PCL-727 12-CHANNEL D/A OUTPUT CARD

USER'S MANUAL

Acknowledgements

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CHAPTER 1. GENERAL INFORMATION

1.1. Description

The PCL-727 provides 12 analog output channels on a single full-size add-on card. Each channel can be individually configured to any of the following output ranges: 0 to 5 V, 0 to 10 V, ±5 V or 4 to 20 mA current output. Designed for operation in rugged environments, the PCL-727 is an ideal and economical solution for industrial applications that require multiple analog voltage and/or current output channels.

In addition to its analog output, the PCL-727 provides 16 digital output channels and 16 digital input channels. D/I and D/O ports are TTL compatible. The D/I and D/O ports are also fully compatible with available daughterboards like the PCLD-782B Isolated D/I Board, PCLD-785B Relay Output Board and the PCLD-786 SSR & Relay Driver Board. The daughterboards mentioned above offer convenient solutions for industrial ON/OFF control and sensing applications.

To assist the user in the calibration process and to minimize programming effort, a utility disk is provided. The utility disk contains a ready-to-run calibration program and several programming examples.

1.2. Features

- 12 D/A output channels
- Double-buffered D/A converters with 12-bit resolution
- Multiple output ranges: 0 to 10 V, 0 to 5 V, ±5 V and 4 to 20 mA current loop (sink)
- 16 digital input and 16 digital output channels (TTL compatible)

- D/I and D/O ports are fully compatible with the following PC-LabCard daughterboards:

  - PCLD-782B 24-channel Opto-isolated D/I Board.
  - PCLD-785B 24-channel Relay Output Board.
  - PCLD-786 8-channel AC/DC Power SSR and Relay Driver Board.

- The PCL-727 utility diskette contains:

  - Calibration program
  - Programming examples

- A screw terminal board (PCLD-880) is available for D/A output signal wiring.

1.3. Specifications

1.3.1. Analog Output

Channels	:	12
Resolution	:	12 bit, double buffered
Output ranges	:	0 to +5 V (unipolar) 0 to +10 V (unipolar) ±5 V (bipolar) 4 to 20 mA current loop (sink).
Reference voltage	:	Internal +5 V_{DC} (±0.05 V)
Conversion type	:	12-bit monolithic multiplying
Analog device	:	MAX 526
Linearity	:	±1 LSB

Temperature drift : 0.5 PPM/^{o}C (0^{o}C-50^{o}C)

Settling time : 70 μsec max.

Current loop : 4 to 20 mA constant current sink

Output drive: : $\pm$5 mA max. (for $\pm$12 V PC supply)
$\pm$3 mA max. (for $\pm$15 V embedded supply)

Current loop excitation voltage : Minimum +8 V_{DC}, maximum 36 V_{DC}

Reset/ Power-on status : All D/A channels will be at 0 V (4 mA) output after reset or power-on (both bipolar and unipolar)

1.3.2. Digital Input

Channels : 16

Level : TTL compatible

Logic level 0 : 0.8 V max.

Logic level 1 : 2.0 V min.

Input loading : 0.5 V @ 0.4 mA max. (low)
2.7 V @ 50 μA max. (high)

1.3.3. Digital Output

Channels : 16

Level : TTL compatible

Logic level 0 : 0.5 V @ 8 mA (sink)

Logic level 1 : 2.4 V @ 0.4 mA (source)

1.3.4. General Specifications

Power supply : +5 V : 500 mA typical, 1A max.
+12 V : 50 mA typical, 110 mA max.
-12 V : 14 mA typical, 90 mA max.

I/O connector : 20-pin post header for Digital I/O ports
37-pin D-type connector for D/A output port

I/O base address : Requires 28 consecutive address locations. Base address is configured through DIP switches for address line A8 - A5. (Factory setting is Hex 2C0)

Operating temp. : 0 to +50°C

Storage temp. : -20 to +65°C

Weight : 10.3 oz. (320 g)

CHAPTER 2. INSTALLATION

2.1. Initial Inspection

Inside the shipping container, you should find this operating manual and the PCL-727 card. The PCL-727 was carefully inspected both mechanically and electrically before being shipped. It should be free of marks and scratches and in perfect working order on receipt.

