PCI2013
User's Manual

Beijing ART Technology Development Co., Ltd.

Contents

Chapter 1 Overview

In the fields of Real-time Signal Processing, Digital Image Processing and others, high-speed and high-precision data acquisition modules are demanded. ART PCI2013 data acquisition module, which brings in advantages of similar products that produced in china and other countries, is convenient for use, high cost and stable performance.

ART PCI2013 is a data acquisition module based on PCI bus. It can be directly inserted into IBM-PC/AT or a computer which is compatible with PCI2013 to constitute the laboratory, product quality testing center and systems for different areas of data acquisition, waveform analysis and processing. It may also constitute the monitoring system for industrial production process.

Unpacking Checklist

Check the shipping carton for any damage. If the shipping carton and contents are damaged, notify the local dealer or sales for a replacement. Retain the shipping carton and packing material for inspection by the dealer.
Check for the following items in the package. If there are any missing items, contact your local dealer or sales.

- PCI2013 Data Acquisition Board
- ART Disk
  a) user's manual (pdf)
  b) drive
  c) catalog
- Warranty Card

FEATURES

Analog Input

- Input Range: ±10V, ±5V, 0~10V
- 12-bit resolution
- Sampling Rate: 1S/s~100KS/s
- Analog Input Mode: 16SE/8DI
- Data Read Mode: non-empty, half-full inquiry mode and interrupt mode
- FIFO Size: 8K word
- Memory Signs: full, non-empty and half-full
- AD Mode: continuum sampling , grouping sampling
- Group Interval: software-configurable, minimum value is sampling period, maximum value is 419430uS
- Clock Source: internal clock
- Trigger Mode: software trigger, hardware trigger(external trigger)
- Trigger Type: rising edge, falling edge
- Trigger Source: ATR, DTR
- Trigger Source ATR Input Range: ±10V
- Trigger Source DTR Input Range: standard TTL level
- AD conversion time: ≤ 10us
- Analog Input Impedance: 10MΩ

- Amplifier Set-up Time: 785nS(0.001%)(max)
- Non-linear error: ±2LSB(Maximum)
- System Measurement Accuracy: 0.1%
- Operating Temperature Range: 0℃~55℃
- Storage Temperature Range: −20℃~70℃

Analog Output

- Output Range: ±10V, ±5V, 0~10V, 0~5V
- 12-bit resolution
- Set-up Time: 10μS(Max)
- Channel No.: 2-channel
- Non-linear error: ±1LSB(Maximum)
- Output Error (full-scale): ±1LSB
- Operating Temperature Range: - 0℃~+50℃
- Storage Temperature Range: - 20℃~+70℃

Digital Input

- Channel No.: 16-channel
- Electric Standard: TTL compatible
- High Voltage: ≧2V
- Low Voltage: ≦0.8V

Digital Output

- Channel No.: 16-channel
- Electrical Standard: TTL compatible
- High Voltage: ≧3.4V
- Low Voltage: ≦0.5V
- Power-on Reset

Other features

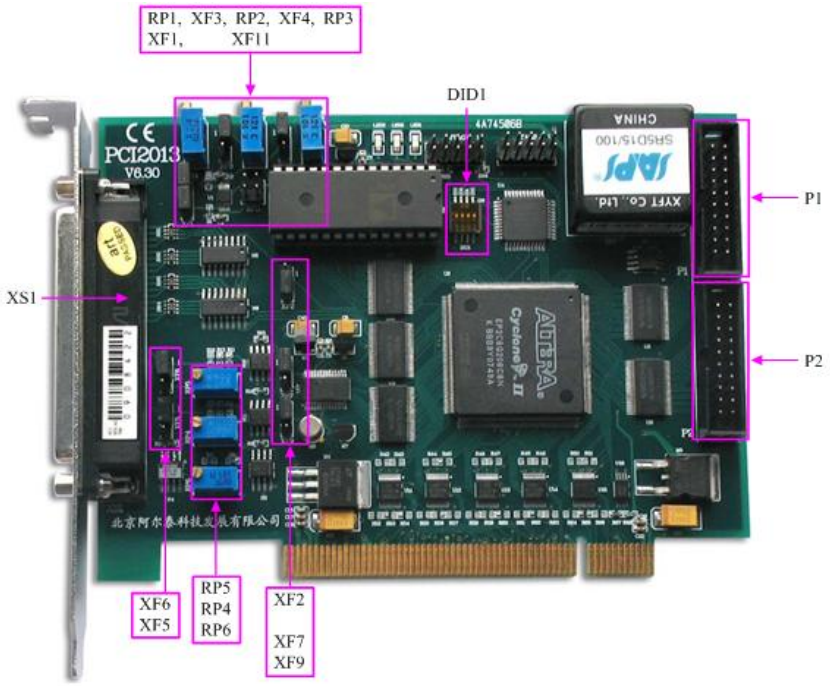
Board Clock Oscillation: 40MHz

Dimension

139mm (L) * 101.5mm (W)* 17mm (H)

Chapter 2 Components Layout Diagram and a Brief Description

2.1 The Main Component Layout Diagram



2.2 The Function Description for the Main Component

2.2.1 Signal Input and Output Connectors

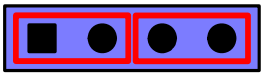
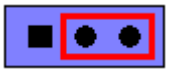
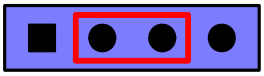
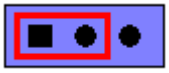
XS1: analog signal input outlet
P1: digital signal input outlet
P2: digital signal output outlet

