

FASTCAM-PCI R2 Hardware Manual

Rev.1.04

Photron
PHOTRON LIMITED
2005

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Memo

Chapter 1 Introduction

1.1. Preface

1.2. Warranty

1.3. How To Use This Manual

1.4. Precautions

1.1. Preface

The FASTCAM-PCI R2 High-Speed Video Camera System will prove itself a truly powerful imaging tool, providing solutions for engineers and scientists in such fields as general research and development, designing, manufacturing, quality assurance, scientific researches, medical and biological researches, and space and aeronautical engineering. The PCI R2 seamlessly connects to a PC, becoming an integral part of the computer, and when combined with its easy-to-use control software provides an image recording and processing system for analyzing captured fast moving or high-speed events immediately, a task which has often proven difficult with conventional video systems.

You will find this new recording technology most useful to capture images of high-speed subjects for subsequent slow-motion observation, motion analysis, and image processing applications. This manual presents the technical details of the PCI R2 system and how to operate it.

Remarks:

1. For the best use of the Photron FASTCAM PCI R2 system, please read through this manual.
2. The content of this manual is based on the best knowledge of the manufacturer. However, in case any error or missed information is found in this manual, please inform the manufacturer of such shortcomings immediately. Notwithstanding the above, the manufacturer is not responsible for any results of the use of this equipment.
3. Copying all or any part of this manual without permission is prohibited.
4. The content of this manual may be changed any time without prior notice.
5. The manufacturer assumes no responsibility for any direct or indirect damages or loss of profit resulting from the use of this equipment
6. The manufacturer assumes no responsibility for any result of the use of this equipment.
7. Copying all or any part of the software included in this system without prior written permission by the author is an infringement of copyright.

1.2. Warranty

New Equipment Warranty PHOTRON FASTCAM-PCI R2

PHOTRON LIMITED warrants this PHOTRON FASTCAM-PCI R2 ("PCI R2") and accessories manufactured by PHOTRON LIMITED to function properly for one year from the date of shipment, provided the warranty registration card was filled out and returned to PHOTRON USA, INC. or PHOTRON EUROPE LIMITED within thirty days of shipment. PHOTRON LIMITED, in conjunction with PHOTRON USA, INC. or PHOTRON EUROPE LIMITED, agrees to perform the following equipment warranty services:

1. Repair service: If shipped to PHOTRON at any of the addresses shown below, repairs will be made at no charge.
2. Parts replacement: Replacement parts installed under warranty will be provided at no charge.

THIS WARRANTY DOES NOT APPLY UNDER THE FOLLOWING CONDITIONS:

Failure to operate the PCI R2 in accordance with Photon's written instructions, including environmental specifications listed in the User's Manual.

If there is evidence of the PCI R2 being subjected to accidental damage, misuse or abuse.

If the PCI R2 has been repaired or tampered with by persons other than PHOTRON personnel, customer personnel trained by PHOTRON or without permission of PHOTRON.

Shipping damage is not covered by this warranty. The purchaser has the responsibility to place a claim of damage in shipment with the carrier.

PHOTRON LIMITED makes no other warranties, express or implied, including the implied warranties of merchantability and fitness for a particular purpose. If this PCI R2 does not function properly during the warranty period, PHOTRON LIMITED will repair it without charge according to the terms stated above. Repair without charge is PHOTRON LIMITED's only obligation under this warranty. PHOTRON LIMITED, PHOTRON USA, INC. or PHOTRON EUROPE LIMITED will not be responsible for any consequential or incidental damages resulting from the sale, use or improper functioning of this equipment even if loss or damage is caused by the negligence or other fault of PHOTRON LIMITED, PHOTRON USA, INC. or PHOTRON EUROPE LIMITED.

Return the equipment that needs warranty service to:

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1.3 How To Use This Manual

DEFINITION OF TERMS

You will notice that some of the information in this manual is presented as a NOTE, CAUTION or WARNING. It is important that you understand the significance of these three terms. For safe operation of the system, please follow the safety instructions below:

“Note” includes information that should be emphasized regarding the operation of the PCI R2.

“Caution” includes important information regarding operation. If it is neglected and the equipment is used in the wrong manner, damage may be caused to the content of recording, the equipment and related peripheral devices.

“Warning” presents very important information regarding safety of the operators. If it is neglected and the equipment is used in the wrong manner, a seriously hazardous sequence involving human injury or death may result. It must not be disregarded.

Chapters

This manual is divided into three chapters each discussing subject matters related to its chapter title.

Chapter 1. Introduction

Contains Warranty, precautions, introduction and how to use this manual.

Chapter 2. Set Up

Introduces you to the components of the PCI R2 and explains the use of each connector, keypad operation and parameter settings for recording.

Chapter 3. Recording

Explains the operation of the PCI R2 for recording.

1.4. Precautions

Ambient Temperature

Photron FASTCAM-PCI R2 has been designed to work properly in an ambient temperature range of 0 to 40 degrees Celsius (32 to 104 degrees Fahrenheit), no condensation.

Storage Temperature

The PCI R2 must be stored in a place with an ambient temperature range of -20 to +70 degrees Celsius (-4 to +158 degrees Fahrenheit), no condensation.

Transportation

Save the original carton the unit came in for future transportation. Do not transport the unit under ambient temperature of below -20 degrees Celsius (-4 degrees Fahrenheit) or above 70 degrees Celsius (+158 degrees Fahrenheit).

FEDERAL COMMUNICATIONS COMMISSION STATEMENTS

WARNING: This equipment generates, uses and can radiate radio frequency energy and if not installed and used in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class computing device pursuant to Subpart A of Part 15 of the FCC Rules and VDE 0871 Class B which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

This device complies with Part 15 of the FCC Rules and VDE 0871. Operation is subject to the following two conditions: (1) this equipment may cause harmful interference, and (2) this equipment must accept any interference received including interference that may cause undesired operation.

WARNING

This product is grounded through the power cord. This protective ground connection is essential for safe operation of the equipment. Avoid electrical shock by plugging the power cord into a properly wired power outlet. A loss of the protective grounding, for any reason, could result in electrical shock. Use the proper power cord and insure that it is in good condition.

Memo

Chapter 2. Set Up

2.1. Introduction

2.2. About the Camera

2.3. Installation of Hardware

2.4. Setting up for Multiple Camera Recording

2.5. Random Reset Trigger Mode

2.6. Limitation of Recording Duration

2.1. Introduction

2.1.1. Unpacking

The PCI R2 consists of the following items. When you open up the package, be sure to check all components are present.

1. Camera Head (with 6-Meter Camera Cable)	1
2. Grabber Board (PCI Board)	1
3. Lens Mount Cap	1
4. Driver/Application Setup CD-ROM	1
5. FASTCAM-PCI R2 Hardware Manual	1
6. FASTCAM Control Software Operation Manual	1
7. Warranty Registration Card	1
8. External Accessory Cables	2 (1 each of 2 types)

2.1.2. Optional Accessories

The following item is offered as an optional accessory.

16 meter long camera cable

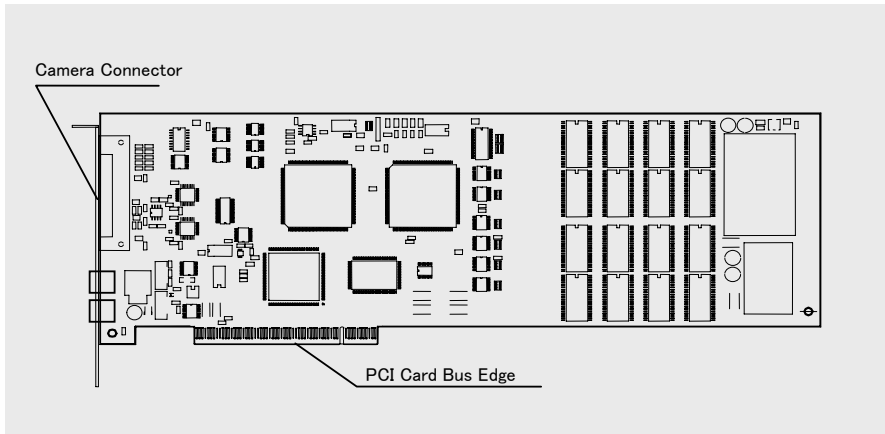
Note: This 16-meter cable requires readjustment of the PCI board. Consult your distributor when ordering.

2.2. About the Camera

The FASTCAM-PCI R2 consists of a Grabber Board (PCI Board), camera head and control software program set.

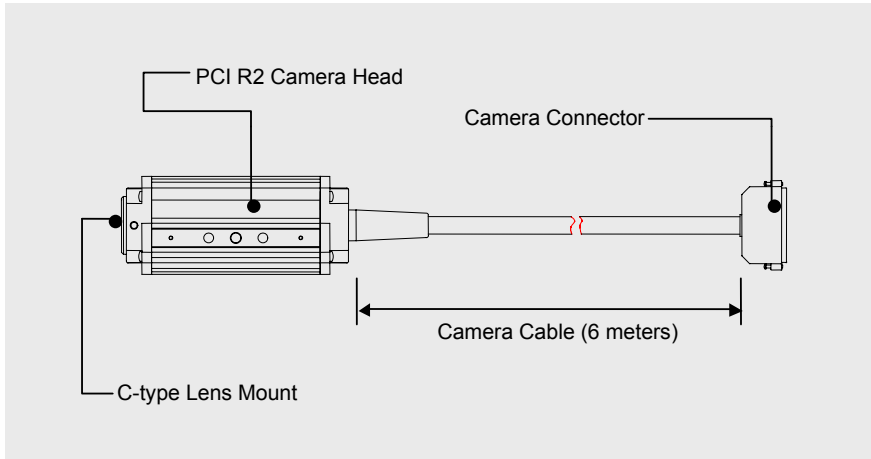
2.2.1. Grabber Board

The grabber board of the FASTCAM-PCI R2 has been designed so that up to four FASTCAM-PCI R2 cards can be installed in ATX standard PCI slots of a PC.



