



fishcamp engineering

FPCI-DIO - Digital Input/Output Card for PCI bus

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Limited Warranty

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The information covered in this manual is subject to change without notice.

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Chapter 1 - Introduction

1.0 Introduction

The FPCI-DIO card is a parallel digital interface for personal computers supporting the PCI expansion bus. It provides for 96 TTL compatible signal lines which may be configured, in groups of eight, to act as either input or output signals. Interconnection between the user's circuitry and the FPCI-DIO card is via three 50-pin ribbon cable headers on the card. Each of the connectors carries 32 signal lines as well as ground reference and protected +5V power from the computer.

The FPCI-DIO card is compatible with Rev 2.1 of the PCI local bus specification. The PCI implementation supports a +5 Volt only bus interface in a short card form factor. A full 32 bit interface as well as on board FIFOs enables zero wait-state burst mode operation over the bus.

Software control of the FPCI-DIO card is facilitated by a device driver compatible with the various operating systems supported. Currently the MacOS and Windows 95 are the only operating systems supported by fishcamp engineering. Contact fishcamp engineering for information on support for other operating systems.

We have provided as much information as possible about the FPCI-DIO card so that users will never be stymied in their development cycle because of the lack of relevant information. To this end we have provided both schematic diagrams of the hardware logic on the card and software source code listings of interface software shipped with the card. The user is encouraged to examine these documents when more detail is needed on the architecture of the FPCI-DIO card.

2.0 Hardware Installation

The card installation procedure you follow depends upon which model of computer you have. For detailed installation instructions, please refer to the manual that came with your computer. The card may be installed into any 32 bit PCI slot. The FPCI-DIO card operates from +5V only. It does not support the 64 Bit nor +3.3V options in the PCI specification. The edge connector of the FPCI-DIO card is keyed to prevent any installation errors in computers supporting these bus options.

Use a standard 50-Pin ribbon cable header to access the customer I/O signals. Carefully route the ribbon cables through the card's metal bracket and out of the access slot from the computer.

The FPCI-DIO card may be plugged into any PCI slot in the computer. The accompanying software does not assume any particular slot. There are no switches nor jumpers to set on the card.

WARNING When handling the FPCI-DIO card, hold the card by its edges to avoid touching any of the integrated circuits or the connector that plugs into the slot on the main logic board of your computer. Make sure the power to the computer is off before installation.

2.1 Software Installation

The various software drivers for the FPCI-DIO card are documented in the appendices of this manual. Since each computer platform supported by the FPCI-DIO card will have a unique software installation procedure, the reader should refer to the appendix of interest. Appendix A documents the installation of the FPCI-DIO software driver for the MacOS. Windows95 software installation is documented in Appendix B.

2.2 Checkout

This section describes the 'FPCI-DIO Check' program included on the distribution disks. This program is used to verify the correct operation of the FPCI-DIO card in the computer. It also checks for the proper installation of the required software for the card. It should be run after installing both the FPCI-DIO card itself and the software driver for the card.

The operation of the 'FPCI-DIO Check' program is identical on each platform supported and thus is documented here without reference to any particular computer platform's specifics. Run the application by double-clicking on the program's icon. The 'FPCI-DIO Check' program's icon looks like:



FPCI-DIO Check

Figure 1 - FPCI-DIO Check program icon.

The program will perform a test while launching in order to determine if the software for the card has been properly loaded. If various software files are not found, the program will display an error message informing the user of the problem. If there is a problem in this area the program will then terminate. The reader should refer to the appendix detailing the software installation for the particular platform being used if this error occurs.

If the software is properly installed, after the program starts, you will see the following window displayed on the computer's screen:

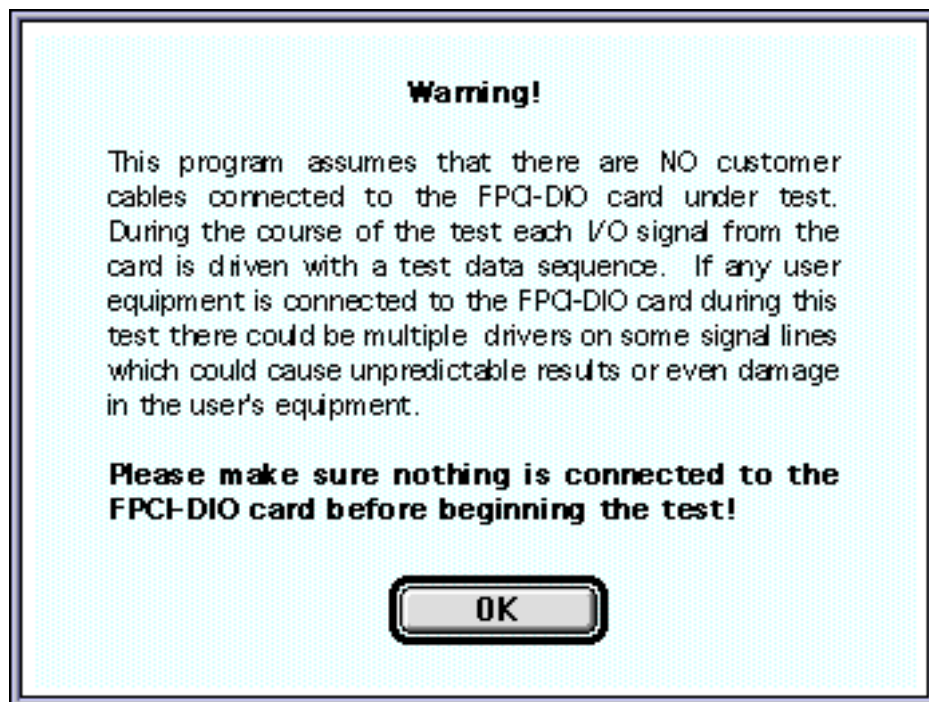


Figure 2 - FPCI-DIO Check Program Warning.

This message reminds the user that the test program will periodically drive the I/O signal lines on the card during the performance of its test routines. Because of this the user should make sure that nothing is connected to the I/O ports on the card before running this test.

The user should click the 'OK' button to dismiss the warning message's window. Afterwards, the program will display the main test window. This window will look as shown in figure 3.

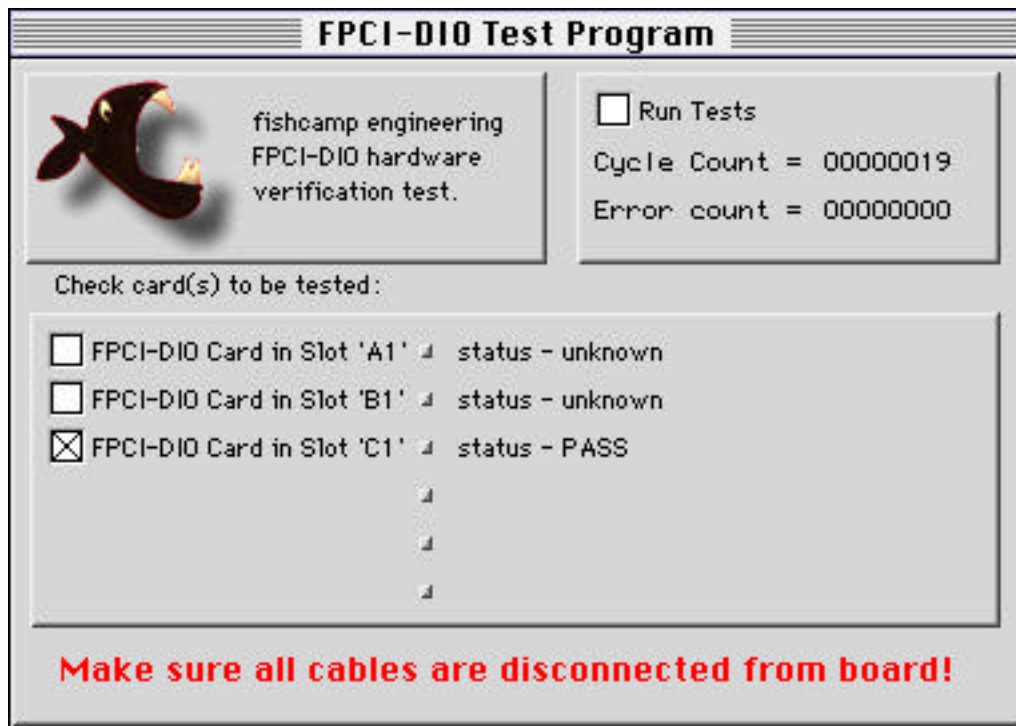


Figure 3 - FPCI-DIO Check Program Main Window

Displayed in the center of the main program's window, will be displayed a status line for each FPCI-DIO card detected in the computer. The number of the slot for each card will be displayed as well as the status of any test run on the particular card. On the beginning of each card's status line is displayed a check box which will allow you to select that particular card to be tested. Check the box by clicking the mouse cursor within the box. Multiple cards may be selected before beginning the test.

After you have selected the desired card(s) to test, you must check the 'Run Tests' check box in the upper right hand corner of the window. The program will then begin cycling through all of its test routines for each card selected. Also in the upper right of the window are two status lines. One line will display the total number of times the program has cycled through one complete set of tests for each board selected. The other line, labeled as 'Error count' will display the total number of errors detected since the test was begun. This count is a summary of all errors found on any of the boards currently being tested.

The status line for the individual cards themselves will show any error relating to the particular card in question. If no errors are detected for a particular card, then its status line will show a 'status- PASS' message. Any other errors detected on the card will be displayed with a unique error description for the particular error detected. If multiple errors were detected on a card, then only the first error will be displayed.

During the course of running the test, the FPCI-DIO Check program will detect problems of a hardware nature only. If any errors are detected, the card will have to be returned to fishcamp facilities for replacement or repair. There are no user reparable components on the card.

3.0 Overview

The FPCI-DIO card's logic is implemented on a 7" long PCI card. This 'half-length' card should be capable of being used in any of the computer platforms which support the PCI interface. Only +5 volt power is required by the card. The card is not compatible with the +3.3 volt subset of the PCI specification. It supports 32 bit transfers over the PCI bus as well as a full 32 bit data path to the customer I/O ports on the card.

Three memory spaces are mapped from the card into the memory space of the host computer via the PCI base address registers on the FPCI-DIO card. The first memory space is mapped to respond to either memory or I/O accesses and contains all of the PCI bus related configuration registers on the card. The second memory space contains the I/O port registers and the port configuration register of the user I/O ports on the FPCI-DIO card. The I/O port registers correspond to the I/O signal lines accessible via the user I/O connectors. Simple memory READ and WRITE operations provide the mechanism by which data is transferred between the host computer and the I/O ports. The third memory space is allocated to give the host CPU access to the Expansion ROM on the card. All data paths on the card are a full 32 bits wide with the exception of the Expansion ROM. Access to the ROM is performed via an 8 bit data path.

