The PC Parallel Ports — Chapter 21

The original IBM PC design provided support for three parallel printer ports that IBM designated LPT1:, LPT2:, and LPT3:[1]. IBM probably envisioned machines that could support a standard dot matrix printer, a daisy wheel printer, and maybe some other auxiliary type of printer for different purposes, all on the same machine (laser printers were still a few years in the future at that time). Surely IBM did not anticipate the general use that parallel ports have received or they would probably have designed them differently. Today, the PC's parallel port controls keyboards, disk drives, tape drives, SCSI adapters, ethernet (and other network) adapters, joystick adapters, auxiliary keypad devices, other miscellaneous devices, and, oh yes, printers. This chapter will not attempt to describe how to use the parallel port for all these various purposes – this book is long enough already. However, a thorough discussion of how the parallel interface controls a printer and one other application of the parallel port (cross machine communication) should provide you with enough ideas to implement the next great parallel device.

21.1 Basic Parallel Port Information

There are two basic data transmission methods modern computes employ: parallel data transmission and serial data transmission. In a serial data transmission scheme (see "The PC Serial Ports" on page 1223) one device sends data to another a single bit at a time across one wire. In a parallel transmission scheme, one device sends data to another several bits at a time (in parallel) on several different wires. For example, the PC's parallel port provides eight data lines compared to the serial port's single data line. Therefore, it would seem that the parallel port would be able to transmit data eight times as fast since there are eight times as many wires in the cable. Likewise, it would seem that a serial cable, for the same price as a parallel cable, would be able to go eight times as far since there are fewer wires in the cable. And these are the common trade-offs typically given for parallel vs. serial communication methods: speed vs. cost.

In practice, parallel communications is not eight times faster than serial communications, nor do parallel cables cost eight times as much. In generally, those who design serial cables (.e.g, ethernet cables) use higher materials and shielding. This raises the cost of the cable, but allows devices to transmit data, still a bit at a time, much faster. Furthermore, the better cable design allows greater distances between devices. Parallel cables, on the other hand, are generally quite inexpensive and designed for very short connections (generally no more than about six to ten feet). The real world problems of electrical noise and cross-talk create problems when using long parallel cables and limit how fast the system can transmit data. In fact the original Centronics printer port specification called for no more than 1,000 characters/second data transmission rate, so many printers were designed to handle data at this transmission rate. Most parallel ports can easily outperform this value; however, the limiting factor is still the cable, not any intrinsic limitation in a modern computer.

Although a parallel communication system could use any number of wires to transmit data, most parallel systems use eight data lines to transmit a byte at a time. There are a few notable exceptions. For example, the SCSI interface is a parallel interface, yet newer versions of the SCSI standard allow eight, sixteen, and even thirty-two bit data transfers. In this chapter we will concentrate on byte-sized transfers since the parallel port on the PC provides for eight-bit data.

A typical parallel communication system can be one way (or *unidirectional*) or two way (*bidirectional*). The PC's parallel port generally supports unidirectional communications (from the PC to the printer), so we will consider this simpler case first.

In a unidirectional parallel communication system there are two distinguished sites: the transmitting site and the receiving site. The transmitting site places its data on the data lines and informs the receiving site that data is available; the receiving site then reads the data lines and informs the transmitting site that it

1. In theory, the BIOS allows for a fourth parallel printer port, LPT4:, but few (if any) adapter cards have ever been built that claim to work as LPT4:.

has taken the data. Note how the two sites synchronize their access to the data lines – the receiving site does not read the data lines until the transmitting site tells it to, the transmitting site does not place a new value on the data lines until the receiving site removes the data and tells the transmitting site that it has the data. *Handshaking* is the term that describes how these two sites coordinate the data transfer.

To properly implement handshaking requires two additional lines. The *strobe* (or data strobe) line is what the transmitting site uses to tell the receiving site that data is available. The *acknowledge* line is what the receiving site uses to tell the transmitting site that it has taken the data and is ready for more. The PC's parallel port actually provides a third handshaking line, *busy*, that the receiving site can use to tell the transmitting site that it is busy and the transmitting site should not attempt to send data. A typical data transmission session looks something like the following:

Transmitting site:

1) The transmitting site checks the busy line to see if the receiving is busy. If the busy line is active, the transmitter waits in a loop until the busy line becomes inactive.
2) The transmitting site places its data on the data lines.
3) The transmitting site activates the strobe line.
4) The transmitting site waits in a loop for the acknowledge line to become active.
5) The transmitting site sets the strobe inactive.
6) The transmitting site waits in a loop for the acknowledge line to become inactive.
7) The transmitting site repeats steps one through six for each byte it must transmit.

Receiving site:

1) The receiving site sets the busy line inactive (assuming it is ready to accept data).
2) The receiving site waits in a loop until the strobe line becomes active.
3) The receiving site reads the data from the data lines (and processes the data, if necessary).
4) The receiving site activates the acknowledge line.
5) The receiving site waits in a loop until the strobe line goes inactive.
6) The receiving site sets the acknowledge line inactive.
7) The receiving site repeats steps one through six for each additional byte it must receive.

By carefully following these steps, the receiving and transmitting sites carefully coordinate their actions so the transmitting site doesn't attempt to put several bytes on the data lines before the receiving site consumes them and the receiving site doesn't attempt to read data that the transmitting site has not sent.

Bidirectional data transmission is often nothing more than two unidirectional data transfers with the roles of the transmitting and receiving sites reversed for the second communication channel. Some PC parallel ports (particularly on PS/2 systems and many notebooks) provide a bidirectional parallel port. Bidirectional data transmission on such hardware is slightly more complex than on systems that implement bidirectional communication with two unidirectional ports. Bidirectional communication on a bidirectional parallel port requires an extra set of control lines so the two sites can determine who is writing to the common data lines at any one time.

21.2 The Parallel Port Hardware

The standard unidirectional parallel port on the PC provides more than the 11 lines described in the previous section (eight data, three handshake). The PC's parallel port provides the following signals:

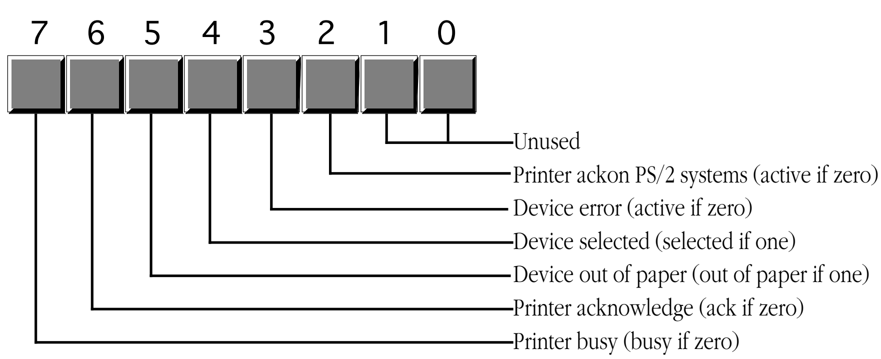
Table 79: Parallel Port Signals

Pin Number on Connector	I/O Direction	Active Polarity	Signal Description
1	output	0	Strobe (data available signal).
2-9	output	-	Data lines (bit 0 is pin 2, bit 7 is pin 9).
10	input	0	Acknowledge line (active when remote system has taken data).
11	input	0	Busy line (when active, remote system is busy and cannot accept data).
12	input	1	Out of paper (when active, printer is out of paper).
13	input	1	Select. When active, the printer is selected.
14	output	0	Autofeed. When active, the printer automatically inserts a line feed after every carriage return it receives.
15	input	0	Error. When active, there is a printer error.
16	output	0	Init. When held active for at least 50 μsec, this signal causes the printer to initialize itself.
17	output	0	Select input. This signal, when inactive, forces the printer off-line
18-25	-	-	Signal ground.

