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Model PCL-711B

PC-MultiLab Card

PCL-711 B

PC-MultiLab CARD

USER'S MANUAL

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Part No. 2003711010 Rev. Al
Printed in Taiwan, Aug. 1992

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CHAPTER 1. INTRODUCTION

The PCL-711B PC-MultiLab Card is an easy-to-use and cost/effective IBM PC/XT/AT compatible multifunction data acquisition card. This card's specifications and user-friendly software driver make it a popular solution for a wide range of industrial and laboratory applications. Such applications include: data acquisition, process control, automatic testing, and factory automation.

1.1. Features

- 12-bit resolution A/D conversion
- Accepts 8 single-ended analog inputs
- Programmable analog input ranges: ±5V, ±2.5V, ±1.25, ±0.625V, ±0.3125V
- Support software trigger, programmable pacer trigger, and external trigger
- Programmable IRQ level for A/D data transfer
- One 12-bit multiplying D/A output channel, with the output range of 0 to +5V or 0 to +10V
- On-board 16-bit digital input and digital output
- Versatile language drivers including BASIC, PASCAL, C and C++

1.2. Specifications

1.2.1. Analog Input (A/D Converter)

Channels: 8 single-ended inputs.

Resolution: 12 bits, successive approximation.

Input range: ±5V, ±2.5V, ±1.25, ±0.625V, and ±0.3125V, software programmable.

Converter: AD574 or equivalent.

Conversion time: 25μs max.

Accuracy: 0.015% of reading $\pm$1 LSB.

Nonlinearity: $\pm$1 bit.

Amplification gains: x1, x2, x4, x8, and x16, software programmable.

Trigger mode: By software, pacer and external trigger.

Data transfer: By software or interrupt.

Overvoltage: Continuous $\pm$30V max.

IRQ level: IRQ2 to IRQ7.

1.2.2. Analog Output (D/A Converter)

Channels: One channel.

Resolution: 12 bits

Output range: 0 to +5V or 0 to +10V.

Settling time: 30μs.

Reference voltage: Internal -5V and -10V ($\pm$0.05V).

Converter: PM7548GP or equivalent.

Nonlinearity: $\pm$½ LSB.

Output capacity: $\pm$5mA max.

1.2.3. Digital Input

Channels: 16 bits, TTL compatible

Input voltage: Low - 0.8V max.
High - 2.0V min.

Input load: Low - 0.4mA max. @0.5V
High - 0.05mA max. @2.7

1.2.4. Digital Output

Channel: 16 bits, TTL compatible

Output voltage: Low (sink): 8mA @0.5V max.
High (source): 0.4mA @2.4V min.

1.2.5. General Specifications

Power consumption:
+5V: 100mA, typical; 500mA max.
+12V: 40mA, typical; 100mA max.
-12V: 20mA, typical; 50mA max.

I/O connector:
- One 20-pin connector for A/D and D/A
- One 20-pin connector for digital input
- One 20-pin connector for digital output

I/O ports: requires 16 consecutive I/O ports per card

Operating temperature: 0 to 50°C (32 to 122°F).

Storage temperature: -20 to 65°C (-4 to 149°F).

Weight: 127 gm (4.49 oz.).

CHAPTER 2. INSTALLATION

2.1. Initial Inspection

The PCL-711B was thoroughly inspected before being shipped to you. Before installing the card into your PC, make sure that everything has been included with the package. You should also inspect the card for any defects or damages that may have occurred during shipment. If you find anything missing, defective or damaged, contact your PC-LabCard dealer immediately.

Here is a list of the materials included with your PCL-711B package:

- One PCL-711B PC-MultiLab Card
- One User's Manual
- One utility diskette which includes the card's software driver

In the PCL-711S package, two additional accessories are also included:

- One PCLD-7115 Wiring Terminal Board
- One 1 meter cable

2.2. Switch and Jumper Settings

The PCL-711B has been designed with ease-of-use in mind. On board the card you will notice that there is only one DIP switch (SW1), and only one set of jumper pins (JP1). These are used to set the PCL-711B's base address, and to select its D/A output voltage range. The following sub-sections go into this in more detail.

