User's Guide

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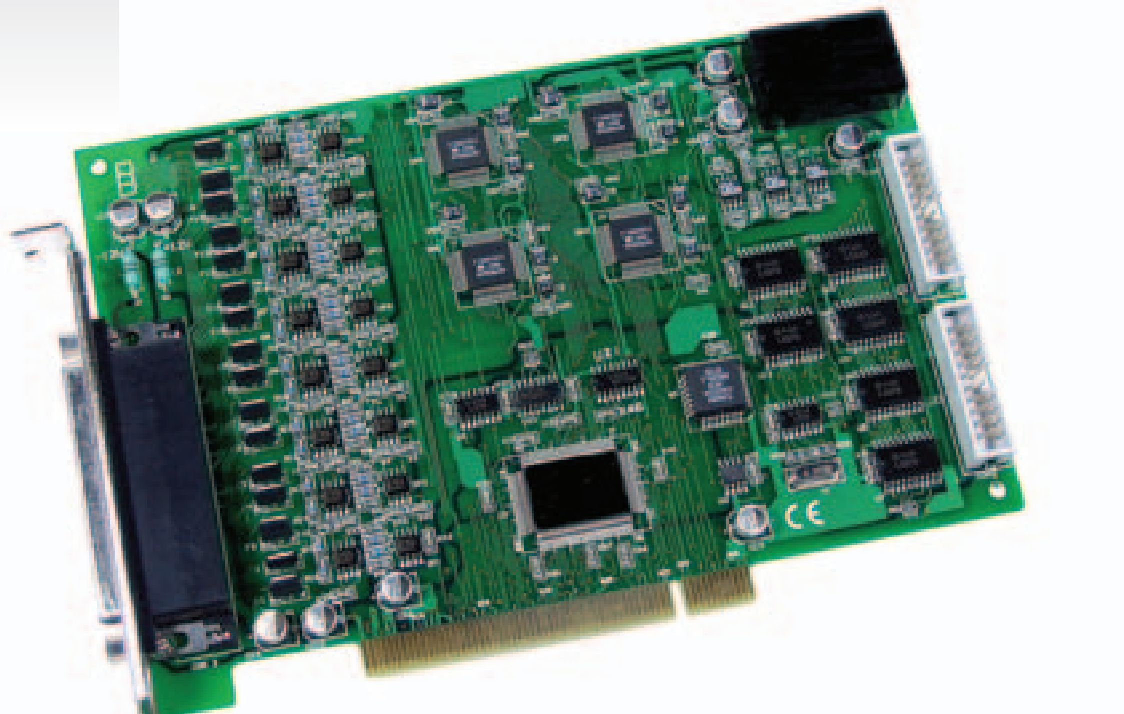

OME-PIO-DA16/DA8/DA4

PCI-Bus Analog Output Board

Hardware Manual

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OME-PIO-DA16/DA8/DA4

User’s Manual

Tables of Contents

1. INTRODUCTION

The OME-PIO-DA16, OME-PIO-DA8 and OME-PIO-DA4 are multi-channel D/A boards for the PCI bus for IBM or compatible PC.

The OME-PIO-DA16/8/4 offers 16/8/4 channels double-buffered analog output. The output range may be configured in different ranges: ±10V, ±5V, 0~10V, 0~5V voltage output or 4~20mA, 0~20mA current loop sink.

The innovative design eliminates several drawbacks of the conventional D/A boards. For examples: 1. designed without jumpers and without trim-pot. 2. The calibration is performed under software control eliminating manual trim-pot adjustments. The calibration data is stored in EEPROM. 3. Each channel can be selected as voltage or current output. 4. High channel count output can be implemented in half size.

Note: This card need ±12V power supply (usually found in PC).

1.1 Features

- PCI bus
- 16/8/4 channels, 14-bit analog output
- Unipolar or bipolar outputs available from each converter
- Output type (Unipolar or bipolar) and output range (0~5V, ±5V, 0~10V, ±10V) can be software programmable
- 4~20mA or 0~20mA current sink to ground for each converter
- Two pacer timer interrupt source
- Double-buffered D/A latches
- Software calibration
- 16 channels of DI, 16 channels of DO
- SMD, short card
- One D-Sub connector, two 20-pin flat cable connectors
- Connects directly to OME-DB-16P, OME-DB-16R, OME-DB-24C, OME-DB-24PR and OME-DB-24POR
- Automatically detected by Windows 95/98/2000/XP
- No base address or IRQ jumper need to set

1.2 Specifications

Digital Inputs/Outputs

- All inputs/outputs are TTL compatible
- Logic high Voltage V_{IH}: 2.4V(Min.)
- Logic low Voltage V_{IL}: 0.8V(Max.)
- Sink current I_{OL}: 8mA(Max.)
- Source current I_{OH}: 0.4mA(Max.)

Analog Outputs

- D/A converter: Quad 14 bits MDAC
- Channels: 16/8/4 independent
- Resolution: 14 bits
- Type: double-buffered, multiplying
- Integral linearity: 0.006% FSR (typical)
- Differential linearity: 0.006% FSR (typical)

Voltage Output Range:

- Unipolar: 0~5V or 0~10V
- Bipolar: ±10V or ±5V
- Current drive: ±5mA
- Absolute accuracy : 0.01% FSR (typical)

Current Output Range:

- 0~20mA or 4~20mA
- Absolute accuracy: 0.1% FSR (typical)
- Excitation voltage range: +7V to +40V dc

Power Consumption:

- OME-PIO-DA4: +5VDC @ 600mA
- OME-PIO-DA8: +5VDC @ 800mA
- OME-PIO-DA16: +5VDC @ 1400mA

Environmental:

- Operating Temp.: 0~60°C
- Storage Temp.: -20°C~80°C
- Humidity : 0~90% non-condensing

Dimension:

- 180 mm × 115mm

1.3 Order Description

- OME-PIO-DA16 : PCI bus 16 channel D/A board
- OME-PIO-DA8 : PCI bus 8 channel D/A board
- OME-PIO-DA4 : PCI bus 4 channel D/A board

1.3.1 Options

- OME-DB-16P: 16 channel isolated D/I board
- OME-DB-16R: 16 channel relay board
- OME-DB-24PR: 24 channel power relay board
- OME-DB-24POR: 24 channel Photo MOS output board
- OME-DB-24C: 24-channel open-collector output board
- OME-ADP-20/PCI : extender, 20-pin header to 20-pin header for PCI Bus I/O

1.4 PCI Data Acquisition Family

We provide a family of PCI bus data acquisition cards. These cards can be divided into three groups as follows:

1. **PCI-series: first generation, isolated or non-isolated cards**
   OME-PCI-1002/1202/1800/1802/1602: multi-function family, non-isolated
   OME-PCI-P16R16/P16C16/P16POR16/P8R8: D/I/O family, isolated
   OME-PCI-TMC12: timer/counter card, non-isolated
2. **PIO-series: cost-effective generation, non-isolated cards**
   OME-PIO-D168/D144/D96/D64/D56/D48/D24: D/I/O family
   OME-PIO-DA16/DA8/DA4: D/A family
3. **PISO-series: cost-effective generation, isolated cards**
   OME-PISO-813: A/D card
   OME-PISO-P32C32/P64/C64/A64/P32A32: D/I/O family
   OME-PISO-P8R8/P8SSR8AC/P8SSR8DC: D/I/O family
   OME-PISO-730: D/I/O card

1.5 Product Check List

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

- One piece of OME-PIO-DA16/8/4 card
- One piece of software floppy diskette or CD
- One piece of release note

It is recommended to read the release note firstly. All important information will be given in release note as follows:

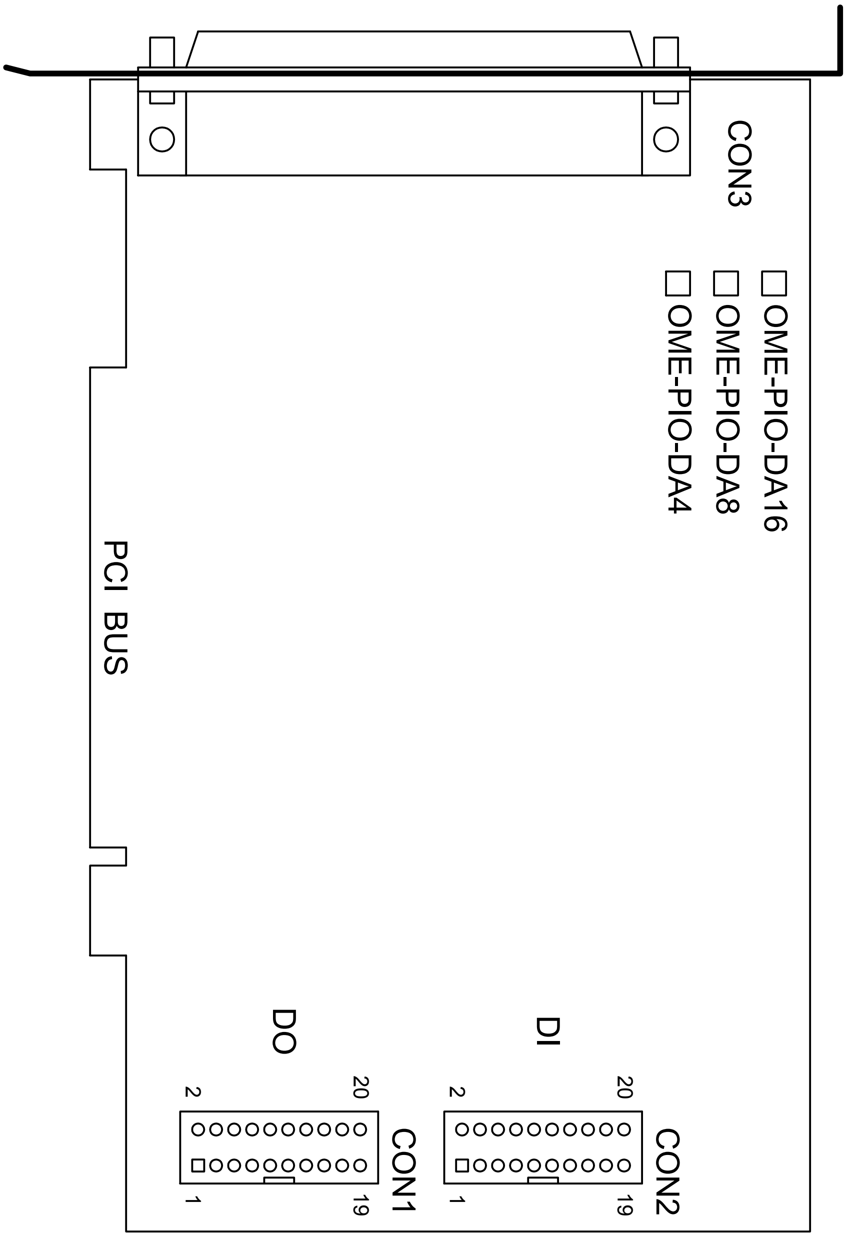
1. Where you can find the software driver & utility?
2. How to install software & utility?
3. Where is the diagnostic program?
4. FAQ

Attention!

If any of these items is missing or damaged, please contact Omega Engineering immediately. Save the shipping materials and the box in case you want to ship or store the product in the future.

2. Hardware configuration

2.1 Board Layout



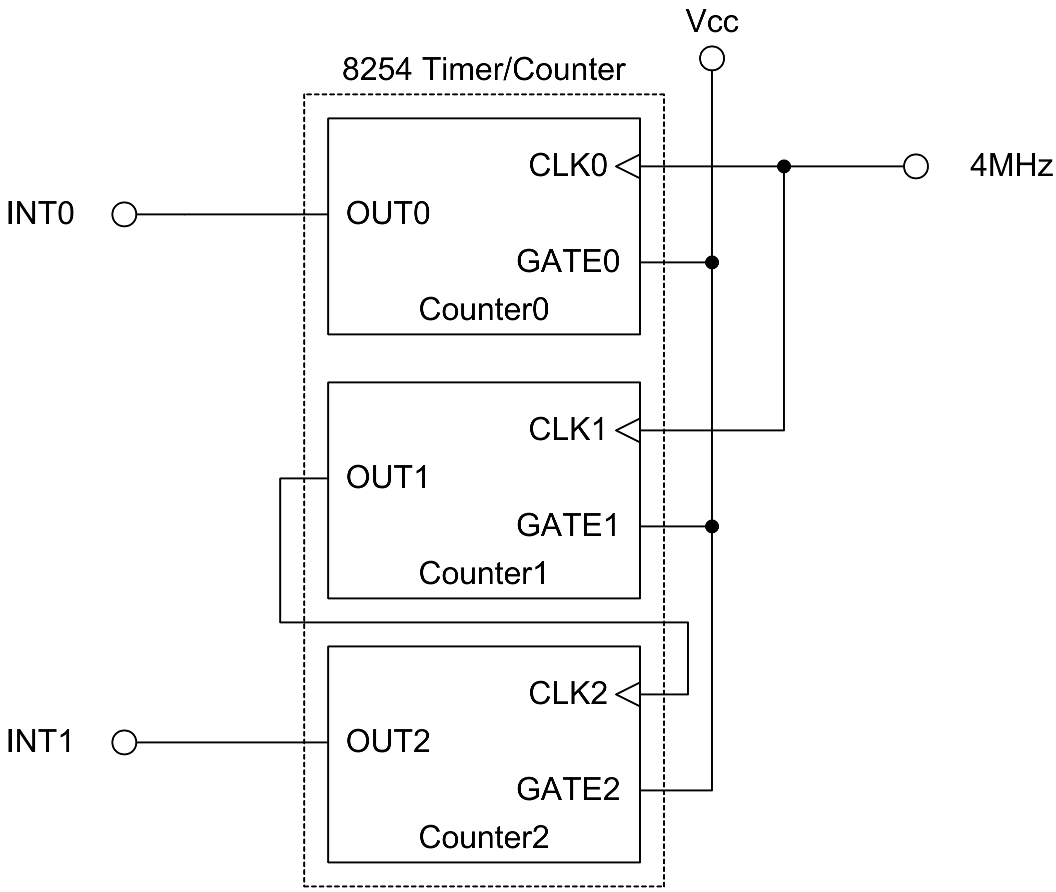
CON1: 16 channels D/O

CON2: 16 channels D/I

CON3: 16/8/4 channels D/A converted voltage/current output

2.2 Counter Architecture

There is one 8254(Timer/Counter) chip on the OME-PIO-DA16/8/4 card. The block diagram is given as follows:



It provides two interrupt source, one is 16 bits timer output (INT0) and the other one is 32 bits timer output (INT1).