The I/O signals from the card are made available to the user via three 50-pin ribbon cable headers. They are referenced in the software as 'port0', 'port1', and 'port2'. The connectors are labeled 'PORT 0', 'PORT 1' and 'PORT 2' on the silkscreen on the printed circuit card. Each port/connector carries 32 of the 96 signals supported by the FPCI-DIO card. Along with the 32 I/O signals are included 17 ground connections and protected +5v power from the host computer.

The +5v power can be used to power custom circuitry in the user's interface provided that the limit of the computer's power supply is not exceeded. Each model of computer has its own power specification and the user should consult the documentation for the particular model being used. In any case, the +5v power lines made available to the user are protected with a single 1 Amp resettable fuse in order to protect the computer incase of power shorts in the user's equipment. Therefore, maximum combined current draw from all three customer I/O ports should be limited to 1Amp.

The resettable fuse used to protect the +5 volt customer power lines will latch into its high impedance mode when tripped. It will remain in this mode once tripped. To reset the fuse, the user will need to power off the computer for a short while and correct the fault condition before re-applying power. The protector requires no manual resetting or replacement.

A total of seventeen ground connections are provided on each connector in order to help maintain signal integrity in noisy environments or when using long cable runs. Each of the three connectors have the same pinout thus simplifying interconnection to the user's equipment.

3.1 PCI Local Bus Interface Logic

The FPCI-DIO card implements a full 32-bit interface to the PCI local bus. The control logic allows the FPCI-DIO card to respond as a slave only device on the PCI bus. Therefore, only host CPU generated READ and WRITE operations are supported. The card cannot assume bus mastership nor generate interrupts. Zero wait-state burst mode transfers are supported by means of on board FIFOs. There is a separate FIFO for READ and WRITE operations to the board. Each FIFO is sixteen long-words deep.

Normally, the user's program simply READs from or WRITEs to the addresses assigned to the I/O port registers on the card. In this way the user may acquire the state of the input signals or write new values to the output signals.

The addresses of the I/O port registers on the FPCI-DIO card are not constant values. This is because the PCI Bus specification requires that interface card address values be dynamically assigned by the host computer during the boot-up process. The FPCI-DIO card defines three memory regions on the card which are to be dynamically assigned by the host system.

The first memory region is that which contains the PCI configuration space registers. This region is 128 bytes deep and can be accessed via either a memory access or an I/O cycle access over the PCI Bus. The PCI Base address register at location 10h of the configuration space is used to map these registers for memory cycle accesses. The PCI Base address register at location 14h of the configuration space is used to map these registers for I/O cycle accesses. Normally these registers are not of any concern to the application driving the FPCI-DIO card. They are used primarily during the host system boot-up procedure.

The second memory region on the FPCI-DIO card is where the Expansion ROM is mapped. This region is 128K bytes in size and can be accessed via a memory cycle access over the PCI Bus. The PCI Base address register at location 30h of the configuration space is used to map the expansion ROM for memory cycle accesses. The Expansion ROM is used to store two vital pieces of data. The first data block is for the logic fuse map to a field programmable gate array on the card. This gate array implements much of the hardware logic for the FPCI-DIO card. Normally the fuse map data is used to configure the logic on the card upon power-up and is not normally read by the host CPU. It is accessible by the host CPU for diagnostic purposes during board manufacture. The second data block is for driver code for the card. This driver provides for card initialization under various operating systems. Currently supported are an Open Firmware and PC-AT compatible data structures. The Expansion ROM memory space on the FPCI-DIO card is mapped as a byte-wide interface to the PCI Bus. This was done in order to save on the cost to manufacture the card. It does not compromise performance during the normal operation of the card since the driver code within the Expansion ROM is read into system memory upon startup and then executed out of system memory after that. All I/O operations to the user ports on the card are always performed in full 32 bit operations.

The last memory region on the FPCI-DIO card is the area where the user I/O port and port configuration register exist. This region is 64K bytes in size and can be accessed via a memory cycle access over the PCI Bus. The PCI Base address register at location 18h of the configuration space is used to map this region for memory cycle accesses. There are four memory registers in this group which may be written or read by the host computer's processor. Three of these registers are assigned to the I/O ports on the card. One register for each port. These port registers are a full 32 bits wide with a bit corresponding to its respective signal on the I/O port. Because the FPCI-DIO card's PCI interface logic implements the full 32 bit interface, all of the signals on a port may be accessed in a single memory reference operation by the processor. The fourth register is a control register which, among other things, allows the user to specify the direction of the I/O signals. Only 14 bits are defined in the control register. For more information on the control register please refer to section 3.2.

3.2 Port Logic

As mentioned in the previous section, there are four user I/O registers defined in the memory map of the FPCI-DIO card. The first register is a control register which is located at address offset

0xC000 from the base address register at location 18h. The control register is cleared to all zero's upon restart of the computer or whenever the driver for the card is opened.

Only 14 of the bits are valid within the control register. The 12 least significant bits control the direction of the I/O port signals on the card. Each of the three I/O ports on the FPCI-DIO card provide for 32 user signal lines on its interface. These 32 signal bits are grouped into four groups of eight bits (four bytes). Within each byte the user has control over the direction of the signal flow within that particular byte. All eight of the signals in the byte will assume the same signal direction flow. The way the user specifies the signal direction is by that byte's corresponding direction control bit in the control register. There are 12 direction control bits defined in the register. One for each of the 12 bytes or 96 signal lines provided for by the FPCI-DIO card. A '1' written into the data direction bit will set the 'output' mode for that particular byte. Conversely, a '0' programmed into the data direction bit will set that byte to the 'input' mode of operation. The FPCI-DIO card will clear all of the bits in the control register each time the host computer is restarted. Therefore all 96 signal lines will be placed in the 'input' mode of operation and the card will not drive any of the I/O signals. The driver's initialization code is responsible for clearing all of the registers on the card.

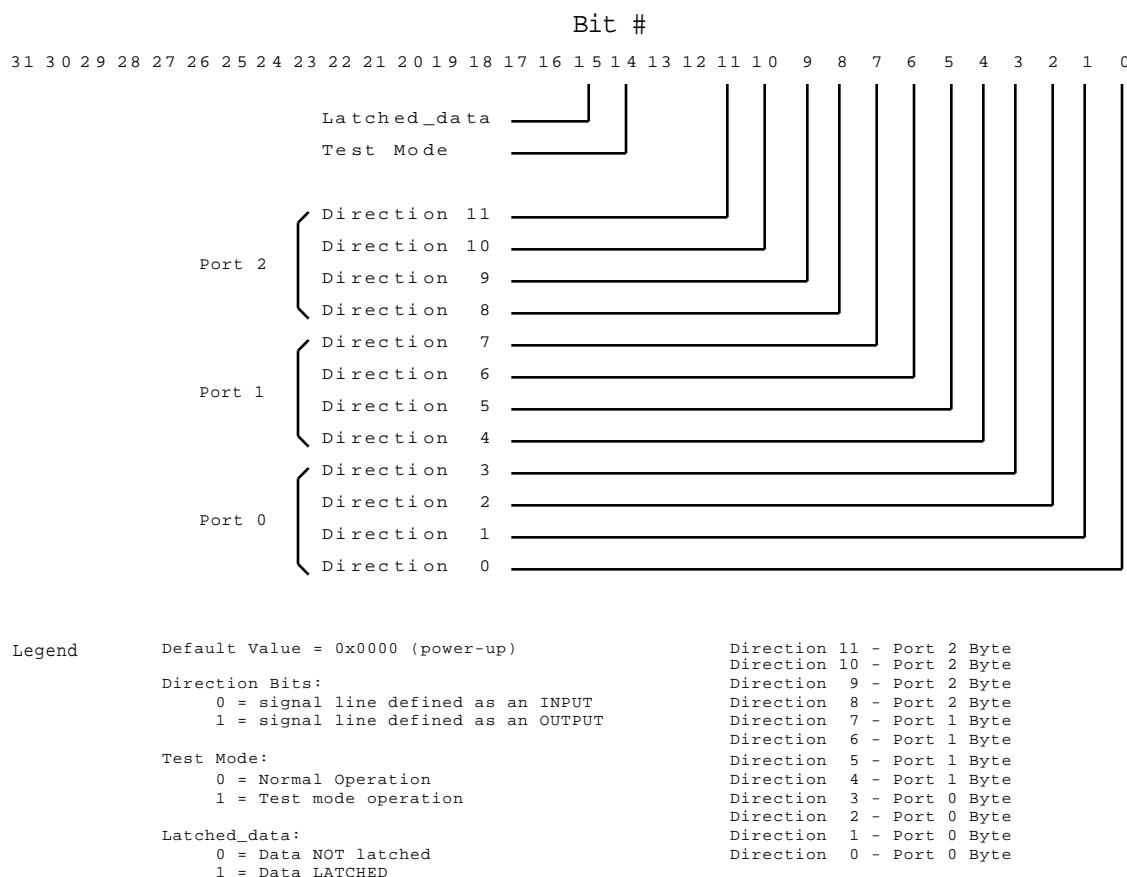


Figure 4 - Control Register Bit definitions.

The other two bits defined in the control register are used to define certain modes of operation of the FPCI-DIO card. The 'latch_data' bit is used to enable a data sampling clock on the card. This clock is used to latch the state of the input signals being acquired by the FPCI-DIO card from the user's equipment before being read by the host CPU. Even though it is true that any data acquisition program running on the host computer will usually be sampling the user's inputs asynchronously to any events in the user's equipment, it is sometimes advantageous to enable the 'latch_data' bit in the control register on the FPCI-DIO card. This is usually done if the FPCI-DIO card will be sampling very fast changing data or when the input signal's transition time is very slow. When the 'latch_data' bit is set in the control register, the FPCI-DIO card will clock the input data into an intermediate register with a sample clock signal prior to sending the data on to the host computer's processor during a 'read' operation. This input latch has a much smaller sample window than the normal input logic on the card and thus will be better able to correctly sample data during these periods of uncertainty. The 'latch_data' bit is cleared to '0' upon restart of the host computer.

The last bit defined in the control register is a bit which is used to facilitate testing of the FPCI-DIO board during its manufacture at the fishcamp facilities. Normally this bit is left in the cleared ('0') state during operation. The user should never set this bit to a '1' during operation of the FPCI-DIO card. This bit is cleared upon restart of the host computer via the card's driver initialization code.

The remaining three user registers defined in the memory map of the FPCI-DIO card correspond to the three I/O ports of the card. It is thru these three registers that the user's program can input or output data from the FPCI-DIO card.

