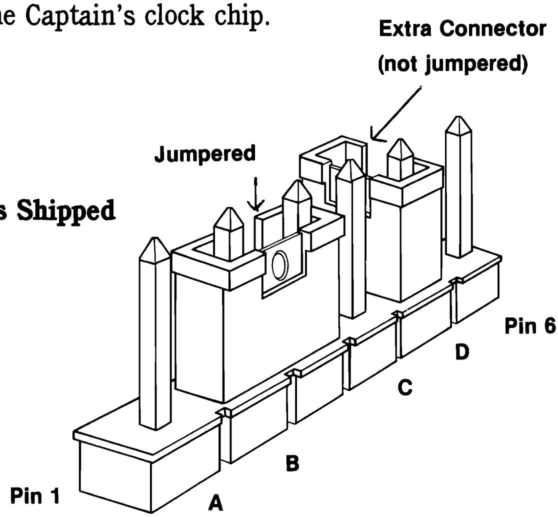
You must connect the serial port to an Interrupt Request Line (IRQ line) in your computer.

Jumper block JPR3 can be used to connect the serial ports and the clock/calendar to various IRQ lines.

Your Captain was shipped jumpered at position B. This setting, illustrated below, is appropriate for most applications.

You do not use an IRQ line for the clock/calendar unless you will be using a special application that requires generating an interrupt from the Captain's clock chip.

As Shipped



Jumper Block JPR3

The connections at jumper block JPR3 are shown below.

Table 2. Connections at Jumper Block JPR3

Position	Interrupt Source	Interrupt Request Line	Interrupt No.
A	Serial Port	IRQ3 (for COM2)	0B Hex
B	Serial Port	IRQ4 (for COM1)	0C Hex
C	Clock/Calendar	IRQ5	0D Hex
D	Clock/Calendar	IRQ7	0F Hex

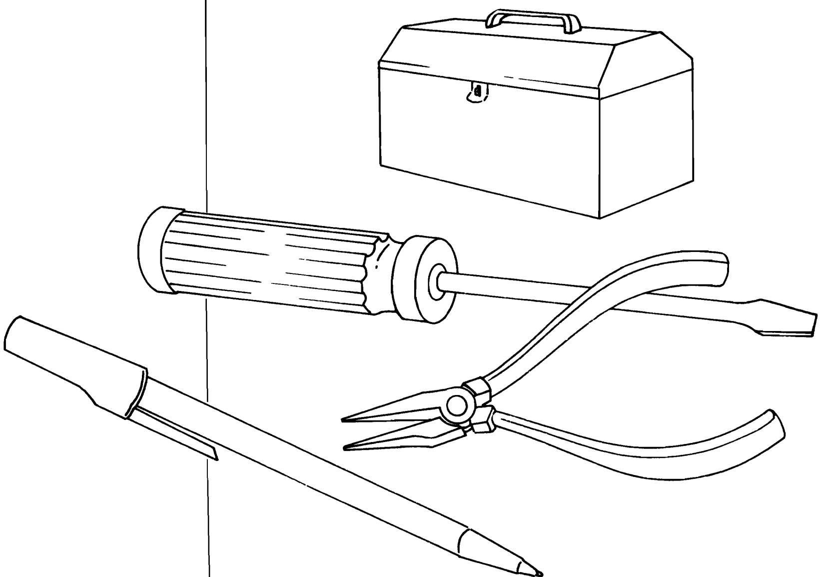
To connect the two pins corresponding to one of the functions, place one of the jumper connectors provided with the board over the two pins of the jumper position. For more information on the serial port interrupt, see Chapter 3 of the Technical Reference section.

Before going to the next chapter, make a final check of all switch and jumper settings.

Chapter 3

Installing the Captain

This chapter of the manual shows you how to install your Captain in your personal computer or Expansion Chassis.



Advance Preparation

At this point, power to your system should be off, the system cover should have been removed, and all system and Captain switches and jumpers should be set. You are now ready to install Captain into your system. Follow the step by step instructions below.

■ If you want to use the printer port, two adjacent slots in your computer or Expansion Chassis should be used.

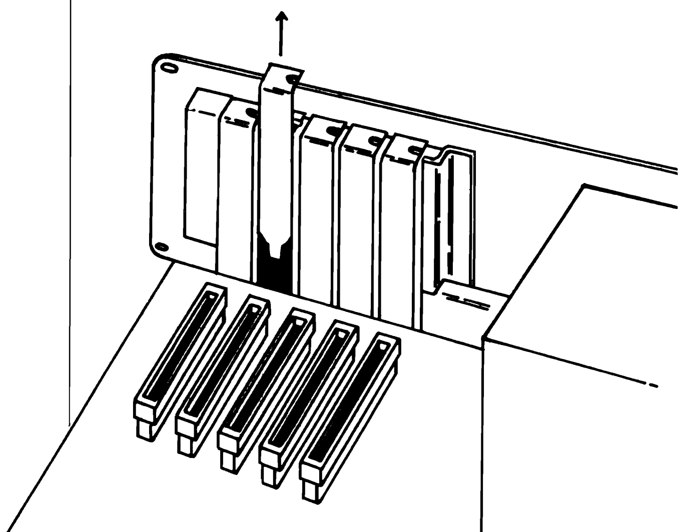
Captain will be installed in one slot. The Captain printer port connector, which is attached to the board by a ribbon cable, will be installed in the other slot.

Choose the two slots in the computer where Captain will be installed. You may need to move another board to have the two Captain slots adjacent to each other.

Removing The Slot Cover

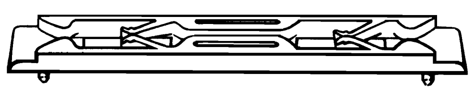
■ Face the front of the computer or Expansion Chassis. Remove the slot cover in the leftmost chosen slot by removing the screw that holds it in place.

Set the slot cover and screw aside. You will need the screw later.



Card Edge Guide

■ If a plastic card edge guide is not already present on the front wall of your computer, install the one included with your Captain. The card edge guide will hold the front edge of your board in place.

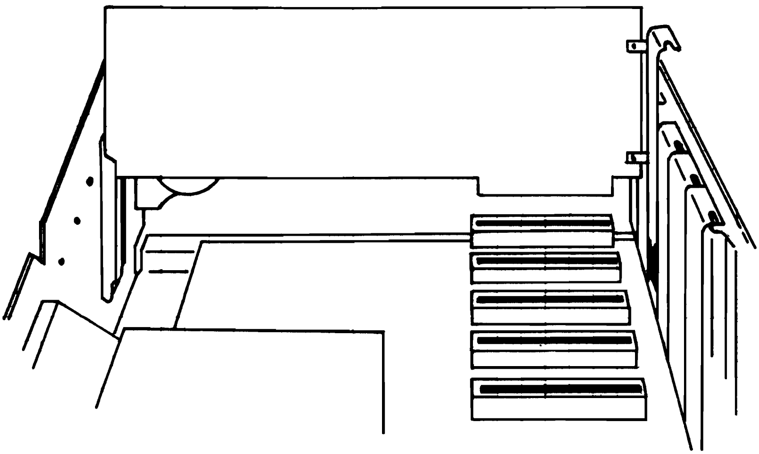


Card Edge Guide

Inserting The Captain

■ Slide the Captain down into the slot, inserting the metal mounting bracket attached to the end of the board into the opening created by the removal of the slot cover (see below).

Make sure that the gold "fingers" of the edge connectors on the bottom of the board are completely in the computer slot. The serial port contained in the mounting bracket should now be accessible from the back of the computer.



Securing The Captain

■ Replace the screw which you previously removed from the slot cover by installing it in the top of the mounting bracket. This will secure the Captain firmly in place.

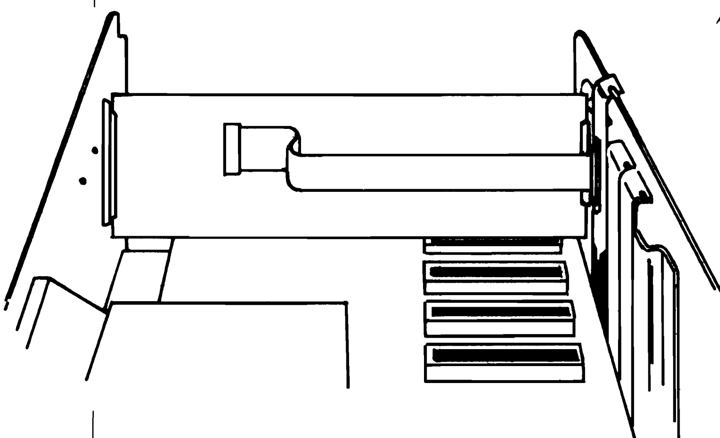
Second Slot

■ Remove the slot cover from the remaining empty slot adjacent to the Captain by removing the screw that holds it in place. Set the slot cover and screw aside.

Inserting the Mounting Bracket

■ The parallel printer cable is attached at one end to the P2 connector and at the other end to a black metal mounting bracket.

Place the mounting bracket attached to the end of the printer cable into the open slot as shown below.



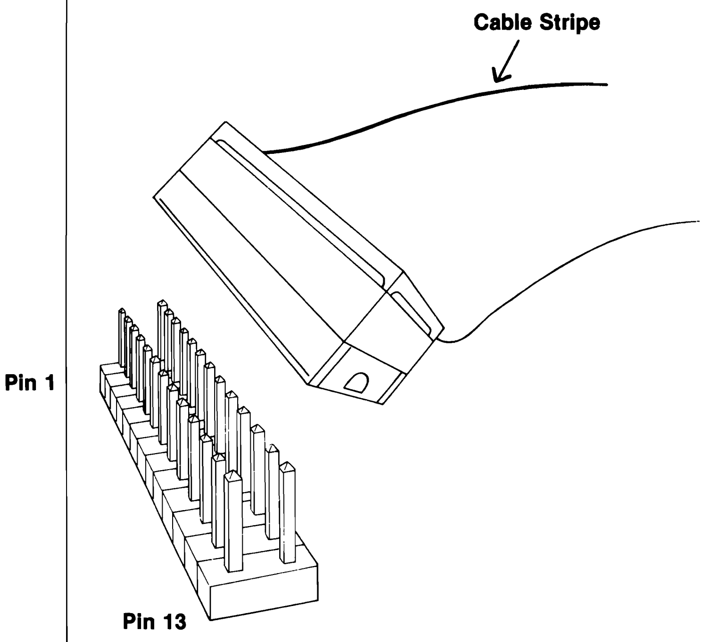
Captain and Mounting Bracket Installed

Note: You must use shielded interface cables when connecting to printers, modems, or other options in order to comply with FCC regulations.

Checking the Printer Cable

- Make sure that the cable connector on the Captain is firmly attached to the printer port pins (P2).
- Your printer cable comes already attached to the P2 connector when you purchase the Captain board.

  If it happens to come loose and you need to reattach it, make sure that the cable stripe is aligned with *pin one* on the P2 connector, as shown below.



P2 Connector

Securing The Printer Port

- Install the screw that you previously removed from the second slot cover by installing it in the top of the mounting bracket. This will secure the printer port firmly in place.

Cleanup

- Remove all tools from the inside of the computer.

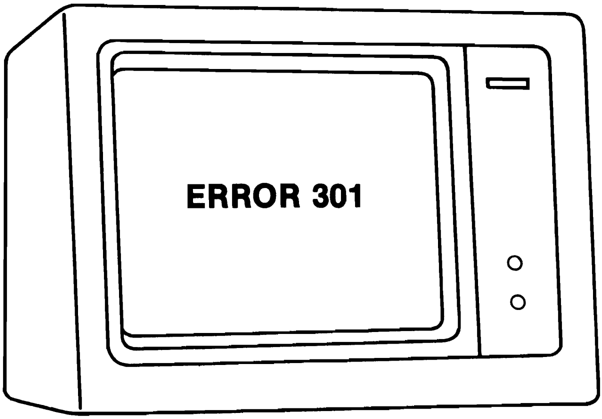
Replacing The Cover

- Replace the cover of your IBM Personal Computer, Tecmar Expansion Chassis or other compatible computer using the instructions found in the **Guide to Cover Removal and Replacement.**

This completes the installation of your Captain. It is now safe to apply power to your computer.

Chapter 4

If Problems Occur



If Problems Occur

This chapter provides suggestions for solving problems that might occur after you install the Captain. For additional help or service, contact your Tecmar dealer.

See the **Treasure Chest Technical Reference** manual for explanations of Treasure Chest programs. See your DOS manual for information on DOS commands.

Problem

You get a "Clock Not Found" Message.

