



# User's Manual

## Line Scan Camera

Type: RMSL4K100CL



**NIPPON ELECTRO-SENSORY DEVICES CORPORATION**

## For Customers in the U.S.A.

This equipment has been tested and found to comply with the limits for a Class A digital device, in accordance with 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 or her own expense.

## For Customers in the EU

This equipment has been tested and found to comply with the essential requirements of the EMC Directive 2004/108/EC, based on the following specifications applied:

EU Harmonized Standards

EN55032:2015 Class A

EN55011:2009+A1:2010 Class A

EN61000-6-2:2005

### Warning

This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

### **Directive on Waste Electrical and Electronic Equipment (WEEE)**

Please return all End of Life NED products to the distributor from whom the product was purchased for adequate recycling and / or disposal. All costs of returning the Product to NED are borne by the shipper.

## Introduction

Thank you for purchasing NED's Line Scan Camera. We look forward to your continued custom in the future.

## For safety use

- ◆ For your protection, please read these safety instructions completely before operating the product and keep this manual for future reference.
- ◆ The following symbols appear next to important information regarding safe product handling.

 <b>Warning</b>	If the product is not handled properly, this may result in serious injury or possible death.
 <b>Caution</b>	If the product is not handled properly, this may result in physical injury or cause property damage.

## Safety precaution

### Warning

- ◆ Never disassemble or modify this product, unless otherwise specified to do so in this manual.
- ◆ When hands are wet, avoid handling this product and do not touch any of the connection cable pins or other metallic components.
- ◆ Do not operate this product in an environment that is exposed to rain or other severe external elements, hazardous gases or chemicals.
- ◆ If the product is not to be used for an extended period of time, as a safety precaution, always unplug the connection cable from the camera unit.
- ◆ If the product installation or inspection must be executed in an overhead location, please take the necessary measures to prevent the camera unit and its components from accidentally falling to the ground.
- ◆ If smoke, an abnormal odor or strange noise is emitted from the camera unit, first turn OFF power, then unplug the cable from the camera unit.
- ◆ This product is not intended for use in a system configuration built for critical applications.

## Instructions before use

- ◆ Only operate this product within the recommended environmental temperature range.
- ◆ Use only the specified power source and voltage rating.
- ◆ Do not drop this product. Avoid exposure to strong impact and vibrations.
- ◆ Install the camera unit in a well-ventilated environment, in order to prevent the camera from overheating.
- ◆ If the camera must be installed in an environment containing dust or other particles, take required measures to protect the camera unit from dust adhesion.
- ◆ Do not unplug the cable while power is being supplied to the camera unit. To prevent product damage, always shut down the power supply before unplugging the power cable.
- ◆ When the surface of the camera window becomes dirty due to dust or grime, black smudges appear in the displayed image. Use an air blower to remove the dust particles. Dip a cotton swab into ethanol alcohol and clean the camera window. Be careful not to scratch the glass.
- ◆ Use of non-infrared lighting such as a fluorescent lamp is recommended. If halogen lighting is employed, always install an infrared filter into your system configuration.
- ◆ Please note that exposure to long wavelength light outside of the sensors visible optical range can affect the image.
- ◆ Sensitivity may fluctuate depending on the spectral response level of the light source. In cases like this, changing the light source to one with a different spectral response level may reduce this problem.
- ◆ Do not use the ultraviolet rays and the X-rays wavelength as the lighting source because a characteristic of the image sensor may deteriorate.
- ◆ Avoid exposing the image sensor under excessive light quantity for a long period.
- ◆ For stabilized image capturing, turn On the power supply and execute aging for ten to twenty minutes before actually using the camera unit.
- ◆ Do not share the power supply with motor units or other devices that generate noise interference.
- ◆ The signal ground (SG) and the frame ground (FG) are connected inside the camera unit. Design the system configuration so that a loop will not be formed by the ground potential differential.
- ◆ Do not disconnect the camera while rewriting an embedded memory.
- ◆ When you change exposure mode that is set at NED factory, input control signal (CC1) from the capture board.

## Product Warranty

### Warranty Period

- ◆ The product warranty period, as a general rule, is two years from purchase; however for detailed conditions please contact the sales representative for your region/country.
- ◆ However, in some cases due to the usage environment, usage conditions and/or frequency of use, this warranty period may not be applicable.

### Warranty Scope

- ◆ Product repair will be performed on a Return To Manufacturer basis. On-site maintenance will incur additional charges.
- ◆ If defects in material or workmanship occur during the warranty period, the faulty part will be replaced or repaired by us free of charge. Return shipping charges must be paid by the sender. However, the following cases fall outside of the scope of this warranty:
- ◆ The expired date of the warranty period on the product repaired or replaced during the warranty period of the original product is the same as the expired date of the warranty period on the original product.

### Exclusions from Warranty Coverage

- ◆ We will under no circumstances assume responsibility for the following cases: damage caused by fire, earthquake, other acts of a third party, other accidents, negligent or intentional misuse by the user, or other usage under extraordinary circumstances.
- ◆ Damages (e.g. loss of business profits, business interruption, etc.) resulting from use or non-use.
- ◆ Damages caused by use other than as described in this document.
- ◆ Damages resulting from malfunction due to a connected device.
- ◆ Damages resulting from repairs or modifications performed by the customer.

### Fault Diagnosis

- ◆ As a general rule, in the first instance fault diagnosis should take the form of a telephone call or an email to enable us to assess the circumstances of the malfunction.
- ◆ However, depending on the customer's requests, we, or our agent, may require an additional fee for this service.

### Exclusion of Liability for Compensation for Missed Opportunities

- ◆ Regardless of whether within the warranty period or not, our warranty does not cover compensation for missed opportunities for our customers, or our customers' customers, caused by a fault of our products, nor for damage to products other than our own, or related business.

### Note about Product Usage

- ◆ This product has been designed and manufactured as a general-purpose product for general industry. In applications expected to be life-critical or safety-critical, the installer or user is requested to install double or triple failsafe systems.

### Repair Service Outline

- ◆ The cost of dispatching engineers etc. for repair service is not included in the price of purchased and supplied goods. On request, arrangements can be made separately.

### Scope of Repair Service

- ◆ The above assumes business dealings and usage to take place in the customer's region / country. In cases of business dealings and/or usage outside the customer's region/country, separate consultation is required.

## Table of Contents

1	Product Outline.....	10
1.1	Features.....	10
1.2	Application.....	10
1.3	Image Sensor.....	11
1.4	Performance Specifications.....	11
2.	Camera Setting and Optical Interface.....	13
2.1	Setting the Camera.....	13
2.2	Fixing the Camera.....	13
2.3	Dimensions of Camera.....	14
2.4	Optical Interface.....	15
3.	Hardware.....	16
3.1	Camera Connection.....	16
3.2	Input / Output Connectors and Indicator.....	17
3.3	Connectors · Pin Assignments · Cables.....	18
3.4	Power Supply.....	24
4	Camera Control.....	25
4.1	Flow of Camera Control.....	25
4.1.1	Command Overview.....	25
4.1.2	Camera Receiving Message (PC Sending Command).....	25
4.1.3	Camera Sending Message (PC Receiving Message).....	26
4.1.4	Camera Control Commands.....	27
4.1.5	Memory Setup Values (Factory Settings).....	28
4.2	Details on Commands.....	29
4.2.1	Setting Analog Gain.....	29
4.2.2	Setting Digital Gain.....	29
4.2.3	Setting Digital Offset.....	29
4.2.4	Setting Exposure Mode.....	29
4.2.5	Setting Exposure Time.....	30
4.2.6	Setting Scan Rate.....	30
4.2.7	Pixel Format.....	31
4.2.8	Clock Frequency of Camera Link.....	31
4.2.9	Output Tap Pattern (Geometry).....	31
4.2.10	Setting Scanning Direction.....	31
4.2.11	Scan Direction Control Setting.....	32
4.2.12	Readout Pixel Quantity.....	32

4.2.13 Pixel Number of reading start position .....	33
4.2.14 Horizontal Pixel Binning .....	33
4.2.15 Pixel Binning Mode .....	33
4.2.16 Setting Gamma correction.....	34
4.2.17 Test Pattern Display .....	34
4.2.18 Readout Camera Internal PCB Temperature .....	34
4.2.19 Memory Initializing (Initializing Camera Settings) .....	35
4.2.20 Memory Load (Readout the Camera setting from the flash memory) .....	35
4.2.21 Memory Save.....	35
4.2.22 Setting Pixel Correction mode .....	36
4.2.23 Pixel Correction Target Level .....	36
4.2.24 Pixel Correction Data Acquisition (shading) .....	36
4.2.25 Pixel Correction Data Acquisition (illuminating).....	36
4.2.26 Returning the Camera Settings to the its original status.....	37
4.2.27 Setting Transmission speed.....	37
4.3 Digital Processing flow in FPGA .....	38
4.4 Startup .....	38
4.5 Saving and Loading Camera Settings .....	38
4.6 Serial Communication Settings.....	39
4.7 Setting Gain .....	40
4.8 Setting Offset.....	41
4.9 Exposure Mode and Timing Chart.....	41
4.9.1 Free Run Exposure Mode (Programming time setting).....	42
4.9.2 External Trigger Exposure Mode (Trigger Edge) .....	43
4.9.3 External Trigger Exposure Mode (Trigger Level).....	44
4.10 Video Output Format.....	45
4.10.1 Pixel Format .....	45
4.10.2 Clock Frequency of Camera Link .....	45
4.10.3 Tap Geometry .....	46
4.10.4 Camera Scan Readout Direction Setting .....	47
4.10.5 Pixel Selection (ROI) .....	48
4.10.6 Horizontal Pixel Binning .....	48
4.10.7 Gamma Correction Setting.....	49
4.11 Pixel Correction .....	52
4.11.1 Operating Procedure.....	53
<b>5 Sensor Handling Instructions.....</b>	<b>54</b>
5.1 Electrostatic Discharge and the Sensor .....	54
5.2 Protecting Against Dust, Oil and Scratches.....	54
5.3 Cleaning the Sensor Window.....	54

---

<b>6 Troubleshooting</b> .....	<b>55</b>
<b>6.1 When there is no Image</b> .....	<b>55</b>
<b>6.2 When Noise is present in the Image</b> .....	<b>57</b>
<b>6.3 When the Camera becomes hot</b> .....	<b>59</b>
<b>7 Others</b> .....	<b>60</b>
<b>7.1 Notice</b> .....	<b>60</b>
<b>7.2 Contact for support</b> .....	<b>60</b>
<b>7.3 Product Support</b> .....	<b>61</b>
<b>7.3.1 Warranty card (attach a separate)</b> .....	<b>61</b>
<b>7.3.2 When you need to repair</b> .....	<b>61</b>

# 1 Product Outline

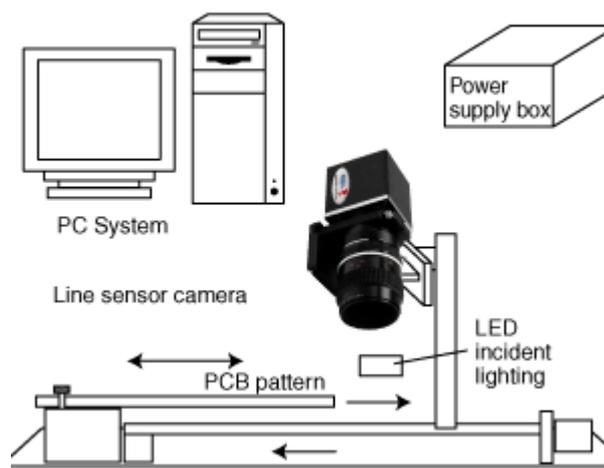
## 1.1 Features

- High speed readout (100KHz)
- Resolution (4096 pixels)
- Easy control of gain / offset / video output with external software.
- Easy connection with a variety of frame grabber boards via Camera Link interface
- Single power source DC 12V to 15V for operation
- PRNU / Shading correcting function

## 1.2 Application

- Inspection of Transparent panels and PCBs
- Inspection of high speed moving objects
- Flat panel display inspection
- Inspection of glass and sheet-like objects
- Visual inspection of printed circuit boards
- This camera utilizes an Intelligent Transportation System
- Outdoor surveillance

An example of Visual Inspection is shown below.



**Figure 1-2-1 Visual Inspection of PCBs**

**Object of inspection (example)**   ▪ printed circuit boards

**Device specification**

1. Camera: Colour Line scan camera
2. Controller: Dedicated software for PC system

### 1.3 Image Sensor

The camera adopts a monochromatic CMOS sensor with 4096 pixels to acquire high responsivity and superior quality images.

### 1.4 Performance Specifications

The Performance Specifications are shown in Table 1-4-1. It shows the data when the camera is operating at maximum scan rate, unless otherwise specified.

**Table 1-4-1 Performance Specifications**

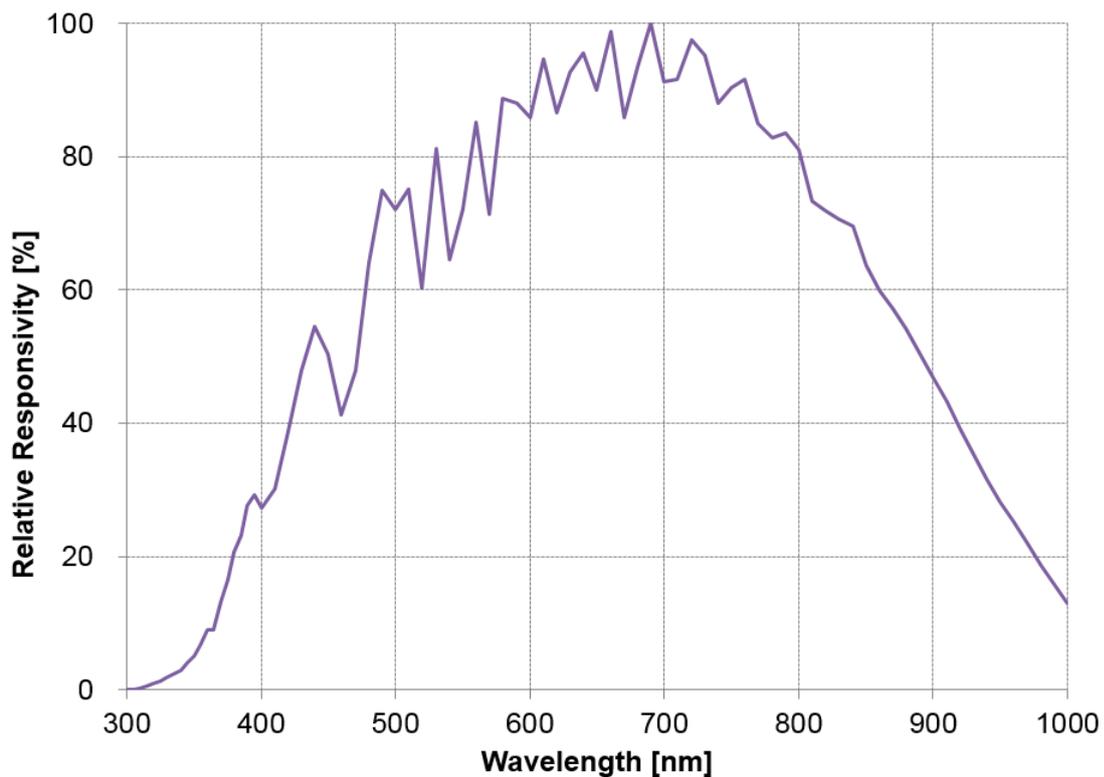
Items		Specifications
Number of Pixels		4096
Pixel Size H x V (μm)		7 x 7
Sensor Length (mm)		28.672
Clock frequency of Camera Link(MHz)		80 or 40
Max Scan Rate (kHz)		100
Min Scan Period(μs)		10
Saturation Exposure (lx·s) (typically) [Minimum Gain]		0.067
Responsivity (V/ [lx·s]) (typically) [Minimum Gain]		75 * Analog 5V Conversion Sensitivity
Gain Adjustable Range *Analog Amplifier +Digital		Analog Amplifier : x1,x2,x4,x8,x10,x18 Digital : x1 to x2 (512 Steps)
Digital Offset Adjustable Range (DN)		Digital : -40 to 40 (161 Steps) 8-bit -160 to 160 (161 Steps) 10-bit
Video output Camera Link		Camera Link Base,Medium,Full,Deca Configuration
Control Input		CC1 : External Trigger Signal CC3 : Scan Direction Switching CC2,4 : Not in use
Connectors	Data/Controller	3M : SDR26[Mini Camera Link] x 2
	Power Supply	Hirose: HR10A (6-Pin)
Lens Mount		Nikon F Mount
Operating Humidity (%RH) No Condensation		0 to 50
Power Supply Voltage (V)		DC12 to 15 [+/-5%]
Consumption Current (mA) (typically)		860
Size W x H x D (mm)		60 x 100 x 74.1(F Mount)
Mass (g) (Camera only)		450(F Mount)

Additional Functions	1 Shading Correction、 Gamma Correction 2 Pixel Selection (ROI) 3 Binning
----------------------	--

**Notes:**

- 1) Measurements were made at room temperature, daylight fluorescent light, a visible range and initial setting value of pixel correction in factory shipment.