Each port is addressed from the software by means of long-word memory READs and WRITEs to that port's register memory location on the FPCI-DIO. Each of the 32 bits in the long-word corresponds to a particular signal on the connector of the I/O port for that register. Since the FPCI-DIO card is designed as a full 32 bit PCI Bus interface, all 32 signals lines may be written or read in a single long-word memory operation from the host computer's processor. The hardware logic on the FPCI-DIO card actually requires that only long-word operations to be performed. The software drivers provided by fishcamp engineering enforce this requirement. The following table lists the user I/O port mapping of the card:

Register Memory Address Offset	Port Connector
0x8000	Port 0
0x8010	Port 1
0x8020	Port 2

Figure 5 - I/O Register Port Mapping.

When writing applications programs which drive the FPCI-DIO card, the programmer should keep in mind that the FPCI-DIO hardware conforms to the PCI Bus specification's 'little-endian' data format. The byte lane alignment of the data may be an issue to the programmer depending upon which host computer platform the FPCI-DIO board is being used. The fishcamp engineering drivers for the various computer platforms supported automatically take care of any endian conversion required by the platform.

3.3 Connector Pinouts

Each of the three ports on the FPCI-DIO card has its signals made available for the customer's use via a standard 50-pin ribbon cable header. These headers have contacts made up of 25mil square pins. There are two rows of 25 pins each for a total of 50 pins. The pin spacing is a standard 100 mils. The numbering of the pins is as shown in figure 6. For clarity, only one port connector is shown. All three port connectors have the same numbering.

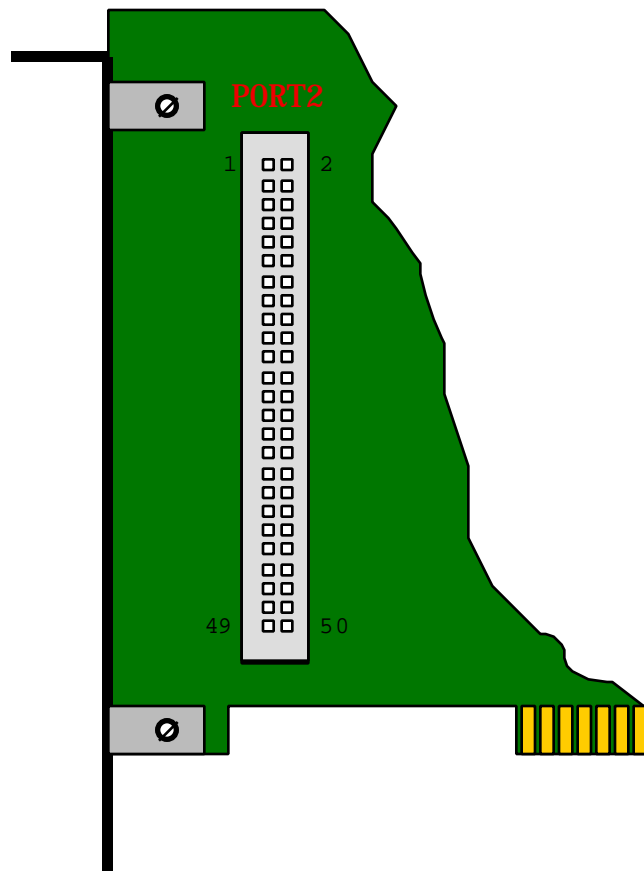


Figure 6 - I/O port pin numbering.
(The view shown is from the component side of the FPCI-DIO card.)

Each of the connectors contains all of the signals for a single port on the FPCI-DIO card or 32 signal lines. The remaining pins carry logic ground (17 pins) and protected +5V power (1 pin) from the computer's power supply. All three connectors have the same pinout defined for the signals on their respective ports.

<u>I/O Connector Pin</u>	<u>Signal</u>
Port 0 - 1	Port 0 - Data Bit 0
Port 0 - 2	+5V
Port 0 - 3	Port 0 - Data Bit 1
Port 0 - 4	Ground
Port 0 - 5	Port 0 - Data Bit 2
Port 0 - 6	Ground
Port 0 - 7	Port 0 - Data Bit 3
Port 0 - 8	Ground
Port 0 - 9	Port 0 - Data Bit 4
Port 0 - 10	Ground
Port 0 - 11	Port 0 - Data Bit 5
Port 0 - 12	Ground
Port 0 - 13	Port 0 - Data Bit 6
Port 0 - 14	Ground
Port 0 - 15	Port 0 - Data Bit 7
Port 0 - 16	Port 0 - Data Bit 8
Port 0 - 17	Port 0 - Data Bit 9
Port 0 - 18	Ground
Port 0 - 19	Port 0 - Data Bit 10
Port 0 - 20	Port 0 - Data Bit 11
Port 0 - 21	Ground
Port 0 - 22	Port 0 - Data Bit 12
Port 0 - 23	Port 0 - Data Bit 13
Port 0 - 24	Ground
Port 0 - 25	Port 0 - Data Bit 14
Port 0 - 26	Port 0 - Data Bit 15
Port 0 - 27	Ground
Port 0 - 28	Port 0 - Data Bit 16
Port 0 - 29	Port 0 - Data Bit 17
Port 0 - 30	Ground
Port 0 - 31	Port 0 - Data Bit 18
Port 0 - 32	Port 0 - Data Bit 19
Port 0 - 33	Ground
Port 0 - 34	Port 0 - Data Bit 20
Port 0 - 35	Port 0 - Data Bit 21
Port 0 - 36	Ground
Port 0 - 37	Port 0 - Data Bit 22
Port 0 - 38	Port 0 - Data Bit 23
Port 0 - 39	Ground
Port 0 - 40	Port 0 - Data Bit 24
Port 0 - 41	Port 0 - Data Bit 25
Port 0 - 42	Ground
Port 0 - 43	Port 0 - Data Bit 26
Port 0 - 44	Port 0 - Data Bit 27
Port 0 - 45	Ground
Port 0 - 46	Port 0 - Data Bit 28
Port 0 - 47	Port 0 - Data Bit 29
Port 0 - 48	Ground
Port 0 - 49	Port 0 - Data Bit 30
Port 0 - 50	Port 0 - Data Bit 31

Figure 7- Port 0 Pinouts.

<u>I/O Connector Pin</u>	<u>Signal</u>
Port 1 - 1	Port 1 - Data Bit 0
Port 1 - 2	+5V
Port 1 - 3	Port 1 - Data Bit 1
Port 1 - 4	Ground
Port 1 - 5	Port 1 - Data Bit 2
Port 1 - 6	Ground
Port 1 - 7	Port 1 - Data Bit 3
Port 1 - 8	Ground
Port 1 - 9	Port 1 - Data Bit 4
Port 1 - 10	Ground
Port 1 - 11	Port 1 - Data Bit 5
Port 1 - 12	Ground
Port 1 - 13	Port 1 - Data Bit 6
Port 1 - 14	Ground
Port 1 - 15	Port 1 - Data Bit 7
Port 1 - 16	Port 1 - Data Bit 8
Port 1 - 17	Port 1 - Data Bit 9
Port 1 - 18	Ground
Port 1 - 19	Port 1 - Data Bit 10
Port 1 - 20	Port 1 - Data Bit 11
Port 1 - 21	Ground
Port 1 - 22	Port 1 - Data Bit 12
Port 1 - 23	Port 1 - Data Bit 13
Port 1 - 24	Ground
Port 1 - 25	Port 1 - Data Bit 14
Port 1 - 26	Port 1 - Data Bit 15
Port 1 - 27	Ground
Port 1 - 28	Port 1 - Data Bit 16
Port 1 - 29	Port 1 - Data Bit 17
Port 1 - 30	Ground
Port 1 - 31	Port 1 - Data Bit 18
Port 1 - 32	Port 1 - Data Bit 19
Port 1 - 33	Ground
Port 1 - 34	Port 1 - Data Bit 20
Port 1 - 35	Port 1 - Data Bit 21
Port 1 - 36	Ground
Port 1 - 37	Port 1 - Data Bit 22
Port 1 - 38	Port 1 - Data Bit 23
Port 1 - 39	Ground
Port 1 - 40	Port 1 - Data Bit 24
Port 1 - 41	Port 1 - Data Bit 25
Port 1 - 42	Ground
Port 1 - 43	Port 1 - Data Bit 26
Port 1 - 44	Port 1 - Data Bit 27
Port 1 - 45	Ground
Port 1 - 46	Port 1 - Data Bit 28
Port 1 - 47	Port 1 - Data Bit 29
Port 1 - 48	Ground
Port 1 - 49	Port 1 - Data Bit 30
Port 1 - 50	Port 1 - Data Bit 31

Figure 8 - Port 1 Pinouts.

<u>I/O Connector Pin</u>	<u>Signal</u>
Port 2 - 1	Port 2 - Data Bit 0
Port 2 - 2	+5V
Port 2 - 3	Port 2 - Data Bit 1
Port 2 - 4	Ground
Port 2 - 5	Port 2 - Data Bit 2
Port 2 - 6	Ground
Port 2 - 7	Port 2 - Data Bit 3
Port 2 - 8	Ground
Port 2 - 9	Port 2 - Data Bit 4
Port 2 - 10	Ground
Port 2 - 11	Port 2 - Data Bit 5
Port 2 - 12	Ground
Port 2 - 13	Port 2 - Data Bit 6
Port 2 - 14	Ground
Port 2 - 15	Port 2 - Data Bit 7
Port 2 - 16	Port 2 - Data Bit 8
Port 2 - 17	Port 2 - Data Bit 9
Port 2 - 18	Ground
Port 2 - 19	Port 2 - Data Bit 10
Port 2 - 20	Port 2 - Data Bit 11
Port 2 - 21	Ground
Port 2 - 22	Port 2 - Data Bit 12
Port 2 - 23	Port 2 - Data Bit 13
Port 2 - 24	Ground
Port 2 - 25	Port 2 - Data Bit 14
Port 2 - 26	Port 2 - Data Bit 15
Port 2 - 27	Ground
Port 2 - 28	Port 2 - Data Bit 16
Port 2 - 29	Port 2 - Data Bit 17
Port 2 - 30	Ground
Port 2 - 31	Port 2 - Data Bit 18
Port 2 - 32	Port 2 - Data Bit 19
Port 2 - 33	Ground
Port 2 - 34	Port 2 - Data Bit 20
Port 2 - 35	Port 2 - Data Bit 21
Port 2 - 36	Ground
Port 2 - 37	Port 2 - Data Bit 22
Port 2 - 38	Port 2 - Data Bit 23
Port 2 - 39	Ground
Port 2 - 40	Port 2 - Data Bit 24
Port 2 - 41	Port 2 - Data Bit 25
Port 2 - 42	Ground
Port 2 - 43	Port 2 - Data Bit 26
Port 2 - 44	Port 2 - Data Bit 27
Port 2 - 45	Ground
Port 2 - 46	Port 2 - Data Bit 28
Port 2 - 47	Port 2 - Data Bit 29
Port 2 - 48	Ground
Port 2 - 49	Port 2 - Data Bit 30
Port 2 - 50	Port 2 - Data Bit 31

Figure 9 - Port 2 Pinouts.

