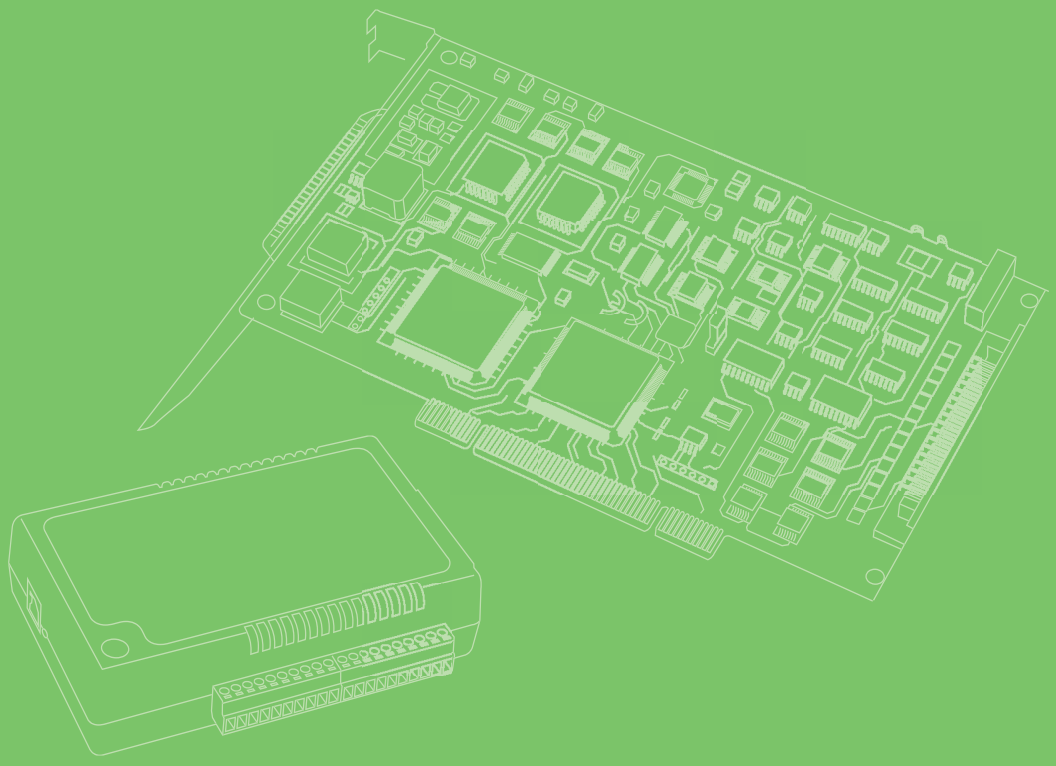

User Manual

PCIE-1203

EtherCAT Master PCI Express Card

ADVANTECH

Enabling an Intelligent Planet

Copyright

Acknowledgements

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All other product names or trademarks are properties of their respective owners.

Product Warranty (2 years)

Advantech warrants the original purchaser that each of its products will be free from defects in materials and workmanship for two years from the date of purchase.

This warranty does not apply to any products that have been repaired or altered by persons other than repair personnel authorized by Advantech, or products that have been subject to misuse, abuse, accident, or improper installation. Advantech assumes no liability under the terms of this warranty as a consequence of such events.

Because of Advantech's high quality-control standards and rigorous testing, most customers never need to use our repair service. If an Advantech product is defective, it will be repaired or replaced free of charge during the warranty period. For out-of-warranty repairs, customers will be billed according to the cost of replacement materials, service time, and freight. Please consult your dealer for more details.

If you believe your product to be defective, follow the steps outlined below.

1. Collect all the information about the problem encountered. (For example, CPU speed, Advantech products used, other hardware and software used, etc.) Note anything abnormal and list any onscreen messages displayed when the problem occurs.
2. Call your dealer and describe the problem. Please have your manual, product, and any helpful information readily available.
3. If your product is diagnosed as defective, obtain a return merchandise authorization (RMA) number from your dealer. This allows us to process your return more quickly.
4. Carefully pack the defective product, a completed Repair and Replacement Order Card, and a proof of purchase date (such as a photocopy of your sales receipt) into a shippable container. Products returned without a proof of purchase date are not eligible for warranty service.
5. Write the RMA number clearly on the outside of the package and ship the package prepaid to your dealer.

Part No. 2003120350 Edition 1

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Declaration of Conformity

CE

This product has passed the CE test for environmental specifications when shielded cables are used for external wiring. We recommend the use of shielded cables. This kind of cable is available from Advantech. Please contact your local supplier for ordering information.

FCC Class A

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FM

This equipment has passed the FM certification. According to the National Fire Protection Association, work sites are classified into different classes, divisions and groups, based on hazard considerations. This equipment is compliant with the specifications of Class I, Division 2, Groups A, B, C and D indoor hazards.

Technical Support and Assistance

1. Visit the Advantech website at www.advantech.com/support to obtain the latest product information.
2. Contact your distributor, sales representative, or Advantechcenter for technical support if you need additional assistance. Please have the following information ready before calling:
   - Product name and serial number
   - Description of your peripheral attachments
   - Description of your software (operating system, version, application software, etc.)
   - A complete description of the problem
   - The exact wording of any error messages

Safety Precaution - Static Electricity

Follow these simple precautions to protect yourself from harm and the products from damage.

- To avoid electrical shock, always disconnect the power from your PC chassis before you work on it. Don't touch any components on the CPU card or other cards while the PC is on.