2.2.2 Potentiometer

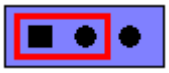
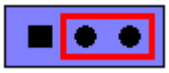
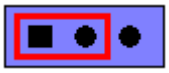
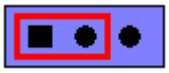
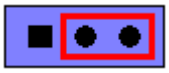
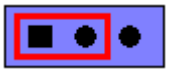
RP1: unipolar analog input zero point adjustment potentiometer
RP2: bipolar analog input zero point adjustment potentiometer
RP3: analog signal input full-scale adjustment potentiometer
RP4: AO1 analog signal output full-scale adjustment potentiometer
RP5: AO0 analog signal output full-scale adjustment potentiometer
RP6: AO analog signal output zero point adjustment potentiometer

2.2.3 Jumper

XF1, XF2: analog input single-ended, differential input selection

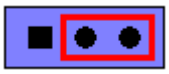
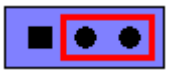
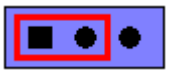
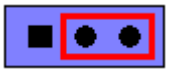
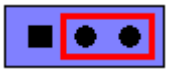
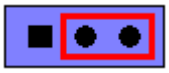
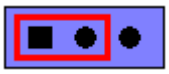
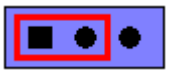
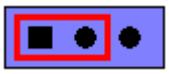
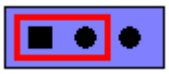
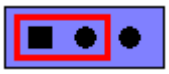
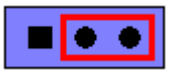
Input Mode	XF1	XF2
SE		
DI		

XF3, XF4: analog input range selection

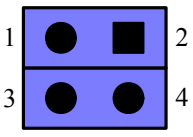
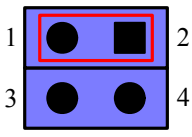
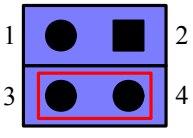
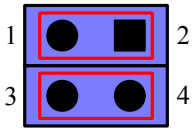
Input Range	XF3	XF4
±10V		
±5V		
0～10V		

XF7, XF9: analog output unipolar, bipolar selection

XF5, XF6: AO1~AO0 range selection

Output Range	XF7	XF9	XF6(DA0) XF5(DA1)
0～5V			
0～10V			
±5V			
±10V			

XF11: hardware gain selection

Gain	XF11	Gain	XF11
1		4	
2		8	

2.2.4 Physical ID of DIP Switch

DID1: Set physical ID number. When the PC is installed more than one PCI2013 , you can use the DIP switch to set a physical ID number for each board, which makes it very convenient for users to distinguish and visit each board in the progress of the hardware configuration and software programming. The following four-place numbers are expressed by the binary system: When DIP switch points to "ON", that means "1", and when it points to the other side, that means "0." (Test software of the company often uses the logic ID management equipments and at this moment the physical ID DIP switch is invalid. If you want to use more than one kind of the equipments in one and the same system at the same time, please use the physical ID as much as possible.).

The above chart shows"1111", so it means that the physical ID is 15.

The above chart shows"0111", so it means that the physical ID is 7.

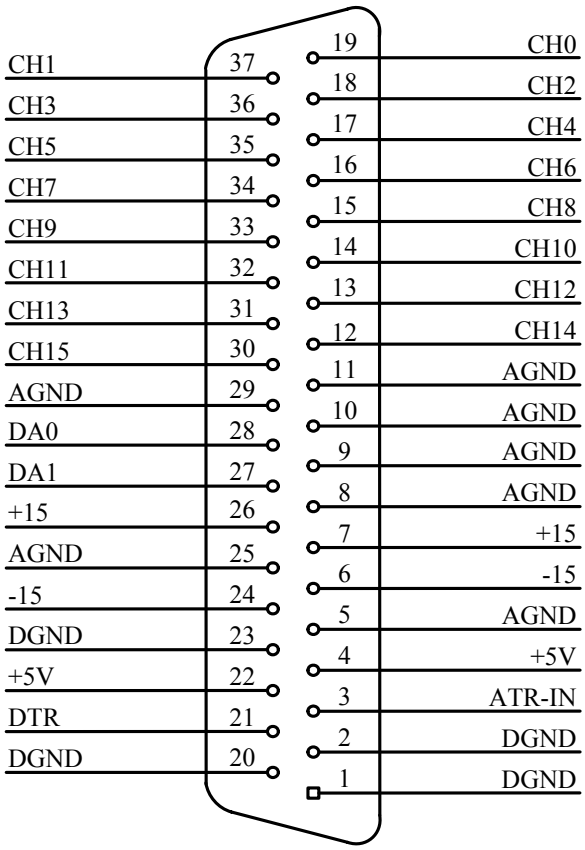
The above chart shows"0101", so it means that the physical ID is 5.