When unpacking, check the unit for signs of shipping damage (damaged box, scratches, dents, etc.). If the unit is damaged or does not meet specifications, notify your local sales representative immediately.

Remove the PCL-727 interface card from its protective packaging by grasping the rear metal panel. Save PCL-727's protective packing in case you need to remove the card in the future and want to store it.

NOTE: To prevent static electricity from damaging the card's integrated circuits, it is recommended that the board is handled by the edges only, and that the person handling the board wear a static discharge wrist-strap. Also avoid allowing the card to make contact with materials that create static electricity such as plastic, vinyl, and styrofoam. When the card is not installed in a PC, always use its original packaging for storage.

2.2. Jumper Settings

You will find one DIP switch (SW1) and several jumpers on the PCL-727 card. The function of each is discussed in this section. Refer to Appendix B for the locations of the DIP switch and jumpers.

2.2.1. Base Address Selection

Switch name: SW1, positions 1 to 4

Most PC peripheral devices and interface cards are controlled through the input/output (I/O) ports. These ports are addressed using the I/O port address space. Appendix C provides a PC I/O port address map to help you locate appropriate addresses for different devices.

The I/O port's base address is selectable through the DIP switch SW1. The PCL-727 requires 26 consecutive address locations in the I/O space. Valid addresses range from Hex 200 to Hex 3E0. The default factory setting for the PCL-727's I/O base address is Hex 2C0. When another device's address setting conflicts with the PCL-727's default I/O base address setting, you will need to change one of them. If you choose to adjust the PCL-727's I/O base address, refer to the table below which lists the switch settings for various base addresses.

I/O Address Range (Hex)		Switch Position 4 A9	3 A8	2 A7	1 A6	A5
200-21F		1	0	0	0	0
220-23F		1	0	0	0	1
.						
.						
2C0-2DF	*	1	0	1	1	0
.						
.						
300-31F		1	1	0	0	0
.						
3E0-3FF		1	1	1	1	1

Notes: ON = 0, OFF = 1
A5...A9 correspond to PC bus address lines
* means default factory setting

2.2.2. Output Range and Mode Selection

Jumper names: JP3 to JP26
JP28 to JP31

There are two jumpers for each D/A conversion channel to select unipolar, bipolar and current output ranges. The jumpers used for each of the twelve channels, along with typical jumper settings, are shown below.

CH.	JP-n	JP-m
0	JP3	JP4
1	JP5	JP6
2	JP7	JP8
3	JP9	JP10
4	JP11	JP12
5	JP13	JP14

CH.	JP-n	JP-m
6	JP15	JP16
7	JP17	JP18
8	JP19	JP20
9	JP21	JP22
10	JP23	JP24
11	JP25	JP26

Output Range	JP-n	JP-m
0 to +5 V Unipolar		
0 to +10 V Unipolar		
-5 V to +5 V Bipolar		
* 4 to 20 mA Current Sink		

* **Note**: Channels 1 to 7 employ separate D/A Output Connector pins for voltage and current outputs (See connector pin assignment diagram for D/A Output Connector CN3 in Section 2.3). Channels 8 to 11 use the same connector pins for both voltage and current outputs. For these channels, voltage/current output must be selected with jumpers JP28 to JP31. Settings for these jumpers are shown below.

	JP 28 CH #8	JP 29 CH #9	JP 30 CH#10	JP 31 CH#11
Voltage	o [o] o	o [o] o	o [o] o	o [o] o
Current	[o] o	[o] o	[o] o	[o] o

2.2.3. Output Power Supply Selection

Jumper names: JP1 to JP2

D/A outputs may be driven from either the PC ±12 V power supply, or from the embedded ±15 V supply. When the PC's ±12 V supply has an already heavy load, it may not be capable of supplying the full 10 V output on the 0 to 10 V range. In this case, you should utilize the embedded ±15 V supply. Factory default setting is for the ±12 V PC supply. Jumper settings are shown below.

	JP1	JP2
±12 V PC SUPPLY	[o] o	[o] o
* ±15 V EMBEDDED SUPPLY	o [o]	o [o]

*** Note:** When the ±15 V embedded supply is used, output drive capability is ±3 mA.

2.3. Connector Pin Assignment

The PCL-727 is equipped with a 37-pin D-type connector, accessible from the rear plate, and two on-board 20-pin insulation displacement connectors. All connectors accommodate the same type of flat cable, or can be connected to 37-pin D-type connectors through our PCLK-1050 industrial wiring kit. Please refer to Appendix B for the location of each connector.