2.3 Interrupt Operation

There are two interrupt sources in OME-PIO-DA16/8/4. These two signals are named as INT0 and INT1.Their signal sources are given as follows:

INT0: 8254 counter0 output (Refer to Sec. 2.2)
INT1: 8254 counter2 output (Refer to Sec. 2.2)

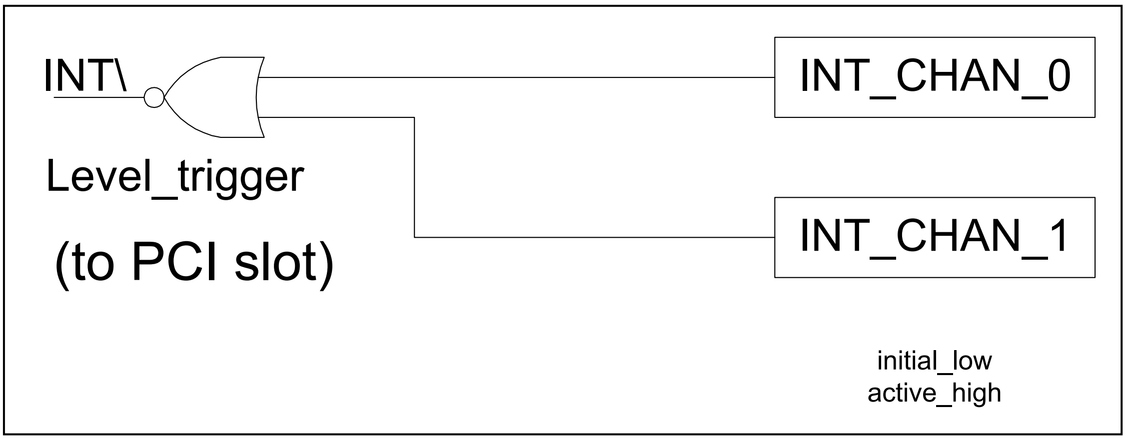
If only one interrupt signal source is used, the interrupt service routine doesn't have to identify the interrupt source. Refer to DEMO3.C and DEMO4.C for more information.

If there are more than one interrupt source, the interrupt service routine has to identify the active signals as follows: (Refer to DEMO5.C and DEMO6.C)

1. Read the new status of all interrupt signal source
2. Compare the new status with old status to identify the active signals
3. If INT0 is active, service it
4. If INT1 is active, service it
5. Save the new status to old status

Note: If the interrupt signal is too short, the new status may be as same as old status. In that condition the interrupt service routine cannot identify which interrupt source is active. So the interrupt signal must be hold_active long enough 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 most operating systems.

2.3.1 Interrupt Block Diagram of OME-PIO-DA16/8/4



The interrupt output signal of OME-PIO-DA16/8/4, **INT\, is Level-Trigger & Active_Low.** If the INT\ generate a low_pulse, the OME-PIO-DA16/8/4 will interrupt the PC once a time. If INT\ is fixed in low_level, the OME-PIO-DA16/8/4 will interrupt the PC continuously. So the **INT_CHAN_0/1 must be controlled in a pules_type signals. They must be fixed in low_level statue normally and generated a high_pulse to interrupt the PC.**

The priority of INT_CHAN_0/1 is the same. If all these two signals are active at the same time, then INT\ will be active only once a time. So the interrupt service routine has to read the status of all interrupt channels for multi channels interrupt. Refer to Sec. 2.3 for more information.

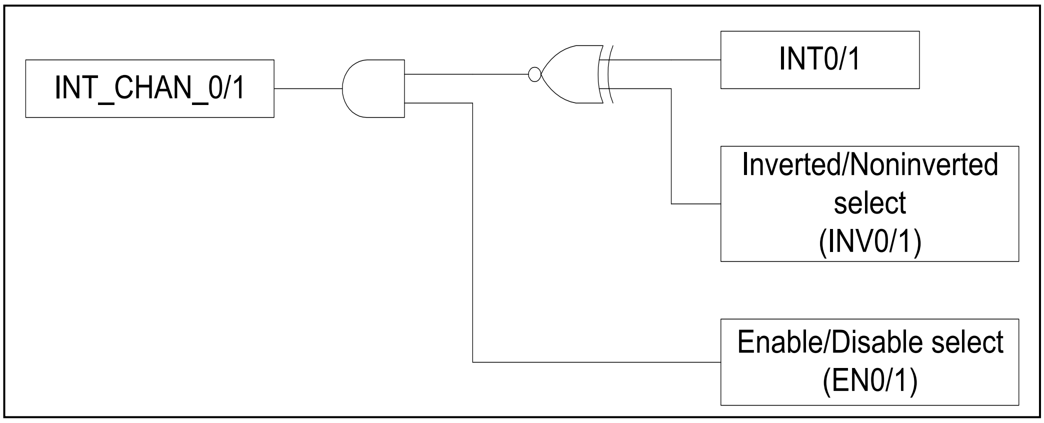
DEMO5.C → for INT_CHAN_0 & INT_CHAN_1

If only one interrupt source is used, the interrupt service routine doesn't have to read the status of interrupt source. The demo programs DEMO3.C - DEMO4.C are designed for single-channel interrupt demo as follows:

DEMO3.C → for INT_CHAN_1 only (initial high)

DEMO4.C → for INT_CHAN_1 only (initial low)

2.3.2 INT_CHAN_0/1



The architecture of INT_CHAN_0 and INT_CHAN_1 is the same as above figure. The only difference between INT0 and INT1 is that INT_CHAN_0 signal source from 8254 counter0 output and INT_CHAN_1 signal source from 8254 counter2 output.

The INT_CHAN_0/1 must be fixed in low level state normally and generate a high_pulse to interrupt the PC.

The EN0/1 can be used to enable/disable the INT_CHAN_0/1 as follows: (Refer to Sec.3.3.4)

EN0/1 = 0 → INT_CHAN_0/1 = disable
EN0/1 = 1 → INT_CHAN_0/1 = enable

The INV0/1 can be used to invert/non-invert the INT0/1 as follows: (Refer to Sec.3.3.6)

INV0/1 = 0 → INT_CHAN_0/1 = inverted state of INT0/1
INV0/1 = 1 → INT_CHAN_0/1 = non-inverted state of INT0/1

If the INT\ fixed in low level state, the OME-PIO-DA16/8/4 will interrupt the PC continuously. So interrupt service routine should use INV0/1 to invert/non-invert the INT0/1 to generate high_pulse (Refer to next section)

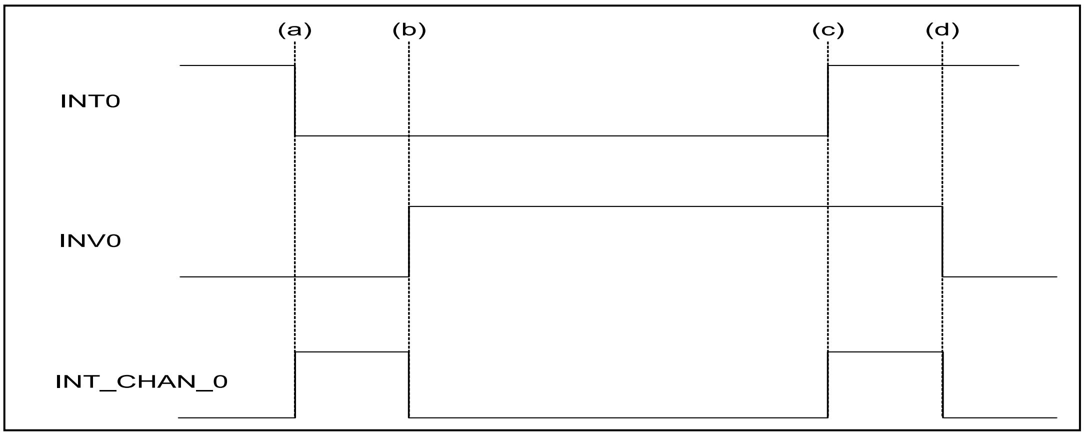
2.3.3 Initial_high, active_low Interrupt source

If the INT0 (8254 counter0 output) is an initial_high, active_low signal (depend on 8254 counter mode), the interrupt service routine should use INV0 to invert/ non-invert the INT0 for high_pulse generation as follows: (Refer to DEMO3.C)

Initial set:

```
now_int_state=1;                       /* initial state for INT0      */
outportb(wBase+0x2a,0);                /* select the inverted INT0  */
```

```
void interrupt irq_service()
{
if (now_int_state==1)       /* now INT0 is changed to LOW         */(a)
   {                        /* --> INT_CHAN_0=!INT0=HIGH now      */
   COUNT_L++;               /* find a LOW_pulse (INT0)            */
   If((inport(wBase+7)&1)==0)/* the INT0 is still fixed in LOW    */
     {                      /* → need to generate a high_pulse   */
     outportb(wBase+0x2a,1);/* INV0 select the non-inverted input */(b)
                            /* INT_CHAN_0=INT0=LOW -->            */
                            /* INT_CHAN_0 generate a high_pulse   */
     now_int_state=0;       /* now INT0=LOW                       */
     }
   else now_int_state=1;    /* now INT0=HIGH                      */
                            /* don't have to generate high_pulse  */
   }
else                        /* now INT0 is changed to HIGH        */(c)
   {                        /* --> INT_CHAN_0=INT0=HIGH now       */
   COUNT_H++;               /* find a HIGH_pulse (INT0)           */
   If((inport(wBase+7)&1)==1)/* the INT0 is still fixed in HIGH   */
     {                      /* need to generate a high_pulse      */
     outportb(wBase+0x2a,0);/* INV0 select the inverted input   */(d)
                            /* INT_CHAN_0=!INT0=LOW -->           */
                            /* INT_CHAN_0 generate a high_pulse   */
     now_int_state=1;       /* now INT0=HIGH                      */
     }
   else now_int_state=0;    /* now INT0=LOW                       */
                            /* don't have to generate high_pulse  */
   }
if (wIrq>=8) outportb(A2_8259,0x20);
outportb(A1_8259,0x20);
}
```



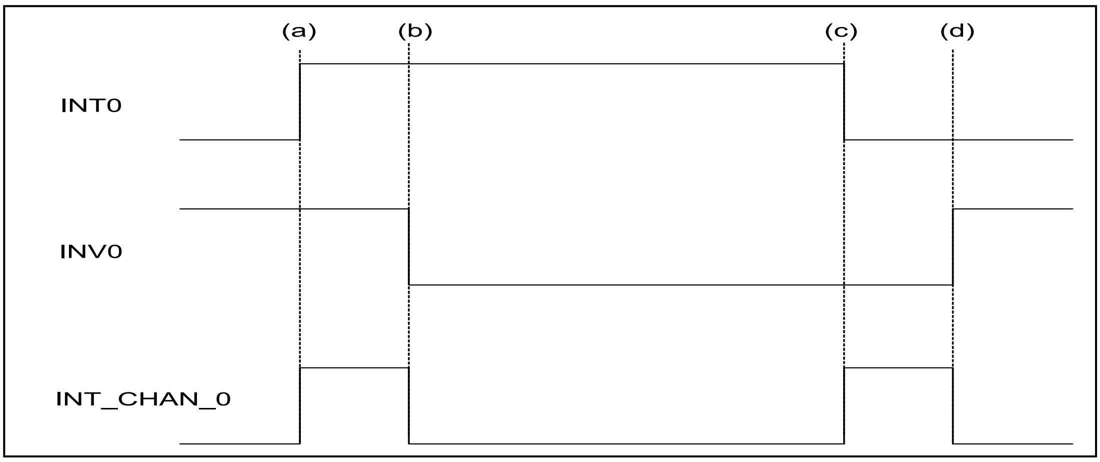
2.3.4 Initial_low, active_high Interrupt source

If the INT0 (8254 counter0 output) is an initial_low, active_high signal (depend on 8254 counter mode), the interrupt service routine should use INV0 to invert/non-invert the INT0 for high_pulse generation as follows: (Refer to DEMO4.C)

Initial set:

```
now_int_state=0;                    /* initial state for INT0         */
outportb(wBase+0x2a,1);             /* select the non-inverted INT0 */
```

```
void interrupt irq_service()
{
if (now_int_state==1)        /* now INT0 is changed to LOW          */(c)
   {                         /* --> INT_CHAN_0=!INT0=HIGH now       */
   COUNT_L++;                /* find a LOW_pulse (INT0)             */
   If((inport(wBase+7)&1)==0)/* the INT0 is still fixed in LOW     */
     {                       /* → need to generate a high_pulse    */
     outportb(wBase+0x2a,1);/* INV0 select the non-inverted input */(d)
                             /* INT_CHAN_0=INT0=LOW -->             */
                             /* INT_CHAN_0 generate a high_pulse    */
     now_int_state=0;        /* now INT0=LOW                        */
     }
   else now_int_state=1;     /* now INT0=HIGH                       */
                             /* don't have to generate high_pulse   */
   }
else                         /* now INT0 is changed to HIGH         */(a)
   {                         /* --> INT_CHAN_0=INT0=HIGH now        */
   COUNT_H++;                /* find a High_pulse (INT0)            */
   If((inport(wBase+7)&1)==1)/* the INT0 is still fixed in HIGH    */
     {                       /* need to generate a high_pulse       */
     outportb(wBase+0x2a,0);/* INV0 select the inverted input    */(b)
                             /* INT_CHAN_0=!INT0=LOW -->            */
                             /* INT_CHAN_0 generate a high_pulse    */
     now_int_state=1;        /* now INT0=HIGH                       */
     }
   else now_int_state=0;     /* now INT0=LOW                        */
                             /* don't have to generate high_pulse   */
   }
if (wIrq>=8) outportb(A2_8259,0x20);
outportb(A1_8259,0x20);
}
```