The spectral responsivity is shown below.



**Figure 1-4-1 Spectral Responsivity**

The quantum efficiency is shown below.

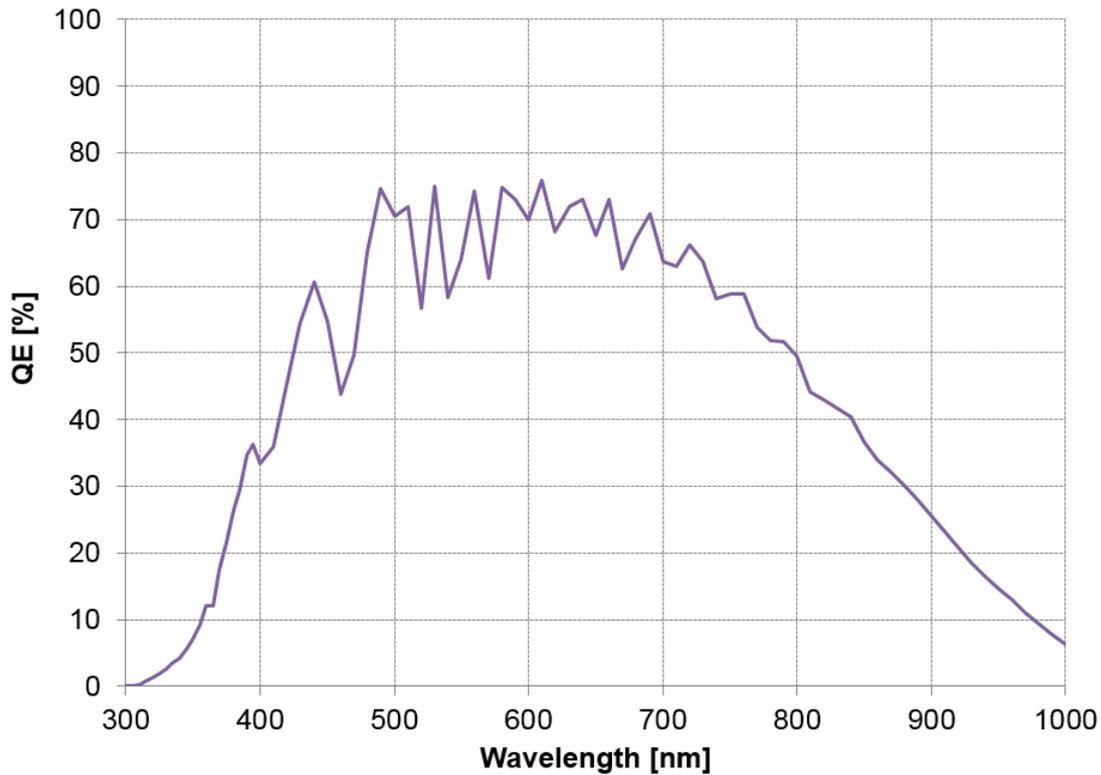


Figure 1-4-2 Quantum Efficiency

## 2. Camera Setting and Optical Interface

### 2.1 Setting the Camera

Use the M4 screw holes or the tripod screw hole to set the camera.

Use the camera mounting bracket with excellent heat radiation property to radiate the heat of the camera from camera front panel to the camera mounting bracket.

### 2.2 Fixing the Camera

- Use the M4 screw holes (4 places at the front, 8 places at the side) to fix the camera.
- Or use the 1/4"-20UNC screw hole for a tripod (1 place at the side).
- ◆ If using the front panel M4 mounting holes, the screw length for fixing the camera should be less than 8mm at the front, and less than 6mm at the side.
- ◆ No X-, Y-axis orientation and tilt adjustment mechanism is available. Please provide an adjustment mechanism yourself as necessary.

### 2.3 Dimensions of Camera

The dimensions of the camera are shown below.

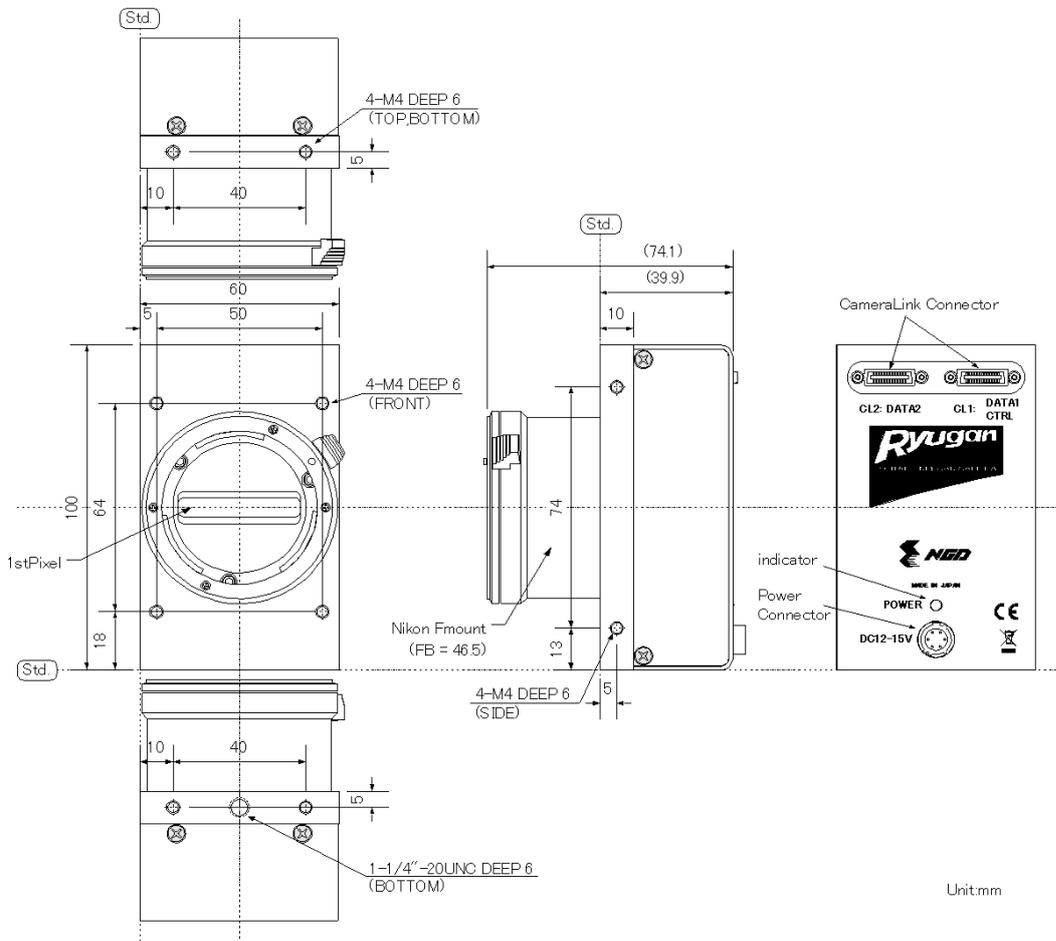


Figure 2-3-1 Dimensions of the Camera (F Mount)

## 2.4 Optical Interface

Nikon F mount is provided as standard. The amount and wavelengths of light required to capture useful images depend on the intended use. Factors include the physical properties, speed, the object's spectral characteristics, exposure time, the light source characteristics, the specifications of the acquisition system and so on.

The exposure amount (exposure time x light amount) is the most important factor in getting desirable images. Please determine the exposure amount after studying what is most important to your system.

Keep these guidelines in mind when setting up your light source:

- LED light sources are relatively inexpensive, provide a uniform field and longer life span compared to other light sources. However, they also require a camera with excellent sensitivity.
- Halogen light sources generally provide very little blue light but have high infrared light (IR) proportions.
- Fiber-optic light distribution systems generally transmit very little blue light relative to IR.
- Metal halide light sources are very bright but have a shorter life span compared to other light sources.
- Generally speaking, the brighter the light sources, the shorter the life span.

CMOS image sensors are sensitive to infrared (IR). We recommend using daylight colour fluorescent lamps that have low IR emissions. If you use a halogen light source, to prevent infrared from distorting the images use an IR cutoff filter that does not transmit wavelengths.

## 3. Hardware

### 3.1 Camera Connection

Use the camera in the following way:

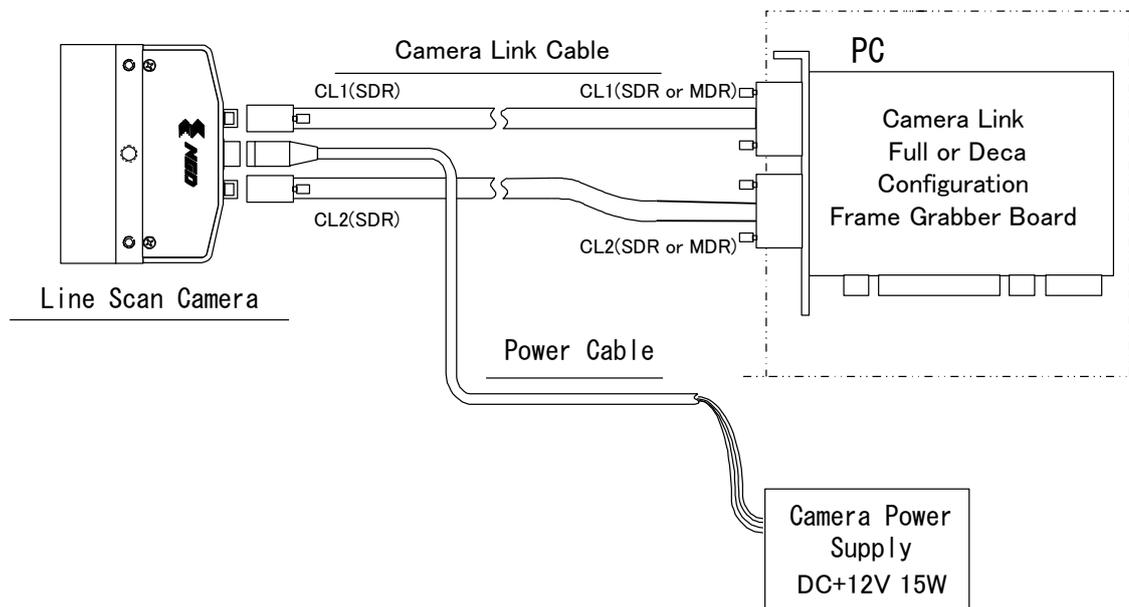
- ( 1 ) Camera Link cables must be used to connect the camera unit with the frame grabber board.

Notes:

Use two cables of the same length and the same manufacturer. If you use asymmetric Camera Link cables, connect the camera with the connector labeled as "Camera side".

- ( 2 ) Connect the camera with the designated power supply.

Use the designated power cable to connect the camera with the power source for the camera. Insert the plug end of the cable into the camera. Attach the opposite end (loose wires) to the power unit. Other than those above, a personal computer, a frame grabber board, a compatible lens, a lens mount, a light source and an encoder are necessary, depending on the situation.



**Figure 3-1-1 Connections between Camera and Frame Grabber Board and Power Supply**

**Notes:**

- 1) There are two connectors available for the Camera Link Medium or Full Configuration board. Always check the frame grabber board specifications before making connections.

<Note: Choosing the appropriate Camera Link cable length>

According to the Camera Link Specification, the maximum cable length is 10m. But the maximum cable length to be able to transfer data depends on the type of cable performance and clock speed. The actual maximum transmission distance becomes less than 10m at faster clock speeds, though the transmission distance of 10m is feasible at slower clock speeds.

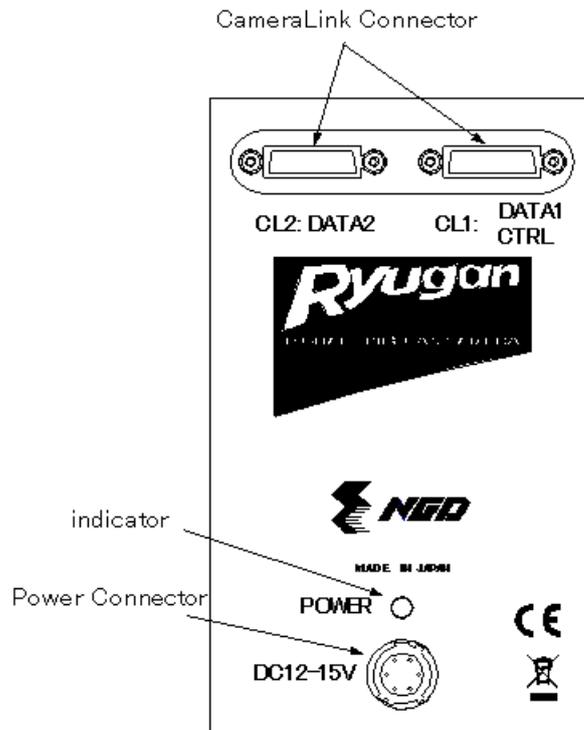
The following table shows values being calculated in accordance with the Camera Link Specification 2007.Version1.2, using a typical cable (14B26-SZLB-xxx-0LC from 3M) and frame grabber board (Solios from Matrox). Please choose the appropriate Camera Link cable type and length for your application. We recommend you perform a connection test in advance.

**Table 3-1-1 calculated value of maximum cable length**

Solios model	clock speed (MHz)	maximum cable length (m)
SOL 6M CL E* (20~66MHz)	40	9.8
	66	8.0
SOL 6M FC E* (20~85MHz)	75	7.6
	85	5.8

### 3.2 Input / Output Connectors and Indicator

The layout of input /output connectors and the LED indicator are as follows.



**Figure 3-2-1 Input / Output Connectors and Power connector**

### 3.3 Connectors • Pin Assignments • Cables

This camera adopts Base~Full (Deca) Configuration of Camera Link interface standards. The figure shown below shows the interface for the camera and a typical implementation for the frame grabber interface.