Disconnect power before making any configuration changes. The sudden rush of power as you connect a jumper or install a card may damage sensitive electronic components.

Safety Instructions

1. Read these safety instructions carefully.
2. Retain this user manual for future reference.
3. Disconnect the equipment from all power outlets before cleaning. Use only a damp cloth for cleaning. Do not use liquid or spray detergents.
4. For pluggable equipment, the power outlet socket must be located near the equipment and easily accessible.
5. Protect the equipment from humidity.
6. Place the equipment on a reliable surface during installation. Dropping or letting the equipment fall may cause damage.
7. The openings on the enclosure are for air convection. Protect the equipment from overheating. Do not cover the openings.
8. Ensure that the voltage of the power source is correct before connecting the equipment to a power outlet.
9. Position the power cord away from high-traffic areas. Do not place anything over the power cord.
10. All cautions and warnings on the equipment should be noted.
11. If the equipment is not used for a long time, disconnect it from the power source to avoid damage from transient over voltage.
12. Never pour liquid into an opening. This may cause fire or electrical shock.
13. Never open the equipment. For safety reasons, the equipment should be opened only by qualified service personnel.
14. If any of the following occurs, have the equipment checked by service personnel:

- The power cord or plug is damaged.
- Liquid has penetrated the equipment.
- The equipment has been exposed to moisture.
- The equipment is malfunctioning, or does not operate according to the user manual.
- The equipment has been dropped and damaged.

15. The equipment shows obvious signs of breakage.
16. DO NOT LEAVE THIS EQUIPMENT IN AN ENVIRONMENT WHERE THE STORAGE TEMPERATURE MAY GO BELOW -20° C (-4° F) OR ABOVE 60° C (140° F). THIS COULD DAMAGE THE EQUIPMENT. THE EQUIPMENT SHOULD BE IN A CONTROLLED ENVIRONMENT.
17. CAUTION: DANGER OF EXPLOSION IF BATTERY IS INCORRECTLY REPLACED. REPLACE ONLY WITH THE SAME OR EQUIVALENT TYPE RECOMMENDED BY THE MANUFACTURER, DISCARD USED BATTERIES ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS.
18. The sound pressure level at the operator's position according to IEC 704-1:1982 is no more than 70 dB (A).

DISCLAIMER: These instructions are provided according to IEC 704-1 standards. Advantech disclaims all responsibility for the accuracy of any statements contained herein.

Contents

Chapter 1

Introduction

1.1 EtherCAT Introduction

EtherCAT (Ethernet Control Automation Technology) is a high-performance, Ethernet-based fieldbus industrial network system. The protocol is standardized in IEC 61158 and applies to automation applications that need faster and more efficient communications. Short data update times with precise synchronization make EtherCAT suitable for real-time requirements in automation technology.

1.1.1 EtherCAT

1.1.1.1 Functional Principle

EtherCAT is a real time, high speed and flexible Ethernet based protocol. In EtherCAT network, the master sends Ethernet frames through all of the slave nodes. Standard Ethernet packets or frames are no longer received, interpreted, and copied as process data at every node. Instead, slave devices read the data addressed to them and the input data are inserted at the same time while the telegram passes through the device, processing data “on the fly”. Typically the entire network can be addressed with just one frame.In comparison to other Ethernet based communication solutions EtherCAT utilizes the available full duplex bandwidth efficiently.

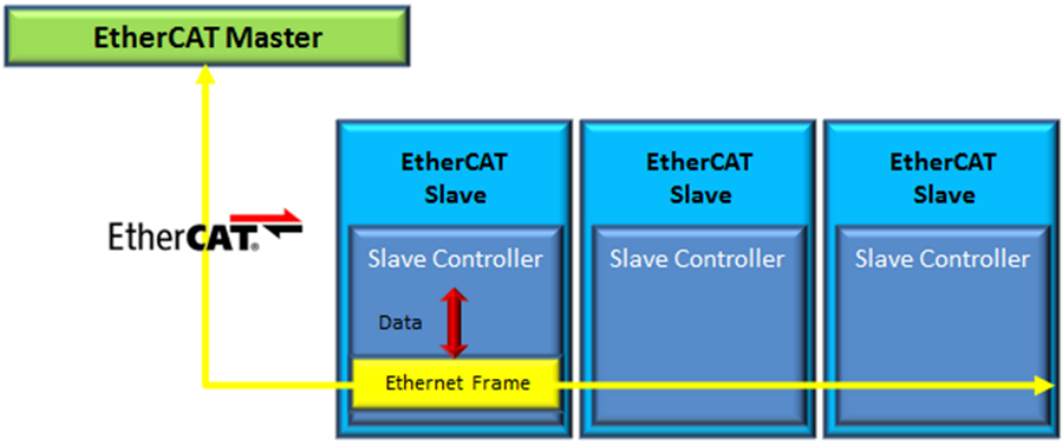


Figure 1.1 EtherCAT Function Principle

1.1.1.2 Protocol

Data exchange are cyclically updated between EtherCAT master and slaves. Data in EtherCAT frames are transported directly within the standard IEEE 802.3 Ethernet frame using Ethertype 0x88a4 and are processed by the EtherCAT Slave Controller on the fly. Each EtherCAT datagram is a command that consists of a header, data and a working counter. The datagram header indicates what type of access the master device would like to execute:

- Read, write, read-write
- Access to a specified slave device through direct addressing
- Access to multiple slave devices through logical addressing

Logical addressing is used for the cyclical exchange of process data. The header and data are used to specify the operation that the slave must perform, and the working counter is updated by the slave to let the master to know that a slave has processed the command.