2.2.2. Camera Head

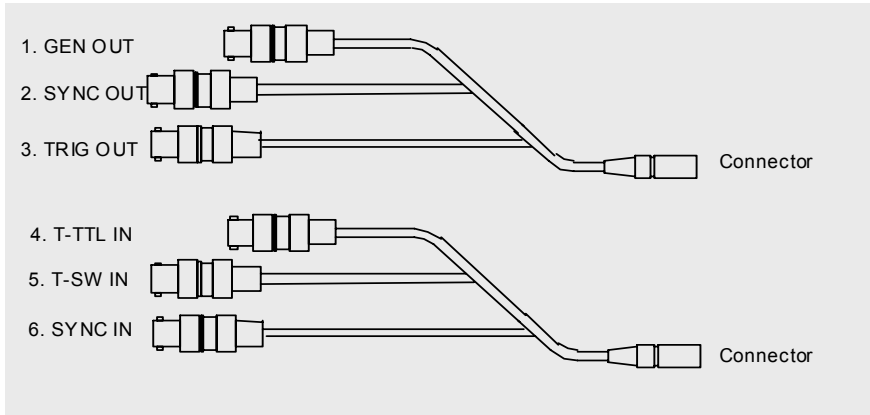
The PCI R2 camera head is of lightweight and compact structure specifically designed for easy handling in varied recording conditions. It takes lenses of C-type mount. A tripod screw hole is provided on each side of the camera.



2.2.3. Accessories

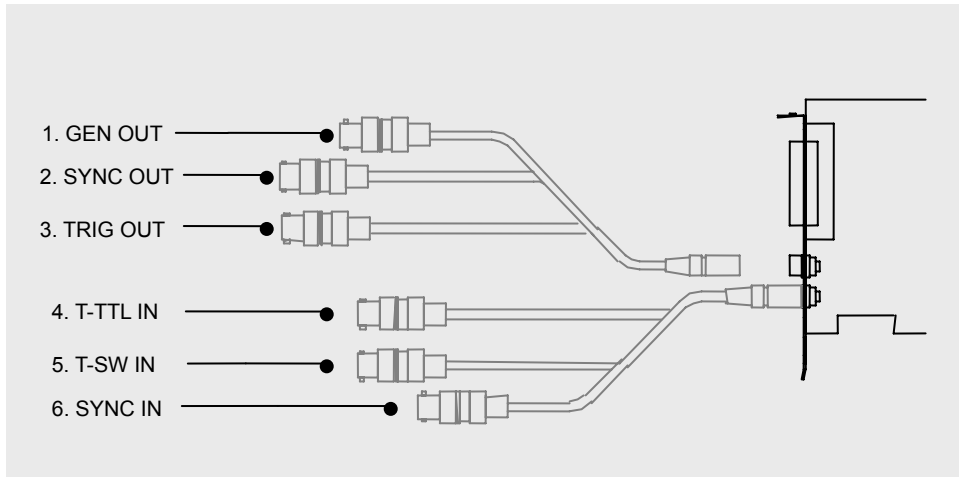
EXT OUT/ EXT IN Cable

The Grabber Board has two compound connectors to connect it to external equipment and devices via cables to receive and send out signals such as external trigger and sync signals. Two compound cables are included in the package as shown below.



2.2.4. Connector Specifications

Details of the two compound cables are follows:



1 GENERAL Output (GEN OUT) Connector

A BNC connector that outputs the following signals under software control.

Expose pos/neg : A signal that specifies the exposure period of CCD sensor. Signal is present during both LIVE display and recording.

Rec pos/neg : A signal that specifies the recording process period of the Grabber Board.

RT Expose pos/neg : A signal that specifies the first exposure period after triggering in a RANDOM RESET TRIGGER mode recording.

2 EXTERNAL SYNC Output (SYNC OUT) Connector

A BNC connector that outputs the camera's vertical sync signal to synchronize external equipment such as strobe unit and pulsed laser.

3 TRIGGER TTL Output (TRIG OUT) Connector

A BNC connector that outputs trigger signal for slaved boards to follow.

4 TRIGGER TTL IN Input(T-TTL IN) Connector

A BNC connector that receives TTL signal from external source to control the start and end of a recording in currently selected recording mode. Input signal is a pulse of +5V, 5µsec wide, positive going. Current is 10mA, recommended, and 20mA maximum.

5 TRIGGER SW IN Input (T-SW IN) Connector

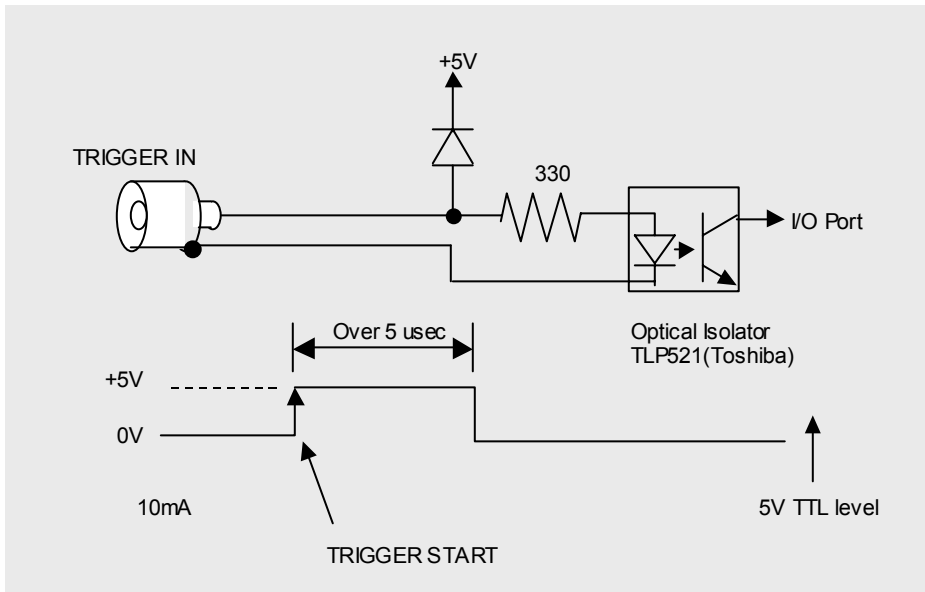
A BNC connector whose co-axial cable shield and center conductors are used to send contact closure signals to control the start and end of a recording in currently selected recording mode.

Caution: To avoid possible damage to the camera system, do NOT input signals other than contact closure to T-SW IN connector.

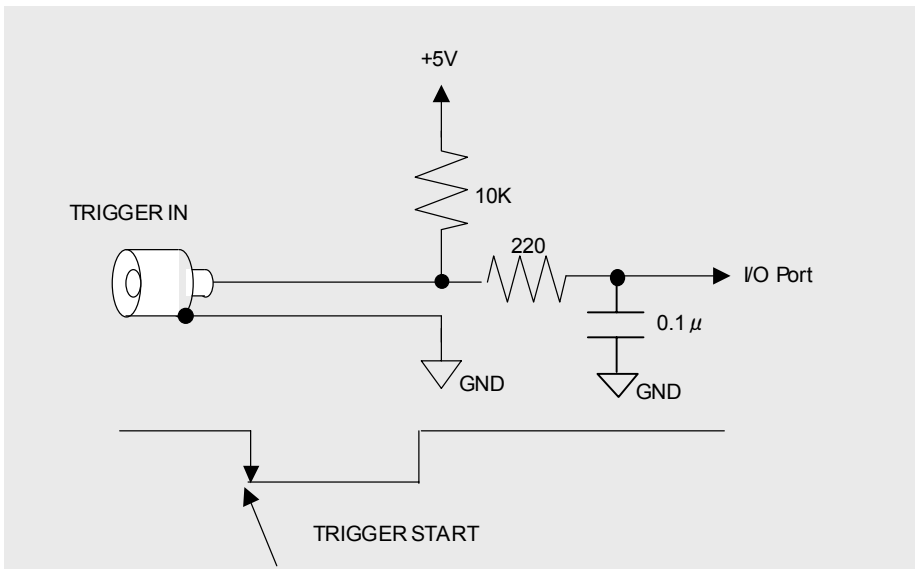
6 EXTERNAL SYNC Input(SYNC IN) Connector

A BNC connector that receives sync signal from master board or external equipment.

TRIGGER TTL IN (T-TTL IN) Input Circuit



TRIGGER SW IN (T-SW IN) Input Circuit



Note: TRIGGER TTL IN works at the rising edge of the TTL signal and TRIGGER SW IN at the falling edge.

2.3. Installation of Hardware

Warning:

Turn off the computer and unplug the power cord from power outlet before connecting between the camera head and Grabber Board, and installing the Grabber Board in the PC to avoid electrical shock and possible damage to the system and/or components.

Caution: Remove the cable twist-ties before connecting.

2.3.1. Installing Grabber Board in PC

Follow the procedure below to install the Grabber Board in the PC:

1. Turn off the PC and unplug the power cable.
2. Remove covers of the PC following the PC's instruction manual.
3. Make sure there are unused PCI slot(s).
4. Remove the metal cover plate in the back of the unused PCI slot where you wish to install the Grabber Board.
5. Insert the Grabber Board into the unused PCI slot. Firmly press the edge of the Grabber Board so the connector engages perfectly. Fasten the board with retaining screws.
6. Replace the covers on the PC following the PC instruction manual.
7. Connect the camera cable to the camera connector on the Grabber Board. Be careful about the connector orientation. Fasten the retaining screws tightly. Pull the cable lightly to check if the connector does not come loose.

Caution:

Be sure to tightly fasten the retaining screws on the camera cable connector shell to avoid damage to the system by unintentional disconnection during operation.

Warning:

Turn off the PC and unplug the power cord before installing the Grabber Board in the PC.

2.4. Setup for Multiple-Camera Recording

The FASTCAM-PCI R2 is capable of multiple camera operation, up to four cameras can be connected to a single PC. It also supports synchronized recording by sync signal supplied from external equipment (signal generator, etc.). In multiple camera operation, the cameras record a common subject from different perspectives along a shared timeline. This capability can also be used to record images of a fast-moving subject, together with other subjects related to it, from different viewpoints simultaneously.

This section describes how to set up the FASTCAM-PCI R2 for multiple camera operation.

Multiple camera operation requires the following setups.