2.2.1. I/O Address Selection

Most peripheral devices and interface cards are controlled via your PC's I/O ports. These devices and cards should be placed in an appropriate I/O space so that there will be no conflicts between them and the PCL-711B. Keep in mind that the PCL-711B uses 16 consecutive address locations in your PC's I/O space. Appendix A provides an I/O port address map for your reference. This will assist you in locating an appropriate address for your peripheral devices and interface cards.

I/O port base addresses are selected from the 6-position DIP switch, SW1, on-board the PCL-711B. Valid addresses are from 000 to 3F0 (hexadecimal). The factory default address setting is 220. From time to time, you may find that you will have to use some of these spaces for other devices. If this is the case, then you can change the address according to the information given in the following table.

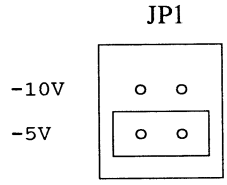
I/O ADDRESS RANGE (HEXADECIMAL)	SWITCH POSITION (SW1) 1 A9	2 A8	3 A7	4 A6	5 A5	6 A4
000 - 00F	0	0	0	0	0	0
100 - 10F	0	1	0	0	0	0
.						
.						
200 - 20F	1	0	0	0	0	0
210 - 21F	1	0	0	0	0	1
220 - 22F *	1	0	0	0	1	0
.						
300 - 30F	1	1	0	0	0	0
.						
3F0 - 3FF	1	1	1	1	1	1

NOTE: 0 = ON, 1 = OFF
A4 through A9 correspond to your PC's address lines.
* Factory default

2.2.2. D/A Range Selection

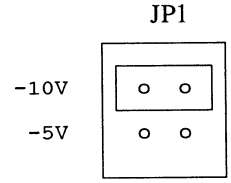
PCL-711B's D/A output range depends on the reference voltage you select at the jumper, JP1. The reference voltages can be assigned as either -5V or -10V, which gives you an D/A output range of 0 to +5V or 0 to +10V, respectively.

When an D/A output range of 0 to +5V is required, set the jumper to -5V (see the illustration below).



*Factory default

If your application requires an D/A output range of 0 to +10V, then set the jumper to -10V (refer to the illustration below).



NOTE: When -10V reference is selected, the maximum D/A output voltage should be +10V. However, it may be less than +10V because the +12V voltage source supplied by your PC may be lower than +11.5V which is required by the D/A circuit.

2.3. Connector Pin Assignment

The PCL-711B is equipped with three 20-pin connectors. Two connectors are located at CN3 and CN4. These are used for digital input (CN4), and digital output (CN3). The third connector is located at CN1, and is used for analog I/O.

Each of these connectors can be connected with the same type of ribbon cables. They can also be connected to a D37 connector using the PCLK-1050 industrial wiring kit.

An illustration of each of these connectors are given in the following illustrations.

Key:

A/D	=	Analog input
AGND	=	Analog ground
D/A	=	Analog output
D/O	=	Digital output
D/I	=	Digital input
DGND	=	Digital ground
VREF	=	Voltage reference

Analog I/O (CN1)

A/D 0	1	2	AGND
A/D 1	3	4	AGND
A/D 2	5	6	AGND
A/D 3	7	8	AGND
A/D 4	9	10	AGND
A/D 5	11	12	AGND
A/D 6	13	14	AGND
A/D 7	15	16	AGND
D/A	17	18	AGND
AGND	19	20	AGND

Digital Output (CN3)

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
DGND	17	18	DGND
+5V	19	20	+12V

Digital Input (CN4)

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

2.4. Plugging the PCL-711B into Your PC

Before you plug the PCL-711B into your PC, make sure that the computer's power is turned off, and that all power cords and peripheral devices have been disconnected from the system.

Use the following procedures as a guideline for plugging the PCL-711B into your computer.

1. Remove the cover from your PC's chassis, and locate a vacant expansion slot on your passive backplane or motherboard for installing the PCL-711B.

2. Take the card and insert its edge connector into the expansion slot, pressing the card firmly into place. Use the card's mounting bracket as a guide between the chassis' rear panel and backplane or motherboard.