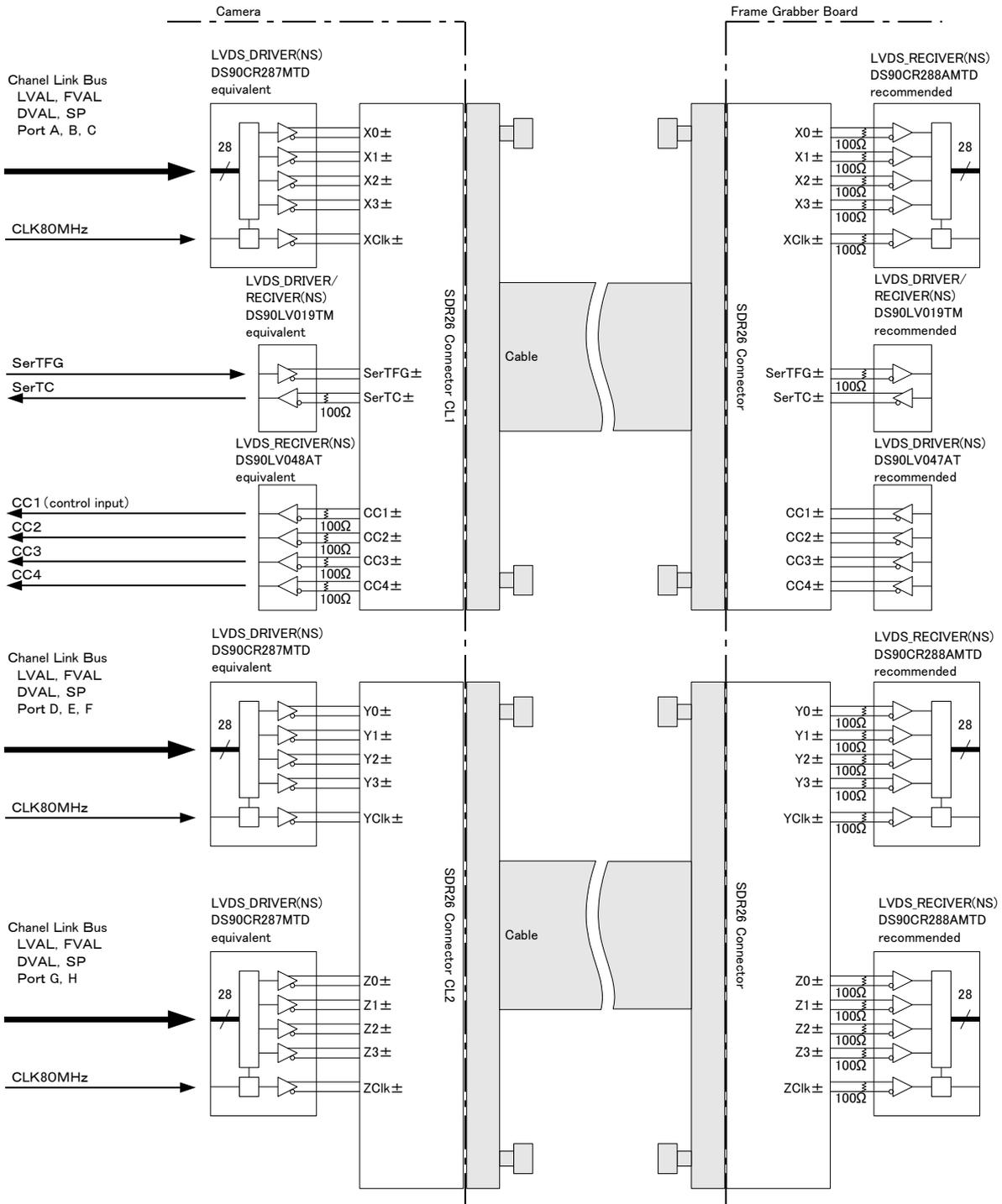


Figure 3-3-1 Camera / Frame Grabber Interface (Base, Medium, and Full)

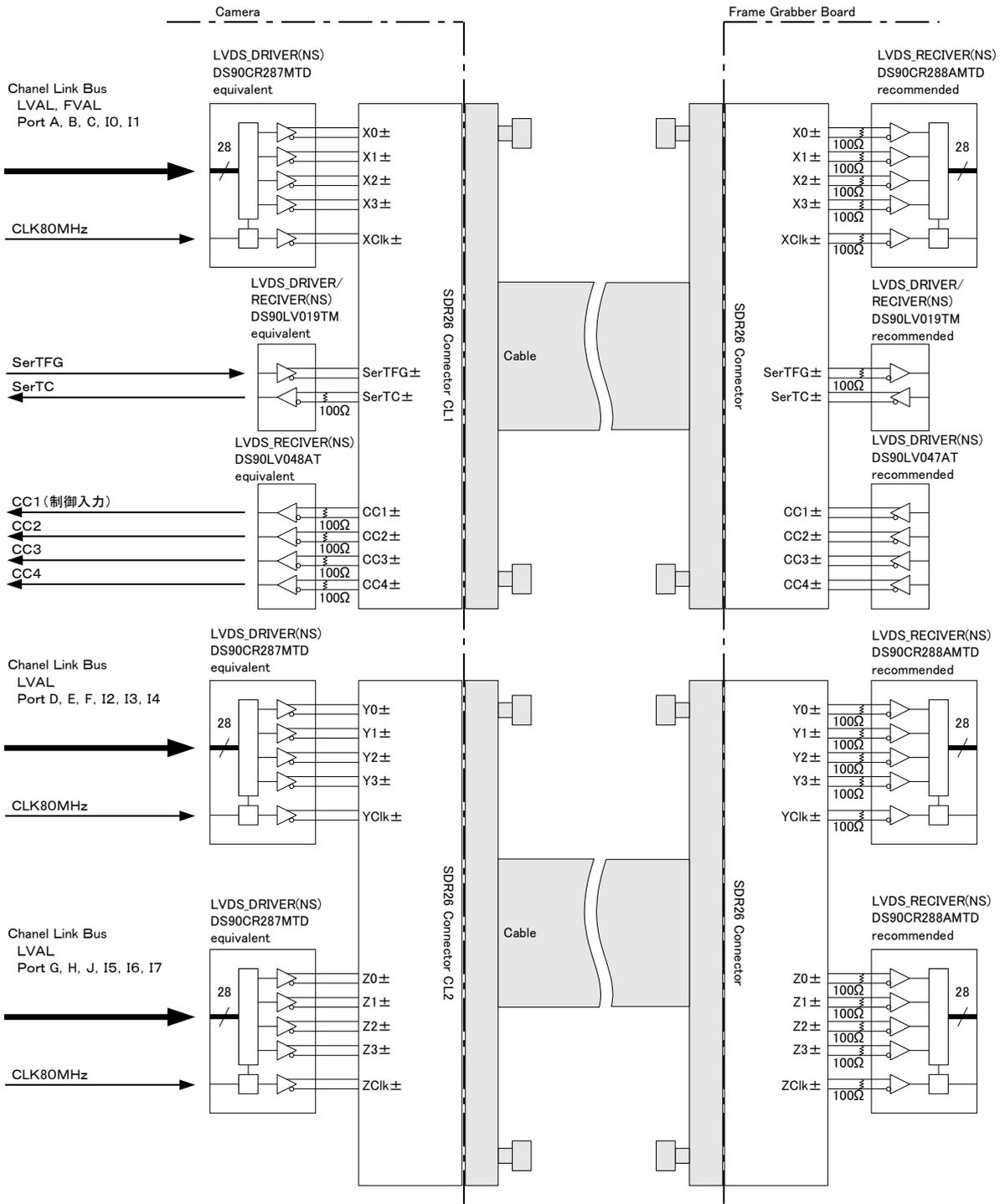


Figure 3-3-2 Camera / Frame Grabber Interface (Deca 80bit 8tap/10bit)

The table below shows the Camera Link port assignments.

**Table 3-3-1 Camera Link Output bit assignments**

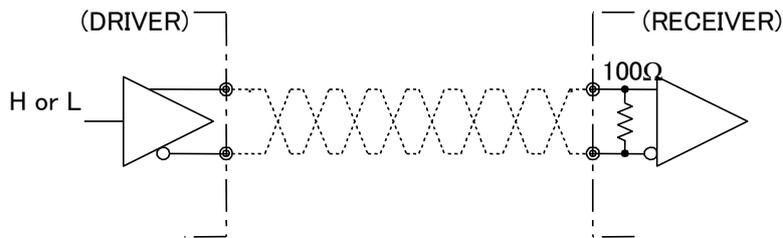
		CN No.	1 zone in X with 2 taps.		1 zone in X with 4 taps.		1 zone in X with 8 taps.	
			Mono8	Mono10	Mono8	Mono10	Mono8	Mono10
Base	Port A0	CL1	A0	A0	A0	A0	A0	A2
	Port A1		A1	A1	A1	A1	A1	A3
	Port A2		A2	A2	A2	A2	A2	A4
	Port A3		A3	A3	A3	A3	A3	A5
	Port A4		A4	A4	A4	A4	A4	A6
	Port A5		A5	A5	A5	A5	A5	A7
	Port A6		A6	A6	A6	A6	A6	A8
	Port A7		A7	A7	A7	A7	A7	A9
	Port B0		B0	A8	B0	A8	B0	B2
	Port B1		B1	A9	B1	A9	B1	B3
	Port B2		B2	—	B2	—	B2	B4
	Port B3		B3	—	B3	—	B3	B5
	Port B4		B4	B8	B4	B8	B4	B6
	Port B5		B5	B9	B5	B9	B5	B7
	Port B6		B6	—	B6	—	B6	B8
	Port B7		B7	—	B7	—	B7	B9
	Port C0		—	B0	C0	B0	C0	C2
	Port C1		—	B1	C1	B1	C1	C3
	Port C2		—	B2	C2	B2	C2	C4
	Port C3		—	B3	C3	B3	C3	C5
	Port C4		—	B4	C4	B4	C4	C6
Port C5	—	B5	C5	B5	C5	C7		
Port C6	—	B6	C6	B6	C6	C8		
Port C7	—	B7	C7	B7	C7	C9		
Midium	Port D0	CL2	—	—	D0	D0	D0	D2
	Port D1		—	—	D1	D1	D1	D3
	Port D2		—	—	D2	D2	D2	D4
	Port D3		—	—	D3	D3	D3	D5
	Port D4		—	—	D4	D4	D4	D6
	Port D5		—	—	D5	D5	D5	D7
	Port D6		—	—	D6	D6	D6	D8
	Port D7		—	—	D7	D7	D7	D9

		CN No.	1 zone in X with 2 taps.		1 zone in X with 4 taps.		1 zone in X with 8 taps.	
			Mono8	Mono10	Mono8	Mono10	Mono8	Mono10
Medium	Port E0	CL2	—	—	—	C0	E0	E2
	Port E1		—	—	—	C1	E1	E3
	Port E2		—	—	—	C2	E2	E4
	Port E3		—	—	—	C3	E3	E5
	Port E4		—	—	—	C4	E4	E6
	Port E5		—	—	—	C5	E5	E7
	Port E6		—	—	—	C6	E6	E8
	Port E7		—	—	—	C7	E7	E9
	Port F0		—	—	—	C8	F0	F2
	Port F1		—	—	—	C9	F1	F3
	Port F2		—	—	—	—	F2	F4
	Port F3		—	—	—	—	F3	F5
	Port F4		—	—	—	D8	F4	F6
	Port F5		—	—	—	D9	F5	F7
	Port F6		—	—	—	—	F6	F8
	Port F7		—	—	—	—	F7	F9
	Full		Port G0	—	—	—	—	G0
Port G1			—	—	—	—	G1	G3
Port G2			—	—	—	—	G2	G4
Port G3			—	—	—	—	G3	G5
Port G4			—	—	—	—	G4	G6
Port G5			—	—	—	—	G5	G7
Port G6			—	—	—	—	G6	G8
Port G7			—	—	—	—	G7	G9
Port H0			—	—	—	—	H0	H2
Port H1			—	—	—	—	H1	H3
Port H2			—	—	—	—	H2	H4
Port H3		—	—	—	—	H3	H5	
Port H4		—	—	—	—	H4	H6	
Port H5		—	—	—	—	H5	H7	
Port H6	—	—	—	—	H6	H8		
Port H7	—	—	—	—	H7	H9		

		CN No.	1 zone in X with 2 taps.		1 zone in X with 4 taps.		1 zone in X with 8 taps.	
			Mono8	Mono10	Mono8	Mono10	Mono8	Mono10
Deca 80bit 8tap/10bit	Port I0	CL1	—	—	—	—	—	A0
	Port I1		—	—	—	—	—	A1
	Port I2	CL2	—	—	—	—	—	B0
	Port I3		—	—	—	—	—	B1
	Port I4		—	—	—	—	—	C0
	Port I5		—	—	—	—	—	C1
	Port I6		—	—	—	—	—	D0
	Port I7		—	—	—	—	—	D1
	Port J0		—	—	—	—	—	E0
	Port J1		—	—	—	—	—	E1
	Port J2		—	—	—	—	—	F0
	Port J3		—	—	—	—	—	F1
	Port J4		—	—	—	—	—	G0
	Port J5		—	—	—	—	—	G1
	Port J6		—	—	—	—	—	H0
	Port J7		—	—	—	—	—	H1

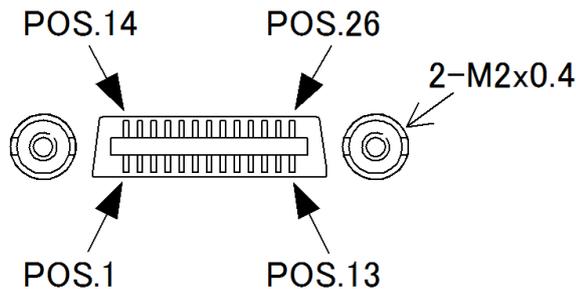
**Notes:**

- 1) Set the LVDS, Channel Link receiver side to 100-ohm termination.
- 2) With the driver side of LVDS, even if not used, do not make it open but set the logic to H or L.



**Figure 3-3-3 Circuit of LVDS**

The camera has 26-pin SDR connectors(0.8mm pitch) for control signals of Camera Link, data signals and serial communications.



**Figure 3-3-4 Mini Camera Link Connector**

**Table 3-3-2 Camera Link Connector (26-pin SDR Connector) pin assignments**

CL1(Base Configuration)					CL2(Medium or Full Configuration)				
No	NAME	No	NAME	I/O	No	NAME	No	NAME	I/O
1	Inner Shield	14	Inner Shield		1	Inner Shield	14	Inner Shield	
2	X0-	15	X0+	Out	2	Y0-	15	Y0+	Out
3	X1-	16	X1+	Out	3	Y1-	16	Y1+	Out
4	X2-	17	X2+	Out	4	Y2-	17	Y2+	Out
5	Xclk-	18	Xclk+	Out	5	Yclk-	18	Yclk+	Out
6	X3-	19	X3+	Out	6	Y3-	19	Y3+	Out
7	SerTC+	20	SerTC-	In	7	100Ω terminated	20	100Ω terminated	
8	SerTFG-	21	SerTFG+	Out	8	Z0-	21	Z0+	Out
9	CC1-	22	CC1+	In	9	Z1-	22	Z1+	Out
10	CC2+	23	CC2-	In	10	Z2-	23	Z2+	Out
11	CC3-	24	CC3+	In	11	Zclk-	24	Zclk+	Out
12	CC4+	25	CC4-	In	12	Z3-	25	Z3+	Out
13	Inner Shield	26	Inner Shield		13	Inner Shield	26	Inner Shield	

● Explanation of Signals

Inner Shield: Shield cable (GND)

X0+, X0-...X3+, X3-: Data output (Channel Link)

Xclk+, Xclk-: Clock output for above data output synchronization  
(Channel Link)

Y0+, Y0-...Y3+, Y3-: Data output (Channel Link)

Yclk+, Yclk-: Clock output for above data output synchronization  
(Channel Link)

Z0+, Z0-...Z3+, Z3-: Data output (Channel Link)

Zclk+, Zclk -: Clock output for above data output synchronization (Channel Link)

SerTC+, SerTC- : Serial data input (LVDS)

SerTFG+, SerTFG-: Serial data output (LVDS)

CC1+, CC1- : External synchronous signal input (LVDS)

CC2+, CC2-: Not in use (LVDS)

CC3+, CC3-: External scan direction control (LVDS) ※When external control is used.

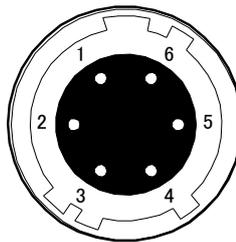
CC4+, CC4-: Not in use (LVDS)

- Camera Link compatible cable  
3M: SDR-MDR : 1MF26-L560-00C-xxx by or equivalent  
3M: SDR-SDR : 1SF26-L120-00C-xxx by or equivalent

Notes:

- 1) To avoid uncoupling of the cable connectors during power on, make sure to clamp them with the locking screws.
- 2) Do not unplug the cables while power is being supplied to the camera.

This camera uses 6-pin round shape push-pull lock type connector for the Power Supply



**Figure 3-3-5 Power Supply Connector (HIROSE: HR10G-7R-6PB)**

**Table 3-3-3 Pin Assignment of Power Supply Connector**

No	NAME	Colour of Cable
1	DC12 –15V	White
2	DC12 –15V	Red
3	DC12 –15V	—
4	GND	Green
5	GND	Black
6	GND	—

Note:

The cable colour in the table describes the compatible cable DGPSH-10.

### 3.4 Power Supply

The camera requires a single power supply (DC+12 to +15V).

The indicator (LED) blinks orange when power is supplied. After a short period, it changes to a solid green light, indicating that the camera is operational.