- If the Captain is set as LPT2, run the Treasure Chest programs SETTIME -2 and DOSTIME -2.
- The battery on your Captain board might need replacing. Have this done by a factory trained technician.

Problem

You get an "Invalid Clock" message.

- Reset the time with the DOS TIME and DATE commands. Then use the Treasure Chest SETTIME (or SETTIME -2) program to set the Captain's clock.

Problem

The message "TECMAR, The Power Behind The PC" appears when you try to run a Treasure Chest program.

- The Captain's printer port might be disabled. Check your switch and jumper settings.
- Your battery might need replacing. Have this done by a factory trained technician.

Problem

Your IBM XT, Portable, PC, or look-alike recognizes only 256K Bytes of memory after you install the Captain.

- Check the switch settings on the Captain. (See Chapter 2).
- Use IBM'S ADVANCED Diagnostics Diskette to locate a bad chip.
- See the section on Parity Check errors at the end of this chapter.

Problem

You get a Device Timeout Error when you try to use your serial port.

- Check the switch and jumper settings on your Captain. For cables designated for IBM's serial port, the Captain should be set for DTE and jumpers for RS-232.
- If the cable was designed for an IBM serial port, it might allow DSR to float. Read the note on page 74 of Chapter 3 of the Technical Reference Section of this manual.
- Follow the instructions in your DOS manual to change the serial port with the MODE command.

Problem

Your parallel printer does not print properly, or does not print at all.

- Check your switch settings to make sure the printer port on the Captain can be recognized by your system. Review the pages in Chapter 3 on Port Setups and SW1 switch settings.
- Make sure that you don't have two printer ports at the same address.
- Check your cable to make sure it is attached firmly and has no visible breaks.
- Make sure your cable is designed for an IBM printer (parallel) port.
- Use the Treasure Chest PARTEST program to test your printer port.

Problem

You cannot bring up the Treasure Chest Menu by pressing Ctrl-Alt-M.

- Make sure that the Treasure Chest programs TICK, CRON, and MENU are installed.

Problem

You get an "xxxx - 201 Parity Check 2" error message ("xxxx" could be any number).

The first set of numbers shows which memory address is causing the problem. There might be a conflict between the Captain memory and existing memory, or your switch settings might indicate more memory than you actually have.

- Make sure that two serial ports are not set at the same address, such as both set as COM1.
- Check the speed of the RAM chips on the Captain board. All the chips in a vertical row should be the same speed. For example, 4164-15 is a 150 nanosecond chip and 4164-20 is a 200 nanosecond chip.
- Study the charts below to identify the memory bank that caused the error message.

Table 1

1st two characters of error	Corresponding section on Captain Board when the system board has: 64K	256K	Range of Memory (Decimal)	Range of Memory (HEX)
00	System board		0-64K	0000-FFFF
10	1	system board	64-128K	10000
20	2	system board	128-192K	20000
30	3	system board	192-256K	30000
40	4	1	256-320K	40000
50	5	2	320-384K	50000
60	6	3	384-448K	60000
70		4	448-512K	70000
80		5	512-576K	80000
90		6	576-640K	90000

Table 2

Last two characters of error number	Row on Captain Board
01	0
02	1
04	2
08	3
10	4
20	5
40	6
80	7

If the first two characters of the error number are '00', then the switches on your system board have been set wrong. Review Chapter 2 of the Installation Section, and then check your system board switches.

If the last two characters of the error number are anything other than the numbers given in Table 2, then either your parity chip is defective (the parity chip is at the bottom in each column) or there is a problem with another chip on your Captain board. Contact your dealer.

If the last two characters do appear on the table in Figure 2, then the problem could be one of the following: 1) a chip is in backwards (refer to Appendix B), 2) a chip has a bent leg or 3) a switch on the Captain board is set incorrectly. Check the switches on your Captain board and also the chips in the indicated row.

Section 2

Technical Reference

About this Section

This section provides information for the advanced programmer.

Organization

The section contains five chapters.

Chapter 1

Technical Description:
Provides a block diagram with description and information on the I/O Sections.

Chapter 2

Direct Control of the Printer Port:
Provides pin descriptions and functions.

Chapter 3

Direct Control of the Serial Port:
Provides pin descriptions, information on jumper use, baud rate latches, serial port registers, and a sample program with explanation.

Chapter 4

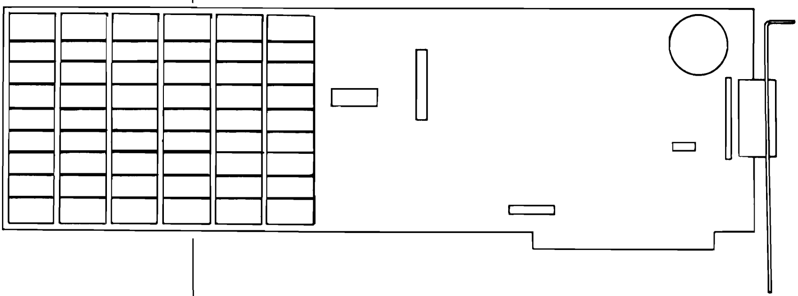
Direct Control of the Timer Chip:
Provides information on I/O locations and functions, the 58167 chip, programming the counters, latches, and interrupts, and gives software examples.

Chapter 5

The Programmable Array Logic (PAL) Option:
Provides information on PAL functions and programs.

Chapter 1

Technical Description



Block Diagram Description

Data Buffer

A bidirectional buffer transfers data between the IBM data lines and the RAM and I/O sections of the board.

Memory Control

This section controls the selection, refresh and address timing of the 256K Bytes of RAM. Using the settings of switches SW1 and SW2, this section determines which 64K Byte sections of memory will be addressed. The refresh provides the signals to the memory necessary to maintain the integrity of the memory. It is user transparent.

384K Bytes RAM

An array of RAM modules providing 256K bytes by 8 bits + 1 parity bit of memory space.

Parity Generator

When any word is written into the memory, this section produces the correct parity bit, and when any word is read from the Captain Board memory this section checks for the correct parity. (Checks to verify the data is correct).

I/O Select Logic

When the address is correct, this section selects one of the I/O read or write operations

Serial I/O

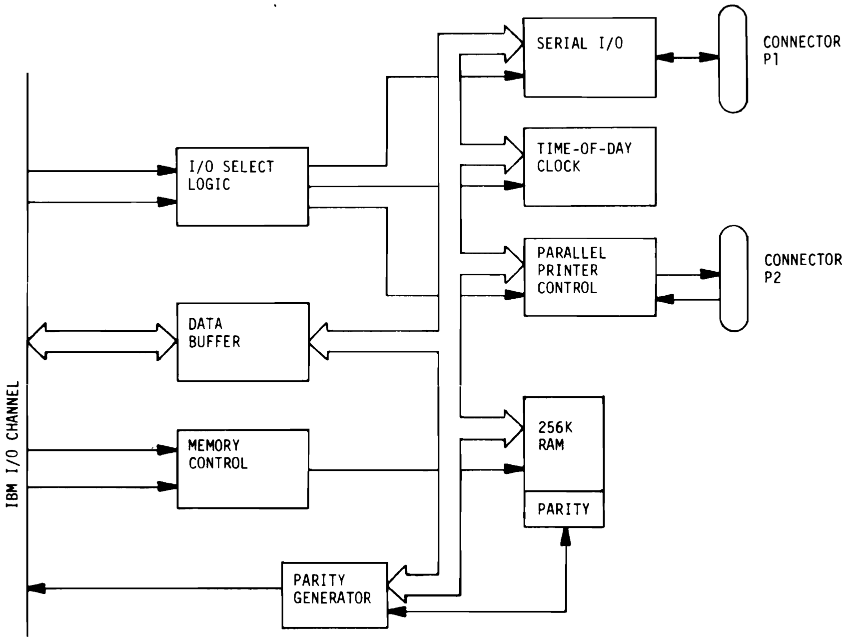
An RS-232 standard serial I/O port, jumper configurable as either 'DTE' or 'DCE'. The serial port also can be used as a 20ma current loop port and has modem control signals. The serial port is available through connector P1.

Time-of-day clock

The real-time clock is made up of an address latch, the clock itself (MM58167) and the battery for standby power.

Parallel Printer Port

The printer port is completely compatible with all IBM software and is meant to connect to an IBM, EPSON or equivalent printer. The parallel printer port is available through connector P2.



Block Diagram

Using The I/O Sections

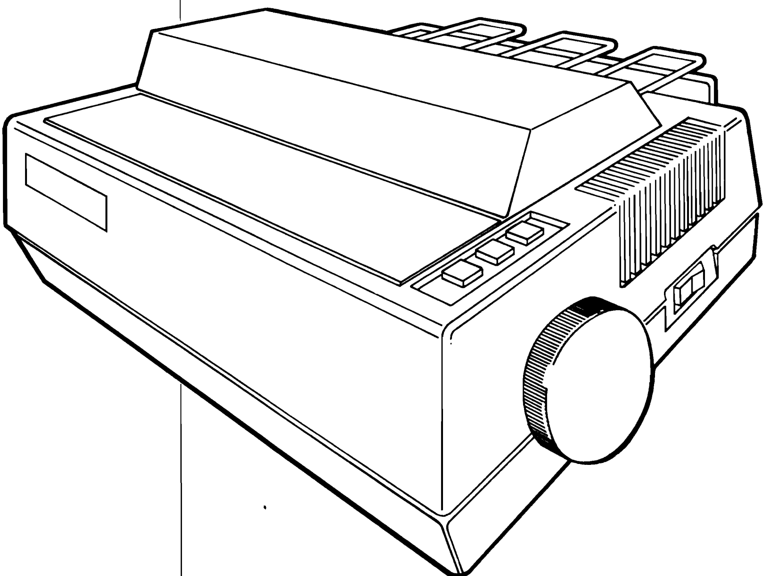
I/O addresses used:

Address	Function		Read and/or Write
888 Dec(378 Hex)	Printer Data		R/W
889 Dec(379 Hex)	Printer Status	as LPT1	R
890 Dec(37A Hex)	Printer Control		R/W
632 Dec(278 Hex)	Printer Data		R/W
633 Dec(279 Hex)	Printer Status	as LPT2	R
634 Dec(27A Hex)	Printer Control		R/W
893 Dec(37D Hex)	Clock Address latch		W
895 Dec(37F Hex)	Clock Data	as TIME1	R/W
637 Dec(27D Hex)	Clock Address latch		W
639 Dec(27F Hex)	Clock Data	as TIME2	R/W
1016 Dec(3F8 Hex)	Serial Data or		R/W
	Divisor Latch LSB		W
1017 Dec(3F9 Hex)	Interrupt enable register or		R/W
	Divisor Latch MSB		W
1018 Dec(3FA Hex)	Interrupt identification		R
	register	as COM1	
1019 Dec(3FB Hex)	Line Control Register		W/R
1020 Dec(3FC Hex)	Modem Control Register		W/R
1021 Dec(3FD Hex)	Line Status Register		R
1022 Dec(3FE Hex)	Modem Status Register		R
760 Dec(2F8 Hex)	Serial Data or		R/W
	Divisor Latch LSB		W
761 Dec(2F9 Hex)	Interrupt enable register or		R/W
	Divisor Latch MSB		W
762 Dec(2FA Hex)	Interrupt identification	as COM2	R
	register		
763 Dec(2FB Hex)	Line control register		W/R
764 Dec(2FC Hex)	Modem control register		W/R
765 Dec(2FD Hex)	Line status register		R
766 Dec(2FE Hex)	Modem status register		R

In the rest of this manual all programming references assume the Captain board is configured as Time 1, COM1, and LPT1. If any of these three sections is addressed at its alternate location then use the corresponding address for that location.

Chapter 2

Direct Control of the Printer Port



Pin Description

The printer port is hardware and software compatible with the IBM parallel printer adapter interface. It can be easily used with an IBM printer or Epson MX80 using the IBM software. It could also be used as a general parallel port for input and output. The board has 12 buffered output points which are latched and can be written to or read from under program control and 5 steady-state input points that may be read at any time.

All signals associated with this port are on connector P2. The signal names apply only when connecting the port to an IBM printer (or equivalent).

The pin-out of P2 is:

Pin No.	Signal Name	Pin No.	Signal Name
1	–Strobe	14	–AUTO FEED
2	D0	15	ERROR
3	D1	16	–INIT
4	D2	17	SEL INP
5	D3	18	GROUND
6	D4	19	GROUND
7	D5	20	GROUND
8	D6	21	GROUND
9	D7	22	GROUND
10	–ACK	23	GROUND
11	+BUSY	24	GROUND
12	+PE	25	GROUND
13	+SEL		

Address Functions

The Parallel Printer Port responds to two output and three input instructions. The output instructions transfer data into two latches whose outputs are available on P2. These outputs are also available to the CPU with two of the input instructions. The third input instruction allows the CPU to read the steady-state input points.