Note that the parallel port provides 12 output lines (eight data lines, strobe, autofeed, init, and select input) and five input lines (acknowledge, busy, out of paper, select, and error). Even though the port is unidirectional, there is a good mixture of input and output lines available on the port. Many devices (like disk and tape drives) that require bidirectional data transfer use these extra lines to perform bidirectional data transfer.

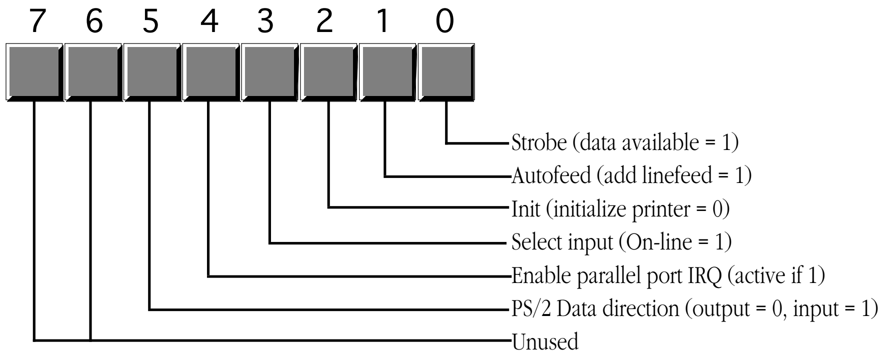
On bidirectional parallel ports (found on PS/2 and laptop systems), the strobe and data lines are both input and output lines. There is a bit in a control register associated with the parallel port that selects the transfer direction at any one given instant (you cannot transfer data in both direction simultaneously).

There are three I/O addresses associated with a typical PC compatible parallel port. These addresses belong to the *data register, the status register,* and *the control register*. The data register is an eight-bit read/write port. Reading the data register (in a unidirectional mode) returns the value last written to the data register. The control and status registers provide the interface to the other I/O lines. The organization of these ports is as follows:



Parallel Port Status Register (read only)

Bit two (printer acknowledge) is available only on PS/2 and other systems that support a bidirectional printer port. Other systems do not use this bit.



Parallel Port Control Register

The parallel port control register is an output register. Reading this location returns the last value written to the control register *except for bit five* that is write only. Bit five, the data direction bit, is available only on PS/2 and other systems that support a bidirectional parallel port. If you write a zero to this bit, the strobe and data lines are output bits, just like on the unidirectional parallel port. If you write a one to this bit, then the data and strobe lines are inputs. Note that in the input mode (bit 5 = 1), bit zero of the control register is actually an input. Note: writing a one to bit four of the control register enables the printer IRQ (IRQ 7). However, this feature does not work on all systems so very few programs attempt to use interrupts with the parallel port. When active, the parallel port will generate an int 0Fh whenever the printer acknowledges a data transmission.

Since the PC supports up to three separate parallel ports, there could be as many as three sets of these parallel port registers in the system at any one time. There are three *parallel port base addresses* associated with the three possible parallel ports: 3BCh, 378h, and 278h. We will refer to these as the base addresses for LPT1:, LPT2:, and LPT3:, respectively. The parallel port data register is always located at the base address for a parallel port, the status register appears at the base address plus one, and the control register appears at the base address plus two. For example, for LPT1:, the data register is at I/O address 3BCh, the status register is at I/O address 3BDh, and the control register is at I/O address 3BEh.

There is one minor glitch. The I/O addresses for LPT1:, LPT2:, and LPT3: given above are the *physical addresses* for the parallel ports. The BIOS provides *logical addresses* for these parallel ports as well. This lets users remap their printers (since most software only writes to LPT1:). To accomplish this, the BIOS reserves eight bytes in the BIOS variable space (40:8, 40:0A, 40:0C, and 40:0E). Location 40:8 contains the base address for logical LPT1:, location 40:0A contains the base address for logical LPT2:, etc. When software accesses LPT1:, LPT2:, etc., it generally accesses the parallel port whose base address appears in one of these locations.

21.3 Controlling a Printer Through the Parallel Port

Although there are many devices that connect to the PC's parallel port, printers still make up the vast number of such connections. Therefore, describing how to control a printer from the PC's parallel port is probably the best first example to present. As with the keyboard, your software can operate at three different levels: it can print data using DOS, using BIOS, or by writing directly to the parallel port hardware. As with the keyboard interface, using DOS or BIOS is the best approach if you want to maintain compatibility with other devices that plug into the parallel port[2]. Of course, if you are controlling some other type of

2. Many devices connect to the parallel port with a pass-through plug allowing you to use that device and still use the parallel port for your printer. However, if you talk directly to the parallel port with your software, it may conflict with that device's operation.

device, going directly to the hardware is your only choice. However, the BIOS provides good printer support, so going directly to the hardware is rarely necessary if you simply want to send data to the printer.

21.3.1 Printing via DOS

MS-DOS provides two calls you can use to send data to the printer. DOS function 05h writes the character in the dl register directly to the printer. Function 40h, with a file handle of 04h, also sends data to the printer. Since the chapter on DOS and BIOS fully describes these functions, we will not discuss them any further here. For more information, see "MS-DOS, PC-BIOS, and File I/O" on page 699 .

21.3.2 Printing via BIOS

Although DOS provides a reasonable set of functions to send characters to the printer, it does not provide functions to let you initialize the printer or obtain the current printer status. Furthermore, DOS only prints to LPT1:. The PC's int 17h BIOS routine provides three functions, print, initialize, and status. You can apply these functions to any supported parallel port on the system. The print function is roughly equivalent to DOS' print character function. The initialize function initializes the printer using system dependent timing information. The printer status returns the information from the printer status port along with time-out information. For more information on these routines, see "MS-DOS, PC-BIOS, and File I/O" on page 699.

21.3.3 An INT 17h Interrupt Service Routine

Perhaps the best way to see how the BIOS functions operate is to write a replacement int 17h ISR for a printer. This section explains the handshaking protocol and variables the printer driver uses. It also describes the operation and return results associated with each machine.

There are eight variables in the BIOS variable space (segment 40h) the printer driver uses. The following table describes each of these variables:

Table 80: BIOS Parallel Port Variables

Address	Description
40:08	Base address of LPT1: device.
40:0A	Base address of LPT2: device.
40:0C	Base address of LPT3: device.
40:0E	Base address of LPT4: device.
40:78	LPT1: time-out value. The printer port driver software should return an error if the printer device does not respond in a reasonable amount of time. This variable (if non-zero) determines how many loops of 65,536 iterations each a driver will wait for a printer acknowledge. If zero, the driver will wait forever.
40:79	LPT2: time-out value. See description above.
40:7A	LPT3: time-out value. See description above.
40:7B	LPT4: time-out value. See description above.