4.0 Software

Although the hardware design of the FPCI-DIO card allows its use in any platform that has PCI 2.1 compliant expansion slots, each platform will require a software driver specific to that platform before the card can be utilized. This is because of the multitude of different processors which may be used in the host machine (eg. PowerPC, x86, SPARC) and the various requirements of the operating system being used (MacOS, Win95, OS/2, etc.).

This manual has the software support for each of the platforms supported described in the appendixes in this manual. In addition to the documentation for the card's driver, there may be documentation for other software such as higher level code libraries or test utilities. Refer to the appendix of interest for information on the desired platform support.

Appendix A - MacOS Software Support

A.1 Overview

Programming of the FPCI-DIO card under the MacOS is facilitated by two software packages included with the card. The first is the card's driver code, which is a MacOS 'NDRV' code segment stored in the file 'FPCIDioDrvr'. This driver is loaded into memory from the computer's hard disk and executed during the boot-up routine of the computer. Once loaded, the driver routines may be called via any programming language which supports calling the MacOS Device Manager. The driver contains routines which allow the calling application to access all features of the FPCI-DIO card. Generally, these routines are at a very low level and just provide basic functionality. The card device driver is compiled to native code for the PowerPC processor.

The second software package included with the FPCI-DIO card is a Dynamic Link Library stored in the file 'FPCIManager'. This library contains other routines than those available in the standard card device driver. These routines take care of many of the details of calling the MacOS Device Manager and are at a much higher level than those of the standard card device driver. Because of the ease of use and added functionality, the user will generally wish to call the routines in this library rather than the card's driver routines directly. The library is loaded into memory from disk anytime an application calls one of its routines. The Library is compiled to native code for the PowerPC processor.

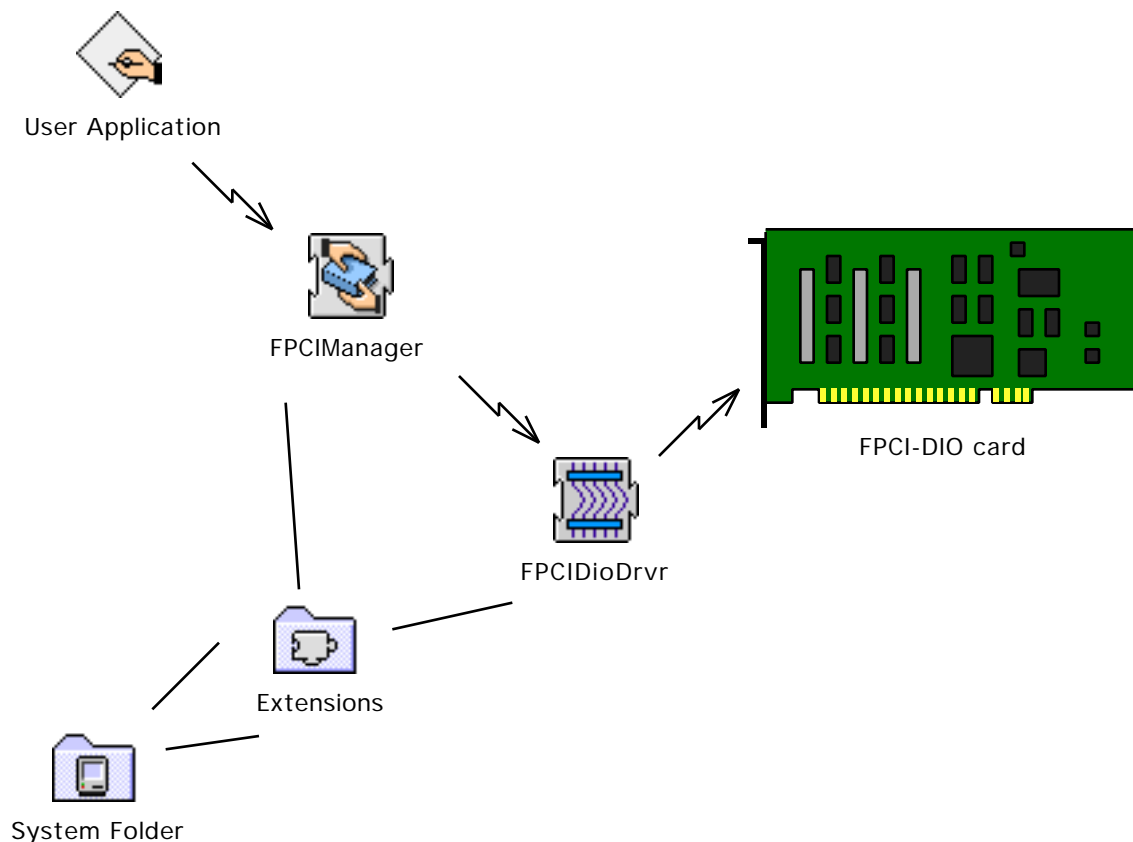


Figure A.1 - FPCI-DIO card Software relationships

A.2 Software Installation

Copy the 'FPCIDioDrvr' and 'FPCIManager' file from the distribution floppy over to the 'System' folder on the MAC. These files' icons look like:



Figure A.2 - FPCIDioDrvr and FPCIManager icons.

The system will ask you if you want the files placed in the 'Extensions' folder within the 'System' folder. Answer 'yes' to the question. The files will then be copied over to the extensions folder. You will then have to re-boot the computer.

The 'FPCIDioDrvr' file is the actual software driver for the FPCI-DIO card. The driver gets loaded by the MacOS upon restart. All I/O calls to the FPCI-DIO card are made thru this driver.

The 'FPCIManager' file is a SOMobjects™ Library file which implements a higher level API than that provided by the 'FPCIDioDrvr' driver code. The library is a Dynamic Link Library which is loaded only when needed by an application. The 'FPCIManager' makes all of its calls to the FPCI-DIO card hardware via the standard calls provided by the 'FPCIDioDrvr' code. To take advantage of the routines provided for by the 'FPCIManager', you will have to have SOMobjects™ previously loaded on your computer. SOMobjects™ is Apple Computer's implementation of IBM's SOMobjects™ on the Macintosh. SOMobjects™ is a multi-platform standard providing for system-level sharable objects in a language-neutral way.

A.3 Device Driver

The driver is stored in a file that is normally located within the Extensions folder within the System folder on the boot-up volume. It is read into memory and executed by the MacOS upon system restart. The user may call the driver routines via any programming language which supports the MacOS Device Manager. As long as the calling parameters are followed as directed, the routines will execute regardless of what programming language was used to call them.

At boot-up time of the computer, the MacOS will match the driver up with the FPCI-DIO card by means of the PCI Device and Vendor IDs stored in the configuration ROM of the card. When the match is found, the MacOS will load the driver and call the driver's *Initialization* and *Open* routines. The driver is then available to be used by the user's applications.

The driver has four primary routines which will need to be called by the user's application code. Two of the routines are used only for operating system housekeeping. They are the *Open* and *Close* routines which need to be called at the start and finish respectively of your application. The other two routines, the *Read* and *Write* routines, are used to do the actual data transfers between your

program and the user I/O ports on the FPCI-DIO interface card.

Included on the distribution disk for the FPCI-DIO card is header file that contains some definitions needed when writing your application program. The file is named 'FPCIDioDriver.h' and defines certain data structures and constants which are used by the driver routines for the card.

The 'FPCIDioDrvrParam' structure is the single most important data type defined. Critical information required during data transfer operations with the port registers are defined in this data structure. This record is a 12 byte long data type with 3 distinct fields within it used. The format of 'FPCIDioDrvrParam' is:

```
struct FPCIDioDrvrParam {
    UInt32      portNumber;    /* -> the port number desired          */
    Nanoseconds updateDelay;    /* -> # Nanoseconds between port writes */
    UInt32      errorCode;     /* <- error code                      */
};

typedef struct FPCIDioDrvrParam FPCIDioDrvrParam, *FPCIDioDrvrParamPtr;
```

Figure A.3 - FPCIDioDrvrParam Structure Definition.

The use of the 'FPCIDioDrvrParam' structure will be documented below, in the sections describing the *Read* and *Write* routines of the FPCIDioDrvr.

A.3.1 *OpenDriver* Routine

The standard MacOS *OpenDriver* routine can be used to open the FPCI-DIO card's driver and get it ready for subsequent data transfer operations. The PASCAL string "\p.FPCIDioDrvr" should be used to specify the driver for the FPCI-DIO card. The following C language syntax should be used for the call:

```
OSErr    err;
short    refNum;

err = OpenDriver(kDriverNamePString, &refNum);
```

This call will call the *Open* routine within the FPCIDioDrvr and return the 'refNum' to be used for all succeeding calls to the driver. If more than one FPCI-DIO card is installed in the computer, the *OpenDriver* call will select the first card that the MacOS finds. For information on using multiple cards in the computer please refer to the section on the 'FPCIManager' software. If all goes well, the execution of the *OpenDriver* routine will return 'noErr' in the 'err' variable. The constant 'kDriverNamePString' is defined in the 'FPCIDioDriver.h' include file.

A.3.2 *CloseDriver* Routine

After you are all finished making calls to the 'FPCIDioDrvr', you should close the driver with a call to the MacOS *CloseDriver* routine. The 'refNum' parameter returned to you in the original

OpenDriver call should be used in the parameter to this routine. The following C language syntax should be used for the call:

```
OSErr    err;
short    refNum;

err = CloseDriver(refNum);
```

If all goes well, the execution of the *CloseDriver* routine will return 'noErr' in the 'err' variable. The 'FPCIDioDrvr' will be available for use by other application programs after the execution of this call. Typically, you would make a call to this routine just before your application terminates.

