User's Manual

Provisional edition

Line Scan Camera

Type : XCM8040SAT8

CAMERA Link

NIPPON ELECTRO-SENSORY DEVICES CORPORATION

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.

Warning	If the product is not handled properly, this may result in serious injury or possible death.
Caution	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.
- 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.

Exclusion Clause

- The manufacturer assumes no responsibility for damages resulting from natural disasters, earthquakes, or acts executed by a third party. Warranty excludes any accidents resulting from improper handling or misuse of this product, whether intentional or not, and any camera operations conducted under abnormal conditions.
- The manufacturer assumes no responsibility for any incidental damages (loss of corporate profits, interruption of business, etc.) resulting form use or non-use of this product.
- The manufacturer assumes no responsibility for damages resulting from failure to follow the instructions and procedures indicated in this User's Manual.
- The manufacturer assumes no responsibility for any damages resulting from malfunctions caused by combined use of this product with other peripheral equipment.
- The manufacturer assumes no responsibility for damages resulting from malfunctions caused by non-authorized repair or modifications made to this product.

Table of Contents

1 Product Outline

1.1 Features

- High speed readout（320MH z ）
- High resolution（8192pixels）
- On-chip AD conversion
- Easy control of gain / offset with software outside the camera.
- Easy connection with a variety of frame grabber boards via Camera Link interface
- Single power source DC12V to 15 for operation
- Flat-field correction – minimizes lens vignetting, non-uniform lighting and sensor FPN and PRNU

1.2 Application

- Inspection of Transparent panels and PCBs
  - Wide dynamic range prevents saturation caused by direct rays and specular reflection rays.
  - High speed inspection is possible because of the cameras high data output speed.
  - Using random access reading, High speed inspection becomes possible because only the required data is being transferred.
- Inspection of high speed moving objects
- Flat panel display inspection
- Inspection of glass and sheet-like objects
- Printed circuit board inspection
- This camera utilizes an Intelligent Transportation System
  - Wide dynamic range prevents the camera from saturation caused by direct rays and specular reflection rays.
- Outdoor surveillance

  Wide dynamic range prevents the camera from saturation caused by direct rays and specular refection rays.

An example of Visual Inspection of PCBs is shown below.

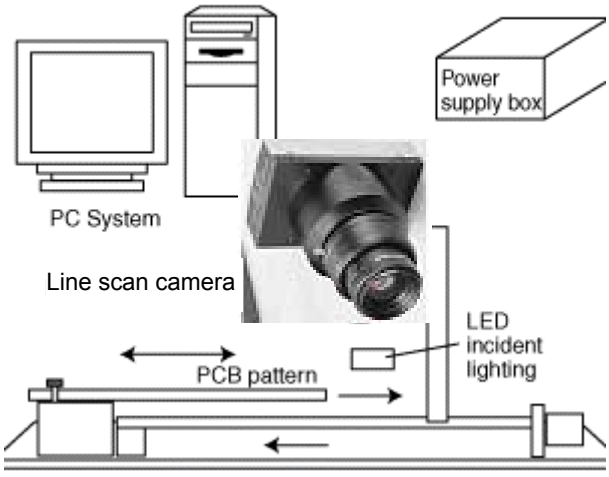


Figure 1-2-1 Visual Inspection of PCBs

Applicable Work

COB, BGA and MCM printed circuit boards

Performance

1. Maximum board size: 100mm×200mm
2. Resolution: 10μm
3. Inspection time: less than 30 seconds

Unit Configuration

1. Camera: Line scan camera
2. Controller: Dedicated software for PC system
3. Size: L930 x D500 x H500 (mm)

Applicable Fields

Inspection of patterns on film PCBs

1.3 Image Sensor

The camera adopts a CMOS sensor with the maximum data rate of 320MHz to acquire high quality images.

The pixels are 7μmx7μm.

The camera outputs its 8192 pixel data through 40MHz-8Tap.