2.4.1. Master/Slave Mode Setup

2.4.2. Connection of Multiple Cameras

2.4.3. Setting up ID on Each Camera

2.4.4. Setting up Software (PFV – Photron FASTCAM Viewer)

2.4.5. Tips on Multiple-Camera Sync Recording

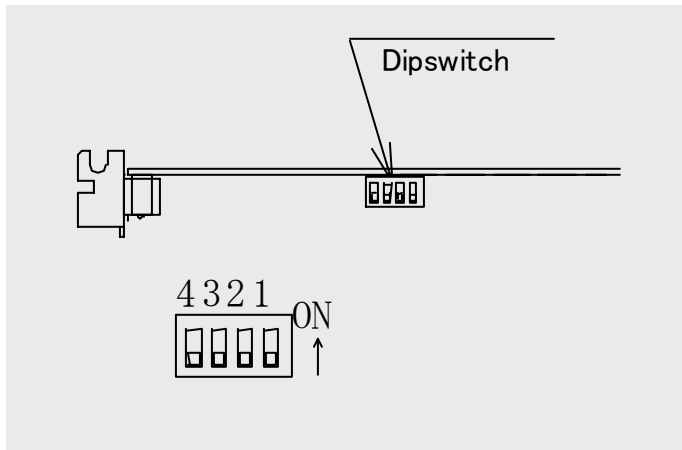
2.4.1. Master/Slave Mode Setup

For multiple-camera synchronized operation, one of the cameras must be set up as the master camera and the other cameras set up as slaves. With cameras set up in this way, the slaves operate following the sync signal provided by the master. As a result, all the cameras record images in a shared timeline.

To set up cameras in these modes, dipswitches on the Grabber Board must be positioned in the following manner:

1) Location of Dipswitches

The dipswitches for master/slave mode setup are located on the top surface of the Grabber Board. The following figure shows the location of dipswitches as seen from above.



2) Setting Up Master/Slave Mode Dipswitches

Operate dipswitches to set up one board for master and the others for slave as shown in the following table.

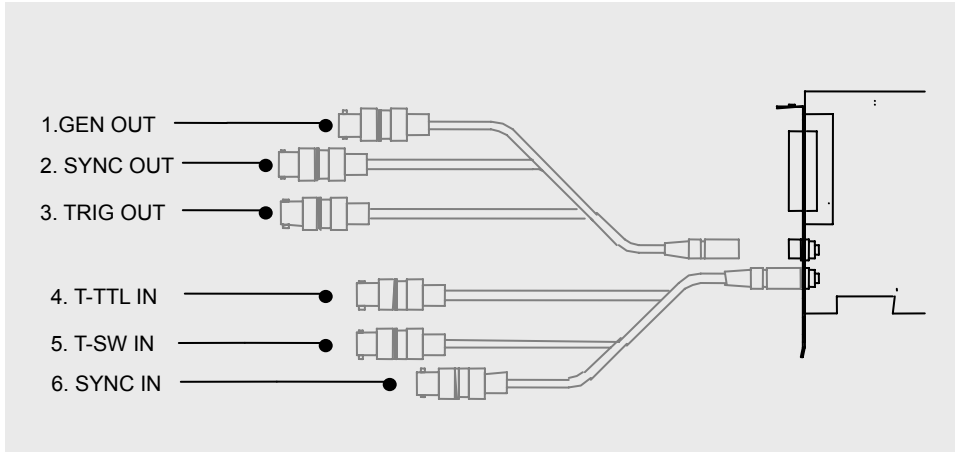
Warning: Turn the PC and cameras off and unplug power cord before opening the computer enclosure.

	Dipswitch Position	Mode of Operation
Master Mode	<p>4 3 2 1 ON</p> <p>All four in OFF position</p>	<p>Multiple-Camera Operation: This camera feeds its internally generated sync and trigger signals to the slaves to follow, and enables trigger signal from software.</p> <p>External Sync Operation: Disables the setup from software menu.</p>
Slave Mode	<p>4 3 2 1 ON</p> <p>SW 4 in ON position</p>	<p>Multiple-Camera Operation: This camera follows the sync and trigger signals provided by the master.</p> <p>External Sync Operation: This camera follows sync and trigger signals from external source.</p>

2.4.2. Connection of Multiple Cameras

After master/slave camera setup, connect sync cables between boards as described in the following subsections:

2.4.2.1. Details of Connectors



1. GENERAL Output (GEN OUT) Connector
2. EXTERNAL SYNC Output (SYNC OUT) Connector
3. TRIGGER TTL Output (TRIG OUT) Connector
4. TRIGGER TTL IN Input (T-TTL IN) Connector
5. TRIGGER SW IN Input (T-SW IN) Connector
6. EXTERNAL SYNC Input (SYNC IN) Connector

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2.4.2.2. Connection for Multiple Camera Sync Operation

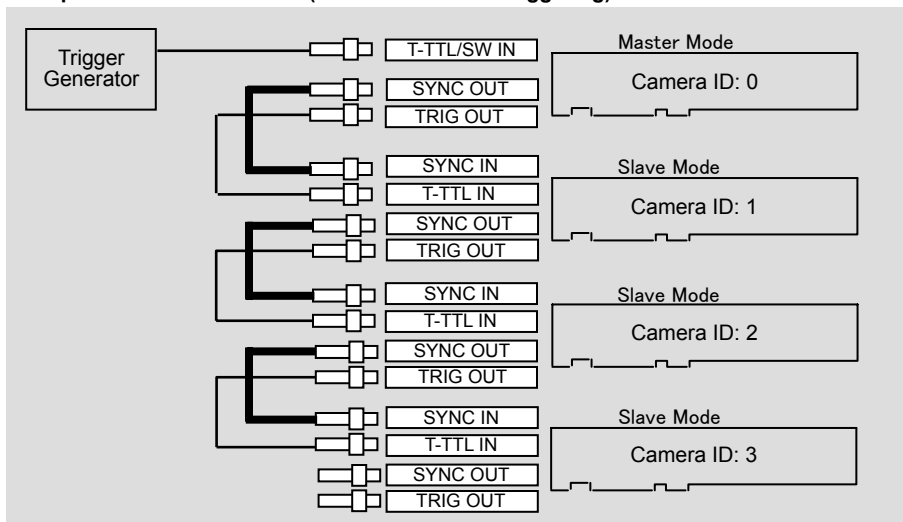
The following figures show how to connect between master and slave boards for sync recording. Connect cables so that the sync and trigger signals are fed to the input of slave boards.

Note: External signal cables have JJ (male-female conversion) connectors. Remove them before connecting to respective boards. Retain the removed conversion connectors for future use.

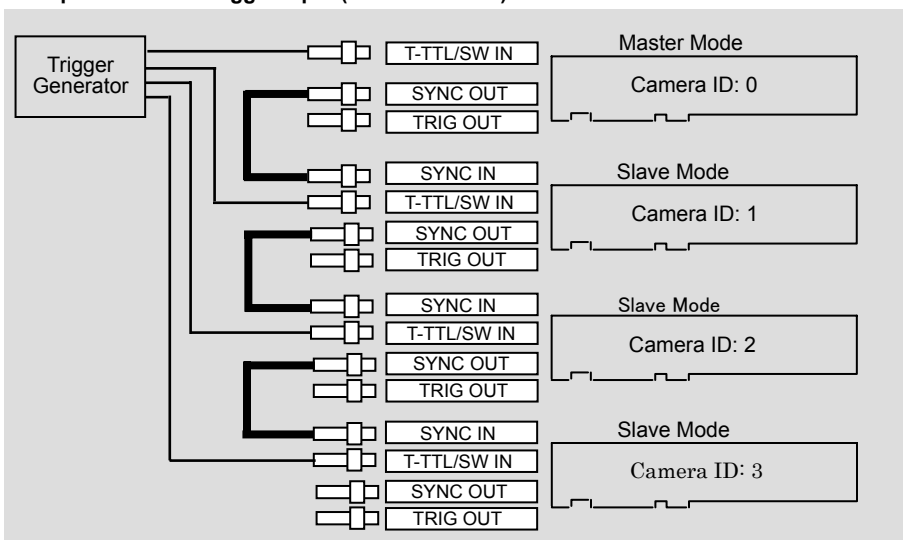
2.4.2.2.1. Connection between FASTCAM-PCI R2 Cameras

The following two figures show sync cable connection for multiple PCI R2 cameras. Due to delay of signals between the boards, Example 2 is recommended, except for using software trigger (see Section 3.4. Timing Charts).

Example 1: Basic Connection (Good for software triggering)



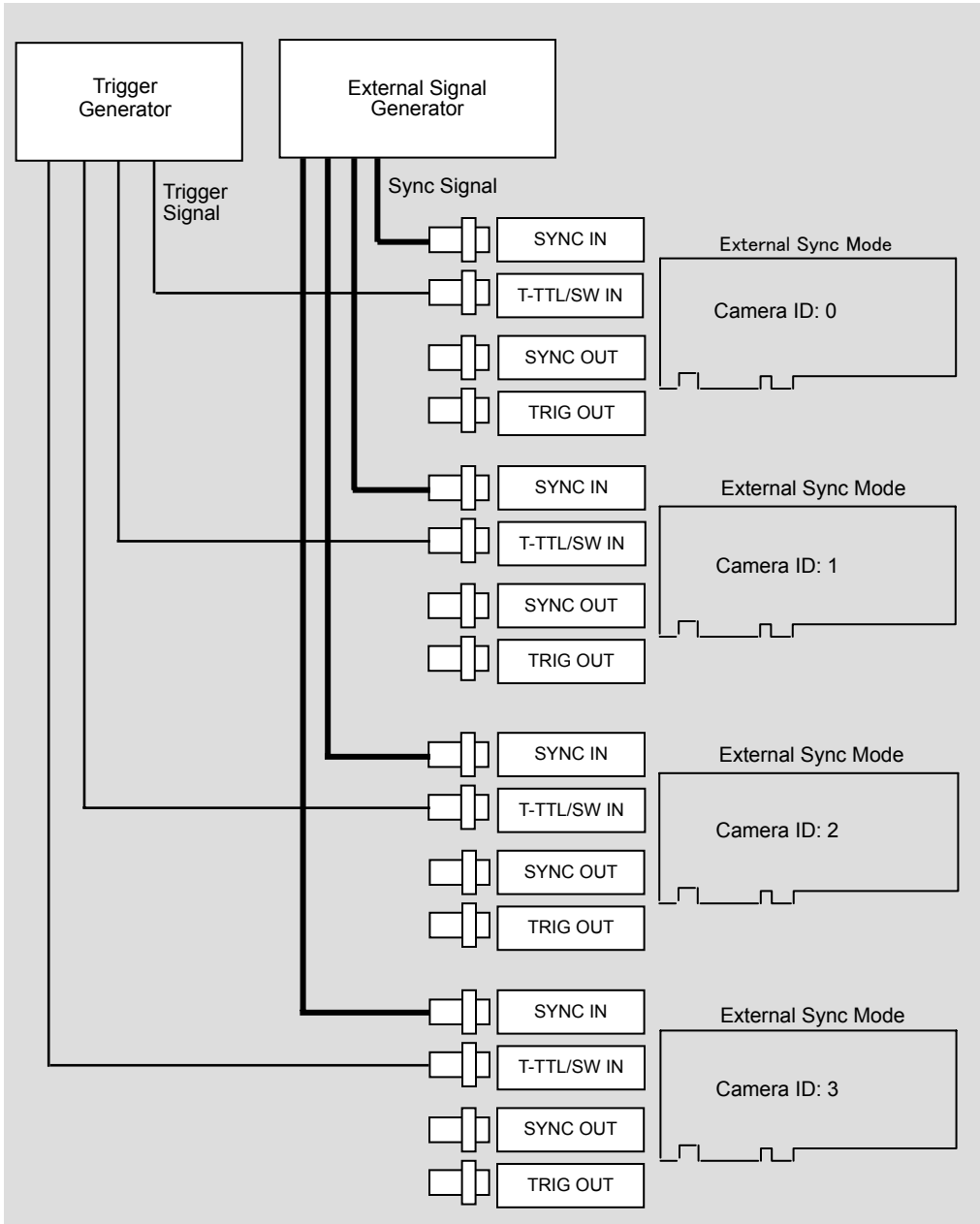
Example 2: Parallel Trigger Input (Recommended)