The five instructions, their addresses and functions are:

The five instructions, their addresses and functions are:

■ Output to 378 Hex — Printer data

Output Bit:	7	6	5	4	3	2	1	0
P2 Pin:	9	8	7	6	5	4	3	2

The 8 bit value written to 378 Hex appears on the respective pins of P2. These pins are capable of sourcing 2.6mA and sinking 24mA.

■ Input from 378 Hex — Printer data

The 8 bit value read from 378 hex is the 8 bit value latched by the most recent output to 378 hex.

■ Output to 37A Hex — Printer control

Output Bit:	7	6	5	4	3	2	1	0
Function:	No function			Interrupt Enable	17	16	14	1
					P2 pins			

Bit 0 thru 3 are used as control signals for the printer. Of these, bits 3, 1, and 0 are sent out inverted.

If bit 4 is a 1, the card will interrupt the CPU if pin 10 of P2 goes from high to low. A 0 in bit 4 disables the interrupt. The power on reset clears all these bits to zero.

The four output pins are driven by open collector drivers pulled up to +5v through 4.7Kohm resistors. They can each sink 7mA.

■ Input from 37A Hex — Printer control

The value read from 37AH is the data latched by the most recent output to 37AH.

■ Input from 379 Hex — Printer status

The value read from 379H presents the CPU with the real time status of the following pins:

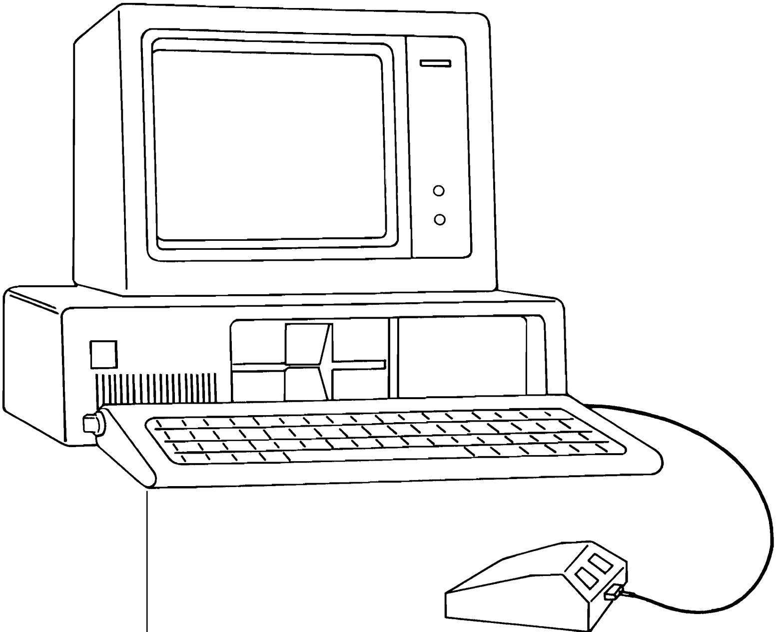
Data Bit:	7	6	5	4	3	2	1	0
P2 Pin No.:	11	10	12	13	15			
Signal Name:	Busy	ACK	PE	SEL	ERROR	No function		

The Parallel Printer Port may be used with any IBM software that uses a parallel printer.

For a description of each of the printer signals, refer to the printer manual.

Chapter 3

Direct Control of the Serial Port



Pin Description

The serial port is fully programmable and supports asynchronous communications only. It will add and remove start bits, stop bits, and parity bits. A programmable baud rate generator allows operations from 50 baud to 9600 baud. Five, six, seven or eight bit characters with 1 or 2 stop bits are supported. A fully prioritized interrupt system controls transmit, receive, error, line status and data set interrupts. Diagnostic capabilities provide loopback functions of transmit/receiver and input/output signals. It is implemented using an INS8250 serial communication I.C. The serial port signals are available on connector P1 and the pin-out is listed below.

P1: Serial Port Pinout - configured as 'DTE' (25-pin RS232 Serial Port)

Pin	Signal
7	Ground
20	DTR (Data Terminal Ready)
4	RTS (Request to Send)
2	Serial Data Out
3	Serial Data In
11	Data Out (Current Loop)
9	Current Loop Return for Data Out
18	Current Loop Return for Data In
25	Optically Coupled Data In (Current Loop)
8	RLSD (Received Line Signal Detect)
6	DSR (Data Set Ready)
5	CTS (Clear To Send)
22	RI (Ring Indicator)

Note: There is a small but important difference between the IBM Asynchronous Communications Adapter and Tecmar's IBM-compatible serial ports. IBM's serial port may function even when the Data Set Ready (DSR) line is left 'floating' (either unconnected or not driven by the serial device used); however, we do not recommend this. Tecmar serial ports, by contrast, will operate in 'DTE' mode only when the DSR line (pin #6) is driven by the remote device. If this line is not driven, the operating system will respond with a 'Device Timeout' error. Analogously, if the Captain board is used in 'DCE' mode, pin #20 must be driven by the remote device or a 'Device Timeout' error will occur. To use Tecmar boards with a serial device which does not drive DSR, pin #6 must be jumpered to pin #20 on the Tecmar serial port (in either 'DTE' mode or 'DCE' mode). An alternate way to remedy this situation is to change the settings on JPR1 by first removing the jumpers from pins 8 and 9 and from pins 6 and 7, and then jumpering pin 6 to pin 8.

P1: Serial Port Pinout - configured as 'DCE' (25-pin RS232 Serial Port)

Pin	Signal
7	Ground
20	DSR (Data Set Ready)
4	CTS (Clear To Send)
2	Serial Data In
3	Serial Data Out
8	RLSD (Received Line Signal Detect)
6	DTR (Data Terminal Ready)
5	RTS (Request To Send)
22	RI (Ring Indicator)

The functions of these signals are:

■ **Data Terminal Ready (DTR):**

When low, informs the MODEM or data set that the INS8250 is ready to communicate. The DTR output signal can be set to an active low by programming Bit 0 (DTR) of the MODEM Control Register to a high level. The DTR signal is reset high upon a Master Reset operation.

■ **Request to Send (RTS):**

When low, informs the MODEM or data set that the INS8250 is ready to transmit data. The RTS output signal can be set to an active low by programming Bit 1 (RTS) of the MODEM Control Register to be high. The RTS signal is reset high upon a Master Reset operation.

■ **Serial Output (SOUT):**

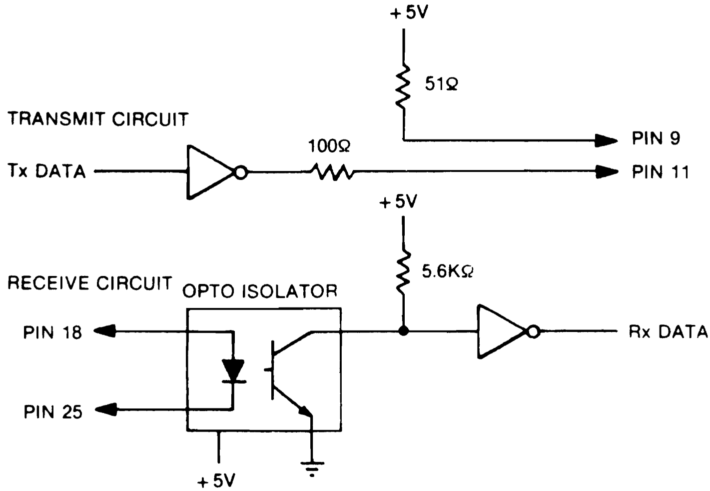
Serial data output to the communications link (peripheral, MODEM or data set). The SOUT is set to the Marking (Logic 1) state upon a Master Reset operation.

■ **Serial Input (SIN):**

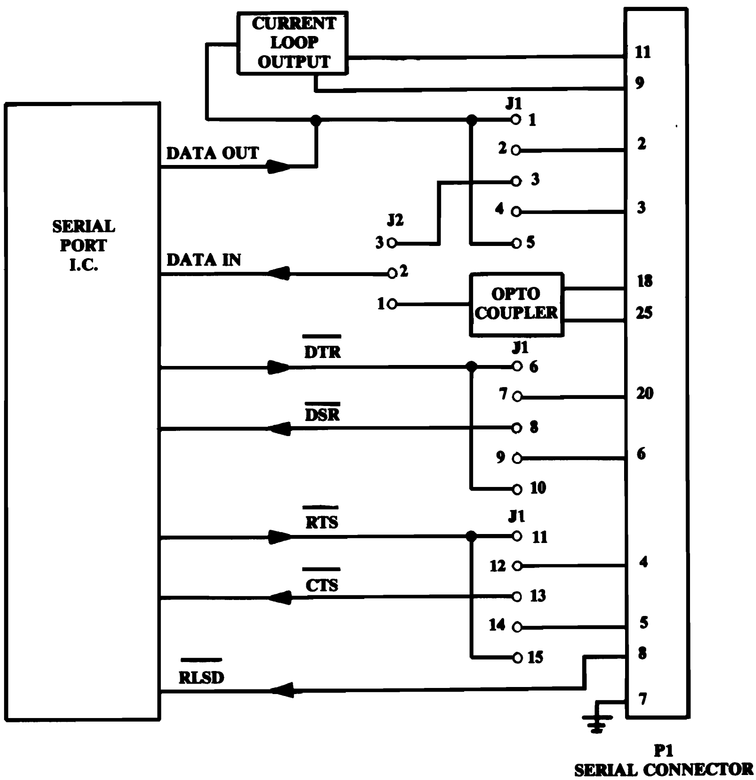
Serial data input from the communications link (peripheral device, MODEM, or data set).

■ **Current Loop Data In and Out:**

The Current Loop Data In and Out is the same as the Serial Data In and Out except that the interface is implemented as illustrated below.


+5V
51Ω
TRANSMIT CIRCUIT
100Ω
PIN 9
Tx DATA
PIN 11
+5V
5.6KΩ
RECEIVE CIRCUIT
OPTO ISOLATOR
PIN 18
Rx DATA
PIN 25
+5V

Jumper Use


CURRENT LOOP OUTPUT
11
9
J1
1
2
SERIAL PORT I.C.
DATA OUT
3
4
3
J2
5
DATA IN
2
1
OPTO COUPLER
18
25
DTR
J1
6
7
20
DSR
8
9
6
10
RTS
J1
11
12
4
CTS
13
14
5
15
8
RLSD
7
P1
SERIAL CONNECTOR

■ **Received Line Signal Detect (RLSD):**

When low, indicates that the data carrier has been detected by the MODEM or data set. The RLSD signal is a MODEM-Control function input whose condition can be tested by the CPU by reading Bit 7 (RLSD) of the MODEM Status Register. Bit 3 (DRLSD) of the MODEM Status Register indicates whether the RLSD input has changed state since the previous reading of the MODEM Status Register.

Note: Whenever the RLSD bit of the MODEM Status Register changes state, an interrupt is generated if the MODEM Status Interrupt is enabled.

■ **Data Set Ready (DSR):**

When low, indicates that the MODEM or data set is ready to establish the communications link and transfer data with the INS8250. The DSR signal is a MODEM control function input whose condition can be tested by the CPU by reading Bit 5 (DSR) of the MODEM Status Register. Bit 1 (DDSR) of the MODEM Status Register indicates whether the DSR input has changed state since the previous reading of the MODEM Status Register.

Note: Whenever the DSR bit of the MODEM Status Register changes state, an interrupt is generated if the MODEM Status Interrupt is enabled.

■ **Clear to Send (CTS):**

The CTS signal is a MODEM control function input whose condition can be tested by the CPU by reading Bit 4 (CTS) of the MODEM Status Register. Bit 0 (DCS) of the MODEM Status Register indicates whether the CTS input has changed state since the previous reading of the MODEM Status Register.

Note: Whenever the CTS bit of the MODEM Status Register changes state, an interrupt is generated if the MODEM Status Interrupt is enabled.

- **Ring Indicator (RI):**

When low, indicates that a telephone ringing signal has been received by the MODEM or data set. The RI signal is a MODEM-control function input whose condition can be tested by the CPU by reading Bit 6 (RI) of the MODEM Status Register. Bit 2 (TERI) of the MODEM Status Register indicates whether the RI input has changed from a low to a high state since the previous reading of the MODEM Status Register.

Note: Whenever the RI bit of the MODEM Status Register changes from a high to a low state, an interrupt is generated if the MODEM Status Interrupt is enabled.