You will notice a slight deviation in the handshake protocol in the following code. This printer driver does not wait for an acknowledge from the printer *after* sending a character. Instead, it checks to see if the printer has sent an acknowledge to the previous character *before* sending a character. This saves a small amount of time because the program printer then characters can continue to operating in parallel with the receipt of the acknowledge from the printer. You will also notice that this particular driver does not monitor the busy lines. Almost every printer in existence leaves this line inactive (not busy), so there is no need to check it. If you encounter a printer than does manipulate the busy line, the modification to this code is trivial. The following code implements the int 17h service:

```
; INT17.ASM
;
; A short passive TSR that replaces the BIOS' int 17h handler.
; This routine demonstrates the function of each of the int 17h
; functions that a standard BIOS would provide.
;
; Note that this code does not patch into int 2Fh (multiplex interrupt)
; nor can you remove this code from memory except by rebooting.
; If you want to be able to do these two things (as well as check for
; a previous installation), see the chapter on resident programs. Such
; code was omitted from this program because of length constraints.
;
;
; cseg and EndResident must occur before the standard library segments!

cseg           segment    para public 'code'
cseg           ends

; Marker segment, to find the end of the resident section.

EndResident    segment    para public 'Resident'
EndResident    ends

               .xlist
               include    stdlib.a
               includelib stdlib.lib
               .list


byp            equ        <byte ptr>

cseg           segment    para public 'code'
               assume     cs:cseg, ds:cseg

OldInt17       dword      ?


; BIOS variables:

PrtrBase       equ        8
PrtrTimeOut    equ        78h




; This code handles the INT 17H operation. INT 17H is the BIOS routine
; to send data to the printer and report on the printer's status. There
; are three different calls to this routine, depending on the contents
; of the AH register. The DX register contains the printer port number.
;
; DX=0 -- Use LPT1:
; DX=1 -- Use LPT2:
; DX=2 -- Use LPT3:
; DX=3 -- Use LPT4:
;
; AH=0 --      Print the character in AL to the printer. Printer status is
;              returned in AH. If bit #0 = 1 then a timeout error occurred.
;
; AH=1 --      Initialize printer. Status is returned in AH.
;
; AH=2 --      Return printer status in AH.
;
;
; The status bits returned in AH are as follows:
;
```

```
; Bit    Function                      Non-error values
; ---    -------------------------     ----------------
;  0     1=time out error                 0
;  1     unused                           x
;  2     unused                           x
;  3     1=I/O error                      0
;  4     1=selected, 0=deselected.        1
;  5     1=out of paper                   0
;  6     1=acknowledge                    x
;  7     1=not busy                       x
;
; Note that the hardware returns bit 3 with zero if an error has occurred,
; with one if there is no error. The software normally inverts this bit
; before returning it to the caller.
;
;
; Printer port hardware locations:
;
; There are three ports used by the printer hardware:
;
; PrtrPortAdrs ---       Output port where data is sent to printer (8 bits).
; PrtrPortAdrs+1 ---     Input port where printer status can be read (8 bits).
; PrtrPortAdrs+2 ---     Output port where control information is sent to the
;                        printer.
;
; Data output port- 8-bit data is transmitted to the printer via this port.
;
; Input status port:
;            bit 0:     unused.
;            bit 1:     unused.
;            bit 2:     unused.
;
;            bit 3:     -Error, normally this bit means that the
;                       printer has encountered an error. However,
;                       with the P101 installed this is a data
;                       return line for the keyboard scan.
;
;            bit 4:     +SLCT, normally this bit is used to determine
;                       if the printer is selected or not. With the
;                       P101 installed this is a data return
;                       line for the keyboard scan.
;
;            bit 5:     +PE, a 1 in this bit location means that the
;                       printer has detected the end of paper. On
;                       many printer ports, this bit has been found
;                       to be inoperative.
;
;            bit 6:     -ACK, A zero in this bit position means that
;                       the printer has accepted the last character
;                       and is ready to accept another. This bit
;                       is not normally used by the BIOS as bit 7
;                       also provides this function (and more).
;
;            bit 7:     -Busy, When this signal is active (0) the
;                       printer is busy and cannot accept data.
;                       When this bit is set to one, the printer
;                       can accept another character.
;
;
;
; Output control port:
;
;            Bit 0:     +Strobe, A 0.5 us (minimum) active high pulse
;                       on this bit clocks the data latched into the
;                       printer data output port to the printer.
;
;            Bit 1:     +Auto FD XT - A 1 stored at this bit causes
;                       the printer to line feed after a line is
;                       printed. On some printer interfaces (e.g.,
;                       the Hercules Graphics Card) this bit is
;                       inoperative.
;
;            Bit 2:     -INIT, a zero on this bit (for a minimum of
;                       50 us) will cause the printer to (re)init-
```

```
;                       ialize itself.
;
;               Bit 3:  +SLCT IN, a one in this bit selects the
;                       printer. A zero will cause the printer to
;                       go off-line.
;
;               Bit 4:  +IRQ ENABLE, a one in this bit position
;                       allows an interrupt to occur when -ACK
;                       changes from one to zero.
;
;               Bit 5:  Direction control on BI-DIR port. 0=output,
;                       1=input.
;               Bit 6:  reserved, must be zero.
;               Bit 7:  reserved, must be zero.

MyInt17         proc    far
                assume  ds:nothing

                push    ds
                push    bx
                push    cx
                push    dx

                mov     bx, 40h                 ;Point DS at BIOS vars.
                mov     ds, bx

                cmp     dx, 3                   ;Must be LPT1..LPT4.
                ja      InvalidPrtr

                cmp     ah, 0                   ;Branch to the appropriate code for
                jz      PrtChar                 ; the printer function
                cmp     ah, 2
                jb      PrtrInit
                je      PrtrStatus

; If they passed us an opcode we don't know about, just return.

InvalidPrtr:    jmp     ISR17Done



; Initialize the printer by pulsing the init line for at least 50 us.
; The delay loop below will delay well beyond 50 usec even on the fastest
; machines.

PrtrInit:       mov     bx, dx                  ;Get printer port value.
                shl     bx, 1                   ;Convert to byte index.
                mov     dx, PrtrBase[bx]        ;Get printer base address.
                test    dx, dx                  ;Does this printer exist?
                je      InvalidPrtr             ;Quit if no such printer.
                add     dx, 2                   ;Point dx at control reg.
                in      al, dx                  ;Read current status.
                and     al, 11011011b           ;Clear INIT/BIDIR bits.
                out     dx, al                  ;Reset printer.
                mov     cx, 0                   ;This will produce at least
PIDelay:        loop    PIDelay                 ; a 50 usec delay.
                or      al, 100b                ;Stop resetting printer.
                out     dx, al
                jmp     ISR17Done


; Return the current printer status. This code reads the printer status
; port and formats the bits for return to the calling code.

PrtrStatus:     mov     bx, dx                  ;Get printer port value.
                shl     bx, 1                   ;Convert to byte index.
                mov     dx, PrtrBase[bx]        ;Base address of printer port.
                mov     al, 00101001b           ;Dflt: every possible error.
                test    dx, dx                  ;Does this printer exist?
                je      InvalidPrtr             ;Quit if no such printer.
                inc     dx                      ;Point at status port.
                in      al, dx                  ;Read status port.
                and     al, 11111000b           ;Clear unused/timeout bits.
                jmp     ISR17Done
```

```
; Print the character in the accumulator!

PrtChar:        mov       bx, dx
                mov       cl, PrtrTimeOut[bx] ;Get time out value.
                shl       bx, 1             ;Convert to byte index.
                mov       dx, PrtrBase[bx]  ;Get Printer port address
                or        dx, dx            ;Non-nil pointer?
                jz        NoPrtr2           ; Branch if a nil ptr

; The following code checks to see if an acknowlege was received from
; the printer. If this code waits too long, a time-out error is returned.
; Acknowlege is supplied in bit #7 of the printer status port (which is
; the next address after the printer data port).

                push      ax
                inc       dx                ;Point at status port
                mov       bl, cl            ;Put timeout value in bl
                mov       bh, cl            ; and bh.
WaitLp1:        xor       cx, cx            ;Init count to 65536.
WaitLp2:        in        al, dx            ;Read status port
                mov       ah, al            ;Save status for now.
                test      al, 80h           ;Printer acknowledge?
                jnz       GotAck            ;Branch if acknowledge.
                loop      WaitLp2           ;Repeat 65536 times.
                dec       bl                ;Decrement time out value.
                jnz       WaitLp1           ;Repeat 65536*TimeOut times.

; See if the user has selected no timeout:

                cmp       bh, 0
                je        WaitLp1

; TIMEOUT ERROR HAS OCCURRED!
;
; A timeout - I/O error is returned to the system at this point.
; Either we fall through to this point from above (time out error) or
; the referenced printer port doesn't exist. In any case, return an error.

NoPrtr2:        or        ah, 9             ;Set timeout-I/O error flags
                and       ah, 0F9h          ;Turn off unused flags.
                xor       ah, 40h           ;Flip busy bit.

; Okay, restore registers and return to caller.

                pop       cx                ;Remove old ax.
                mov       al, cl            ;Restore old al.
                jmp       ISR17Done


; If the printer port exists and we've received an acknowlege, then it's
; okay to transmit data to the printer. That job is handled down here.

GotAck:         mov       cx, 16            ;Short delay if crazy prtr
GALp:           loop      GALp              ; needs hold time after ack.
                pop       ax                ;Get char to output and
                push      ax                ; save again.
                dec       dx                ;Point DX at printer port.
                pushf                       ;Turn off interrupts for now.
                cli
                out       dx, al            ;Output data to the printer.

; The following short delay gives the data time to travel through the
; parallel lines. This makes sure the data arrives at the printer before
; the strobe (the times can vary depending upon the capacitance of the
; parallel cable's lines).

                mov       cx, 16            ;Give data time to settle
DataSettleLp:   loop      DataSettleLp      ; before sending strobe.

; Now that the data has been latched on the printer data output port, a
; strobe must be sent to the printer. The strobe line is connected to
```

```
; bit zero of the control port. Also note that this clears bit 5 of the
; control port. This ensures that the port continues to operate as an
; output port if it is a bidirectional device. This code also clears bits
; six and seven which IBM claims should be left zero.

                inc     dx                  ;Point DX at the printer
                inc     dx                  ; control output port.
                in      al, dx              ;Get current control bits.
                and     al, 01eh            ;Force strobe line to zero and
                out     dx, al              ; make sure it's an output port.


                mov     cx, 16              ;Short delay to allow data
Delay0:         loop    Delay0              ; to become good.

                or      al, 1               ;Send out the (+) strobe.
                out     dx, al              ;Output (+) strobe to bit 0

                mov     cx, 16              ;Short delay to lengthen strobe
StrobeDelay:    loop    StrobeDelay

                and     al, 0FEh            ;Clear the strobe bit.
                out     dx, al              ;Output to control port.
                popf                        ;Restore interrupts.

                pop     dx                  ;Get old AX value
                mov     al, dl              ;Restore old AL value

ISR17Done:      pop     dx
                pop     cx
                pop     bx
                pop     ds
                iret
MyInt17         endp


Main            proc

                mov     ax, cseg
                mov     ds, ax

                print
                byte    "INT 17h Replacement",cr,lf
                byte    "Installing....",cr,lf,0

; Patch into the INT 17 interrupt vector. Note that the
; statements above have made cseg the current data segment,
; so we can store the old INT 17 value directly into
; the OldInt17 variable.

                cli                         ;Turn off interrupts!
                mov     ax, 0
                mov     es, ax
                mov     ax, es:[17h*4]
                mov     word ptr OldInt17, ax
                mov     ax, es:[17h*4 + 2]
                mov     word ptr OldInt17+2, ax
                mov     es:[17h*4], offset MyInt17
                mov     es:[17h*4+2], cs
                sti                         ;Okay, ints back on.


; We're hooked up, the only thing that remains is to terminate and
; stay resident.

                print
                byte    "Installed.",cr,lf,0

                mov     ah, 62h             ;Get this program's PSP
                int     21h                 ; value.

                mov     dx, EndResident;Compute size of program.
                sub     dx, bx
                mov     ax, 3100h           ;DOS TSR command.
```

