PIO-D144

User's Manual

Warranty

All products manufactured by ICP DAS are warranted against defective materials for a period of one year from the date of delivery to the original purchaser.

Warning

ICP DAS assume no liability for damages consequent to the use of this product. ICP DAS reserves the right to change this manual at any time without notice. The information furnished by ICP DAS is believed to be accurate and reliable. However, no responsibility is assumed by ICP DAS for its use, nor for any infringements of patents or other rights of third parties resulting from its use.

Copyright

Copyright © 1999 by ICP DAS. All rights are reserved.

Trademark

The names used for identification only maybe registered trademarks of their respective companies.

Tables of Contents

1. Introduction

The PIO-D144 consists of one DB-37 & five 50-pin flat-cable connectors. There are three 8-bit port, PA, PB & PC in each connector. Every port consists of 8-bit programmable D/I/O. So the PIO-D144 can provide 144 channels of TTL-compatible D/I/O.

1.1 specifications

- PC compatible PCI bus
- One DB-37 connector and five 50-pin flat-cable connectors
- Each port consists of three 8-bit port, PA, PB & PC in every connector
- Each port can be programmed as D/I or D/O independently.
- Each board = 6 connector = 6×3 port = 6×3×8 bit =144 bit
- 4 interrupt sources: PC0,PC1,PC2,PC3
- **All signals are TTL compatible**
- Operating Temperature: 0°C to 60°C
- Storage Temperature: -20°C to 80°C
- Humility: 0 to 90% non-condensing
- Dimension: 180mm X 105mm
- Power Consumption: +5V @ 1100mA

1.2 Product Check List

In addition to this manual, the package includes the following items:

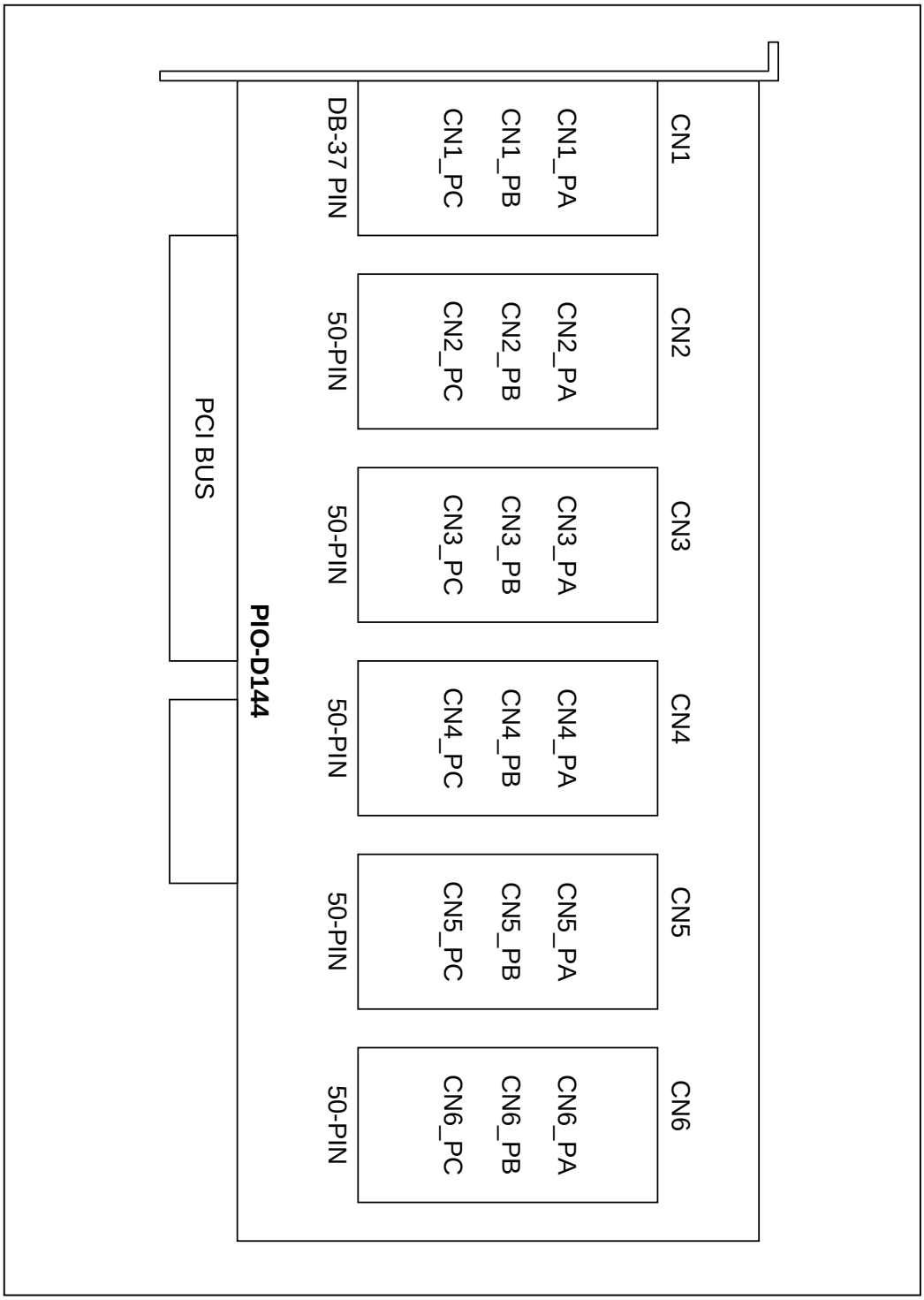
- PIO-D144 card
- Demo program diskette

Attention !

If any of this items is missing or damaged, contact the dealer from whom you purchased the product. Save the shipping materials and carton in case you want to ship or store the product in the future.

2. Hardware configuration

2.1 Board Layout



2.2 I/O Port Location

There are eighteen 8-bit I/O ports in the PIO-D144. Every I/O port can be programmed as D/I or D/O port. When the PC is first power-on, all eighteen ports are used as D/I port. The I/O port location is given as following:

Connector of PIO-D144	PA0 to PA7	PB0 to PB7	PC0 to PC7
CN1	CN1_PA	CN1_PB	CN1_PC
CN2	CN2_PA	CN2_PB	CN2_PC
CN3	CN3_PA	CN3_PB	CN3_PC
CN4	CN4_PA	CN4_PB	CN4_PC
CN5	CN5_PA	CN5_PB	CN5_PC
CN6	CN6_PA	CN6_PB	CN6_PC

Refer to Sec. 2.1 for board layout & I/O port location.

Note: PC0, PC1, PC2, PC3 of CN1 can be used as interrupt signal source. Refer to Sec. 2.5 for more information.

2.3 Enable I/O Operation

When the PC is first power-on, all operation of D/I/O port are disable. The enable/disable of D/I/O is controlled by the RESET\ signal. Refer to Sec. 3.3.1 for more information about RESET\ signal. The power-on states are given as following:

- All D/I/O operations are disable
- All eighteen D/I/O ports are configured as D/I port
- All D/O latch register are undefined.(refer to Sec. 2.4)

The user has to perform some initialization before using these D/I/O. The recommended steps are given as following:

Step 1: Make sure which ports are D/O ports.

Step 2: Enable all D/I/O operation.(refer to Sec. 3.3.1).

Step 3: Select the active port (refer to Sec. 3.3.8).

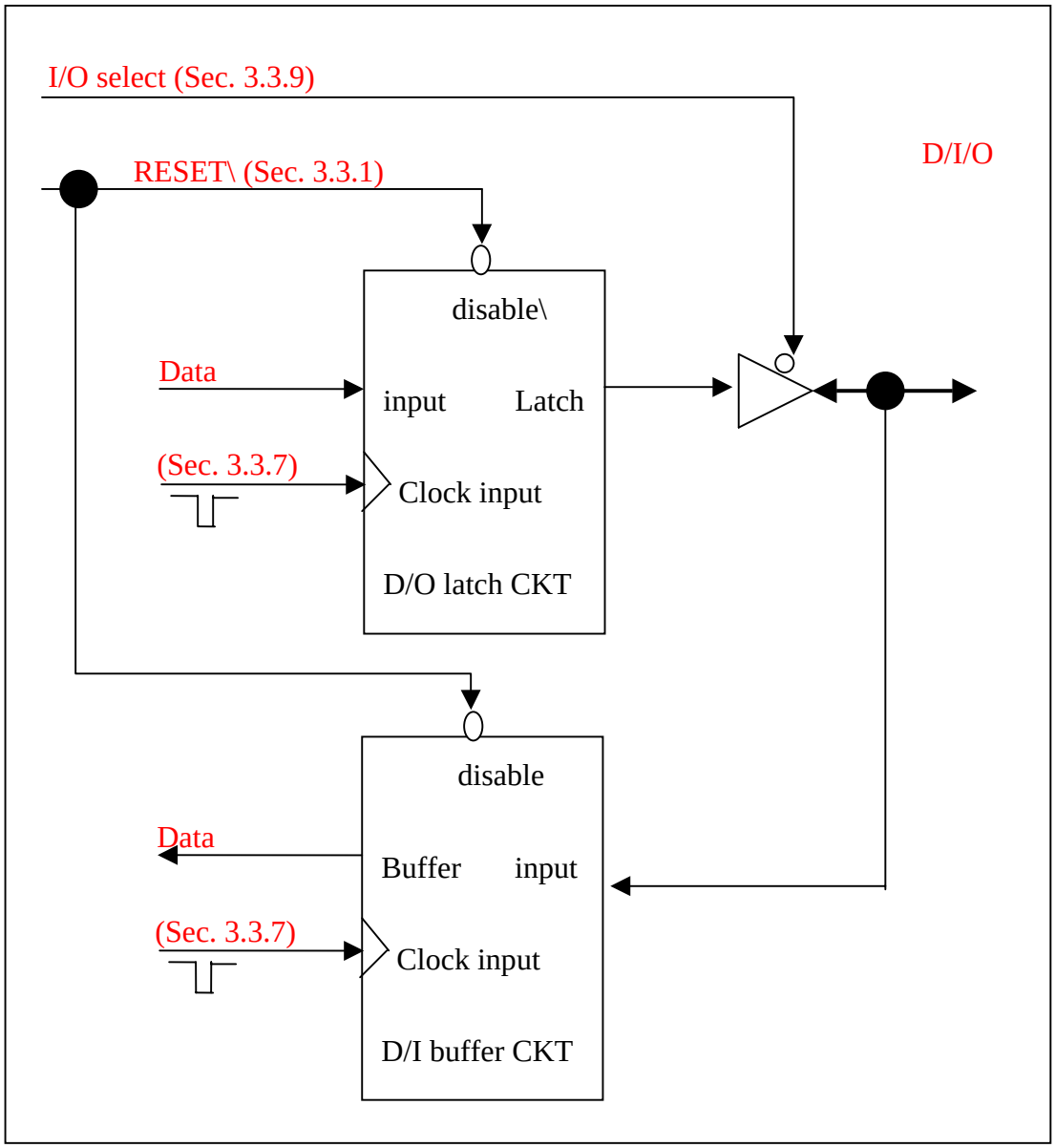
Step 4: Send initial-value to the D/O latch register of this active port. (Refer to Sec. 2.4 & Sec. 3.3.7)

Step 5: Repeat Step3 & Step4 for all D/O ports

Step 6: Configure all eighteen D/I/O ports to their expected D/I or D/O state. (Refer to Sec. 3.3.9)

Refer to DEMO1.C for demo program.