The following tables detail the pin assignments for each connector.

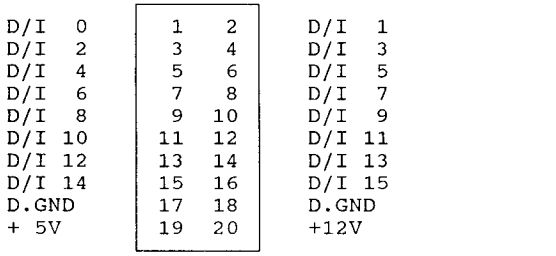
Legend :

V OUT	:	Analog voltage output
I OUT	:	Analog current sink
REF OUT	:	Reference voltage output
REF IN	:	Voltage reference input
D/O	:	Digital output
D/I	:	Digital input
D.GND	:	Digital and power supply ground
A.GND	:	Analog ground
NC	:	No connection

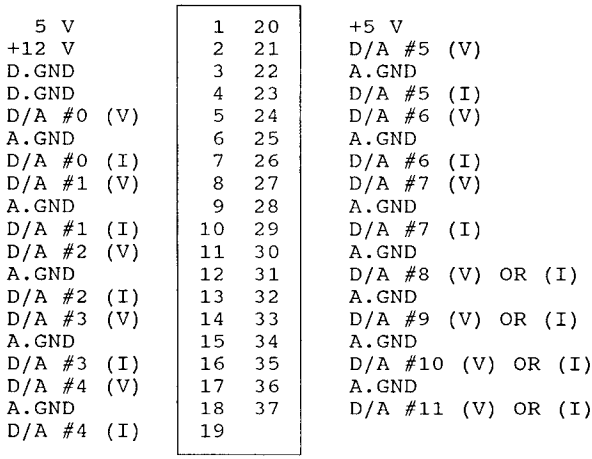
Connector 1 (CN1) - Digital Output

D/O 0		1	2		D/O 1
D/O 2		3	4		D/O 3
D/O 4		5	6		D/O 5
D/O 6		7	8		D/O 7
D/O 8		9	10		D/O 9
D/O 10		11	12		D/O 11
D/O 12		13	14		D/O 13
D/O 14		15	16		D/O 15
D.GND		17	18		D.GND
+5 V		19	20		+12 V

Connector 2 (CN2) - Digital Input



Connector 3 (CN3) - D/A Output



2.4. Hardware Installation

Installing the card in your computer:

1. Disconnect power from the computer and from all connected peripheral devices - printer, monitor, etc..

2. Remove the power cable and any other cables from the back of the computer. Turn the system unit so the back of the unit faces you.

3. Remove the system unit cover (refer to your computer users guide).

4. Locate the expansion slots and choose any unused slot.

5. Remove the screw that secures the expansion slot cover to the system unit. Save the screw to secure the interface card retaining bracket.

6. Carefully grasp the upper edge of the PCL-727 card. Align the hole in the retaining bracket with the hole on top of the expansion slot, and align the gold striped edge connector with the expansion slot socket. Press the board firmly into the socket.

7. Replace the screw in the expansion slot retaining bracket.

8. Attach the accessories required by your application (e.g. 37 pin D-type cable) to the interface card.

9. Replace the system unit cover. Reconnect the cables you removed in step 2, and power up the computer and all peripherals.

The hardware installation is now completed. Proceed with the installation of the software driver.

2.5. Software Installation

A floppy diskette, containing PCL-727 utility software, is shipped with each PCL-727. This disk is intended to minimize application programming effort and support calibration of the PCL-727. The utility diskette includes:

1. Programming examples.

2. Calibration program.

It is strongly recommended that you make a working copy from the master diskette and keep the master diskette in a safe place. You may use the DOS COPY or DISKCOPY commands to copy the diskette files to another floppy disk, or use the COPY command to copy the files to a hard disk. Refer to your MS-DOS user's manual for detailed instructions how to make backup copies of your diskettes.