**Notes:**

- 1) When selecting a power source, choose one with the capacity to allow for inrush current. (15 W or more recommended)
- 2) When the power supply starts up, the required voltage must be increased monotonously within 500msec..
- 3) Insert the cable plug securely until it locks into position. This is to prevent the connector from coming loose during power transmission.

- 4) Take the necessary countermeasures in the electric supply line for lightning surge protection, if the camera is used in the area where lightning strikes often occur.
- 5) Do not share the power supply and ground connection with the apparatus such as the inverter controlled motor units or other devices that generate noise interference to avoid the failure and malfunction of the camera. Place the camera far away from the apparatus generating noise. Do not arrange the signal cables and the power supply cable for camera adjacently.
- 6) If the lamp fails to illuminate even after power is switched on, turn off power immediately. Inspect wiring. Check the voltage and capacity of the supplied power source.
- 7) It is recommended that the shield processing of the power cable to be connected with GND on the power supply side.

## 4 Camera Control

The camera can be controlled directly by commands through the serial communication. The attached camera control software can also be used for camera control.

Once the camera has been set up according to your requirements, the camera can be used to read data without need of controlling it via the serial interface.

### 4.1 Flow of Camera Control

#### 4.1.1 Command Overview

The serial interface uses a simple ASCII-based command.

- Communication begins when the computer sends control commands to the camera.
- The camera receives and interprets the computer commands and then executes control operations accordingly.
- Transmission ends when the camera returns the analyzed results of the control commands to the computer.
- ◆ Always allow the previous transmission to end before starting the next transmission. (Only one command can be sent per transmission.)

#### 4.1.2 Camera Receiving Message (PC Sending Command)

- Format S1    CMD CR
- Format S2    CMD □ VAL CR

CMD: Control text (3 Bytes) Use 3 lowercase letters only. No numerals allowed.

CR : Carriage Return (0x0D)

□ : Space (0x20) or Comma (0x2C)

VAL : Setting value (decimal), numerical values only

### 4.1.3 Camera Sending Message (PC Receiving Message)

- Format R 1 >R CR >[SB] CR EOT
  - Format R 2 (for "sta" command) >R CR >[MEM] CR >[SB] CR EOT
- > : Results start text (0 x 3E)  
 R: Camera receive command analyzed results  
 [SB] : Camera receive command send back  
 [MEM] : Memory data readout value  
 CR: Separated text (0 x 0D)  
 EOT: Send command all text end text (0 x 04)

**Table 4-1-3-1 Error Messages**

Camera Response	Meaning
OK	Camera executed command
CMD ERR!	Command is not valid
CMD OVR ERR!	Command text line is too long When the control character exceeds 254 characters
VAL ERR!	Parameter accepted was outside of specified
MEM ERR!	Camera memory error
TRG ERR!	When the scanning interval becomes more than a few seconds when arbitrary pixel correction data is acquired.

#### 4.1.4 Camera Control Commands

Table 4-1-4-1 shows the list of Camera Control Commands.

**Table 4-1-4-1 Lists of Camera Control Commands**

Control Item	CMD	VAL	Control Description
Analog Gain	gax	0~5	x1,x2,x4,x8,x10,x18 (x1-x8 recommended)
Digital Gain	gdx	0~511	x1...x2(x0.003906/step)
Digital Offset	odx	-80~80	- 40~+ 40DN(5DN/step at 8-bit) -160~+160DN(2.0DN/step at 10-bit)
Exposure Mode	inm	0/1/2	Free Run/Ext Edge/Ext Level
Programmable Exposure Time	expo	3600~ 1998000	3600~1998000ns(100ns/step)
Scan Rate	prd	500~100000	500~100000Hz(100ns/step)
Pixel Format	pxf	0/1	Mono8/Mono10
Output Tap Pattern (Geometry)	tapg	0/1/2	GenIcam 1X2/1X4/1X8
Clock Frequency of Camera Link	clkcl	80/40	80/40MHz
Scanning Direction	rev	0/1	0: Forward / 1: Reverse
Scan Direction Control	revxi	0/1	Command of Scan Direction/ Control Input CC3
Pixel Number	width	256~4096	256~4096 pixels (8/step at binning 1)
Pixel Offset	offx	0~3840	0~3840 pixels (8/step at binning 1)
Test Pattern	tpn	0/1/2	OFF/Horizontal Ramp/ Horizontal Vertical Ramp
Horizontal Binning Pixel Number	bh	1/2	1 (OFF) /2 pixels
Horizontal Binning Mode	bhm	1/2	Addition/ Addition Average
Transmission Speed (baud rate) Setting	sbaud	9600/115200	9600(initial) /115200bps
Gamma Correction setting	gamma	250~4000	$\gamma$ 0.25~4.00
Pixel Correction Setting	ffcm	0/1	Factory correction data / User arbitrary correction data
Pixel Correction target level	ffct	1~1023	1~1023DN(at 10-bit)
Pixel Correction Data Save [dark]	blk		Arbitrary user's correction data is acquired and stored in the memory.
Pixel Correction Data Save [gray]	wht		Arbitrary user's correction data is acquired and stored in the memory.
Memory Initializing	rst		Reset to factory settings
Memory Load	rfd		Readout setup data in memory
Memory Save	sav		Store present setup data in memory
Readout Internal Temperature	temp		Displays internal PCB temperature (°C)
Operation Status Readout	sta		Readout the current camera settings

#### 4.1.5 Memory Setup Values (Factory Settings)

The memory setup values (factory settings) are shown in Table 4-1-5-1.

**Table 4-1-5-1 Memory Setup Values (Factory Settings)**

Control Item	CMD	VAL	Control Description
Analog Gain	gax	1	x2(6.0dB)
Digital Gain	gdx	0	x1
Digital Offset	odx	0	±0DN
Exposure Mode	inm	0	Free Run
Programmable Exposure Time	expo	98000	98000ns
Scan Rate	prd	10000	10000Hz
Pixel Format	pxf	0	Mono8
Output Tap Pattern(Geometry)	tapg	2	GenIcam 1X8(1zone in X with 8taps)
Clock Frequency of Camera Link	clkcl	80	80MHz
Scanning Direction	rev	0	Forward
Scan Direction Switching	revxi	0	Scan Direction Command Control
Pixel Number	width	4096	4096 pixels
Pixel Offset	offx	0	0 pixel
Test Pattern	tpn	0	OFF
Horizontal Binning Pixel Number	bh	0	1 pixel (OFF)
Horizontal Binning Mode	bhm	0	Addition
Transmission Speed (baud rate)	sbaud	9600	9600bps
Gamma Correction Setting	gamma	1000	$\gamma$ 1.00
Pixel Correction Setting	ffcm	0	Factory correction data On
Pixel Correction target level	ffct	768	768DN(at 10-bit)

## 4.2 Details on Commands

### 4.2.1 Setting Analog Gain

Sets analog gain.

- Format S2, R1
- CMD gax
- VAL 0(x1),1(x2),2(x4),3(x8),4(x10),5(x18)

<Example>

Send: gax □ 4 CR (Setting analog gain 4(x10))

Receive : >OK CR>gax □ 4 CR EOT

### 4.2.2 Setting Digital Gain

Sets the camera digital gain.

- Format S2, R1
- CMD gdx
- VAL 0(x1)~511(x2)

<Example>

Send : gdx □ 256 CR (Setting digital gain 256 (1+256/511) =x1. 50)

Receive : >OK CR > gdx □ 256 CR EOT

### 4.2.3 Setting Digital Offset

Sets digital offset

- Format S2, R1
- CMD odx
- VAL -80 ~ 80

<Example>

Send : odx □ 20 CR (Sets Digital Offset to +10DN at 8-bit/+40DN at 10-bit)

Receive : >OK CR >odx □ 20 CR EOT

### 4.2.4 Setting Exposure Mode

Sets the exposure mode.

- Format S2, R1
- CMD inm
- VAL 0,1,2

<Example>

Send : inm □ 1 CR (Sets the exposure mode to Ext Edge)

Receive : >OK CR >inm □ 1 CR EOT

#### 4.2.5 Setting Exposure Time

Sets the exposure time. Only operates at Free Run/Ext Edge.

- Format S2, R1
- CMD expo
- VAL 3600~1998000(nS)

<Example>

Send : expo □ 100000 CR (Setting exposure time 100μs)

Receive : >OK CR > expo □ 100000 CR EOT

#### Notes :

- 1) This can be operated at the settings of Free Run mode and Ext Edge mode.
- 2) Set the value by 100nS unit. Less than 100ns is cut off automatically at the time when you attempt to set the value with less than 100nS.  
The value without less than 100nS of the exposure time can be obtained by the present value acquisition command

#### 4.2.6 Setting Scan Rate

Sets the Scan Rate.

- Format S2, R1
- CMD prd
- VAL 500~100000(Hz)

<Example>

Send : prd □ 10000 CR (Setting scan rate 100KHz)

Receive : >OK CR > prd □ 10000 CR EOT

#### Notes :

- 1) This can be operated at the setting of Free Run mode
- 2) The relation between the scan rate and the exposure time is as follows.  
Scan period (reciprocal number of the scan rate)  

$$> \text{Exposure time} + 2\mu\text{s}$$
 If the inequality mentioned as above is not met when you attempt to set the scan rate, the camera coordinates the exposure time automatically to meet the above inequality.  
The coordinated exposure time can be obtained by the present value acquisition command.
- 3) If the inequality mentioned as above is not met when you attempt to set the exposure time the camera coordinates the scan rate automatically to meet the above inequality.  
The coordinated scan rate can be obtained by the present value acquisition command.

#### 4.2.7 Pixel Format

Sets the pixel format of the output signal of the camera.

- Format S2, R1
- CMD pxf
- VAL 0(Mono8),1(Mono10)

<Example>

Send : pxf □ 1 CR (Setting the pixel format: 1[Mono] as Monochrome 10bits)

Receive : >OK CR > pxf □ 1 CR EOT

#### 4.2.8 Clock Frequency of Camera Link

Sets the clock frequency of the output signal of the camera.

- Format S2, R1
- CMD clkcl
- VAL 80,40(MHz)

<Example>

Send : clkcl □ 40 CR (Setting the clock frequency:40 as 40MHz)

Receive : >OK CR > clkcl □ 40 CR EOT

#### 4.2.9 Output Tap Pattern (Geometry)

Sets the tap pattern (geometry) of the output signal of the camera.

- Format S2, R1
- CMD tapg
- VAL 0(1X2),1(1X4),2(1X8)

<Example>

Send : tapg □ 1 CR (Setting the tap:1[Genlcam 1X4 ] as 1 zone in X with 4taps)

Receive : >OK CR > tapg □ 1 CR EOT

#### 4.2.10 Setting Scanning Direction

Switches scanning direction.

- Format S2, R1
- CMD rev
- VAL 0(Forward),1(Reverse)

<Example>

Send : rev □ 1 CR (Reverse output)

Receive : >OK CR > rev □ 1 CR EOT

**Note :**

- 1) This can be set only when the scan direction control of 4.2.11 is set to the "0 (Command setting for scan direction)".

#### 4.2.11 Scan Direction Control Setting

Selects the “Command setting” or the “Control Input setting” for the scan direction control of the output signal of the camera.

- Format S2, R1
- CMD revxi
- VAL 0( Command setting for scan direction),  
1(Control Input setting of CC3)

<Example>

Send : revxi □ 1 CR (Setting the scan direction control: 1[Control Input of CC3])

Receive : >OK CR > revxi □ 1 CR EOT

#### Note :

- 1) “L” is the forward direction and “H” is the reverse direction on the Control Input setting of CC3.

#### 4.2.12 Readout Pixel Quantity

Sets the quantity of the readout pixels as ROI (Region of Interest) of the output signal of the camera.

- Format S2, R1
- CMD width
- VAL 256~4096 (pixels)

<Example>

Send : width □ 2048 CR (Setting the quantity of readout pixels :2048 as 2048 pixels)

Receive : >OK CR > width □ 2048 CR EOT

#### Notes :

- 1) Set the value by eight pixels of units at the horizontal binning 1 pixel.

The total values of the quantity of the readout pixels which is set by this and the pixel number of reading start position which is set by 4.2.13 must be less than 4,096.

- 2) Set the value by four pixels of units at the horizontal binning 2 pixels.

The total values of the quantity of the readout pixels which is set by this and the pixel number of reading start position which is set by 4.2.13 must be less than 2,048.

- 3) The value displayed by the operating conditions reading command at the horizontal pixel binning 2 pixels shows a half of pixel numbers.

#### 4.2.13 Pixel Number of reading start position

Sets the pixel number of the reading start position of the output signal of the camera.

- Format S2, R1
- CMD offx
- VAL 0~3840 (pixel)

<Example>

Send : offx □ 512 CR (Setting the pixel number of the reading start position :512 as 512-pixel)

Receive : >OK CR > offx □ 512 CR EOT

#### Notes :

- 1) When the value of the pixel number of reading start position is 0, the reading begins with the first pixel.
- 2) Set the value by eight pixels of units at the horizontal binning 1 pixel.  
The total values of the pixel number of reading start position which is set by this and the quantity of the readout pixels which is set by 4.2.12 must be less than 4,096.
- 3) Set the value by four pixels of units at the horizontal binning 2 pixels.  
The total values of the pixel number of reading start position which is set by this and the quantity of the readout pixels which is set by 4.2.12 must be less than 2,048..
- 4) The value displayed by the operating conditions reading command at the horizontal pixel binning 2 pixels shows a half of pixel numbers.

#### 4.2.14 Horizontal Pixel Binning

Sets the number of horizontal pixel binning of the output signal of the camera.

- Format S2, R1
- CMD bh
- VAL 1(1 pixel, OFF of horizontal pixel binning ), 2(2 pixels)

<Example>

Send : bh □ 2 CR (Setting the horizontal pixel binning:2 as 2pixels)

Receive : >OK CR > bh □ 2 CR EOT

#### 4.2.15 Pixel Binning Mode

Sets the pixel binning mode of the output signal of the camera.

- Format S2, R1
- CMD bhm
- VAL 1(Addition), 2(Addition average)

<Example>

Send : bhm □ 2 CR (Setting the pixel binning mode:2 ([Additon average])

Receive : >OK CR > bhm □ 2 CR EOT

#### 4.2.16 Setting Gamma correction

Sets the gamma correction value.

- Format S2, R1
- CMD gamma
- VAL 250( $\gamma$  0.25)~4000( $\gamma$  4.00)

<Example>

Send : gamma □ 450 CR (Setting the gamma correction coefficient: 0.45)

Receive : >OK CR > gamma □ 450 CR EOT

**Note :**

1) 1/1000 of VAL becomes the coefficient.

#### 4.2.17 Test Pattern Display

Switches the test pattern displays.

- Format S2, R1
- CMD tpn
- VAL 0(OFF), 1(Horizontal ramp pattern), 2(Horizontal & Vertical ramp pattern)

<Example>

Send : tpn □ 1 CR (Setting the test pattern:1(Horizontal ramp pattern))

Receive : >OK CR > tpn □ 1 CR EOT

#### 4.2.18 Readout Camera Internal PCB Temperature

Reads out the camera's internal PCB temperature (Accurate to +/-2C)

- Format S1, R2
- CMD temp

<Example>

Send : temp CR

Receive : >OK CR > Camera Temp= 51.1 Celsius CR > temp CR EOT

**Note :**

1) Temperatures will be expressed in degrees centigrade (Celsius).

#### 4.2.19 Memory Initializing (Initializing Camera Settings)

Resets the flash memory to the factory default.

- Format S1, R2
- CMD rst

<Example>

Send : rst CR

Receive : >OK CR >Model=RMSL4K100CL CR >Ver.=x.xx\_0xxxxx CR  
>Serial=123456 CR >gax 1 CR >gdx 0 CR >odx 0 CR >inm 0 CR  
>prd 10000 CR >expo 98000 CR >ffcm 0 CR >ffct 768 CR >tpn 0 CR  
>rev 0 CR >revxi 0 CR >pxf 0 CR >clkcl 80 CR >tapg 2 CR  
>offx 0 CR >width 4096 CR >bh 1 CR >bhm 1 CR >gamma 1000 CR  
>logmode 1 CR >rst CR EOT

#### 4.2.20 Memory Load (Readout the Camera setting from the flash memory)

Reads out the camera settings from the flash memory.