ID3	ID2	ID1	ID0	Physical ID（Hex）	Physical ID（Dec）
OFF（0）	OFF（0）	OFF（0）	OFF（0）	0	0
OFF（0）	OFF（0）	OFF（0）	ON（1）	1	1
OFF（0）	OFF（0）	ON（1）	OFF（0）	2	2
OFF（0）	OFF（0）	ON（1）	ON（1）	3	3
OFF（0）	ON（1）	OFF（0）	OFF（0）	4	4
OFF（0）	ON（1）	OFF（0）	ON（1）	5	5
OFF（0）	ON（1）	ON（1）	OFF（0）	6	6
OFF（0）	ON（1）	ON（1）	ON（1）	7	7
ON（1）	OFF（0）	OFF（0）	OFF（0）	8	8
ON（1）	OFF（0）	OFF（0）	ON（1）	9	9
ON（1）	OFF（0）	ON（1）	OFF（0）	A	10
ON（1）	OFF（0）	ON（1）	ON（1）	B	11
ON（1）	ON（1）	OFF（0）	OFF（0）	C	12
ON（1）	ON（1）	OFF（0）	ON（1）	D	13
ON（1）	ON（1）	ON（1）	OFF（0）	E	14
ON（1）	ON（1）	ON（1）	ON（1）	F	15

Chapter 3 Signal Connectors

3.1 The Definition of Analog Signal Connector

37 core plug on the XS1 pin definition

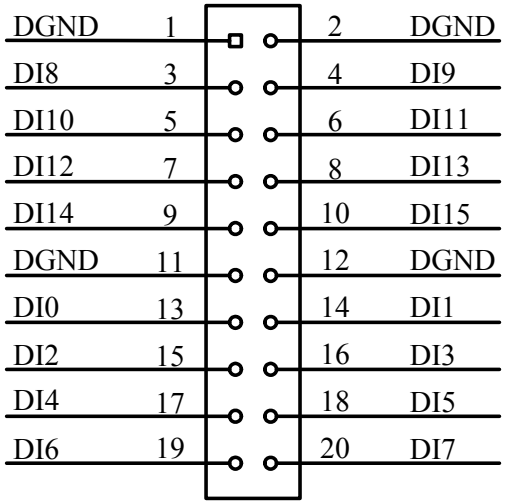


Pin definition

Signal Name	Type	Definition
CH0～CH15	Input	Analog signal input pins, the reference ground is AGND.
AO0~AO1	Output	Analog signal output pins, the reference ground is AGND.
AGND	GND	Analog signal ground.
DGND	GND	Digital signal ground.
ATR-IN	Input	Analog trigger signal input, AGND for reference ground
DTR	Input	Digital trigger signal input, DGND for reference ground
+5V	Output	Output 5V power supply
+15	Input	+15V power input
-15	Input	-15V power input

3.2 The Definition of Digital Input Connector

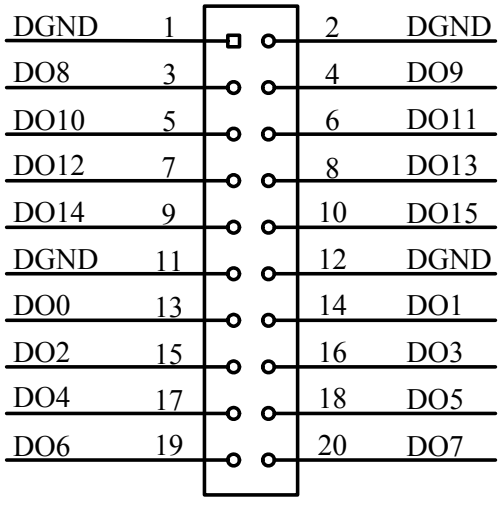
P1:



Signal Name	Type	Definition
DI0-DI15	Input	Digital input
DGND	GND	Digital ground

3.3 The Definition of Digital Input Connector

P2:



Signal Name	Type	Definition
DO0-DO15	Output	Digital output
DGND	GND	Digital ground

Chapter 4 Connection Ways for Each Signal

4.1 Analog signal single-ended input mode

Single-ended mode can achieve a signal input by one channel, and several signals use the common reference ground. This mode is widely applied in occasions of the small interference and relatively many channels.

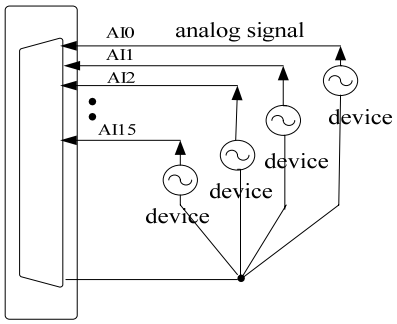


Figure 4.1 single-ended input connection

4.2 Analog signal differential-ended input mode

Double-ended input mode, which was also called differential input mode, uses positive and negative channels to input a signal. This mode is mostly used when biggish interference happens and the channel numbers are few. Single-ended/double-ended mode can be set by the software, please refer to PCI2013 software manual.

According to the diagram below, PCI2013 board can be connected as analog voltage double-ended input mode, which can effectively suppress common-mode interference signal to improve the accuracy of acquisition. Positive side of the 8-channel analog input signal is connected to AI0~AI7, the negative side of the analog input signal is connected to AI8~AI15, equipments in industrial sites share the AGND with PCI2013 board.