There is one other signal associated with the serial port and that is the serial port interrupt that goes to IRQ4. The interrupt is enabled by setting the INS8250 OUT2 output to zero (low).

- **Interrupt:**

Goes high whenever any one of the following interrupt types has an active high condition and is enabled via the Interrupt Enable Register: Receiver Error Flag; Received Data Available; Transmitter Holding Register Empty; and MODEM Status. The INTRPT Signal is reset low upon the appropriate interrupt service or a Master Reset operation. This interrupt is routed thru IRQ4 for COM1 or IRQ3 for COM2.

Baud Rate Latches

The INS8250 contains a programmable Baud Rate Generator that takes the clock input (1.8432 MHz) and divides it by the 16-bit value in the two divisor latches. The result of this divison is 16 times the Baud rate that will be produced. Address 3F8 (DLAB=1) is the least significant byte of the 16-bit divisor. Address 3F9 (DLAB=1) is the most significant byte of the divisor. These Divisor latches must be loaded during initialization in order to ensure the desired operation of the Baud Rate Generator. The table below indicates the divisors to use for various Baud Rates.

Interrupt Control Functions

Desired Baud Rate	Divisor Used to Generate 16x Clock	Percent Error Difference Between Desired and Actual
50	2304 Dec	—
75	1536 Dec	—
110	1047 Dec	0.026
134.5	857 Dec	0.058
150	768 Dec	—
300	374 Dec	—
600	192 Dec	—
1200	96 Dec	—
1800	64 Dec	—
2000	58 Dec	0.69
2400	48 Dec	—
3600	32 Dec	—
4800	24 Dec	—
7200	16 Dec	—
9600	12 Dec	—

Serial Port Registers

Since the INS8250 is completely programmable, the system programmer may set up the serial port for any of the different modes available as needed for communicating with a particular device. The 8250 must first be initialized to the desired mode. The table below shows the reset conditions of all registers in the 8250. The control 'Master Reset' is the power-on reset generated anytime the IBM Personal Computer power is turned on.

Reset Control of Registers and Pinout Signals

Register/Signal	Reset Control	Reset State
Interrupt Enable Register	Master Reset	All Bits Low (0-3 Forced and 4-7 Permanent)
Interrupt Identification Register	Master Reset	Bit 0 is High, Bits 1 and 2 Low Bits 3-7 are Permanently Low
Line Control Register	Master Reset	All Bits Low
MODEM Control Register	Master Reset	All Bits Low
Line Status Register	Master Reset	All Bits Low Except Bits 5 & 6 are High
MODEM Status Register	Master Reset	Bits 0-3 Low Bits 4-7 - Input Signal
SOUT	Master Reset	High
INTRPT (RCVR Errs)	Read LSR/MSR	Low
INTRPT (RCVR Data Ready)	Read RBR/MR	Low
INTRPT (RCVR Data Ready)	Read IIR/Write THR/MR	Low
INTRPT (MODEM Status Changes)	Read MSR/MR	Low
OUT2	Master Reset	High
RTS	Master Reset	High
DTR	Master Reset	High
OUT 1	Master Reset	High

MR=Master Reset

All programming is accomplished by selecting the address of the 8250 register to be used and either reading from it or writing the data to it with the IBM Personal Computer's input or output instructions. The 8250's registers, their addresses and the function of each bit of data are shown in the following table. Following the table is a description of each register and its use.

Summary of INS8250 Accessible Registers

	Register Address									
	0 DLAB 0	0 DLAB 0	1 DLAB 0	2	3	4	5	6	0 DLAB 1	1 DLAB 1
Bit No	Receiver Buffer Register (Read Only)	Holding Register (Write Only)	Interrupt Enable Register	Interrupt Identification Register	Line Control Register	MODEM Control Register	Line Status Register	MODEM Status Register	Divisor Latch (LS)	Divisor Latch (MS)
0	Data Bit 0*	Data Bit 0	Enable Received Data Available Interrupt (ERBFI)	0 if Interrupt Pending	Word Length Select Bit 0 (WLS0)	Data Terminal Ready (DTR)	Data Ready (DR)	Delta Clear to Send (DCTS)	Bit 0	Bit 8
1	Data Bit 1	Data Bit 1	Enable Transmitter Holding Register Empty Interrupt (ETBEI)	Interrupt ID Bit (0)	Word Length Select Bit 1 (WLS1)	Request to Send (RTS)	Overrun Error (OR)	Delta Data Set Ready (DDSR)	Bit 1	Bit 9
2	Data Bit 2	Data Bit 2	Enable Receiver Line Status Interrupt (ELSI)	Interrupt ID Bit (1)	Number of Stop Bits (STB)	Out 1	Parity Error (PE)	Trailing Edge Ring Indicator (TERI)	Bit 2	Bit 10
3	Data Bit 3	Data Bit 3	Enable MODEM Status Interrupt (EDSSI)	0	Parity Enable (PEN)	Out 2	Framing Error (FE)	Delta Receive Line Signal Detect (DSLSD)	Bit 3	Bit 11
4	Data Bit 4	Data Bit 4	0	0	Even Parity Select (EPS)	Loop	Break Interrupt (BI)	Clear to Send (CTS)	Bit 4	Bit 12
5	Data Bit 5	Data Bit 5	0	0	Stick Parity	0	Transmitter Holding Register Empty (THRE)	Data Set Ready (DSR)	Bit 5	Bit 13
6	Data Bit 6	Data Bit 6	0	0	Set Break	0	Transmitter Shift Register Empty (TSRE)	Ring Indicator (RI)	Bit 6	Bit 14
7	Data Bit 7	Data Bit 7	0	0	Divisor Latch Access Bit (DLAB)	0	0	Received Line Signal Detect (RLSD)	Bit 7	Bit 15

*Bit 0 is the least significant bit. It is the first bit serially transmitted or received.

■ Line Status Register — 3FD Hex

This 8-bit register provides status information concerning the data transfer. The contents of the register are described below.

■ Bit 0:

This bit is the receiver Data Ready (DR) indicator. Bit 0 is set to a logic 1 whenever a complete incoming character has been received and transferred into the Receiver Buffer Register. Bit 0 may be reset to a logic 0 either by the CPU reading the data in the Receiver Buffer Register or by writing a logic 0 into it from the CPU.

■ Bit 1:

This bit is the Overrun Error (OE) indicator. Bit 1 indicates that data in the Receiver Buffer Register was not read by the CPU before the next character was transferred into the Receiver Buffer Register, thereby destroying the previous character. The OE indicator is reset after the CPU reads the contents of the Line Status Register.

■ Bit 2:

This bit is the Parity Error (PE) indicator. Bit 2 indicates that the received data character does not have the correct even or odd parity, as selected by the even parity-select bit. The PE bit is set to a logic 1 upon detection of a parity error and is reset to a logic 0 after the CPU reads the contents of the Line Status Register.

■ **Bit 3:**

This bit is the Framing Error (FE) indicator. Bit 3 indicates that the received character did not have a valid Stop bit. Bit 3 is set to a logic one whenever the Stop bit following the last data bit or parity bit is detected as a zero bit (Spacing level). It is reset after a read from the Line Status Register.

■ **Bit 4:**

This bit is the Break Interrupt (BI) indicator. Bit 4 is set to a logic 1 whenever the received data input is held in the Spacing (logic 0) state for longer than a full word transmission time (that is, the total time of Start bit + data bits + Parity + Stop bits).

Note: Bits 1 through 4 are the error conditions that produce a Receiver Line Status interrupt whenever any of the corresponding conditions are detected.

■ **Bit 5:**

This bit is the Transmitter Holding Register Empty (THRE) indicator. Bit 5 indicates that the INS8250 is ready to accept a new character for transmission. In addition, this bit causes the INS8250 to issue an interrupt to the CPU when the Transmit Holding Register Empty Interrupt enable is set high. The THRE bit is set to a logic 1 when a character is transferred from the Transmitter Holding Register into the Transmitter shift Register. The bit is reset to logic 0 concurrently with the loading of the Transmitter Holding Register by the CPU.

■ **Bit 6:**

This bit is the Transmitter Shift Register Empty (TSRE) indicator. Bit 6 is set to logic 1 whenever the Transmitter Shift Register is idle. It is reset to logic 0 upon a data transfer from the Transmitter Holding Register to the Transmitter Shift Register. Bit 6 is a read-only bit.

■ **Bit 7:**

This bit is permanently set to logic 0.

■ Interrupt Identification Register - 3FAH

The INS8250 has an on-chip interrupt capability that allows for complete flexibility in interfacing to the microprocessor. In order to provide minimum software overhead during data character transfers, the INS8250 prioritizes interrupts into four levels. The four levels of interrupt conditions are as follows: Receiver Line Status (priority 1); Received Data Ready (priority 2); Transmitter Holding Register Empty (priority 3); and MODEM Status (priority 4).

Information indicating that a prioritized interrupt is pending and the type of that interrupt are stored in the Interrupt Identification Register (refer to the table below). The Interrupt Identification Register (IIR), when addressed, freezes the highest priority interrupt pending and no other interrupts are acknowledged until that particular interrupt is serviced by the CPU. The contents of the IIR are indicated and described below.

One interrupt line is provided to the system. This interrupt is IRQ4 and will be active high. To allow the serial port to send an interrupt to the system, Bit 3 of the Modem Control Register must be set=0 (low). At this point, any interrupts allowed by the Interrupt Enable Register will cause an interrupt.

■ **Bit 0:**

This bit can be used in either a hardwired prioritized or polled environment to indicate whether an interrupt is pending. When bit 0 is a logic 0, an interrupt is pending and the IIR contents may be used as a pointer to the appropriate interrupt service routine. When bit 0 is a logic 1, no interrupt is pending and polling (if used) may continue.

■ **Bits 1 and 2:**

These two bits of the IIR are used to identify the highest priority interrupt pending as indicated in the following table.

■ **Bits 3 through 7:**

These five bits of the IIR are always logic 0.

Interrupt Control Functions

Interrupt Identification Register			Interrupt Set and Reset Functions			
Bit 2	Bit 1	Bit 0	Priority Level	Interrupt Flag	Interrupt Source	Interrupt Reset Control
0	0	1	–	None	None	–
1	1	0	Highest	Receiver Line Status	Overrun Error or Parity Error or Framing Error or Break Interrupt	Reading the Line Status Register
1	0	0	Second	Received Data Available	Receiver Data Available	Reading the Receiver Buffer Register
0	1	0	Third	Transmitter Holding Register Empty	Transmitter Holding Register Empty	Reading the IIR Register (if source of interrupt) or Writing into the Transmitter Holding Register
0	0	0	Fourth	MODEM Status	Clear to Send or Data Set Ready or Ring Indicator or Received Line Signal Detect	Reading the MODEM Status Register

■ **Interrupt Enable Register — 3F9 (DLAB=0):**

This register enables the four types of interrupts of the INS8250 to separately activate the chip Interrupt (INTRPT) output signal. It is possible to totally disable the interrupt system by resetting bits 0 through 3 of the Interrupt Enable Register. Similarly, by setting the appropriate bits of this register to a logic 1, selected interrupts can be enabled. Disabling the interrupt system inhibits the Interrupt Identification Register and the active (high) INTRPT output from the chip. All other system functions operate in their normal manner, including the setting of the Line Status and MODEM Status Registers. The contents of the Interrupt Enable Register are indicated and described below.

■ **Bit 0:**

This bit enables the Received Data Available Interrupt when set to logic 1.

■ **Bit 1:**

This bit enables the Transmitter Holding Register Empty Interrupt when set to logic 1.

■ **Bit 2:**

This bit enables the Receiver Line Status Interrupt when set to logic 1.

■ **Bit 3:**

This bit enables the MODEM Status Interrupt when set to logic 1.

■ **Bits 4 through 7:**

These four bits are always logic 0.

■ MODEM Control Register (MCR) — 3FC Hex:

This register controls the interface with a MODEM or device emulating a MODEM. The use of the Modem Control Register is described below.

■ Bit 0:

This bit controls the Data Terminal Ready (DTR) output. When bit 0 is set to a logic 1, the DTR output is forced to a logic 0. When bit 0 is reset to a logic 0, the DTR output is forced to a logic 1.

Note: The outputs of the INS8250 may be applied to an EIA inverting line driver (such as the DS1488) to obtain the proper polarity input at the MODEM or data set.

■ Bit 1:

This bit controls the Request to Send (RTS) output. Bit 1 affects the RTS output in a manner identical to that described above for bit 0.

■ Bit 2:

No function.

■ Bit 3:

This bit controls the Output 2 (OUT 2) signal, which is an auxiliary user-designated output. Bit 3 affects the OUT 2 output in a manner identical to that described above for bit 0. This OUT 2 enables the serial port interrupt when set to zero.