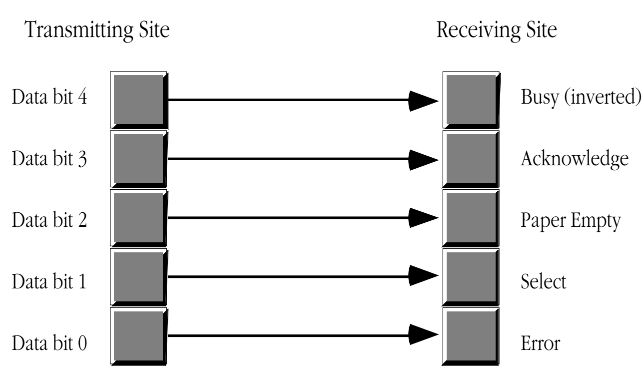
```
                int       21h
Main            endp
cseg            ends

sseg            segment   para stack 'stack'
stk             byte      1024 dup ("stack ")
sseg            ends

zzzzzzseg       segment   para public 'zzzzzz'
LastBytes       byte      16 dup (?)
zzzzzzseg       ends
                end       Main
```

21.4 Inter-Computer Communications on the Parallel Port

Although printing is, by far, the most popular use for the parallel port on a PC, many devices use the parallel port for other purposes, as mentioned earlier. It would not be fitting to close this chapter without at least one example of a non-printer application for the parallel port. This section will describe how to get two computers to transmit files from one to the other across the parallel port.

The Laplink™program from Travelling Software is a good example of a commercial product that can transfer data across the PC's parallel port; although the following software is not as robust or feature laden as Laplink, it does demonstrate the basic principles behind such software.

Note that you cannot connect two computer's parallel ports with a simple cable that has DB25 connectors at each end. In fact, doing so could damage the computers' parallel ports because you'd be connecting digital outputs to digital outputs (a real no-no). However, you purchase "Laplink compatible" cables (or buy *real* Laplink cables for that matter) the provide proper connections between the parallel ports of two computers. As you may recall from the section on the parallel port hardware, the unidirectional parallel port provides five input signals. A Laplink cable routes four of the data lines to four of these input lines in both directions. The connections on a Laplink compatible cable are as follows:



Connections on a Laplink Compatible Cable

Data written on bits zero through three of the data register at the transmitting site appear, unchanged, on bits three through six of the status port on the receiving site. Bit four of the transmitting site appears, inverted, at bit seven of the receiving site. Note that Laplink compatible cables are bidirectional. That is, you can transmit data from either site to the other using the connections above. However, since there are only five input bits on the parallel port, you must transfer the data four bits at a time (we need one bit for the data strobe). Since the receiving site needs to acknowledge data transmissions, we cannot simultaneously transmit data in both directions. We must use one of the output lines at the site receiving data to acknowledge the incoming data.

Since the two sites cooperating in a data transfer across the parallel cable must take turns transmitting and receiving data, we must develop a *protocol* so each participant in the data transfer knows when it is okay to transmit and receive. Our protocol will be very simple – a site is either a transmitter or a receiver, the roles will never switch. Designing a more complex protocol is not difficult, but this simple protocol will suffice for the example you are about to see. Later in this section we will discuss ways to develop a protocol that allows two-way transmissions.