3. Once you have inserted the card firmly into the slot, secure it to the chassis by fastening its mounting bracket with a screw.

4. Attach any ribbon cables to connectors CN1, CN3, and CN4 that your application may require.

5. Now, replace the chassis cover, and connect any power cords and peripheral cables that you disconnected.

The PCL-711B's installation is now complete.

2.5. Signal Connections

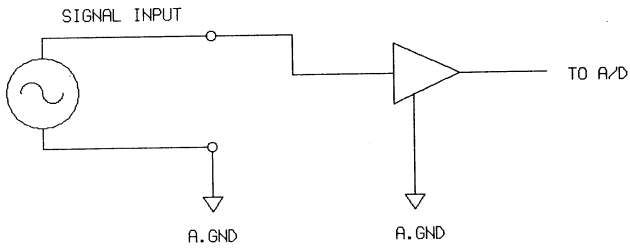
Since most data acquisition applications involve voltage measurement, it is important to make the correct signal connections in order to avoid any damage to your system, and insure accurate data acquisition. This chapter provides some helpful information about making the appropriate and proper signal connections for your application.

2.5.1. Analog Input Connection

As you already know, the PCL-711B supports eight single-ended analog inputs. A single-ended analog input connection uses only one signal wire connected to an analog input terminal which references to a common ground. For example, in order to measure a battery's voltage, simply connect its negative side to the PCL-711B's ground (any one of the AGND pins on connector CN1), and its positive side to one of the card's analog input channels.

NOTE: The PCL-711B does not support differential signal source inputs.

The following diagram illustrates a single-ended, common ground, analog input connection:

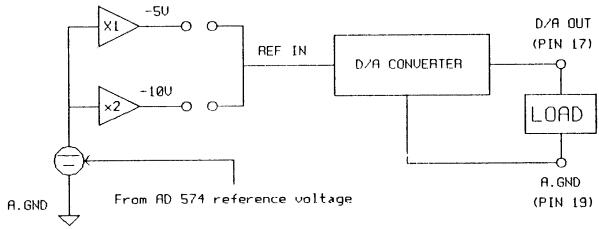


Single-Ended Analog Input Connection

2.5.2. Analog Output Connection

The PCL-711B is equipped with an internal -5 and -10V reference source which generates an output of 0 to +5 and 0 to +10V D/A output. The PCL-711B only provides one D/A output channel. Use Connector CN1 for making your analog output.

The following diagram illustrates a typical analog output or D/A connection:

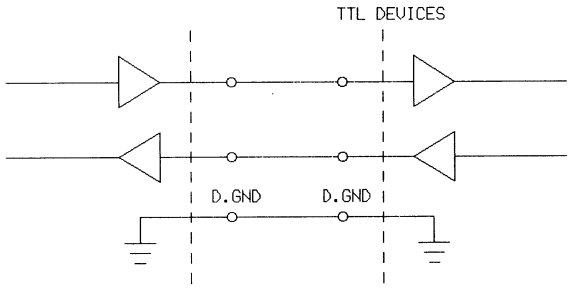


Analog Output Connection

2.5.3. Digital Signal Connection

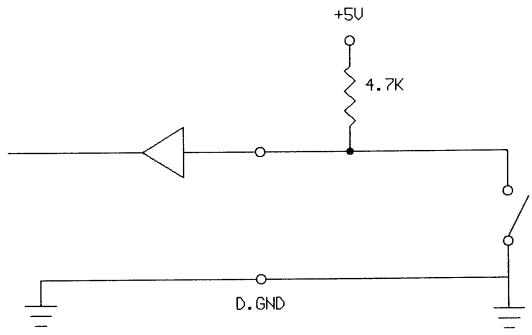
As mentioned in Chapter 1, the PCL-711B provides 16 digital input and 16 digital output channels for usage in digital input/output applications, such as timer/counter operations. All digital I/O levels are TTL compatible.