The following files should be present on the PCL-727 utility diskette:

- DEMO01.C This program demonstrates how to generate a voltage or current output.

- CALB.EXE This calibration program provides a procedure to calibrate the voltage and current outputs of each D/A channel. The program will guide the user in adjusting the variable resistors to obtain most accurate outputs.

CHAPTER 3. SIGNAL CONNECTIONS

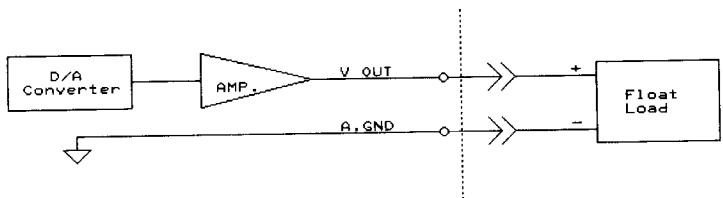
3.1. Introduction

Correct signal connections are one of the most important criteria in making sure that your application will send and receive accurate data. Since most data acquisition applications involve voltage measurement, correct signal connections will ensure maximum accuracy and may prevent costly damage to your equipment. This section provides some useful information on making the correct signal connections in different types of data acquisition applications.

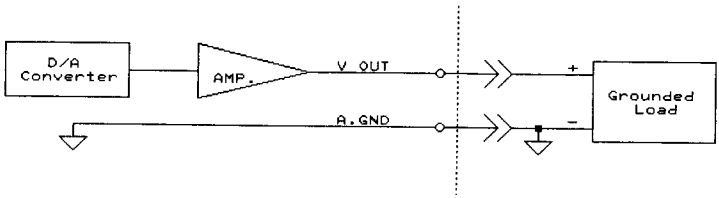
3.2. Voltage Output Connections

The PCL-727 supports 12 channels of D/A voltage output. There is only one output signal wire for each channel, as the voltage is referenced to the common ground. It is fairly simple to connect a voltage output channel with a floating load. A standard wiring diagram is shown below.

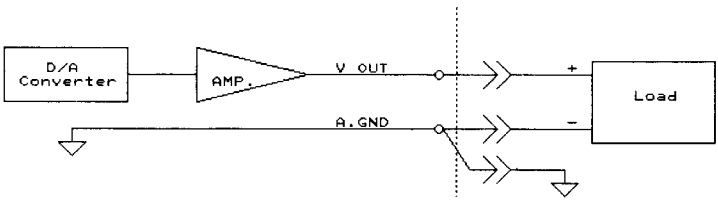
PCL-727 Side External Side



For a grounded load, the signal should be connected as follows.



For some differential input loads, an external ground wire is required. The wiring diagram should be as follows.