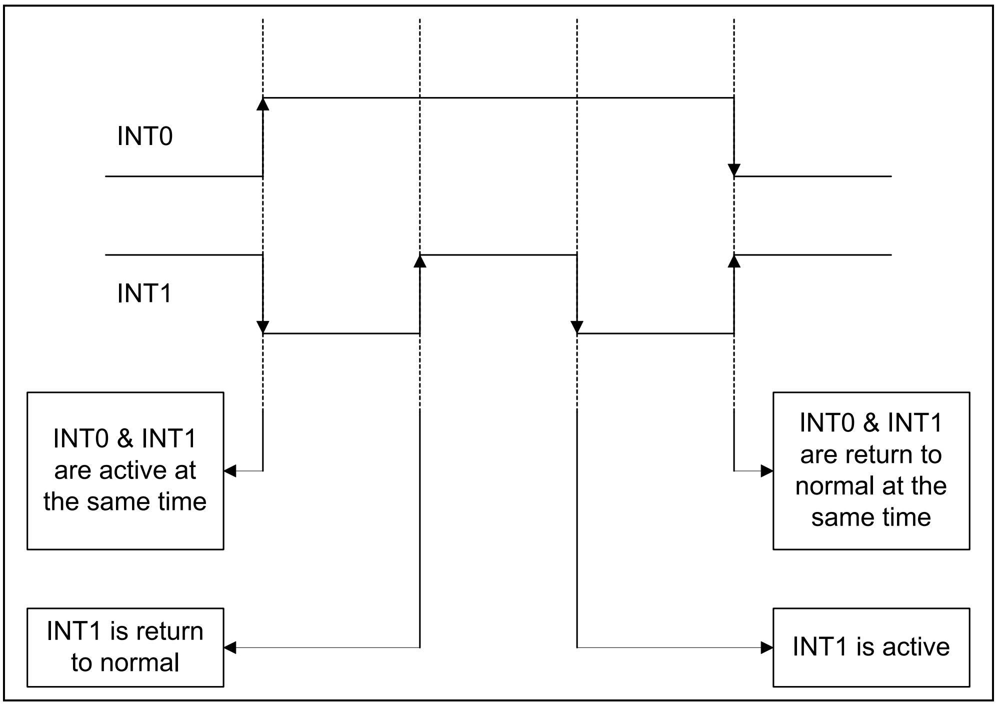


2.3.5 Multiple Interrupt Source

Assume: INT0 is initial Low, active High,

INT1 is initial High, active Low

as follows:



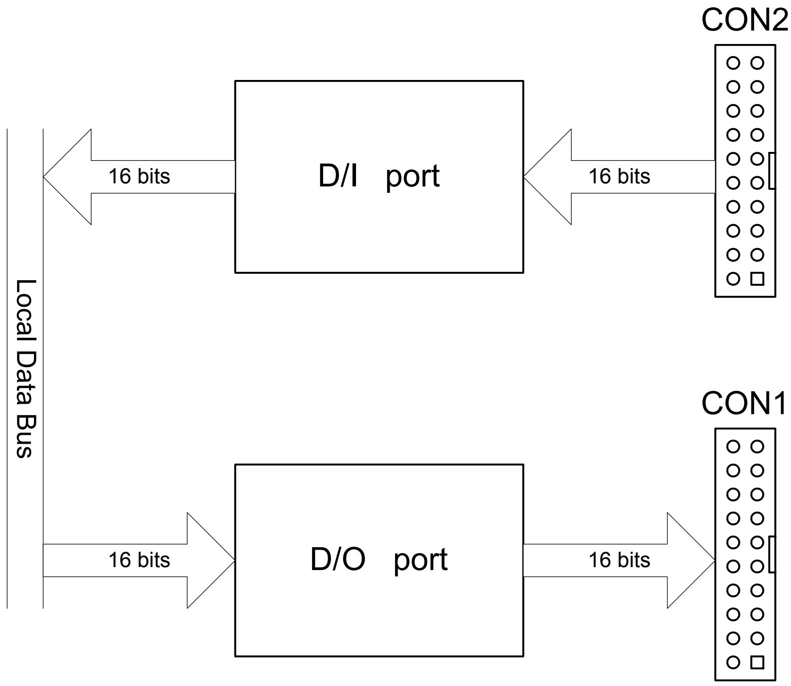
Refer to DEMO5.C for source program. **All of these falling-edge & rising-edge can be detected by DEMO5.C.**

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

```
/* ------------------------------------------------------------- */
/* Note : 1.The hold_time of INT_CHAN_0 & INT_CHAN_1 must long    */
/*          enoug.                                                */
/*        2.The ISR must read the interrupt status again to       */
/*          identify the active interrupt source.                 */
/*        3.The INT_CHAN_0 & INT_CHAN_1 can be active at the same */
/*          time.                                                 */
/* ------------------------------------------------------------- */
void interrupt irq_service()
{
/* now ISR can not know which interrupt is active                 */
new_int_state=inportb(wBase+7)&0x03;      /* read all interrupt   */
                                          /* signal state         */
int_c=new_int_state^now_int_state;        /* compare new_state to */
                                          /* old_state            */

if ((int_c&0x01)==1)             /* INT_CHAN_0 is active          */
   {
   if ((new_int_state&1)==0)     /* INT0 change to low now        */
      {
      INT0_L++;
      }
   else                          /* INT0 change to high now       */
      {
      INT0_H++;
      }
   invert=invert^1;              /* generate high_pulse           */
   }

if ((int_c&0x02)==2)             /* INT_CHAN_1 is active          */
   {
   if ((new_int_state&2)==0)     /* INT1 change to low now        */
      {
      INT1_L++;
      }
   else                          /* INT1 change to high now       */
      {
      INT1_H++;
      }
   invert=invert^2;              /* generate high_pulse           */
   }

now_int_state=new_int_state;     /* update interrupt status       */
outportb(wBase+0x2a,invert);     /* generate a high pulse         */

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

2.4 D/I/O Block Diagram

The OME-PIO-DA16/8/4 provides 16 channels of digital input and 16 channels of digital output. All signal levels are TTL compatible. The connection diagram and block diagram are given as follows:

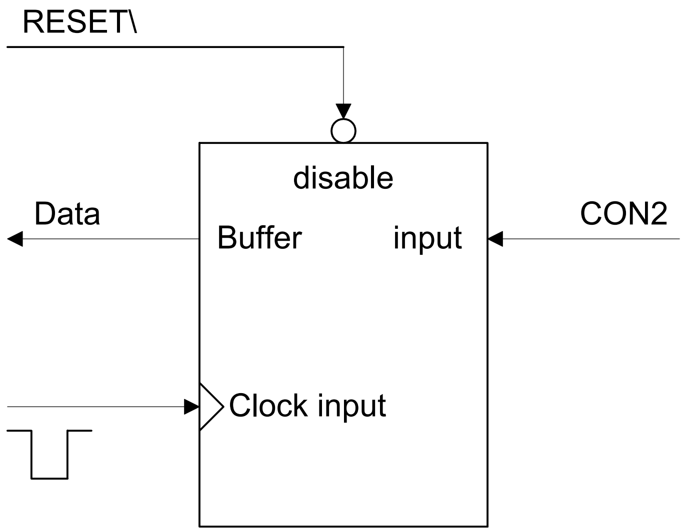


The D/I port can be connected to the OME-DB-16P. The OME-DB-16P is a 16-channel isolated digital input daughter board. The D/O port can be connected to the OME-DB-16R or OME-DB-24PR. The OME-DB-16R is a 16-channel relay output board. The OME-DB-24PR is a 24-channel power relay output board.

2.4.1 DI Port Architecture (CON2)

When the PC is powered-up, all operation of DI port (CON2) is disable. The enable/disable of DI port is controlled by the RESET\ signal. Refer to Sec. 3.3.1 for more information about RESET\ signal.

- The RESET\ is in Low-state → all DI operation is disable
- The RESET\ is in High-state → all DI operation is enable



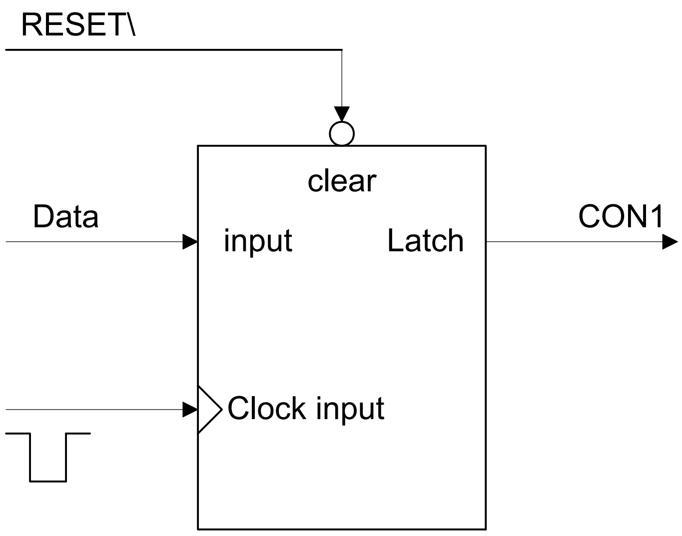
D/I buffer CKT

2.4.2 DO Port Architecture (CON1)

When the PC is powered-up, all of DO states are clear to low state. The RESET\ signal is used to clear DO states. Refer to Sec. 3.3.1 for more information about RESET\ signal.

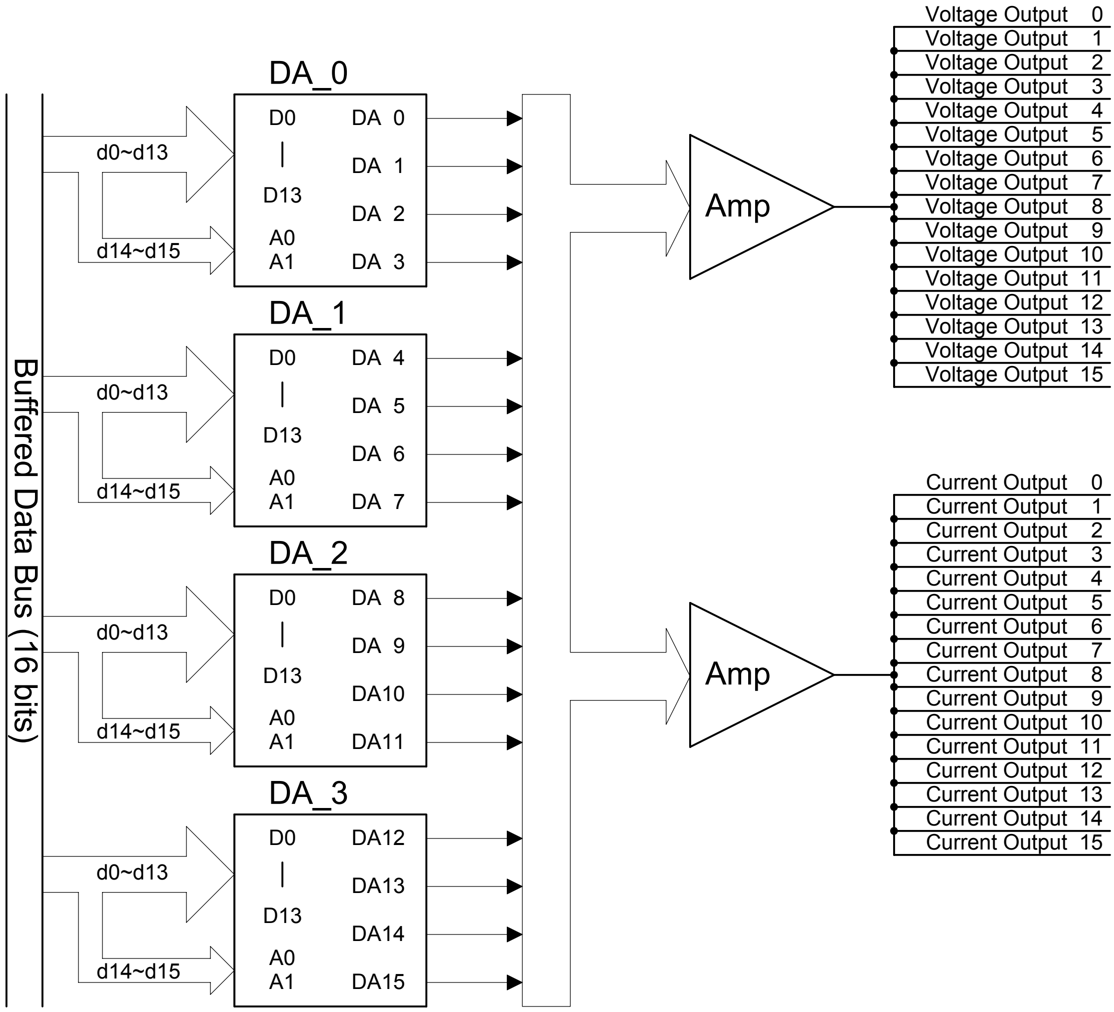
- The RESET\ is in Low-state → all DOs are clear to low state

The block diagram of DO is given as follows:



D/O buffer CKT

2.5 D/A Architecture



The OME-PIO-DA16/8/4 offers 16/8/4 channels double-buffered digital to analog output and provide voltage output & current output simultaneously.

2.6 D/A Convert Operation

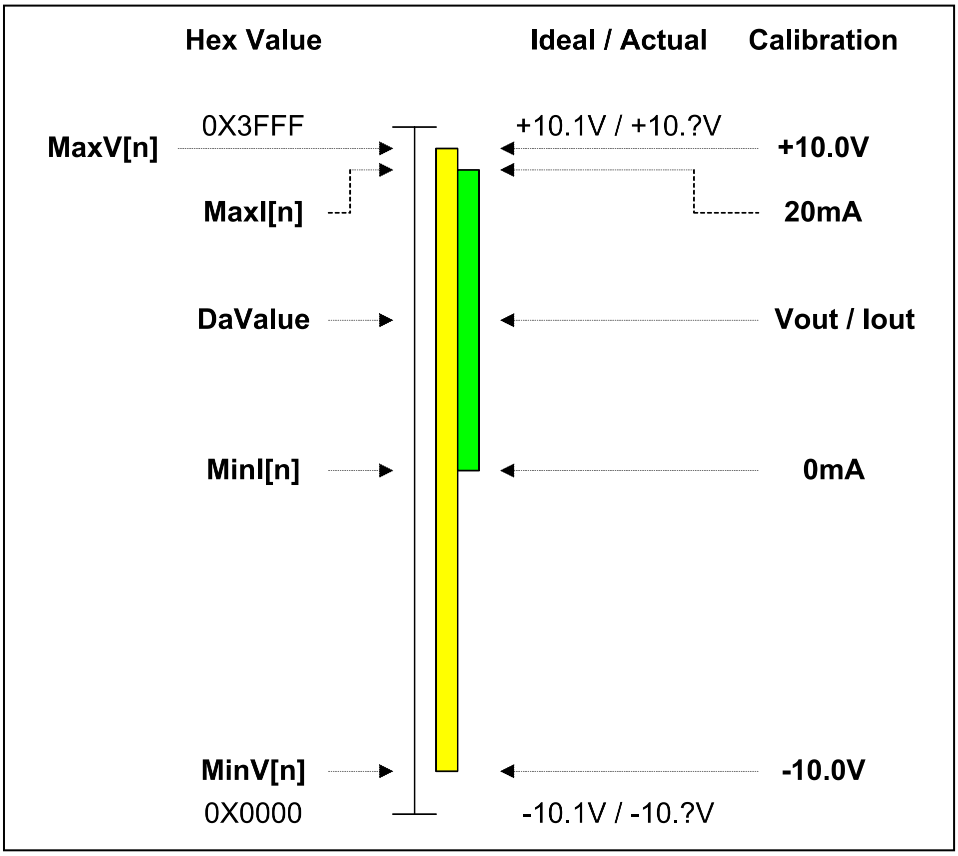
The D/A converters on OME-PIO-DA16/8/4 have 14 bits of resolution, so the digital data value range from 0x0000 to 0x3fff. And the hardware is designed to output voltage range from -10.1~+10.1 as follows:

0x0000 → about –10.1 volt

0x3FFF → about +10.1 volt

In the conventional design, there will be some VRs to adjust to let 0x0000=-10.0V & 0x3fff=+10.0V for voltage output. Also these VRs have to be adjusted to let 0x1fff=0mA & 0x3fff=20mA for current output. In the conventional design, these VRs are common for voltage/current output. So the user has to perform calibration when change from voltage to current. Also If these VRs are changed, the user has to perform calibration again. This procedure is complex & heavy load. The OME-PIO-DA16/8/4 use software calibration to replace this complex procedure as following:

- for each voltage output channel we find two hex value MaxV[n] and MinV[n] (stored to on board EEPROM). MaxV[n] mapping to accurate +10V and MinV[n] mapping to accurate –10V.
- For each current output channel we also find two hex value MaxI[n] and MinI[n] (stored to on board EEPROM). MaxI[n] mapping to accurate 20mA and MinI[n] mapping to accurate 0mA.



Therefore the software can calibrate the analog output without any hardware Trim-pot adjustment. For example,

channel n	MinV[n]	MaxV[n]	MinI[n]	MaxI[n]
0	134	16297	8180	15943
1	137	16293	8172	15976
2	132	16296	8199	15949
3	134	16391	8177	15963
4	135	16298	8165	15955
5	131	16292	8150	15947
6	136	16295	8172	15968
7	134	16297	8163	15961
8	134	16294	8188	15959
9	132	16295	8169	15948
10	135	16298	8172	15946
11	133	16296	8177	15975
12	131	16292	8159	15942
13	134	16297	8173	15973
14	132	16293	8168	15949
15	133	16295	8175	15965

If the user want to send Vout(volt) to channel n, the calibrated hex value, DaValue, sent to D/A converter is give as follows:

```
DeltaV[n]=20.0/(MaxV[n]–MinV[n]);      /* DeltaV[n]=volt per count at channel_n */
DaValue=(Vout+10.0)/DeltaV[n]+MinV[n];   /* DaValue=Hex value send to D/A   */
pio_da16_da(n,DaValue);                  /* send DaValue to channel n        */
```

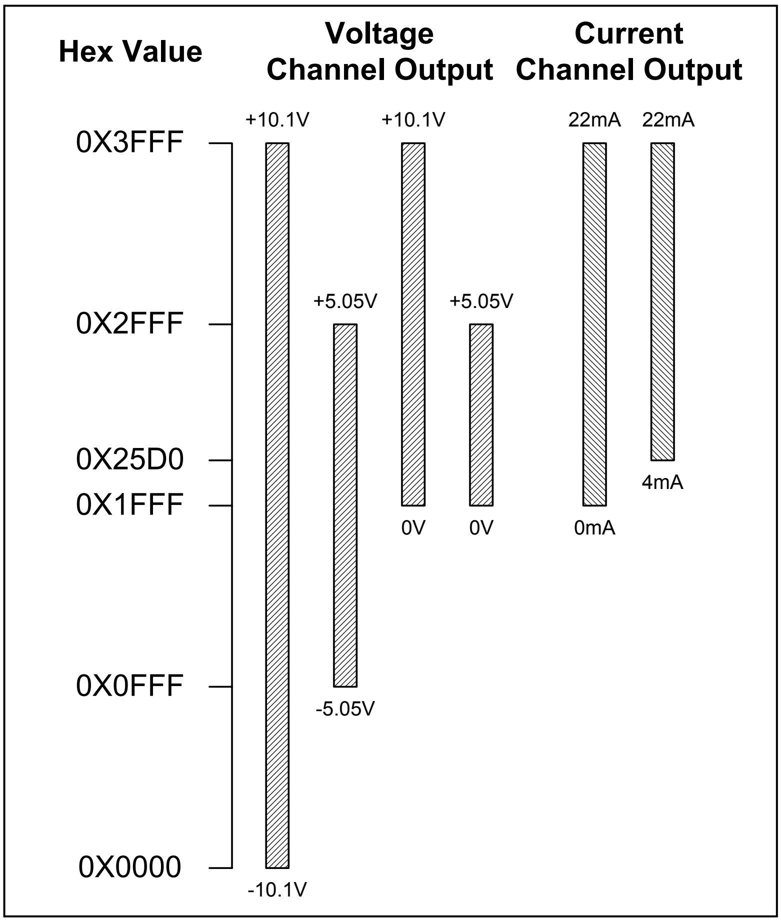
If the user want to send Iout(mA) to channel n, the calibrated hex value, DaValue, sent to D/A converter is give as follows: (Refer to DEMO9.C)