In order to transmit or receive a digital signal to or from other TTL devices, make your signal connection as illustrated in the following diagram:



Digital Signal Connection

To receive an OPEN or SHORT signal from a switch or relay , a pull up resistor must be installed on the PCL-711B. This resistor ensures that a high signal level will be maintained when the switch is open. Refer to the diagram illustrated below for an example of an OPEN/SHORT signal connection.



OPEN/SHORT Signal Connection

2.6. Software Driver

The PCL-711B is supported by Advantech's standard, user-friendly software driver. This driver allows you use standard functions, written in common programming languages, to operate the PCL-711B, without going into detailed register control. Languages supported by the software driver include BASICA, GWBASIC, QUICKBASIC, Microsoft C/C++ and PASCAL, Borland C/C++ and Turbo PASCAL. Please refer to the manual for the software driver for more information.

CHAPTER 3. CONTROLLING THE PCL-711B

This chapter has been written for those of you who wish to write their own software driver instead of using the PCL-711B's. Here, you will find detailed information about the PCL-711B's register formats and control procedures.

3.1. I/O Port Address Map

The following table shows you which base I/O addresses are used by the PCL-711B. Refer to this map from time to time in order to become familiar with each of the card's register formats and their purpose. 16 consecutive registers corresponding to their I/O addresses are used to control the PCL-711B's various functions. The following table has been provided in this chapter as a preface which outlines these addresses relative to their location and control (read or write) assignments.

LOCATION	READ	WRITE
BASE+0	Counter 0	Counter 0
BASE+1	Counter 1	Counter 1
BASE+2	Counter 2	Counter 2
BASE+3	N/A	Counter Control
BASE+4	A/D low byte	D/A low byte
BASE+5	A/D high byte	D/A high byte
BASE+6	D/I low byte	N/A
BASE+7	D/I high byte	N/A
BASE+8	N/A	Clear interrupt status
BASE+9	N/A	Gain control
BASE+10	N/A	Multiplexer scan control
BASE+11	N/A	Mode and interrupt control
BASE+12	N/A	Software A/D trigger
BASE+13	N/A	D/O low byte
BASE+14	N/A	D/O high byte
BASE+15	N/A	N/A

The sections that follow provide further information about each register's data format according to its specific operation.

3.2. A/D Conversion

3.2.1. A/D Data Registers

The PCL-711B uses the data registers located at I/O ports BASE+4 and BASE+5 to store the converted A/D data. The low byte data is stored at BASE+4, and the high byte data is stored at BASE+5.

BASE+4 A/D Low Byte Data (Read)

D7	D6	D5	D4	D3	D2	D1	D0
AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0

BASE+5 A/D High Byte Data (Read)

D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	DRDY	AD11	AD10	AD9	AD8

Where:

AD0 through AD11: Represent the PCL-711B's A/D data bits. AD0 is the Least Significant Bit (LSB), and AD11 is the Most Significant Bit (MSB).

DRDY: Data ready bit. When A/D conversion is in progress, this bit remains as 1. It becomes 0 when the A/D conversion is completed. It will become to 1 after reading the low byte A/D data from BASE+4.

3.2.2. Gain Control Register

BASE+9 is used to set the PCL-711B's amplification gain for A/D conversion. The PCL-711B provides five different gains: x1, x2, x4, x8, and x16.

The following tables outline BASE+9's register format and corresponding gain settings:

BASE+9 Gain Control Register (Write)

D7	D6	D5	D4	D3	D2	D1	D0
-	-	-	-	-	G2	G1	G0

G2	G1	G0	GAIN
0	0	0	**x1**
0	0	1	**x2**
0	1	0	**x4**
0	1	1	**x8**
1	0	0	**x16**

3.2.3. Multiplexer Scan Register

The PCL-711B can multiplex up to 8 channels of analog input. Users have to set this register, located at BASE+10, to select to the desired channel , which is going to be measured, before performing any A/D conversion. The register format is as below:

BASE+10 Multiplexer Scan Control (Write)

D7	D6	D5	D4	D3	D2	D1	D0
-	-	-	-	-	C2	C1	C0

C2	C1	C0	CH.
0	0	0	**0**
0	0	1	**1**
0	1	0	**2**
0	1	1	**3**
1	0	0	**4**
1	0	1	**5**
1	1	0	**6**
1	1	1	**7**

3.2.4. Mode and Interrupt Control Register

The PCL-711B's A/D conversion can be triggered in one of the following three ways:

- **By software**
  Writing any data to BASE+12 will generate a trigger pulse to the PCL-711B's on-board A/D converter.