The following example programs will transmit and receive a single file across the parallel port. To use this software, you run the *transmit* program on the transmitting site and the *receive* program on the receiving site. The transmission program fetches a file name from the DOS command line and opens that file for reading (generating an error, and quitting, if the file does not exist). Assuming the file exists, the transmit program then queries the receiving site to see if it is available. The transmitter checks for the presence of the receiving site by alternately writing zeros and ones to all output bits then reading its input bits. The receiving site will invert these values and write them back when it comes on-line. Note that the order of execution (transmitter first or receiver first) does not matter. The two programs will attempt to handshake until the other comes on line.When both sites cycle through the inverting values three times, they write the value 05h to their output ports to tell the other site they are ready to proceed. A time-out function aborts either program if the other site does not respond in a reasonable amount of time.

Once the two sites are synchronized, the transmitting site determines the size of the file and then transmits the file name and size to the receiving site. The receiving site then begins waiting for the receipt of data.

The transmitting site sends the data 512 bytes at a time to the receiving site. After the transmission of 512 bytes, the receiving site delays sending an acknowledgment and writes the 512 bytes of data to the disk. Then the receiving site sends the acknowledge and the transmitting site begins sending the next 512 bytes. This process repeats until the receiving site has accepted all the bytes from the file.

Here is the code for the transmitter:

```
; TRANSMIT.ASM
;
; This program is the transmitter portion of the programs that transmit files
; across a Laplink compatible parallel cable.
;
; This program assumes that the user want to use LPT1: for transmission.
; Adjust the equates, or read the port from the command line if this
; is inappropriate.

              .286
              .xlist
              include    stdlib.a
              includelib stdlib.lib
              .list


dseg          segment    para public 'data'

TimeOutConst  equ        4000              ;About 1 min on 66Mhz 486.
PrtrBase      equ        10                ;Offset to LPT1: adrs.

MyPortAdrs    word       ?                 ;Holds printer port address.
FileHandle    word       ?                 ;Handle for output file.
FileBuffer    byte       512 dup (?)    ;Buffer for incoming data.

FileSize dword ?                        ;Size of incoming file.
FileNamePtr   dword      ?                 ;Holds ptr to filename

dseg          ends

cseg          segment    para public 'code'
              assume     cs:cseg, ds:dseg


; TestAbort-  Check to see if the user has pressed ctrl-C and wants to
;             abort this program. This routine calls BIOS to see if the
```

```
;               user has pressed a key. If so, it calls DOS to read the
;               key (function AH=8, read a key w/o echo and with ctrl-C
;               checking).

TestAbort       proc        near
                push        ax
                push        cx
                push        dx
                mov         ah, 1
                int         16h                 ;See if keypress.
                je          NoKeyPress          ;Return if no keypress.
                mov         ah, 8               ;Read char, chk for ctrl-C.
                int         21h                 ;DOS aborts if ctrl-C.
NoKeyPress:     pop         dx
                pop         cx
                pop         ax
                ret
TestAbort       endp



; SendByte-     Transmit the byte in AL to the receiving site four bits
;               at a time.

SendByte        proc        near
                push        cx
                push        dx
                mov         ah, al              ;Save byte to xmit.

                mov         dx, MyPortAdrs      ;Base address of LPT1: port.

; First, just to be sure, write a zero to bit #4. This reads as a one
; in the busy bit of the receiver.

                mov         al, 0
                out         dx, al              ;Data not ready yet.

; Wait until the receiver is not busy. The receiver will write a zero
; to bit #4 of its data register while it is busy. This comes out as a
; one in our busy bit (bit 7 of the status register). This loop waits
; until the receiver tells us its ready to receive data by writing a
; one to bit #4 (which we read as a zero). Note that we check for a
; ctrl-C every so often in the event the user wants to abort the
; transmission.

                inc         dx                  ;Point at status register.
W4NBLp:         mov         cx, 10000
Wait4NotBusy:   in          al, dx              ;Read status register value.
                test        al, 80h             ;Bit 7 = 1 if busy.
                loopne      Wait4NotBusy        ;Repeat while busy, 10000 times.
                je          ItsNotbusy          ;Leave loop if not busy.
                call        TestAbort           ;Check for Ctrl-C.
                jmp         W4NBLp

; Okay, put the data on the data lines:

ItsNotBusy:     dec         dx                  ;Point at data register.
                mov         al, ah              ;Get a copy of the data.
                and         al, 0Fh             ;Strip out H.O. nibble
                out         dx, al              ;"Prime" data lines, data not avail.
                or          al, 10h             ;Turn data available on.
                out         dx, al              ;Send data w/data available strobe.

; Wait for the acknowledge from the receiving site. Every now and then
; check for a ctrl-C so the user can abort the transmission program from
; within this loop.

                inc         dx              ;Point at status register.
W4ALp:          mov         cx, 10000       ;Times to loop between ctrl-C checks.
Wait4Ack:       in          al, dx          ;Read status port.
                test        al, 80h         ;Ack = 1 when rcvr acknowledges.
                loope       Wait4Ack        ;Repeat 10000 times or until ack.
                jne         GotAck          ;Branch if we got an ack.
                call        TestAbort       ;Every 10000 calls, check for a
```

```
                jmp       W4ALp          ; ctrl-C from the user.

; Send the data not available signal to the receiver:

GotAck:         dec       dx             ;Point at data register.
                mov       al, 0          ;Write a zero to bit 4, this appears
                out       dx, al         ; as a one in the rcvr's busy bit.


; Okay, on to the H.O. nibble:

                inc       dx             ;Point at status register.
W4NB2:          mov       cx, 10000      ;10000 calls between ctrl-C checks.
Wait4NotBsy2:   in        al, dx         ;Read status register.
                test      al, 80h        ;Bit 7 = 1 if busy.
                loopne    Wait4NotBsy2   ;Loop 10000 times while busy.
                je        NotBusy2       ;H.O. bit clear (not busy)?
                call      TestAbort      ;Check for ctrl-C.
                jmp       W4NB2

; Okay, put the data on the data lines:

NotBusy2:       dec       dx             ;Point at data register.
                mov       al, ah         ;Retrieve data to get H.O. nibble.
                shr       al, 4          ;Move H.O. nibble to L.O. nibble.
                out       dx, al         ;"Prime" data lines.
                or        al, 10h        ;Data + data available strobe.
                out       dx, al         ;Send data w/data available strobe.

; Wait for the acknowledge from the receiving site:

                inc       dx             ;Point at status register.
W4A2Lp:         mov       cx, 10000
Wait4Ack2:      in        al, dx         ;Read status port.
                test      al, 80h        ;Ack = 1
                loope     Wait4Ack2      ;While while no acknowledge
                jne       GotAck2        ;H.O. bit = 1 (ack)?
                call      TestAbort      ;Check for ctrl-C
                jmp       W4A2Lp

; Send the data not available signal to the receiver:

GotAck2:        dec       dx             ;Point at data register.
                mov       al, 0          ;Output a zero to bit #4 (that
                out       dx, al         ; becomes busy=1 at rcvr).

                mov       al, ah         ;Restore original data in AL.
                pop       dx
                pop       cx
                ret
SendByte        endp



; Synchronization routines:
;
; Send0s-       Transmits a zero to the receiver site and then waits to
;               see if it gets a set of ones back. Returns carry set if
;               this works, returns carry clear if we do not get a set of
;               ones back in a reasonable amount of time.

Send0s          proc      near
                push      cx
                push      dx

                mov       dx, MyPortAdrs

                mov       al, 0              ;Write the initial zero
                out       dx, al             ; value to our output port.

                xor       cx, cx             ;Checks for ones 10000 times.
Wait41s:        inc       dx                 ;Point at status port.
                in        al, dx             ;Read status port.
                dec       dx                 ;Point back at data port.
```

```
                and         al, 78h             ;Mask input bits.
                cmp         al, 78h             ;All ones yet?
                loopne      Wait41s
                je          Got1s               ;Branch if success.
                clc                             ;Return failure.
                pop         dx
                pop         cx
                ret

Got1s:          stc                             ;Return success.
                pop         dx
                pop         cx