■ **Bit 4:**

This bit provides a loopback feature for diagnostic testing of the INS8250. When bit 4 is set to logic 1, the following occur: the Transmitter Serial Output (SOUT) is set to the Marking (logic 1) state; the Receiver Serial Input (SIN) is disconnected; the output of the Transmitter Shift Register is 'looped back' into the Receiver Shift Register input; the four MODEM Control inputs (CTS, DSR, RLSD, and RI) are disconnected; and the three MODEM Control outputs (DTR, RTS, OUT 2) are internally connected to the four MODEM control inputs. In the diagnostic mode, data that is transmitted is immediately received. This feature allows the processor to verify the transmit and receive data paths of the INS8250.

In the diagnostic mode, the receiver and transmitter interrupts are fully operational. The MODEM Control Interrupts are also operational but the interrupts' sources are now the lower four bits of the MODEM Control Register instead of the four MODEM Control inputs. The interrupts are still controlled by the Interrupt Enable Register.

The INS8250 interrupt system can be tested by writing into the lower four bits of the MODEM Status Register. Setting any of these bits to a logic 1 generates the appropriate interrupt (if enabled). The resetting of these interrupts is the same as in normal INS8250 operation. To return to normal operation, the registers must be reprogrammed for normal operation and then bit 4 of the MODEM Control Register must be reset to logic 0.

■ Bits 5 through 7:

These bits are permanently set to logic 0.

■ MODEM Status Register - 3FE Hex:

This 8 bit register provides the current state of the control lines from the MODEM (or peripheral device) to the CPU. In addition to this current-state information, four bits (D0 to D3) of the MODEM Status Register provide change information. These bits are set to a logic 1 whenever a control input from the MODEM changes state. They are reset to logic 0 whenever the CPU reads the MODEM Status Register.

The contents of the MODEM Status Register are indicated and described below.

■ **Bit 0:**

This bit is the Delta Clear to Send (DCTS) indicator. Bit 0 indicates that the CTS input to the chip has changed state since the last time it was read by the CPU.

■ **Bit 1:**

This bit is the Delta Data Set Ready (DDSR) indicator. Bit 1 indicates that the DSR input to the chip has changed state since the last time it was read by the CPU.

■ **Bit 2:**

This bit is the Trailing Edge of Ring Indicator (TERI) detector. Bit 2 indicates that the RI input to the chip has changed from an On (Logic 1) to an Off (logic 0) condition.

■ **Bit 3:**

This bit is the Delta Received Line Signal Detector (DRLSD) indicator. Bit 3 indicates that the RLSD input to the chip has changed state.

Note: Whenever bit 0, 1, 2, or 3 is set to a logic 1, a MODEM Status interrupt is generated (if enabled).

■ **Bit 4:**

This bit is the complement of the Clear to Send (CTS) input. If bit 4 (loop) of the MCR (Modem Control Register) is set to a 1, this bit is equivalent to RTS in the MCR.

■ **Bit 5:**

This bit is the complement of the Data Set Ready (DSR) input. If bit 4 of the MCR is set to a 1, this bit is equivalent to DTR in the MCR.

■ **Bit 6:**

This bit is the complement of the Ring Indicator (RI) input. If bit 4 of the MCR is set to a 1, this bit is equivalent to OUT1 in the MCR.

■ **Bit 7:**

This bit is the complement of the Received Line Signal Detect (RLSD) input. If bit 4 of the MCR is set to a 1, this bit is equivalent to OUT 2 of the MCR.

■ **Receiver Buffer Register** - 3F8 Hex (DLAB=0)

The Receiver Buffer Register contains the received character. Bit D0 is the least significant bit and is the first bit received serially.

■ **Transmitter Holding Register** - 3F8 Hex (DLAB=0)

The Transmitter Holding Register is written to with the character to be serially transmitted. Bit D0 is the least significant bit and is the first bit serially transmitted.

■ Line Control Register — 3FB Hex:

This register specifies the format of the asynchronous data communications exchange. This register may also be read at any time to retrieve the contents for inspection. The use of the bits in the Line Control Register are indicated below.

■ Bit 0 and 1:

These two bits specify the number of bits in each transmitted or received serial character. The encoding of bits 0 and 1 is as follows:

Bit 1	Bit 0	Word Length
0	0	5 bits
0	1	6 bits
1	0	7 bits
1	1	8 bits

■ Bit 2:

This bit specifies the number of Stop bits in each transmitted or received serial character. If Bit 2 is a logic 0, 1 Stop bit is generated or checked in the transmit or receive data, respectively. If Bit 2 is logic 1 when 5-bit word length is selected via bits 0 and 1, 1½ Stop bits are generated or checked. If Bit 2 is logic 1 when either a 6, 7 or 8 bit word length is selected, 2 Stop bits are generated or checked.

■ Bit 3:

This bit is the Parity Enable bit. When Bit 3 is a logic 1 a Parity bit is generated (transmit data) or checked (receive data) between the last data word bit and Stop bit of the serial data. (The Parity bit is used to produce an even or odd number of 1's when the data word bits and the Parity bit are summed.)

■ **Bit 4:**

This bit is the Even/Odd Parity Select bit. When Bit 3 is a logic 1 and Bit 4 is a logic 0, an odd number of logic 1's is transmitted or checked in the data word bits and parity bit. When Bit 3 is a logic 1 and Bit 4 is a logic 1, an even number of logic 1's is transmitted or checked.

■ **Bit 5:**

This bit is the Stick Parity bit. When Bit 3 is a logic 1 and Bit 5 is a logic 1, the parity bit is transmitted and then detected by the reciever as a logic 0 if Bit 4 is a logic 1 or as a logic 1 if Bit 4 is a logic 0.

■ **Bit 6:**

This bit is the Set Break Control bit. When Bit 6 is a logic 1, the serial output (SOUT) is forced to the Spacing (logic 0) state and remains there regardless of other transmitter activity. The set break is disabled by setting Bit 6 to a logic 0. This feature enables the CPU to alert a terminal in a computer communications system.

■ **Bit 7:**

This bit is the Divisor Latch Access Bit (DLAB). It must be set high (logic 1) to access the divisor latches of the Baud Rate Generator during a Read or Write operation. It must be set low (logic 0) to access the Receiver Buffer, the Transmitter Holding Register, or the Interrupt Enable Register.

Sample Program

A simple example of setting up the INS 8250 Serial Port follows:

```
10 OUT 1019, 128
20 OUT 1016,  12
30 OUT 1017,   0
40 OUT 1019,   3
50 OUT 1016, DATA
```

Line 10 The address 1019 will access the Line Control Register as shown on the previous page. Data 128 will set bit 7 high, the Division Latch Access Bit, (DLAB=1). With this set high, access can be gained to the Division Latches of the Baud Rate Generator.

Line 20 The address 1016 with DLAB=1 will access the Division Latch, which is the least significant of two 8 bit latches. The data output to this latch will be determined by the desired baud rate. Table 3 shows the proper divisor to use with the 1.8432 MHz crystal. In this case we output 12, since 9600 is the desired baud rate.

Line 30 The address 1017 with DLAB=1 will access the Most Significant of two 8 bit latches. Since our divisor of 12 was not above 255, it is represented by the Least Significant word. Therefore our data output to this register will equal zero.

Line 40 Once again the Line Control Register is accessed. Data output is 3, which sets both word length bits to 1, number of stop bits to zero, all parity bits to zero, Sets Break to zero, and resets the DLAB. Setting both word length bits to 1 will result in a word length of 8 bits. Because bit 3 equals zero, parity is disabled, so bits 4 and 5 will have no effect. Bit 6, Set Break, equals zero, so the transmitter output will not be disabled.

Line 50 With DLAB=0, address 1016 will now access the Transmitter Holding Register. Any data sent to this register will now be output in serial format.

To send or receive, the Line Status Register should be read first. By masking the appropriate bits, Data Ready (receive) or Transmitter Holding Register Empty (transmit) can be ascertained.

Since the Serial Port emulates the IBM serial port, all supporting software supplied by IBM can be used.

PC-DOS initializes the COM1/AUX port to 2400 baud, 8 data bits, 1 stop bit, and no parity. Also, note that BASIC reinitializes this port during its initialization process, and at this point the state of this port is undefined. The user must explicitly define the port parameters using the OPEN statement. For example, the statement:

```
OPEN "COM1:300,E,7,1" as #1
```

will set the COM1 port to 300 baud, even parity, seven data bits, and one stop bit. No spaces occur within the 'COM1:' parameter string in the OPEN statement. No error will be reported in the case of spaces occuring, but initialization will not be performed correctly.

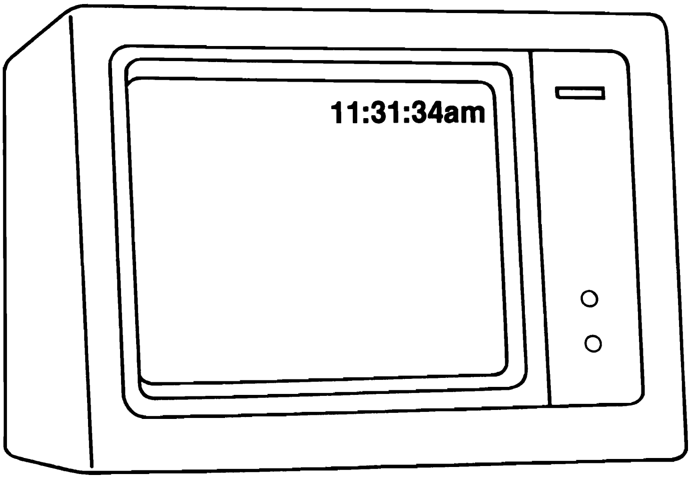
Under 1.0 the PC-DOS and BASIC COM1/AUX software is designed for use with a modem, not necessarily for use with a serial printer. When using a serial printer, one must tie CTS (clear-to-send, pin 7 on P1) to DSR (data-set-ready, pin 6). This will prevent Device Timeout or AUX I/O errors from occuring because of modem expectations. Below is a diagram of sample wiring connections to an Intergral Data Systems Model 460 serial printer as an example:

Board P1 Port Pin #	Function	IDS-460 Printer Pin #
2	TX	3
3	RCV	2
5	CTS	20
6	DSR	20
7	Signal Ground	7

Also, you may experience difficulty when using a serial printer at high speeds. If the printer has a large character buffer, a Device Timeout or Device Fault error may occur during the time required for the printer to empty its buffer.

Chapter 4

Direct Control of the Timer Chip



About This Chapter

This section explains how to program the 58167 Timer chip on the Tecmar Captain board. The I/O ports and their functions are presented. A detailed explanation of the use of the 58167 IC as a time of day counter is given. Example programs are included in this section. The two examples illustrate the setting and reading of the 58167 as a time of day counter, the setting of the latches and the use of the alarm comparator.

■ I/O Locations and Functions

The Captain Board clock address latch is located at 893 decimal (37D Hex) for TIME1 or at 637 decimal (27D Hex) for TIME2 and the Time-of-Day I.C. data is located at 895 decimal (37F Hex) for TIME1 and at 639 decimal (27F Hex) for TIME 2. The use of these two locations is covered below and it is assumed the board is configured as TIME 1.

R - Read Function   W - Write Function

The value written to this location (from 0 through 21 decimal) is the pointer to the internal location in the 58167 that is to be accessed next. The functions of the 22 locations are as follows:

Location		Functional Location in 58167
0	R/W counter	thousandths of seconds
1	R/W counter	hundredths and tenths of seconds
2	R/W counter	seconds
3	R/W counter	minutes
4	R/W counter	hours
5	R/W counter	day of the week
6	R/W counter	day of the month
7	R/W counter	months
8	R/W latch	thousandths of seconds
9	R/W latch	hundredths and tenths of seconds
10	R/W latch	seconds
11	R/W latch	minutes
12	R/W latch	hours
13	R/W latch	day of the week
14	R/W latch	day of the month
15	R/W latch	months
16	R	interrupt status register
17	W	interrupt control register
18	W	counter reset
19	W	latch reset
20	R	rollover bit
21	W	'go' command

The thousandths of seconds, the hundredths and tenths of seconds counters and latches run from 0 to 9. The seconds and minutes run from 0 to 59. The hours use the 24 hour clock and begin with 0 (12 midnight) and run to 23 (11 p.m.). The day of week, day of month and month counters all begin with 1, not 0. The day of week runs from 1=Sunday to 7=Saturday. The day of month ranges from 1 to 31 and the months begin with 1=January through 12=December.