2.4 D/I/O Architecture



- The RESET\ is in Low-state → all D/I/O operation is disable
- The RESET\ is in High-state → all D/I/O operation is enable.
- If D/I/O is configured as D/I port → D/I=external input signal
- If D/I/O is configured as D/O port → D/I = read back of D/O
- If D/I/O is configured as D/I port → send to D/O will change the D/O latch register only. The D/I & external input signal will not change.

2.5 Interrupt Operation

The PC0, PC1, PC2, PC3 of CN1_PC can be used as interrupt signal source. Refer to Sec. 2.1 for PC0/1/2/3 location. The interrupt of PIO-D144 is **level-trigger & Active_High**. The interrupt signal can be **inverted or non-inverted** programmable. The procedures of programming are given as follows:

1. make sure **the initial level is High or Low**
2. if the initial state is High → select the **inverted** signal (Section. 3.3.6)
3. if the initial state is Low → select the **non-inverted** signal (Section. 3.3.6)
4. enable the INT function (Section. 3.3.4)
5. If the interrupt signal is active → program will transfer into the interrupt service routine → **if INT signal is High now → select the inverted input**
   → if INT signal is Low now → select the non-inverted input

Refer to DEMO3.C & DEMO4.C for single interrupt source. Refer to DEMO5.C for four interrupt sources.

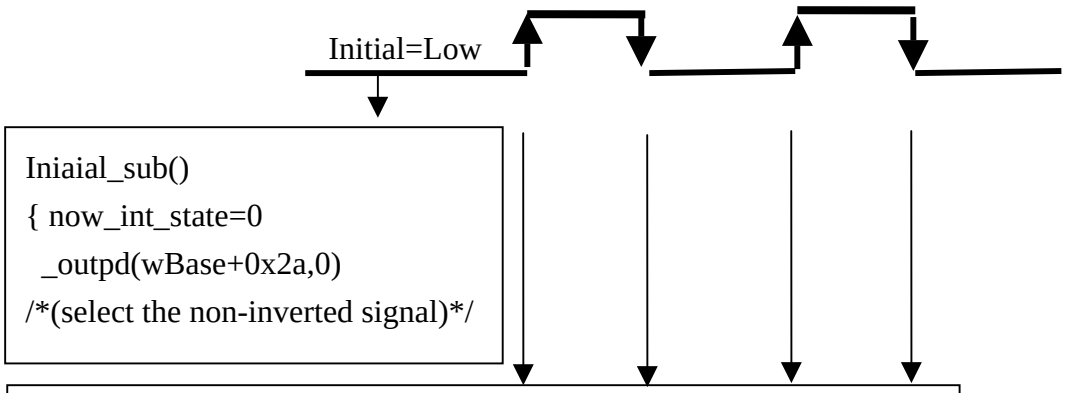
If only one interrupt signal source is used, the interrupt service routine does not have to identify the interrupt source. (Refer to DEMO3.C & DEMO4.C)

If there are more than one interrupt source, the interrupt service routine has to identify the active signals as following: (refer to DEMO5.C)

1. Read the new status of the interrupt signal source
2. Compare the new status with the old status to identify the active signals
3. If PC0 is active, service CN1_PC0 & non-inverter/inverted the CN1_PC0 signal
4. If PC1 is active, service CN1_PC1 & non-inverted/inverted the CN1_PC1 signal
5. If PC2 is active, service CN1_PC2 & non-inverted/inverted the CN1_PC2 signal
6. If PC3 is active, service CN1_PC3 & non-inverted/inverted the CN1_PC3 signal
7. Save the new status to old status

Limitation: if the interrupt signal is too short, the new status may be as same as old status. So the interrupt signal must be hold-active until the interrupt service routine is executed. This hold time is different for different O.S. The hold time can be as short as micro-second or as long as second. In general, 20ms is enough for all O.S.

Example 1: assume initial level=Low, PC0 is used as interrupt source:

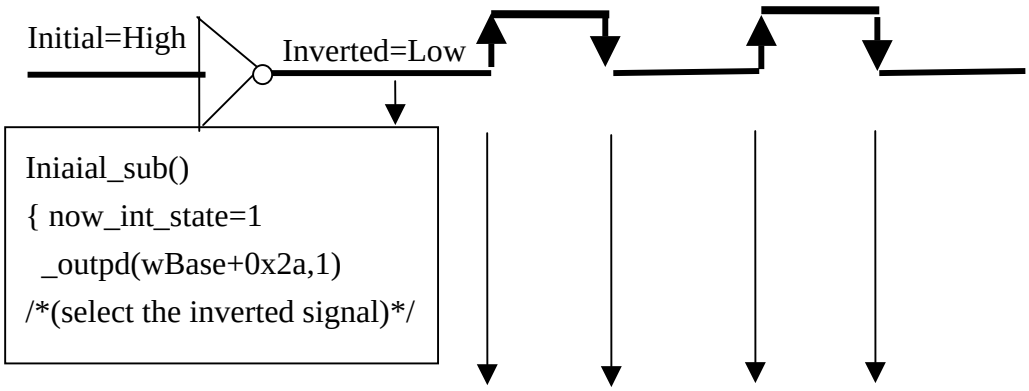



```
Iniaial_sub()
{ now_int_state=0
  _outpd(wBase+0x2a,0)
/*(select the non-inverted signal)*/
```

```
ISR_sub()
{
If (now_int_state==0) /* old state=low → change to high now */
   {
    now_int_state=1;        /* now int_signal is High          */

  /*** application codes are given here ***/

   _outpd(wBase+0x2a,1);      /* select the inverted signal        */
   }
else                          /* old state=high→ change to low now  */
   {
    now_int_state=0;              /* now int_signal is Low          */

/*** application codes are given here ***/

   _outpd(wBase+0x2a,0);      /* select the non-inverted signal */
   }

if (wIrq>=8) outp(A2_8259,0x20);     /*  EOI  */
outp(A1_8259,0x20);                  /*  EOI  */
}
```

Refer to DEMO3.C for source code.

Example 2: assume initial level=High, PC0 is used as interrupt source:

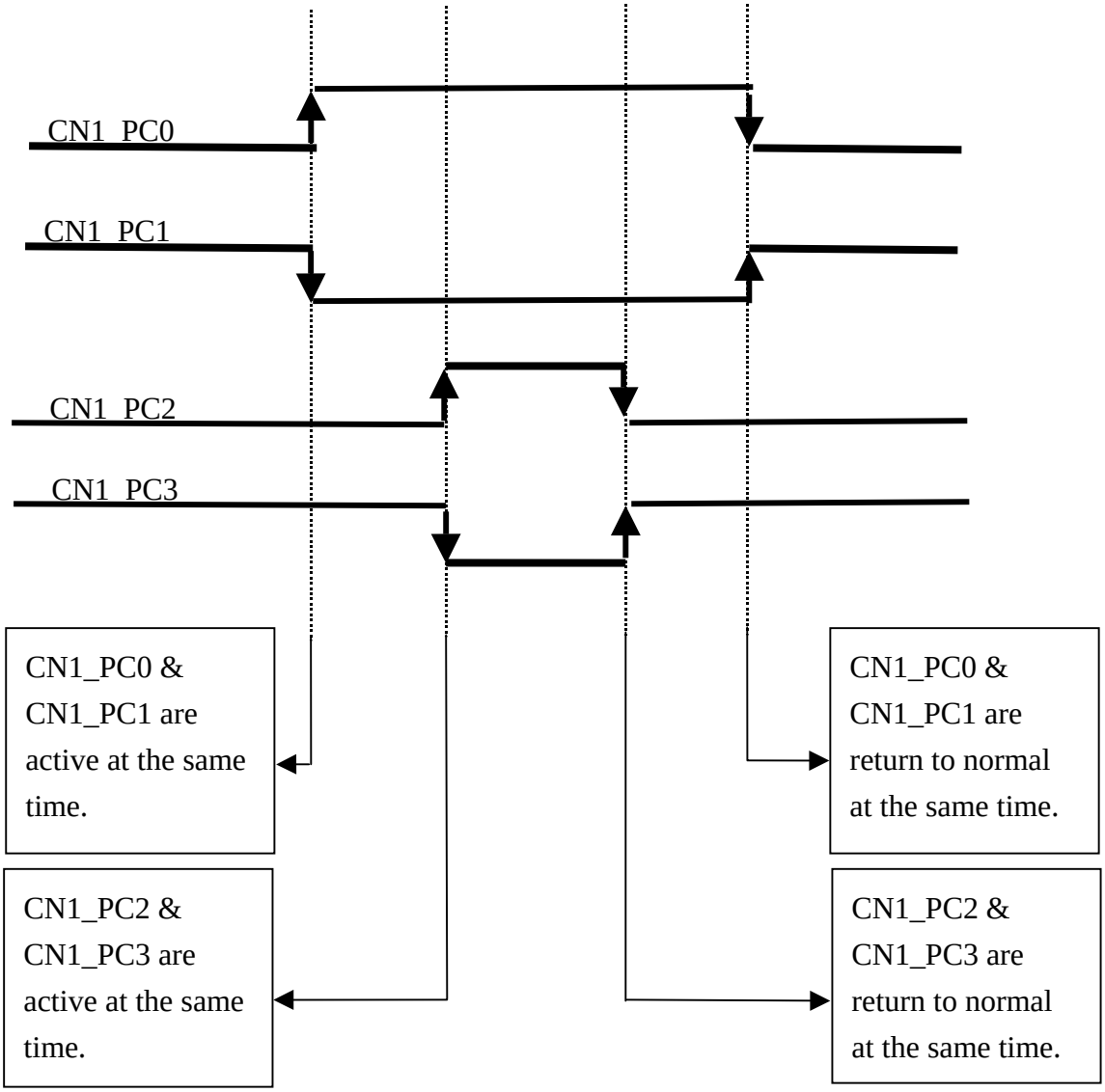



```
ISR_sub()
{
If (now_int_state==0) /* old state=low → change to high now */
  {
   now_int_state=1;       /* now int_signal is High          */

  /*** application codes are given here ***/

  _outpd(wBase+0x2a,1);      /* select the inverted signal        */
  }
else                         /* old state=high→ change to low now  */
  {
   now_int_state=0;              /* now int_signal is Low          */

/*** application codes are given here ***/

  _outpd(wBase+0x2a,0);      /* select the non-inverted signal */
  }

if (wIrq>=8) outp(A2_8259,0x20);     /*  EOI  */
outp(A1_8259,0x20);                  /*  EOI  */
}
```

Refer to DEMO4.C for source code.