                ret
Send0s          endp


; Send1s-       Transmits all ones to the receiver site and then waits to
;               see if it gets a set of zeros back. Returns carry set if
;               this works, returns carry clear if we do not get a set of
;               zeros back in a reasonable amount of time.

Send1s          proc        near
                push        cx
                push        dx

                mov         dx, MyPortAdrs      ;LPT1: base address.

                mov         al, 0Fh             ;Write the "all ones"
                out         dx, al              ; value to our output port.

                mov         cx, 0
Wait40s:        inc         dx                  ;Point at input port.
                in          al, dx              ;Read the status port.
                dec         dx                  ;Point back at data port.
                and         al, 78h             ;Mask input bits.
                loopne      Wait40s             ;Loop until we get zero back.
                je          Got0s               ;All zeros? If so, branch.
                clc                             ;Return failure.
                pop         dx
                pop         cx
                ret


Got0s:          stc                             ;Return success.
                pop         dx
                pop         cx
                ret
Send1s          endp




; Synchronize-  This procedure slowly writes all zeros and all ones to its
;               output port and checks the input status port to see if the
;               receiver site has synchronized. When the receiver site
;               is synchronized, it will write the value 05h to its output
;               port. So when this site sees the value 05h on its input
;               port, both sites are synchronized. Returns with the
;               carry flag set if this operation is successful, clear if
;               unsuccessful.

Synchronize     proc        near
                print
                byte        "Synchronizing with receiver program"
                byte        cr,lf,0

                mov         dx, MyPortAdrs

                mov         cx, TimeOutConst    ;Time out delay.
SyncLoop:       call        Send0s              ;Send zero bits, wait for
                jc          Got1s               ; ones (carry set=got ones).

; If we didn't get what we wanted, write some ones at this point and see
; if we're out of phase with the receiving site.
```

```
Retry0:         call        Send1s              ;Send ones, wait for zeros.
                jc          SyncLoop            ;Carry set = got zeros.

; Well, we didn't get any response yet, see if the user has pressed ctrl-C
; to abort this program.

DoRetry:        call        TestAbort

; Okay, the receiving site has yet to respond. Go back and try this again.

                loop        SyncLoop

; If we've timed out, print an error message and return with the carry
; flag clear (to denote a timeout error).

                print
                byte        "Transmit: Timeout error waiting for receiver"
                byte        cr,lf,0
                clc
                ret

; Okay, we wrote some zeros and we got some ones. Let's write some ones
; and see if we get some zeros. If not, retry the loop.

Got1s:
                call        Send1s              ;Send one bits, wait for
                jnc         DoRetry             ; zeros (carry set=got zeros).

; Well, we seem to be synchronized. Just to be sure, let's play this out
; one more time.

                call        Send0s              ;Send zeros, wait for ones.
                jnc         Retry0
                call        Send1s              ;Send ones, wait for zeros.
                jnc         DoRetry

; We're syncronized. Let's send out the 05h value to the receiving
; site to let it know everything is cool:

                mov         al, 05h             ;Send signal to receiver to
                out         dx, al              ; tell it we're sync'd.

                xor         cx, cx              ;Long delay to give the rcvr
FinalDelay:     loop        FinalDelay      ; time to prepare.

                print
                byte        "Synchronized with receiving site"
                byte        cr,lf,0
                stc
                ret
Synchronize     endp



; File I/O routines:
;
; GetFileInfo- Opens the user specified file and passes along the file
;              name and file size to the receiving site. Returns the
;              carry flag set if this operation is successful, clear if
;              unsuccessful.

GetFileInfo     proc        near

; Get the filename from the DOS command line:

                mov         ax, 1
                argv
                mov         word ptr FileNamePtr, di
                mov         word ptr FileNamePtr+2, es

                printf
                byte        "Opening %^s\n",0
                dword       FileNamePtr
```

```
; Open the file:

                push        ds
                mov         ax, 3D00h           ;Open for reading.
                lds         dx, FileNamePtr
                int         21h
                pop         ds
                jc          BadFile
                mov         FileHandle, ax

; Compute the size of the file (do this by seeking to the last position
; in the file and using the return position as the file length):

                mov         bx, ax              ;Need handle in BX.
                mov         ax, 4202h           ;Seek to end of file.
                xor         cx, cx              ;Seek to position zero
                xor         dx, dx              ; from the end of file.
                int         21h
                jc          BadFile

; Save final position as file length:

                mov         word ptr FileSize, ax
                mov         word ptr FileSize+2, dx

; Need to rewind file back to the beginning (seek to position zero):

                mov         bx, FileHandle      ;Need handle in BX.
                mov         ax, 4200h           ;Seek to beginning of file.
                xor         cx, cx              ;Seek to position zero
                xor         dx, dx
                int         21h
                jc          BadFile


; Okay, transmit the good stuff over to the receiving site:

                mov         al, byte ptr FileSize           ;Send the file
                call        SendByte                        ; size over.
                mov         al, byte ptr FileSize+1
                call        SendByte
                mov         al, byte ptr FileSize+2
                call        SendByte
                mov         al, byte ptr FileSize+3
                call        SendByte

                les         bx, FileNamePtr                 ;Send the characters
SendName:       mov         al, es:[bx]                     ; in the filename to
                call        SendByte                        ; the receiver until
                inc         bx                              ; we hit a zero byte.
                cmp         al, 0
                jne         SendName
                stc                                         ;Return success.
                ret

BadFile:        print
                byte        "Error transmitting file information:",0
                puti
                putcr
                clc
                ret
GetFileInfo     endp


; GetFileData-This procedure reads the data from the file and transmits
;               it to the receiver a byte at a time.

GetFileData     proc        near
                mov         ah, 3Fh             ;DOS read opcode.
                mov         cx, 512             ;Read 512 bytes at a time.
                mov         bx, FileHandle      ;File to read from.
                lea         dx, FileBuffer      ;Buffer to hold data.
                int         21h                 ;Read the data
```

```
                jc          GFDError            ;Quit if error reading data.

                mov         cx, ax              ;Save # of bytes actually read.
                jcxz        GFDDone             ; quit if at EOF.
                lea         bx, FileBuffer      ;Send the bytes in the file
XmitLoop:       mov         al, [bx]            ; buffer over to the rcvr
                call        SendByte            ; one at a time.
                inc         bx
                loop        XmitLoop
                jmp         GetFileData         ;Read rest of file.

GFDError:       print
                byte        "DOS error #",0
                puti
                print
                byte        " while reading file",cr,lf,0
GFDDone:        ret
GetFileData     endp



; Okay, here's the main program that controls everything.

Main            proc
                mov         ax, dseg
                mov         ds, ax
                meminit


; First, get the address of LPT1: from the BIOS variables area.

                mov         ax, 40h
                mov         es, ax
                mov         ax, es:[PrtrBase]
                mov         MyPortAdrs, ax

; See if we have a filename parameter:

                argc
                cmp         cx, 1
                je          GotName
                print
                byte        "Usage: transmit <filename>",cr,lf,0
                jmp         Quit



GotName:        call        Synchronize         ;Wait for the transmitter program.
                jnc         Quit

                call        GetFileInfo     ;Get file name and size.
                jnc         Quit

                call        GetFileData     ;Get the file's data.

Quit:           ExitPgm                     ;DOS macro to quit program.
Main            endp

cseg            ends

sseg            segment     para stack 'stack'
stk             byte        1024 dup ("stack ")
sseg            ends

zzzzzzseg       segment     para public 'zzzzzz'
LastBytes       byte        16 dup (?)
zzzzzzseg       ends
                end         Main
```