2.4.2.2.2. Using External Sync Generator

The below figure shows an example of connection using an external sync generator. To avoid any possible delay of sync and trigger signals between boards, this connection is highly recommended, unless using software triggering (see Subsection 3.4. Timing Charts).

Recommended Connection

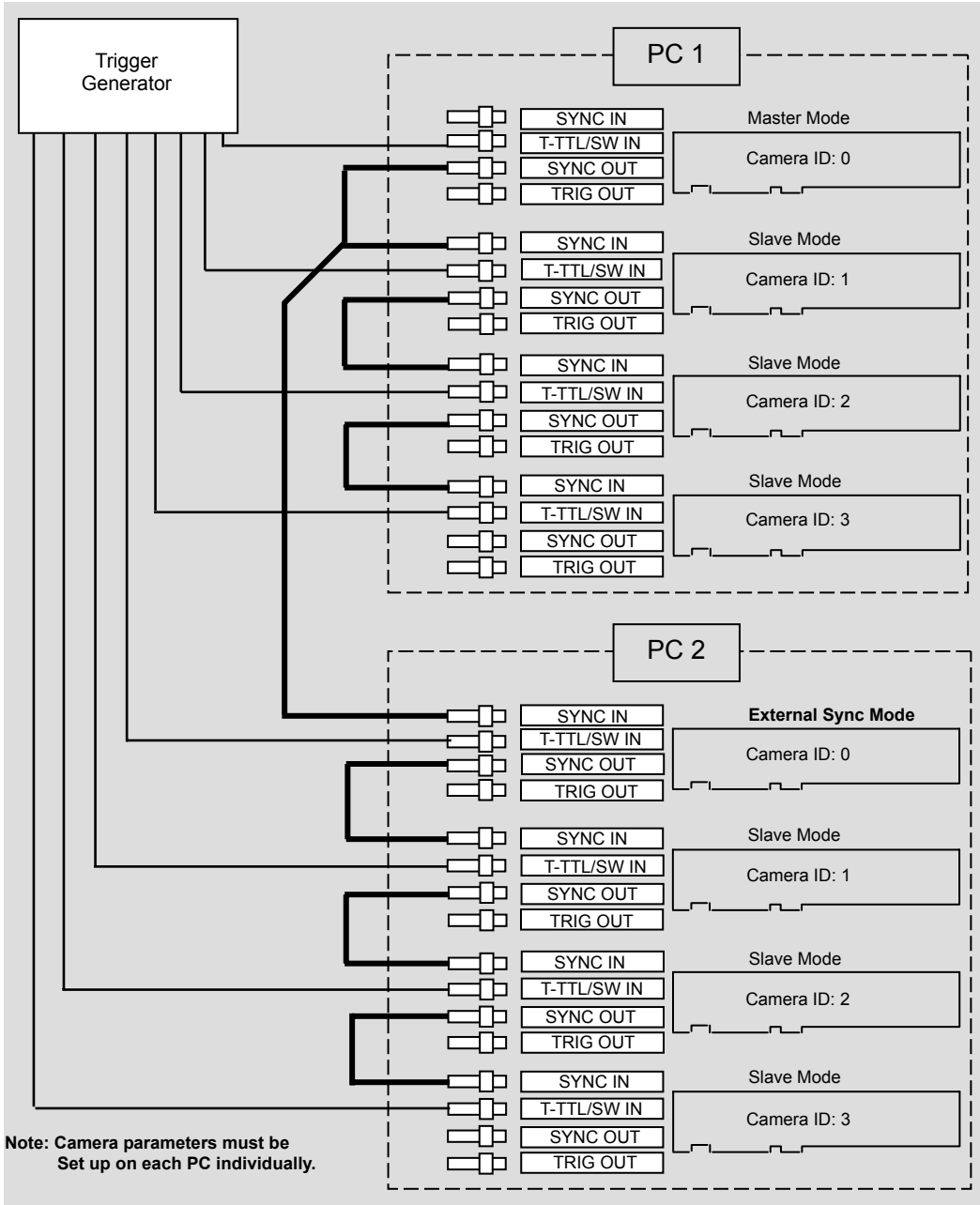


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2.4.2.2.3. Multiple-PC Sync Operation with Multiple-PCI R2 Cameras

The following is an example of connection involving two PC's and eight PCI R2 cameras. This connection is highly recommended to avoid possible delay of sync and trigger signals between cameras (see Subsection 3.4. Timing Charts). The basic connection (shown in 2.4.2.2.1) works but is not recommended because of greater signal delays. Use it for software triggering only.

Recommended Connection



2.4.3. Setting Up Camera ID Numbers

For the software to recognize each camera involved in a multiple-camera operation, an ID number, from 0 to 3, is assigned to each camera. With this ID number, each camera is correctly recognized by the system even if the order of recognition is changed.

The following shows how to assign ID numbers to cameras used in a multiple camera system.

Dipswitch Operation to Set Up Camera ID Number

Camera ID numbers 1 to 4 are defined by the ON/OFF position of dipswitches 1, 2 and 3 as shown below.

ID No.	Dipswitches	SW 3	SW 2	SW 1
0		OFF	OFF	OFF
1		OFF	OFF	ON
2		OFF	ON	OFF
3		OFF	ON	ON

Note: The factory-set ID is 0.

Note: Assign ID No. 1 to the master board (or the board that receives sync signal from an external source), and other numbers to the slaves in the order of PCI slots in the computer chassis.

Note: Do not duplicate an ID number within a multiple-camera system.

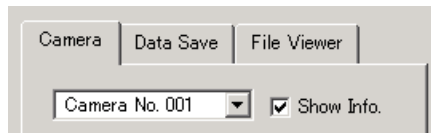
2.4.4. Setting Up Software

Once the setups of the hardware for multiple-camera sync operation procedures in the previous pages are completed, the system can be activated by the software. Follow the below procedure to set up software. For details of software operation, see the Software User's Manual.

2.4.4.1. Setting Up Master Board

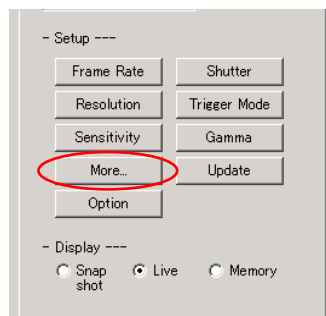
For sync operation of multiple FASTCAM-PCI R2 cameras:

- 1) Select the camera ID number of the master camera of this system from the camera selection box.

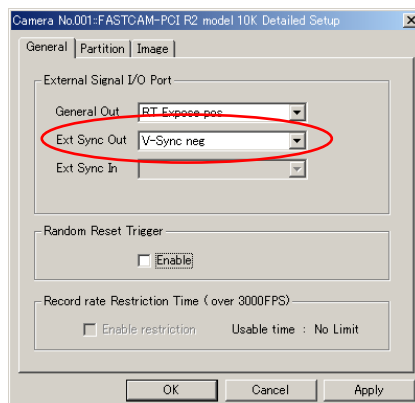


Note: For the relationship between Camera No. and Camera ID, see [Device Information] in [Help].

- 2) Press the 'More' button to set up more details.



- 3) Select the desired polarity of sync signal from the 'Ext Sync Out' box.

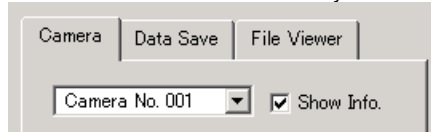


Note: The polarity of sync signal must match that selected for the slave board.

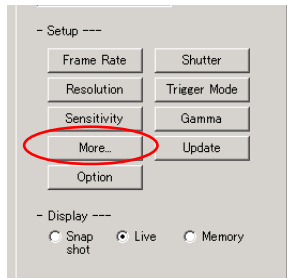
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2.4.4.2. Setting Up Slave Board

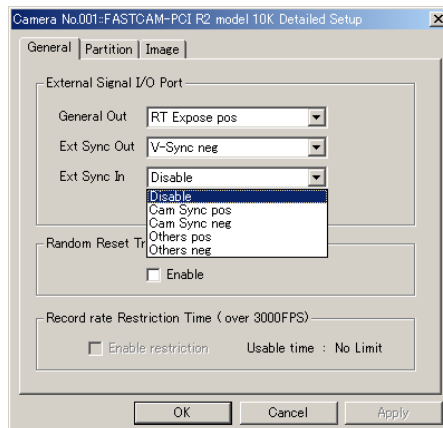
1) Select the camera ID number of the slave camera of this system from the camera selection box.