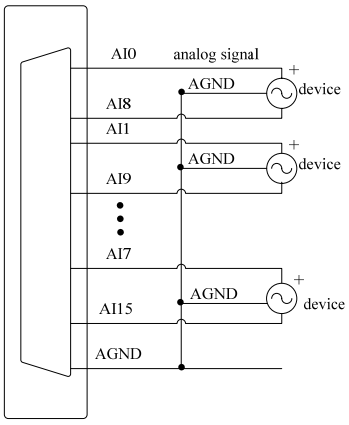


Figure 4.2 Differential-ended input mode

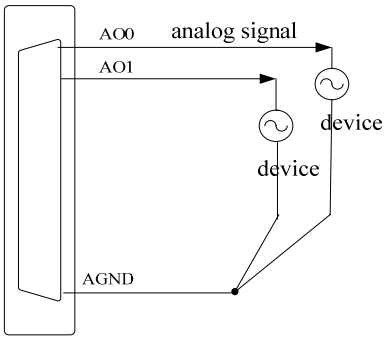


Figure 4.3 analog signal output connection

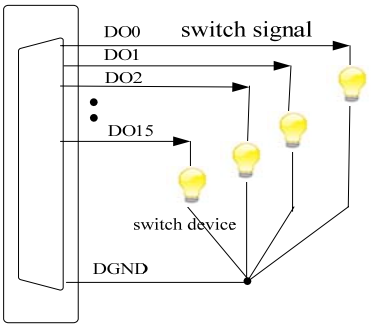


Figure 4.5 digital signal output connection

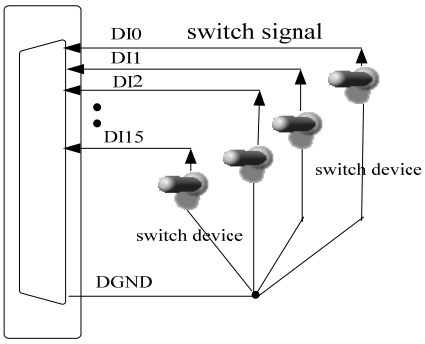


Figure 4.4 digital signal input connection

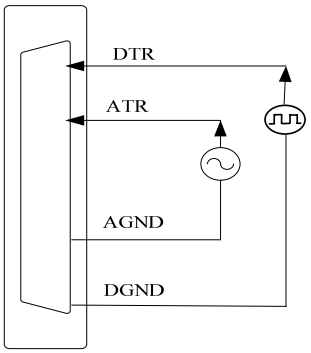
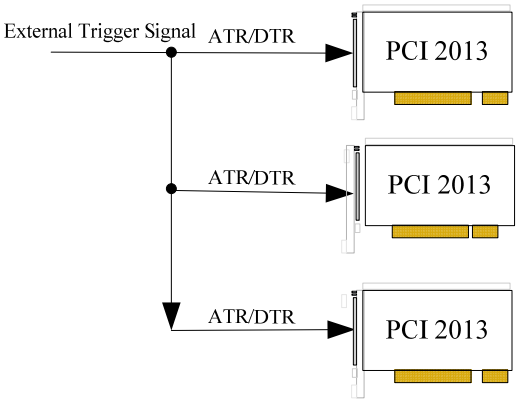


Figure 4.6 Trigger Signal Connection

4.3 Methods of Realizing the Multi-card Synchronization

Common external trigger can realize the synchronization for the PCI2013, the first method is using the cascade master-slave card, the second one is using the common external trigger

When using the common external trigger, please make sure all parameters of different PCI2013 are the same. At first, configure hardware parameters, and use analog or digital signal triggering (ATR or DTR), then connect the signal that will be sampled by PCI2013, input triggering signal from ART pin or DTR pin, then click “Start” button, at this time, PCI2013 does not sample any signal but waits for external trigger signal. When each module is waiting for external trigger signal, use the common external trigger signal to startup modules, at last, we can realize synchronization data acquisition in this way. See the following figure:



Chapter 5 The Instruction of the Trigger Function

5.1 Internal Trigger Mode

When A/D is in the initialization, if the A/D hardware parameter ADPara.TriggerMode = PCI2013_TRIGMODE_SOFT, we can achieve the internal trigger acquisition. In this function, when calling the StartDeviceProAD function, it will generate A/D start pulse, A/D immediately access to the conversion process and not wait for the conditions of any other external hardware. It also can be interpreted as the software trigger.

As for the specific process, please see the figure below, the cycle of the A/D work pulse is decided by the sampling frequency.

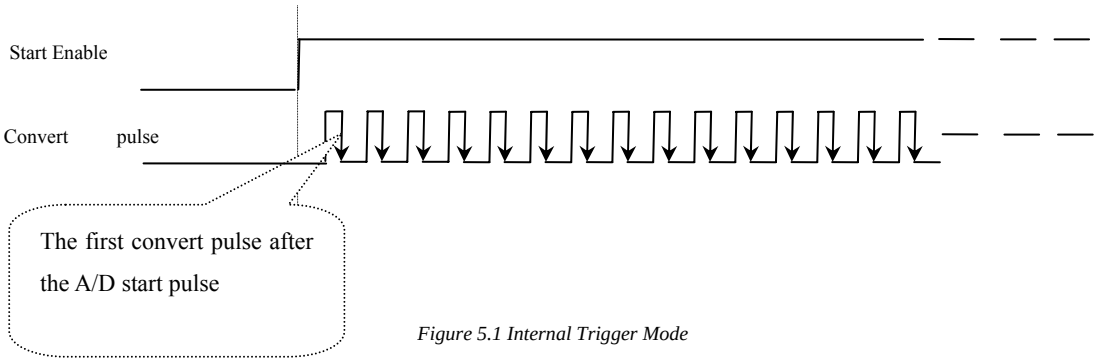


Figure 5.1 Internal Trigger Mode

5.2 External Trigger Mode

When A/D is in the initialization, if the A/D hardware parameter ADPara.TriggerMode = PCI2013_TRIGMODE_POST, we can achieve the external trigger acquisition. In this function, when calling the StartDeviceProAD function, A/D will not immediately access to the conversion process but wait for the external trigger source signals accord with the condition, then start converting the data. It also can be interpreted as the hardware trigger. Trigger source includes the DTR (Digital Trigger Source) and ATR (Analog Trigger Source)

When the trigger signal is the digital signal (standard TTL-level), using the DTR trigger source. When the trigger signal is the analog signal, using the ATR trigger source (Trigger level needs to be set when using the ATR trigger source).