- Format S1, R2
- CMD rfd

<Example>

Send : rfd CR

Receive : >OK CR >Model=RMSL4K100CL CR >Ver.=x.xx\_0xxxxx CR  
>Serial=123456 CR >gax 1 CR >gdx 0 CR >odx 0 CR >inm 0 CR  
>prd 10000 CR >expo 98000 CR >ffcm 0 CR >ffct 768 CR >tpn 0 CR  
>rev 0 CR >revxi 0 CR >pxf 0 CR >clkcl 80 CR >tapg 2 CR  
>offx 0 CR >width 4096 CR >bh 1 CR >bhm 1 CR >gamma 1000 CR  
>logmode 1 CR >rfd CR EOT

#### 4.2.21 Memory Save

Stores the current camera settings in the flash memory.

- Format S1, R1
- CMD sav

<Example>

Send : sav CR

Receive : >OK CR >sav CR EOT

#### 4.2.22 Setting Pixel Correction mode

Sets pixel correction mode.

- Format S2, R1
- CMD ffcM
- VAL 0: Factory correction data On  
1: User arbitrary correction data On

<Example>

Send : ffcM □ 1 CR (User arbitrary correction data)

Receive : >OK CR > ffcM □ 1 CR EOT

#### 4.2.23 Pixel Correction Target Level

Sets the pixel correction target level (10bit output equivalent value)

- Format S2, R1
- CMD ffct
- VAL 1~1023(DN at10 bits)

<Example>

Send : ffct □ 900 CR (Setting the pixel correction target level:900[900DN at10bit])

Receive : >OK CR > ffct □ 900 CR EOT

#### 4.2.24 Pixel Correction Data Acquisition (shading)

Acquires the pixel correction data (in dark) of the user arbitrary and saves it in flash memory. This can be saved by one each by each step of the analog gain.

- Format S1, R1
- CMD blk

<Example>

Send : ffct CR

Receive : >OK CR > blk CR EOT

#### 4.2.25 Pixel Correction Data Acquisition (illuminating)

Acquires the pixel correction data (in illumination) of the user arbitrary and saves it in flash memory. This can be saved by one each by each step of the analog gain.

- Format S1, R1
- CMD wht

<Example>

Send : wht CR

Receive : >OK CR > wht CR EOT

#### 4.2.26 Returning the Camera Settings to the its original status

Returns the current camera settings.

- Format S1, R2
- CMD sta

<Example>

Send : sta CR

Receive : >OK CR >Type=RMSL4K100CL CR >Ver.=x.xx\_0xxxxx CR  
>Serial=123456 CR >gax 1 CR >gdx 0 CR >odx 0 CR >inm 0 CR  
>prd 10000 CR >expo 98000 CR >ffcm 0 CR >ffct 768 CR >tpn 0 CR  
>rev 0 CR >revxi 0 CR >pxf 0 CR >clkcl 80 CR >tapg 2 CR  
>offx 0 CR >width 4096 CR >bh 1 CR >bhm 1 CR >gamma 1000 CR  
>logmode 1 CR >sta CR EOT

#### 4.2.27 Setting Transmission speed

Sets the serial Transmission speed (baud rate) .

- Format S2, R1
- CMD sbaud
- VAL 9600,115200(bps)

<Example>

Send : sbaud □115200 CR (Sets to 115200bps)

Receive : >OK CR > sbaud □115200 CR EOT

#### Notes :

- 1) The initial setting at startup is 9600.
- 2) The software of the PC must be changed at the same time when the above setting is changed.

### 4.3 Digital Processing flow in FPGA

The digital processing flow in FPGA is shown below.

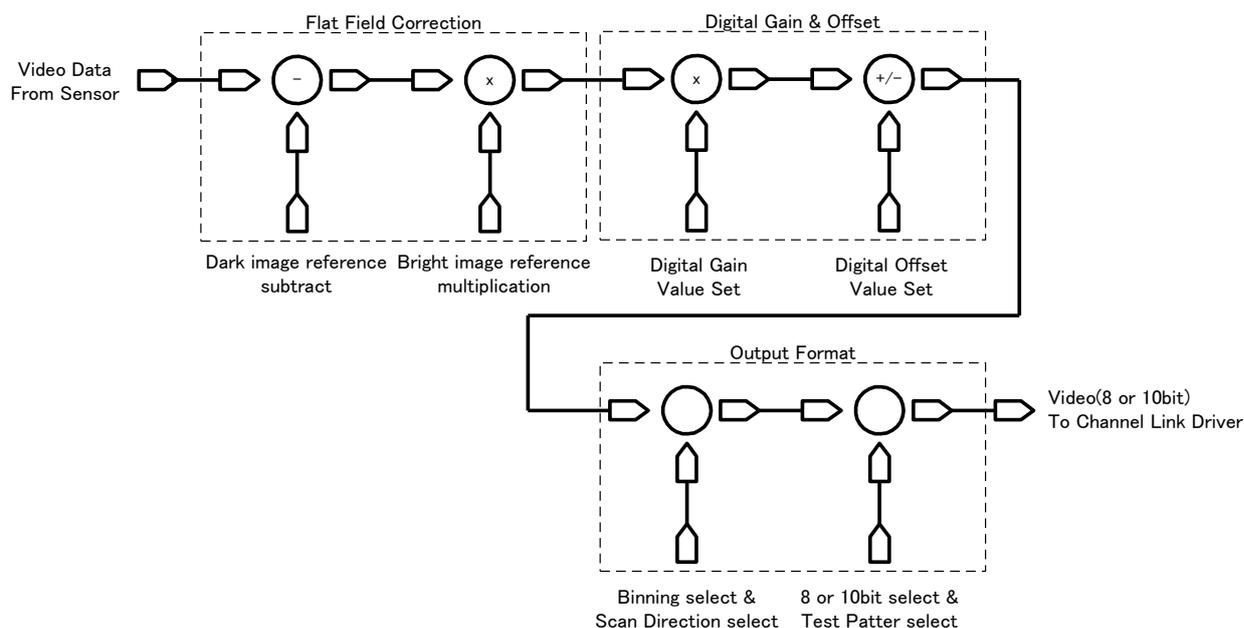


图 4-3-1 FPGA Processing Block Diagram

### 4.4 Startup

After turning on, the camera runs a startup procedure before it starts getting images and outputting data. It takes about 3 seconds.

The startup procedure is as follows:

- (1) The camera hardware initializes. The indicator (LED orange) lights.
- (2) Reads out the latest camera settings from the flash memory. (User settings if any or factory default settings)
- (3) Set up the camera with the setting value from the flash memory.

The colour of the indicator (LED) turns into green from orange.

After those sequences, the camera is ready to get images and output data.

### 4.5 Saving and Loading Camera Settings

The camera settings data is saved in the internal memory (flash memory) and is loaded from the memory when turning on the power supply or loading (sending the "rfd" command).

Commands for rewriting the memory are as follows.

- Reset to factory settings (rst)
- Store present setup data in memory (sav)
- Store pixel correction data in memory (wht,blk)

**Notes:**

- 1) The number of times the flash memory can be rewritten will vary depending on actual operational conditions.
- 2) After turning on the power supply, the camera always checks the memory status. If the data is not within the designated range due to a malfunction or other type of trouble, the memory will be automatically reset to the factory settings.
- 3) If the camera power is disconnected while rewriting the memory, the whole data saved in the memory will be deleted.
- 4) As it takes several seconds to rewrite the memory, do not disconnect power supply before receiving the answer from the camera.
- 5) If you want to change the setting of trigger exposure mode from the factory setting, supply the Control Input signal (CC1) from the frame grabber board to the camera. The image can not be captured if the Control Input signal is not supplied to the camera or the settings of trigger exposure mode is out of the specification range. (See 4.9.2 and 4.9.3 for more details.)
- 6) See 4.2.19, 4.2.20 and 4.2.21 for the information of Commands

**Table 4-5-1 Camera Operation Mode and Control Input**

Camera operation mode (Exposure mode)	Control input (from frame grabber board)
Free Run (Programmable time setting) (Factory Setting)	Not in use
Ext Edge (External trigger edge + Programmable time setting)	External trigger (CC1) is required
Ext Level (External trigger level time setting)	External trigger (CC1) is required

**4.6 Serial Communication Settings**

Serial communication is performed through the Camera Link Interface

Table 4-6-1 shows serial communication settings.

**Table 4-6-1 Communication Settings**

Parameter Items	Setup Value
Communication Speed (Baud rate)	9600bps
Data Length	8bit
Parity Bit	None
Stop bit	1bit
Flow Control	None

**Note :**

- 1) See 4.2.27 for the information of Commands.

## 4.7 Setting Gain

Gain can be adjusted by setting analog gain (6 steps, x1~x18) or digital gain (512 steps, x1~x2). In both cases, increasing the gain setting increases the slope of the camera's response curve, so that the output saturates at a lower level of light. Conversely, with less light, a higher output can be obtained; that is to say, the camera's sensitivity has been increased.

The command "gax" is used for analog gain setting and the command "gdx" is used for digital gain setting.

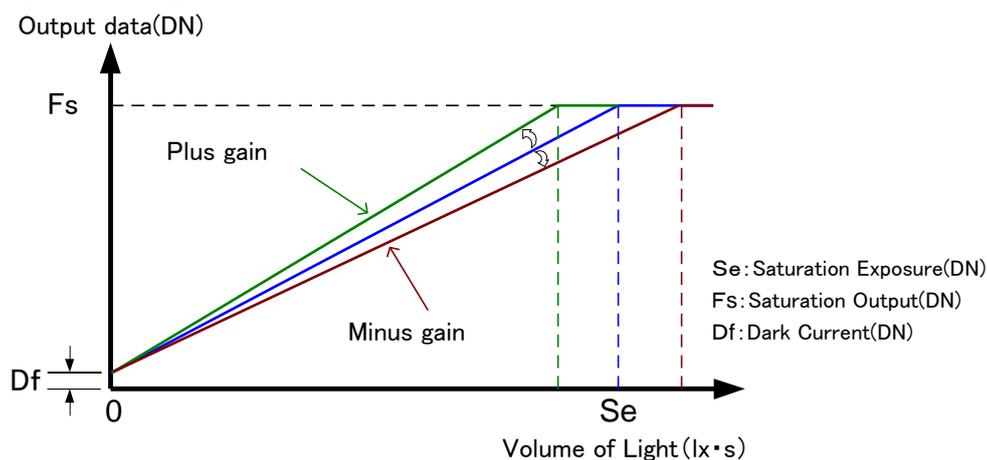


Figure 4-7-1 Gain Adjustment

Gain-Sensitivity at digital gain x1, pixel correction: default, factory white correction data is shown below.

Table 4-7-1 Gain-Sensitivity

コマンド gax	Analog gain	Sensitivity V/(lx · s)
0	x1(0dB)	75
1	x2(6dB)	150
2	x4(12dB)	300
3	x8(18.1dB)	600
4	x10(20dB)	750
5	x18(25.1dB)	1350

The magnification calculating formulas of the digital gain are as follows.

Digital gain setting value : VAL(0~511)、Digital gain magnification : DGAIN(1~2)

$$DGAIN = 1 + VAL/511$$

$$VAL = (gain - 1) \times 511$$

### Notes:

- 1) Gain and noise values are proportionally related. Adjust amount of gain in accordance with the requirements of your camera system.

- 2) We recommend using gain from x1 to x8.
- 3) See 4.2.1 and 4.2.2 for the information of Commands.

#### 4.8 Setting Offset

The digital offset can be set in the ranges from -40 to +40(DN) at Mono8 or from -160 to +160(DN) at Mono10, using the command "odx".

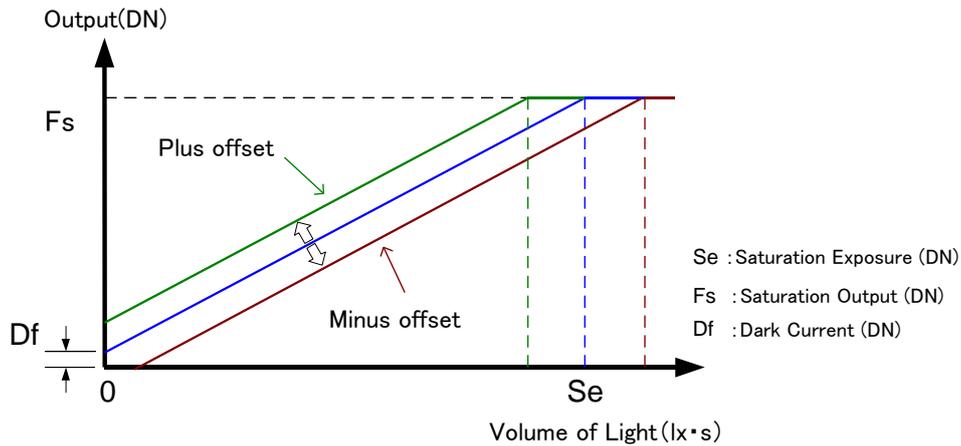


Figure 4-8-1 Saturation Exposure and Dark Current Output

#### Notes:

- 1) Adjust amount of offset in accordance with the requirements of your camera system.
- 2) The gradients of lines do not change.
- 3) See 4.2.3 for the information of Command.

#### 4.9 Exposure Mode and Timing Chart

The mode for the free run exposure, the external trigger exposure (Trigger edge) or the external trigger exposure (Trigger level) can be selected using the command "inm". The overview of each mode and the timing are as follows.

#### Note:

- 1) See 4.2.4 for the information of Command.

### 4.9.1 Free Run Exposure Mode (Programming time setting)

In free-run exposure mode, the exposure time and the scan rate are determined by the settings made through serial communication.

The exposure and the readout repeat themselves in the scan period which is determined by the scan rate.

The exposure time is set by the command “expo” and the scan rate is set by the command “prd”.

The range of programmable exposure time and the timing chart of the exposure and the readout are shown below.

**Table 4-9-1-1 Programmable Exposure Time**

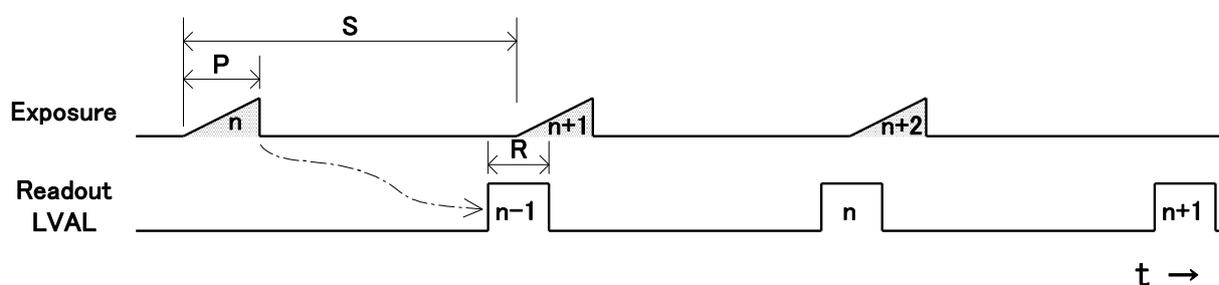
Item	symbol	Time ( $\mu\text{s}$ )
Scan period [Scan rate =1/S]	S	10.0~2000.0 (*1)(*2) [100000~500Hz]
Programmable exposure time	P	3.6~1998 (*1)
Readout time	R	0.0125~51.2 (*2)(*3)

\*1)  $S \geq P + 2\mu\text{s}$

\*2)  $S \geq R + 0.2\mu\text{s}$

\*3)  $R = P_n/T_n/C_k$  (P<sub>n</sub>:Pixel number, T<sub>n</sub>:Tap number,

C<sub>k</sub>: Clock frequency of Camera Link [MHz])



**Figure 4-9-1-1 Free Run Exposure Mode**

**Note:**

1) See 4.2.5 and 4.2.6 for the information of Commands.

### 4.9.2 External Trigger Exposure Mode (Trigger Edge)

In external trigger exposure mode (Trigger Edge), the exposure time is determined by the setting through the serial communication, each exposure starts with the rising edge and the line period is determined by the time from rising edge to rising edge of the trigger pulse.

The exposure time is set by the command “expo”. The range of programmable exposure time, the timing chart of the exposure and the readout are shown below.