Example 3: assume CN1_PC0 is initial Low, active High,
CN1_PC1 is initial High, active Low
CN1_PC2 is initial Low, active High
CN1_PC3 is initial High, active Low

As follows:



Refer to DEMO5.C for source program. **All these four falling-edge & rising-edge can be detected by DEMO5.C.**

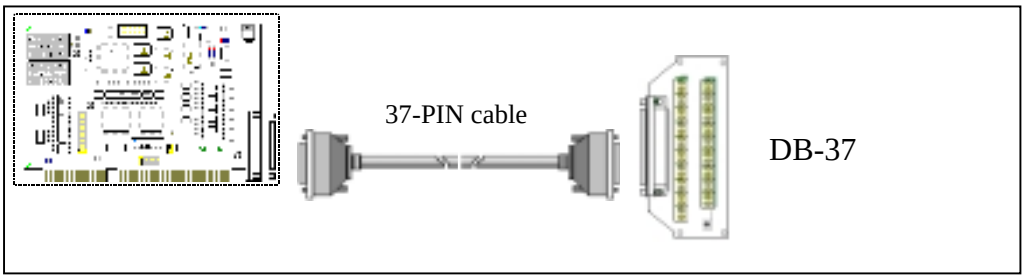
Note: when the interrupt is active, the user program has to identify the active signals. These signals maybe active at the same time. So the interrupt service routine has to service all active signals at the same time.

```
void interrupt irq_service()
{
 char cc;
 int_num++;
 /* 1. Read interrupt signal status */
 new_int_state=inp(wBase+0x07)&0xff;

/* 2. Find the active signal       */
int_c=new_int_state ^ now_int_state;

/* 3. IF PC0 is active             */
if ((int_c&0x01) != 0)
  {
  cc=new_int_state&0x01;
  if (cc !=0) CNT_H1++; else CNT_L1++;
  invert=invert ^ 1;
  }

/* 4. IF PC1 is active             */
if ((int_c&0x02) != 0)
  {
  cc=new_int_state&0x02;
  if (cc !=0) CNT_H2++; else CNT_L2++;
  invert=invert ^ 2;
  }

/* 5. IF PC2 is active             */
if ((int_c&0x04) != 0)
  {
  cc=new_int_state&0x04;
  if (cc !=0) CNT_H3++; else CNT_L3++;
  invert=invert ^ 4;
  }

/* 6. IF PC3 is active             */
if ((int_c&0x08) != 0)
  {
  cc=new_int_state&0x08;
  if (cc !=0) CNT_H4++; else CNT_L4++;
  invert=invert ^ 8;
  }

now_int_state=new_int_state;
outp(wBase+0x2a,invert);

if (wIrq>=8) outp(A2_8259,0x20);
outp(A1_8259,0x20);
}
```

2.6 Daughter Boards

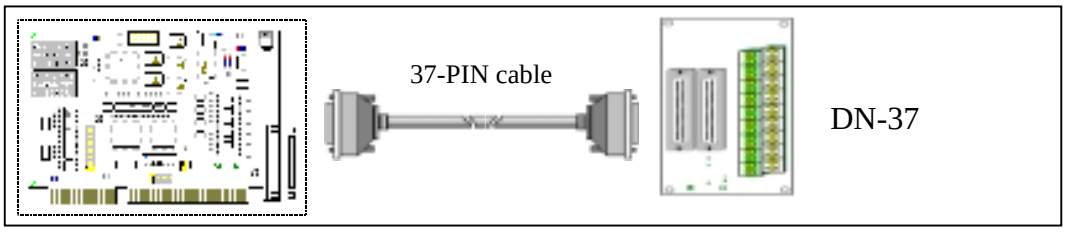
2.6.1 DB-37

The DB-37 is a general purpose daughter board for D-sub 37 pins. It is designed for easy wire connection.



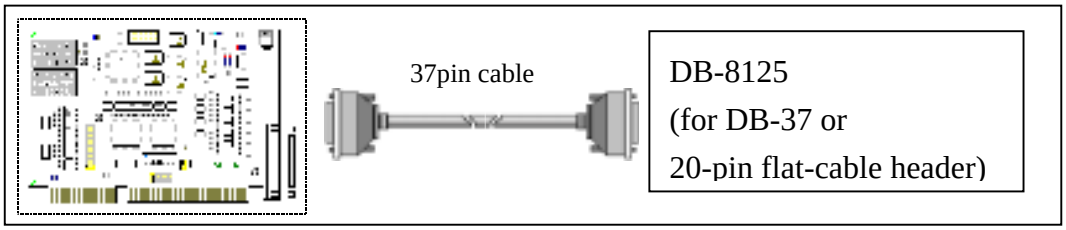
2.6.2 DN-37 & DN-50

The DN-37 is a general purpose daughter board for DB-37 with DIN-Rail Mounting. The DN-50 is designed for 50-pin flat-cable header. They are designed for easy wire connection. Both have Din-Rail mounting.



2.6.3 DB-8125

The DB-8125 is a general purpose screw terminal board. It is designed for easy wire connection. There are one DB-37 & two 20-pin flat-cable header in the DB-8125.



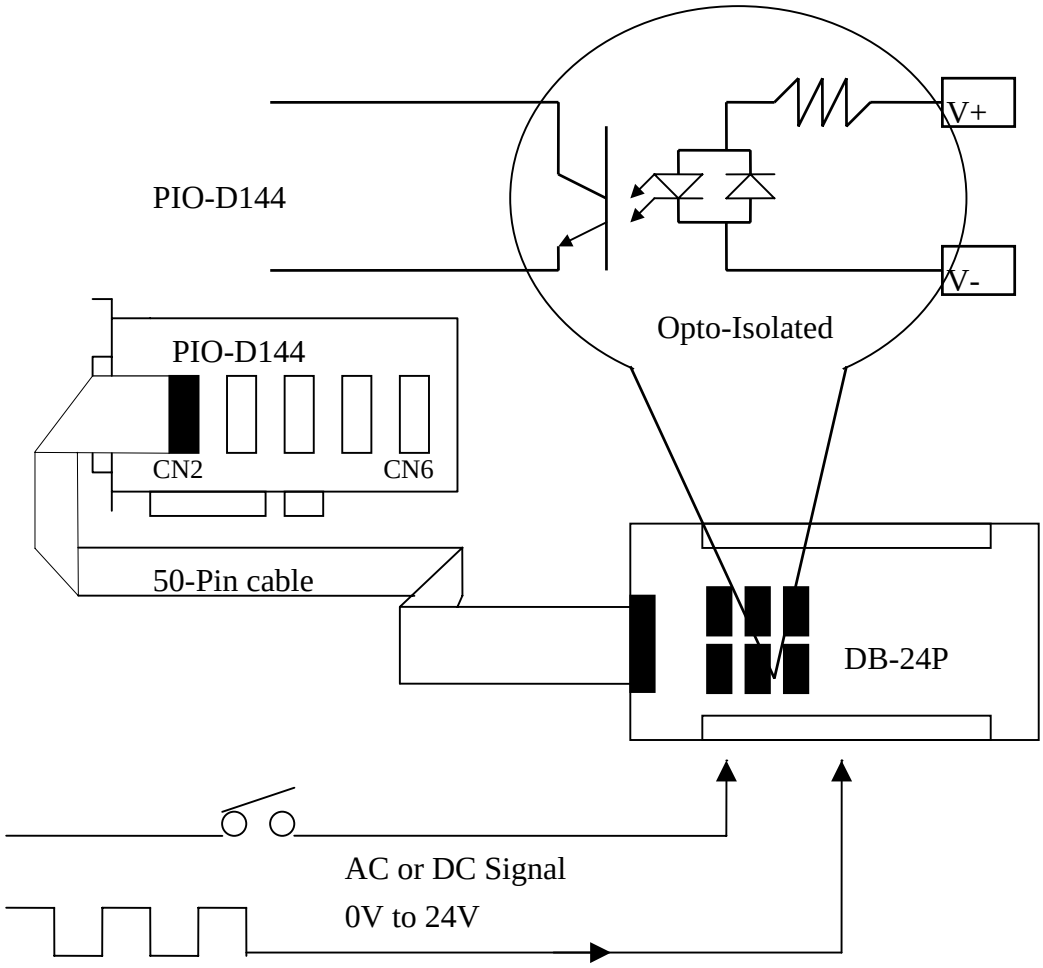
2.6.4 ADP-37/PCI & ADP-50/PCI

The ADP-37/PCI & ADP-50/PCI are extender for 50-pin header. One side of ADP-37/PCI & ADP-50/PCI can be connected to a 50-pin header. The other side can be mounted on the PC chassis as following:

ADP-37/PCI: 50-pin header to DB-37 extender.
ADP-50/PCI: 50-pin header to 50-pin header extender.

2.6.5 DB-24P, DB-24PD Isolated Input Board

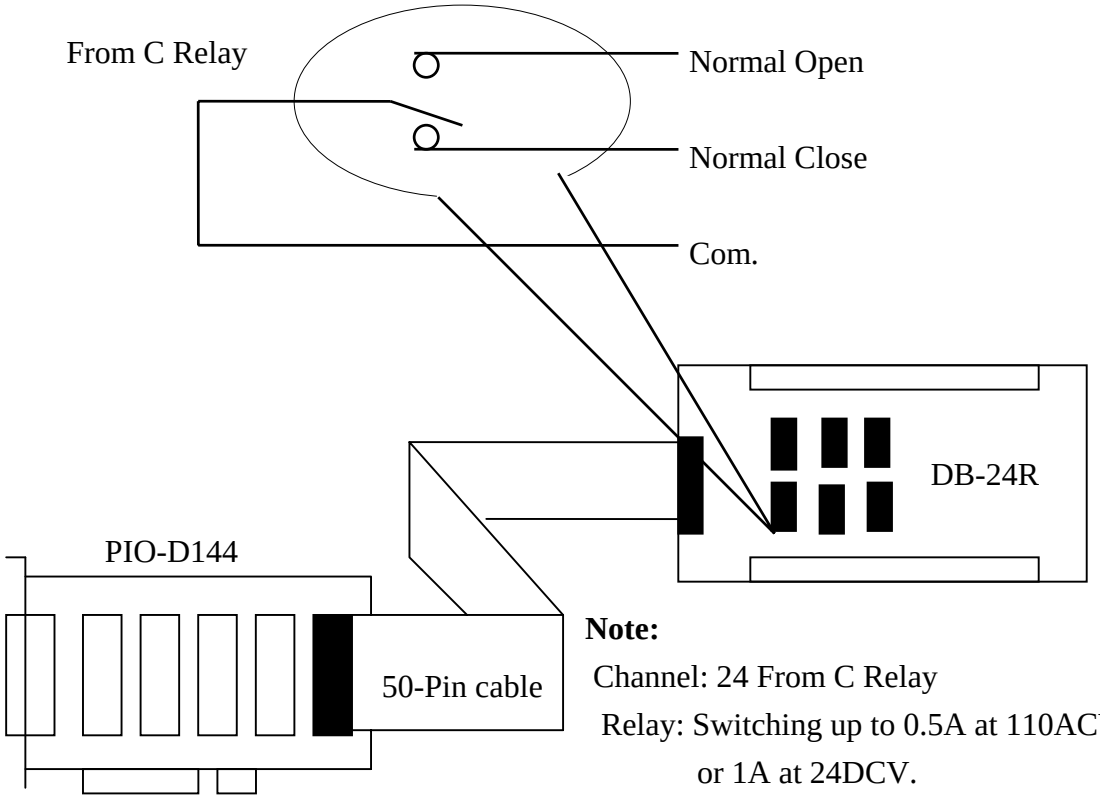
The DB-24P is a 24-channel isolated digital input daughter board. The optically isolated inputs of the DB-24P consists of a bi-directional optocoupler with a resistor for current sensing. You can use the DB-24P to sense DC signal from TTL levels up to 24V or use the DB-24P to sense a wide range of AC signals. You can use this board to isolated the computer from large common-mode voltage, ground loops and transient voltage spike that often occur in industrial environments.