Edge trigger is to capture the characteristics of the changes between the trigger source signal and the trigger level signal to trigger A/D conversion.

(1) DTR Trigger

When ADPara. OutTriggerEdge= PCI2013_FALLING_EDGE, choose the trigger mode as the falling edge trigger. That is, when the DTR trigger signal is on the falling edge, A/D will immediately access to the conversion process, and its follow-up changes have no effect on A/D acquisition.

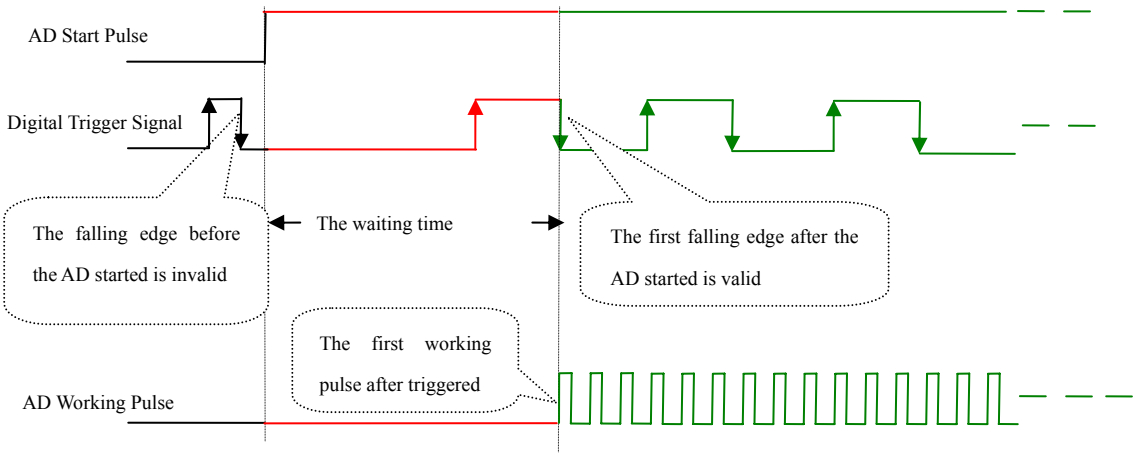


Figure 5.2.1 Falling edge trigger when trigger source is DTR

When ADPara. OutTriggerEdge = PCI2013_RISING_EDGEE, choose the trigger mode as rising edge trigger. That is, when the DTR trigger signal is on the rising edge, A/D will immediately access to the conversion process, and its follow-up changes have no effect on A/D acquisition.

(2) ATR-IN Trigger

When ADPara. OutTriggerEdge= PCI2013_FALLING_EDGE, it means falling edge trigger. When ATR-IN trigger signal is from greater than trigger level to smaller than trigger level, A/D is in the conversion process, in this case, the follow-up state disable.

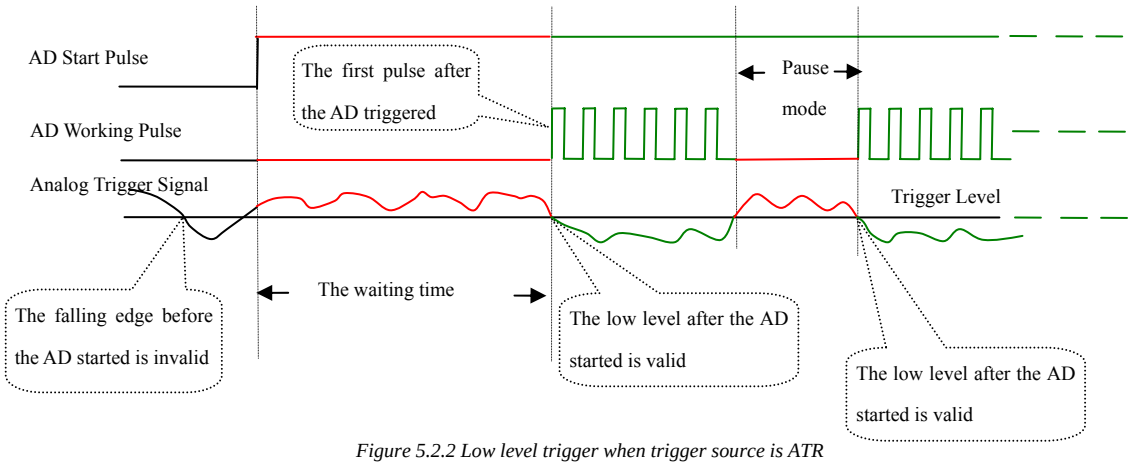


Figure 5.2.2 Low level trigger when trigger source is ATR

When ADPara. OutTriggerEdge = PCI2013_RISING_EDGE, it means rising edge trigger. When ATR-IN trigger signal is from smaller than trigger level to greater than trigger level, A/D is in the conversion process, in this case, the follow-up state disable.

Chapter 6 Methods of Using Internal and External Clock Function

6.1 Internal Clock Function

Internal Clock Function refers to the use of on-board clock oscillator and the clock signals which are produced by the user-specified frequency to trigger the A/D conversion regularly. To use the clock function, the hardware parameters ADPara.ClockSource = PCI2013 _CLOCKSRC_IN should be installed in the software. The frequency of the clock in the software depends on the hardware parameters ADPara.Frequency. For example, if Frequency = 100000, that means A/D work frequency is 100000Hz (that is, 100 KHz, 10μs /point).