A.3.3 Read Routine

This routine is used for all INPUT data transfer operations. That is those operations which transfer data FROM the I/O ports signals TO the host computer's memory. Calls to the driver *Read* routine can be made by either the *PBReadSync* or *PBReadAsync* MacOS routines. The prototype definitions of these routines are specified in the MacOS header file 'Files.h' as:

```
OSErr PBReadSync(ParmBlkPtr paramBlock);
      and
OSErr PBReadAsync(ParmBlkPtr paramBlock);
```

The routines used will depend upon whether or not you wish to make the call synchronously or asynchronously. Generally, you will make the call synchronously if you have very little data to send and/or you want to make sure the data gets transferred before your application does anything else. The *PBReadSync* routine should be called in situations such as this. The MacOS will enter the 'FPCIDioDrvr' and begin reading data from the interface into the computer's main memory. It will remain in a tight loop, continuing to transfer data until the byte count specified by the application is met. Not until all the data has been transferred will the driver return control back to the application. The *PBReadAsync* routine, on the other hand, should be used whenever you are transferring a large amount of data or, because of the *updateDelay* parameter, the operation will take a significant amount of time to complete. In this case, it will be wise to allow the application program to continue processing while the data transfer completes. When a call to *PBReadAsync* is made, the 'FPCIDioDrvr' will queue up the data transfer operation's parameters, begin the transfer, and then return control back to the calling application. The data transfer will continue in background until the byte count parameter is finally met. At this time, a user specified completion routine will be executed in order to inform the application that the data transfer has completed. The use of this kind of data transfer operation will allow the application to provide the user a better experience than otherwise possible. In fact, under certain conditions, the *PBReadSync* may make the computer appear to 'hang' to the user. The *PBReadAsync* routine would never exhibit this kind of effect. Only one outstanding *PBReadAsync* operation can be executing at a time. You must not start another transfer operation until any previous one has fully completed.

Two data structures will need to be filled in and passed as parameters to the *Read* routine. The first is an *IOParam* data structure which is defined in the 'Files.h' header file for the MacOS. A Pointer to this data structure is what is passed as a parameter to either of the two routines. The second data structure is an *FPCIDioDrvrParam* data structure that is defined in the 'FPCIDioDriver.h' file on

the distribution disk.

The 'IOParam' data structure is where you specify all of the standard MacOS device manager parameters. Six fields are parameters which must be filled in by the calling program before the call is made to one of the Device Manager routines. You must return the refNum value which was returned to you in the original *OpenDriver* call in the 'ioRefNum' field. This value will allow the application program to specify a particular FPCI-DIO card in all subsequent driver calls.

The 'ioBuffer' parameter is user to specify a block of memory where all the data values read from the desired I/O port will be stored. This memory block will need to be previously allocated by the calling program before making the driver call. The 'ioReqCount' parameter is used to specify the number of data words to read during the call. This value actually specifies the number of data bytes (8-bit values) which are to be read. Remember that the FPCI-DIO card only supports 32 bit transfers so the 'ioReqCount' field value must therefore be a multiple of 4 bytes. Any other value will result in an error return from the driver call. The 'ioPosMode' field must be specified as the constant 'ioMapBuffer' and is a requirement imposed upon the driver by the MacOS. The last field in the 'IOParam' data structure is the 'ioCompletion' field. This is where the calling application specifies the address of a completion routine and is used whenever the driver call is performed asynchronously. This completion routine will be called after all data words have been transferred by the driver. It is in this way that the calling application will know when the previously specified transfer operation has finally finished. You can specify the completion routine's address by using the MacOS system call 'NewIOCompletionProc'. If the driver call is to be made synchronously then you may specify NULL as the value for the 'ioCompletion' field.

Several fields in the 'IOParam' data structure are used for return parameters. The 'ioActCount' field details the actual number of data bytes transferred during the driver call. Normally it will equal the value specified in the 'ioReqCount' field upon entering the driver call. If it is not, then the driver call encountered some sort of error and examination of the error return fields in the calling data structured needs to be made to determine the nature of the error.

The 'ioResult' field will return any error code supplied by the MacOS. The possible error code values are documented in the Inside Macintosh documentation from Apple Computer. The 'errorCode' field described below in the 'FPCIDioDrvrParam' data structure will contain the code for any errors detected by the 'FPCIDioDrvr' software itself. Typically these will be errors in the calling parameter list. Please see section A.4 for a list of these error codes.

The FPCIDioDrvrParam structure has 3 fields defined. Two of the fields are for parameters to be defined by the calling application. The first of these parameters is the 'portNumber' field. You must specify in this field the desired register or I/O port you wish to read data from. Valid parameters are one of the four port number constants defined in the 'FPCIDioDriver.h' header file:

// Defined board addresses

```
#define kFPCI_DIO_Port0    0x8000
#define kFPCI_DIO_Port1    0x8010
#define kFPCI_DIO_Port2    0x8020
#define kFPCI_DIO_Cntrl    0xC000
```

The first three port numbers correspond to the three physical ports on the FPCI-DIO card. The `kFPCI_DIO_Cntrl` constant actually refers to the configuration control register on the card. For information on the configuration control register, please refer to section 3.2 on the port logic.

The second input parameter is the `'updateDelay'` field. This field is used to specify a time duration between consecutive read operations. This is useful when you want to input data continuously from a given port over a period of time. The calling application will specify the number of port reads to perform and then, in this `'updateDelay'` field, the time in nanoseconds between these reads. The user must understand that the timing of these data transfers is not precise. The `'FPCIDioDrvr'` uses a software interrupt timer mechanism to orchestrate the timing of the transfers. These software interrupt timers have a lower priority than other items in the system such as hardware interrupts and the execution of these interrupt routines will affect the precise time at which the software interrupt timer routine is executed. Typically, the use of the `'updateDelay'` parameter is useful for time intervals of a few microseconds or longer. You should specify a value of zero when you want to read data as fast as possible. When a `'updateDelay'` parameter of zero is specified in a call to `PBReadAsync`, the `'FPCIDioDrvr'` will sit in a tight loop reading data but will periodically return control to the application code so that the application will appear responsive to the user even during lengthy transfer operations.

The third field in the `'FPCIDioDrvrParam'` data structure is used for an error code return from the driver. This field is labeled `'errorCode'` and will normally return zero if everything went fine during the course of execution of the current driver call. If anything goes wrong, you should refer to the code returned in this field to ascertain the nature of the problem. Please refer to section A.4 for a list of possible error codes.

Once the `'FPCIDioDrvrParam'` data structure is setup, you must insert a pointer to it in the `.ioMisc` field of the `IOPParam`. The following C language syntax illustrates the call to `PBReadSync`:

```

OSError      status;
FPCIDioDrvrParam anFPCIDrvrParam;
IOPParam      anIOPParam;
Nanoseconds   aNanosecondVar;
long          aLong;
long          actualTransferCount;

status = noErr;           // assume no error
//
// Setup the MacOS and FPCIDioDrvr parameter blocks
//
CLEAR(anIOPParam);        // the CLEAR macro simply zeros all fields
CLEAR(anFPCIDrvrParam);
anIOPParam.ioRefNum = refnum; // was a return value from the OpenDriver call
anFPCIDrvrParam.portNumber = kFPCI_DIO_Port0; // port 0
aNanosecondVar.hi = 0;
aNanosecondVar.lo = 0;      // read data as fast as possible
anFPCIDrvrParam.updateDelay = aNanosecondVar;
anIOPParam.ioMisc = (Ptr) &anFPCIDrvrParam;
anIOPParam.ioBuffer = (char*) &aLong; // read a single long word from the port
anIOPParam.ioReqCount = 4;           // 4 bytes to read

```

```

anIOParam.ioCompletion = NULL;    // no completion routine
anIOParam.ioPosMode = ioMapBuffer; // tell device manager to map
                                   // (not copy) the ioBuffer data

// all parameters setup, now make the call...
status = PBReadSync((ParmBlkPtr) &anIOParam);

actualTransferCount = anIOParam.ioActCount;
if (anIOParam.ioResult == ioErr)
    SysBeep(2);

```

A.3.4 Write Routine

This routine is used for all OUTPUT data transfer operations. That is those operations which transfer data FROM the host computer's memory TO the I/O ports signals. Calls to the driver *Write* routine can be made by either the *PBWriteSync* or *PBWriteAsync* MacOS routines. The prototype definitions of these routines are specified in the MacOS header file 'Files.h' as:

```

OSErr PBWriteSync(ParmBlkPtr paramBlock);
and
OSErr PBWriteAsync(ParmBlkPtr paramBlock);

```

The routines used will depend upon whether or not you wish to make the call synchronously or asynchronously. Generally, you will make the call synchronously if you have very little data to send and/or you want to make sure the data gets transferred before your application does anything else. The *PBWriteSync* routine should be called in situations such as this. The MacOS will enter the 'FPCIDioDrvr' and begin writing data to the interface from the computer's main memory. It will remain in a tight loop, continuing to transfer data until the byte count specified by the application is met. Not until all the data has been transferred will the driver return control back to the application. The *PBWriteAsync* routine, on the other hand, should be used whenever you are transferring a large amount of data or, because of the *updateDelay* parameter, the operation will take a significant amount of time to complete. In this case, it will be wise to allow the application program to continue processing while the data transfer completes. When a call to *PBWriteAsync* is made, the 'FPCIDioDrvr' will queue up the data transfer operation's parameters, begin the transfer, and then return control back to the calling application. The data transfer will continue in background until the byte count parameter is finally met. At this time, a user specified completion routine will be executed in order to inform the application that the data transfer has completed. The use of this kind of data transfer operation will allow the application to provide the user a better experience than otherwise possible. In fact, under certain conditions, the *PBWriteSync* may make the computer appear to 'hang' to the user. The *PBWriteAsync* routine would never exhibit this kind of effect. Only one outstanding *PBWriteAsync* operation can be executing at a time. You must not start another transfer operation until any previous one has fully completed.

Two data structures will need to be filled in and passed as parameters to the *Write* routine. The first is an *IOParam* data structure which is defined in the 'Files.h' header file for the MacOS. A Pointer to this data structure is what is passed as a parameter to either of the two routines. The second data structure is an 'FPCIDioDrvrParam' data structure that is defined in the 'FPCIDioDriver.h' file on the distribution disk.

The 'IOParam' data structure is where you specify all of the standard MacOS device manager parameters. Six fields are parameters which must be filled in by the calling program before the call is made to one of the Device Manager routines. You must return the 'refNum' value which was returned to you in the original *OpenDriver* call in the 'ioRefNum' field. This value will allow the application program to specify a particular FPCI-DIO card in all subsequent driver calls.