- **By the on-board clock (pacer)**
  The PCL-711B is equipped with a Intel 8253, a programmable interval timer/ counter, to generate precise clock output (pacer). The pacer clock rate of the PCL-711B is between 0.5MHz and 35 minutes per pulse. (See section 3.7 for details on programming the Intel 8253 timer/counter.)

- **By external pulse**
  The PCL-711B allows users to use external signal, from D/I 0 (Pin 1 of the connector CN4), as the A/D trigger pulse. The A/D conversion will be triggered at the rising edge of the external signal.

Also, the PCL-711B provides two ways to transfer the converted A/D data to certain variables:

- **By software control (foreground)**
  The software control data transfer utilizes advantage of the foreground polling concept. After the A/D converter has been triggered, the application program should keep checking the DRDY bit of I/O port BASE+5 until the DRDY bit is detected as 0. Then the program should read data from BASE+4 and BASE+5 to get the whole converted data.

- **By interrupt (background)**
  The PCL-711B also provides background data transfer support, if it is programmed to be in the interrupt data transfer mode. If the PCL-711B is in interrupt data transfer mode, it will generate an interrupt to your PC after each A/D conversion is completed. The corresponding ISR (interrupt service routine) should handle everything to transfer the converted data to memory variables in your program.

I/O port BASE+11 is used to set the PCL-711B's operation mode and the IRQ level. The register format is as following:

BASE+11 Mode and Interrupt Control Register (Write)

D7	D6	D5	D4	D3	D2	D1	D0
-	I3	I1	I0	-	S2	S1	S0

Where:

S0 to S2: mode selection

S2	S1	S0	Operation Mode
0	0	0	S/W trigger with S/W data transfer
0	0	1	
0	1	0	External trigger * with S/W data transfer
0	1	1	External trigger * with INT data transfer
1	0	0	Pacer trigger with S/W data transfer
1	0	1	Reserved
1	1	0	Pacer trigger with INT data transfer
1	1	1	Reserved

Note: External trigger signal go through DI0 of CN4

I0 to I2: IRQ level selection

I2	I1	I0	Interrupt Level
0	0	0	**IRQ2**
0	0	1	**N/A**
0	1	0	**IRQ2**
0	1	1	**IRQ3**
1	0	0	**IRQ4**
1	0	1	**IRQ5**
1	1	0	**IRQ6**
1	1	1	**IRQ7**

3.2.5. Interrupt Status Register

If the PCL-711B is in interrupt data transfer mode, a hardware status flag will be set after each A/D conversion. Users have to clear the status flag, by writing any data to BASE+8, to let the PCL-711B accept next interrupt.

BASE+8 Clear Interrupt Status (Write)

D7	D6	D5	D4	D3	D2	D1	D0
-	-	-	-	-	-	-	-

3.2.6. Software Trigger Register

Writing any data to BASE+12 will generate a trigger pulse to the PCL-711B 's A/D converter.

BASE+12 Software A/D Trigger (Write)

D7	D6	D5	D4	D3	D2	D1	D0
-	-	-	-	-	-	-	-

3.3. D/A Conversion

The PCL-711B provides one D/A output channel. The low byte and the high byte D/A data are set via BASE+4 and BASE+5 respectively.

Since the PCL-711B uses so-called double-buffer D/A output technology to avoid output glitch, the low byte data should be written first and the high byte data second, that is write BASE+4 first and BASE+5 second. The D/A output will not change until BASE+5 is updated.

BASE+4 D/A Low Byte Data (Write)

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

BASE+5 D/A High Byte Data (Write)

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

where:

DA0 through DA11: the D/A output data. DA0 represents the D/A' LSB data, while DA11 represents the D/A' MSB data.

3.4. Digital Input and Output

3.4.1. Digital Input Registers

The PCL-711B provides 16 bits of digital input. The registers are located at BASE+6 and BASE+7.