In the hundredths and tenths of seconds counter and latch, the high order four bits are the tenths of seconds and the low order four bits are the hundredths of seconds.

■ R/W - 58167 Clock Data

After the location is selected by writing its number (0-21) to the clock address latch, data can be written to or read from the 58167 real time clock from this location. The results of writing and reading each of the 22 locations of the clock will be detailed in the next section "Programming the 58167 Timer".

58167 Chip Description

The 58167 chip is a time of day counter with alarm capabilities. Eight 8-bit counters are used to count the time of day. In addition, a series of eight 8-bit latches are provided for setting the alarm comparator. An alarm is triggered when the contents of the latches matches the contents of the timer registers. Counters and latches can be read and latches can be written or read without disturbing the real time clock functions. Interrupts can be controlled by any one of 8 timer sources. The use of all these facilities will be explained below.

All of the timer counters and latches count in BCD and therefore must be written to and read from using BCD notation. BCD (Binary Coded Decimal) is an encoding system whereby each four bits of an 8-bit byte has value of 0 to 9 decimal. The usual binary can code from 0 to 15 decimal in four bits. However, for timer purposes, the use of BCD is simpler and more common. In BCD, a two digit number is always coded in two 4-bit groups. For example, 27 would be 0010 0111 in BCD. The high four bits represent the 2 of 27 and the low four bits represent the 7. BASIC does not distinguish between the use of BCD and normal binary. It is therefore necessary to convert from decimal to BCD to write to the timer and to convert from BCD to decimal when reading from the timer. So to write 27 to the timer, the BCD representation must be determined. This BCD representation must then be written to the timer. We determined above that 27 in BCD is 0010 0111 which equals 39 dec. To set the timer to 27 then, a 39 would have to be sent out the appropriate port.

Fortunately, there are equations for converting from BCD to decimal and from decimal to BCD. This saves the user the trouble of writing down a BCD representation for every value to be sent to the timer and then converting that representation to binary. The conversion equations are as follows:

BCD to Decimal:

Decimal = INT (BCD/16)*10 + BCD MOD 16

> Note: MOD is the remainder of a division operation.
> In this case, BCD MOD 16 = the remainder of BCD/16.
> INT is the function signalling an integer divide.

Decimal to BCD:

BCD = INT (Decimal/10)*6+Decimal

In the first formula the 'BCD number' divided by 16 (integer division) is multiplied by 10 and then the integer remainder of the 'BCD number' which has been divided by 16 (BCD MOD 16) is added. For example:

The BCD number received was 27 hex, which is 39 decimal (2 x 16 + 7 x 1 = 39).
39/16 = 2 (integer result with a remainder of 7)
2 x 10 = 20
(39) mod 16 = 7
20 + 7 = 27 (the decimal number)

As an example of the second formula, the decimal number to be output is 38.
38/10 = 3 (integer result)
BCD = (38/10 x 6) + 38 = (3 x 6) + 38
BCD = 56 decimal which gets output as 38 Hex.

If you are programming in assembly language, any BCD number is equivalent to a hexadecimal number with no digit greater than nine.

Programming the Counters

The eight counters contain the real time clock information. They may be written into to set the time or change it and may be read at any time without affecting the counting.

■ Setting the counters

The procedure for setting or changing the counters is as follows:

1. Write to the clock address latch the number of the counter to which you wish to write. Example: To set the hours, write OUT 893,4.
2. Set the timer by writing to the clock the number to which you wish to set the counter. Example: To set the counter selected to 15, write OUT 895,21. (15 decimal=21 BCD).
3. Continue with these two steps until the counter registers desired are set.

■ Reading the counters

The procedure for reading the counters is very similar to the process of writing the counters. Read the counters as follows:

1. Write to the clock address latch the number of the counter which you wish to read. Example: To read the minutes, write OUT 893,3.
2. Read the counter from the clock. Example: To read the selected counter, give the command X=INP(895). X will equal the value of the counter selected (in BCD).

If you are programming in assembly code, it is possible to use the rollover bit. This bit will go high if any counter changes its value during the read operation. If the rollover bit is set, then the counter must be re-read within 900 microseconds or the rollover bit will be set again. To use this feature, write 20 to the clock address latch to select the rollover register. Then read the data port location to clear the rollover register. Select and read the counter as described above. Select and read the rollover bit again; if it is a '1' re-read the counter immediately. Otherwise, the read was valid and you can continue to the next operation.

■ Resetting the counters

The counters can be reset through the reset registers on the timer chip. To set all the counters to their lowest values, write 255 to the counter reset register as follows:

Write to the clock address latch an '18' to select the counter reset location. (OUT 893,18).

2. Write to the clock a '255' to select reset of all the counters. Example: OUT 895,255 will reset all of the counters to their minimum values.

■ Synchronizing the counters with real time

A special register is provided on the 58167 chip to make synchronizing the counter with real time easier. This register is called the 'Go' register. Writing a '1' to the Go register resets the thousandths, hundredths and tenths of seconds counters and the seconds counter. The purpose of simultaneously resetting these registers is to allow the user to set the slower counters and then issue the Go command at the time when real time indicates that their values should all be zero. Setting each of the faster counters (seconds and faster) individually results in inaccuracy because the setting process takes some time. The time it takes the user to set the tenths of seconds register is more than it takes for the tenths of seconds to advance. Using the Go register allows simultaneous reset of all the fast counting timers, thus reducing this problem.

The procedure for using the Go register is as follows:

1. Use the 'Setting the Counters' procedure to set the months, days of month, days of week, hours, and minutes counters. Example: Set the counter to Thursday, July 29, 10:15 a.m. when your real time clock says 00:14:30.
2. Send a '21' out the clock address latch to select the Go register. (OUT 893,21).
3. Type the command to send a '1' to the real time clock to issue the Go command. (OUT 895,1).
4. Repeat step 3, except this time, do not type the carriage return to send the command.

5. When your real time clock reads exactly 10:15:00:00:00, hit the carriage return to send the Go register command. The command will clear all the counters for seconds and faster, thus synchronizing the timer with your real time clock.

The purpose of setting the timer a few seconds ahead of the real time in step 2 is to assure that the minutes timer is not a minute behind the real time when the Go register is set. Setting the minutes to the actual time minutes would cause the timer to be reset to the beginning of that minute when the Go command is issued the first time. Setting the timer to the next minute allows the counter to be reset to the beginning of that next minute, so that issuing another Go command when the beginning of the next minute actually occurs will synchronize the timer and your real time clock.

Programming the Latches

■ Overview:

The 8 latches are for setting the alarm comparator. When the counters equal the contents of the latches, then the alarm interrupt (interrupts are discussed in the next section) is set. The latches are written, read and reset in a manner very similar to the writing, reading and resetting of the counters.

■ **Setting the latches**

Each latch is set in the same two step process as setting the counters: the latch is selected and the setting is written to it in BCD. If you wish to set a latch to a 'don't care' state, set it to 204 decimal (CC Hex). This has the effect of having the latch always read the same as the counter. So, if you wished to set the latches so that the alarm interrupt would be triggered every day at 3 p.m., you would set the month, day of week, and day of month to 204, the hours to 15 (decimal), and the minutes, seconds and all other latches to 0.

The following procedure details how to program the latches:

1. Select the latch to be set and send its address value (8-15) to the clock address latch. Example: To set the hours, OUT 893,12.
2. Set the latch to a particular value by sending that value (in BCD) to the clock. Example: To set the latch to 25 (decimal), OUT 895,37. To set any latch to 'don't care', send out '204' decimal (OUT 891,204).
3. Repeat from step 1 to continue setting latches.

■ Reading the latches

The procedure to read the latches is nearly the same as the procedure to read the counters:

1. Select the latch to be read and send its address value (8-15) out the clock address latch. Example: To read the month, OUT 893,15.
2. Read the counter from the real time clock address. Example: To set X equal to the value of the latch, X=INP(895). If the value read is 204, then the latch is set to the 'don't care' state.

■ Resetting the latches

The latches are reset in exactly the same manner as the counters except that the address value to select from the clock address latch is 19, the latch reset, instead of 18, the counter reset. See the section 'Resetting the counters' for details and examples of the reset procedure.

Programming the Interrupts

The 58167 timer includes interrupt control and status registers for setting and reading timer-generated interrupts. The interrupts can be generated from any of eight different sources. By setting the interrupt control register, you determine which source will cause an interrupt. Reading the interrupt status register will tell you which source generated an interrupt that has just occurred.

The interrupt control and status registers are organized as follows:

Bit	Interrupt Source
7	month
6	week
5	day
4	hour
3	minute
2	second
1	tenth of second
0	latch alarm output

■ Setting the interrupt control register

The procedure to enable the timer interrupts involves setting the bits of the control register to select the interrupt source. Writing a '1' into the bit will enable the interrupt to occur when the counter indicated by that timer rolls over to zero. A '0' in a bit will disable that interrupt source. If more than one of the interrupt control bits is set to '1', the interrupt will occur at the fastest rate selected.

An interrupt source is chosen and enabled in the following manner:

1. Write a '17' to the clock address latch to select the interrupt control register. (OUT 893,17).
2. Select the interrupt source by writing the decimal number to the clock that will turn on the desired bit(s). Example: To enable an interrupt to occur at the beginning of every hour, OUT 895,16. (Writing a '16' will set the fourth bit to '1' and enable the hour interrupt.) Example: To enable an interrupt to occur when the time set in the latches is the same as the time of the counters, OUT 895,1.

■ Reading the interrupt status register

The interrupt status register can be read to determine the source of an interrupt. A '1' at any bit indicates that the source for which that bit stands was the cause of the interrupt. The bit will be a '0' if that source did not cause the interrupt. The status bits that are '1' and the interrupt output are reset to '0' after a read of the status register.

Note that the status register will reflect valid interrupt source information whether or not the board is interrupt jumpered. This gives the option of not generating real hardware interrupts, but instead reading the status register and acting upon the occurrence of a '1' at any bit as a 'polled' operation.

The interrupt status register is referenced and read in the following way:

1. Write a '16' to the clock address latch to choose the interrupt status register. (OUT 893,16).
2. Read the register from the clock address. The decimal number returned as a result will indicate which of the status bits is turned on. Remember that performing a read on this register will clear it and reset the interrupt output. Example: To read the contents of the status register into the variable X, X=INP (895). If X equals '1', then the alarm comparator was the cause of the interrupt. If X='4' then the seconds counter was the cause of the interrupt.

Software Examples

The following two software examples illustrate the programming procedures outlined in the previous section. Each example treats a different function of the board.

> Example 1 demonstrates setting and reading the time of day and date from the 58167 timer chip.
>
> Example 2 illustrates the programming of the interrupts and how to read them in a 'polled' manner.

Example 1 is written and must be run in BASICA because of the use of key trapping commands not available in BASIC. Example 2 may be run in either BASIC or BASICA.

These example programs are provided to you only in these listings. If you wish to actually run these programs, you must first type the complete program in BASIC or BASICA. Once the program has been completely entered, you can then run it. Complete listings and line by line explanations of each example begin on the next page.

User entries required by the programs are clearly presented in menu form in the programs themselves.

Example 1

Setting and Reading the Time from the Captain Board

General Description

Example 1 illustrates the programming needed to set and read the time of day and date on the Captain board. It allows the user to enter the time of day and then reads the time of day back from the board and prints it once per second.

■ Line by Line Explanation

10-100 Allow entry of the base port. Define functions to convert decimal numbers to BCD and to convert BCD numbers to decimal.

120-170 Menu to allow choice between setting the time, reading the time and exiting the program.

200-390 Prompts entry of the current time of day and date. The entry format is described and the meaningful limits on the entries are given.

420-480 Converts each item entered from decimal to BCD by use of the TOBCD function defined in line 70. All date and time entries must be converted to BCD before being sent to the clock registers.

510-570 Set the time of day and date entered on the 58167 clock. This is accomplished by referencing each time and date registers and writing to it (from the BASE + 1 address) the entered data in proper BCD form. This completes the setting of the time.

600-640 Enables the key trapping function which will allow you to terminate the program execution when you are satisfied that the program is running correctly and the time is set correctly.