6.3 Methods of Using Continuum and Grouping Sampling Function

6.3.1 Continuum Sampling Function

The continuous acquisition function means the sampling periods for every two data points are completely equal in the sampling process of A/D, that is, completely uniform speed acquisition, without any pause, so we call that continuous acquisition.

To use the continuous acquisition function, the hardware parameters ADPara.ADMode = PCI2013 _ADMODE_SEQUENCE should be installed in the software. For example, in the internal clock mode, hardware parameters ADPara.Frequency = 100000 (100KHz) should be installed, and 10 microseconds after the AD converts the first data point, the second data point conversion starts, and then 10 microseconds later the third data point begins to convert, and so on.

6.3.2 Grouping Sampling Function

Grouping acquisition (pseudo-synchronous acquisition) function refers to the sampling clock frequency conversion among the channels of the group in the AD sampling process, and also a certain waiting time exists between every two groups, this period of time is known as the Group Interval. Loops of group refer to numbers of the cycle acquisition for each channel in the same group. In the internal clock mode and the fixed-frequency external clock mode, the time between the groups is known as group cycle. The conversion process of this acquisition mode as follows: a short time stop after the channels conversion in the group (that is, Group Interval), and then converting the next group, followed by repeated operations in order, so we call it grouping acquisition.

The purpose of the application of the grouping acquisition is that: at a relatively slow frequency, to ensure that all of the time difference between channels to become smaller in order to make the phase difference become smaller, thus to ensure the synchronization of the channels, so we also say it is the pseudo-synchronous acquisition function. In a group, the higher the sampling frequency is, the longer Group Interval is, and the better the relative synchronization signal is. The sampling frequency in a group depends on ADPara. Frequency, Loops of group depends on ADPara.LoopsOfGroup, the Group Interval depend on ADPara. Group Interval.

Based on the grouping function, it can be divided into the internal clock mode and the external clock mode. Under the internal clock mode, the group cycle is decided by the internal clock sampling period, the total number of sampling channels, Loops of group and Group Interval together. In each cycle of a group, AD only collects a set of data. Under the external clock mode, external clock cycle ≥ internal clock sampling cycle × the total number of sampling channels × Loops of group + AD chip conversion time, AD data acquisition is controlled and triggered by external clock. The external clock mode is divided into fixed frequency external clock mode and unfixed frequency external clock mode. Under the fixed frequency external clock mode, the group cycle is the sampling period of the external clock.

The formula for calculating the external signal frequency is as follows:

Under the internal clock mode:
Group Cycle = the internal clock sampling period × the total number of sample channels × Loops of group + AD chips conversion time + Group Interval
External signal cycle = (cycle signal points / Loops of group) × Group Cycle
External signal frequency = 1 / external signal cycle

Under the external clock mode: (a fixed-frequency external clock)
Group Cycle = external clock cycle
External signal cycle = (cycle signal points / Loops of group) × Group Cycle
External signal frequency = 1 / external signal cycle

Formula Notes:
The internal sampling clock cycle = 1 / (AD Para. Frequency)
The total number of sampling channels = AD Para. Last Channel – AD Para. First Channel + 1
Loops of group == ADPara.LoopsOfGroup
AD Chips conversion time = see "AD Analog Input Function" parameter
Group Interval = AD Para. Group Interval
Signal Cycle Points = with the display of the waveform signal in test procedures, we can use the mouse to measure the signal cycle points.

Under the internal clock mode, for example, sample two-channel 0, 1, and then 0 and 1 become a group. Sampling frequency (Frequency) = 100000Hz (cycle is 10μs), Loops of group is 1, Group Interval = 50μs, then the acquisition process is to collect a set of data first, including a data of channel 0 and a data of channel 1. We need 10uS to sample the two data, 20μs to convert the data from the two channels. After the conversion time of an AD chip, AD will automatically cut-off to enter into the waiting state until the 50μs group interval ends. We start the next group, begin to convert the data of channel 0 and 1, and then enter into the waiting state again, and the conversion is going on in this way, as the diagram following shows:

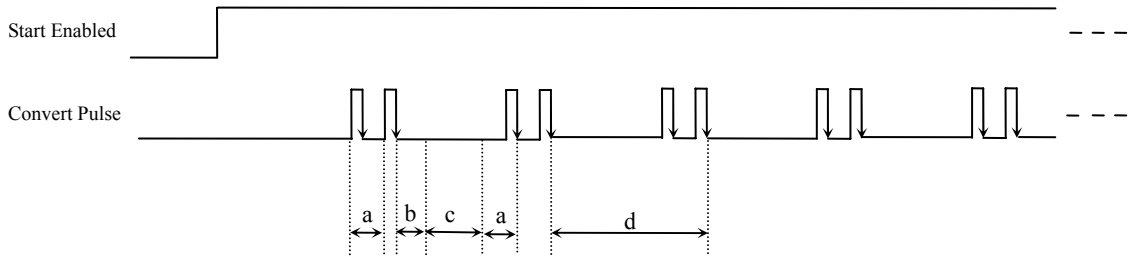


Figure 6.1 Grouping Sampling which grouping cycle No is 1 under the Internal Clock Mode

Note: a— internal clock sample cycle
b— AD chips conversion time
c—Group Interval
d— group cycle

Change the loops of group into 2, then the acquisition process is to collect the first set of data, including two data of channel 0 and two data of channel 1, the conversion order is 0,1,0,1. We need 10μs to sample each of the four data. After the conversion time of an AD chip, AD will automatically stop to enter into the waiting state until the 50μs Group Interval ends. We start the next group, begin to convert the data of channel 0 and 1, and then enter into the waiting state again, and the conversion is going on in this way, as the diagram following shows:

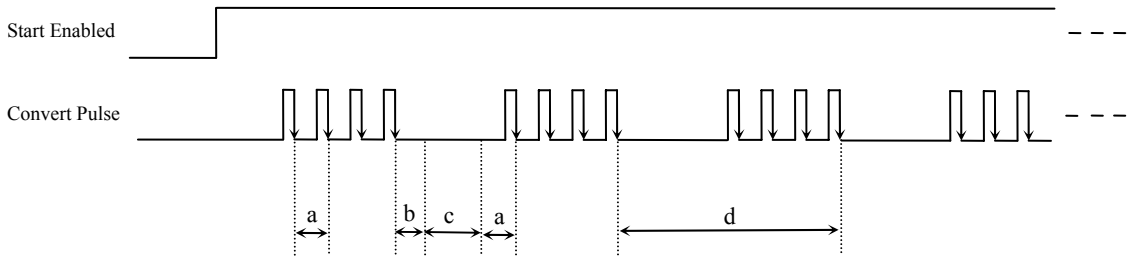


Figure 6.2 Grouping Sampling which grouping cycle No is 2 under the Internal Clock Mode

Notes: a— internal clock sample cycle
b— AD chips conversion time
c—Group Interval
d— group cycle

Under the external clock mode, the requirement is: the external clock cycle ≥ the internal clock sampling period × the total number of sampling channels× Loops of group + AD chip conversion time, otherwise, the external clock appearing in the group conversion time will be ignored.

Under the fixed-frequency external clock mode, for example, when sampling data of two-channel 0, 1, then channel 0 and channel 1 consist of a group. Sampling frequency (Frequency) = 100000Hz (the cycle is 10μs), Loops of group is 2, then the acquisition process is to collect the first set of data, including two data of channel 0 and two data of channel 1, the order of conversion 0,1,0,1, We need 10μs to sample the four data and 40μs to convert of the four data. After the conversion time of an AD chip, AD will automatically stop to enter into the waiting state until the next edge of the

external clock triggers AD to do the next acquisition, and the conversion is going on in this way, as the diagram following shows:

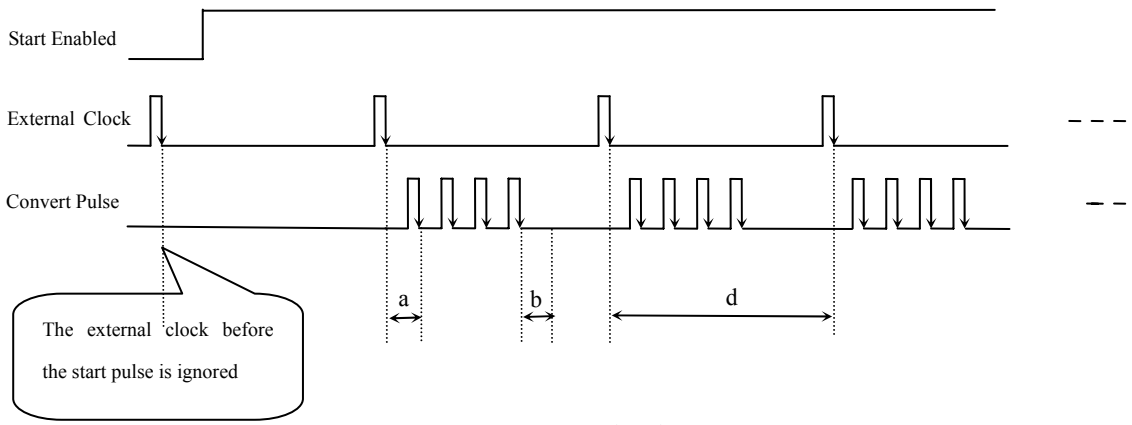


Figure 6.3 Grouping sampling under the fixed frequency external clock mode

Notes: a— internal clock sample cycle
b—AD chips conversion time
d—group cycle（external clock cycle）

Under an unfixed-frequency external clock mode, for example, the grouping sampling principle is the same as that of the fixed-frequency external clock mode. Under this mode, users can control any channel and any number of data. Users will connect the control signals with the clock input of the card (CLKIN), set the sampling channels and Loops of group. When there are external clock signals, it will sample the data which is set by users. Because the external clock frequency is not fixed, the size of external clock cycle is inconsistent but to meet: the external clock cycle ≥ the internal clock sampling period × the total number of sampling channels × Loops of group + AD chip conversion time, , otherwise, the external clock edge appearing in the group conversion time will be ignored.