Every EtherCAT datagram ends with a 16 Bit Working Counter (WKC). The Working Counter counts the number of devices that were successfully addressed by this EtherCAT datagram.

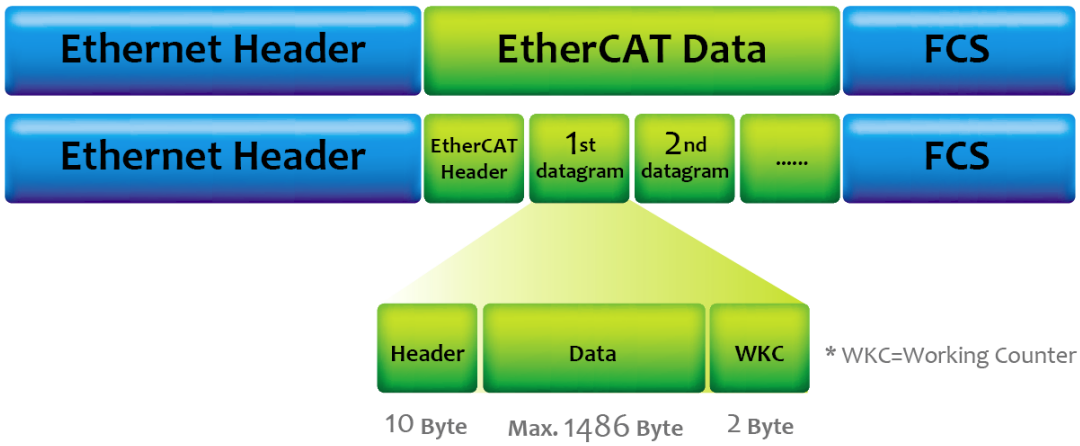


Figure 1.2 EtherCAT Protocol

EtherCAT datagrams are processed before receiving the complete frame.

In case data is invalid, the frame check sum (FCS) is not valid and the slave will not set data valid for the local application.

1.1.1.3 Topology

EtherCAT supports a variety of network topologies, including line, tree, ring and star. The line and tree topologies are more conducive to fieldbus applications because they require fewer connections and utilize a much simpler and more flexible cabling schema that switches and hubs are not necessary for lines or trees topology.

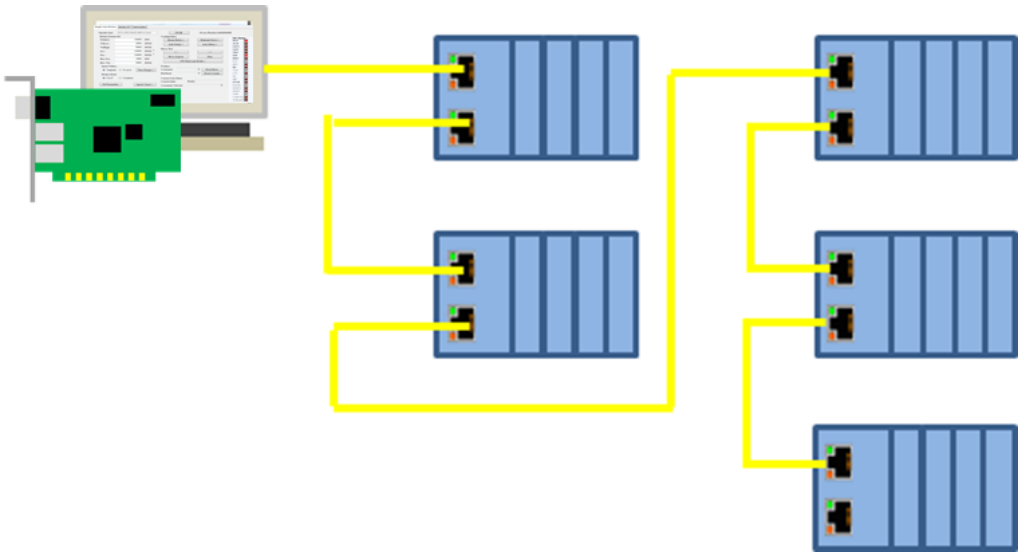


Figure 1.3 EtherCAT Topology

Inexpensive industrial Ethernet cables up to 100m apart, can be used between two nodes in 100BASE-TX mode. EtherCAT makes a pure bus or line topology with hundreds of nodes possible without limitations. Up to 65,535 devices can be connected to EtherCAT, so network expansion is almost unlimited.

EtherCAT supports individual nodes to be connected and disconnected during operation. If one of the slaves in the network is removed, the rest of the network can continue to operate normally. Additionally, EtherCAT also enables other communication features such as cable redundancy or even master redundancy with Hot Standby.

1.1.1.4 Synchronization

A Distributed Clock (DC) mechanism is used to provide highly precise time synchronization between slaves in an EtherCAT network, which is equivalent to the IEEE 1588 Precision Time Protocol standard. By using distributed clocks, EtherCAT is able to synchronize the time in all local bus devices within a very narrow tolerance range. All EtherCAT slaves are provided with an internal clock which named as System Time ($t_{Local\ Time}$). One EtherCAT Slave, usually the first slave, will be used as a Reference Clock and cyclically distributes its Clock.

Possible misalignments between the reference clock and the clocks of the other slaves are usually due to the following reason: when a slave is switched on, the internal free-running register that holds the current time is reset to zero. Unfortunately, this action does not take place exactly at the same time in all the different slaves, and this result in an initial offset (t_{offset}) among clocks that has to be compensated.