2) Press the 'More' button to set up more details.



3) Select a mode of synchronization from the 'Ext Sync In' box. Now this slave camera can be synchronized with, and triggered by, the master camera. In other words, this camera has been set up in the external sync mode. As soon as a selection is made in the 'Ext Sync In' box, the software makes frame-accurate calculation of the frame rate of vertical sync signal to synchronize this slave camera.



Items to choose from in the 'Ext Sync In' box:

Disable	Void	Void external sync.
Cam Sync pos.	Normal Modes	Sync operation of multiple PCI R2 cameras
Cam Sync neg.		
Others pos.	External Sync Modes	Sync operation of multiple PCI R2 cameras with external sync signal. Or, sync operation of multiple PCI R2 cameras with multiple PC's.
Others neg.		

Note: The Ext Sync In window for the master camera is turned gray and no selection can be made.

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Note: The polarity must match that selected in the 'Ext Sync Out' box of the master camera or that of the sync signal from the external source being used.

Note: When more than one slave cameras are involved, each of them must be individually set up.

2.4.4.3 How External Sync Signal Mode Works?

External Sync Signal Mode works as follows (See 2.4.4.1. and 2.4.4.2.):

1. As soon as either the 'Others pos' or 'Others neg' synchronization mode is selected in the 'Ext Sync In' box for a slave camera, this camera can be synchronized with and triggered by the master camera. In other words, this camera has been set up for external sync mode operation.
2. As a selection is made in the 'Ext Sync In' box, the software makes frame-accurate calculations of the frame rate from the vertical sync signal being fed by the external source (master camera or external generator) to synchronize this slave camera.
3. When the vertical sync signal (frame rate) from the external source is changed, you are required to re-select mode of synchronization in the 'Ext Sync In' box so that the software can re-calculate the frame rate for the slave camera to follow.

2.4.5. Tips on Multiple-Camera Sync Recording

2.4.5.1. Using Software Triggers

The software trigger is issued only to a board set up as the master board with ID "0" that has been set up for sync operation with sync signal from external source. It is not issued to any other boards. By relaying the software trigger that is issued to the master, connecting the TRIG OUT of the master board to T-TTL IN of the first slave board and so forth (see Section 2.4.2.2.1. Example 1: Basic Connection), multiple-camera triggering is attained without delays caused within the PCI bus.

Despite the above, however, a slight delay is inevitably caused in trigger and vertical sync signals while they are forwarded from board to board. This delay may, in rare cases, result in an offset of one recorded image frame between the master and a slave camera. To avoid this delay, if necessary, use the parallel sync distribution technique shown in Section 2.4.2.2.2. Example 2: Parallel Trigger Input.

2.4.5.2. Using External Triggers

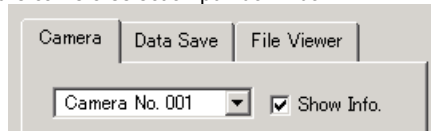
In multiple-camera sync operation with trigger signals from an external source, the use of parallel trigger input is recommended (see Section 2.4.2.2.1 Example 2: Parallel Trigger Input).

Relayed trigger signal (see Section 2.4.2.2.1 Example 1: Basic Connection) works in this operation. But, because of likely delay of relayed trigger, as is the case with the relayed software trigger described in the previous subsection, it is not recommended.

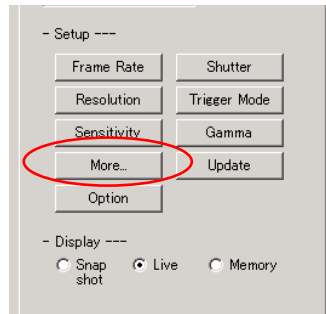
2.5. Random Reset Trigger Mode

The FASTCAM-PCI R2 supports the Random Reset Trigger Mode. Software set up is needed to use this mode and this section describes how to do it. Refer to the Software User's Manual for details of software operation.

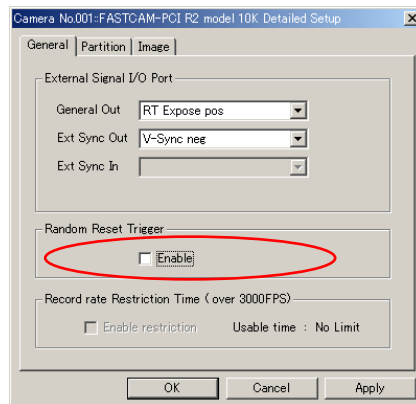
- 1) Select a camera from the camera selection pull-down box.



- 2) Press the 'More' button to set up details.



- 3) Check the 'Random Reset Trigger' box.



Note: Random Reset Trigger Mode can only be enabled in Start and Random recording modes.

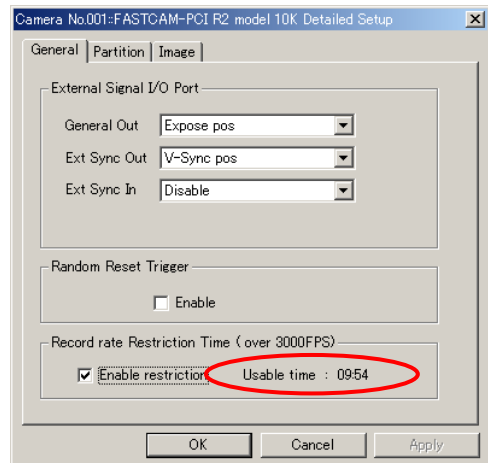
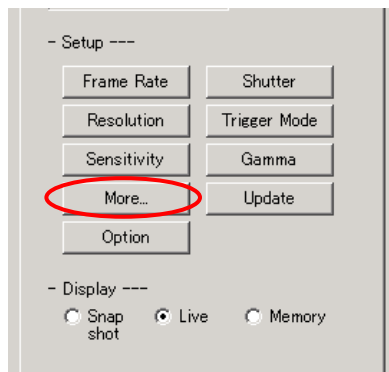
2.6. Restriction of Record Duration

A restriction has been set on the operating duration to avoid possible damage to the camera head caused by heat built up around the imaging sensor within the camera head when operating at framing rates of 3,000 FPS or higher.

The framing rate automatically switches down to 250 FPS after certain a time has elapsed operating at higher framing rates. Leave the camera idling for a while to let it cool down before starting it at a higher framing rate again. The restriction time to each high framing rate is as follows:

Framing Rate	Restriction Time
3,000FPS:	20 minutes
5,000FPS:	10 minutes
10,000FPS:	5 minutes

The remaining current restriction time is confirmed in the 'Record rate Restriction Time' box in the 'More...' menu as shown below:



Caution: The Restriction Time feature can be switched off by removing the check in the [Enable restriction] box making it possible to operate the camera without time restriction at higher framing rates. However, the performance is not guaranteed when the camera is operating at a higher framing rate out of time restriction. Because the camera head gets very hot, you must be extremely careful when touching it for any reason. Also, the high heat may damage the camera head. It is highly recommended to use the camera in the Restriction Time mode at framing rates of 3,000 FPS or higher.

Note: The Restriction Time is set ON by default: the PCI R2 system has been so designed that, even if the Restriction Time feature is switched off, every time the frame rate is changed or the software is restarted, it is automatically switched back to ON status.

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Memo

Chapter 3 Appendix

3.1. Specifications

3.2. Mechanical Data

3.3. Optical Axis and Image Center

3.4. Timing Charts

3.5. Care for Lenses

3.1. Specifications

3.1.1. Basic Specifications

Lens Mount	C mount	
Imaging Sensor	Progressive scan 1/3-inch CCD, Square pixel (7.4 μ m x 7.4 μ m)	
Recording Method	Digital recording in on-board memory	
Recording Capacity	128MB: 544 full frames (2.18 seconds) 256MB: 1,088 full frames (4.35 seconds) 384MB: 1,632 full frames (6.53 seconds) 512MB: 2,176 full frames (8.70 seconds)	
Resolution	Full frame	512 x 480 pixels
	Windowed frames	512 x 240; 256 x 240; 256 x 120 pixels 128 x 120; 128 x 80; 128 x 32 pixels
	Note: Resolution is dependant on framing rate.	
Grayscale	Monochrome: 8 bits (256 steps) Color: 8 bits R, G, B each channel (24 bits, 256 steps) (Bayer color filter)	
Electronic Shutter	Variable from 1/frame rate to 1/230,000 sec. range	
	Selectable shutter speed dependant on framing rate being used.	
External Trigger Input (T-TTL IN / T-SW IN)	TTL input: TTL +5V positive (10mA) Contact input: short circuit	
Sync Signal In (SYNC IN)	+5V TTL for multiple-camera and external sync operation	
External Signal Out 1 (GEN OUT)	+5V TTL: Nonsynchronous random reset trigger timing signal +5V TTL: Recording timing signal +5V TTL: Exposure timing signal Type and polarity set up by software.	
External Signal Out 2 (SYNC OUT)	+5V TTL: Vertical sync signal Polarity set up by software. For multiple-camera sync operation.	
External Signal Out 3 (TRIG OUT)	+5V TTL: Trigger signal (positive) For multiple-camera sync operation.	
Power Supply	+3.3V; +5V; -12V supplied by PCI bus	
Ambient Temperature	0 to 40 deg. C (32 to 104 deg. F), no condensation Note: Ambient temperature range common with PC is limited to the lower of the higher limits, and the higher of the lower limits.	
Power Consumption	+3.3 V: 1 A; +5.0 V: 2 to 4A (at 10k FPS, max); -12 V: 0.2 A	
Dimensions	Camera head: 160mm (6.3") W x 330mm (13")D x 180mm (7.1")H	
	PCI board: 312mm (12.6") W x 106mm (4.2")H x 1.6mm (0.6")T (PCI full size standard)	
Weight (Camera Head)	1.1 kg (2.4 lbs) (incl. 6-meter camera cable)	