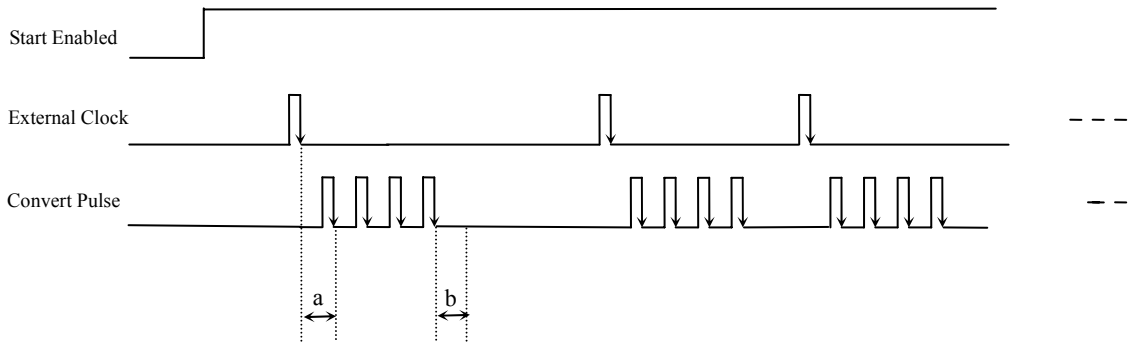


Figure 6.4 Grouping sampling under the not fixed frequency external clock mode

Note: a— internal clock sample cycle
b—AD chips conversion time

Chapter 7 Notes, Calibration and Warranty Policy

7.1 Notes

In our products' packing, user can find a user manual, a PCI2013 module and a quality guarantee card. Users must keep quality guarantee card carefully, if the products have some problems and need repairing, please send products together with quality guarantee card to ART, we will provide good after-sale service and solve the problem as quickly as we can.

When using PCI2013, in order to prevent the IC (chip) from electrostatic harm, please do not touch IC (chip) in the front panel of PCI2013 module.

7.2 Analog Signal Input Calibration

Every device has to be calibrated before sending from the factory. It is necessary to calibrate the module again if users want to after using for a period of time or changing the input range. PCI2013 default input range: ±5V, in the manual, we introduce how to calibrate PCI2013 in ±5V, calibrations of other input ranges are similar.

Prepare a digital voltage instrument which the resolution is more than 5.5 bit, install the PCI2013 module, and then power on, warm-up for fifteen minutes.

1) Zero adjustment: select one channel of analog inputs, take the channel CH0 for example, connect 0V to AI0, and then run ART Data Acquisition Measurement Suite in the WINDOWS. Choose channel 0, ±5V input range and start sampling, adjust potentiometer RP2 in order to make voltage value is 0.000V or about 0.000V. Zero adjustment of other channels is alike.
2) Full-scale adjustment: select one channel of analog inputs, take the channel CH0 for example, connect 4997.55mV to CH0, and then run ART Data Acquisition Measurement Suite in the WINDOWS. Choose channel 0, ±5V input range and start sampling, adjust potentiometer RP3 in order to make voltage value is 4997.55mV or about 4997.55mV. Full-scale adjustment of other channels is alike.
3) Repeat steps above until meet the requirement.

7.3 Analog Signal Output Calibration

In the manual, we introduce how to calibrate PCI2013 in ±10V input range; calibrations of other input ranges are similar.

1) Connect the ground of the digital voltage meter to any analog AGND of the 37 core D-type plug. Connect the input side of the voltage meter to the output channel which needs calibration. Run PCI2013 test procedure under Windows, select the AO output detection.
2) To set AO output is 2048， adjust potentiometer RP6 in order to make AO~AO1 output 0.000V.
3) To set AO output is 4095, adjust potentiometer RP4, RP5 in order to make AO0~AO1 output voltage value is 9995.11mV
4) Repeat steps above until meet the requirement.

7.4 Warranty Policy

Thank you for choosing ART. To understand your rights and enjoy all the after-sales services we offer, please read the following carefully.

1. Before using ART's products please read the user manual and follow the instructions exactly. When sending in damaged products for repair, please attach an RMA application form which can be downloaded from: www.art-control.com.
2. All ART products come with a limited two-year warranty:
   - The warranty period starts on the day the product is shipped from ART's factory
   - For products containing storage devices (hard drives, flash cards, etc.), please back up your data before sending them for repair. ART is not responsible for any loss of data.
   - Please ensure the use of properly licensed software with our systems. ART does not condone the use of pirated software and will not service systems using such software. ART will not be held legally responsible for products shipped with unlicensed software installed by the user.
3. Our repair service is not covered by ART's guarantee in the following situations:
   - Damage caused by not following instructions in the User's Manual.
   - Damage caused by carelessness on the user's part during product transportation.
   - Damage caused by unsuitable storage environments (i.e. high temperatures, high humidity, or volatile chemicals).
   - Damage from improper repair by unauthorized ART technicians.
   - Products with altered and/or damaged serial numbers are not entitled to our service.
4. Customers are responsible for shipping costs to transport damaged products to our company or sales office.
5. To ensure the speed and quality of product repair, please download an RMA application form from our company website.

Products Rapid Installation and Self-check

Rapid Installation

Product-driven procedure is the operating system adaptive installation mode. After inserting the disc, you can select the appropriate board type on the pop-up interface, click the button【driver installation】; or select CD-ROM drive in Resource Explorer, locate the product catalog and enter into the APP folder, and implement Setup.exe file. After the installation, pop-up CD-ROM, shut off your computer, insert the PCI card. If it is a USB product, it can be directly inserted into the device. When the system prompts that it finds a new hardware, you do not specify a drive path, the operating system can automatically look up it from the system directory, and then you can complete the installation.

Self-check

At this moment, there should be installation information of the installed device in the Device Manager (when the device does not work, you can check this item.). Open "Start -> Programs -> ART Demonstration Monitoring and Control System -> Corresponding Board -> Advanced Testing Presentation System", the program is a standard testing procedure. Based on the specification of Pin definition, connect the signal acquisition data and test whether AD is normal or not. Connect the input pins to the corresponding output pins and use the testing procedure to test whether the switch is normal or not.

Delete Wrong Installation

When you select the wrong drive, or viruses lead to driver error, you can carry out the following operations: In Resource Explorer, open CD-ROM drive, run Others-> SUPPORT-> PCI.bat procedures, and delete the hardware information that relevant to our boards, and then carry out the process of section I all over again, we can complete the new installation.