660-700	Reads the seconds register of the clock from the BASE + 1 address and converts the value to decimal using the TODEC function defined in line 100. A value one greater than the current second is determined (PLUSEC). The seconds are read again and again until the seconds roll over, making the value of the seconds equal to the value of PLUSEC.
710-750	Read the rest of the time registers at the end of a one second interval.
770-810	Print the time of day and date on the screen. The printing will occur every second because of the control loop in lines 690-700.
820	Go back to line 680 and wait for another second to pass.
850-920	Sets a string equal to the name of the day of the week so that when the day and date are printed, the name of the day of the week is printed instead of the number associated with that day.
940-1060	Sets a string equal to the name of the month so that when the day and date are printed, the name of the month is printed instead of the number associated with that month.
1090	Upon entry of the 'F1' key, this line is referenced. It returns program control to the main menu.
1120	Prints end of program message and ends the program.

```
10  REM Example 1 - Setting and Reading the Time of Day and Date
                    on the 58167 Time of Day IC.
20  REM
30  REM Set the Clock Address Latch and Real Time Clock Address
40  BASE=893        'Clock Address Latch is at 893
50  REM
60  REM Define a Function to Convert from Decimal to BCD
70  DEF FNTOBCD(X)=(X\10)*6 + X
80  REM
90  REM Define a Function to Convert from BCD to Decimal
100 DEF FNTODEC(X)=(X\16)*10 + X MOD 16
110 REM
120 CLS: PRINT: PRINT "CHOOSE THE FUNCTION YOU WISH TO PERFORM: "
130 PRINT "         1 - SET THE TIME OF DAY AND DATE"
140 PRINT "         2 - READ THE TIME OF DAY AND DATE"
150 PRINT "         3 - EXIT PROGRAM"
160 INPUT "       ";A
170 ON A GOTO 200,600,1120
180 REM
190 REM
200 REM Enter Time of Day and Date from Keyboard
210 CLS
220 PRINT "       WHEN PROMPTED BELOW WITH `MTH,DW,DT' ENTER:"
230 PRINT "           THE MONTH (1-12)"
240 PRINT "           THE DAY OF THE WEEK (1-7)"
250 PRINT "           THE DAY OF THE MONTH (1-31)"
260 PRINT
270 PRINT "       PLEASE SEPARATE YOUR ENTRIES WITH COMMAS"
280 PRINT
290 INPUT "ENTER MONTH, DAY OF WEEK, AND DATE - MTH,DW,DT    ",MONTH,DW,DATE
300 REM
310 PRINT: PRINT
320 PRINT "       WHEN PROMPTED BELOW WITH `HR,MIN,SEC' ENTER:"
330 PRINT "           THE HOUR (0-23)"
340 PRINT "           THE MINUTES (0-59)"
350 PRINT "           THE SECONDS (0-59)"
360 PRINT
370 PRINT "       PLEASE SEPARATE YOUR ENTRIES WITH COMMAS"
380 PRINT
390 INPUT "ENTER TIME OF DAY - HR,MIN,SEC    ",HR,MIN,SEC
400 REM
410 REM
420 REM Convert Time of Day and Date from Decimal to BCD
430 MONTH=FNTOBCD(MONTH)    'convert month
440 DATE=FNTOBCD(DATE)      'convert date
450 DW=FNTOBCD(DW)          'convert day of week
460 HR=FNTOBCD(HR)          'convert hour
470 MIN=FNTOBCD(MIN)        'convert minutes
480 SEC=FNTOBCD(SEC)        'convert seconds
490 REM
500 REM
510 REM Set Time of Day and Date as Entered
520 OUT BASE,7: OUT BASE+2,MONTH      'set month
530 OUT BASE,6: OUT BASE+2,DATE       'set day of month
540 OUT BASE,5: OUT BASE+2,DW         'set day of week
550 OUT BASE,4: OUT BASE+2,HR         'set hour
560 OUT BASE,3: OUT BASE+2,MIN        'set minutes
570 OUT BASE,2: OUT BASE+2,SEC        'set seconds
580 REM
590 REM
```

```
600 REM Read Time of Day and Date from Timer
610 CLS: PRINT "PRESS `F1' KEY TO STOP PRINTING AND RETURN TO MENU"
620 PRINT
630 KEY(1) ON                 'Turn on F1 key for key trapping
640 ON KEY(1) GOSUB 1090      'When F1 key is struck, exit program
650 REM
660 REM Read Time and Print once per Second
670 OUT BASE,2: X=INP(BASE+2): SEC=FNTODEC(X)    'read seconds
680 IF SEC=59 THEN PLUSEC=0 ELSE PLUSEC=SEC+1    'set up rollover check
690 OUT BASE,2: X=INP(BASE+2): SEC=FNTODEC(X)    'read seconds
700 IF SEC<>PLUSEC GOTO 690              'if a second has passed, read the time
710 OUT BASE,3: X=INP(BASE+2): MIN=FNTODEC(X)     'read minutes
720 OUT BASE,4: X=INP(BASE+2): HR=FNTODEC(X)      'read hours
730 OUT BASE,5: X=INP(BASE+2): DW=FNTODEC(X)      'read day of week
740 OUT BASE,6: X=INP(BASE+2): DATE=FNTODEC(X)    'read day of month
750 OUT BASE,7: X=INP(BASE+2): MONTH=FNTODEC(X)    read month
760 REM
770 REM Print Time of Day and Date
780 PRINT: PRINT "Time of Day and Date:  ";
790 ON DW GOSUB 860,870,880,890,900,910,920
800 ON MONTH GOSUB 950,960,970,980,990,1000,1010,1020,1030,1040,1050,1060
810 PRINT DW$;", ";MONTH$;" ";DATE;", ";HR;":";MIN;":";SEC
820 GOTO 680
830 REM
840 REM
850 REM Convert Day of Week Numbers to Day of Week Names
860 DW$="Sunday": RETURN
870 DW$="Monday": RETURN
880 DW$="Tuesday": RETURN
890 DW$="Wednesday": RETURN
900 DW$="Thursday": RETURN
910 DW$="Friday": RETURN
920 DW$="Saturday": RETURN
930 REM
940 REM Convert Month Numbers to Month Names
950 MONTH$="January": RETURN
960 MONTH$="February": RETURN
970 MONTH$="March": RETURN
980 MONTH$="April": RETURN
990 MONTH$="May": RETURN
1000 MONTH$="June": RETURN
1010 MONTH$="July": RETURN
1020 MONTH$="August": RETURN
1030 MONTH$="September": RETURN
1040 MONTH$="October": RETURN
1050 MONTH$="November": RETURN
1060 MONTH$="December": RETURN
1070 REM
1080 REM Stop Printing the Time and Return to the Menu
1090 RETURN 120
1100 REM
1110 REM End of Program
1120 PRINT: PRINT: PRINT "END OF PROGRAM"
```

Example 2

Programming the Latches and Using the Alarm Comparator
General Description

Example 2 demonstrates how to set the latches on the 58167 timer. The alarm comparator interrupt is also used and the procedure of 'polling' the interrupts is demonstrated. When the interrupt status register indicates that an interrupt has occurred, a message to that effect is printed. The example is a purely artificial one, but it demonstrates how this type of process would be programmed in a context where polling the interrupts would be useful.

■ Line by Line Explanation

10-100 Define functions to convert BCD to decimal and decimal to BCD. Set the clock latch address and real time clock address.

120-180 Read the time of day and date from the board starting with the seconds and reading every counter through the month.

200-240 Print the time of day and date.

261-360 Enter the time which you wish to set in the latches. The time you enter here will be the time at which the alarm will occur.

370-380 Call the subroutines to convert the day of the week and month numbers into names.

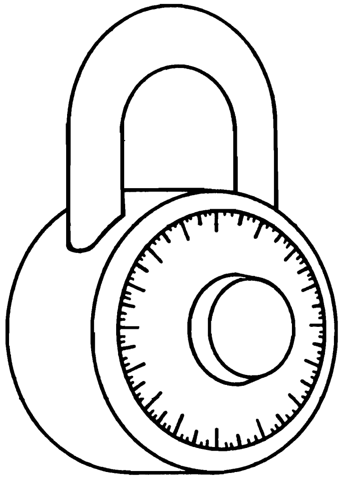
390-460	Print the time at which the interrupt will occur (the time set in the latches) indicating all latches that are set to 'don't care' states. 'Don't care' states are noted by printing that any unit in that counter will satisfy the alarm requirements.
480-540	Convert latch settings to BCD. All 'don't care' entries are set to 204 decimal.
560-620	Write the 'converted times' and 'don't care' codes established in lines 480-540 to the latches.
640-680	Enable the interrupt latch alarm by writing a '1' to the interrupt control register. Read the interrupt status register to clear it.
700-750	Read the interrupt status register until it indicates that the alarm comparator is true, meaning that the time in the latches is the same as the time in the counters. When this occurs, print a message indicating that an interrupt has occurred, print an end of program message, and end the program.
770-850	Subroutines to assign day of the week names to the day of the week numbers. This allows the day of the week to be printed for example as 'Sunday' instead of '1'.
870-990	Subroutines to assign month names to the month numbers. This allows the month to be printed for example as 'May' instead of '5'.

```
10  REM Example 2 - Program to set latches on the 58167 and to cause interrupt
                    on latch comparator alarm
20  REM
30  REM Define a function to convert from BCD to Decimal
40  DEF FNTODEC(X)=(X\16)*10 + X MOD 16
50  REM
60  REM Define a function to convert from Decimal to BCD
70  DEF FNTOBCD(X)=(X\10)*6 + X
80  REM
90  REM Set the Clock Address Latch and Real Time Clock Addresses
100 BASE=893                'Clock Address Latch is at 893
110 REM
120 REM Read time of day and date from the board
130 OUT BASE,2: X=INP(BASE+2): SEC=FNTODEC(X)
140 OUT BASE,3: X=INP(BASE+2): MIN=FNTODEC(X)
150 OUT BASE,4: X=INP(BASE+2): HR=FNTODEC(X)
160 OUT BASE,5: X=INP(BASE+2): DW=FNTODEC(X)
170 OUT BASE,6: X=INP(BASE+2): DATE=FNTODEC(X)
180 OUT BASE,7: X=INP(BASE+2): MONTH=FNTODEC(X)
190 REM
200 REM Print Time of Day and Date
210 CLS:PRINT: PRINT "Time of Day and Date:    ";
220 ON DW GOSUB 790,800,810,820,830,840,850
230 ON MONTH GOSUB 880,890,900,910,920,930,940,950,960,970,980,990
240 PRINT DW$;", ";MNTH$;" ";DATE;", ";HR;":";MIN;":";SEC
250 REM
260 REM Enter the Time to Set in the Latches
270 PRINT: PRINT
280 PRINT "IN RESPONSE TO THE PROMPTS BELOW,  ENTER THE ALARM TIME "
290 PRINT "ENTER A CARRIAGE RETURN TO SET A <DON'T CARE> STATE IN A PARTICULAR L
ATCH"
300 PRINT: PRINT
310 PRINT TAB(10): INPUT "DAY OF WEEK: ",LDW$: LDW=VAL(LDW$)
320 PRINT TAB(10): INPUT "MONTH: ",LMNTH$: LMNTH=VAL(LMNTH$)
330 PRINT TAB(10): INPUT "DATE: ",LDATE$: LDATE=VAL(LDATE$)
340 PRINT TAB(10): INPUT "HOUR: ",LHOUR$: LHOUR=VAL(LHOUR$)
350 PRINT TAB(10): INPUT "MINUTE: ",LMIN$: LMIN=VAL(LMIN$)
360 PRINT TAB(10): INPUT "SECOND: ",LSEC$: LSEC=VAL(LSEC$)
370 ON LDW GOSUB 790,800,810,820,830,840,850
380 ON LMNTH GOSUB 880,890,900,910,920,930,940,950,960,970,980,990
390 PRINT
400 PRINT "INTERRUPT WILL OCCUR: "
410 PRINT TAB(10);: IF LEN(LDW$)=0 THEN PRINT "ANY DAY"; ELSE PRINT DW$;
420 PRINT ", ";: IF LEN(LMNTH$)=0 THEN PRINT "ANY MONTH"; ELSE PRINT MNTH$;
430 PRINT ", ";: IF LEN(LDATE$)=0 THEN PRINT "ANY DATE"; ELSE PRINT LDATE$;
440 PRINT ", ";: IF LEN(LHOUR$)=0 THEN PRINT "ANY HOUR"; ELSE PRINT LHOUR$;
450 PRINT ":";: IF LEN(LMIN$)=0 THEN PRINT "ANY MINUTE"; ELSE PRINT LMIN$;
460 PRINT ":";: IF LEN(LSEC$)=0 THEN PRINT "ANY SECOND" ELSE PRINT LSEC$
470 REM
480 REM Convert data to BCD equivalents. Determine <Don't Care> locations.
490 IF LEN(LMNTH$)=0 THEN LMNTH=204 ELSE LMNTH=FNTOBCD(LMNTH)
500 IF LEN(LDW$)=0 THEN LDW=204 ELSE LDW=FNTOBCD(LDW)
510 IF LEN(LDATE$)=0 THEN LDATE=204 ELSE LDATE=FNTOBCD(LDATE)
520 IF LEN(LHOUR$)=0 THEN LHOUR=204 ELSE LHOUR=FNTOBCD(LHOUR)
530 IF LEN(LMIN$)=0 THEN LMIN=204 ELSE LMIN=FNTOBCD(LMIN)
540 IF LEN(LSEC$)=0 THEN LSEC=204 ELSE LSEC=FNTOBCD(LSEC)
550 REM
560 REM Set times and <Don't Cares> in the latches
570 OUT BASE,15: OUT BASE+2,LMNTH
580 OUT BASE,13: OUT BASE+2,LDW
```

```
590 OUT BASE,14: OUT BASE+2,LDATE
600 OUT BASE,12: OUT BASE+2,LHOUR
610 OUT BASE,11: OUT BASE+2,LMIN
620 OUT BASE,10: OUT BASE+2,LSEC
630 REM
640 REM Enable Interrupt on Latch Alarm
650 OUT BASE,17                         'reference interrupt control register
660 OUT BASE+2,1                        'select to interrupt on latch alarm
670 OUT BASE,16                         'reference interrupt status register
680 X=INP(BASE+2)                       'read interrupt status register to clear
690 REM
700 REM Wait for alarm to occur
710 OUT BASE,16                         'reference interrupt status register
720 X=INP(BASE+2)
730 IF X=0 GOTO 720
740 PRINT: PRINT "INTERRUPT HAS OCCURRED"
750 PRINT: PRINT "END OF PROGRAM": END
760 REM
770 REM Convert day of week numbers to day of week names
780 REM GET DAY OF WEEK AND MONTH NAMES
790 DW$="SUNDAY": RETURN
800 DW$="MONDAY": RETURN
810 DW$="TUESDAY": RETURN
820 DW$="WEDNESDAY": RETURN
830 DW$="THURSDAY": RETURN
840 DW$="FRIDAY": RETURN
850 DW$="SATURDAY": RETURN
860 REM
870 REM Convert month numbers to month names
880 MNTH$="JANUARY": RETURN
890 MNTH$="FEBRUARY": RETURN
900 MNTH$="MARCH": RETURN
910 MNTH$="APRIL": RETURN
920 MNTH$="MAY": RETURN
930 MNTH$="JUNE": RETURN
940 MNTH$="JULY": RETURN
950 MNTH$="AUGUST": RETURN
960 MNTH$="SEPTEMBER": RETURN
970 MNTH$="OCTOBER": RETURN
980 MNTH$="NOVEMBER": RETURN
990 MNTH$="DECEMBER": RETURN
```