BASE+6 D/I Low Byte Data (Read)

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

BASE+7 D/I High Byte Data (Read)

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

3.4.2. Digital Output Registers

The PCL-711B provides 16 bits of digital output. The registers are located at BASE+13 and BASE+14.

BASE+13 D/O Low Byte Data (Write)

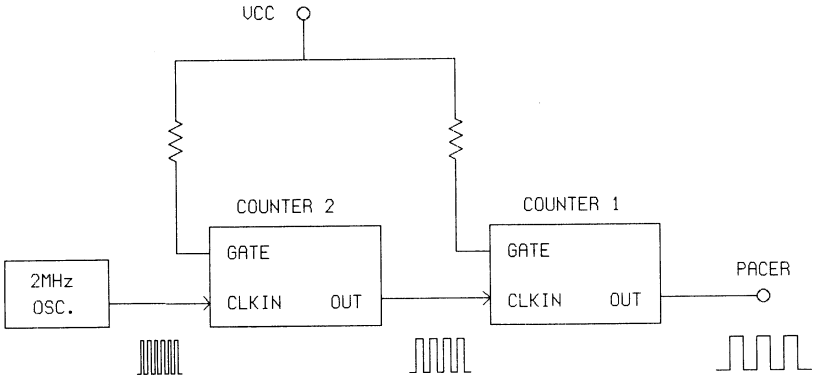
D7	D6	D5	D4	D3	D2	D1	D0
DO7	DO6	DO5	DO4	DO3	DO2	DO1	DO0

BASE+14 D/O High Byte Data (Write)

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

3.5. Pacer Programming

The PCL-711B uses an Intel 8253, a 16-bit programmable counter/timer, to generate pacer clock. Each Intel 8253 provides three independent counter/timer channels, Counter 0, Counter 1 and Counter 2. The PCL-711B cascades Counter 1 and Counter 2 as a 32-bit frequency divider to support wide range of pacer clock rate, as shown below:



Intel 8253 has six operation modes, from Mode 0 through Mode 5. To generate pacer clock, both Counter 1 and Counter 2 should be programmed as Mode 2 (rate generator mode).

Four I/O ports, from BASE+0 through BASE+3, are used to program the on-board Intel 8253:

BASE+0: Counter 0 (Read/Write)
BASE+1: Counter 1 (Read/Write)
BASE+2: Counter 2 (Read/Write)
BASE+3: Counter Control (Write only)

Please refer to the following steps to set desired pacer clock rate:

Step 1: Write '74H' to BASE+3 to make Counter 1 work at Mode 2.

Step 2: Write an appropriate data (16-bit data, ranging from 2 to 65535) to BASE+1 to set Counter 1's divisor constant C1. Since C1 is a 16-bit data, you have to first write the low byte of C1 to BASE+1, then write the high byte of C1 to BASE+1.

Step 3: Write 'B4H' to BASE+3 to make Counter 2 work at Mode 2.

Step 4: Write an appropriate data (16-bit data, ranging from 2 to 65535) to BASE+1 to set Counter 1's divisor constant C2. Since C2 is a 16-bit data, you have to first write the low byte of C2 to BASE+2, then write the high byte of C2 to BASE+2.

The pacer rate is determined by the following formula:

Pacer rate = (2 MHz)/(C1*C2)

In the following example (written in BASIC), C1 is set as 40 and C2 is set as 10, thus the pacer rate will be 5 KHz (5KHz=2MHz/(40*10)).

```
.
.
.
500  OUT (BASE+3,&H74)      ' Set Counter 1 as Mode 2
510  OUT (BASE+1,40)        ' write low byte of C1
520  OUT (BASE+1,0)         ' write high byte of C1
530  OUT (BASE+3,&HB4)      ' Set Counter 2 as Mode 2
540  OUT (BASE+2,10)        ' write low byte of C2
550  OUT (BASE+2,0)         ' write high byte of C2
.
.
.
```

NOTE 1: Counter 0 is reserved to future developement.

NOTE 2: For more detailed information about Intel 8253's register formats, please refer to Appendix B.