	DB-24P	DB-24PD
50-pin flat-cable header	Yes	Yes
D-sub 37-pin header	No	Yes
Other specifications	Same	

2.6.6 DB-24R, DB-24RD Relay Board

The DB-24R, 24-channel relay output board, consists of 24 form C relays for efficient switch of load by programmed control. The relay are energized by apply 12V/24V voltage signal to the appropriated relay channel on the 50-pin flat connector. There are 24 enunciator LED's for each relay, light when their associated relay is activated.



Note:
Channel: 24 From C Relay
Relay: Switching up to 0.5A at 110ACV or 1A at 24DCV.

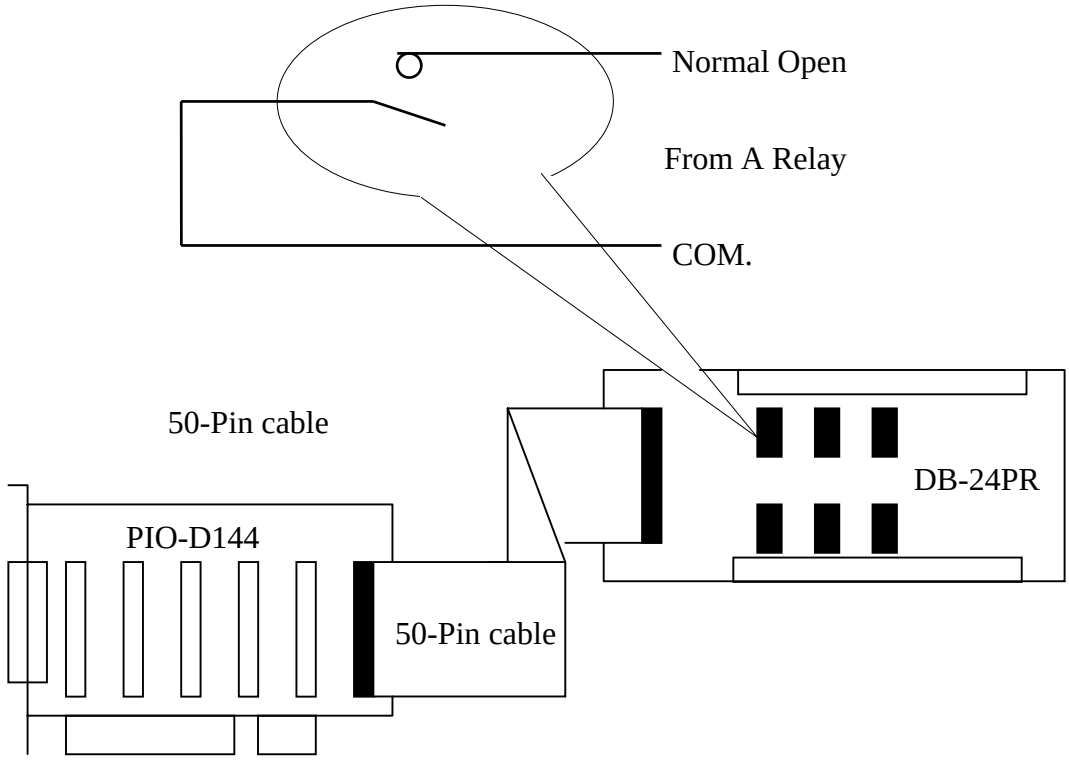
	DB-24R	DB-24RD
50-pin flat-cable header	Yes	Yes
D-sub 37-pin header	No	Yes
Other specifications	Same	

DB-24R, DB-24RD	24 × Relay (120V, 0.5A)
DB-24PR,DB-24PRD	24 × Power Relay (250V, 5A)
DB-24POR	24 × Photo MOS Relay (350V, 01.A)
DB-24SSR	24 × SSR (250VAC, 4A)
DB-24C	24 × O.C. (30V, 100 mA)
DB-16P8R	16 × Relay (120V, 0.5A) + 8 × isolated input

2.6.7 DB-24PR, DB-24POR, DB-24C

DB-24PR	24 × power relay, 5A/250V
DB-24POR	24 × Photo MOS relay, 0.1A/350VAC
DB-24C	24 × open collector, 100mA per channel, 30V max.

The DB-24PR, 24-channel power relay output board, consists of 8 form C and 16 form A electromechanical relays for efficient switching of load programmed control. The contact of each relay can control a 5A load at 250ACV/30VDCV. The relay is energized by applying a 5 voltage signal to the appropriate relay channel on the 20-pin flat cable connector(just used 16 relays) or 50-pin flat cable connector.(OPTO-22 compatible, for DIO-24 series). Twenty - four enunciator LEDs, one for each relay, light when their associated relay is activated. To avoid overloading your PC's power supply , this board needs a +12VDC or +24VDC external power supply.



Note: 50-Pin connector(OPTO-22 compatible), for DIO-24, DIO-48, DIO-144, PCI-D144, PIO-D144, PIO-D96, PIO-D56, PIO-D48, PIO-D24
20-Pin connector for 16 channel digital output, A-82X, A-62X, DIO-64, ISO-DA16/DA8
Channel: 16 Form A Relay , 8 Form C Relay.
Relay: switching up to 5A at 110ACV / 5A at 30DCV.

2.6.8 Daughter Board Comparison Table

	20-pin flat-cable	50-pin flat-cable	D-sub 37-pin
DB-37	No	No	Yes
DN-37	No	No	Yes
ADP-37/PCI	No	Yes	Yes
ADP-50/PCI	No	Yes	No
DB-24P	No	Yes	No
DB-24PD	No	Yes	Yes
DB-16P8R	No	Yes	Yes
DB-24R	No	Yes	No
DB-24RD	No	Yes	Yes
DB-24C	Yes	Yes	Yes
DB-24PR	Yes	Yes	No
Db-24PRD	No	Yes	Yes
DB-24POR	Yes	Yes	Yes
DB-24SSR	No	Yes	Yes

2.7 Pin Assignment

CN1: 37-PIN of D-type female connector.

Pin Number	Description	Pin Number	Description
1	N. C.	20	VCC
2	N. C.	21	GND
3	PB7	22	PC7
4	PB6	23	PC6
5	PB5	24	PC5
6	PB4	25	PC4
7	PB3	26	PC3
8	PB2	27	PC2
9	PB1	28	PC1
10	PB0	29	PC0
11	GND	30	PA7
12	N.C.	31	PA6
13	GND	32	PA5
14	N.C.	33	PA4
15	GND	34	PA3
16	N.C.	35	PA2
17	GND	36	PA1
18	VCC	37	PA0
19	GND	XXXXXXX	This pin not available

All signals are TTL compatible.

CN2/CN3/CN4/CN5/CN6: 50-PIN in of flat-cable connector

Pin Number	Description	Pin Number	Description
1	PC7	2	GND
3	PC6	4	GND
5	PC5	6	GND
7	PC4	8	GND
9	PC3	10	GND
11	PC2	12	GND
13	PC1	14	GND
15	PC0	16	GND
17	PB7	18	GND
19	PB6	20	GND
21	PB5	22	GND
23	PB4	24	GND
25	PB3	26	GND
27	PB2	28	GND
29	PB1	30	GND
31	PB0	32	GND
33	PA7	34	GND
35	PA6	36	GND
37	PA5	38	GND
39	PA4	40	GND
41	PA3	42	GND
43	PA2	44	GND
45	PA1	46	GND
47	PA0	48	GND
49	VCC	50	GND

3. I/O Control Register

3.1 How to Find the I/O Address

The plug&play BIOS will assign a proper I/O address to every PIO/PISO series card in the power-on stage. The fixed IDs of PIO/PISO series card are given as following:

- **Vendor ID = E159**
- **Device ID = 0002**

The sub IDs of **PIO-D144** are given as following:

- **Sub-Vendor ID= 80**
- **Sub-Device ID = 01**
- **Sub-Aux ID = 00**

We provide all necessary functions as following:

1. **PIO_DriverInit(&wBoard, wSubVendor, wSubDevice, wSubAux)**
2. **PIO_GetConfigAddressSpace(wBoardNo,*wBase,*wIrq, *wSubVendor, *wSubDevice, *wSubAux, *wSlotBus, *wSlotDevice)**
3. **Show_PIO_PISO(wSubVendor, wSubDevice, wSubAux)**

All functions are defined in PIO.H. Refer to Chapter 4 for more information. The important driver information is given as following:

1. Resource-allocated information:

- wBase : BASE address mapping in this PC
- wIrq: IRQ channel number allocated in this PC

2. PIO/PISO identification information:

- wSubVendor: subVendor ID of this board
- wSubDevice: subDevice ID of this board
- wSubAux: subAux ID of this board

3. PC's physical slot information:

- wSlotBus: hardware slot ID1 in this PC's slot position
- wSlotDevice: hardware slot ID2 in this PC's slot position

The utility program, **PIO_PISO.EXE**, will detect & show all PIO/PISO cards installed in this PC.

The Sub IDs of PIO/PISO series card are given as follows:

PIO/PISO series card	Description	Sub_vendor	Sub_device	Sub_AUX
PIO-D144	144 × D/I/O	80	01	00
PIO-D96	96 × D/I/O	80	01	10
PIO-D64	64 × D/I/O	80	01	20
PIO-D56	24 × D/I/O + 16 × D/I + 16*D/O	80	01	40
PIO-D48	48 × D/I/O	80	01	30
PIO-D24	24 × D/I/O	80	01	40
PIO-823	Multi-function	80	03	00
PIO-821	Multi-function	80	03	10
PIO-DA16	16 × D/A	80	04	00
PIO-DA8	8 × D/A	80	04	10
PIO-DA4	4 × D/A	80	04	20
PISO-C64	64 × isolated D/O	80	08	00
PISO-P64	64 × isolated D/I	80	08	10
PISO-P32C32	32 + 32	80	08	20
PISO-P8R8	8 × isolated D/I + 8 × 220V relay	80	08	30
PISO-P8SSR8AC	8 × isolated D/I + 8 × SSR /AC	80	08	30
PISO-P8SSR8DC	8 × isolated D/I + 8 × SSR /DC	80	08	30
PISO-730	16 × DI + 16 ×D/O + 16 × isolated D/I + 16* isolated D/O	80	08	40
PISO-813	32 × isolated A/D	80	0A	00
PISO-DA2	2 × isolated D/A	80	0B	00

3.1.1 PIO_DriverInit

PIO_DriverInit(&wBoards, wSubVendor,wSubDevice,wSubAux)

- wBoards=0 to N → Number of boards found in this PC
- wSubVendor → SubVendor ID of board to find
- wSubDevice → SubDevice ID of board to find
- wSubAux → SubAux ID of board to find

This function can detect all PIO/PISO series card in the system. It is implemented based on the PCI Plug&Play mechanism-1. It will find all PIO/PISO series cards installed in this system & save all their resource in the library.