Here is the receiver program that accepts and stores away the data sent by the program above:

```
; RECEIVE.ASM
;
; This program is the receiver portion of the programs that transmit files
; across a Laplink compatible parallel cable.
;
; This program assumes that the user want to use LPT1: for transmission.
; Adjust the equates, or read the port from the command line if this
; is inappropriate.

              .286
              .xlist
              include    stdlib.a
              includelib stdlib.lib
              .list


dseg          segment    para public 'data'

TimeOutConst  equ        100                ;About 1 min on 66Mhz 486.
PrtrBase      equ        8                  ;Offset to LPT1: adrs.

MyPortAdrs    word       ?                  ;Holds printer port address.
FileHandle    word       ?                  ;Handle for output file.
FileBuffer    byte       512 dup (?)        ;Buffer for incoming data.

FileSize      dword      ?                  ;Size of incoming file.
FileName      byte       128 dup (0)        ;Holds filename

dseg          ends

cseg          segment    para public 'code'
              assume     cs:cseg, ds:dseg


; TestAbort-  Reads the keyboard and gives the user the opportunity to
;             hit the ctrl-C key.

TestAbort     proc       near
              push       ax
              mov        ah, 1
              int        16h                ;See if keypress.
              je         NoKeypress
              mov        ah, 8              ;Read char, chk for ctrl-C
              int        21h
NoKeyPress:   pop        ax
              ret
TestAbort     endp



; GetByte-    Reads a single byte from the parallel port (four bits at
;             at time). Returns the byte in AL.

GetByte       proc       near
              push       cx
              push       dx

; Receive the L.O. Nibble.

              mov        dx, MyPortAdrs
              mov        al, 10h            ;Signal not busy.
              out        dx, al

              inc        dx                 ;Point at status port

W4DLp:        mov        cx, 10000
Wait4Data:    in         al, dx             ;See if data available.
              test       al, 80h            ; (bit 7=0 if data available).
              loopne     Wait4Data
              je         DataIsAvail        ;Is data available?
              call       TestAbort          ;If not, check for ctrl-C.
```

```
                jmp         W4DLp

DataIsAvail:    shr         al, 3               ;Save this four bit package
                and         al, 0Fh             ; (This is the L.O. nibble
                mov         ah, al              ; for our byte).

                dec         dx                  ;Point at data register.
                mov         al, 0               ;Signal data taken.
                out         dx, al

                inc         dx                  ;Point at status register.
W4ALp:          mov         cx, 10000
Wait4Ack:       in          al, dx              ;Wait for transmitter to
                test        al, 80h             ; retract data available.
                loope       Wait4Ack            ;Loop until data not avail.
                jne         NextNibble          ;Branch if data not avail.
                call        TestAbort           ;Let user hit ctrl-C.
                jmp         W4ALp

; Receive the H.O. nibble:

NextNibble:     dec         dx                  ;Point at data register.
                mov         al, 10h             ;Signal not busy
                out         dx, al
                inc         dx                  ;Point at status port
W4D2Lp:         mov         cx, 10000
Wait4Data2:     in          al, dx              ;See if data available.
                test        al, 80h             ; (bit 7=0 if data available).
                loopne      Wait4Data2          ;Loop until data available.
                je          DataAvail2          ;Branch if data available.
                call        TestAbort           ;Check for ctrl-C.
                jmp         W4D2Lp

DataAvail2:     shl         al, 1               ;Merge this H.O. nibble
                and         al, 0F0h            ; with the existing L.O.
                or          ah, al              ; nibble.
                dec         dx                  ;Point at data register.
                mov         al, 0               ;Signal data taken.
                out         dx, al

                inc         dx                  ;Point at status register.
W4A2Lp:         mov         cx, 10000
Wait4Ack2:      in          al, dx              ;Wait for transmitter to
                test        al, 80h             ; retract data available.
                loope       Wait4Ack2           ;Wait for data not available.
                jne         ReturnData          ;Branch if ack.
                call        TestAbort           ;Check for ctrl-C
                jmp         W4A2Lp

ReturnData:     mov         al, ah              ;Put data in al.
                pop         dx
                pop         cx
                ret
GetByte         endp



; Synchronize- This procedure waits until it sees all zeros on the input
;               bits we receive from the transmitting site. Once it receives
;               all zeros, it writes all ones to the output port. When
;               all ones come back, it writes all zeros. It repeats this
;               process until the transmitting site writes the value 05h.

Synchronize     proc        near

                print
                byte        "Synchronizing with transmitter program"
                byte        cr,lf,0

                mov         dx, MyPortAdrs
                mov         al, 0               ;Initialize our output port
                out         dx, al              ; to prevent confusion.
                mov         bx, TimeOutConst    ;Time out condition.
```

```
SyncLoop:       mov     cx, 0           ;For time out purposes.
SyncLoop0:      inc     dx              ;Point at input port.
                in      al, dx          ;Read our input bits.
                dec     dx
                and     al, 78h         ;Keep only the data bits.
                cmp     al, 78h         ;Check for all ones.
                je      Got1s           ;Branch if all ones.
                cmp     al, 0           ;See if all zeros.
                loopne  SyncLoop0

; Since we just saw a zero, write all ones to the output port.

                mov     al, 0FFh      ;Write all ones
                out     dx, al

; Now wait for all ones to arrive from the transmitting site.

SyncLoop1:      inc     dx              ;Point at status register.
                in      al, dx          ;Read status port.
                dec     dx              ;Point back at data register.
                and     al, 78h         ;Keep only the data bits.
                cmp     al, 78h         ;Are they all ones?
                loopne  SyncLoop1       ;Repeat while not ones.
                je      Got1s           ;Branch if got ones.

; If we've timed out, check to see if the user has pressed ctrl-C to
; abort.

                call    TestAbort       ;Check for ctrl-C.
                dec     bx              ;See if we've timed out.
                jne     SyncLoop        ;Repeat if time-out.

                print
                byte    "Receive: connection timed out during synchronization"
                byte    cr,lf,0
                clc                     ;Signal time-out.
                ret

; Jump down here once we've seen both a zero and a one. Send the two
; in combinations until we get a 05h from the transmitting site or the
; user presses Ctrl-C.

Got1s:          inc     dx              ;Point at status register.
                in      al, dx          ;Just copy whatever appears
                dec     dx              ; in our input port to the
                shr     al, 3           ; output port until the
                and     al, 0Fh         ; transmitting site sends
                cmp     al, 05h         ; us the value 05h
                je      Synchronized
                not     al              ;Keep inverting what we get
                out     dx, al          ; and send it to xmitter.
                call    TestAbort       ;Check for CTRL-C here.
                jmp     Got1s


; Okay, we're synchronized. Return to the caller.

Synchronized:
                and     al, 0Fh         ;Make sure busy bit is one
                out     dx, al          ; (bit 4=0 for busy=1).
                print
                byte    "Synchronized with transmitting site"
                byte    cr,lf,0
                stc
                ret
Synchronize     endp


; GetFileInfo- The transmitting program sends us the file length and a
;              zero terminated filename. Get that data here.

GetFileInfo     proc    near
                mov     dx, MyPortAdrs
                mov     al, 10h         ;Set busy bit to zero.
```

```
                out       dx, al            ;Tell xmit pgm, we're ready.

; First four bytes contain the filesize:

                call      GetByte
                mov       byte ptr FileSize, al
                call      GetByte
                mov       byte ptr FileSize+1, al
                call      GetByte
                mov       byte ptr FileSize+2, al
                call      GetByte
                mov       byte ptr FileSize+3, al

; The next n bytes (up to a zero terminating byte) contain the filename:

                mov       bx, 0
GetFileName:    call      GetByte
                mov       FileName[bx], al
                call      TestAbort
                inc       bx
                cmp       al, 0
                jne       GetFileName

                ret
GetFileInfo     endp


; GetFileData-  Receives the file data from the transmitting site
;               and writes it to the output file.

GetFileData     proc      near

; First, see if we have more than 512 bytes left to go

                cmp       word ptr FileSize+2, 0           ;If H.O. word is not
                jne       MoreThan512                      ; zero, more than 512.
                cmp       word ptr FileSize, 512           ;If H.O. is zero, just
                jbe       LastBlock                        ; check L.O. word.

; We've got more than 512 bytes left to go in this file, read 512 bytes
; at this point.

MoreThan512:    mov       cx, 512                          ;Receive 512 bytes
                lea       bx, FileBuffer                   ; from the xmitter.
ReadLoop:       call      GetByte                          ;Read a byte.
                mov       [bx], al                         ;Save the byte away.
                inc       bx                               ;Move on to next
                loop      ReadLoop                         ; buffer element.

; Okay, write the data to the file:

                mov       ah, 40h                          ;DOS write opcode.
                mov       bx, FileHandle                   ;Write to this file.
                mov       cx, 512                          ;Write 512 bytes.
                lea       dx, Filebuffer                   ;From this address.
                int       21h
                jc        BadWrite                         ;Quit if error.

; Decrement the file size by 512 bytes:

                sub       word ptr FileSize, 512           ;32-bit subtraction
                sbb       word ptr FileSize, 0             ; of 512.
                jmp       GetFileData

; Process the last block, that contains 1..511 bytes, here.

LastBlock:
                mov       cx, word ptr FileSize            ;Receive the last
                lea       bx, FileBuffer                   ; 1..511 bytes from
ReadLB:         call      GetByte                          ; the transmitter.
                mov       [bx], al
                inc       bx
                loop      ReadLB
```

```
                mov         ah, 40h                         ;Write the last block
                mov         bx, FileHandle                  ; of bytes to the
                mov         cx, word ptr FileSize           ; file.
                lea         dx, Filebuffer
                int         21h
                jnc         Closefile

BadWrite:       print
                byte        "DOS error #",0
                puti
                print
                byte        " while writing data.",cr,lf,0

; Close the file here.

CloseFile:      mov         bx, FileHandle                  ;Close this file.
                mov         ah, 3Eh                         ;DOS close opcode.
                int         21h
                ret
GetFileData     endp



; Here's the main program that gets the whole ball rolling.

Main            proc
                mov         ax, dseg
                mov         ds, ax
                meminit


; First, get the address of LPT1: from the BIOS variables area.

                mov         ax, 40h             ;Point at BIOS variable segment.
                mov         es, ax
                mov         ax, es:[PrtrBase]
                mov         MyPortAdrs, ax

                call        Synchronize         ;Wait for the transmitter program.
                jnc         Quit

                call        GetFileInfo         ;Get file name and size.

                printf
                byte        "Filename: %s\nFile size: %ld\n",0
                dword       Filename, FileSize

                mov         ah, 3Ch             ;Create file.
                mov         cx, 0               ;Standard attributes
                lea         dx, Filename
                int         21h
                jnc         GoodOpen
                print
                byte        "Error opening file",cr,lf,0
                jmp         Quit

GoodOpen:       mov         FileHandle, ax
                call        GetFileData         ;Get the file's data.

Quit:           ExitPgm                         ;DOS macro to quit program.
Main            endp

cseg            ends

sseg            segment     para stack 'stack'
stk             byte        1024 dup ("stack ")
sseg            ends

zzzzzzseg       segment     para public 'zzzzzz'
LastBytes       byte        16 dup (?)
zzzzzzseg       ends
                end         Main
```