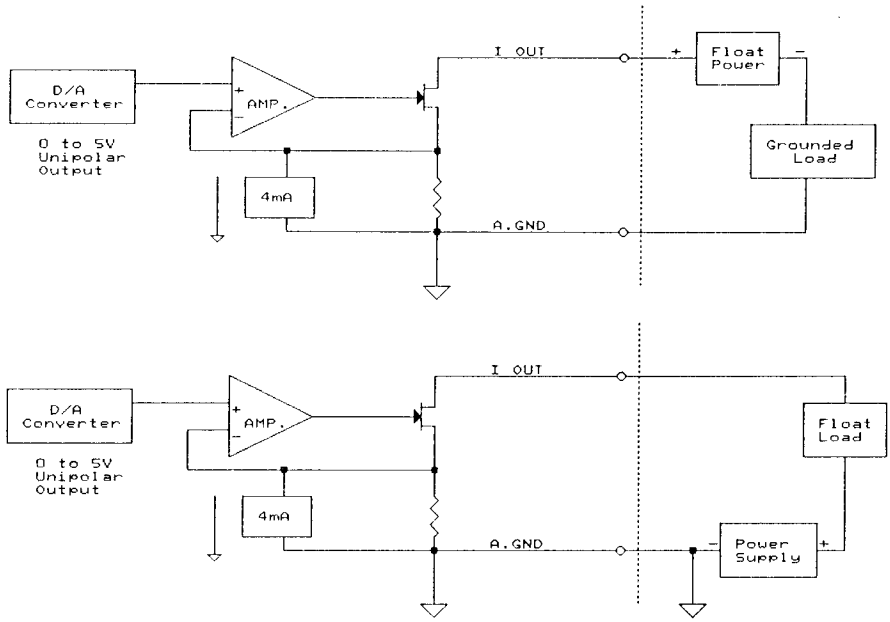


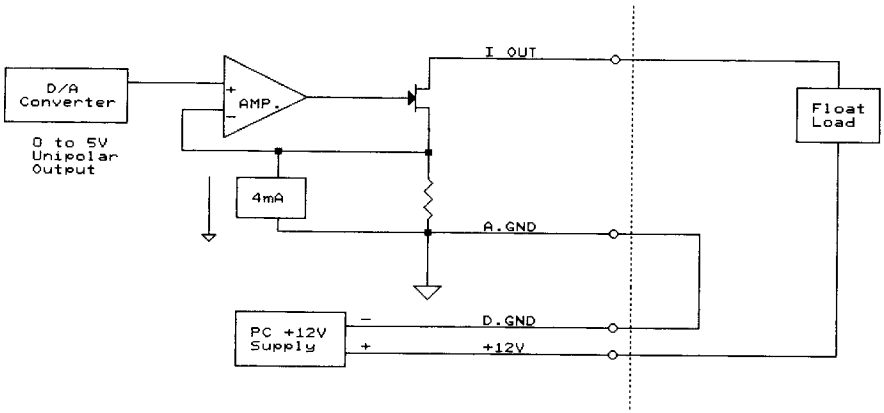
3.3. 4 to 20 mA Current Output Connections

The PCL-727 provides 12 channels of 4 to 20 mA current output. The current loop utilizes 0 to 5 V (unipolar) voltage output as the driving source. The PCL-727's current drive circuit consists of a power FET, a reverse protection diode and a constant current source. The voltage bias of this current output should be within 8 to 36 V to insure correct operation. An external 24 V power supply is ideal for this application. The PCL-727 also provides an internal 12 V power source for current loops should this be required. There are three ways of connecting the load:

1. a grounded load with a floating supply
2. a floating load with a grounded power supply
3. a floating load with the internal 12 V supply

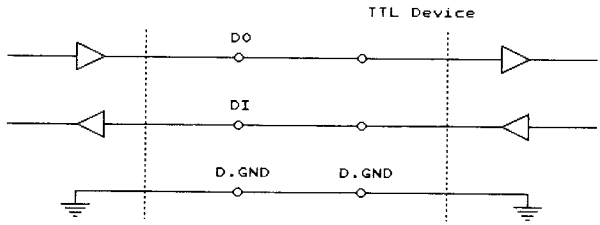
The connections for each configuration are shown below.



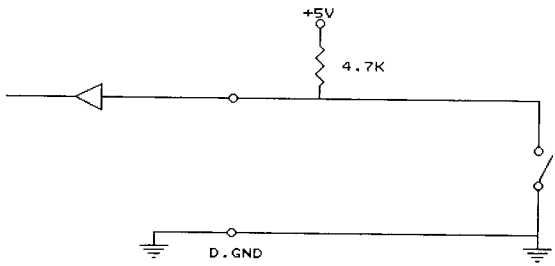


3.4. Digital Signal Connections

The PCL-727 has 16 digital input and 16 digital output channels. The digital I/O levels are TTL compatible. To transmit or receive digital signals to and from other TTL devices, the connection should be as follows.



When used to detect an OPEN/SHORT signal from a switch or relay, a pull-up resistor must be added to ensure the input is tied to a high (+5 V) when the contact is open. The following diagram shows this configuration.



CHAPTER 4. REGISTER STRUCTURE AND FORMAT

4.1. Introduction

The PCL-727 requires 16 consecutive addresses in I/O space. The most important issue in programming the PCL-727 is understanding the meaning of the 16 registers addressable from the selected I/O port base address. A summary map of the functions of each address and the data format of each register are given in the following sections.

4.2. I/O Port Address Map

The following table details the location of each register, the driver relative to the base address, and its usage.