```
DeltaI[n]=20.0/(MaxI[n]–MinI[n]);        /* DeltaI[n]=mA per count at channel_n */
DaValue=Iout/DeltaI[n]+MinI[n];          /* DaValue=Hex value send to D/A       */
pio_da16_da(n,DaValue);                  /* send DaValue to channel n           */
```

Refer to DEMO7.C and DEMO9.C for more information.

2.6.1 Output Range and Resolution

The voltage output range of OME-PIO-DA16/8/4 is always in ±10.1V and the current output range is always in 0~22mA as following:



The resolution of each range is given as follows:

Configuration	Equivalent Bit	Resolution
-10V ~ +10V	14 bit	1.22mV
0V ~ 10V	13 bit	1.22mV
-5V ~ +5V	13 bit	1.22mV
0V ~ +5V	12 bit	1.22mV
0mA ~ 20mA	13 bit	2.70uA
4mA ~ 20mA	13 bit	2.70uA

2.6.2 The ±10V Voltage Output

The voltage output of OME-PIO-DA16/8/4 is always in ±10.1V range. If the user needs to output ±10V range, the software is same as described in Sec.2.6. Because the user wants to output ±10V range, Vout will be in ±10V range, the DaValue will be about from 0x0000 to 0x3fff. This means the resolution is about 14 bit.

2.6.3 The ±5V Voltage Output

The voltage output of OME-PIO-DA16/8/4 is always in ±10.1V range. If the user needs to output ±5V range, the software is same as described in Sec.2.6. Because the user wants to output ±5V range, Vout will be in ±5V range, the DaValue will be about from 0x0fff to 0x2fff. This means the resolution is about 13 bits.

2.6.4 The 0~10V Voltage Output

The voltage output of OME-PIO-DA16/8/4 is always in ±10V.1 range. If the user needs to output 0~10V range, the software is same as described in Sec.2.6. Because the user wants to output 0~10V range, Vout will be in 0~10V range, the DaValue will be about from 0x1fff to 0x3fff. This means the resolution is about 13 bits.

2.6.5 The 0~5V Voltage Output

The voltage output of OME-PIO-DA16/8/4 is always in ±10.1V range. If the user needs to output 0~5V range, the software is same as described in Sec.2.6. Because the user wants to output 0~5V range, Vout will be in 0~5V range, the wDaValue will be about from 0x1fff to 0x2fff. This means the resolution is about 12 bits.

2.6.6 The 0~20mA Current Output

The current output of OME-PIO-DA16/8/4 is always in 0~22mA range. If the user needs to output 0~20mA, the software is the same as described in Sec.2.6. Because the user wants to output 0~20mA, Iout will be in the 0~20mA range. So the DaValue will be about from 0x1fff to 0x3fff. This means the resolution is about 13 bits.

2.6.7 The 4~20mA Current Output

The current output of OME-PIO-DA16/8/4 is always in 0~22mA range. If the user needs to output 4~20mA, the software is the same as described in Sec.2.6. Because the user wants to output 4~20mA, Iout will be in the 4~20mA range. So the DaValue will be about from 0x2600 to 0x3fff. This means the resolution is about 13 bits.

2.6.8 No VR & No Jumper Design

In the conventional 12-bit D/A board, for example OME-A-626/A-628, there are jumpers for the following functions:

(1) select the reference voltage (internal –10/-5/or external)
(2) select unipolar/bipolar (0-10V or ±10V)
(3) select different output range (0-10V or 0-5V)

And there are many VRs for the following functions:

(1) voltage output offset adjustment
(2) voltage output full-scale adjustment
(3) current output offset adjustment
(4) current output full-scale adjustment

There are so many VRs and jumpers, this make the QC and re-calibration very difficult. Every step must be performed manually making is difficult to calibrate these D/A boards.

The design of the OME-PIO-DA/16/8/4 removed all these VRs and jumpers but still maintain the same precision and performance. There is a 14-bit D/A converter and software calibration to provide at least the same performance & precision as OME-A-626/A-628 as follows:

Configuration	Equivalent Bit	Resolution
-10V ~ +10V	14 bit	1.22mV
0V ~ 10V	13 bit	1.22mV
-5V ~ +5V	13 bit	1.22mV
0V ~ +5V	12 bit	1.22mV
0mA ~ 20mA	13 bit	2.70uA
4mA ~ 20mA	13 bit	2.70uA

- All these VRs and jumpers are removed.
- All calibrations can be done by software.
- All channel configurations can be selected by software, no need to change any hardware.
- The Precision is at least the same as OME-A-626/A628.
- All these 16 channels can be configured and used in the different configuration at the same time. (For example, channel_0=±10V, channel_1=4~20mA, channel_2=0~5V, …).
- All these features can be implemented in a small, compact, reliable and half-size PCB.

2.6.9 Factory Software Calibration

It is recommended to use a 16-bit A/D card to calibration the OME-PIO-DA16/8/4. The OME-I-7000 series is a set of precision remote control modules. The I-7017 is 8-channel 16-bit precision A/D module (24-bit sigma-delta A/D converter), we use two OME-I-7017 for voltage output calibration and another two OME-I-7017 for current output calibration.

The steps for channel_n voltage calibration are given as follows:

Step 1: DaValue=0
Step 2: send DaValue to OME-PIO-DA16/8/4 channel_n
Step 3: measure the I-7017 channel_n,
 If this value is just >= -10V, than goto step 5
Step 4: incrememt DaValue, goto step 2
Step 5: MinV[n]=DaValue-1
Step 6: DaValue=0x3fff
Step 7: send DaValue to OME-PIO-DA16/8/4 channel_n
Step 8: measure the I-7017 channel_n,
 If this value is just >= +10V, than goto step 10
Step 9: increment DaValue, goto step 7
Step 10: MaxV[n]=DaValue
Note: MinV[n] & MaxV[n] are discribed in Sec.2.6

The steps for channel_n current calibration are given as follows:

Step 1: DaValue=0x1fff
Step 2: send DaValue to OME-PIO-DA16/8/4 channel_n
Step 3: measure the I-7017 channel_n,
 If this value is just >= 0mA, than goto step 5
Step 4: incrememt DaValue, goto step 2
Step 5: MinI[n]=DaValue-1
Step 6: DaValue=0x3fff
Step 7: send DaValue to OME-PIO-DA16/8/4 channel_n
Step 8: measure the I-7017 channel_n,
 If this value is just >= 20mA, than goto step 10
Step 9: increment DaValue, goto step 7
Step 10: MaxI[n]=DaValue
Note: MinI[n] & MaxI[n] are discribed in Sec.2.6

2.6.10 User Software Calibration

User can perform calibration with a voltage meter and a current meter.

Step1: Run DEMO12.EXE

Step2: Select card number (OME-PIO-DA16/OME-PIO-DA8/OME-PIO-DA4) that you want to calibrate

Step3: Select which item (MinV[n]/MaxV[n]/MinI[n]/MaxI[n]) that you want to calibrate

Step4: To measure the analog output by voltage meter or current meter and decide to increment or decrement DaValue. The DaValue will send to D/A converter at once. By the measured result user can find the proper value of DaValue that mapping to accurate output value.

Step5: Repeat step 4 for each channel

After this procedure, the new data of MinV[n]/MaxV[n]/MinI[n]/MaxI[n] will be stored to on board EEPROM.

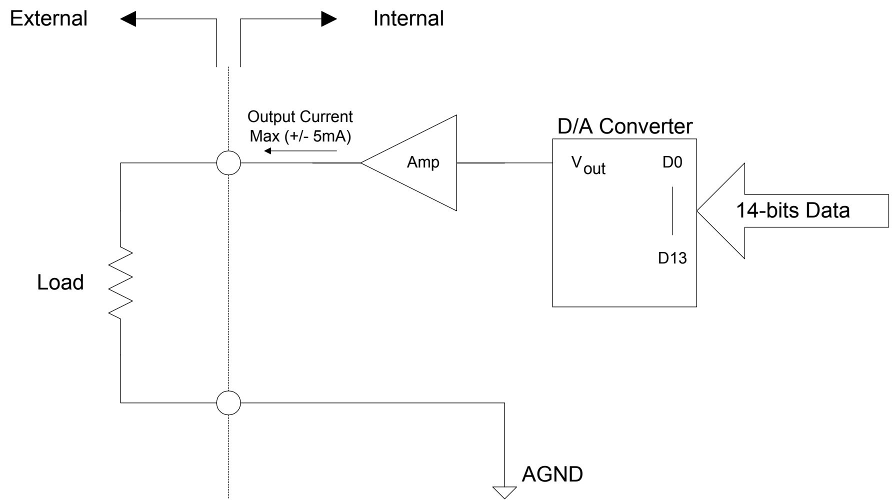
User can run DEMO10.EXE to back-up the old calibration data to "A:\DA16.DAT" before new calibration.

If something error during the new calibration, user can run DEMO11.EXE to download data from "A:\DA16.DAT" to EEPROM.

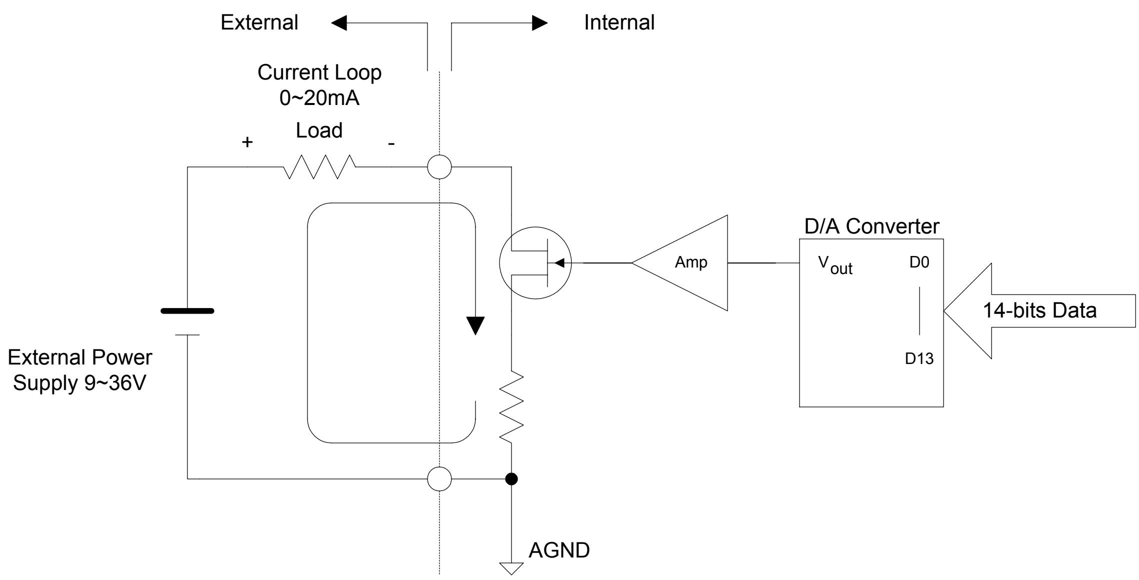
Note :

DEMO10.EXE → save old calibration data
DEMO11.EXE → download old calibration data
DEMO12.EXE → perform new calibration

2.6.10 Voltage Output Connection



2.6.11 Current Output Connection



2.7 The Connectors

CON1: Digital Output Connector

Pin Assignment:

Pin	Name	Pin	Name
1	Digital Output 0	2	Digital Output 1
3	Digital Output 2	4	Digital Output 3
5	Digital Output 4	6	Digital Output 5
7	Digital Output 6	8	Digital Output 7
9	Digital Output 8	10	Digital Output 9
11	Digital Output 10	12	Digital Output 11
13	Digital Output 12	14	Digital Output 13
15	Digital Output 14	16	Digital Output 15
17	PCB ground	18	PCB ground
19	PCB +5V	20	PCB +12V

All signals are TTL compatible.

CON2: Digital input connector

Pin assignment:

Pin	Name	Pin	Name
1	Digital Input 0	2	Digital Input 1
3	Digital Input 2	4	Digital Input 3
5	Digital Input 4	6	Digital Input 5
7	Digital Input 6	8	Digital Input 7
9	Digital Input 8	10	Digital Input 9
11	Digital Input 10	12	Digital Input 11
13	Digital Input 12	14	Digital Input 13
15	Digital Input 14	16	Digital Input 15
17	PCB ground	18	PCB ground
19	PCB +5V	20	PCB +12V

All signals are TTL compatible.

CON3: Analog Output Connector

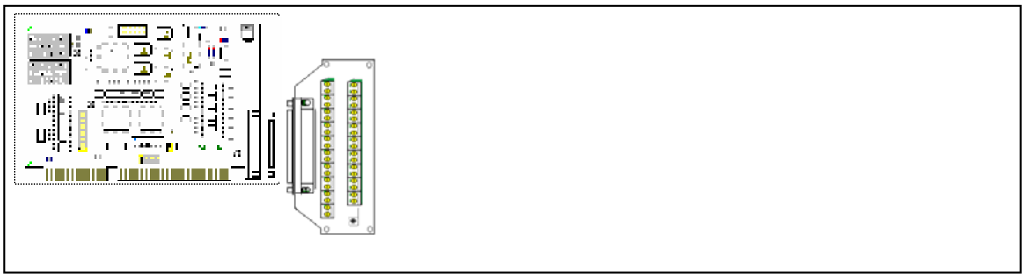
Pin Assignment:

Pin	Name	Pin	Name
1	Voltage Output 0	20	Current Output 0
2	Voltage Output 1	21	Current Output 1
3	Voltage Output 2	22	Current Output 2
4	Voltage Output 3	23	Current Output 3
5	Analog ground	24	Analog ground
6	Voltage Output 4	25	Current Output 4
7	Voltage Output 5	26	Current Output 5
8	Voltage Output 6	27	Current Output 6
9	Voltage Output 7	28	Current Output 7
10	Analog ground	29	Analog ground
11	Voltage Output 8	30	Current Output 8
12	Voltage Output 9	31	Current Output 9
13	Voltage Output 10	32	Current Output 10
14	Voltage Output 11	33	Current Output 11
15	Analog ground	34	Current Output 12
16	Voltage Output 12	35	Current Output 13
17	Voltage Output 13	36	Current Output 14
18	Voltage Output 14	37	Current Output 15
19	Voltage Output 15		

2.8 Daughter Boards

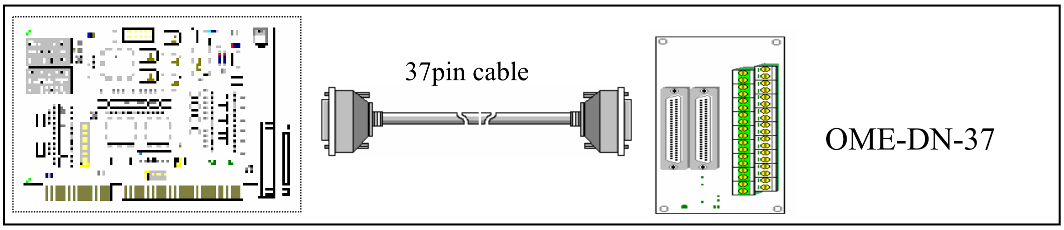
2.8.1 OME-DB-37

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



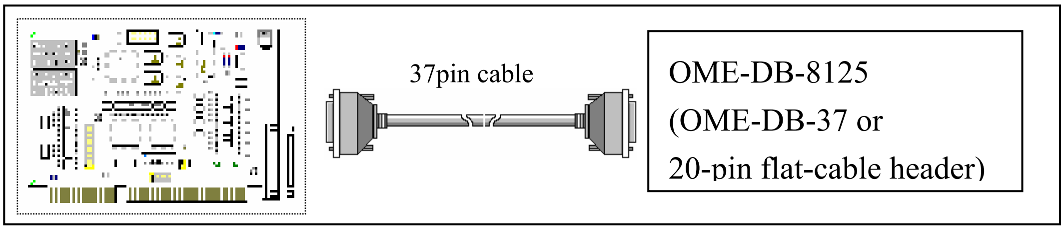
2.8.2 OME-DN-37

The OME-DN-37 is a general purpose daughter board for OME-DB-37 with DIN-Rail Mounting. This board is designed for easy wire connection.



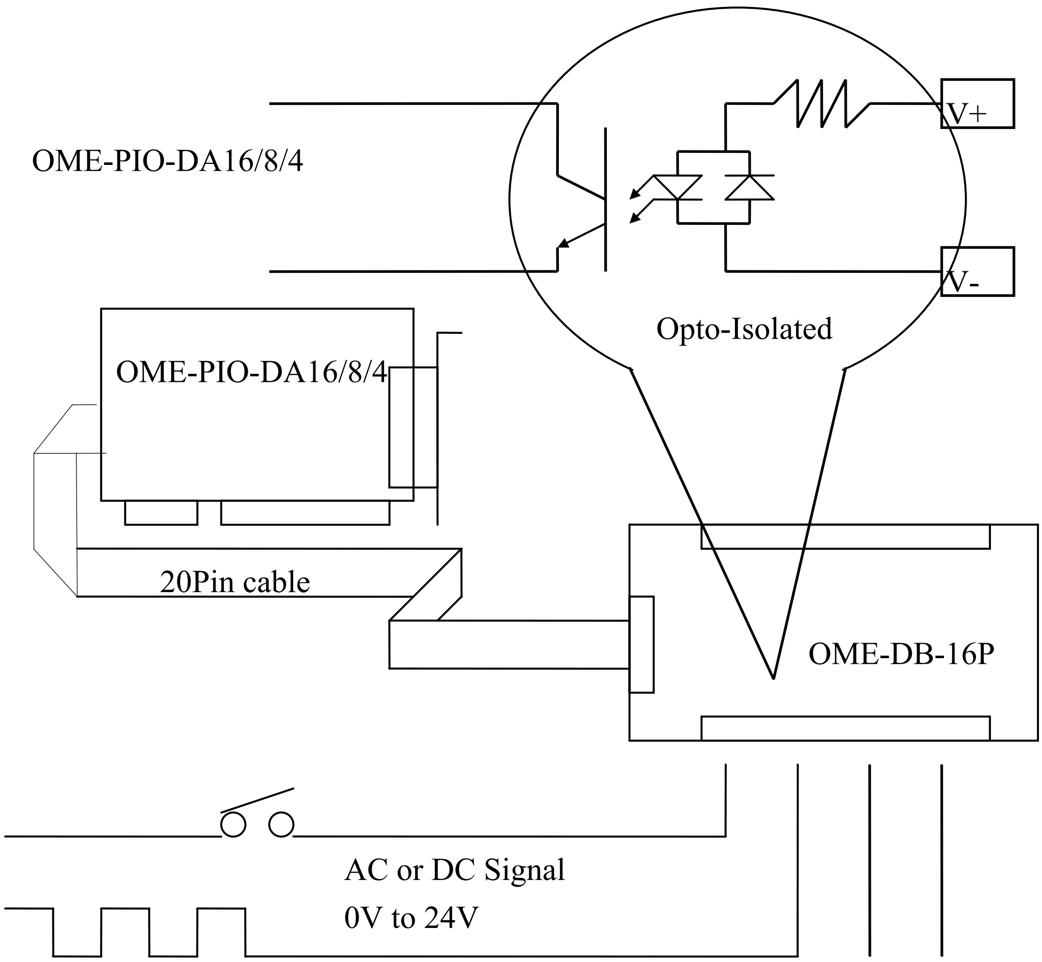
2.8.3 OME-DB-8125

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



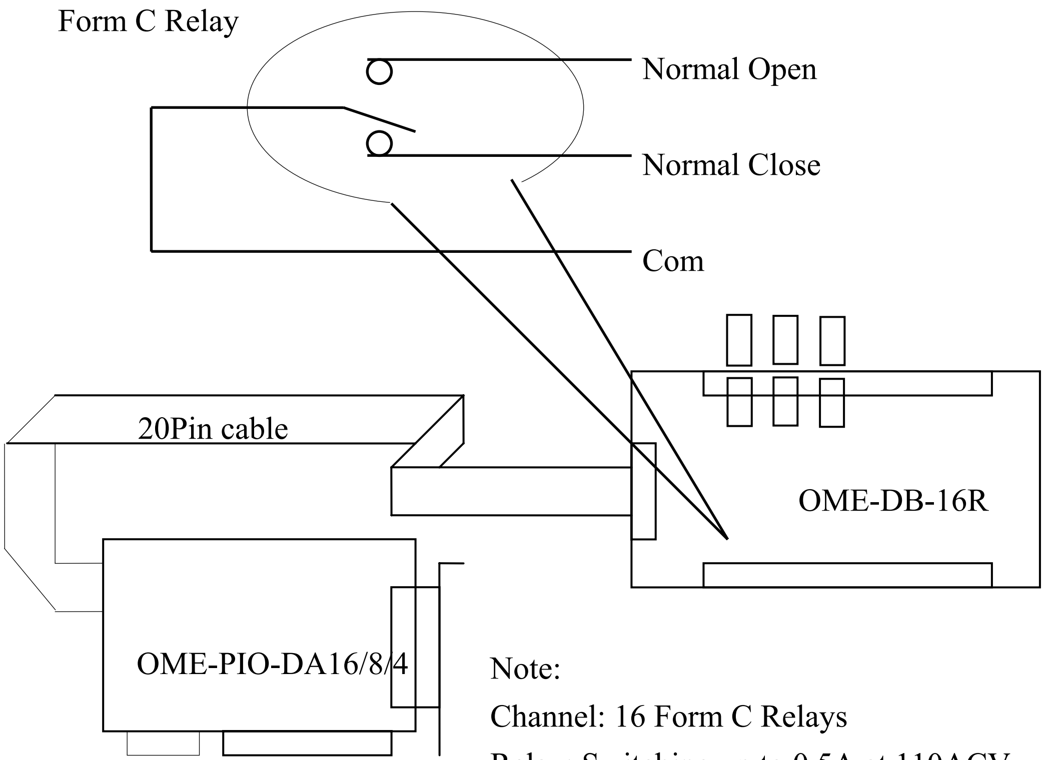
2.8.4 OME-DB-16P Isolated Input Board

The OME-DB-16P is a 16-channels isolated digital input daughter board. The optically isolated inputs of the OME-DB-16P consist of a bi-directional opto-coupler with a resistor for current sensing. You can use the OME-DB-16P to sense DC signal from TTL levels up to 24V or use the OME-DB-16P to sense a wide range of AC signals. You can use this board to isolate the computer from large common-mode voltage, ground loops and transient voltage spike that often occur in industrial environments.



2.8.5 OME-DB-16R Relay Board

The OME-DB-16R, 16-channel relay output board, consists of 16 form C relays for efficient switch of load by programmed control. It is connector and functionally compatible with 785 series board but with industrial type terminal block. The relay are energized by apply 5 volt signal to the appropriated relay channel on the 20-pin flat connector. There are 16 enunciator LEDs for each relay, light when their associated relay is activated. To avoid overloading your PC's power supply, this board provides a screw terminal for external power supply.

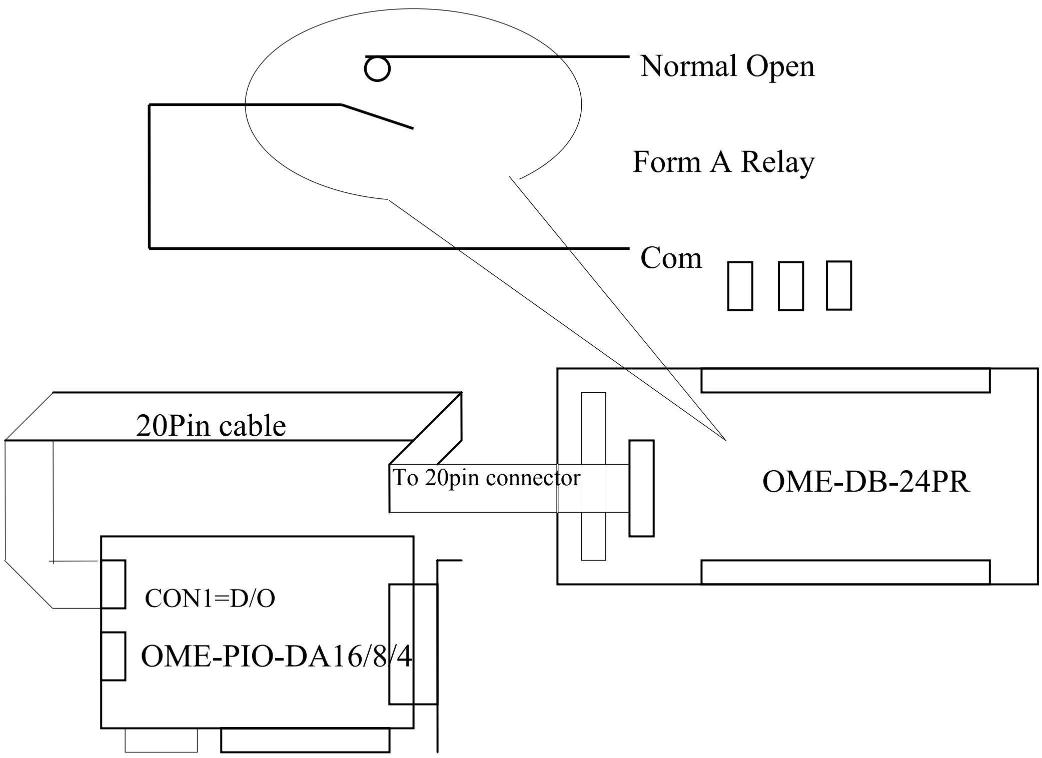


Note:
Channel: 16 Form C Relays
Relay: Switching up to 0.5A at 110ACV
or 1A at 24DCV

2.8.6. OME-DB-24PR/DB-24POR/DB-24C

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

The OME-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 volt 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 OME-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:
A 50-Pin connector (OPTO-22 compatible) for OME-DIO-24, OME-DIO-48, OME-DIO-144, OME-PIO-D144, OME-PIO-D96, OME-PIO-D56, OME-PIO-D48, OME-PIO-D24
A 20-Pin connector for 16 channel digital output, OME-A-82X, OME-A-62X, OME-DIO-64, OME-ISO-DA16/DA8, OME-PIO-D56, OME-PIO-DA16/8/4

Channel: 16 Form A Relays, 8 Form C Relays
Relay: switching up to 5A at 110ACV / 5A at 30DCV

2.8.7. Daughter Board Comparison Table

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

Note: There are no 50 pin flat-cable headers on the OME-PIO-DA16/8/4 board. The OME-PIO-DA16/8/4 has one DB-37 connector and two 20-pin flat-cable headers.

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 OME-PIO/PISO series card in the power-up stage. The IDs of the OME-PIO-DA16/8/4 series cards are given as follows:

< REV 1.0 ~ REV 3.0 > :	< REV 4.0 or above > :
• Vendor ID = 0xE159	• Vendor ID = 0xE159
• Device ID = 0x02	• Device ID = 0x01
• Sub-vendor ID = 0x80	• Sub-vendor ID = 0x4180
• Sub-device ID = 0x04	• Sub-device ID = 0x00
• Sub-aux ID = 0x00	• Sub-aux ID = 0x00

We provide all necessary functions as follows:

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 follows:

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. Refer to Sec. 4.1 for more information.

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 OME-PIO/PISO series card in the system. It is implemented based on the PCI plug & play mechanism-1. It will find all OME-PIO/PISO series cards installed in this system & save all their resource information in the library.

Sample program 1: find all OME-PIO-DA16/8/4 in this PC