APPENDIX A. CALIBRATION

In data acquisition and control application, it is important to constantly calibrate your measurement device to maintain its accuracy. A calibration program, CAL711B.EXE is provided in the PCL-711B software disk to assist your calibration work.

Minimum equipment required to perform a satisfactory calibration is a 4 1/2 digit digital multimeter. In addition, a voltage calibrator or a stable noise free d.c. voltage source that can be used in conjunction with the digital multimeter is required. A card extender, such as the PC-LabCard model PCL-757 is an inexpensive device that you will find greatly improves access to the board during calibration and will probably be useful with other boards.

Calibration is easily performed using the CAL711B.EXE program. This program will lead you through the calibration and set up procedure with variety of prompts and graphic displays directing you to correct settings and adjustment the variable resistors. The explanatory material in this section is brief and is intended for use in conjunction with the calibration program.

A.1. VR Assignments

The PCL-711B has five on-board VRs, which allow you to make accurate calibration adjustments for the card's A/D and D/A functions. Each VR's location is indicated in Figure A-1. The function of each VR is listed below:

VR1	D/A full scale adjustment
VR2	D/A offset adjustment
VR3	A/D offset adjustment
VR4	A/D full scale adjustment
VR5	Programmable amplifier offset adjustment

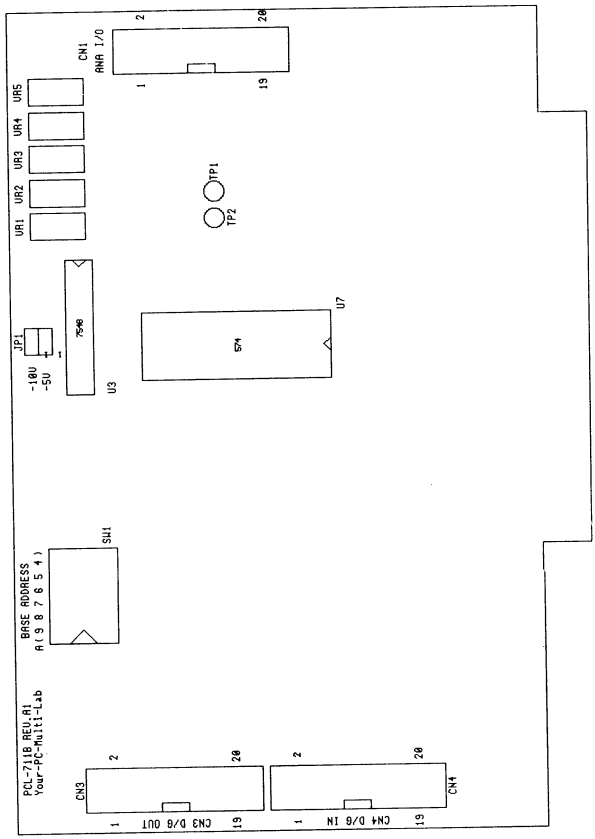


Figure A-1 VR location

A.2. D/A Calibration

The user should first choose the D/A output range to be calibrated by setting the J1 (5V or 10V). The zero offset and full scale of D/A channel can be tuned through two VRs: VR1 is for the full scale adjustment of D/A and VR2 is for the zero offset adjustment of D/A. The user should use a precision voltmeter to measure the D/A output.

Calibration steps:

1. Full scale adjustment. The D/A digital data is sent to 4095. Adjust VR1 until the reading of your voltmeter equals to VREF(reference voltage of D/A output) with opposite sign.

2. Offset adjustment. The D/A digital data is sent to 0. Adjust VR2 until the reading of your voltmeter is 0 volts.

A.3. A/D Calibration

Because the PCL-711B supports versatile A/D input ranges, accurately calibrated result for certain A/D range may still cause a small offset for the other ranges. It is suggested that you make a calibration again when you are going to use different A/D input range.

Calibration steps:

1. Short the A/D input of Channel 0 to AGND. Then, adjust the VR3 until the reading of the A/D conversion flickers between 2047 and 2048.

2. Apply a voltage with the full sacle value corresponding to the specific A/D input range to A/D Channel 0. Then,adjust the VR4 until the reading of A/D conversion flickers between 4094 and 4095.