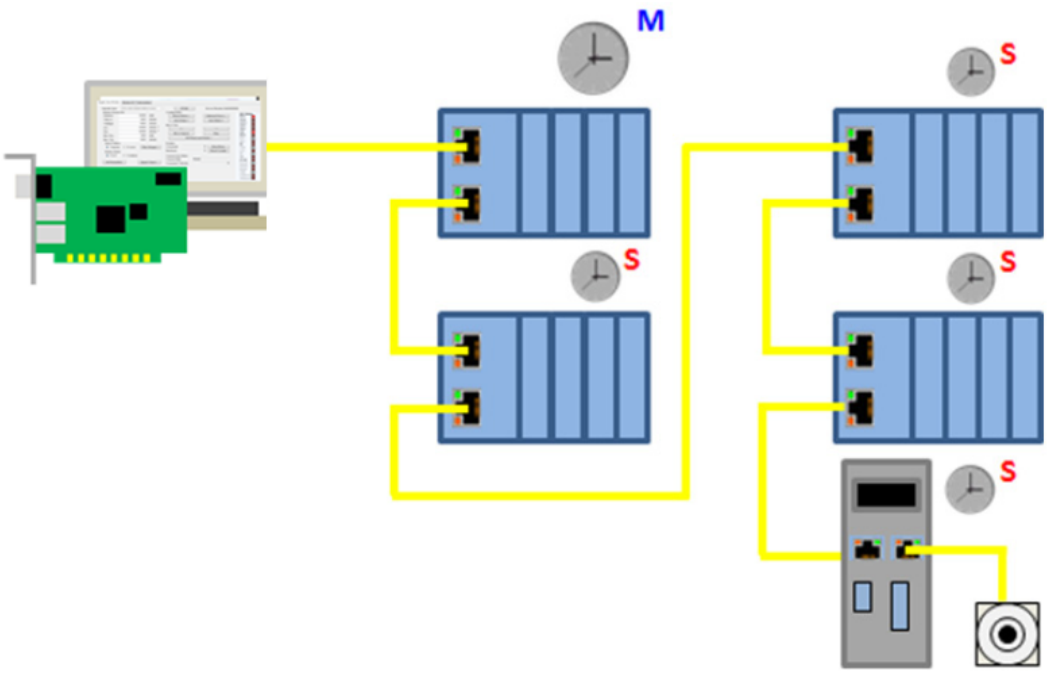


Figure 1.4 EtherCAT Distributed Clock

Typically, the master sends a broadcast to all other slaves in the system. Once receiving the message, slaves will latch the value of their internal clock. There are two latch values, one is receiving and the other is returning back. Thus, the master can read all latched values and calculate the delay for each slave ($t_{Propagation\ Delay}$). Delays will be stored into offset register. In the following, master will send a message periodically to all other slaves in EtherCAT network to make the first slave the reference clock and forcing all other slaves to set their internal clock by the calculated offset.

$$\Delta t = (t_{Local\ Time} + t_{Offset} - t_{Propagation\ Delay}) - t_{Received\ System\ Time}$$

Because synchronization between slaves in DC mode is done by internal clocks in hardware, EtherCAT guarantee the time jitter is less than 1us.

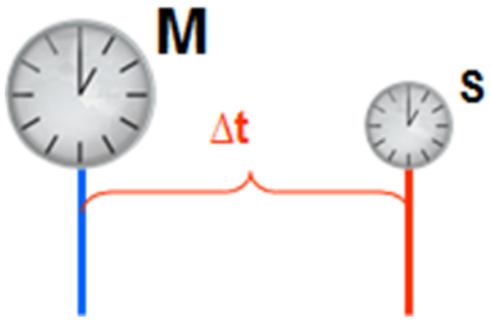


Figure 1.5 EtherCAT Distributed Clock Jitter

1.1.1.5 Diagnosis with exact localization

EtherCAT is an ultra -fast I/O system. To reach the best high-speed communication, high communication accuracy is demanded. EtherCAT comprises a wide range of system-inherent diagnostic features which help detect and locate system errors precisely. Apart from broken wire detection and localization, the protocol, physical layer and topology of the EtherCAT system enable individual quality monitoring of each individual transmission segment.

As mentioned, every EtherCAT datagram ends with a 16 bit Working Counter (WKC) to count the number of devices that were successfully addressed by this EtherCAT datagram. Master can check the data exchange situation by WKC in the same cycle and the error frame can be detected by analyzing the nodes' error counters. The slave application will be executed only as the frame is received correctly. The automatic evaluation of the associated error counters enables precise localization of critical network sections.

Bit errors during transmission are detected reliably by the analysis of the CRC (Cyclic Redundancy Check) check sum. CRC is an error-detecting code commonly used in digital networks and storage devices to detect accidental changes to raw data. In addition to the error detection and localization protocol, transmission physics and topology of the EtherCAT system allow an individual quality monitoring of every single transmission path. There is a very effective monitoring mechanism in EtherCAT.

1.2 Features

Advantech's EtherCAT hardware master solutions can be divided into PCIE-1203, PCIE-1203L and PCIE-1203IO with two EtherCAT ports acting as Motion and I/O Master, respectively. Please refer to the comparison table below to get the function difference:

PCIE-1203 (Full function, PCIE interface)

PCIE-1203L (Basic function, PCIE interface)

PCIE-1203IO (IO function only, PCIE interface)

Process of data exchange and memory location in EtherCAT communication can be executed automatically by PCIE-1203 series. User can benefit from EtherCAT high performance communication feature without handling complicated EtherCAT communication protocol.