**Table 4-9-2-1 Programmable Exposure Time**

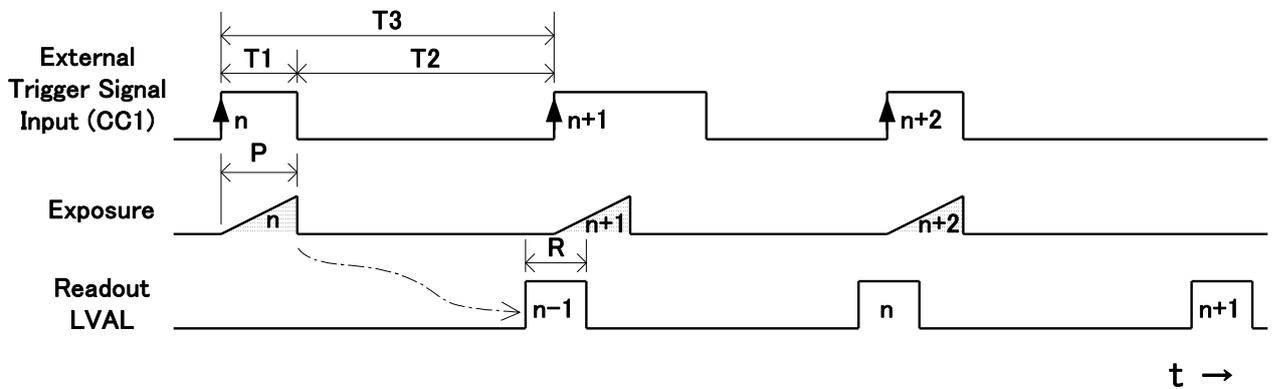
Item	symbol	Time (μs)
Trigger pulse H time	T1	≥ 0.1
Trigger pulse L time	T2	≥ 0.1
Trigger pulse cycle (Scan period)	T3	≥ 10.0 (*1)(*2)
Programmable exposure time	P	3.6~1998 (*1)
Readout time	R	0.0125~51.2 (*2)(*3)

\*1)  $T3 \geq P + 2\mu s$

\*2)  $T3 \geq R + 0.2\mu s$

\*3)  $R = Pn/Tn/Ck$  (Pn:Pixel number, Tn:Tap number,

Ck: Clock frequency of Camera Link [MHz])



**Figure 4-9-2-1 External Trigger (Trigger Edge) Exposure Mode**

**Note:**

- 1) See 4.2.5 for the information of Command.

### 4.9.3 External Trigger Exposure Mode (Trigger Level)

In external trigger exposure mode (Trigger Level), the exposure time is determined by the high trigger pulse time, each exposure starts with the rising edge and the line period is determined by the time rising edge to rising edge of trigger pulse. The range of programmable exposure time, the timing chart of the exposure and the readout are shown below.

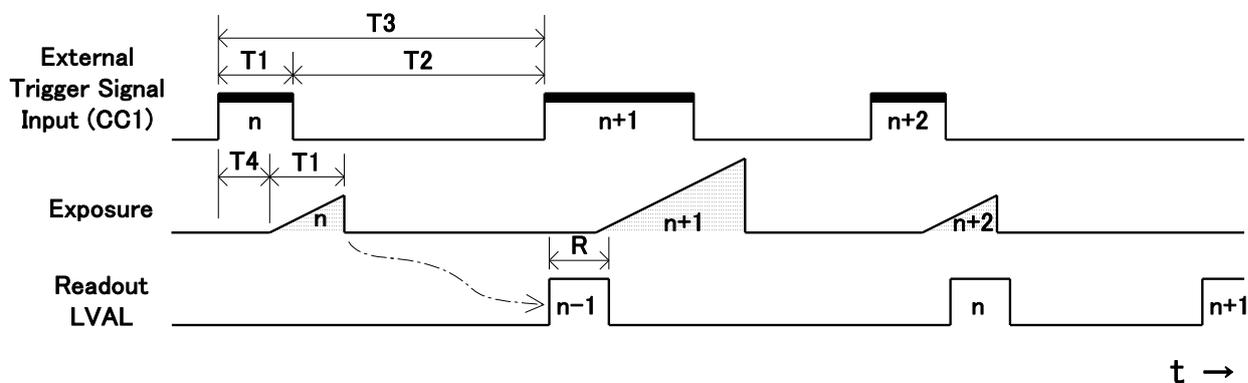
**Table 4-9-3-1 Programmable Exposure Time (Trigger Level)**

Item	Symbol	Time ( $\mu\text{s}$ )
Trigger pulse H time (Exposure Time)	T1	$\geq 8$
Trigger pulse L time	T2	$\geq 2$
Trigger pulse cycle (Scan period)	T3	$\geq 10.0$ (*1)
Exposure delay time	T4	3.533
Readout time	R	0.0125~51.2 (*1)(*2)

\*1)  $T3 \geq R + 0.2\mu\text{s}$

\*2)  $R = P_n/T_n/C_k$  ( $P_n$ :Pixel number,  $T_n$ :Tap number,

$C_k$ : Clock frequency of Camera Link [MHz])



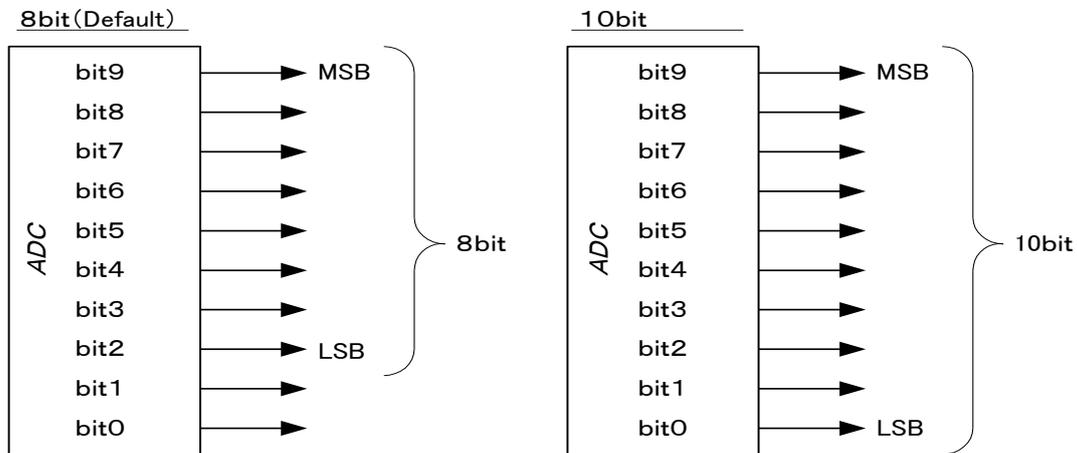
**Figure 4-9-3-1 External Trigger (Trigger Level) Exposure Mode**

## 4.10 Video Output Format

### 4.10.1 Pixel Format

The camera outputs 8-bit or 10-bit digital data.

This can be set using the command "pxf".



**Figure 4-10-1-1 Assignments of Digital Data**

**Notes :**

- 1) The A/D converter of the camera has a 10-bit resolution. For 8-bit output, the upper 8-bits of the signal can be output as video data.
- 2) See 4.2.7 for the information of Command.

### 4.10.2 Clock Frequency of Camera Link

The clock frequency, 80MHz or 40MHz can be set using the command "clkcl".

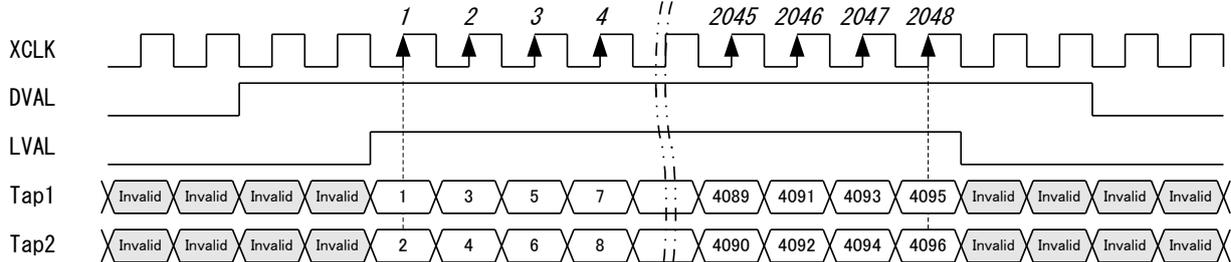
**Notes :**

- 1) This selection affects the scan rate. (See 4.9.1, 4.9.2 and 4.9.3)
- 2) This selection affects the cable length of Camera Link (See 3.1)
- 3) See 4.2.8 for the information of Command.

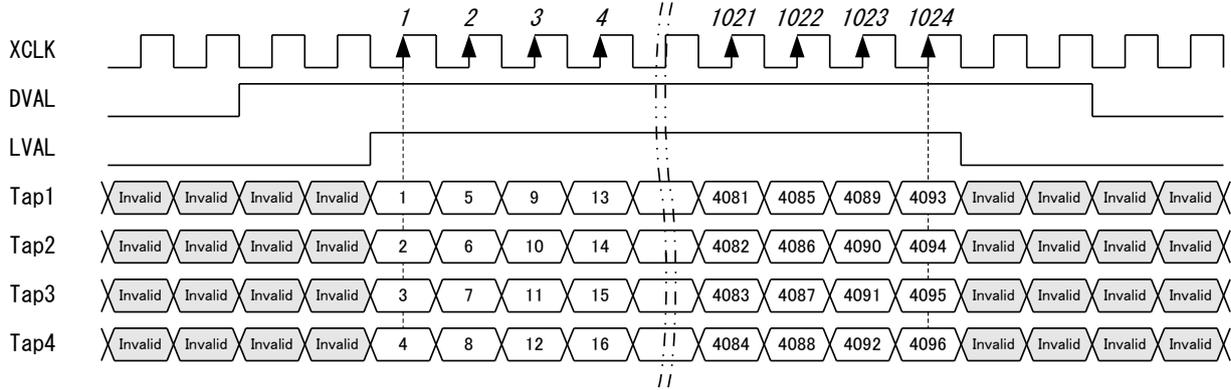
### 4.10.3 Tap Geometry

The tap geometry, GenICam 1X2, 1X4, 1X8 can be selected using the command “tapg”.

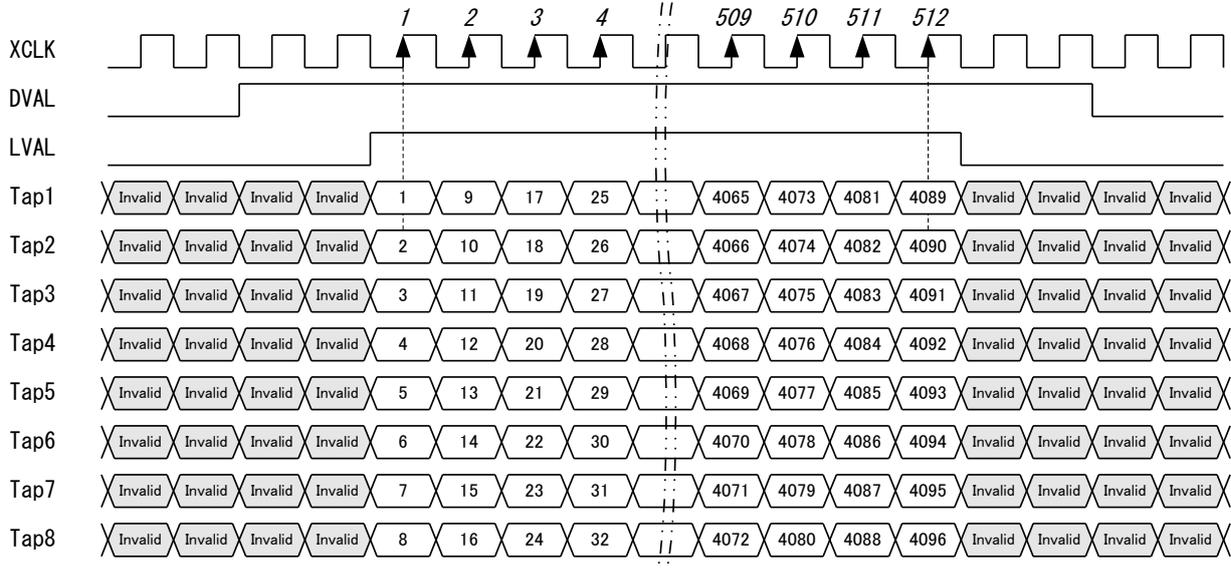
#### GenICam 1x2(1zone in X with 2taps)



#### GenICam 1x4(1zone in X with 4taps)



#### GenICam 1x8(1zone in X with 8taps)



◆ FVAL = 0 (low level) fixed

Figure 4-10-3 Video Output Phase of the Camera

**Notes :**

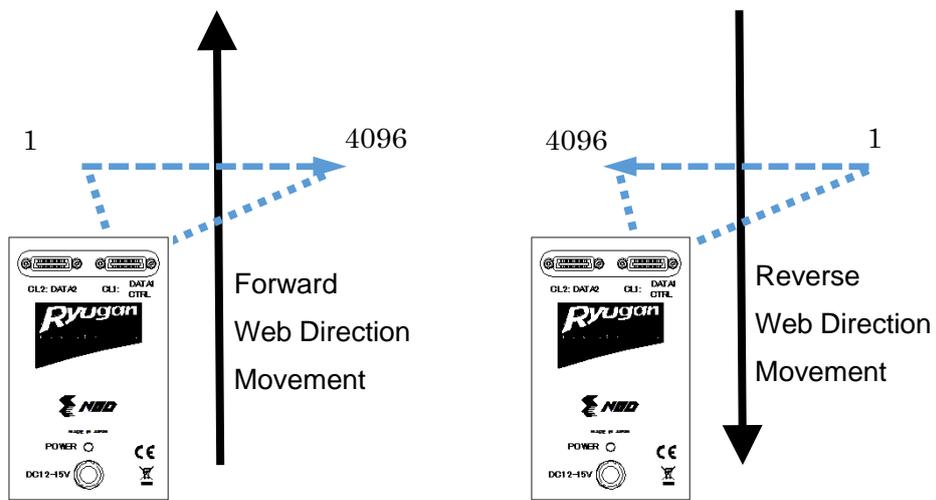
- 1) This selection affects the scan rate. (See 4.9.1, 4.9.2 and 4.9.3)
- 2) See 4.2.9 for the information of Command.

### 4.10.4 Camera Scan Readout Direction Setting

The camera scan readout direction can be changed from forward to reverse, or vice versa using the command “rev”.

The scan direction control can be set by Control Input signal (CC3).  
 When the level is “L”, the camera scan readout direction is forward.  
 When the level is “H”, the camera scan readout direction is reverse.

The scan direction control can be set by the command “revxi”.  
 The correlation between the camera scan readout direction and web (object movement) direction is shown below.



① Forward Camera Scan Readout Direction

② Reverse Camera Scan Readout Direction

**Figure 4-10-4 Correlation of Camera Scan Readout Direction and Object Movement Direction**

**Note :**

1) See 4.2.10 and 4.2.11 for the information of Commands.

#### 4.10.5 Pixel Selection (ROI)

The regions for ROI (Region of Interest) and ROI-offset are shown below.

The quantity of the readout pixels as ROI (Region of Interest) and the pixel number of the reading start position can be set.

The quantity of the readout pixels can be set by the command “width”: 256 to 4096

The pixel number of the reading start position can be set by the command “offx”: 0 to 3840.

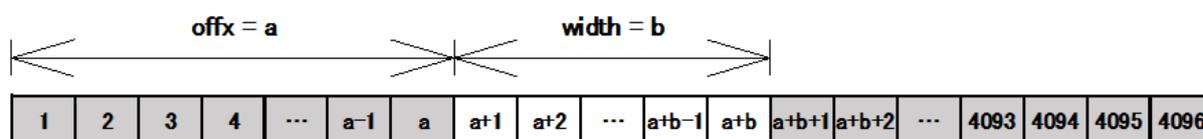


Fig. 4-10-5 ROI width and offset

#### Notes :

- 1) This selection affects the scan rate. (See 4.9.1, 4.9.2 and 4.9.3)
- 2) See 4.2.12 and 4.2.13 for the information of Commands.

#### 4.10.6 Horizontal Pixel Binning

The horizontal pixel data (one pixel of +2 pixel, three pixels of +4 pixel ...4095 pixel +4,096 pixel) can be calculated on the addition or addition average and can be output.