1.4 Performance Specifications

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

Table 1-4-1 Performance Specifications

Items	Specifications
	XCM8040SAT8
Number of Pixels	8192
Pixel Size H x V (μm)	7 x 7
Sensor Length (mm)	57.344
Spectral Responsivity (nm)	400 -1000 (Peak : 625, See Figure 1-4-1)
Data Rate (MHz)	320（40 x 8）
Maximum Scan Rate (μs) / [kHz]	29.78/ [33.58]
Saturation Exposure（lx･s）（typically)	0.071[Minimum Gain, Pixel Correction Initial Value, Daylight Fluorescent Light]
Responsivity（typically）［Minimum Gain, Pixel Correction Initial Value, Daylight Fluorescent Light］Visible Area（400～700nm）	70(V/[lx･s]） Analog 5V Conversion Sensitivity
	40.7(V/[μJ/cm^2])
Gain Adjustable Range *Analog Amplifier +Digital	Analog Amplifier： x 1 to x 11.2（21 Steps） Digital： x 1 to x 2（512 Steps）
Offset Adjustable Range *Digital	Digital：-15 to 15DN (31Steps) 8bit

FPN (Fixed Pattern Noise)		Typically 5 DN (without correction, at minimum gain) 2 DN (with correction, at minimum gain)
PRNU (Photo Response Non Uniformity)		Typically 20 DN (without correction, at minimum gain) 4 DN (with correction, at minimum gain)
Random Noise		Typically 20DN (peak value at minimum gain)
Video output		Camera Link Full Configuration (8 bit / 8tap)
Control Input		CC1: External Trigger Signal, CC2-4: Not in use
Connectors	Data/Controller	3M: MDR26 [Camera Link] x 2
	Power Supply	Hirose：HR10A (4Pin)
Maximum Cable Length(m) *1)		10
Lens Mount		M72 x 0.75 Screw
Operating Temperature (˚C) No Condensation		0 to 50
Power Supply Voltage (V)		DC12 to 15 [+/-5%]
Consumption Current (mA) (typically)		500
Size W x H x D (mm)		80 x120 x 65
Mass (g) (Camera only)		Approx. 600
Additional Function		1 Shading Correction 2 Gain/Offset Adjustable 3 Test Pattern Output 4 Programmable Exposure Control 5 Scan Direction Switching

*1) Tested under the following conditions.

i Camera Link Cable :14B26-SZLB-A00-0LC by 3M (Full Configuration 10m)

(Please see section 3.1 Camera Connection Note: Regarding the choice of Camera Link cable, when you use the Camera Link Cable of other than those above.)

ii Frame Grabber Board : Matrox : SOL 6M FCF by Matrox (Solios : Full Configuration compatible)

*2) DN : Digital Number (10bit : 0 -1023)

*3) Measurements were made at room temperature.

The spectral Responsivity is shown below.