The 'ioBuffer' parameter is user to specify a block of memory where all the data values to be written to the desired I/O port are initially stored. This memory block will need to be previously allocated and the desired data stored there by the calling program before making the driver call. The 'ioReqCount' parameter is used to specify the number of data words to write during the call. This value actually specifies the number of data bytes (8-bit values) which are to be written. Remember that the FPCI-DIO card only supports 32 bit transfers so the 'ioReqCount' field value must therefore be a multiple of 4 bytes. Any other value will result in an error return from the driver call. The 'ioPosMode' field must be specified as the constant 'ioMapBuffer' and is a requirement imposed upon the driver by the MacOS. The last field in the 'IOParam' data structure is the 'ioCompletion' field. This is where the calling application specifies the address of a completion routine and is used whenever the driver call is performed asynchronously. This completion routine will be called after all data words have been transferred by the driver. It is in this way that the calling application will know when the previously specified transfer operation has finally finished. You can specify the completion routine's address by using the MacOS system call 'NewIOCompletionProc'. If the driver call is to be made synchronously then you may specify NULL as the value for the 'ioCompletion' field.

Several fields in the 'IOParam' data structure are used for return parameters. The 'ioActCount' field details the actual number of data bytes transferred during the driver call. Normally it will equal the value specified in the 'ioReqCount' field upon entering the driver call. If it is not, then the driver call encountered some sort of error and examination of the error return fields in the calling data structures needs to be made to determine the nature of the error.

The 'ioResult' field will return any error code supplied by the MacOS. The possible error code values are documented in the Inside Macintosh documentation from Apple Computer. The 'errorCode' field described below in the 'FPCIDioDrvrParam' data structure will contain the code for any errors detected by the 'FPCIDioDrvr' software itself. Typically these will be errors in the calling parameter list. Please see section A.4 for a list of these error codes.

The 'FPCIDioDrvrParam' structure has 3 fields defined. Two of the fields are for parameters to be defined by the calling application. The first of these parameters is the 'portNumber' field. You must specify in this field the desired register or I/O port you wish to write data to. Valid parameters are one of the four port number constants defined in the 'FPCIDioDriver.h' header file:

// Defined board addresses

```
#define kFPCI_DIO_Port0    0x8000
#define kFPCI_DIO_Port1    0x8010
#define kFPCI_DIO_Port2    0x8020
#define kFPCI_DIO_Cntrl    0xC000
```

The first three port numbers correspond to the three physical ports on the FPCI-DIO card. The kFPCI_DIO_Cntrl constant actually refers to the configuration control register on the card. For information on the configuration control register, please refer to section 3.2 on the port logic.

The second input parameter is the ‘updateDelay’ field. This field is used to specify a time duration between consecutive write operations. This is useful when you want to output data continuously to a given port over a period of time. The calling application will specify the number of port writes to perform and then, in this ‘updateDelay’ field, the time in nanoseconds between these writes. The user must understand that the timing of these data transfers is not precise. The ‘FPCIDioDrvr’ uses a software interrupt timer mechanism to orchestrate the timing of the transfers. These software interrupt timers have a lower priority than other items in the system such as hardware interrupts and the execution of these interrupt routines will affect the precise time at which the software interrupt timer routine is executed. Typically, the use of the ‘updateDelay’ parameter is useful for time intervals of a few microseconds or longer. You should specify a value of zero when you want to write data as fast as possible. When an ‘updateDelay’ parameter of zero is specified in a call to PBWriteAsync, the ‘FPCIDioDrvr’ will sit in a tight loop writing data but will periodically return control to the application code so that the application will appear responsive to the user even during lengthy transfer operations.

The third field in the ‘FPCIDioDrvrParam’ data structure is used for an error code return from the driver. This field is labeled ‘errorCode’ and will normally return zero if everything went fine during the course of execution of the current driver call. If anything goes wrong, you should refer to the code returned in this field to ascertain the nature of the problem. Please refer to section A.4 for a list of possible error codes.

Once the ‘FPCIDioDrvrParam’ data structure is setup, you must insert a pointer to it in the .ioMisc field of the IOParam. The following C language syntax illustrates the call to PBWriteSync:

```

OSError      status;
FPCIDioDrvrParam  anFPCIDrvrParam;
IOParam      anIOParam;
Nanoseconds  aNanosecondVar;
long         aLong;
long         actualTransferCount;

status = noErr;          // assume no error
//
// Setup the MacOS and FPCIDioDrvr parameter blocks
//
aLong = 0x12345678;      // data to send
CLEAR(anIOParam);        // the CLEAR macro simply zeros all fields
CLEAR(anFPCIDrvrParam);
anIOParam.ioRefNum = refnum; // was a return value from the OpenDriver call
anFPCIDrvrParam.portNumber = kFPCI_DIO_Port0; // port 0
aNanosecondVar.hi = 0;
aNanosecondVar.lo = 0;   // output data as fast as possible
anFPCIDrvrParam.updateDelay = aNanosecondVar;
anIOParam.ioMisc = (Ptr) &anFPCIDrvrParam;
anIOParam.ioBuffer = (char*) &aLong; // write a single long word to the port
anIOParam.ioReqCount = 4;           // 4 bytes to read
anIOParam.ioCompletion = NULL;      // no completion routine
anIOParam.ioPosMode = ioMapBuffer;  // tell device manager to map
                                   // (not copy) the ioBuffer data

```

```

// all parameters setup, now make the call...
status = PBWriteSync((ParmBlkPtr) &anIOParam);

actualTransferCount = anIOParam.ioActCount;
if (anIOParam.ioResult == ioErr)
    SysBeep(2);

```

A.4 Error Codes

The file 'FPCIDioDrvr.h' header file included on the distribution disks define several error codes which may be returned by the 'FPCIDioDrvr' software in response to an error condition. These error codes will always be returned in the 'FPCIDioDrvrParam.errorCode' data field. The user's application code should always examine the contents of this field after every driver call is made. The following definition is reproduced here from the 'FPCIDioDrvr.h' file:

```

// FPCIDioDrvr error codes returned in the FPCIDioDrvrParam.errorCode field
enum {
    kFPCIDioDrvrNoErr          = 0, /* no error */
    kFPCIDioDrvrUnkErr        = 1, /* unknown error */
    kFPCIDioDrvrBadPortNum    = 2, /* bad port number specified */
    kFPCIDioDrvrBadDataCount  = 3, /* invalid data count specified */
    kFPCIDioDrvrAsynchOpInProg = 4 /* Asynch operation specified
                                     when one is already executing */
};

```

A.5 Cookbook

This section of the manual will take you thru an example program of how to call the routines in the driver for the FPCI-DIO card. The example is written in 'C' and should compile under all of the popular development environments available for the MacOS. The user may wish to translate the code from 'C' into another programming language if desired. All that is required is that the pass parameter conventions expected by the driver are adhered to.

The example makes use of the 'FPCIDioDriver.h' header file included on the distribution disk. In this file are defined constants and data structures that will be needed to utilize the driver calls. The user is encouraged to browse this file for more information on the driver interface.

On with the example...

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

#include "FPCIDioDriver.h"          // FPCI-DIO driver specifics

//
// global flag to signal execution of the asynch I/O completion routine.
// we clear this flag before calling the asynchronous I/O read operation.
// when the operation completes the completion routine will set this
// flag to signal the main program.
//

Boolean    gDidCompletionRoutine;

//
// A handy macro to clear a (small) structure.
//
#undef CLEAR
#define CLEAR(what)    ClearMemory((Ptr) &what, sizeof what)

// function prototypes
void ClearMemory(register Ptr memPtr, register Size memSize);
void AsynchIOCompletionRoutine(ParmBlkPtr paramBlock);

void ClearMemory(register Ptr memPtr, register Size memSize)
{
    while (memSize > 0) {
        *memPtr++ = 0;
        --memSize;
    }
}

//
// my own completion routine for asynch I/O. We will give the driver
// a pointer to this routine so that it gets called after any I/O
// operation executed asynchronously.
//
```

```

void AsynchIOCompletionRoutine(ParmBlkPtr paramBlock)
{
    gDidCompletionRoutine = true;
}

void main(void)
{
    OSErr            err;
    short            refNum;
    IOParam          anIOParam;
    long             aLong[10];           // test data buffer
    long             i;
    Boolean          done;
    long             timer;
    long             actualTransferCount;
    UInt32           driverErrorCode;
    FPCIDioDrvrParam anFPCIDrvrParam;
    Nanoseconds      aNanosecondVar;

    // open the driver
    err = OpenDriver(kDriverNamePString, &refNum);    // use the name "\p.FPCIDioDrvr"
    if (err == noErr)
        printf("Just opened the <.FPCIDioDrvr> driver with no error.\n\n");
    else
        printf("Could not open the <.FPCIDioDrvr> driver.\n\n");

    // first configure PORT 0 as an output port
    CLEAR(anIOParam);
    CLEAR(anFPCIDrvrParam);

    // setup the FPCIDioDrvrParam data structure
    anFPCIDrvrParam.portNumber = kFPCI_DIO_Cntrl;    // the address of the CONTROL register
    aNanosecondVar.hi = 0;
    aNanosecondVar.lo = 0;
    anFPCIDrvrParam.updateDelay = aNanosecondVar;

    // setup the IOParam data structure
    anIOParam.ioMisc = (Ptr) &anFPCIDrvrParam;
    anIOParam.ioRefNum = refNum;
    aLong[0] = 0x000f;                                // specify all four bytes of PORT 0
                                                    // as OUTPUT bytes
    anIOParam.ioBuffer = (char*) &aLong[0];          // the data buffer to write
    anIOParam.ioReqCount = 4;                          // will write a single long-word,
                                                    // expressed as 4 bytes

    anIOParam.ioCompletion = NULL;

    err = PBWriteSync((ParmBlkPtr) &anIOParam);

    if (err == noErr)
    {

```

```

printf("Just configured PORT 0 as OUTPUT with no error.\n");
actualTransferCount = anIOParam.ioActCount;    // get the actual number of bytes
                                                // transfered
driverErrorCode = anFPCIDrvrParam.errorCode;   // get any error code from the driver
printf("    Actual number of bytes transfered = %ld\n", actualTransferCount);
printf("    Driver error code = %ld\n\n", driverErrorCode);
}
else
printf("Just configured PORT 0 as OUTPUT but got an error!\n\n");

// setup a data pattern to send to the port
for (i = 0; i < 10; i++)
{
    aLong[i] = i;    // aLong[9] will equal a 9,
                    // this will be the last value written to the port
}

// try a synchronous write call.
CLEAR(anIOParam);
CLEAR(anFPCIDrvrParam);

// setup the FPCIDioDrvrParam data structure
anFPCIDrvrParam.portNumber = kFPCI_DIO_Port0;
aNanosecondVar.hi = 0;
aNanosecondVar.lo = 100000000;    // write a data word every 100mSec
anFPCIDrvrParam.updateDelay = aNanosecondVar;