The number of horizontal pixel binning can be set by the command “bh”.

The horizontal pixel binning mode can be set by the command “bhm”.

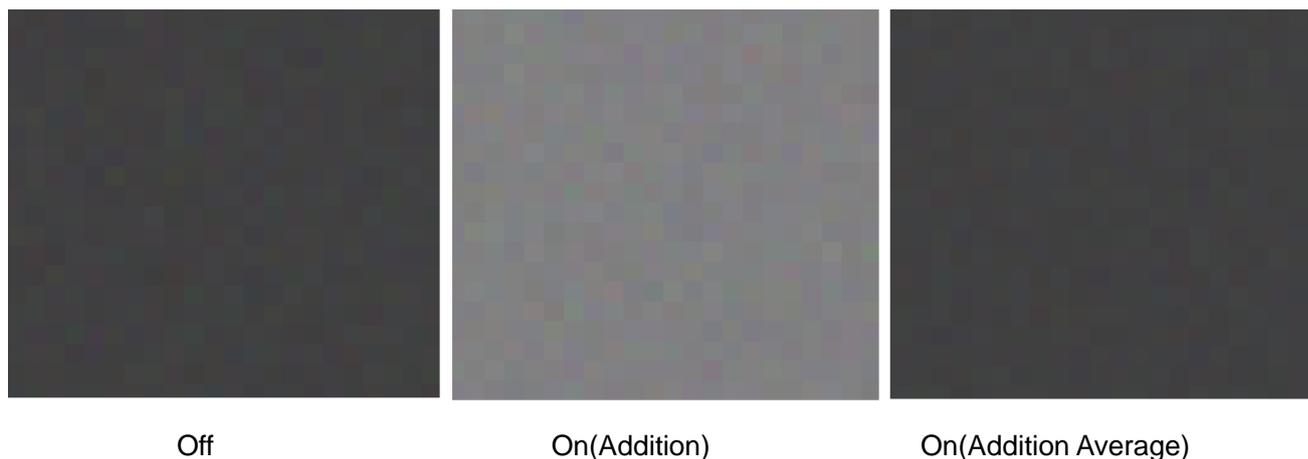


Fig. 4-10-6 Horizontal pixel binning image

#### Notes :

- 1) The sensitivity doubles and the noise is increased  $\sqrt{2}$  times by the binning addition mode.
- 2) The sensitivity is the same and the noise reduces in  $1/\sqrt{2}$  by the binning addition average mode.

- 3) The resolution (the number of the output pixels) becomes 1/2 by the binning addition average mode.
- 4) This selection affects the scan rate. (See 4.9.1, 4.9.2 and 4.9.3)
- 5) See 4.2.14 and 4.2.15 for the information of Commands.

#### 4.10.7 Gamma Correction Setting

The gamma correction coefficient can be set in the range of 0.45-4.00 using the command "gamma".

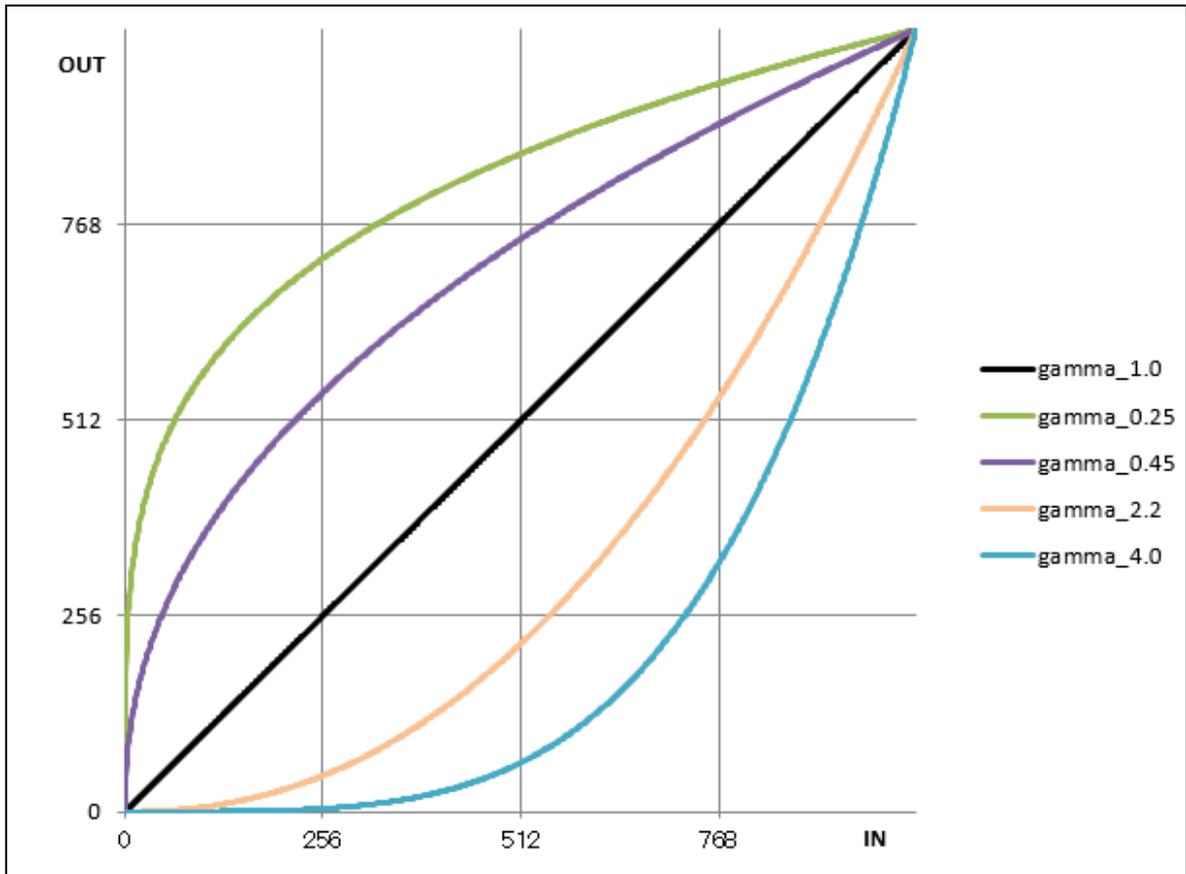


Figure 4-10-7 Gamma Correction Characteristics

**Note :**

- 1) See 4.2.16 for the information of Command.

### 4.10.8 Test Pattern

This camera can generate two types of patterns as follows.

The test patterns can be selected using the command “tpn”.

Use these test patterns to verify the proper timing and connections between the camera and the frame grabber board.

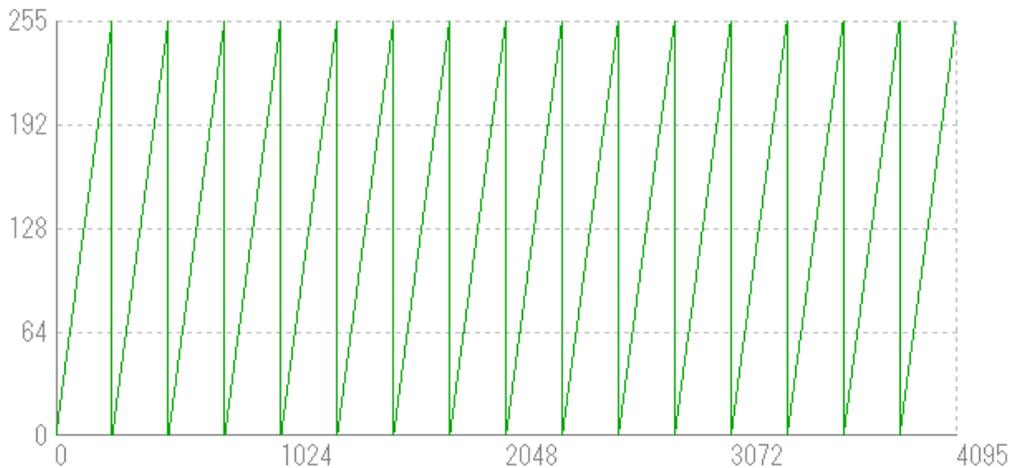


Figure 4-10-8-1 Waveforms of the horizontal ramp pattern on Mono8



Figure 4-10-8-2 Image of the horizontal ramp pattern on Mono8

Where pixel 0 has the value 0DN, the value increases by 1DN each pixel, up to 255DN, then the pattern repeats.



Figure 4-10-8-3 Waveforms of the horizontal ramp pattern on Mono10



Figure 4-10-8-3 Image of the horizontal ramp pattern on Mono1

Where pixel 0 has the value 0DN, the value increases by 1DN each pixel, up to 1023DN, then the pattern repeats.

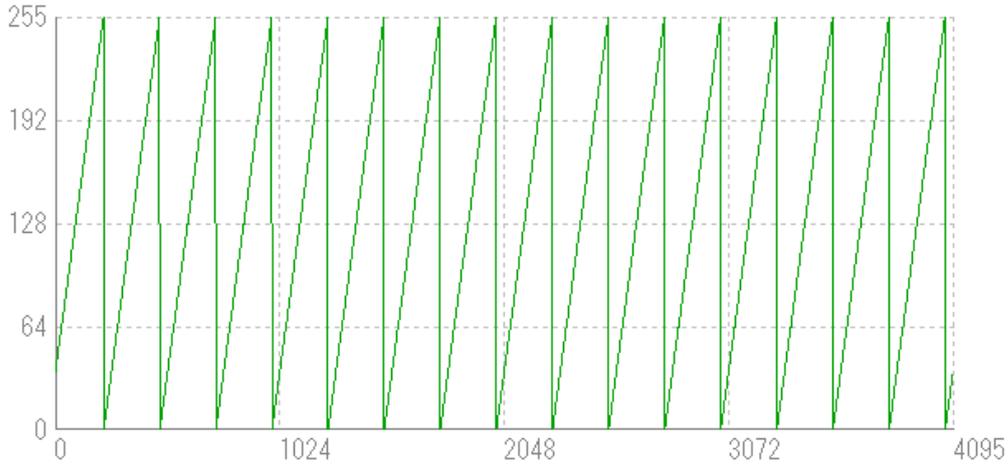


Figure 4-10-8-5 Waveforms of the XY(horizontal vertical) ramp pattern on Mono8



Figure 4-10-8-6 Image of the XY(horizontal vertical) ramp pattern on Mono8

The value increases by 1DN each pixel, up to 255DN in both X-direction and Y-direction, the pattern repeats.



Figure 4-10-8-7 Waveforms of the XY(horizontal vertical) ramp pattern on Mono10



Figure 4-10-8-8 Image of the XY(horizontal vertical) ramp pattern on Mono10

The value increases by 1DN each pixel, up to 255DN in both X-direction and Y-direction, the pattern repeats.

**Notes :**

- 1) See 4.2.17 for the information of Command.

### 4.11 Pixel Correction

Generally speaking, image sensors (CCD, CMOS and so on) have fixed pattern noise and photo response non-uniformity. Lens shadings and light sources also can cause non-uniformity. The camera is set to the optimal correction before shipping in order to provide images of high grade.

The camera also has the function of user white correction to cope with lens shading and non-uniform illumination.

Vo : Output data (After correction)

Vi : Input data (Before correction)

bl : Output data of each pixel in perfect dark(factory correction or user arbitrary correction)

wh : Output data of each pixel in uniform illumination (factory correction) or when viewing a subject for correction (user arbitrary correction)

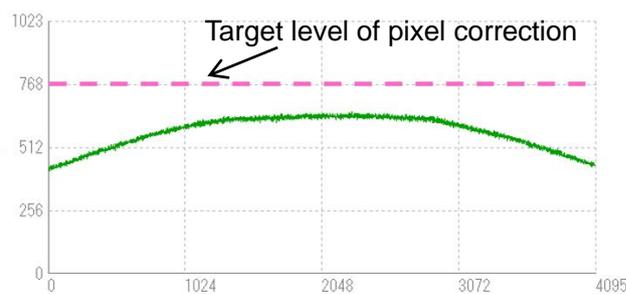
Tv : Target value for user correction (10-bit output conversion value)

The corrected data is expressed in the following equation.

$$Vo = (Vi - bl) \times Tv / (wh - bl)$$



Image “before” user arbitrary pixel is corrected.



Luminance Profile of left image

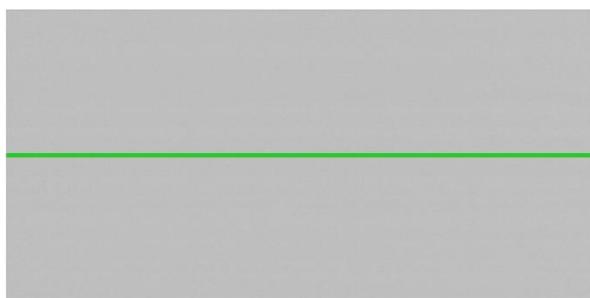


Image “after” user arbitrary pixel is corrected.



Luminance Profile of left image

Figure 4-11-1 Waveform before and after bit correction

#### 4.11.1 Operating Procedure

Put on a lens cap etc. to darken the camera view. Now we can acquire User Arbitrary Correction Data (dark). Send the command “blk CR” via the COM port. The camera should return “>OK” “>blk”. Now the User Arbitrary Correction Data (dark) has been written to the camera’s flash memory.

Next, remove the lens cap so that light enters the camera.

Place a uniformly white object fully in the camera view. Now we can acquire User Arbitrary Correction Data (gray). When this is done with the lens attached, lens and illumination shading will also be corrected at the same time. However, dark and light details of the white object will be picked out, so the lens should be defocused. Next, send the command “wht CR” over the COM port. The camera should return “>OK” “>wht”. Now the User Arbitrary Correction Data (gray) has been written to the camera’s flash memory.

When the target level for pixel correction is set to 900 for example, follow the steps below.

Send the command “ffct 900 CR” via the COM port.

Make sure that the camera return “>OK CR >ffct 900 CR EOT”.

Now the target level for pixel correction has been set.

This pixel correction data can be replaced by User Arbitrary Correction Data as the following steps.

Send the command “ffcm 1 CR” via COM port.

Make sure that the camera return “>OK CR >ffcm 1 CR EOT”.

Now the pixel correction data has been replaced by User Arbitrary Correction Data.

#### Notes:

- 1) For “Val” above, substitute the target value, 0~1023 (10-bit).
- 2) The pixel correction target value should be set slightly higher than the obtained image brightness in order to attain the full range of output.
- 3) The processing for acquiring correction data takes some time. It depends on scan rate.
- 4) See 4.2.22, 4.2.23, 4.2.24 and 4.2.25 for the information of Commands.

## 5 Sensor Handling Instructions

### 5.1 Electrostatic Discharge and the Sensor

CMOS sensors are susceptible to damage from electrostatic discharge and can become defective.