Find all PIO/PISO in this PC

```
/* Step 1:Detect all PIO/PISO series in this PC */
  wRetVal=PIO_DriverInit(&wBoards, 0xff, 0xff, 0xff);              /*Find all PIO_PISO*/
  printf("\nThrer are %d PIO_PISO Cards in this PC",wBoards);
  if (wBoards==0 ) exit(0);

   /* Step2: Save resource of all PIO/ISO cards installed in this PC */
  printf("\n-----------------------------------------------------");
  for(i=0; i<wBoards; i++)
   {
    PIO_GetConfigAddressSpace(i, &wBase, &wIrq, &wSubVendor, &wSubDevice, &wSubAux,
                              &wSlotBus, &wSlotDevice);
   printf("\nCard_%d:wBase=%x,wIrq=%x,subID=[%x,%x,%x],
           SlotID=[%x,%x]",i,wBase,wIrq,wSubVendor,wSubDevice,
           wSubAux,wSlotBus,wSlotDevice);
   printf(" --> ");
   ShowPioPiso(wSubVendor,wSubDevice,wSubAux);
   }
```

Find all PIO-D144 in this PC

```
/* Step1: Detect all PIO-D144 cards first */
wSubVendor=0x80; wSubDevice=0x01; wSubAux=0x00; /* for PIO_D144 */
wRetVal=PIO_DriverInit(&wBoards, wSubVendor, wSubDevice, wSubAux);
printf("Threr are %d PIO-D144 Cards in this PC\n",wBoards);

/* Step2: Save resource of all PIO-D144 cards installed in this PC */
for (i=0; i<wBoards; i++)
   {
PIO_GetConfigAddressSpace(i, &wBase, &wIrq, &wID1, &wID2, &wID3, &wID4, &wID5);
printf("\nCard_%d: wBase=%x, wIrq=%x", i, wBase, wIrq);
wConfigSpace[i][0]=wBaseAddress;                    /* save all resource of this card */
wConfigSpace[i][1]=wIrq;                            /* save all resource of this card */
  }
```

3.1.2 PIO_GetConfigAddressSpace

PIO_GetConfigAddressSpace(wBoardNo,*wBase,*wIrq, *wSubVendor, *wSubDevice, *wSubAux,*wSlotBus,*wSlotDevice)

- wBoardNo=0 to N → totally N+1 boards found by PIO_DriveInit(...)
- wBase → base address of the board control word
- wIrq → allocated IRQ channel number of this board
- wSubVendor → subVendor ID of this board
- wSubDevice → subDevice ID of this board
- wSubAux → subAux ID of this board
- wSlotBus → hardware slot ID1 of this board
- wSlotDevice → hardware slot ID2 of this board

The user can use this function to save resource of all PIO/PISO cards installed in this system. Then the application program can control all functions of PIO/PISO series card directly.

Find the configure address space of PIO_D144

```
/* Step1: Detect all PIO-D144 cards first */
wSubVendor=0x80; wSubDevice=0x01; wSubAux=0x00;       /* for PIO-D144 */
wRetVal=PIO_DriverInit(&wBoards, wSubVendor,wSubDevice,wSubAux);
printf("Threr are %d PIO-D144 Cards in this PC\n",wBoards);

/* Step2: Save resource of all PIO-D144 cards installed in this PC */
for (i=0; i<wBoards; i++)
   {
   PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&t1,&t2,&t3,&t4,&t5);
   printf("\nCard_%d: wBase=%x, wIrq=%x", i,wBase,wIrq);
  wConfigSpace[i][0]=wBaseAddress;              /* save all resource of this card */
  wConfigSpace[i][1]=wIrq;                      /* save all resource of this card */
  }

/* Step3: Control the PIO-D144 directly */
wBase=wConfigSpace[0][0];                       /* get base address the card_0 */
outp(wBase,1);                                  /* enable all D/I/O operation of card_0 */

wBase=wConfigSpace[1][0];                       /* get base address the card_1 */
outp(wBase,1);                                  /* enable all D/I/O operation of card_1 */
```

3.1.3 Show_PIO_PISO

Show_PIO_PISO(wSubVendor, wSubDevice, wSubAux)

- wSubVendor → subVendor ID of board to find
- wSubDevice → subDevice ID of board to find
- wSubAux → subAux ID of board to find

This function will show a text string for this special subIDs. This text string is the same as that defined in PIO.H

The demo program is given as follows:

```
wRetVal=PIO_DriverInit(&wBoards,0xff,0xff,0xff);  /* find all PIO_PISO series card*/
printf("\nThrer are %d PIO_PISO Cards in this PC",wBoards);
if (wBoards==0 ) exit(0);

printf("\n-----------------------------------------------------");
for(i=0; i<wBoards; i++)
{
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,
        &wSubDevice,&wSubAux,&wSlotBus,&wSlotDevice);

printf("\nCard_%d:wBase=%x,wIrq=%x,subID=[%x,%x,%x],
        SlotID=[%x,%x]",i,wBase,wIrq,wSubVendor,wSubDevice,
        wSubAux,wSlotBus,wSlotDevice);
printf(" --> ");
ShowPioPiso(wSubVendor,wSubDevice,wSubAux);
}
```

3.2 The Assignment of I/O Address

The Plug&Play BIOS will assign the proper I/O address to PIO/PISO series card. If there is only one PIO/PISO board, the user can identify the board as card_0. If there are two PIO/PISO boards in the system, the user will be very difficult to identify which board is card_0 ? The software driver can support 16 boards max. Therefore the user can install 16 boards of PIO/PSIO series in one PC system. How to find the card_0 & card_1 ?

It is difficult to find the card NO. The simplest way to identify which card is card_0 is to use wSlotBus & wSlotDevice as follows:

1. Remove all PIO-D144 from this PC
2. Install one PIO-D144 into the PC's PCI_slot1, run PIO_PISO.EXE & record the wSlotBus1 & wSlotDevice1
3. Remove all PIO-D144 from this PC
4. Install one PIO-D144 into the PC's PCI_slot2, run PIO_PISO.EXE & record the wSlotBus2 & wSlotDevice2
5. Repeat (3) & (4) for all PCI_slot?, record all wSlotBus? & wSlotDevice?

The records may be as follows:

PC's PCI slot	**WslotBus**	**WslotDevice**
Slot_1	**0**	**0x07**
Slot_2	**0**	**0x08**
Slot_3	**0**	**0x09**
Slot_4	**0**	**0x0A**
PCI-BRIDGE		
Slot_5	**1**	**0x0A**
Slot_6	**1**	**0x08**
Slot_7	**1**	**0x09**
Slot_8	**1**	**0x07**

The above procedure will record all wSlotBus? & wSlotDevice? in this PC. These values will be mapped to this PC's physical slot. This mapping will not be changed for any PIO/PISO cards. So it can be used to identify the specified PIO/PISO card as following:

Step1: Record all wSlotBus? & wSlotDevice?

Step2: Use PIO_GetConfigAddressSpace(…) to get the specified card's wSlotBus & wSlotDevice

Step3: The user can identify the specified PIO/PISO card if he compare the wSlotBus & wSlotDevice in step2 to step1.

The simplest way to find the card number is to use DEM10.EXE given in DOS or WINDWS demo program.

This demo program will send a value to D/O of CN2 and read back from D/I of CN3. If the user install a 50-pin flat-cable between CN2 & CN3, the value read from D/I will be the same as D/O. The operation steps are given as follows:

1. Remove all 50-pin flat-cable between CN2 and CN3
2. Install all PIO-D144 cards into this PC system
3. Power-on and run DEM10.EXE
4. Now all D/I value will be different from D/O value
5. Install a 50-pin flat cable into CN2 & CN3 of any PIO-D144 card
6. There will be one card's D/I value = D/O value, the card number is also show in screen

Therefore the user can find the card number very easy if he install a 50-pin flat-cable into PIO-D144 one-by-one.

3.3 The I/O Address Map

The I/O address of PIO/PISO series card is automatically assigned by the main board ROM BIOS. The I/O address can also be re-assigned by user. **It is strongly recommended not to change the I/O address by user. The Plug&Play BIOS will assign proper I/O address to each PIO/PISO series card very well.** The I/O address of PIO-D144 are given as follows:

Address	**Read**	**Write**
WBase+0	RESET\ control register	Same
WBase+2	Aux control register	Same
WBase+3	Aux data register	Same
WBase+5	INT mask control register	Same
WBase+7	Aux pin status register	Same
WBase+0x2a	INT polarity control register	Same
WBase+0xc0	Read 8-bit data from D/I port	Write 8-bit data to D/O port
WBase+0xc4	Reserved	Select the active I/O port
WBase+0xc8	Reserved	I/O Port 0-5 direction control
WBase+0xcc	Reserved	I/O Port 6-11 direction control
WBase+0xd0	Reserved	I/O Port 12-17 direction control

Note. Refer to Sec. 3.1 for more information about wBase.

3.3.1 RESET\ Control Register

(Read/Write): wBase+0

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	RESET\

Note. Refer to Sec. 3.1 for more information about wBase.

When the PC is first power-on, the RESET\ signal is in Low-state. **This will disable all D/I/O operations.** The user has to set the RESET\ signal to High-state before any D/I/O command.

```
outp(wBase,1);          /*  RESET\=High → all D/I/O are enable now */

outp(wBase,0);          /*  RESET\=Low → all D/I/O are disable now */
```

3.3.2 AUX Control Register

(Read/Write): wBase+2

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Aux7	Aux6	Aux5	Aux4	Aux3	Aux2	Aux1	Aux0

Note. Refer to Sec. 3.1 for more information about wBase.

Aux?=0→ this Aux is used as a D/I

Aux?=1→ this Aux is used as a D/O

When the PC is first power-on, All Aux? signal are in Low-state. All Aux? are designed as D/I for all PIO/PISO series. Please set all Aux? in D/I state.

3.3.3 AUX data Register

(Read/Write): wBase+3

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Aux7	Aux6	Aux5	Aux4	Aux3	Aux2	Aux1	Aux0

Note. Refer to Sec. 3.1 for more information about wBase.

When the Aux is used as D/O, the output state is controlled by this register. This register is designed for feature extension, so don't control this register now.

3.3.4 INT Mask Control Register

(Read/Write): wBase+5

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	CN1_PC3	CN1_PC2	CN1_PC1	CN1_PC0

Note. Refer to Sec. 3.1 for more information about wBase.

PC0=0→ Disable PC0 of CN1 as a interrupt signal (Default).