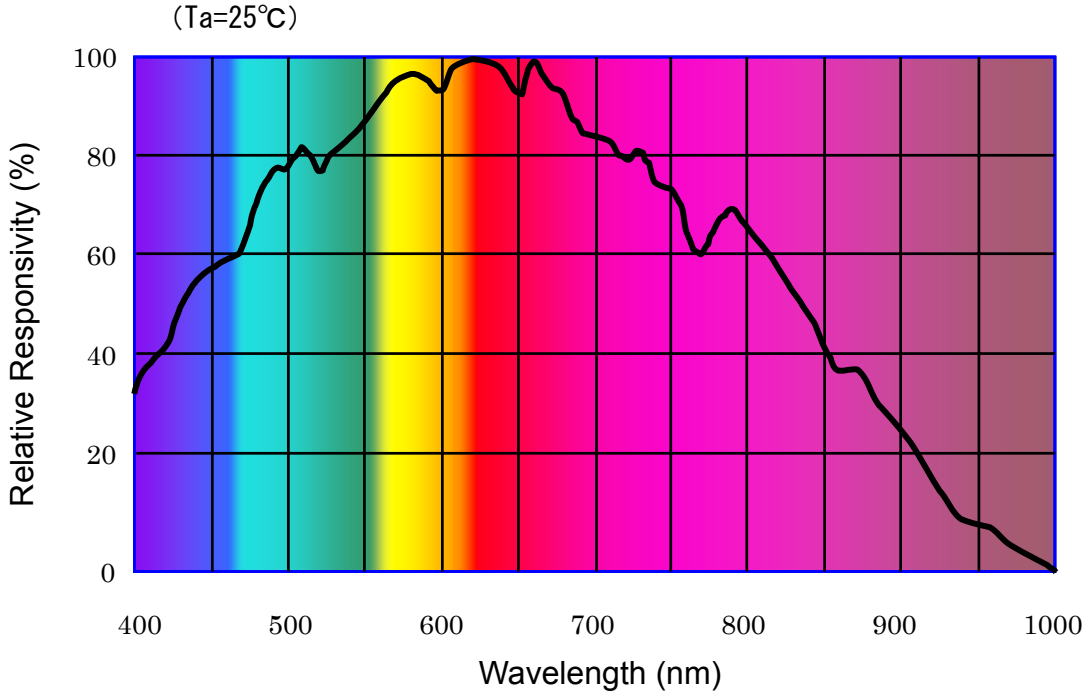


Figure 1-4-1 Spectral Responsivity

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.
An optional mounting base (sold separately) is available.

2.2 Fixing the Camera

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

The dimensions of the camera are shown below.