3.1.2. Specifications – Recording System

Recording Method		Digital recording of 8-bit/pixel data in on-board memory
Memory Partitioning		Memory can be partitioned in up to eight divisions.
Trigger Modes	START	Records image data until memory is full and stops recording.
	END	Loop recording stops at trigger.
	CENTER	Loop recording stops at trigger with same number of frames recorded before and after trigger.
	MANUAL	Loop recording stops at trigger with preset numbers of frames recorded before and after trigger.
	RANDOM	Records a preset number of frames at each trigger. (Number of frames can be set up by software)
		Random Reset Trigger Mode supported in START and RANDOM modes. (On/Off switchable from software)
Frame Rate	Full Frame	30; 60; 125; 250 FPS
	Windowed Frame	500; 1000; 2000; 3000; 5000; 10000 FPS
Models by Memory Capacity		500; 1k; 2k; 10k models

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3.1.3. Framing Rate vs. Model

Frame Rate FPS	Models			
	FASTCAM-PCI 500	FASTCAM-PCI 1k	FASTCAM-PCI 2k	FASTCAM-PCI 10k
30	✓	✓	✓	✓
60	✓	✓	✓	✓
125	✓	✓	✓	✓
250	✓	✓	✓	✓
500	✓	✓	✓	✓
1000	NA	✓	✓	✓
2000	NA	NA	✓	✓
3000	NA	NA	NA	✓
5000	NA	NA	NA	✓
10000	NA	NA	NA	✓

3.1.4. Frame Rate vs. Image Resolution

Frame Rate (FPS)	Image Resolution						
	512 x 480	512 x 240	256 x 240	256 x 120	128 x 120	128 x 80	128 x 32
30	✓	✓	✓	✓	✓	✓	✓
60	✓	✓	✓	✓	✓	✓	✓
125	✓	✓	✓	✓	✓	✓	✓
250	✓	✓	✓	✓	✓	✓	✓
500	NA	✓	✓	✓	✓	✓	✓
1000	NA	NA	✓	✓	✓	✓	✓
2000	NA	NA	NA	✓	✓	✓	✓
3000	NA	NA	NA	NA	✓	✓	✓
5000	NA	NA	NA	NA	NA	✓	✓
10000	NA	NA	NA	NA	NA	NA	✓

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3.1.5. Shutter Speed vs. Framing Rate

Note: Available shutter speeds depend on the current framing rate.

For Framing Rates of 30, 60, 125, 250 and 500 FPS

Shutter Speed	Frame Rate				
	30FPS	60FPS	125FPS	250FPS	500FPS
1/30	✓	-	-	-	-
1/60	✓	✓	-	-	-
1/125	✓	✓	✓	-	-
1/250	✓	✓	✓	✓	-
1/500	✓	✓	✓	✓	✓
1/1000	✓	✓	✓	✓	✓
1/2000	✓	✓	✓	✓	✓
1/3000	✓	✓	✓	✓	✓
1/5000	✓	✓	✓	✓	✓
1/10000	✓	✓	✓	✓	✓
1/24000	✓	✓	✓	✓	✓
1/35000	✓	✓	✓	✓	✓
1/70000	✓	✓	✓	✓	✓

For Framing Rates of 1000 and 2000 FPS

Shutter Speed	Frame Rate	
	1000FPS	2000FPS
1/1000	✓	-
1/2000	✓	✓
1/3000	✓	✓
1/5000	✓	✓
1/11000	✓	✓
1/22000	✓	✓
1/44000	✓	✓
1/66000	✓	✓
1/132000	✓	✓

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For Framing Rates of 3000, 5000 and 10000 FPS

Shutter Speed	Framing Rate		
	3000FPS	5000FPS	10000FPS
1/3000	✓	-	-
1/5000	✓	✓	-
1/10000	✓	✓	✓
1/20000	✓	✓	✓
1/40000	✓	✓	✓
1/60000	✓	✓	✓
1/115000	✓	✓	✓
1/230000	✓	✓	✓

**3.1.6. Number of Recorded Frames
and Record Duration**

Record Duration and Number of Recorded Frames (30 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
30	512×480	544	18.13	1,088	36.27	1,632	54.40	2,176	72.53
	512×240	1,088	36.27	2,176	72.53	3,264	108.80	4,352	145.07
	256×240	2,176	72.53	4,352	145.07	6,528	217.60	8,704	290.13
	256×120	4,368	145.60	8,736	291.20	13,104	436.80	17,472	582.40
	128×120	8,736	291.20	17,472	582.40	26,208	873.60	34,944	1164.80
	128×80	13,104	436.80	26,208	873.60	39,312	1310.40	52,416	1747.20
	128×32	32,768	1092.27	65,536	2184.53	98,304	3276.80	131,072	4369.07

Record Duration and Number of Recorded Frames (60 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
60	512×480	544	9.07	1,088	18.13	1,632	27.20	2,176	36.27
	512×240	1,088	18.13	2,176	36.27	3,264	54.40	4,352	72.53
	256×240	2,176	36.27	4,352	72.53	6,528	108.80	8,704	145.07
	256×120	4,368	72.80	8,736	145.60	13,104	218.40	17,472	291.20
	128×120	8,736	145.60	17,472	291.20	26,208	436.80	34,944	582.40
	128×80	13,104	218.40	26,208	436.80	39,312	655.20	52,416	873.60
	128×32	32,768	546.13	65,536	1092.27	98,304	1638.40	131,072	2184.53

Record Duration and Number of Recorded Frames (125 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
125	512×480	544	4.35	1,088	8.70	1,632	13.06	2,176	17.41
	512×240	1,088	8.70	2,176	17.41	3,264	26.11	4,352	34.82
	256×240	2,176	17.41	4,352	34.82	6,528	52.22	8,704	69.63
	256×120	4,368	34.94	8,736	69.89	13,104	104.83	17,472	139.78
	128×120	8,736	69.89	17,472	139.78	26,208	209.66	34,944	279.55
	128×80	13,104	104.83	26,208	209.66	39,312	314.50	52,416	419.33
	128×32	32,768	262.14	65,536	524.29	98,304	786.43	131,072	1048.58

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Record Duration and Number of Recorded Frames (250 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
250	512×480	544	2.18	1,088	4.35	1,632	6.53	2,176	8.70
	512×240	1,088	4.35	2,176	8.70	3,264	13.06	4,352	17.41
	256×240	2,176	8.70	4,352	17.41	6,528	26.11	8,704	34.82
	256×120	4,368	17.47	8,736	34.94	13,104	52.42	17,472	69.89
	128×120	8,736	34.94	17,472	69.89	26,208	104.83	34,944	139.78
	128×80	13,104	52.42	26,208	104.83	39,312	157.25	52,416	209.66
	128×32	32,768	131.07	65,536	262.14	98,304	393.22	131,072	524.29

Record Duration and Number of Recorded Frames (500 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
500	512×240	1,088	2.18	2,176	4.35	3,264	6.53	4,352	8.70
	256×240	2,176	4.35	4,352	8.70	6,528	13.06	8,704	17.41
	256×120	4,368	8.74	8,736	17.47	13,104	26.21	17,472	34.94
	128×120	8,736	17.47	17,472	34.94	26,208	52.42	34,944	69.89
	128×80	13,104	26.21	26,208	52.42	39,312	78.62	52,416	104.83
	128×32	32,768	65.54	65,536	131.07	98,304	196.61	131,072	262.14

Record Duration and Number of Recorded Frames (1000 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
1,000	256×240	2,176	2.18	4,352	4.35	6,528	6.53	8,704	8.70
	256×120	4,368	4.37	8,736	8.74	13,104	13.10	17,472	17.47
	128×120	8,736	8.74	17,472	17.47	26,208	26.21	34,944	34.94
	128×80	13,104	13.10	26,208	26.21	39,312	39.31	52,416	52.42
	128×32	32,768	32.77	65,536	65.54	98,304	98.30	131,072	131.07

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Record Duration and Number of Recorded Frames (2000 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
2,000	256×120	4,368	2.18	8,736	4.37	13,104	6.55	17,472	8.74
	128×120	8,736	4.37	17,472	8.74	26,208	13.10	34,944	17.47
	128×80	13,104	6.55	26,208	13.10	39,312	19.66	52,416	26.21
	128×32	32,768	16.38	65,536	32.77	98,304	49.15	131,072	65.54

Record Duration and Number of Recorded Frames (3000 FPS)

Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
3,000	128×120	8,736	2.91	17,472	5.82	26,208	8.74	34,944	11.65
	128×80	13,104	4.37	26,208	8.74	39,312	13.10	52,416	17.47
	128×32	32,768	10.92	65,536	21.85	98,304	32.77	131,072	43.69

Record Duration and Number of Recorded Frames (5000 FPS)

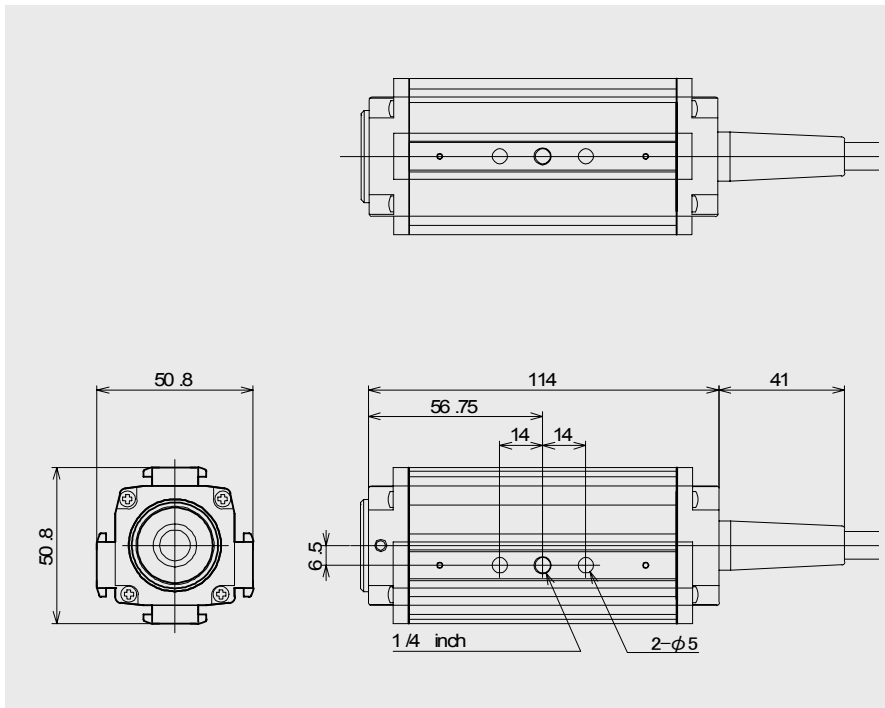
Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
5,000	128×80	13,104	2.62	26,208	5.24	39,312	7.86	52,416	10.48
	128×32	32,768	6.55	65,536	13.11	98,304	19.66	131,072	26.21