Legend

D/A : Analog output
D/O : Digital output
D/I : Digital Input
R : Read operation on that byte
W : Write operation on that byte

Address	R/W	Usage
BASE + 0	W	D/A ch #0 high byte data (bit 0-3)
BASE + 1	W	D/A ch #0 low byte data
BASE + 2	W	D/A ch #1 high byte data (bit 0-3)
BASE + 3	W	D/A ch #1 low byte data
BASE + 4	W	D/A ch #2 high byte data (bit 0-3)
BASE + 5	W	D/A ch #2 low byte data
BASE + 6	W	D/A ch #3 high byte data (bit 0-3)
BASE + 7	W	D/A ch #3 low byte data
BASE + 8	W	D/A ch #4 high byte data (bit 0-3)
BASE + 9	W	D/A ch #4 low byte data
BASE + 10	W	D/A ch #5 high byte data (bit 0-3)
BASE + 11	W	D/A ch #5 low byte data
BASE + 12	W	D/A ch #6 high byte (bit 0-3)

BASE + 13	W	D/A ch #6 low byte
BASE + 14	W	D/A ch #7 high byte (bit 0-3)
BASE + 15	W	D/A ch #7 low byte
BASE + 16	W	D/A ch #8 high byte (bit 0-3)
BASE + 17	W	D/A ch #8 low byte
BASE + 18	W	D/A ch #9 high byte (bit 0-3)
BASE + 19	W	D/A ch #9 low byte
BASE + 20	W	D/A ch #10 high byte (bit 0-3)
BASE + 21	W	D/A ch #10 low byte
BASE + 22	W	D/A ch #11 high byte (bit 0-3)
BASE + 23	W	D/A ch #11 low byte
BASE + 24	W	D/O ch 8-15
BASE + 25	W	D/O ch 0-7
BASE + 0	R	D/I ch 8-15
BASE + 1	R	D/I ch 0-7

4.3. D/A Output Registers

The D/A output registers are write registers using address BASE+0 to BASE+25.

Data Format

BASE+0 (2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22)
D/A #0 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11) high byte

D7	D6	D5	D4	D3	D2	D1	D0
X	X	X	X	DA11	DA10	DA9	DA8

BASE+1 (3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23)
D/A #0 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11) low byte

D7	D6	D5	D4	D3	D2	D1	D0
DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0

LEGEND:

DA11 to DA0: Digital to analog data.
DA0 is the least significant byte (LSB)
DA11 is the most significant byte (MSB) of the D/A data.

X: Don't care

The D/A circuit utilizes a double buffer technique to eliminate the transient stage between writing operations of the high byte and low byte data. The high byte data (only the lower four bytes are significant) must be written first and it is then latched into a latch for temporary storage and does not immediately change the analog output. While the low byte is being sent, the high byte reaches the D/A converter at the same time as the low byte data.

NOTE: The high byte data must be sent first!

4.4. Digital I/O Registers

The PCL-727 offers 16 digital input channels and 16 digital output channels. The digital input channels use the I/O addresses BASE +0 and BASE +1. The digital output channels use the I/O addresses BASE +24 and BASE +25. The data format of each port is as follows.

Data format

BASE+24
D/O high byte

D7	D6	D5	D4	D3	D2	D1	D0
DO15	DO14	DO13	DO12	DO11	DO10	DO9	DO8

BASE+25
D/O low byte

D7	D6	D5	D4	D3	D2	D1	D0
DO7	DO6	DO5	DO4	DO3	DO2	DO1	DO0

BASE+0
D/I high byte

D7	D6	D5	D4	D3	D2	D1	D0
DI15	DI14	DI13	DI12	DI11	DI10	DI9	DI8

BASE+1
D/I low byte

D7	D6	D5	D4	D3	D2	D1	D0
DI7	DI6	DI5	DI4	DI3	DI2	DI1	DI0

LEGEND:

DO15 to DO0: Digital output data.
DO7 to DO0 is the low byte data (LSB)
DO15 to DO7 is the high byte data (MSB)

DI15 to DI0: Digital input data.
DI7 to DIO is the low byte data (LSB)
DI15 to DI7 is the high byte data (MSB)

CHAPTER 5. APPLICATIONS

5.1. D/A Applications

The PCL-727 provides 12 channels which use double buffered 12-bit multiplying D/A converters. The D/A registers are write registers using address BASE +0 to BASE +23.