### 5.2 Protecting Against Dust, Oil and Scratches

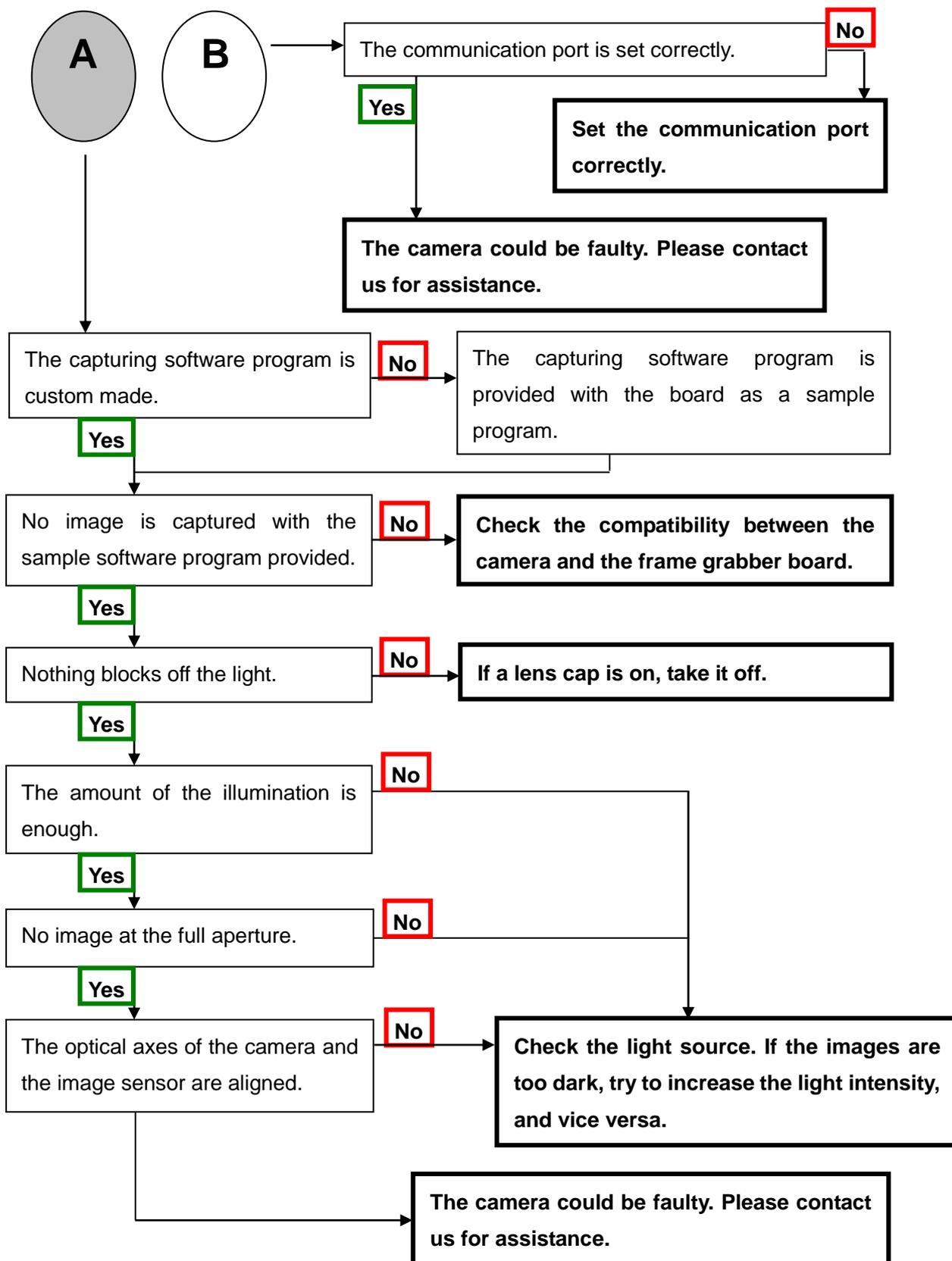
The CMOS sensor window is part of the optical path and should be handled like other optical components with care. If you use the camera in a dusty area, prepare a dust-proof enclosure. Dust can obscure pixels, producing dark lines on the image.

### 5.3 Cleaning the Sensor Window

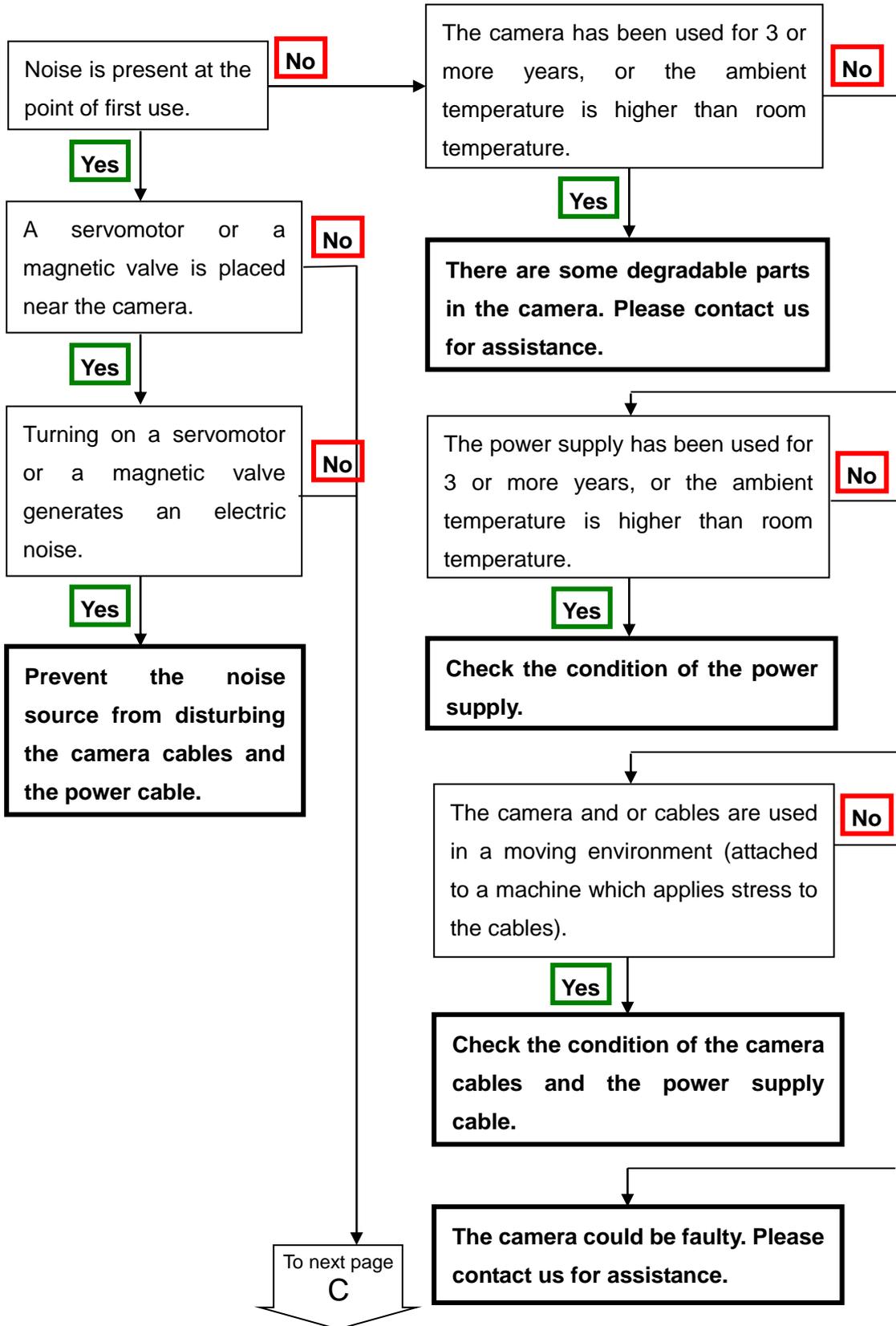
Dust: Can usually be removed by blowing the window surface using a compressed air blower.

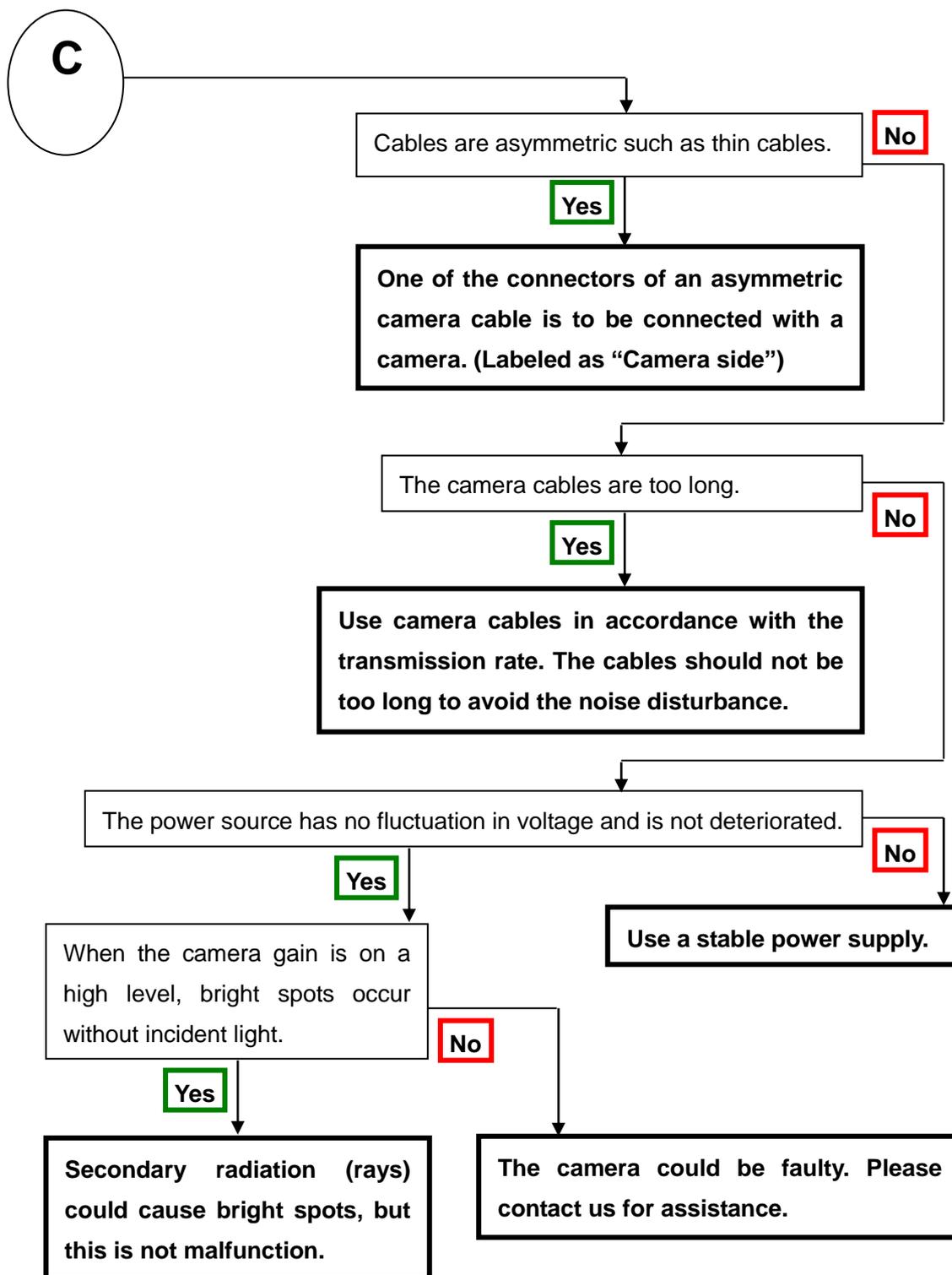
Oil: Wipe the window with a lint-free cloth wiper moistened with ethyl alcohol carefully and slowly.



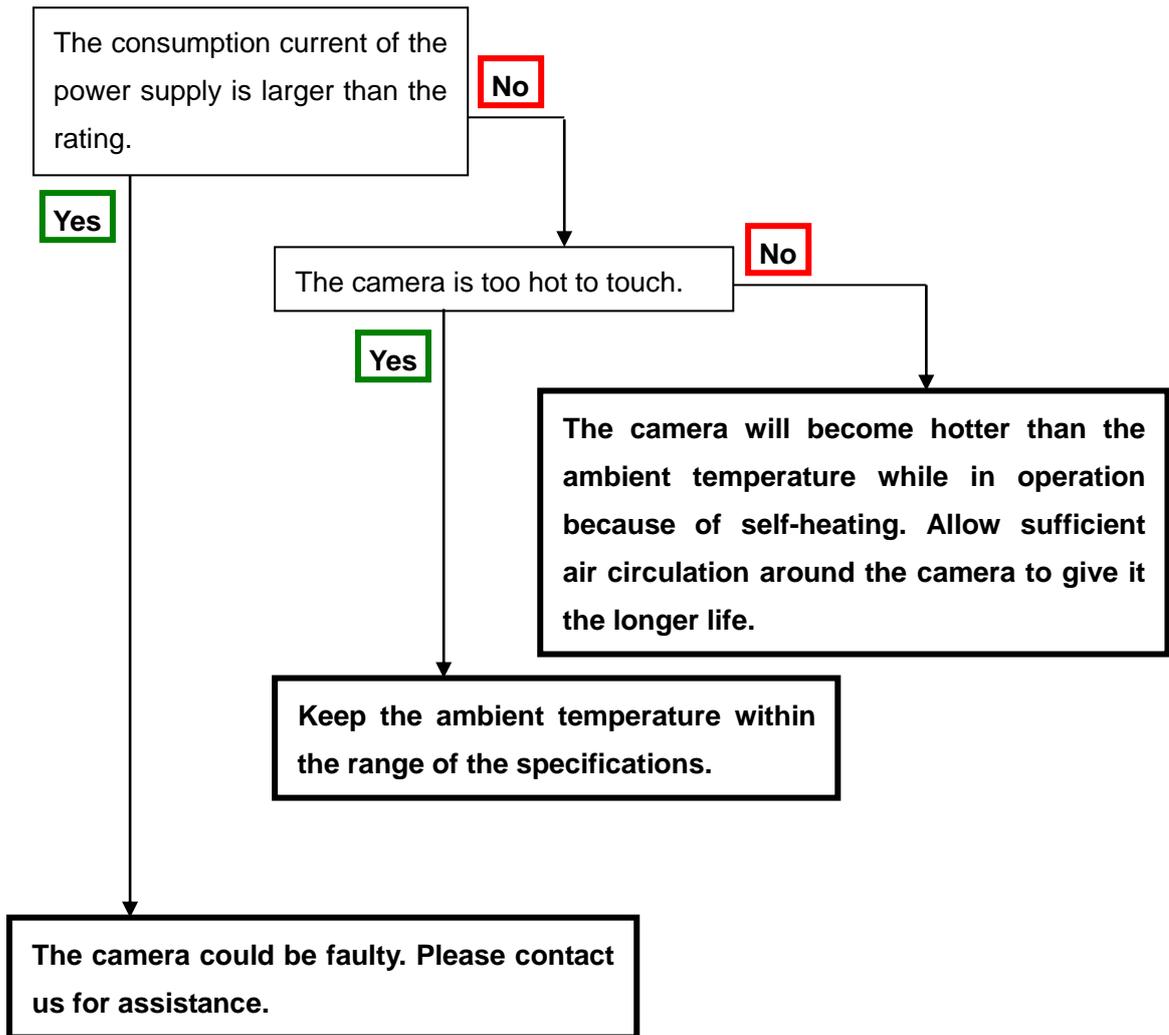


### 6.2 When Noise is present in the Image





### 6.3 When the Camera becomes hot



## 7 Others

### 7.1 Notice

- No part of this document may be reproduced in any form, in whole or in part, without the expressed written consent of NED.
- Contents of this document are subject to change without prior notice.
- Every care has been taken in the preparation of this User's Manual. If you should discover any errors or omissions, please notify your nearest NED representative.

### 7.2 Contact for support

Nippon Electro-Sensory Devices Corporation

#### Head Office

2-5-12, Itachibori, Nishi-ku, Osaka 550-0012, Japan

Phone +81-6-6534-5300

Fax +81-6-6534-6080

#### Tokyo Branch

Jiburaruta Seimei Oi BLDG., Room No.402

1-45-2, Oi, Shinagawa-ku, Tokyo 140-0014, Japan

Phone +81-3-5718-3181

Fax +81-3-5718-0331

#### Nishi-Nippon Branch

Twin Square 1-8-28 Enokida, Hakata-ku, Fukuoka, 812-0004, Japan

Phone +81-92-451-9333

Fax +81-92-451-9335

#### URL

<http://ned-sensor.co.jp/>

#### E-Mail

[sales@ned-sensor.com](mailto:sales@ned-sensor.com)

## 7.3 Product Support

### 7.3.1 Warranty card (attach a separate)

Read carefully the Warranty card, please trasure it.

### 7.3.2 When you need to repair

If there is still a problem with your camera after checking it in accordance with the troubleshooting guide, turn off the power and call your NED representative.

In such case, please inform us of the status of the camera. You can get the status by executing the “sta” command.

The example of the camera status.

```
sta
>OK
>Model=RMSL4K100CL
>Ver.=x.xx_0xxxx
>Serial=xxxxxx
>gax 1
>gdx 0
>odx 0
>inm 0
>prd 100000
>expo 8000
.
.
.
>sta
```

## Revision History

Revision Number	Date	Changes
01	Apr. 26, 2018	Initial release
02	July 29, 2020	Table 4-9-3-1 Numerical value correction Deleted The description on the Camera Control Software.