Chapter 5

The Programmable Array Logic (PAL) Option



PAL Functions

Programmable Array Logic chips (PALs) perform pre-programmed logical operations on data inputs. The logical operations PALs can perform may be very simple, but are often highly complex. In the microcomputer realm, PALs may perform functions ranging from data-manipulation aids for fast-Fourier transforms and butterfly sorts to software 'locks' to prevent unauthorized software access.

Sorts

Fast-Fourier transforms and butterfly sorts, for example, require that the bits in a byte of data be reversed. Software algorithms to perform this operation are slow and cumbersome. A PAL could, on the other hand, be programmed to do bit reversals of this kind with much greater speed, and they eliminate the cumbersome software one normally needs for such operations.

Encoding

One use of the PAL enables you to 'scramble' data according to a set of predefined rules. If a PAL is programmed in such a way, whole disks full of data may be translated via PAL logic into an unintelligible form; if the data is fed back through the PAL again, then with proper programming it can be translated back into its original form.

Security

Another important use of the PAL provides your system with a software 'lock-out'. In such applications, machine-code instructions are imbedded in the software to write an eight-bit byte to the PAL and to read the returned byte. If the appropriate byte is not returned, the software 'knows' that the properly programmed PAL is not installed in the computer being used. It can then abort operation to keep important software from being accessed by non-privileged systems.

Custom Programs

For the user who lacks the resources necessary for PAL programming, a limited service is offered by Tecmar to provide custom-programmed software lock-out PALs. You specify a 'key number' and a 'response number', and Tecmar will program your PAL so that when the key number you selected is written to PAL, the PAL will always return your selected response number.

The user who wishes to custom-program his PAL must have: (1) a thorough understanding of PAL logic, and (2) a properly equiped PROM programmer. Refer to the **PAL Programmable Array Logic Handbook** (Monolothic Memories, 1981) for complete information on PAL programming.

Appendixes

Appendix A

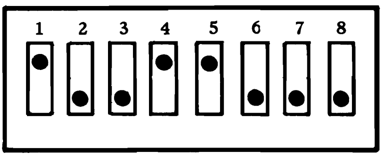
Switches and Jumpers

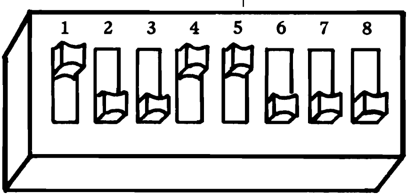
Switch Modules

Many types of switch modules may be found on system boards or adapter boards. Three different types are shown below in the drawings labeled Slide, Rocker, or Toggle Switch Module.

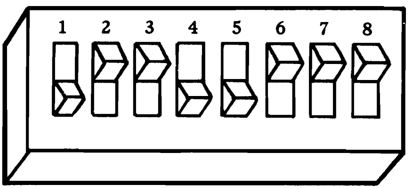
In these examples switches one, four, and five are ON, while the rest are OFF.

The top drawing with the black dots inside the rectangles shows the way switch settings are depicted throughout this manual.

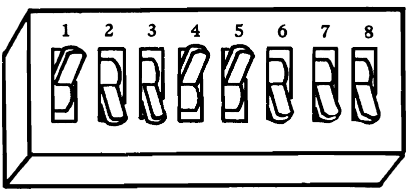




Slide Switch Module



Rocker Switch Module



Toggle Switch Module

You set the switch modules by depressing one side of the designated rocker switch or by pushing a slide or toggle switch towards one side of the switch module with a ballpoint pen or small screwdriver. Do not use a pencil.

A switch set OFF is depressed or moved towards the bottom of the switch module, and a switch set ON is depressed or moved towards the top of the switch module.

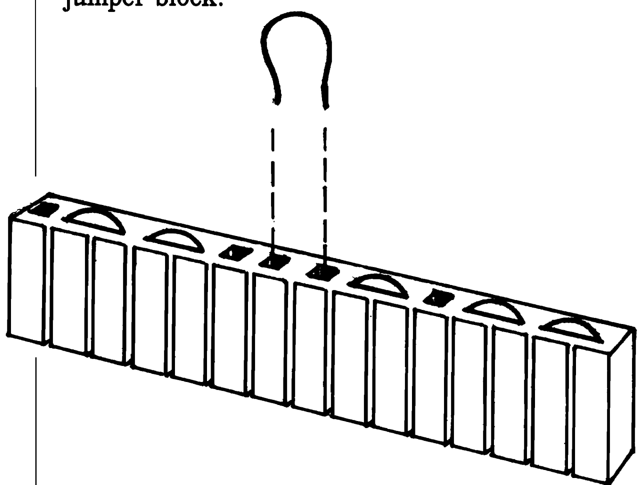
Note: When a switch is OPEN, it is turned OFF. When it is CLOSED, it is ON. Labels vary from one switch module to another. Some have only the word ON, while others have only the word OPEN.

Labels such as SW1, SW2, etc. or S1, S2, etc. are generally used on system or adapter boards to identify switch modules.

Jumper Blocks

There are various types of jumper blocks. The types pictured here are often found on Tecmar boards.

One kind of jumper block is a plastic rectangle with small holes on the top surface. Positions in this type of jumper block are connected by placing a U-shaped wire in two adjacent holes. The two holes represent one position of the jumper block.

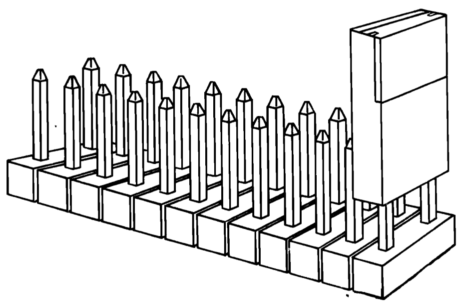


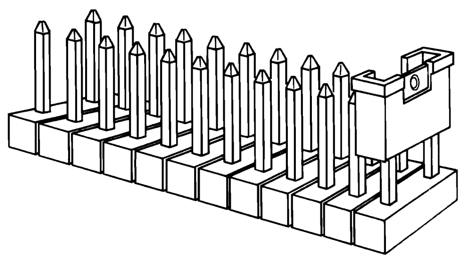
To disconnect a position on the jumper block, remove the piece of wire with a pair of needle-nose pliers.

When the U-shaped wire is in place, a connection has been made and the position is jumpered.

Another type of jumper block is a plastic block with wire pins protruding from its top surface. Positions are connected by placing a plastic cap over two adjacent pins. The two pins represent one position on the jumper block.

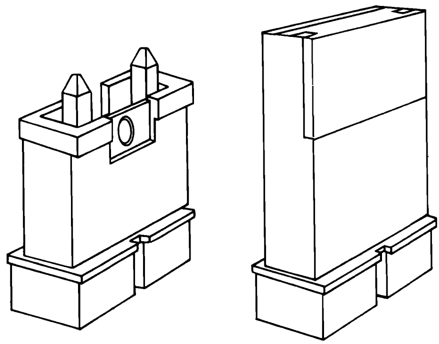
This type is shown below with two different styles of plastic caps.



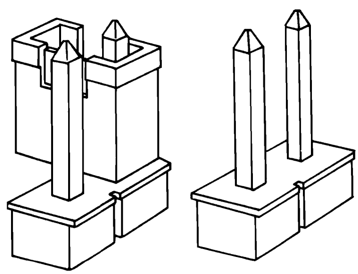


To disconnect a position, remove the plastic cap by hand or with a pair of tweezers or needle-nose pliers.

When the U-shaped wire or plastic cap is in place, a connection has been made and that position is jumpered.



Jumpered



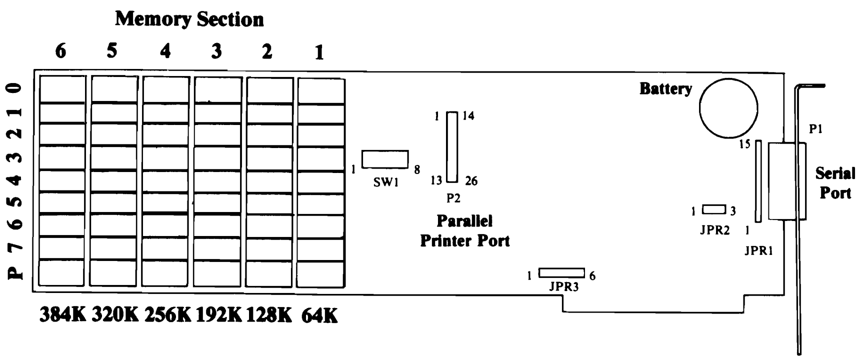
Not Jumpered

Appendix B

Adding Memory to Captain

There are four rows or sections on your board where RAM chips may be installed for memory expansion. When a section is filled with nine chips (eight RAM chips and one chip for parity) then 64K of memory has been installed.

The RAM chips must be installed in specified sections on the Captain board. These rows and the order in which they should be filled are shown below.



When adding memory, insert the modules so that Pin 1 of each module is in the lower left hand corner of the socket. There is always a mark on every chip to indicate which end Pin 1 is on. This mark is usually a notch or a small depression on the top of the plastic case. Do not assume that the printing on the top of the module will orient it correctly.

Appendix C

Specifications

Slots	One slot in IBM PC, XT, IBM Portable, or Tecmar Expansion Chassis.
I/O Address	Fixed at IBM serial and IBM parallel printer I/O locations. (COM1, or COM2, LPT1 or LPT2)
Clock/ Calendar Address	Jumper-selectable to 37D Hex or 27D Hex.
Load	1 TTL load/bus line max
PAL IC	PAL16R8
RAM IC:	Intel 4164 or equivalent
Battery Life	Approximately one year (Not user replacable)
Baud:	(Serial Port) 50-19,200
Power	(with 256K) 1.6 @ +5V max 25mA @ −12V max 25mA @ +12V max

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Product Comment Form

Captain

Your comments are a vital tool in assisting us in our efforts to continue the improvement of PC-Mate products and the accompanying manuals.

Suggestions may be used or distributed by Tecmar in any form it believes appropriate without any obligation whatever. This does not limit your use of the information that you originate and supply to Tecmar.

Comments:

Name ______________________________

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