PC0=1→ Enable PC0 of CN1 as a interrupt signal

```
outp(wBase+5,0);     /* Disable interrupt                                          */
outp(wBase+5,1);     /* Enable interrupt CN1_PC0                                   */
outp(wBase+5,0x0f);/* Enable interrupt CN1_PC0,CN1_PC1,CN1_PC2,CN1_PC3 */
```

3.3.5 Aux Status Register

(Read/Write): wBase+7

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Aux7	Aux6	Aux5	Aux4	Aux3	Aux2	Aux1	Aux0

Note. Refer to Sec. 3.1 for more information about wBase.

Aux0=CN_PC0, Aux1=CN1_PC1, Aux2=CN1_PC2, CN1_Aux3=PC3, Aux7~4=Aux-ID. Refer to DEMO5.C for more information. The Aux0~3 are used as interrupt source. The interrupt service routine has to read this register for interrupt source identification. Refer to Sec. 2.5 for more information.

3.3.6 Interrupt Polarity Control Register

(Read/Write): wBase+0x2A

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	CN1_PC3	CN1_PC2	CN1_PC1	CN1_PC0

Note. Refer to Sec. 3.1 for more information about wBase.

PC0=0→ select the non-inverted signal from PC0 of CN1_PC.
PC0=1→ select the inverted signal from PC0 of CN1_PC.

```
outp(wBase+0x2a,0);      /* select the non-inverted input CN1_PC0/1/2/3    */
outp(wBase+0x2a,0x0f); /* select the inverted input of CN1_PC0/1/2/3       */

outp(wBase+0x2a,1);      /* select the inverted input of CN1_PC0            */
                         /* select the non-inverted input CN1_PC1/2/3       */

outp(wBase+0x2a,3);      /* select the inverted input of CN1_PC0/1          */
                         /* select the non-inverted input CN1_PC2/3         */
```

Refer to Sec. 2.5 for more information.
Refer to DEMO5.C for more information.

3.3.7 Read/Write 8-bit data Register

(Read/Write): wBase+0xc0

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

Note. Refer to Sec. 3.1 for more information about wBase.

There are eighteen 8-bit I/O port in the PIO-D144. Every I/O port can be programmed as D/I or D/O port. Refer to Sec. 3.3.9 for D/I or D/O selection. When the PC is first power-on, all eighteen ports are used as D/I port.

```
outp(wBase+0xc0,Val);       /* write to D/O port  */
Val=inp(wBase+0xc0);        /* read from D/I port */
```

3.3.8 Active I/O Port Control Register

(Read/Write): wBase+0xc4

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

Note. Refer to Sec. 3.1 for more information about wBase.

There are eighteen 8-bit I/O port in the PIO-D144. Only one I/O port can be active at the same time.

```
outp(wBase+0xc4,0);         /*  I/O port_0 is active now   */

outp(wBase+0xc4,1);         /*  I/O port_1 is active now   */

outp(wBase+0xc4,17);        /*  I/O port_17 is active now */
```

Refer to Sec. 2.2 for I/O port location.

3.3.9 I/O Selection Control Register

(Write): wBase+0xc8

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	CN2_PC	CN2_PB	CN2_PA	CN1_PC	CN1_PB	CN1_PA

(Write): wBase+0xcc

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	CN4_PC	CN4_PB	CN4_PA	CN3_PC	CN3_PB	CN3_PA

(Write): wBase+0xd0

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	CN6_PC	CN6_PB	CN6_PA	CN5_PC	CN5_PB	CN5_PA

Note. Refer to Sec. 3.1 for more information about wBase.

For example:

CN1_PA=1→ This port is used as a D/I port.

CN1_PA=0→ This port is used as a D/O port.

There are eighteen 8-bit I/O port in the PIO-D144. Every I/O port can be programmed as D/I or D/O port. When the PC is first power-on, all eighteen ports are used as D/I port. The I/O port location is given as follows:

Connector of PIO-D144	PA0 to PA7	PB0 to PB7	PC0 to PC7
CN1	CN1_PA	CN1_PB	CN1_PC
CN2	CN2_PA	CN2_PB	CN2_PC
CN3	CN3_PA	CN3_PB	CN3_PC
CN4	CN4_PA	CN4_PB	CN4_PC
CN5	CN5_PA	CN5_PB	CN5_PC
CN6	CN6_PA	CN6_PB	CN6_PC

```
outp(wBase+0xc8,0);       /* CN1_PA/PB/PC to CN2_PA/PB/PC are all D/O port */

outp(wBase+0xcc,0x3f);    /* CN3_PA/PB/PC to CN4_PA/PB/PC are all D/I port */

outp(wBase+0xd0,0x38);    /* CN5_PA/PB/PC are all D/O port */
                          /* CN6_PA/PB/PC are all D/I port  */
```

Refer to Sec. 2.2 for I/O Port Location.

4. Demo Program

There are about 5 demo program given in the DOS floppy disk or CD- ROM. The program sources of library & demo program are all given in the disk. These demo program will help the user to solve their real world problem more easy.

- \TC*.* → for Turbo C 2.xx or above
- \TC\LARGE*.* → for large model
- \TC\LARGE\LIB*.* → for library source code
- \TC\LARGE\DEMO?*.* → demo program source code

- \TC\LARGE\LIB\PIO.H → library header file
- \TC\LARGE\LIB\PIO.C → library source file
- \TC\LARGE\LIB\A.BAT → compiler file
- \TC\LARGE\LIB\B.BAT → link file
- \TC\LARGE\LIB\PIO.LIB → library file

- \TC\LARGE\DEMO1\PIO.H → library header file
- \TC\LARGE\DEMO1\DEMO1.C → demo1 source file
- \TC\LARGE\DEMO1\DEMO1.PRJ → TC project file
- \TC\LARGE\DEMO1\IOPORTL.LIB → I/O port library file
- \TC\LARGE\DEMO1\PIO.LIB → library file
- \TC\LARGE\DEMO1\DEMO1.EXE → demo1 execution file

4.1 PIO-D144.H

```
/* The header file for PIO-D144 card */
#define Disable          0
#define Enable           1
#define D144             wBase+0x00
#define IO_SCR0          wBase+0xc8
#define IO_SCR1          wBase+0xcc
#define IO_SCR2          wBase+0xd0
#define AUX_CR           wBase+0x02
#define AUX_DR           wBase+0x03
#define INT_MCR          wBase+0x05
#define AUX_SR           wBase+0x07
#define INT_PCR          wBase+0x2a
#define RW_8BitDR        wBase+0xc0
#define ACT_IOPCR        wBase+0xc4
#define CN1_PA           0
#define CN1_PB           1
#define CN1_PC           2
#define CN2_PA           3
#define CN2_PB           4
#define CN2_PC           5
#define CN3_PA           6
#define CN3_PB           7
#define CN3_PC           8
#define CN4_PA           9
#define CN4_PB           10
#define CN4_PC           11
#define CN5_PA           12
#define CN5_PB           13
#define CN5_PC           14
#define CN6_PA           15
#define CN6_PB           16
#define CN6_PC           17
```

4.2 Demo1: Use D/O of CN1

```
/* ------------------------------------------------------- */
/* demo 1 : D/O demo                                       */
/* step 1 : connect a DB-24C to CN1 of PIO-D144            */
/* step 2 : run DEMO1.EXE                                  */
/* step 3 : check the LEDs of DB-24C will turn on sequentially */
/* ------------------------------------------------------- */

#include "PIO.H"

int main()
{
int  i;
WORD wBoards;
WORD wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
char c;

clrscr();
PIO_DriverInit(&wBoards,0x80,0x01,0x00);   /* for PIO-D144 */
printf("\n(1) Threr are %d PIO-D144 Cards in this PC",wBoards);
if ( wBoards==0 )
   {
   putch(0x07);  putch(0x07);  putch(0x07);
   printf("(1) There are no PIO-D144 card in this PC !!!\n");
exit(0);
   }

printf("\n(2) The Configuration Space ->   wBase");
for(i=0; i<wBoards; i++)
   {
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\nCard_%d:wBase=%x,wIrq=%x,subID=[%x,%x,%x],SlotID=[%x,%x]"
   ,i,wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice);
   }

/* select card_0 */
PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                         &wSubAux,&wSlotBus,&wSlotDevice);

printf("\n(3) *** Card_0 D/O test, wBase=%x ***",wBase);

/* step 1: make sure which ports are D/O ports              */
/* in this demo --> only CN1_PA, CN1_PB, CN1_PC are D/O port */

/* step 2: enable all D/I/O port              */
outp(wBase,1);         /* enable D/I/O        */

/* step 3: select the active port             */
outp(wBase+0xc4,0);     /* select CN1_PA      */

/* step 4: send initial-value to D/O latch register of active port */
outp(wBase+0xc0,0);     /* set CN1_PA0 to CN1_PA7 to 0 */

/* step 5: repeat for all D/O ports                   */
outp(wBase+0xc4,1);     /* select CN1_PB              */
outp(wBase+0xc0,0);     /* set CN1_PB0 to CN1_PB7 to 0 */
outp(wBase+0xc4,2);     /* select CN1_PC              */
outp(wBase+0xc0,0);     /* set CN1_PC0 to CN1_PC7 to 0 */

/* step 6: configure all I/O port                     */
outp(wBase+0xc8,0x00);   /* CN1 to CN2 port are all output */
```

```
outp(wBase+0xcc,0x00);   /* CN3 to CN4 port are all output */
outp(wBase+0xd0,0x00);   /* CN5 to CN6 port are all output */

for (;;)
{
printf("\nCN1 : PA=0x55, PB=0xAA, PC=0x5A, press Q to stop");
outp(wBase+0xc4,0);     /* select CN1_PA   */
outp(wBase+0xc0,0x55);  /* set CN1_PA=0x55 */

outp(wBase+0xc4,1);     /* select CN1_PB   */
outp(wBase+0xc0,0xaa);  /* set CN1_PB=0xaa */

outp(wBase+0xc4,2);     /* select CN1_PC   */
outp(wBase+0xc0,0x5a);  /* set CN1_PC=0x5a */
c=getch(); if ((c=='Q') || (c=='q')) break;

printf("\nCN1 : PA=0xAA, PB=0x55, PC=0xA5, press Q to stop");
outp(wBase+0xc4,0);     /* select CN1_PA   */
outp(wBase+0xc0,0xAA);  /* set CN1_PA=0xAA */

outp(wBase+0xc4,1);     /* select CN1_PB   */
outp(wBase+0xc0,0x55);  /* set CN1_PB=0x55 */

outp(wBase+0xc4,2);     /* select CN1_PC    */
outp(wBase+0xc0,0xa5);  /* set CN1_PC=0xA5  */
c=getch(); if ((c=='Q') || (c=='q')) break;
}

PIO_DriverClose();
}
```