```
wSubVendor=4180; wSubDevice=00; wSubAux=0x00;   /* for PIO_DA16/8/4 */
wRetVal=PIO_DriverInit(&wBoards, wSubVendor,wSubDevice,wSubAux);
printf("There are %d OME-PIO-DA16 Cards in this PC\n",wBoards);

/* step2: save resource of all OME-PIO-DA16/8/4 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         */
   }
```

Sample program 2: find all OME-PIO/PISO in this PC (refer to Sec. 4.1 for more information)

```
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);

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); }
```

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

OME-PIO/PISO series card	Description	Sub_vendo Old (New)	Sub_device Old (New)	Sub_AUX
OME-PIO-D144 (Rev4.0)	144 × D/I/O	80(5C80)	01	00
OME-PIO-D96 (Rev4.0)	96 × D/I/O	80(5880)	01	10
OME-PIO-D64 (Rev2.0)	64 × D/I/O	80(4080)	01	20
OME-PIO-D56 (Rev6.0)	24 × D/I/O + 16 × D/I + 16*D/O	80(C080)	01	40
OME-PIO-D48 (Rev2.0)	48 × D/I/O	80(0080)	01	30
OME-PIO-D24 (Rev6.0)	24 × D/I/O	80(C080)	01	40
OME-PIO-821	Multi-function	80	03	10
OME-PIO-DA16(Rev4.0)	16 × D/A	80(4180)	04(00)	00
OME-PIO-DA8 (Rev4.0)	8 × D/A	80(4180)	04(00)	00
OME-PIO-DA4 (Rev4.0)	4 × D/A	80(4180)	04(00)	00
OME-PISO-C64 (Rev4.0)	64 × isolated D/O **(Current sinking)**	80(0280)	08(00)	00
OME-PISO-A64 (Rev3.0)	64 × isolated D/O **(Current sourcing)**	80(8280)	08(00)	50
OME-PISO-P64 (Rev4.0)	64 × isolated D/I	80(0280)	08(00)	10
OME-PISO-P32C32 (Rev5.0)	32*isolated D/O **(Current sinking)** +32*isolated D/I	80(0280)	08(00)	20
OME-PISO-P32A32 (Rev3.0)	32*isolated D/O **(Current sourcing)** +32*isolated D/I	80(8280)	08(00)	70
OME-PISO-P8R8 (Rev2.0)	8 × isolated D/I + 8 × 220V relay	80(4200)	08(00)	30
OME-PISO-P8SSR8AC (Rev2.0)	8 × isolated D/I + 8 × SSR /AC	80(4200)	08(00)	30
OME-PISO-P8SSR8DC (Rev2.0)	8 × isolated D/I + 8 × SSR /DC	80(4200)	08(00)	30
OME-PISO-730 (Rev2.0)	16 × DI +16 ×D/O + 16 × isolated D/I + 16* isolated D/O **(Current sinking)**	80(C2FF)	08(00)	40
OME-PISO-730A (Rev3.0)	16 × DI +16 ×D/O + 16 × isolated D/I + 16* isolated D/O **(Current sourcing)**	80(62FF)	08(00)	80
OME-PISO-813 (Rev2.0)	32 × isolated A/D	80(4280)	0A(02)	00
OME-PISO-DA2 (Rev5.0)	2 × isolated D/A	80(4280)	0B(03)	00

Note: If your board is a different version, it may also have different Sub IDs. However this will present no actual problem. No matter which version of the board you select, we offer the same function calls.

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 information of all OME-PIO/PISO cards installed in this system. Then the application program can control all functions of OME-PIO/PISO series card directly.

The sample program source is given as follows:

```
/* step1: detect all OME-PIO-DA16/8/4 cards first */
wSubVendor=0x80; wSubDevice=4; wSubAux=0x00;   /* for PIO_DA16/8/4 */
wRetVal=PIO_DriverInit(&wBoards, wSubVendor,wSubDevice,wSubAux);
printf("Threr are %d OME-PIO-DA16/8/4 Cards in this PC\n",wBoards);

/* step2: save resource of all OME-PIO-DA16/8/4 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 OME-PIO-DA16/8/4 directly */
wBase=wConfigSpace[0][0];/* get base address the card_0                     */
outport(wBase,1);         /* enable all D/I/O operation of card_0            */

wBase=wConfigSpace[1][0];/* get base address the card_1                     */
outport(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 these 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*/
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 the OME-PIO/PISO series card. If there is only one OME-PIO/PISO board, the user can identify the board as card_0. If there are two OME-PIO/PISO boards in the system, it will be difficult to identify which board is card_0? The software driver can support 16 boards max. Therefore the user can install 16 boards of OME-PIO/PSIO series in one PC system. How to find the card_0 & card_1?

The simplest way to identify which card is card_0 is to use wSlotBus & wSlotDevice as following:

1. Remove all OME-PIO-DA16/8/4 from this PC
2. Install one OME-PIO-DA16/8/4 into the PC's PCI_slot1, run PIO_PISO.EXE & record the wSlotBus1 & wSlotDevice1
3. Remove all OME-PIO-DA16/8/4 from this PC
4. Install one OME-PIO-DA16/8/4 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 the 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:

Step 1: Record all wSlotBus? & wSlotDevice?

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

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

3.3 The I/O Address Map

The I/O addresses of OME-PIO/PISO series card are automatically assigned by the main board ROM BIOS. The I/O address can also be re-assigned by user. **It is strongly recommended to the user to not change the I/O address. The plug & play BIOS will assign proper I/O address to each OME-PIO/PISO series card very well.** The I/O addresses of the OME-PIO-DA16/8/4 cards 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 8254-counter0	Write 8254-counter0
wBase+0xc4	Read 8254-counter1	Write 8254-counter1
wBase+0xc8	Read 8254-counter2	Write 8254-counter2
wBase+0xcc	Read 8254 control word	Write 8254 control word
wBase+0xe0	Read low byte of D/I	DA_0 chip select
wBase+0xe4	Read high byte of D/I	DA_1 chip select
wBase+0xe8	Read low byte of D/I	DA_2 chip select
wBase+0xec	Read high byte of D/I	DA_3 chip select
wBase+0xf0	Read low byte of D/I	Write low byte of D/A
wBase+0xf4	Read high byte of D/I	Write high byte of D/A
wBase+0xf8	Read low byte of D/I	Write low byte of D/O
wBase+0xfc	Read high byte of D/I	Write high byte of D/O

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-up, 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.

```
outportb(wBase,1);      /*  RESET\=High → all D/I/O are enable now */
outportb(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 do not control this register.

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	0	0	EN1	EN0

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

EN0=0→ disable INT0 as a interrupt signal (default)
EN0=1→ enable INT0 as a interrupt signal

EN1=0→ disable INT1 as a interrupt signal (default)
EN1=1→ enable INT1 as a interrupt signal

```
outportb(wBase+5,0);        /* disable all interrupts                   */
outportb(wBase+5,1);        /* enable interrupt of INT0                 */
outportb(wBase+5,2);        /* enable interrupt of INT1                 */
outportb(wBase+5,3);        /* enable all two channels of interrupt */
```

Refer to the following demo programs for more information:
DEMO3.C & DEMO4.C → single interrupt source
DEMO5.C & DEMO6.C → multiple interrupt sources

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=INT0, Aux1=INT1, Aux2~3=controll EEPROM, Aux7~4=Aux-ID. Refer to Sec. 4.1 for more information. The Aux 0~1 are used as interrupt sources. The interrupt service routine has to read this register for interrupt source identification. Refer to Sec. 2.3 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	×	×	INV1	INV0

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

INV0/1=0→ select the inverted signal from INT0/1

INV0/1=1→ select the non-inverted signal from INT0/1

```
outportb(wBase+0x2a,0);     /* select the inverted input from all 2 channels       */
outportb(wBase+0x2a,3);     /* select the non-inverted input from all 2 channels */

outportb(wBase+0x2a,2);     /* select the inverted input of INT0                  */
                            /* select the non-inverted input from the others      */
```

Refer to Sec. 2.3 for more information.
Refer to DEMO3/4/5/6.C for more information.

3.3.7 Digital Input

(Read): wBase+0xf8 → Low byte of D/I port

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DI7	DI6	DI5	DI4	DI3	DI2	DI1	DI0

(Read): wBase+0xfc → High byte of D/I port

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DI15	DI14	DI13	DI12	DI11	DI10	DI9	DI8

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

```
wDiLoByte = inportb(wBase+0xf8);          /* read D/I states (DI  7~DI0) */
wDiHiByte = inportb(wBase+0xfc);          /* read D/I states (DI15~DI8) */
wDiValue = (wDiHiByte<<8)|wDiLoByte;
```

Refer to DEMO2.C for more information.

3.3.8 Digital Output

(Write): wBase+0xf8 → Low byte of D/O port

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DO7	DO6	DO5	DO4	DO3	DO2	DO1	DO0

(Write): wBase+0xfc → High byte of D/O port

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DO15	DO14	DO13	DO12	DO11	DO10	DO9	DO8

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