APPENDIX B. INTEL 8253 REFERENCE

B.1. Operation Modes

B.1.1. Mode 0 Stop on Terminal Count

In Mode 0, the counter/timer's output will initially be set low. The output will remain low, and the counter will start to count after the count has been loaded into the selected count register. When the terminal count has been reached, the output will be set high, and remain high until the selected counter is reloaded with this mode or a new count has been loaded. The counter will continue to decrement after the terminal count has been reached. Rewriting data to a counter register during counting generates the following results:

1. Writing to the first byte stops the current count.
2. Writing to the second byte starts a new count.

B.1.2. Mode 1 Programmable One-Shot

When in this mode, the output will be set low on the count that follows the gate input's rising edge. The output goes high on the terminal count. If a new count value is loaded while the output is set low, then it will not affect the duration of the one-shot pulse until after the succeeding trigger. The current count can be read at any time without affecting the one-shot pulse. The one-shot is retriggerable. This allows the output to remain low for the full count after any rising edge from the gate input.

B.1.3. Mode 2 Rate Generator

When in Mode 2, the counter/timer's output will be set at low for one period of the input clock. The period from one output pulse to the next is equal to the number of input counts in the counter register. If the counter register is reloaded between output pulses, the present period will not be affected.

B.1.4. Mode 3 Square Wave Generator

This mode is similar to Mode 2, with the exception that the output remains high until one half of the count value has been completed (for even values), and then low for the other half of the count. This is accomplished by decreasing the counter by two on the falling edge of each clock pulse. When the counter reaches the terminal count, the output's state will be changed. The counter will be reloaded with the full count, repeating the entire process.

If the count value is odd, and the output high, then the first clock pulse (after the count is loaded) decrements the count by one. Subsequent clock pulses will decrement the count by two. After a timeout period, the output is set low, and the full count value is then reloaded. The clock pulse (following the reload) decrements the counter by three. Subsequent clock pulses decrement the count by two until a timeout occurs, then the whole process is repeated. In this way, if the count value is odd, the output will be set high for (N + 1)/2 counts, and low for (N - 1)/2 counts.

B.1.5. Mode 4 Software Triggered Strobe

Mode 4 sets the counter/timer's output high. When the count value is loaded. the counter begins counting. The output will be set low for one input clock period when the terminal count is reached, after which it will be set high again.

If the count register is reloaded during counting, the new count will be loaded on the next clock pulse. Also, the count will be inhibited while the gate input is low.

B.1.6. Mode 5 Hardware Triggered Strobe

When in Mode 5, the counter will start counting after the trigger input's rising edge, and will then be set low for one clock period when the terminal count is reached. The counter is retriggerable in this mode.

B.2. Counter Control Register Format

BASE+3 Counter Control Register (Write)

D7	D6	D5	D4	D3	D2	D1	D0
SC1	SC0	RW1	RW0	M2	M1	M0	BCD

Key:

SC1 & SC0 Select Counter

SC1	SC0	COUNTER
0	0	**0**
0	1	**1**
0	0	**2**
1	1	**illegal**

RW1 & RW0 Select Read/Write Operation

RW1	RW0	OPERATION
0	0	**Counter latch**
0	0	**Read/Write LSB**
0	1	**Read/Write MSB**
1	1	**Read/Write LSB first, then MSB**

M2, M1, & M0 Select Operation Mode

M2	M1	M0	MODE
0	0	0	**0 = Interrupt on terminal count**
0	0	1	**1 = Programmable one shot**
X	1	0	**2 = Rate generator**
X	1	1	**3 = Square wave rate generator**
1	0	0	**4 = Software triggered strobe**
1	0	1	**5 = Hardware triggered strobe**

BCD Select Binary or BCD Counting

BCD	PURPOSE
0	**16-bit binary counter**
1	**Binary coded decimal (BCD) counter with four decades**

The BCD is defaulted to count in binary mode. The count can be set to any value from 0 up to 65535. If you set this bit to BCD (logic 1), then the count may be set to any value from 0 up to 9999.

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