4.3 Demo2: Use D/O of CN1~CN6

```
/* ------------------------------------------------------------ */
/* demo 2 : D/O demo for CN1 ~ CN6                               */
/* step 1 : connect a DB-24C to CN1 ~ CN6 of PIO-D144           */
/* step 2 : run DEMO2.EXE                                       */
/* step 3 : check the LED's of DB-24C will turn on sequentially */
/* ------------------------------------------------------------ */

#include "PIO.H"

int main()
{
int  i,j,k,jj;
WORD wBoards,wRetVal;
WORD wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
char c;

clrscr();
PIO_DriverInit(&wBoards,0x80,0x01,0x00);  /* for PIO-D144 */
printf("\n(1) Threr are %d PIO-D144 Cards in this PC",wBoards);
if ( wBoards==0 )
   {
   putch(0x07);  putch(0x07);  putch(0x07);
   printf("(1) There are no PIO-D144 card in this PC !!!\n");
exit(0);
   }

printf("\n(2) The Configuration Space ->   wBase");
for(i=0; i<wBoards; i++)
   {
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\nCard_%d: wBase=%x,wIrq=%x,subID=[%x,%x,%x],SlotID=[%x,%x]"
   ,i,wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice);
   }

/* select card_0 */
PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                        &wSubAux,&wSlotBus,&wSlotDevice);

/* step 1: make sure which ports are D/O ports             */
/* in this demo --> all D/O ports are output port          */

/* step 2: enable all D/I/O port                  */
outp(wBase,1);      /* enable D/I/O           */

/* step 3: select the active port                 */
/* step 4: send initial-value to D/O latch register of active port */
/* step 5: repeat for all D/O ports               */
for (i=0; i<18; i++)
    {
    outp(wBase+0xc4,i); /* select CN1 to CN6 port          */
    outp(wBase+0xc0,0); /* set 8-bit D/O latch register    */
    }

/* step 6: configure all I/O port */
outp(wBase+0xc8,0x00);  /* CN1 to CN2 port are all output  */
outp(wBase+0xcc,0x00);  /* CN3 to CN4 port are all output  */
outp(wBase+0xd0,0x00);  /* CN5 to CN6 port are all output  */

/*   K=PA/PB/PC                    */
```

```
/* CN1 : K=0/1/2     --> key in 0  */
/* CN2 : K=3/4/5     --> key in 3  */
/* CN3 : K=6/7/8     --> key in 6  */
/* CN4 : K=9/10/11   --> key in 9  */
/* CN5 : K=12/13/14  --> key in 12 */
/* CN6 : K=15/16/17  --> key in 15 */

printf("\nk="); scanf("%d",&k);

for (jj=k; jj<(3+k); jj++)       /* PA/PB/PC               */
{
outp(wBase+0xc4,jj);             /* select the active port */
printf("\nSelect Port-%d",jj);
outp(wBase+0xc0,0x55);           /* D/O=0x55       */
printf(", D/O=0x55"); getch();
outp(wBase+0xc0,0xAA);           /* D/O=0xAA       */
printf(", D/O=0xAA"); getch();

outp(wBase+0xc0,0x1); getch();   /* PA0/PB0/PC0        */
outp(wBase+0xc0,0x2); getch();   /* PA1/PB1/PC1        */
outp(wBase+0xc0,0x4); getch();   /* PA2/PB2/PC2        */
outp(wBase+0xc0,0x8); getch();   /* PA3/PB3/PC3        */
outp(wBase+0xc0,0x10); getch();  /* PA4/PB4/PC4        */
outp(wBase+0xc0,0x20); getch();  /* PA5/PB5/PC5        */
outp(wBase+0xc0,0x40); getch();  /* PA6/PB6/PC6        */
outp(wBase+0xc0,0x80); getch();  /* PA7/PB7/PC7        */
}

PIO_DriverClose();
}
```

This demo program is designed for CN1 ~ CN6. The user can install a DB-24C into CN1 ~ CN6 of PIO-D144. This demo will request the user to input a number K as following:

If the DB-24C is installed in CN1 → key in 0

If the DB-24C is installed in CN2 → key in 3

If the DB-24C is installed in CN3 → key in 6

If the DB-24C is installed in CN4 → key in 9

If the DB-24C is installed in CN5 → key in 12

If the DB-24C is installed in CN6 → key in 15

Then this demo program will test D/O of PA, PB, PC sequentially.

4.4 Demo3: Interrupt demo1

```
/* ------------------------------------------------------------ */
/* demo 3 : count high pulse of CN1_PC0                         */
/*      (initial Low & active High)                             */
/* step 1 : run demo3.exe                                       */
/* ------------------------------------------------------------ */

#include "PIO.H"

#define A1_8259 0x20
#define A2_8259 0xA0
#define EOI 0x20

WORD init_low();
static void interrupt irq_service();
int COUNT,irqmask,now_int_state;
WORD wBase,wIrq;

int main()
{
int  i,j;
WORD wBoards,wRetVal;
WORD wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
char c;
DWORD dwVal;

clrscr();
PIO_DriverInit(&wBoards,0x80,0x01,0x00);
printf("\n(1) Threr are %d PIO-D144 Cards in this PC",wBoards);
if ( wBoards==0 )
   {
   putch(0x07);  putch(0x07);  putch(0x07);
   printf("(1) There are no PIO-D144 card in this PC !!!\n");
exit(0);
    }

printf("\n(2) Show the Configuration Space of all PIO-D144:");
for(i=0; i<wBoards; i++)
   {
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\nCard_%d: wBase=%x,wIrq=%x,subID=[%x,%x,%x],SlotID=[%x,%x]"
   ,i,wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice);
   }

/* select card_0 */
PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);

printf("\n(3) *** Card_0, wBaseAddr=%x ***",wBaseAddr);

COUNT=0;
outp(wBase+0xc8,0xff);    /* port_0 to port_5 are all input */
printf("\n(4) *** show the count of High_pulse **\n");
init_low();

for (;;)
    {
    printf("\nCOUNT=%d",COUNT);
    if (kbhit()!=0) {getch(); break;}
    }
```

```
outp(wBase+5,0);        /* disable all interrupt */
PIO_DriverClose();
}

/* ------------------------------------------------------------- */
/* Use PC0 as external interrupt signal                          */

WORD init_low()
{
DWORD dwVal;

disable();

outp(wBase+5,0);        /* disable all interrupt */
if (wIrq<8)
   {
   irqmask=inp(A1_8259+1);
   outp(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   setvect(wIrq+8, irq_service);
   }
else
   {
   irqmask=inp(A1_8259+1);
   outp(A1_8259+1,irqmask & 0xfb);     /* IRQ2 */
   outp(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   irqmask=inp(A2_8259+1);
   outp(A2_8259+1,irqmask & (0xff ^ (1 << (wIrq-8))));
   setvect(wIrq-8+0x70, irq_service);
   }

outp(wBase+0x2a,0);     /* select the non-inverte input */
now_int_state=0;        /* now int_signal is low        */
outp(wBase+5,1);        /* enable interrupt             */
enable();
}

void interrupt irq_service()
{
if (now_int_state==0)
   {
   COUNT++;               /* find a high_pulse        */
   outp(wBase+0x2a,1);    /* select the inverte input */
   now_int_state=1;       /* now int_signal is High   */
   }
else
   {
                           /* find a low_pulse here        */
   outp(wBase+0x2a,0);     /* select the non-inverte input */
   now_int_state=0;        /* now int_signal is High       */
   }

if (wIrq>=8) outp(A2_8259,0x20);
outp(A1_8259,0x20);
}
```

Refer to Sec. 2.5.1 for more information.

4.5 Demo4: Interrupt demo2

```
/* ------------------------------------------------------------*/
/* demo 4 : count low  pulse of PC0                            */
/*      (Initial High & active Low)                            */
/* step 1 : run demo4.exe                                      */
/* ------------------------------------------------------------ */

#include "PIO.H"

#define A1_8259 0x20
#define A2_8259 0xA0
#define EOI 0x20

WORD init_high();
WORD wBase,wIrq;

static void interrupt irq_service();
int COUNT,irqmask,now_int_state;

int main()
{
int  i,j;
WORD wBoards;
WORD wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
char c;
DWORD dwVal;

clrscr();
PIO_DriverInit(&wBoards,0x80,0x01,0x00);
printf("\n(1) Threr are %d PIO-D144 Cards in this PC",wBoards);
if ( wBoards==0 )
   {
   putch(0x07);  putch(0x07);  putch(0x07);
   printf("(1) There are no PIO-D144 card in this PC !!!\n");
exit(0);
   }

printf("\n(2) Show the Configuration Space of all PIO-D144:");
for(i=0; i<wBoards; i++)
   {
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\nCard_%d: wBase=%x,wIrq=%x,subID=[%x,%x,%x],SlotID=[%x,%x]"
   ,i,wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice);
   }

/* select card_0 */
PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                         &wSubAux,&wSlotBus,&wSlotDevice);

printf("\n(3) *** Card_0, wBaseAddr=%x ***",wBaseAddr);

COUNT=0;
outp(wBase+0xc8,0xff);    /* CN1 to CN2 port are all input      */
printf("\n(4) *** show the count of High_pulse **\n");
init_high();

for (;;)
    {
    printf("\nCOUNT=%d",COUNT);
    if (kbhit()!=0) {getch(); break;}
    }
```

```
outp(wBase+5,0);        /* disable all interrupt */
PIO_DriverClose();
}

/* ------------------------------------------------------------ */
/* Use PC0 as external interrupt signal                         */
WORD init_high()
{
DWORD dwVal;

disable();

outp(wBase+5,0);        /* disable all interrupt */
if (wIrq<8)
   {
   irqmask=inp(A1_8259+1);
   outp(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   setvect(wIrq+8, irq_service);
   }
else
   {
   irqmask=inp(A1_8259+1);
   outp(A1_8259+1,irqmask & 0xfb);             /* IRQ2 */
   outp(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   irqmask=inp(A2_8259+1);
   outp(A2_8259+1,irqmask & (0xff ^ (1 << (wIrq-8))));
   setvect(wIrq-8+0x70, irq_service);
   }

outp(wBase+5,1);        /* enable interrupt         */
now_int_state=1;        /* now int_signal is low    */
outp(wBase+0x2a,1);     /* select the inverte input */
enable();
}

void interrupt irq_service()
{
if (now_int_state==0)
   {
                           /* find a high_pulse here   */
   outp(wBase+0x2a,1);     /* select the inverte input */
   now_int_state=1;        /* now int_signal is High   */
   }
else
   {
   COUNT++;                /* find a low_pulse             */
   outp(wBase+0x2a,0);     /* select the non-inverte input */
   now_int_state=0;        /* now int_signal is High       */
   }

if (wIrq>=8) outp(A2_8259,0x20);
outp(A1_8259,0x20);
}
```

Refer to Sec. 2.5.2 for more information.