21.5 Summary

The PC's parallel port, though originally designed for controlling parallel printers, is a general purpose eight bit output port with several handshaking lines you can use to control many other devices in addition to printers.

In theory, parallel communications should be many times faster than serial communications. In practice, however, real world constraints and economics prevent this from being the case. Nevertheless, you can still connect high performance devices to the PC's parallel port.

The PC's parallel ports come in two varieties: unidirectional and bidirectional. The bidirectional versions are available only on PS/2s, certain laptops, and a few other machines. Whereas the eight data lines are output only on the unidirectional ports, you can program them as inputs or outputs on the bidirectional port. While this bidirectional operation is of little value to a printer, it can improve the performance of other devices that connect to the parallel port, such as disk and tape drives, network adapters, SCSI adapters, and so on.

When the system communicates with some other device over the parallel port, it needs some way to tell that device that data is available on the data lines. Likewise, the devices needs some way to tell the system that it is not busy and it has accepted the data. This requires some additional signals on the parallel port known as handshaking lines. A typical PC parallel port provides three handshaking signals: the data available strobe, the data taken acknowledge signal, and the device busy line. These lines easily control the flow of data between the PC and some external device.

In addition to the handshaking lines, the PC's parallel port provides several other auxiliary I/O lines as well. In total, there are 12 output lines and five input lines on the PC's parallel port. There are three I/O ports in the PC's address space associated with each I/O port. The first of these (at the port's base address) is the data register. This is an eight bit output register on unidirectional ports, it is an input/output register on bidirectional ports. The second register, at the base address plus one, is the status register. The status register is an input port. Five of those bits correspond to the five input lines on the PC's parallel port. The third register (at base address plus two) is the control register. Four of these bits correspond to the additional four output bits on the PC, one of the bits controls the IRQ line on the parallel port, and a sixth bit controls the data direction on the birdirectional ports.

For more information on the parallel port's hardware configuration, see:

- "Basic Parallel Port Information" on page 1199
- "The Parallel Port Hardware" on page 1201

Although many vendors use the parallel port to control lots of different devices, a parallel printer is still the device most often connected to the parallel port. There are three ways application programs commonly send data to the printer: by calling DOS to print a character, by calling BIOS' int 17h ISR to print a character, or by talking directly to the parallel port. You should avoid this last technique because of possible software incompatibilities with other devices that connect to the parallel port. For more information on printing data, including how to write your own int 17h ISR/printer driver, see:

- "Controlling a Printer Through the Parallel Port" on page 1202
- "Printing via DOS" on page 1203
- "Printing via BIOS" on page 1203
- "An INT 17h Interrupt Service Routine" on page 1203

One popular use of the parallel port is to transfer data between two computers; for example, transferring data between a desktop and a laptop machine. To demonstrate how to use the parallel port to control other devices besides printers, this chapter presents a program to transfer data between computers on the unidirectional parallel ports (it also works on bidirectional ports). For all the details, see

- "Inter-Computer Communications on the Parallel Port" on page 1209