Record Duration and Number of Recorded Frames (10,000 FPS)

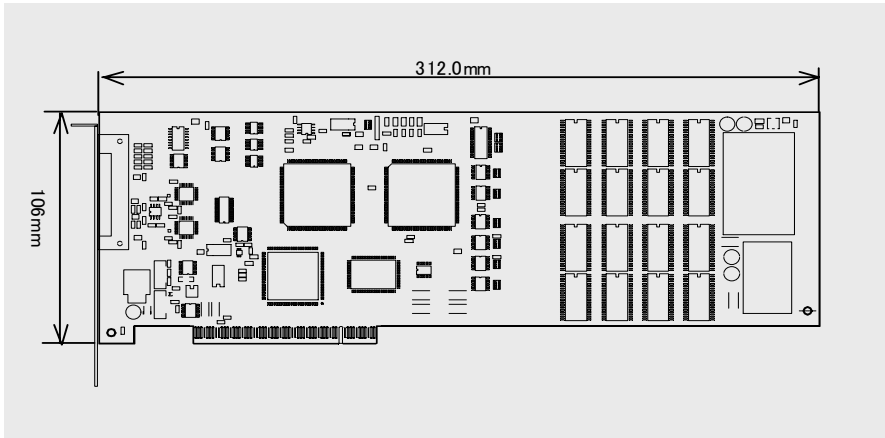
Frame Rate (FPS)	Resolution	Memory Capacity / Record Duration / Number of Recorded Frames							
		128MByte		256MByte		384MByte		512MByte	
		Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)	Frames	Duration (sec.)
10,000	128×32	32,768	3.28	65,536	6.55	98,304	9.83	131,072	13.11

3.2. Dimensions

3.2.1. Camera Head (Millimeters)



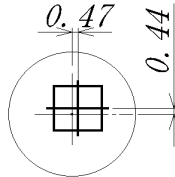
3.2.2. Grabber Board (Millimeters)



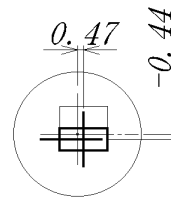
3.3. Optical Axis and Image Center

The center of image of the PCI R2 camera does not coincide with the optical axis and deviates by the framing rate and as shown below (millimeters):

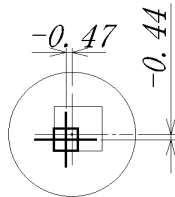
250FPS



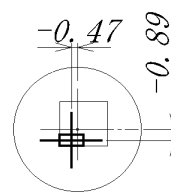
500FPS



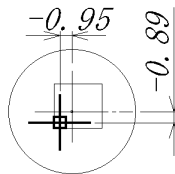
1000FPS



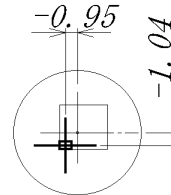
2000FPS



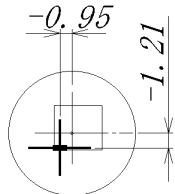
3000FPS



5000FPS



10000FPS

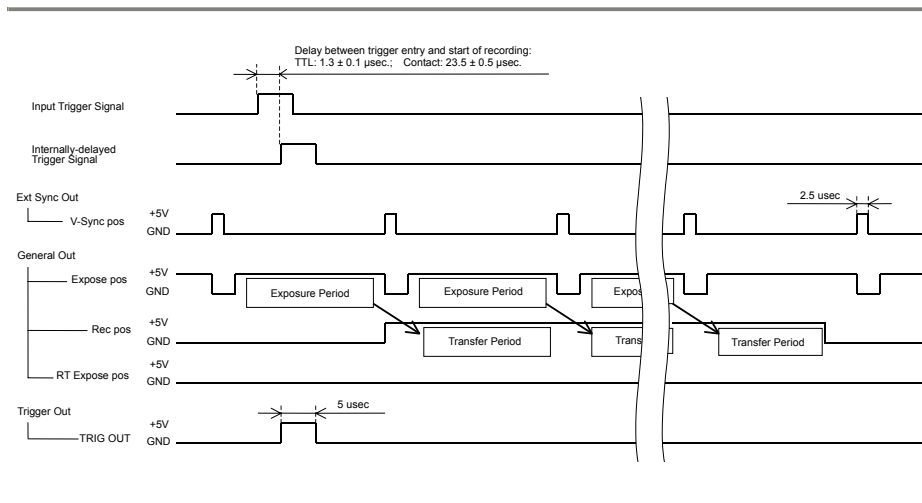


3.4. Timing of Recording Operation

3.4.1 Timing Charts for Recording Operation

3.4.1.1. Timing Chart for START and RANDOM Recording Modes

The below chart shows the temporal relationship between signals related to recording operation in START and RANDOM trigger modes (random reset not effective).



Note: START trigger mode starts recording when a trigger is received and records images until the memory is full. RANDOM mode records a preset number of frames at each trigger and records until the memory is full.

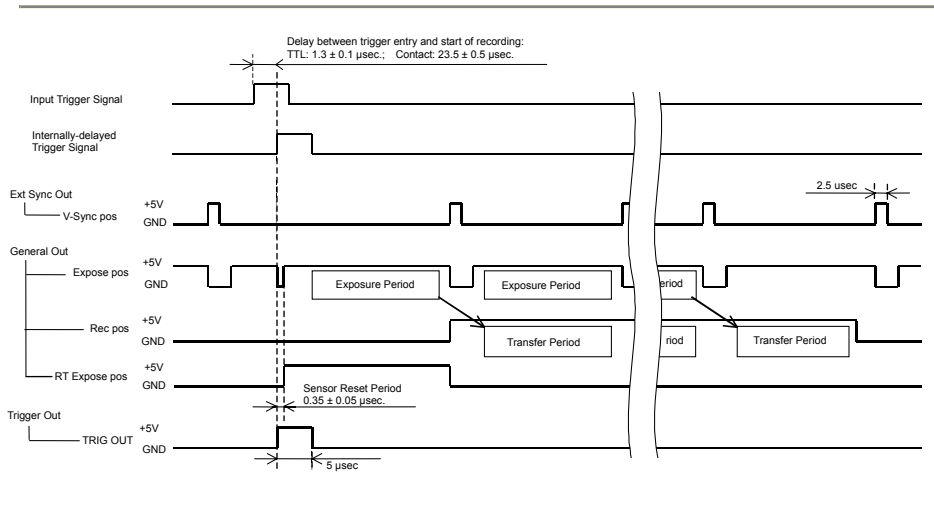
Note: When shutter is used, the exposure period becomes shorter than the above. See details in the timing chart in 3.4.1.3.

Note: The amount of delay between the incoming and internal triggers greatly depends on the type of incoming triggers. For example, the delay is over 23 μsec with a contact closure trigger, while it is only 1.3 μsec with a TTL trigger.

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3.4.1.2. Timing Chart for START and RANDOM Trigger Modes with “Reset” in Effect

When “Reset” function is activated, Expose pos (vertical sync) signal is reset by the incoming trigger so that the timing of the incoming trigger signal and the start of exposure coincide more accurately as shown in the below chart.



Note: START trigger mode starts recording when a trigger is received and continues recording images until the memory is full. RANDOM mode records a preset number of frames at each trigger and records until the memory is full.

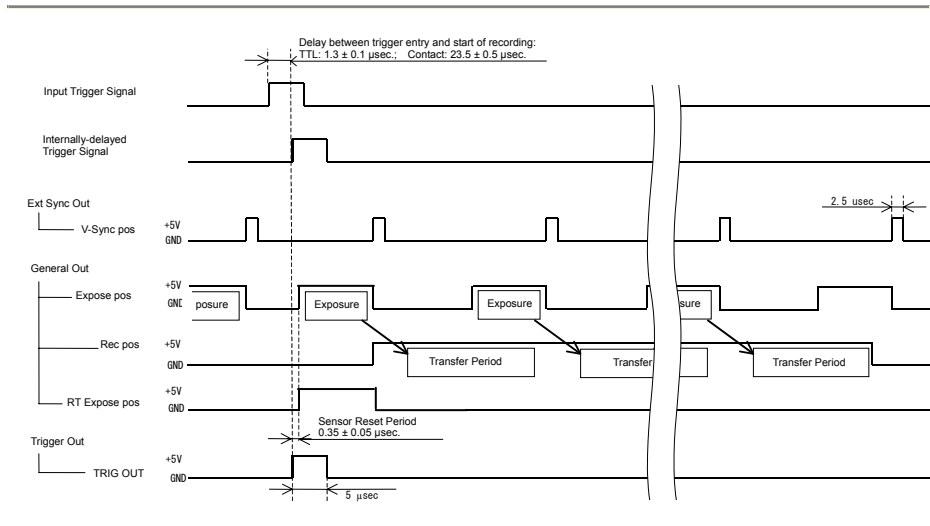
Note: The amount of delay between the incoming and internal triggers greatly depends on the type of incoming triggers. For example, the delay is over 23 μsec with a contact closure trigger, while it is only 1.3 μsec with a TTL trigger.

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3.4.1.3. Timing Chart for Shuttered Operation in START and RANDOM Trigger Modes with "Reset" in Effect

The below chart shows the temporal relationship between timing signals when shuttering function is added to START and RANDOM trigger mode with Reset is in effect.

Note: A shorter exposure period is set by the shuttering function, in addition to the Expose pos signal being reset at the incoming trigger.