4.6 Demo5: Interrupt demo3

```
/* ------------------------------------------------------------ */
/* demo 5 : four interrupt source                               */
/*      CN1_PC0: initial Low, active High                       */
/*      CN1_PC1: initial High, active Low                       */
/*      CN1_PC2: initial Low, active High                       */
/*      CN1_PC3: initial High, active Low                       */
/* step 1 : run demo5.exe                                       */
/* ------------------------------------------------------------ */

#include "PIO.H"

#define A1_8259 0x20
#define A2_8259 0xA0
#define EOI 0x20

WORD init_low();
WORD wBase,wIrq;

static void interrupt irq_service();
int  irqmask,now_int_state,invert,new_int_state,int_c,int_num;
int  CNT_L1,CNT_L2,CNT_L3,CNT_L4;
int  CNT_H1,CNT_H2,CNT_H3,CNT_H4;

int main()
{
int  i,j;
WORD wBoards,wRetVal;
WORD wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
char c;
DWORD dwVal;

clrscr();
PIO_DriverInit(&wBoards,0x80,0x01,0x00);
printf("\n(1) Threr are %d PIO-D144 Cards in this PC",wBoards);
if ( wBoards==0 )
   {
   putch(0x07);  putch(0x07);  putch(0x07);
   printf("(1) There are no PIO-D144 card in this PC !!!\n");
exit(0);
   }

printf("\n(2) Show the Configuration Space of all PIO-D144:");
for(i=0; i<wBoards; i++)
   {
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\nCard_%d: wBase=%x,wIrq=%x,subID=[%x,%x,%x],SlotID=[%x,%x]",
   i,wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice);
    }

/* select card_0 */
PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);

printf("\n(3) *** Card_0, wBaseAddr=%x ***",wBaseAddr);

outp(wBase+0xc8,0xff);    /* CN1 to CN2 port are all input */
printf("\n(4) *** show the count of High_pulse **\n");
init_low();
```

```
for (;;)
    {
    printf("\n(CNT_L, CNT_H) = (%d,%d) (%d,%d) (%d,%d) (%d,%d) %x",
        CNT_L1,CNT_H1,CNT_L2,CNT_H2,CNT_L3,CNT_H3,CNT_L4,CNT_H4,
int_num);
    if (kbhit()!=0) {getch(); break;}
    }

outp(wBase+5,0);        /* disable all interrupt */
PIO_DriverClose();
}

/* ------------------------------------------------------------ */
/* Use PC0 as external interrupt signal                         */

WORD init_low()
{
DWORD dwVal;

disable();

outp(wBase+5,0);        /* disable all interrupt */
if (wIrq<8)
   {
   irqmask=inp(A1_8259+1);
   outp(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   setvect(wIrq+8, irq_service);
   }
else
   {
   irqmask=inp(A1_8259+1);
   outp(A1_8259+1,irqmask & 0xfb);              /* IRQ2 */
   outp(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   irqmask=inp(A2_8259+1);
   outp(A2_8259+1,irqmask & (0xff ^ (1 << (wIrq-8))));
   setvect(wIrq-8+0x70, irq_service);
   }


invert=0x05;
outp(wBase+0x2a,invert);    /*     CN1_PC0 = non-inverte input */
                /*     CN1_PC1 =     inverte input */
                /*     CN1_PC2 = non-inverte input */
                /*     CN1_PC3 = non-inverte input */
now_int_state=0x0a;     /* Now CN1_PC0 = low       */
                /*     CN1_PC1 = high          */
                /*     CN1_PC2 = low           */
                /*     CN1_PC3 = high          */
CNT_L1=CNT_L2=CNT_L3=CNT_L4=0;  /* low pulse count  */
CNT_H1=CNT_H2=CNT_H3=CNT_H4=0;  /* high pulse count */
int_num=0;
outp(wBase+5,0x0f);     /* enable interrupt PC0,PC1,PC2,PC3 of CN1 */
enable();
}

void interrupt irq_service()
{
char cc;

int_num++;
new_int_state=inp(wBase+0x07)&0xff;
int_c=new_int_state ^ now_int_state;
```

```
if ((int_c&0x01) != 0)
   {
   cc=new_int_state&0x01;
   if (cc !=0) CNT_H1++; else CNT_L1++;
   invert=invert ^ 1;
   }

if ((int_c&0x02) != 0)
   {
   cc=new_int_state&0x02;
   if (cc !=0) CNT_H2++; else CNT_L2++;
   invert=invert ^ 2;
   }

if ((int_c&0x04) != 0)
   {
   cc=new_int_state&0x04;
   if (cc !=0) CNT_H3++; else CNT_L3++;
   invert=invert ^ 4;
   }

if ((int_c&0x08) != 0)
   {
   cc=new_int_state&0x08;
   if (cc !=0) CNT_H4++; else CNT_L4++;
   invert=invert ^ 8;
   }

now_int_state=new_int_state;
outp(wBase+0x2a,invert);

if (wIrq>=8) outp(A2_8259,0x20);
outp(A1_8259,0x20);
}
```

4.7 DEMO 6: Outport of CN1-CN6

```
/* ------------------------------------------------------------ */
/* demo 6 : D/O demo                                            */
/* step 1 : connect a DB-24C to CN1 of PIO-D144                 */
/* step 2 : run DEMO6.EXE                                       */
/* step 3 : check the LED's of DB-24C will turn on sequentially */
/* ------------------------------------------------------------ */
#include "PIO.H"
```

```
#include "PIO-D144.H"
int main()
{
int  i;
char c;
WORD wBoards;
WORD wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;

clrscr();
PIO_DriverInit(&wBoards,0x80,0x01,0x00);  /* for PIO-D144 */
printf("\n(1) Threr are %d PIO-D144 Cards in this PC",wBoards);
if ( wBoards==0 )  {
   putch(0x07);  putch(0x07);  putch(0x07);
   printf("(1) There are no PIO-D144 card in this PC !!!\n");
exit(0);
}
printf("\n(2) The Configuration Space ->   wBase");
for(i=0; i<wBoards; i++)   {
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\nCard_%d: wBase=%x,wIrq=%x,subID=[%x,%x,%x],SlotID=[%x,%x]"
   ,i,wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice);
   }
PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\n(3) *** Card_0 D/O test, wBase=%x ***",wBase);
outp(D144,Disable);      /* Reset DIO of D144 */
outp(D144,Enable);
outp(IO_SCR0,0x00);

while(1)  {
printf("\n");
for(i=1;i<=0x80;i=i<<1) {
printf("\nCN1: PA=%02xH, PB=%02xH, PC=%02xH, press Q to stop",i,i,i);
outp(Act_IOPCR,CN1_PA);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN1_PB);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN1_PC);
outp(RW_8BitDR,i);
sleep(1);
   }
printf("\n");
for(i=1;i<=0x80;i=i<<1)  {
printf("\nCN2: PA=%02xH, PB=%02xH, PC=%02xH, press Q to stop",i,i,i);
outp(Act_IOPCR,CN2_PA);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN2_PB);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN2_PC);
outp(RW_8BitDR,i);
sleep(1);
  }
outp(IO_SCR1,0x00);
printf("\n");
for(i=1;i<=0x80;i=i<<1) {
printf("\nCN3: PA=%02xH, PB=%02xH, PC=%02xH, press Q to stop",i,i,i);
outp(Act_IOPCR,CN3_PA);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN3_PB);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN3_PC);
outp(RW_8BitDR,i);
sleep(1);
```

```
  }
printf("\n");
for(i=1;i<=0x80;i=i<<1)       {
printf("\nCN4: PA=%02xH, PB=%02xH, PC=%02xH, press Q to stop",i,i,i);
outp(Act_IOPCR,CN4_PA);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN4_PB);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN4_PC);
outp(RW_8BitDR,i);
sleep(1);
  }
outp(IO_SCR2,0x00);
printf("\n");
for(i=1;i<=0x80;i=i<<1) {
printf("\nCN5: PA=%02xH, PB=%02xH, PC=%02xH, press Q to stop",i,i,i);
outp(Act_IOPCR,CN5_PA);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN5_PB);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN5_PC);
outp(RW_8BitDR,i);
sleep(1);
  }
printf("\n");
for(i=1;i<=0x80;i=i<<1) {
printf("\nCN6: PA=%02xH, PB=%02xH, PC=%02xH, press Q to stop",i,i,i);
outp(Act_IOPCR,CN6_PA);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN6_PB);
outp(RW_8BitDR,i);
outp(Act_IOPCR,CN6_PC);
outp(RW_8BitDR,i);
sleep(1);            }
if(i==0x80)  { i=0x01; break; }
    if (kbhit()!=0) {
       c=getch();
       if ((c=='q') || (c=='Q') ||  c==27 )
       return;                 }
} /* end of while */

PIO_DriverClose();
}
```

4.8 Demo10: Find Card Number

```
/* ------------------------------------------------------------ */
/* demo 10: Find card number                                    */
/* step 1 : run demo10.exe                                      */
/* step 2 : connect a 50-pin flat-cable to CON2 & CON3 of card_? */
/* step 3 : The card number is shown in screen as TEST OK       */
/* ------------------------------------------------------------ */

#include "PIO.H"

WORD wBase,wIrq;
WORD wBoards,wRetVal;
WORD wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;

int main()
{
int  i,j,k;

char c;

clrscr();
PIO_DriverInit(&wBoards,0x80,0x01,0x00);  /* for PIO-D144 */
printf("\n(1) Threr are %d PIO-D144 Cards in this PC",wBoards);
if ( wBoards==0 )
   {
   putch(0x07);  putch(0x07);  putch(0x07);
   printf("(1) There are no PIO-D144 card in this PC !!!\n");
exit(0);
   }

printf("\n(2) The Configuration Space ->   wBase");
for(i=0; i<wBoards; i++)
   {
PIO_GetConfigAddressSpace(i,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);
printf("\nCard_%d: wBase=%x,wIrq=%x,subID=[%x,%x,%x],SlotID=[%x,%x]"
   ,i,wBase,wIrq,wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice);
    }
    PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                              &wSubAux,&wSlotBus,&wSlotDevice);
for (;;)
    {
    printf("\n------------- press any key to stop -------------");
    for (i=0; i<wBoards; i++) test_card(i);
    delay_ms(1000); /* delay 1 sec */
    if (kbhit()!=0) {getch(); break;}
    }

PIO_DriverClose();
}

/* ------------------------------------------------------------ */
test_card(int card)
{
int i,j,k,ok,val;
PIO_GetConfigAddressSpace(card,&wBase,&wIrq,&wSubVendor,&wSubDevice,
                          &wSubAux,&wSlotBus,&wSlotDevice);

outp(wBase,1);            /* enable D/I/O     */
```

```
ok=1;
outp(wBase+0xc8,0x00);    /* CN2_PA is output */
outp(wBase+0xcc,0x01);    /* CN3_PA is input  */

outp(wBase+0xc4,3);       /* select CN2_PA    */
outp(wBase+0xc0,0x55);    /* CN2_PA=0x55      */
outp(wBase+0xc4,6);       /* select CN2_PA    */
val=inp(wBase+0xc0)&0xff; /* read CN3_PA      */
if (val != 0x55) ok=0;

outp(wBase+0xc4,3);       /* select CN2_PA    */
outp(wBase+0xc0,0xAA);    /* CN2_PA=0xAA      */
outp(wBase+0xc4,6);       /* select CN3_PA    */
val=inp(wBase+0xc0)&0xff; /* read CN3_PA      */
if (val != 0xaa) ok=0;

printf("\nCard Number=%d, wBase=%x",card,wBase);
if (ok==1) printf(", Test OK"); else printf(", Test ERROR");
}

/* ------------------------------------------------------------ */

delay_ms(int t)
{
int i,j,k,l,m;

for (i=0; i<t; i++)
for (j=0; j<100; j++)
    {
    m=0;
    for (k=0; k<100; k++) {l=(j+t)*i; m+=l;}
    }
}
```