Application		 PCIE-1203IO	 PCIE-1203L	 PCIE-1203
IO	DIO & AIO	V	V	V
PTP	Point to point		V	V
	Line		V	V
Trajectory	Arc			V
	Path Table			V
AOI	Compare Trigger			V (Onboard)
	Position Latch			V (Onboard)
Synchronization	E-CAM			V
	Gantry			V

1.2.1 Multi Master Mode

- Support for separated master instances simultaneously using different EtherCAT ports on PCIE-1203 series.
- Motion master cycle time is up to 500 us
- I/O master cycle time is up to 200 us

1.2.2 Multi-Axis Interpolation

- Supports up to 64 axes (PCIE-1203/PCIE-1203L)
- Supports 8 groups and 8-axis linear interpolation per group

Note: PCIE-1203IO supports I/O control only.

1.2.3 Huge I/O Data Processing Capability

- PCIE-1203 series Advantech AMAX-4800/AMAX-5000 EtherCAT I/O slaves
- PCIE-1203 supports on-board Encoder * 2-CH, Trigger* 2-CH, Latch* 2-CH and Hand-wheel * 1-CH. It also supports 1 set of CMP+/- to realize high speed differential trigger outputs. (PCIE-1203L and PCIE-1203IO doesn't support on-board I/O).

1.2.4 On-board Real-Time OS Support

- Process data by on-board 650MHz dual-core ARM processor without wasting CPU resource in PC
- Supports high-accuracy trajectory planning and fast-response time
- Speed optimized exchange of cyclic data

1.2.5 Distributed Clocks (DC)

- Synchronizes all slave clocks with one slave reference clock
- Delay compensation
- Runtime monitoring and correction of deviation

1.2.6 Supports Common Motion SDK

- Support “Common Motion API” to integrate all Advantech SoftMotion controller
- EtherCAT slaves are completely configurable via the API without ENI data
- Graphical utility interface is easy to use and configure EtherCAT system

1.2.7 Error Detection and Diagnostic

- Lost link monitoring
- Detection and retry of timed out and failed EtherCAT command
- Comprehensive diagnostic data of physical, device and master layer.

1.3 Specifications

1.3.1 EtherCAT

Number of Axes	64
Number of Rings	2
Surge Protection	10kV
Communication Time	Motion: 500us (32 axes), 1ms (64 axes) I/O: 200us
Communication Motion Slave	64 Servo Drive Max.
Communication IO Slave	128 port DI (128 byte) 128 port DO (128 byte) 128 channel AI (256 byte) 128 channel AO (256 byte) *Total 1280 bytes

1.3.2 Encoder Input

Channels		ENC*2
Max frequency		2.5MHz
Type		Two terminal, opto-isolated
Input voltage	L(max)	1.5 V_{dc}
	H(min)	3.2 V_{dc}
	H(max)	12 V_{dc}
Protection		2500V Isolation

Min. width for Hi / Lo pulse	350 ns

1.3.3 Digital Input

Channels		LTC*2, MPG*1, DI*4
Type		One terminal, opto-isolated
Input voltage	L(max)	3 V_{dc}
	H(min)	10 V_{dc}
	H(max)	30 V_{dc}
Max. input delay time		LTC, DI 0-1:350 ns
		MPG, DI 2-3:100 us
Protection		2500V Isolation
Input resistance		8.4 kΩ

1.3.4 Digital Output

Channels		CMP*2 & DO*2
Type		One terminal, opto-isolated, sink type
Operation Voltage	min	3.3 V_{dc}
	max	30 V_{dc}
Max. sink current		300 mA per channel
Max. output delay time		100 ns
Protection		2500V Isolation

1.3.5 Differential Output

Channels		CMP+/-*1
Max frequency		1 MHz
Type		Differential
Operation Voltage	Low	1.7V_{dc} @ 100mA
	High	4.6 V_{dc} @ 0 mA
Protection		2500V Isolation

1.3.6 General

Bus Type	Universal PCI Express x1-compliant
Power	+5V_{DC} (from PCI-Bus)
Certification	CE, FCC Class A
Connectors	RJ45 x 2, DB26 x 1
Dimensions (L x H)	175 x 100 mm (6.9" x 3.9")
Power Consumption	5 V_{DC} @ 0.5 A typical
Humidity	5 ~ 95% RH, non-condensing (IEC 60068-2-3)
Operating Temp.	0 ~ 60°C (32 ~ 140°F)
Storage Temp.	-20 ~ 85°C (-4 ~ 185°F)

Chapter 2

Installation

2.1 Unpacking

After receiving your PCIE-1203 series package, inspect the contents first. The package should include the following items:

- PCIE-1203 card

The PCIE-1203 series card has certain electronic components vulnerable to electro static discharge (ESD). ESD could easily damage the integrated circuits and certain components if preventive measures are not carefully taken.

Before removing the card from the antistatic plastic bag, you should take the following precautions to prevent ESD damage:

- Touch the metal part of your computer chassis with your hand to discharge static electricity accumulated on your body. Or one can also use a grounding strap.
- Touch the antistatic bag to a metal part of your computer chassis before opening the bag.
- Hold of the card only by the metal bracket when taking it out of the bag.

After taking out the card, you should first:

- Inspect the card for any possible signs of external damage (loose or damaged components, etc.). If the card is visibly damaged, notify our service department or the local sales representative immediately. Avoid installing a damaged card into your system.

Also pay extra attention to the followings to ensure a proper installation:

- Avoid physical contact with materials that could hold static electricity such as plastic, vinyl and Styrofoam.
- Whenever you handle the card, grasp it only by its edges. DO NOT TOUCH the exposed metal pins of the connector or the electronic components.