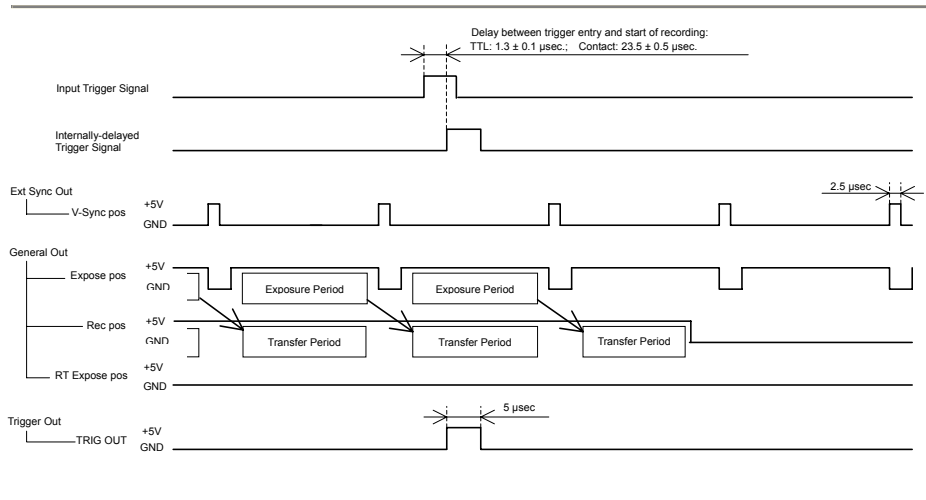
Note: START trigger mode starts recording when a trigger is received and continues recording images until the memory is full. RANDOM mode records a preset number of frames at each trigger and records until the memory is full.

Note: The amount of delay between the incoming and internal triggers greatly depends on the type of incoming triggers.

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3.4.1.4. Timing Chart for END, CENTER and MANUAL Trigger Modes

The below chart shows the temporal relationship of timing signals in END trigger mode. Note the exposure, and consequently recording, ends as soon as a trigger comes in.



Note: CENTER trigger mode ends recording after filling the latter half of the available memory. MANUAL trigger mode records a preset number of frames after a trigger comes in.

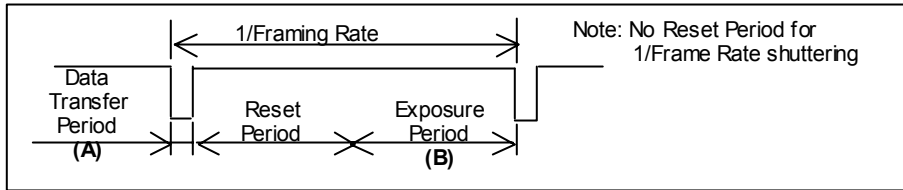
Note: When shutter is used, the exposure period becomes shorter depending on the shutter speed. See example in the timing chart in 3.4.1.3.

Note: The amount of delay between the incoming and internal triggers greatly depends on the type of incoming triggers.

3.4.2. Shutter Setup and Exposure Period

When shutter is not used, the whole period defined by 1/Framing Rate (sec) is virtually the exposure period for each framing cycle. There is no reset period during this framing cycle.

When shutter is used, the exposure period is defined by the current shutter speed and is preceded by a reset period.



Following tables show the transfer and exposure periods for each framing rate and shutter speed.

Transfer and Exposure Periods in micro seconds (µsec.)

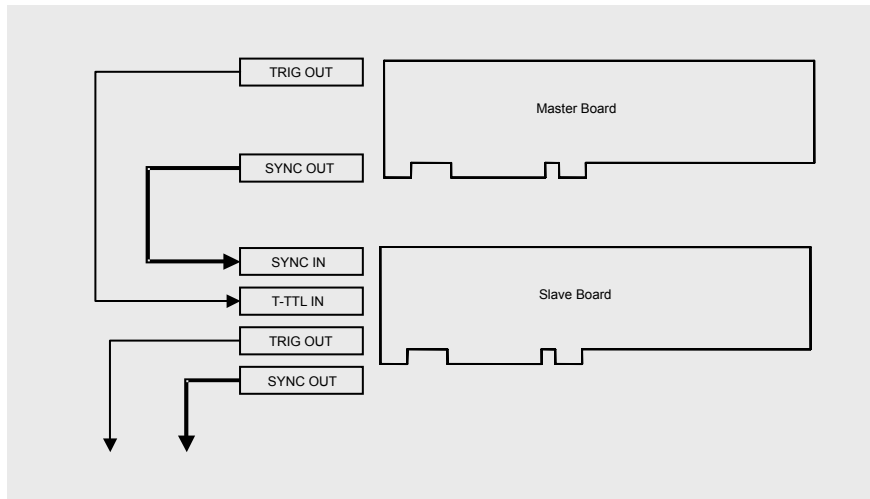
FPS	Shutter Speed													
	Transfer Period (A)	1/F sec (B)	1/60 (B)	1/125 (B)	1/250 (B)	1/500 (B)	1/1000 (B)	1/2000 (B)	1/3000 (B)	1/5000 (B)	1/10000 (B)	1/24000 (B)	1/35000 (B)	1/70000 (B)
30 FPS	29.49	33304	1667	800	3973	1995	996.9	505.5	337.0	196.6	98.28	42.12	28.08	14.04
60 FPS	28.79	16638	—	800	3973	1995	996.9	505.5	337.0	196.6	98.28	42.12	28.08	14.04
125 FPS	39.09	7961	—	—	3973	1995	996.9	505.5	337.0	196.6	98.28	42.12	28.08	14.04
250 FPS	26.57	3973	—	—	—	1995	996.9	505.5	337.0	196.6	98.28	42.12	28.08	14.04
500 FPS	34.34	1966	—	—	—	—	996.9	505.5	337.0	196.6	98.28	42.12	28.08	14.04

FPS	Shutter Speed									
	Transfer Period (A)	1/Frame sec (B)	1/2000 (B)	1/3000 (B)	1/5000 (B)	1/11000 (B)	1/22000 (B)	1/44000 (B)	1/66000 (B)	1/132000 (B)
1000 FPS	30.30	969.7	500.0	333.3	197.0	90.91	45.45	22.73	15.15	7.576
2000 FPS	30.30	469.7	—	333.3	197.0	90.91	45.45	22.73	15.15	7.576

FPS	Shutter Speed								
	Transfer Period (A)	1/Frame sec (B)	1/5000 (B)	1/10000 (B)	1/20000 (B)	1/40000 (B)	1/60000 (B)	1/115000 (B)	1/230000 (B)
3000 FPS	29.29	304.0	199.8	99.90	5.212	2.606	1.737	0.8687	0.4343
5000 FPS	26.26	173.7	—	99.90	5.212	2.606	1.737	0.8687	0.4343
10000 FPS	26.16	73.84	—	—	5.212	2.606	1.737	0.8687	0.4343

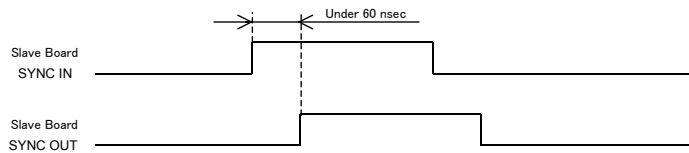
3.4.3 Sync Timing in Multi-Camera Operation

In multiple-camera operation of FASTCAM-PCI R2 cameras, if sync and trigger signals are connected in series as shown below, signal delay inevitably becomes obvious. In extreme cases, this delay may cause an offset of one full image frame between cameras involved in multiple-camera operation. To avoid this drawback, other connection methods shown in 2.4.2. are recommended.



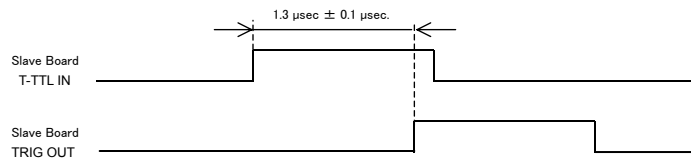
3.4.3.1. Magnitude of Delay - Vertical Sync Signal:

A delay of up to 60 nsec is caused between SYNC IN and OUT within a slave board.



3.4.3.2. Magnitude of Delay - TTL Trigger Signal

A delay of up to 1.3 μ sec is caused between T-TTL IN and TRIG OUT within a slave board.

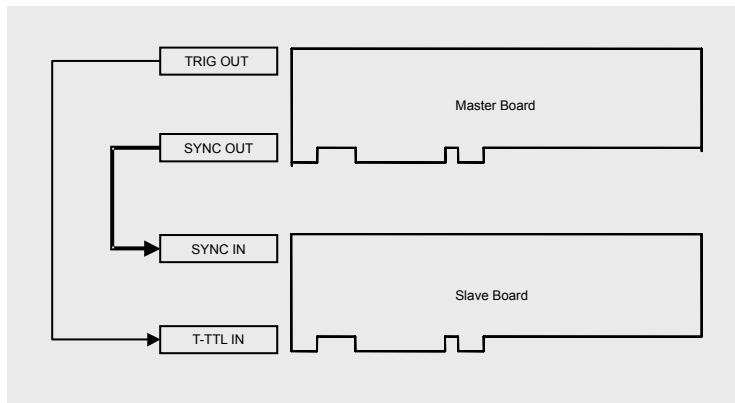


3.4.4. Delay of EXT OUT Signals

For 2-camera operation, the vertical sync and trigger signals are connected with BNC cables as shown in below. It is known that the BNC cable causes considerable delay of signals between the PCI boards, the delay being proportional to the length of the cable.

In addition to the delay, the quality of signal also deteriorates proportionally, which may cause the the slave camera to malfunction.

For stable, synchronized operation of cameras, it is recommended that the cable length is reduced as much as possible when designing a simultaneous recording system.



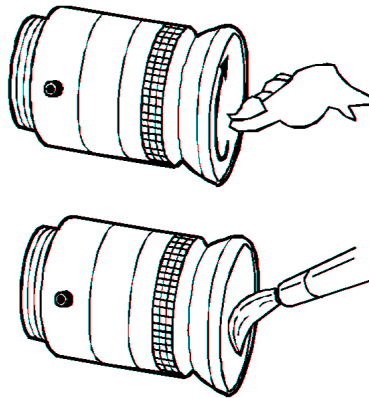
The below table shows actual signal delays measured using type 3C2VS BNC cables.

Cable Length (Meters)	Delay (nsec)
5	25
10	50
20	100
30	150
40	200
50	250

3.5. Care of Lenses

The surface of photographic lenses has thin coatings that reduce unwanted reflections. Extra care must be taken to protect these fragile coatings.

Protect the lens by installing a lens cap when you are not using the camera. Brush the lens gently with a camel hairbrush or loosely folded piece of lens paper to remove dust particles. For stubborn dirt use photographic lens cleaning solution and lens wipes. Never rub the lens with direct pressure or drop cleaning solution directly on the lens surface.



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