// setup the IOParam data structure
anIOParam.ioMisc = (Ptr) &anFPCIDrvrParam;
anIOParam.ioRefNum = refNum;
anIOParam.ioBuffer = (char*) &aLong[0];    // the data buffer to write from
anIOParam.ioReqCount = sizeof(aLong);    // will write 10 long-words,
                                          // expressed as 40 bytes

anIOParam.ioCompletion = NULL;

err = PBWriteSync((ParmBlkPtr) &anIOParam);
if (err == noErr)
{
    printf("Just perfomed PBWriteSync call with no error.\n");
    actualTransferCount = anIOParam.ioActCount;    // get the actual number of bytes
                                                // transfered
    driverErrorCode = anFPCIDrvrParam.errorCode;   // get any error code from the driver
    printf("    Actual number of bytes transfered = %ld\n", actualTransferCount);
    printf("    Driver error code = %ld\n\n", driverErrorCode);
}
else
printf("Just perfomed PBWriteSync call but got an error!\n\n");

```

```

// now try a READ but do it asynchronously.
CLEAR(anIOParam);
CLEAR(anFPCIDrvrParam);

// setup the FPCIDioDrvrParam data structure
anFPCIDrvrParam.portNumber = kFPCI_DIO_Port0;
aNanosecondVar.hi = 0;
aNanosecondVar.lo = 100000000; // input a data word every 100mSec
anFPCIDrvrParam.updateDelay = aNanosecondVar;

// setup the IOParam data structure
anIOParam.ioMisc = (Ptr) &anFPCIDrvrParam;
anIOParam.ioRefNum = refNum;
anIOParam.ioBuffer = (char*) &aLong[0]; // the data buffer to read to
anIOParam.ioReqCount = sizeof(aLong); // will read 10 long-words,
// expressed as 40 bytes
anIOParam.ioCompletion = NewIOCompletionProc(AsynchIOCompletionRoutine);

gDidCompletionRoutine = false; // this flag raised when call is done
err = PBReadAsync((ParmBlkPtr) &anIOParam);
printf("Just performed PBReadAsync!\n");
printf("    Entering my wait-loop waiting for the completion routine to execute...\n");

done = false;
timer = TickCount();
while (!done)
{
    if ((timer + 600) < TickCount()) // wait for first of:
    // Completion routine execution or
    // 10 seconds
    // the transfer should only take
    // 1 second (10 words every 100 mSec)
    {
        printf("    Timer expired while waiting for the asynch I/O call to complete.\n\n");
        done = true;
    }

    if (gDidCompletionRoutine)
    {
        printf("    Asynch I/O routine just finished!\n");

        actualTransferCount = anIOParam.ioActCount; // get the actual number of bytes
                                                    // transfered
        driverErrorCode = anFPCIDrvrParam.errorCode; // get any error code from the
                                                    // driver

        printf("    Actual number of bytes transfered = %ld\n", actualTransferCount);
        printf("    Driver error code = %ld\n", driverErrorCode);

        // if everything went alright, we should have read the last value written to
        // PORT 0 in the previous call. That should have been the value <9>
    }
}

```

```

        printf("        Value read from PORT 0 = %ld", aLong[0]);
        printf("                (Should have been a '9')\n\n");

        done = true;
    }
}

// cleanup
err = CloseDriver(refNum);

if (err == noErr)
    printf("Just closed the driver with no error.\n\n");
else
    printf("Just closed the driver but got an error!\n\n");
}

```

A.6 FPCIManager Library

A.6.1 Overview

This section of the manual describes a Dynamic Link Library which has been designed to make the programming of the FPCI-DIO card easier. As the previous sections of this appendix show, the basic card driver provides only minimal functionality and requires extensive call setup code in order to use. The 'FPCIManager' code library attempts to address these two limitations of the card driver software.

First, it takes care of many of the details necessary to call any of the basic card driver routines. Such tasks such as the filling in of certain function pass parameters required by the MacOS and the use of fishcamp defined driver constants are handled automatically for the user. Much of the time associated with documentation reference can thus be eliminated.

Second, the library provides additional high level routines which will greatly enhance the kinds of things which can be accomplished by the application without having to specifically write your own code to do it. For example, there are routines included to handle multiple FPCI-DIO cards plugged into a single computer as well as routines for detecting which slot a particular card is inserted.

The 'FPCIManager' library is designed as a Dynamic Link library which runs under Apple's implementation of IBM's SOMobjects™ on the Macintosh. SOMobjects™ is a multi-platform standard providing for system-level sharable objects in a language-neutral way. To take advantage of the routines provided for by the 'FPCIManager', you will have to have SOMobjects™ previously loaded on your computer. Apple has stated that SOMobjects™ will be supported under the next generation of operating system (code-named Copland) for the Mac. This should help preserve the user's investment in code which utilizes the 'FPCIManager' library.

The 'FPCIManager' makes all of its calls to the FPCI-DIO card hardware via the standard calls provided by the 'FPCIDioDrvr' code. The library routines never bypass the driver to write directly to the hardware.

A.6.2 FPCIManager Use

The development process of writing applications which utilize the 'FPCIManager' is very straight forward. Two files... 'FPCIManager.xh' and 'FPCIManager.idl' are included on the distribution disk. These two files and the 'FPCIManager' library itself are the only things needed. The 'FPCIManager.xh' file is a header file which you will need to include in your source code. It contains all of the function prototypes of the routines in the 'FPCIManager'. The 'FPCIManager.idl' file is the Interface Description Language (IDL) file used to build the 'FPCIManager' itself. While the actual source code to the 'FPCIManager' is not included on the disk, you can refer to this file for the routine calling conventions during your development cycle.

FPCIManager will support up to 12 fishcamp engineering PCI cards plugged into this computer.

A.6.3 FPCIManager Cookbook

This section of the manual will take you thru an example program of how to call the routines in the FPCIManager. The example is written in 'C++' and should compile under all of the popular development environments available for the MacOS.

The example makes use of the 'FPCIManager.xh' header file included on the distribution disk. In this file are defined constants and data structures that will be needed to utilize the driver calls. The user is encouraged to browse this file for more information on the FPCIManager interface.

The example program will make a call to each and every function implemented within the FPCIManager library.

On with the example...

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

#include "FPCIManager.xh"    // the C++ header file for the 'FPCIManager' library

//
// global flag to signal execution of the asynch I/O completion routine.
// The FPCIManager has a default completion routine which gets called
// after an asynchronous I/O transfer completes. The default routine
// does nothing and simply returns. We can specify our own completion
// routine which can do something usefull in our application by calling
// the FPCIManager _set_completionRoutine function. In this example
// program we simply set a flag signalling the completion of the data
// transfer. you may do other data processing functions in your own
// application
//

booleanDidCompletionRoutine;    // flag to signal end of data transfer
long    gActualTransferCount;   // actual number of byte transfered
                                   // during our asynchronous I/O transfer

//
// my own completion routine for asynch I/O. We will give the FPCIManager
// object a pointer to this routine so that it gets called after any I/O
// operation executed asynchronously.
//
void AsynchIOCompletionRoutine(ParmBlkPtr paramBlock)
{
    IOParam*    myParamBlkPtr;

    gDidCompletionRoutine = true;

    myParamBlkPtr = (IOParam*) paramBlock;
    gActualTransferCount = myParamBlkPtr->ioActCount;
}
```

```

//
// main program for our example application. The program will perform one
// each of every function implemented in the FPCIManager library. All
// result data is written to the std output window.
// This example was written with the MetroWerks development environment.
//

void main ( void )
{
    Environment      ev;
    long             numBoards = 0;
    boolean          isOurBoard = false;
    short            refnum = 0;
    OSErr            err = 0;
    FPCIManager      *obj;
    char             *slotName;
    long             aLong;
    long             actualTransferCount;
    long             timer;
    long             i;
    unsigned long     driverErrCode;
    long             aBuffer[1000];
    UniversalProcPtr  myIoCompletionRoutine;
    UniversalProcPtr  oldIoCompletionRoutine;
    boolean          done;
    CntrlParam        aCntrlParam;

    //
    // the following call is made to satisfy some general housekeeping
    // for the SOM environment.
    //
    SOM_InitEnvironment ( & ev );

    printf ("This project uses the SIOUX console library:\n");
    printf ("    choose 'Quit' from the file menu to quit.\n\n");

    //    allocate a FPCIManager object
    obj = new FPCIManager;
    if ( obj ) {

        //
        // find out how many of fishcamp engineering's boards are installed
        // in this computer. Right now the 'FPCIManager' only counts
        // FPCI-DIO type boards.
        numBoards = obj -> HowManyFishcampBoards( & ev );

        //
        // we will now find out how many FPCI-DIO type boards are installed in this computer
        numBoards = obj -> HowManyFPCIDioBoards( & ev );

        //

```

```

// check each of the three slots in this computer for a fishcamp engineering
// data acquisition board. The test is being run from a PowerMac 7500 which
// has three PCI slots. These slots are labeled 'A1', 'B1', and 'C1'.
isOurBoard = obj -> BoardIsFishcamps( & ev, "A1");
isOurBoard = obj -> BoardIsFishcamps( & ev, "B1");
isOurBoard = obj -> BoardIsFishcamps( & ev, "C1");

//
// now check the same three slots but look specifically for a FPCI-DIO card.
isOurBoard = obj -> BoardIsFPCIDio( & ev, "A1");
isOurBoard = obj -> BoardIsFPCIDio( & ev, "B1");
isOurBoard = obj -> BoardIsFPCIDio( & ev, "C1");

//
// The FPCIManager keeps track of the number of FPCI-DIO cards installed
// in this computer. We can query certain parameters of these boards
// by referring to them by their number. Board #1, Board #2, etc.
// in this example we find out the slot name that the first FPCI-DIO board
// (board #1) is plugged into.
err = obj -> GetThisFPCIDioBoardSlotName( & ev, 1, & slotName);

// we do the same query for FPCI-DIO board #2.
// Find out the slot name that the second FPCI-DIO board is plugged into.
err = obj -> GetThisFPCIDioBoardSlotName( & ev, 2, & slotName);

//
// try to open a FPCI-DIO card's driver. In this call the very first
// FPCI-DIO card that the FPCIManager detected is opened. This call is mostly
// usefull when only a sinf FPCI-DIO card is installed in the computer
// since in the case of multiple boards, you would want to be specific.
// in all cases, when we call one of the FPCIManager's routines which opens
// the driver for a particular card, the library routine will return a
// driver reference number (refnum). This is the same refnum that the MacOS
// returns to the library routine. All subsequent data transfer operations
// will specify this card by supplying this refnum back to the library function.
// you will therfore need to store this away in a variable for later use by
// you application.
err = obj -> OpenFirstFPCIDioBoard( & ev, & refnum);

//
// close the FPCI-DIO card's driver that we just opened. Normally you would
// open the driver for the card at the beginning of your application's code
// execution and then clos that driver befor you application terminates. We
// make this call here an an example only.
if (refnum != 0)
    err = obj -> CloseFPCIInterfaceBoard( & ev, & refnum);

//
// try to open the first FPCI-DIO card's driver. In this example we perform