When programming the D/A channels, please note that the most significant byte (high byte) should be sent first. It is temporarily stored in a register in the D/A, and is not passed on to the D/A converter until the least significant byte is received. Upon receiving the least significant byte, the two bytes are sent to the D/A converter simultaneously. The double buffering process protects the D/A data-integrity using single step updates.

The PCL-727 provides an internal precision reference voltage, fixed at +5 V_{DC}. This voltage is used as the D/A reference.

Connector CN3 supports all signal connections. The pin assignment of this connector is described in Section 2.3.

The PCL-727 D/A functions can be controlled by writing I/O instructions directly to the register. A commonly used D/A application is clearly illustrated in the demonstration program on the PCL-727 utility diskette. The demonstration program DEMO01.C provides complete programming examples of both single and multiple D/A channel applications.

The following steps illustrate how to program D/A channel 0 to generate a voltage.

1. Output high byte data to port BASE +0
2. Output low byte data to port BASE +1
3. D/A channel 0 will output the set voltage

5.2. Digital Input and Output

The PCL-727 provides 16 digital input channels and 16 digital output channels. The digital input and output channels are fairly easy to program. Attention should be paid to the pin assignments of Connectors CN1 (digital output) and CN2 (digital input). (See Section 2.3, Connector Pin Assignment)

A reading operation performed on any of the D/I ports will read in the values of the eight corresponding digital input channels. To access the D/I ports in C, use the following statement:

```
VALUE = INPORTB (ADDRESS)
```

where ADDRESS is BASE +0 (high byte) or BASE +1 (low byte)

A writing operation to any of the D/O ports will set the desired value of the 8 corresponding digital output channels. To access the D/O ports in C, use the following statement:

```
OUTPORTB (ADDRESS, DATA)
```

where ADDRESS is BASE +24 (high byte) or BASE +25 (low byte)

APPENDIX A - CALIBRATION

In the application of data acquisition and measurement, it is important to regularly and systematically calibrate your measurement devices in order to maintain maximum accuracy. A calibration program CALB.EXE is provided on the PCL-727 utility disk to assist users in this task.

A.1 VR Assignment

There are 13 variable resistors (VRs) on the PCL-727 PCB to facilitate accurate and independent adjustment of each D/A channel. The functions of the VR channels are listed below.

VR5 : CH #0 current offset adjustment (4 mA)
VR6 : CH #1 current offset adjustment (4 mA)
VR7 : CH #2 current offset adjustment (4 mA)
VR8 : CH #3 current offset adjustment (4 mA)
VR9 : CH #4 current offset adjustment (4 mA)
VR10 : CH #5 current offset adjustment (4 mA)
VR11 : CH #6 current offset adjustment (4 mA)
VR12 : CH #7 current offset adjustment (4 mA)
VR13 : CH #8 current offset adjustment (4 mA)
VR14 : CH #9 current offset adjustment (4 mA)
VR15 : CH #10 current offset adjustment (4 mA)
VR16 : CH #11 current offset adjustment (4 mA)
VR17 : D/A bipolar offset adjustment

A.2 D/A Calibration

A calibration program, CALB.EXE, is provided on the PCL-727 utility disk. The default I/O port address in the program is 2C0. If address 2C0 is already occupied by another device, either replace that device with the PCL-727 or modify the address setting in the CALB.EXE

Once the calibration program has been loaded and executed, it will use a graphic display to guide you through the calibration process.

A 5½ digit multimeter is required to complete the calibration procedure. Use of Advantech's PCL-755A Slot Extension Card is recommended to simplify access to the VRs during calibration.

A step-by-step procedure to perform the calibration is detailed below.

Step 1: To calibrate the PCL-727, the measurement point is TP1. Adjust VR17 for 5V at this point.

Step 2: To adjust the D/A precision 4 mA constant current source, adjust the appropriate VR (VR5 to VR16). See the preceding section (D.1) for VR assignments.

NOTE: The voltage output gain in bipolar mode depends on the gain in unipolar mode, and therefore it does not need separate adjustment. The current gain is dependent on a high-stability fixed resistor, and requires no adjustment.

APPENDIX B - PIN ASSIGNMENT FOR PCLD-880