2.2 Driver Installation

We recommend you install the driver before you install the PCIE-1203 series card into your system.

The DLL driver setup program for the card is included on the companion CD-ROM that is shipped with package. Follow the steps below to install the driver software:

1. Insert the companion CD-ROM into your CD-ROM drive.
2. The setup program will be launched automatically if you have the auto-play function enabled on your system.
3. Select the proper Windows OS option according to your operating system. Just follow the installation instructions step by step to complete your DLL driver setup.
4. Then setup the PCIE-1203 series Motion Utility automatically.

For further information on driver-related issues, an online version of the Device Drivers Manual is available by accessing the following path:

\Program Files\Advantech\Common Motion\Manual

The example source codes could be found under the corresponding installation folder, such as the default installation path:

\Program Files\Advantech\Common Motion\Example_1203

2.3 Hardware Installation

Note! *Make sure you have installed the driver first before you install the card (refer to2.2 Driver Installation).*

After the DLL driver installation is completed, you can now go on to install the PCIE-1203 card in any PCI slot on your computer. But it is suggested that you refer to the computer's user manual or related documentations if you have any doubt. Follow the steps below to install the card on your system.

1. Turn off your computer and remove any accessories connected to the computer.

Warning! *CUT OFF power supply of your computer whenever you install or remove any card, or connect and disconnect cables.*

2. Disconnect the power cord and any other cables from the back of the computer.
3. Remove the cover of the computer.
4. Select an empty +3.3/+5 V PCI Express slot. Remove the screws that secures the expansion slot cover to the system unit. Save the screws to secure the retaining bracket of interface card.
5. Carefully grasp the upper edge of the PCIE-1203 series. Align the hole in the retaining bracket with the hole on the expansion slot and align the gold striped edge connector with the expansion slot socket. Press the card into the socket gently but firmly. Make sure the card fits the slot tightly. Use of excessive force must be avoided; otherwise the card might be damaged.
6. Fasten the bracket of the PCI Express card on the back panel rail of the computer with screws.
7. Connect appropriate accessories (cable, wiring terminals, etc. if necessary) to the PCI Express card.
8. Replace the cover of your computer and connect the cables you removed in step 2.
9. Turn on your computer.

Chapter 3

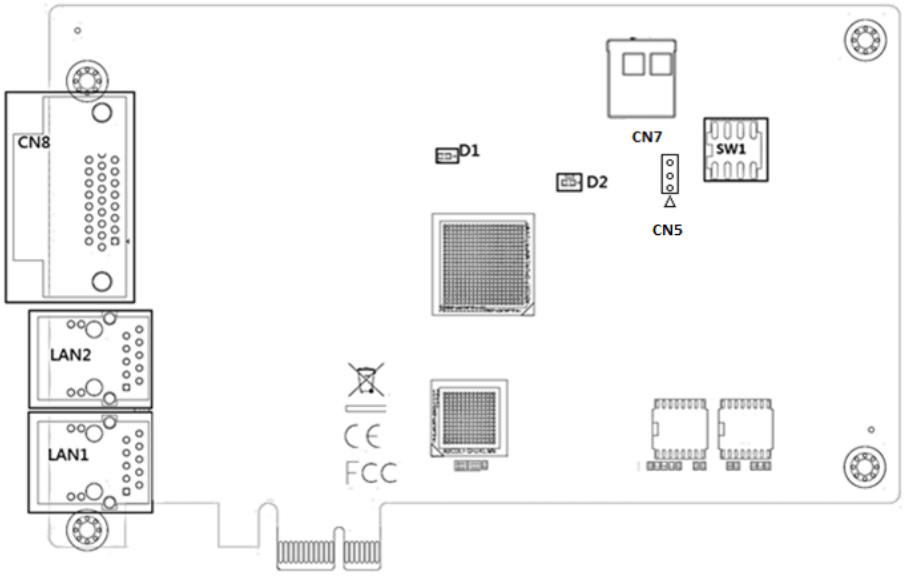
Hardware

3.1 Outline

Table 3.1 shows location of the connectors and switches of the PCIE-1203.

Table 3.1: Point to point

No.	Part Reference	Function
1	CN8	Isolated digital input/output connector
2	LAN1	RJ45 with Transformer (Motion)
3	LAN2	RJ45 with Transformer (IO)
4	Gold finger	PCI Express x 1
5	CN7	Micro-SD card slot
6	SW1	Board ID switch
7	CN5	Boot master from flash memory (Short Pin1 and Pin2)
8	D1	LED
9	D2	LED



Note! *Confirm that Pin1 and Pin2 of CN5 are short-circuited by a jumper before using PCIE-1203.*

3.2 Board ID Switch (SW1)

Table 3.2: Board ID Setting

SW1

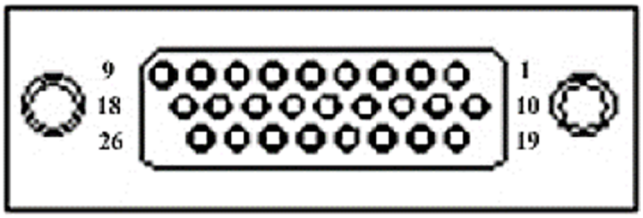
Pin	Label	Switch ON	Switch OFF
1	ID3	0 (ID3 Value =0)	1 (ID3 Value =1)
2	ID2	0 (ID2 Value =0)	1 (ID2 Value =1)
3	ID1	0 (ID1 Value =0)	1 (ID1 Value =1)
4	ID0	0 (ID0 Value =0)	1 (ID0 Value =1)

Board ID = (8×ID3 Value) + (4×ID2 Value) + (2×ID1 Value) + (ID0 Value)
The defaulted setting is ON, e.g. the defaulted values is 0.