```
outportb(wBase+0xf8,wDoValue);        /* Control the DO state (DO  7~DO0)   */
outportb(wBase+0xfc,wDoValue>>8);     /* Control the DO state (DO15~DO8)  */
```

Refer to DEMO1/2.C for more information.

3.3.9 Read/Write 8254

(Read/Write): wBase+0xc0=8254-counter-0

(Read/Write): wBase+0xc4=8254-counter-1

(Read/Write): wBase+0xc8=8254-counter-2

(Read/Write): wBase+0xcc=8254 control word

8254 control word

SC1	SC0	RL1	RL0	M2	M1	M0	BCD

BCD: 0: binary count 1: BCD count

M2,M1,M0: 000:mode0 interrupt on terminal count
001:mode1 programmable one-shot
010:mode2 rate generator
011:mode3 square-wave generator
100:mode4 software triggered pulse
101:mode5 hardware triggered pulse

RL1,RL0: 00: counter latch instruction
01: read/write low counter byte only
10: read/write high counter byte only
11: read/write low counter byte first, then high counter byte

SC1,SC0: 00: counter0
01: counter1
10: counter2
11: read -back command

```
WORD pio_da16_c0(char cConfig, char cLow, char cHigh)/*COUNTER_0 */
{
outportb(wBase+0xcc,cConfig);
outportb(wBase+0xc0,cLow);
outportb(wBase+0xc0,cHigh);
return(NoError);
}
WORD pio_da16_c1(char cConfig, char cLow, char cHigh)/*COUNTER_1 */
{
outportb(wBase+0xcc,cConfig);
outportb(wBase+0xc4,cLow);
outportb(wBase+0xc4,cHigh);
return(NoError);
}
WORD pio_da16_c2(char cConfig, char cLow, char cHigh)/*COUNTER_2 */
{
outportb(wBase+0xcc,cConfig);
outportb(wBase+0xc8,cLow);
outportb(wBase+0xc8,cHigh);
return(NoError);
}
```

3.3.10 D/A Select

There are 4/2/1 D/A converters in respective OME-PIO-DA16/8/4 card. It is necessary to select which D/A converter is desired after D/A data had be sent. D/A channels allocate as follows:

Write	A1	A0	
WBase+0xe0	0	0	D/A output channel 0
	0	1	D/A output channel 1
DA_0	1	0	D/A output channel 2
	1	1	D/A output channel 3
Wbase+0xe4	0	0	D/A output channel 4
	0	1	D/A output channel 5
DA_1	1	0	D/A output channel 6
	1	1	D/A output channel 7
Wbase+0xe8	0	0	D/A output channel 8
	0	1	D/A output channel 9
DA_2	1	0	D/A output channel10
	1	1	D/A output channel11
Wbase+0xec	0	0	D/A output channel12
	0	1	D/A output channel13
DA_3	1	0	D/A output channel14
	1	1	D/A output channel15

Note: Refer to Sec.3.3.11 for more information about A1, A0

```
outportb(wBase+0xf0,wDaValue);              /* output low byte of D/A data          */
outportb(wBase+0xf4,(wDaValue>>8)|0x02);    /* output high byte of D/A data and     */
                                            /* select channel 2 on this converter   */
outportb(wBase+0xe0,0);                     /* select DA_0                          */
                                            /* after this procedure wDaValue will   */
                                            /* be sent to channel_2                 */
```

Refer to DEMO6.C, DEMO7.C, DEMO8.C and DEMO9.C for more information.

3.3.11 D/A Data Output

(write):wBase+0xf0

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
D7	D6	D5	D4	D3	D2	D1	D0

(write):wBase+0xf4

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
A1	A0	D13	D12	D11	D10	D9	D8

Note: Refer to Sec.3.3.10 For more information about A1,A2

Each D/A converter has four channels of analog output. When write data to D/A converter has to indicate which channel is desire by A1 and A0.

D/A programming sequence:
1. Send data to D/A converter. (This data will be buffered)
2. Select D/A converter. (Start convert)

```
outportb(wBase+0xf0,wDaValue);              /* output low byte of D/A data          */
outportb(wBase+0xf4,(wDaValue>>8)|0x02); /* output high byte of D/A data and   */
                                          /* select channel 2 on this converter  */
outportb(wBase+0xe0,0);                   /* select DA_0                          */
                                          /* after this procedure wDaValue will */
                                          /* be sent to channel_2               */

pio_da16_da(2,wDaValue);                  /* send wDaValue to channel_2          */

void pio_da16_da(char cChannel_no,int iVal)
{
iVal=iVal+(cChannel_no%4)*0x4000;        /* cChannel_no : 0 - 15               */
outportb(wBase+0xf0,iVal);                /* iVal : 0x0000 - 0x3fff             */
outportb(wBase+0xf4,(iVal>>8));
outportb(wBase+0xe0+4*(cChannel_no/4),0xff);
}
```

Refer to DEMO6.C, DEMO7.C, DEMO8.C and DEMO9.C for more information.

4. Demo Program

It is recommended to read the release note first. All importance information will be given in release note as follows:

1. Where you can find the software driver & utility?
2. **How to install software & utility?**
3. Where is the diagnostic program?
4. FAQ

The demo programs are provided on the software floppy disk or CD. After the software installation, the driver will be installed into disk as follows:

- \TC*.* → for Turbo C 2.xx or above
- \MSC*.* → for MSC 5.xx or above
- \BC*.* → for BC 3.xx or above

- \TC\LIB*.* → for TC library
- \TC\DEMO*.* → for TC demo program

- \TC\LIB\Large*.* → TC large model library
- \TC\LIB\Huge*.* → TC huge model library
- \TC\LIB\Large\PIO.H → TC declaration file
- \TC\\LIB\Large\TCPIO_L.LIB → TC large model library file
- \TC\LIB\Huge\PIO.H → TC declaration file
- \TC\\LIB\Huge\TCPIO_H.LIB → TC huge model library file

- \MSC\LIB\Large\PIO.H → MSC declaration file
- \MSC\LIB\Large\MSCPIO_L.LIB → MSC large model library file
- \MSC\LIB\Huge\PIO.H → MSC declaration file
- \MSC\\LIB\Huge\MSCPIO_H.LIB → MSC huge model library file

- \BC\LIB\Large\PIO.H → BC declaration file
- \BC\LIB\Large\BCPIO_L.LIB → BC large model library file
- \BC\LIB\Huge\PIO.H → BC declaration file
- \BC\\LIB\Huge\BCPIO_H.LIB → BC huge model library file

NOTE: The library is validated for all OME-PIO/PISO series cards.

Demo programs:

DEMO1.EXE: D/O demo program
DEMO2.EXE: D/I/O demo program
DEMO3.EXE: Single interrupt source (initial high)
DEMO4.EXE: Single interrupt source (initial low)
DEMO5.EXE: Two interrupt source
DEMO6.EXE: Waveform generator without calibration
DEMO7.EXE: Waveform generator with calibration
DEMO8.EXE: D/A hex value output without calibration
DEMO9.EXE: D/A hex value output with calibration
DEMO10.EXE: Save EEPROM data to file
DEMO11.EXE: Download EEPROM data from file
DEMO12.EXE: User software calibration
DEMO13.EXE: Factory calibration

Note: Not all demo programs may be listed in this manual. Please refer to software floppy disk or CD.

4.1 PIO_PISO

```
/* -------------------------------------------------------------- */
/* Find all OME-PIO_PISO series cards in this PC system          */
/* step 1 : plug all OME-PIO_PISO cards into PC                   */
/* step 2 : run PIO_PISO.EXE                                      */
/* -------------------------------------------------------------- */

#include "PIO.H"

WORD wBase,wIrq;
WORD wBase2,wIrq2;

int main()
{
int  i,j,j1,j2,j3,j4,k,jj,dd,j11,j22,j33,j44;
WORD wBoards,wRetVal;
WORD wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
char c;
float ok,err;

clrscr();
wRetVal=PIO_DriverInit(&wBoards,0xff,0xff,0xff);  /*for PIO-PISO*/
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);
   }

PIO_DriverClose();
}
```

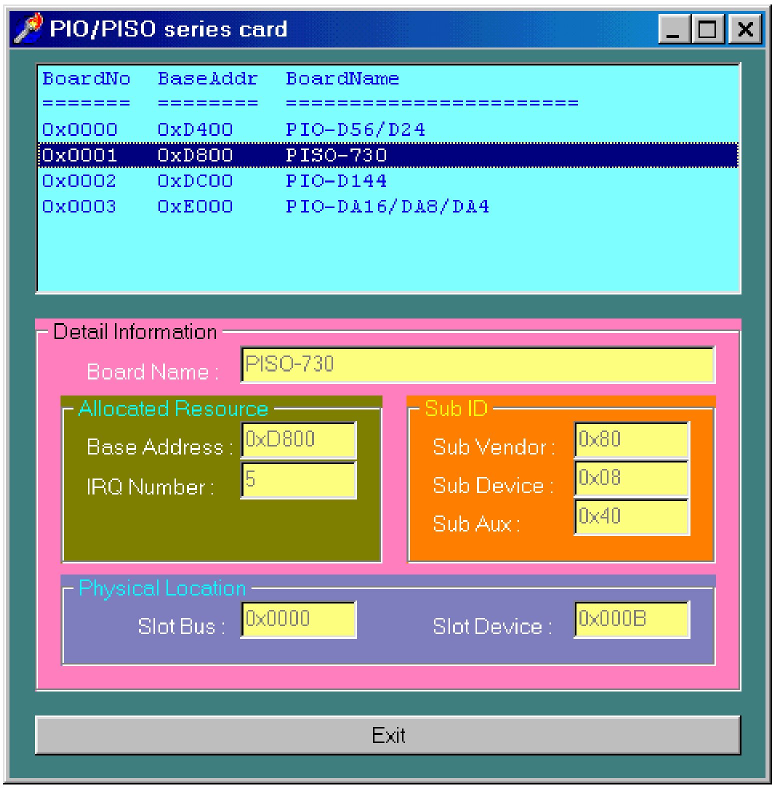
NOTE**: the PIO_PISO.EXE is valid for all PIO/PISO cards**. The user can execute the PIO_PISO.EXE to get the following information:

- List all PIO/PISO cards installed in this PC
- List all resources allocated to every PIO/PISO cards
- List the wSlotBus & wSlotDevice for specified OME-PIO/PISO card identification.
  (Refer to Sec. 3.2 for more information)

4.1.1 PIO_PISO.EXE for Windows

User can find this utility on the CD or the floppy disk. It is useful for all OME-PIO/PISO series card.

After executing the utility, detail information for all OME-PIO/PISO cards that installed in the PC will be show as follows:



4.2 DEMO1

```
/* DEMO1 : D/O demo for OME-PIO-DA16/8/4
*/
/* step1 : Run DEMO1.EXE                                          */
/* step2 : Check the LEDs of OME-DB-24C will turn on sequentially
*/
/* -------------------------------------------------------------- */
#include "PIO.H"
void pio_da16_do(WORD wDo);
WORD wBase,wIrq;
int main()
{
int  i,j;
WORD wBoards,wRetVal,t1,t2,t3,t4,t5,t6;
WORD wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
clrscr();

/* step1 : find address-mapping of PIO/PISO cards                */
wRetVal=PIO_DriverInit(&wBoards,0x80,0x04,0x00);/*for OME-PIO-
DA16/8/4*/
printf("\n(1) Threr are %d OME-PIO-DA16/8/4 Cards in this
PC",wBoards);
if ( wBoards==0 )  exit(0);

printf("\n\n-------------- The Configuration Space --------------");
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);
   }

PIO_GetConfigAddressSpace(0,&wBase,&wIrq,&t1,&t2,&t3,&t4,&t5);
                                                 /* select card_0 */
/* step2 : enable all D/I/O port                                  */
outportb(wBase,1);                                /* /RESET -> 1  */
printf("\n\n(2) DEMO1 D/O test");
j=1;
for(;;)
   {
   gotoxy(1,8);
   pio_da16_do(j);
   printf("\nDO ==> %4x",j);
   delay(10000);
   if (kbhit()!=0) break;
   j=j<<1; j=j&0x0ffff;if (j==0) j=1;
   }
PIO_DriverClose();
}
/* -------------------------------------------------------------- */
void pio_da16_do(WORD wDo)
{
outportb(wBase+0xf8,wDo);          /* 0xf8 : low  byte of DO port */
outportb(wBase+0xfc,(wDo>>8));     /* 0xfc : high byte of DO port */
}
```

4.3 DEMO2

```
/* DEMO2 : D/I/O demo for OME-PIO-DA16/8/4
*/
/* step1 : Connect CON1 & CON2 with a 20-pin 1 to 1 flat cable    */
/* step2 : Run DEMO2.EXE                                          */
/* -------------------------------------------------------------- */
#include "PIO.H"

void pio_da16_di(WORD *wDi);
void pio_da16_do(WORD wDo);
WORD wBase,wIrq;

int main()
{
int  i,j,k;
WORD wBoards,wRetVal,t1,t2,t3,t4,t5,t6;
WORD wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;

clrscr();

/* step1 : find address-mapping of PIO/PISO cards                 */
           .
           .
/* step2 : enable all D/I/O port                                  */
outportb(wBase,1);                             /* /RESET -> 1  */

printf("\n\n(2) DEMO2  D/I/O test");
j=1;
for(;;)
   {
   pio_da16_do(j);
   pio_da16_di(&k);
   gotoxy(1,9);
   printf("DO = %4x , DI = %4x",j,k);
   if (k!=j) printf(" <-- Test Error       ");
   else      printf(" <-- Test Ok           ");
   j++; j=j&0x0ffff;if (j==0) j=1;
   if (kbhit()!=0) break;
   }
PIO_DriverClose();
}
/* -------------------------------------------------------------- */
void pio_da16_di(WORD *wDi)
{
int  in_l,in_h;
in_l=inportb(wBase+0xe0)&0x0ff;
in_h=inportb(wBase+0xe4)&0x0ff;
(*wDi)=(in_h<<8)+in_l;
}
/* -------------------------------------------------------------- */
void pio_da16_do(WORD wDo)
{
outportb(wBase+0xf8,wDo);          /* 0xf8 : low  byte of DO port */
outportb(wBase+0xfc,(wDo>>8));     /* 0xfc : high byte of DO port */