```

```

// the same operation of opening the first card's driver but we use a call
// which allows us to be explicit about which board we want (board #1).
err = obj -> OpenThisFPCIDioBoard( & ev, 1, & refnum);

//
// again, we close the FPCI-DIO card's driver.
if (refnum != 0)
    err = obj -> CloseFPCIInterfaceBoard( & ev, & refnum);

//
// now try to open the second FPCI-DIO card's driver (board #2).
err = obj -> OpenThisFPCIDioBoard( & ev, 2, & refnum);

//
// close the FPCI-DIO card's driver
if (refnum != 0)
    err = obj -> CloseFPCIInterfaceBoard( & ev, & refnum);

//
// try to open the driver for the FPCI-DIO card in slot 'C1'. The following
// library call will open the card by specifying the slot name of the slot
// that the board is plugged into. In this case slot 'C1'.
err = obj -> OpenIntfcBoardSlotName( & ev, "C1", & refnum);

//
// close the FPCI-DIO card's driver
if (refnum != 0)
    err = obj -> CloseFPCIInterfaceBoard( & ev, & refnum);

//
// test the general I/O data transfer routine. we will first need to open the
// driver for the card we will use. In this case we simply specify the first
// card found by the FPCIManager.
err = obj -> OpenFirstFPCIDioBoard( & ev, & refnum);

//
// In our first data transfer example, we will write a long word value to the
// control register on the FPCI-DIO card. The control register is used primarily
// for setting the direction of the signal lines on the port signals. Upon
// power-up reset, or whenever the driver is opened, the control register will
// be cleared thus specifying a direction of 'Input' for all signal lines.
// We will write a value of 0x0000000f to this port. The 'f' value specifies
// that all four bytes within port 0 will be used as output signals.
//
// The DoFPCIDrvrIO function call is a general purpose call... we specify all
// of the specifics of the data transfer via routine parameters. The following
// parameters will need to be defined in this call:

```

```

//
// Function prototype:
//     short  DoFPCIDrvrIO( Environment *ev,
//                           short refnum,
//                           boolean isInput,
//                           unsigned long portNumber,
//                           char* dataBufferPtr,
//                           long transferCount,
//                           long* actualTransferCount,
//                           boolean asynch,
//                           long updateDelay);
//
//
// *ev          - value returned by the call to SOM_InitEnvironment
// refnum       - value returned from the call to open the card's driver
// isInput      - true to transfer data FROM the application TO the card
//               false to transfer data FROM the card TO the application
// portNumber   - The destination address of the data. Valid addresses
//               are defined as follows:
//               Defined board addresses:
//               #definekFPCI_DIO_Port0    0x8000
//               #definekFPCI_DIO_Port1    0x8010
//               #definekFPCI_DIO_Port2    0x8020
//               #definekFPCI_DIO_Cntrl    0xC000
// dataBufferPtr - The data buffer used to store the data to be transfered.
//               This buffer will hold the data to be writtin on OUTPUT
//               operations, and will receive the data being read on INPUT
// transferCount - The number of BYTES you wish to transfer. Remeber that
//               the FPCI-DIO card only allows long word transfers so this
//               value must be a multiple of four bytes.
// actualTransferCount - This variable will return the actual number of bytes
//               transfered during this operation. normally this number
//               will contain the same number specified in the 'transferCount'
//               parameter. It will be difference if an error was encountered
//               during the excecution of the call.
// asynch       - Boolean to specify asynchronous or synchronous I/O. Pass
//               true to specify asynchronous I/O transfers.
// updateDelay  - For transfers of data buffers of more than a single long-word,
//               the application can specify the time between consecutive
//               transfers. This parameter is used and is specified in
//               nanoseconds.
//
aLong = 0x0f; // set port 0 to outputs
err = obj -> DoFPCIDrvrIO( & ev,
                           refnum,          /* from previous open command */
                           false,            /* Input, output */
                           0x0C000,         /* FPCI-DIO control register number */
                           (char*)&aLong,   /* User data buffer */
                           4,               /* desired transfer count in bytes */
                           &actualTransferCount,
                           false,           /* TRUE if we want this to be an
                                           asynchronous operation */
                           0,               /* # Nanoseconds between data
                                           transfer operations */
                           );

```

```

//
// we now make the same call to write some data to port 0. we only change
// the 'portNumber' value to the address of port 0.
// output a value to port 0
aLong = 0x01;           // value to output
err = obj -> DoFPCIDrvrIO( & ev,
                           refnum,           /* from previous open command */
                           false,            /* Input, output */
                           0x8000,          /* FPCI-DIO port 0 register */
                           (char*)&aLong,   /* User data buffer */
                           4,               /* desired transfer count in bytes */
                           &actualTransferCount,
                           false,          /* TRUE if we want this to be an
                                           asynchronous operation */
                           0                /* # Nanoseconds between data
                                           transfer operations */
                           );

//
// The above calls were made synchronously. We will now try transferring
// a large data buffer and do it asynchronously. We will do this to show
// asynchronous operation with a completion routine specified in our program
// as well as utilizing the 'updateDelay' parameter to time consecutive words
// sent to the port.
//
// try an asynchronous routine with a long buffer and a delay between updates.
for (i = 0; i < 1000; i++)
    aBuffer[i] = i;           // setup some test data (1000 bytes worth)

//
// save a reference to the default completion routine incase we need to restore it.
oldIoCompletionRoutine = (UniversalProcPtr)obj -> _get_completionRoutine( & ev);

//
// setup my own I/O completion routine so I know when the operation is done.
myIoCompletionRoutine = NewIOCompletionProc(AsynchIOCompletionRoutine);
obj -> _set_completionRoutine( & ev, (Ptr)myIoCompletionRoutine);

gDidCompletionRoutine = false; // semaphore to signal end of I/O operation
                               // my completion routine will set this flag
                               // when it gets called.

err = obj -> DoFPCIDrvrIO( & ev,
                           refnum,           /* from previous open command */
                           false,            /* Input, output */
                           0x8000,          /* FPCI-DIO register number */
                           (char*)&aBuffer[0], /* User data buffer or NULL */
                           1000,            /* desired transfer count in bytes */
                           &actualTransferCount,
                           true,            /* TRUE if we want this to be an
                                           asynchronous operation */
                           10000000         /* # Nanoseconds between data
                                           transfer operations. In this

```



```

                                an asynchronous operation      */
                                /* # Nanoseconds between data
                                transfer operations             */
                                0
                                );

//
// get the error code. The codes returned here are those documented in the
// driver documentation
driverErrCode = obj -> GetDriverErrorCode( & ev, refnum);

err = obj -> CloseFPCIInterfaceBoard( & ev, & refnum);

//
// the next group of calls will perform simple synchronous I/O calls by explicitly calling
// a read or a write function for the defined registers on the FPCI-DIO card.
err = obj -> OpenFirstFPCIDioBoard( & ev, & refnum);

aLong = 0x01;      // some data value to write

//
// a simple write buffer function
err = obj -> FPCIDioWrBuffer(& ev, refnum, 0x8000, (char*)&aLong, 4, 0);

//
// a simple read buffer function
err = obj -> FPCIDioRdBuffer(& ev, refnum, 0x8000, (char*)&aLong, 4, 0);

//
// a simple write control register function
obj -> FPCIDioWrCntrlReg(& ev, refnum, 0xffff);

//
// a simple read control register function
aLong = obj -> FPCIDioRdCntrlReg(& ev, refnum);

//
// a simple write port 0 register function
obj -> FPCIDioWrPort0(& ev, refnum, 0x11111111);

//
// a simple read port 0 register function
aLong = obj -> FPCIDioRdPort0(& ev, refnum);

//
// a simple write port 1 register function
obj -> FPCIDioWrPort1(& ev, refnum, 0x22222222);

//
// a simple read port 1 register function
aLong = obj -> FPCIDioRdPort1(& ev, refnum);

//

```

```

// a simple write port 2 register function
obj -> FPCIDioWrPort2(& ev, refnum, 0x33333333);

//
// a simple read port 2 register function
aLong = obj -> FPCIDioRdPort2(& ev, refnum);

err = obj -> CloseFPCIInterfaceBoard( & ev, & refnum);

// test the PCI specific routines
err = obj -> OpenFirstFPCIDioBoard( & ev, & refnum);

err = obj -> FPCIConfigReadLong( & ev, refnum, 0x30, &anUnsignedLong);

err = obj -> FPCIConfigWriteLong( & ev, refnum, 0x30, anUnsignedLong);

err = obj -> CloseFPCIInterfaceBoard( & ev, & refnum);


// perform some housekeeping before the application terminates.
obj -> somFree ();
}

SOM_UninitEnvironment ( & ev );

printf ("Program execution complete!\n\n");
}

```

FPCI-DIO Specifications

General:

Card form factor	4.25" X 7" PCI card
Operating temperature	0 to 70 degrees Celsius
Storage temperature	-55 to 150 degrees Celsius
Operating humidity	5% to 90%, non-condensing

PCI Local Bus:

PCI Bus vendor ID	1230 ₁₆
PCI Bus Device ID	0001 ₁₆
Transfer Types	Slave Only
Local Bus FIFO depth	16 long-words
I/O port data path width	32 bits
Expansion ROM bus width	8 bits
Byte Lane Alignment	Little Endian

Power Requirement:

Supply Voltage	+5 VDC ($\pm 5\%$)
Current Consumption	870 mA

Customer I/O:

Number of channels	96 Total signals organized into 3 - 32 bit ports
Data direction control	Independent direction control for each byte lane
Data transfer	Programmed I/O
Maximum data transfer rate	9 Mbytes/sec
Interface connectors	50 pin ribbon cable headers with .1" pin centers
Power Available @ I/O Connector	+5 VDC ($\pm 10\%$) fused @ 1 A
+5 volt fuse trip current	2.2 Amps
+5 volt fuse hold current	1.1 Amps
Logic Levels	TTL

Level	Minimum	Typical	Maximum
Input low voltage	-0.3 V	-	+0.8 V
Input high voltage	+2.0 V	-	+5.5 V
Output low voltage (I _{out} = 12 mA)	-	0.25	+0.4 V
(I _{out} = 24 mA)	-	0.35	+0.5 V
Output high voltage (I _{out} = -3.0 mA)	+2.4 V	3.2	-
(I _{out} = -15 mA)	+2.0 V		-



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