3.3 LAN Port (LAN1, LAN2)

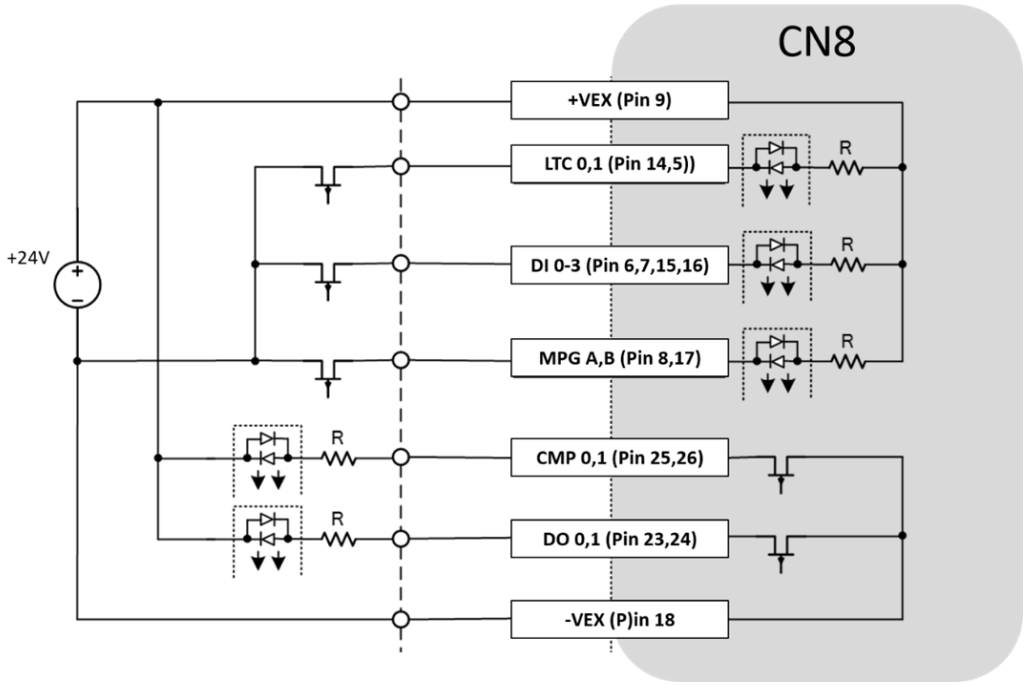
There two RJ45 10/100/1000 LAN port connectors, which connect to EtherCAT slaves via a Cat.5e LAN cable. CN20 is designed to the EtherCAT motor driver slaves (e.g. Panasonic A5B). CN21 is used for the EtherCAT IO slaves (e.g. AMAX-4800/5000 series).

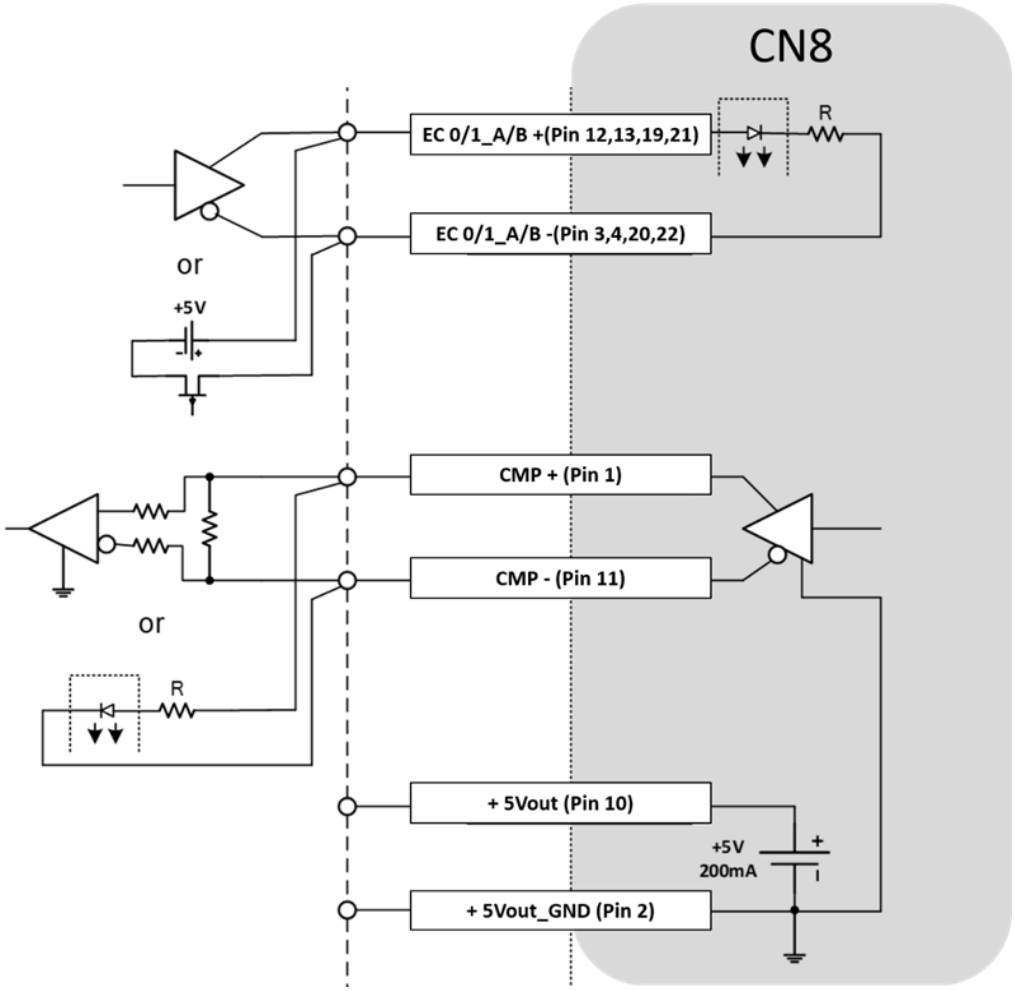
3.4 D-Sub Connector (CN8)