}
```

4.4 DEMO3

```
/* DEMO3 : INT_CHAN_1, timer interrupt demo (initial high)        */
/*         (It is designed to be a machine independent timer)     */
/* step1 : Run DEMO3.EXE                                          */
/* -------------------------------------------------------------- */
#include "PIO.H"
#define A1_8259 0x20
#define A2_8259 0xA0
static void interrupt irq_service();
void pio_da16_c0(char cConfig, char cLow, char cHigh);
void pio_da16_c1(char cConfig, char cLow, char cHigh);
void pio_da16_c2(char cConfig, char cLow, char cHigh);
void init_int1_high();
WORD wBase,wIrq;
int  COUNT_L,COUNT_H,irqmask,now_int_state;
int main()
{
int   i,j;
WORD  wBoards,wRetVal,t1,t2,t3,t4,t5,t6;
WORD  wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
clrscr();
/* step1 : find address-mapping of PIO/PISO cards                 */
           .
           .
/* step2 : enable all D/I/O port                                  */
outportb(wBase,1);                              /* /RESET -> 1  */
printf("\n\n(2) DEMO3 Interrupt (1Hz) test");
init_int1_high();       /* interrupt initialize, INT1 is high now */
COUNT_L=0;COUNT_H=0;
printf("\n\n*** Show the count of Low_pulse ***\n");
for (;;)
    {
    gotoxy(1,10);
    printf("\nINT count = %d",COUNT_L);
    if (kbhit()!=0) break;
    }
outportb(wBase+5,0);                      /* disable all interrupt */
PIO_DriverClose();
}
/* Use INT_CHAN_1 as internal interrupt signal                    */
void init_int1_high()
{
DWORD dwVal;
disable();
outportb(wBase+5,0);                      /* disable all interrupt */
if (wIrq<8)
   {
   irqmask=inportb(A1_8259+1);
   outportb(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   setvect(wIrq+8, irq_service);
   }
else
   {
   irqmask=inportb(A1_8259+1);
   outportb(A1_8259+1,irqmask & 0xfb);                   /* IRQ2 */
   irqmask=inportb(A2_8259+1);
   outportb(A2_8259+1,irqmask & (0xff ^ (1 << (wIrq-8))));
   setvect(wIrq-8+0x70, irq_service);
   }
/* CLK source = 4 MHz */
pio_da16_c1(0x76,0x90,0x01);       /* COUNTER1, mode3, div    400 */
pio_da16_c2(0xb6,0x10,0x27);       /* COUNTER2, mode3, div  10000 */
```

```
                                   /* program Cout2 1Hz          */
/* note : the 8254 need extra 2-clock for initialization          */
for (;;)
    {
    if ((inportb(wBase+7)&2)==2) break;      /* wait Cout2 = high */
    }
/* note : Cout2 = high, INV1 must select the inverted Cout2       */
/*        --> INT_CHAN_1 = !Cout2 = init_low, active_high         */
outportb(wBase+0x2a,0);            /* INV1 = 0, inverted Cout2    */

now_int_state=1;                   /* now Cout2 is high           */
outportb(wBase+5,2);               /* EN1 = 1, enable INT_CHAN_1  */
                                   /* as interrupt source         */
enable();
}
/* ------------------------------------------------------------- */
void interrupt irq_service()
{
if (now_int_state==1)          /* now INT1(Cout2) changed to low  */
   {                           /* --> INT_CHAN_1=!INT1=high now   */
   COUNT_L++;                  /* find a low pulse (INT1)         */
   if((inportb(wBase+7)&2)==0) /* INT1 is still fixed in low  ->  */
     {                         /* need to generate a high pulse   */
     outportb(wBase+0x2a,2);   /* INV1 select non-inverted input  */
                               /* INT_CHAN_1=INT1=low -->         */
                               /* INT_CHAN_1 generate high pulse  */
     now_int_state=0;          /* now INT1=low                    */
     }
   else now_int_state=1;       /* now INT1=high                   */
                               /* don't have to gen. high pulse   */
   }
else                           /* now INT1(Cout2) changed to high */
   {                           /* --> INT_CHAN_1=INT1=high now    */
   COUNT_H++;                  /* find a low pulse (INT1)         */
   if((inportb(wBase+7)&2)==2) /* INT1 is still fixed in high ->  */
     {                         /* need to generate a high pulse   */
     outportb(wBase+0x2a,0);   /* INV1 select inverted input      */
                               /* INT_CHAN_1=!INT1=low -->        */
                               /* INT_CHAN_1 generate high_pulse  */
     now_int_state=1;          /* now INT1=high                   */
     }
   else now_int_state=0;       /* now INT1=low                    */
                               /* don't have to gen. high pulse   */
   }
if (wIrq>=8) outportb(A2_8259,0x20);
outportb(A1_8259,0x20);
}
/* ------------------------------------------------------------- */
void pio_da16_c0(char cConfig, char cLow, char cHigh) /* COUNTER0 */
{
outportb(wBase+0xcc,cConfig);
outportb(wBase+0xc0,cLow);
outportb(wBase+0xc0,cHigh);
}
```

4.5 DEMO5

```
/* DEMO5 : INT_CHAN_0 & INT_CHAN_1 timer interrupt demo          */
/*         (It is designed to be a machine independent timer)     */
/* step1 : Run DEMO5.EXE                                          */
/* -------------------------------------------------------------- */
#include "PIO.H"
#define A1_8259 0x20
#define A2_8259 0xA0
static void interrupt irq_service();
WORD wBase,wIrq;
int  irqmask,now_int_state,new_int_state,int_c;
int  INT0_L,INT0_H,INT1_L,INT1_H;
int  b0,b1,invert;
int main()
{
int   i,j;
WORD  wBoards,wRetVal,t1,t2,t3,t4,t5,t6;
WORD  wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;
clrscr();
/* step1 : find address-mapping of PIO/PISO cards                 */
           .
           .
/* step2 : enable all D/I/O port                                  */
outportb(wBase,1);                                /* /RESET -> 1  */
printf("\n\n(2) DEMO5 Interrupt test");
init_high();    /* interrupt initialize, INT_CHAN_0/1 is high now */
printf("\n\n*** Show the count of Low_pulse ***\n");
INT0_L=INT0_H=INT1_L=INT1_H=0;
for (;;)
    {
    gotoxy(1,10);
    printf("\nINT0[%x,%x],INT1[%x,%x]",INT0_H,INT0_L,INT1_H,INT1_L);
    if (kbhit()!=0) break;
    }
outportb(wBase+5,0);                     /* disable all interrupt */
PIO_DriverClose();
}
/* Use INT_CHAN_0 & INT_CHAN_1 as internal interrupt signal       */
void init_high()
{
DWORD dwVal;
disable();
outportb(wBase+5,0);                     /* disable all interrupt */
if (wIrq<8)
   {
   irqmask=inportb(A1_8259+1);
   outportb(A1_8259+1,irqmask & (0xff ^ (1 << wIrq)));
   setvect(wIrq+8, irq_service);
   }
else
   {
   irqmask=inportb(A1_8259+1);
   outportb(A1_8259+1,irqmask & 0xfb);                  /* IRQ2 */
   irqmask=inportb(A2_8259+1);
   outportb(A2_8259+1,irqmask & (0xff ^ (1 << (wIrq-8))));
   setvect(wIrq-8+0x70, irq_service);
   }
/* CLK source = 4 MHz */
pio_da16_c0(0x36,0x20,0x4e);       /* COUNTER0, mode3, div 20000  */
                                   /* program Cout0 200Hz         */
pio_da16_c1(0x76,0x90,0x01);       /* COUNTER1, mode3, div  400   */
pio_da16_c2(0xb6,0x64,0x00);       /* COUNTER2, mode3, div  100   */
```

```
                                   /* program Cout2 100Hz          */
/* note : the 8254 need extra 2-clock for initialization          */
for (;;)
    {
    if ((inportb(wBase+7)&3)==3) break;/* wait Cout0&Cout2 = high */
    }
/* note : Cout0/2 = high, INV0/1 must select the inverted Cout0/2 */
/*        --> INT_CHAN_0 = !Cout0 = init_low, active_high         */
/*        --> INT_CHAN_1 = !Cout2 = init_low, active_high         */
outportb(wBase+0x2a,0);           /* INV0=0, INV1=0 inverted       */
now_int_state=3;                  /* now Cout0 & Cout2 is high     */
outportb(wBase+5,3);              /* enable INT_CHAN_0/1 interrupt */
enable();
}
/* -------------------------------------------------------------- */
/* Note : 1.The hold_time of INT_CHAN_0 & INT_CHAN_1 must long    */
/*          enoug.                                                */
/*        2.The ISR must read the interrupt status again to       */
/*          identify the active interrupt source.                 */
/*        3.The INT_CHAN_0 & INT_CHAN_1 can be active at the same */
/*          time.                                                 */
/* -------------------------------------------------------------- */
void interrupt irq_service()
{
/* now ISR can not know which interrupt is active                 */
new_int_state=inportb(wBase+7)&0x03;       /* read all interrupt   */
                                           /* signal state         */
int_c=new_int_state^now_int_state;         /* compare new_state to */
                                           /* old_state            */
if ((int_c&0x01)==1)              /* INT_CHAN_0 is active          */
   {
   if ((new_int_state&1)==0)      /* INT0 change to low now        */
      {
      INT0_L++;
      }
   else                           /* INT0 change to high now       */
      {
      INT0_H++;
      }
   invert=invert^1;               /* generate high_pulse           */
   }
if ((int_c&0x02)==2)              /* INT_CHAN_1 is active          */
   {
   if ((new_int_state&2)==0)      /* INT1 change to low now        */
      {
      INT1_L++;
      }
   else                           /* INT1 change to high now       */
      {
      INT1_H++;
      }
   invert=invert^2;               /* generate high_pulse           */
   }
now_int_state=new_int_state;      /* update interrupt status       */
outportb(wBase+0x2a,invert);      /* generate a high pulse         */
if (wIrq>=8) outportb(A2_8259,0x20);
outportb(A1_8259,0x20);
}
```

4.6 DEMO8

```
/* DEMO8 : D/A Output without calibration                          */
/* step1 : Run DEMO8.EXE                                           */
/* --------------------------------------------------------------- */
#include "PIO.H"

void pio_da16_da(int cChannel_no,int iVal);

WORD  wBase,wIrq;

int main()
{
int   i,j,k;
WORD  wBoards,wRetVal,t1,t2,t3,t4,t5,t6;
WORD  wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;

clrscr();

/* step1 : find address-mapping of PIO/PISO cards                  */
           .
           .
/* step2 : enable all D/I/O port                                   */
outportb(wBase,0x11);                            /* /RESET -> 1    */

printf("\n\n(2) A/D Output without calibration test");

printf("\n\n    (a)  1.23V Voltage output to each channel");
for (i=0; i<16; i++)
    {
    j=1.23*16383/20.0+8192;
    pio_da16_da(i,j);
    }
getch();
printf("\n\n    (b) 1.23mA Current output to each channel");
for (i=0; i<16; i++)
    {
    j=1.23*8192/20+8191;
    pio_da16_da(i,j);
    }
getch();

outportb(wBase+5,0);                       /* disable all interrupt */
outportb(wBase+3,0);                       /* all D/O are Low       */
outportb(wBase+2,0);                       /* all AUX as D/I        */
PIO_DriverClose();
}
/* --------------------------------------------------------------- */
void pio_da16_da(int iChannel_no,int iVal)
{
iVal=iVal+(iChannel_no%4)*0x4000;         /* iChannel_no : 0 - 15   */
outportb(wBase+0xf0,iVal);                /* iVal : 0x0000 - 0x3fff */
outportb(wBase+0xf4,(iVal>>8));
outportb(wBase+0xe0+4*(iChannel_no/4),0xff);
}
```

4.7 DEMO9

```
/* DEMO9 : D/A Output with calibration                              */
/* step1 : Run DEMO9.EXE                                            */
/* ---------------------------------------------------------------- */
#include "PIO.H"
void pio_da16_da(int cChannel_no,int iVal);
WORD  wBase,wIrq;
WORD  wN10V[16],wP10V[16],w00mA[16],w20mA[16],EEP;
float fDeltaV[16],fDeltaI[16];
int main()
{
int   i,j,k;
WORD  wBoards,wRetVal,t1,t2,t3,t4,t5,t6;
WORD  wSubVendor,wSubDevice,wSubAux,wSlotBus,wSlotDevice;

clrscr();

/* step1 : find address-mapping of PIO/PISO cards                   */
           .
           .
/* step2 : enable all D/I/O port                                    */
outportb(wBase,0x11);                              /* /RESET -> 1   */
outportb(wBase+2,0x1c);           /* AUX 4/3/2 are D/O, othes D/I */
outportb(wBase+3,0);              /* all D/O are Low                */

printf("\n\n(2) A/D Output with calibration test");

for (i=0; i<64;i++)
    {
    if (i<16)
       {
       EEP_READ(i,&j,&k);
       wN10V[i]=(j<<8)+k;
       }
    if ((i>=16)&&(i<32))
       {
       EEP_READ(i,&j,&k);
       wP10V[i-16]=(j<<8)+k;
       }
    if ((i>=32)&&(i<48))
       {
       EEP_READ(i,&j,&k);
       w00mA[i-32]=(j<<8)+k;
       }
    if (i>=48)
       {
       EEP_READ(i,&j,&k);
       w20mA[i-48]=(j<<8)+k;
       }
    }

for (i=0; i<16; i++)
    {
    fDeltaV[i]=20.0/(wP10V[i]-wN10V[i]);
    fDeltaI[i]=20.0/(w20mA[i]-w00mA[i]);
    }

printf("\n\n    (a)   1.23V Voltage output to each channel");
for (i=0; i<16; i++)
    {
    j=(1.23+10.0)/fDeltaV[i]+wN10V[i];
    pio_da16_da(i,j);
```

```
    }
getch();
printf("\n\n    (b) 1.23mA Current output to each channel");
for (i=0; i<16; i++)
    {
    j=1.23/fDeltaI[i]+w00mA[i];
    pio_da16_da(i,j);
    }
getch();

outportb(wBase+5,0);                        /* disable all interrupt */
outportb(wBase+3,0);                        /* all D/O are Low       */
outportb(wBase+2,0);                        /* all AUX as D/I        */
PIO_DriverClose();
}
```

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