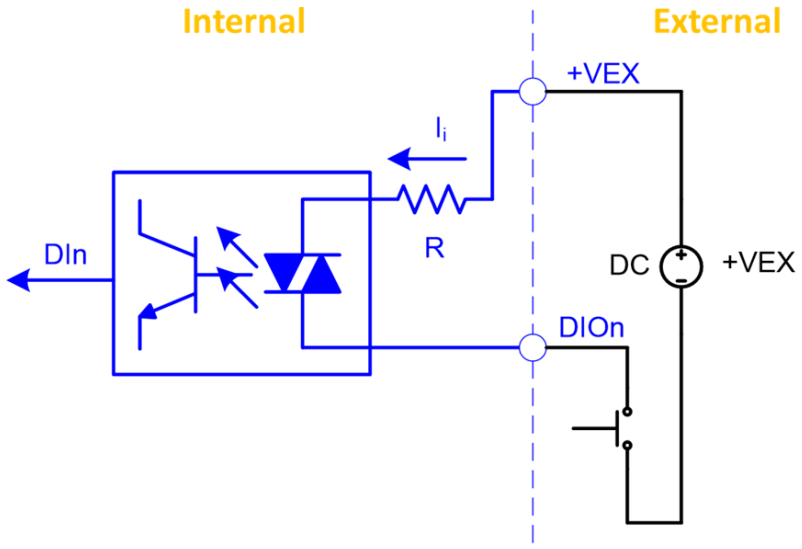
Pin	Name	Description
1	CMP+	Differential Compare Output +
2	+5Vout_GND	5V Ground
3	EC0A-	Encoder In 0 Phase A -
4	EC0B-	Encoder In 0 Phase B -
5	LTC1	Position Latch Input 1
6	DI1	General Digital Input 1
7	DI3	General Digital Input 3
8	MPGB	Hand Wheel Phase B
9	VEX+	External 24 Voltage In
10	+5Vout	5V Output (0.2A max)
11	CMP-	Differential Compare Output -
12	EC0A+	Encoder In 0 Phase A +
13	EC0B+	Encoder In 0 Phase B +
14	LTC0	Position Latch Input 0
15	DI0	General Digital Input 0
16	DI2	General Digital Input 2
17	MPGA	Hand Wheel Phase A
18	VEX-	24V Ground
19	EC1A+	Encoder In 1 Phase A +
20	EC1A-	Encoder In 1 Phase A -
21	EC1B+	Encoder In 1 Phase B +
22	EC1B-	Encoder In 1 Phase B -
23	DO0	General Digital Output 0
24	DO1	General Digital Output 0
25	CMP0	Position Compare Output 0
26	CMP1	Position Compare Output 1

3.4.1 Wiring


CN8
+VEX (Pin 9)
LTC 0,1 (Pin 14,5))
DI 0-3 (Pin 6,7,15,16)
MPG A,B (Pin 8,17)
CMP 0,1 (Pin 25,26)
DO 0,1 (Pin 23,24)
-VEX (P)in 18
+24V
R

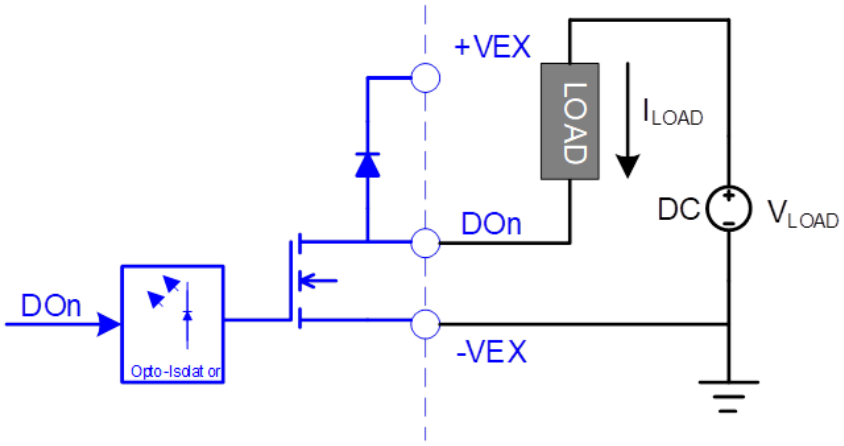

CN8
EC 0/1_A/B +(Pin 12,13,19,21)
EC 0/1_A/B -(Pin 3,4,20,22)
or
+5V
CMP + (Pin 1)
CMP - (Pin 11)
or
R
+ 5Vout (Pin 10)
+5V
200mA
+ 5Vout_GND (Pin 2)

3.4.1.1 Digital Input



Note: All the above DI are common with +VEX pin

3.4.1.2 Digital Output



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