M72 × 0.75 screw mount

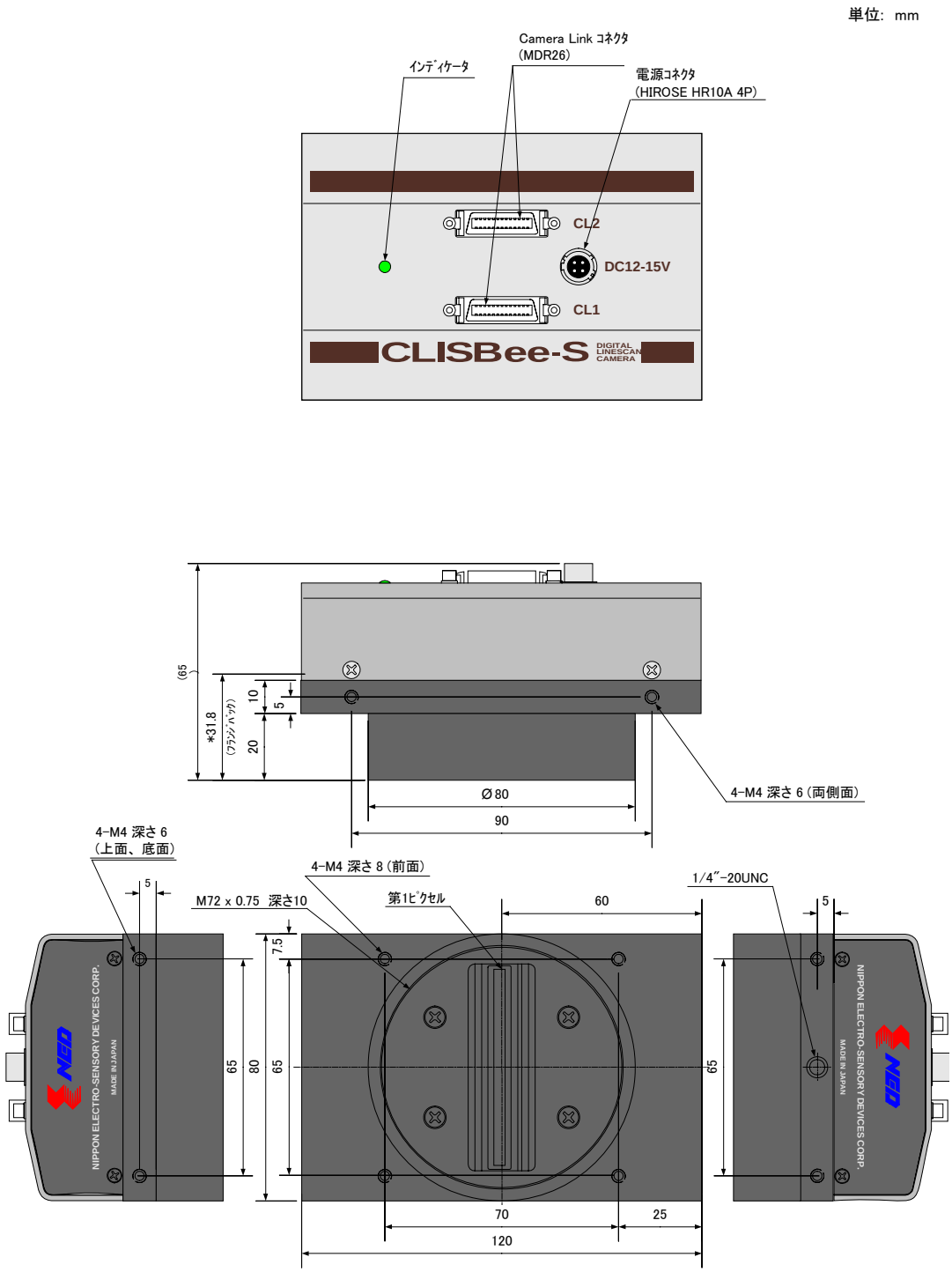


Figure 2-2-1 Dimensions of the Camera

2.3 Optical Interface

For XCM8040SAT8, M72 × 0.75 screw mount is available.

The amount and wavelengths of light required to capture useful images depend on the intended use. Factors include the property, speed, the objects 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 color 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 Full Configuration cables must be used to connect the camera unit with the frame grabber board.

◆ Use two cables of the same length and the same manufacturer. Use asymmetric Camera Link Full Configuration cables and 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.

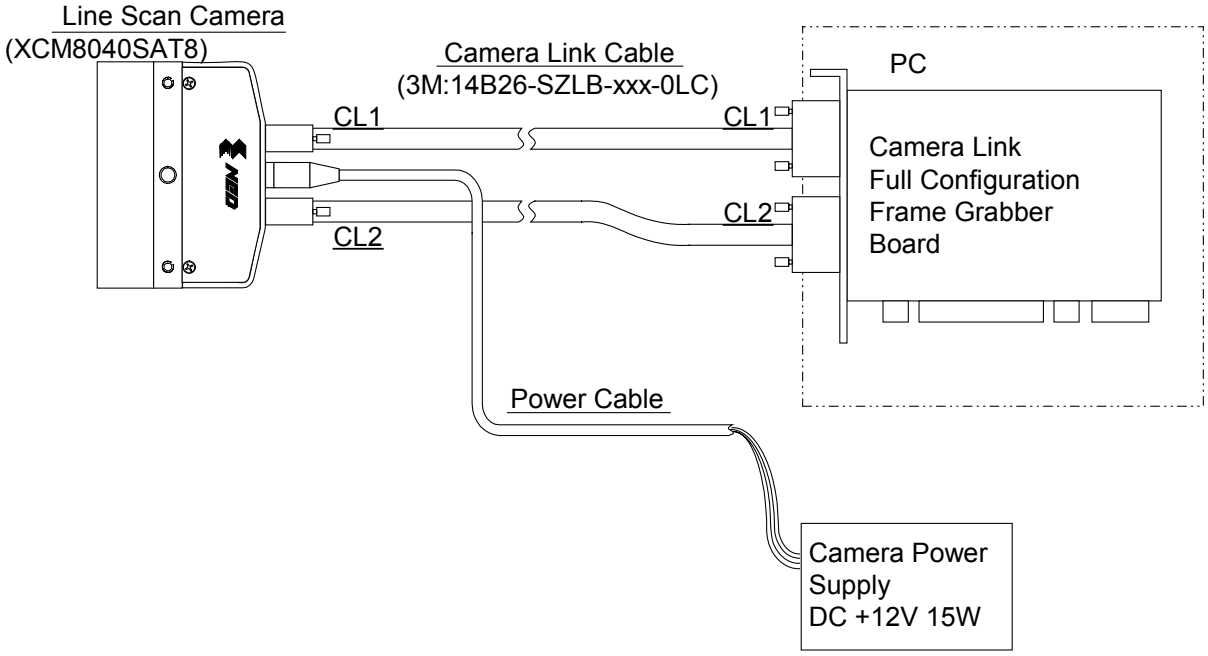


Figure 3-1-1 Connections between Camera and Frame Grabber Board and Power Supply

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

<Note: Regarding the choice of Camera Link cable>
Although it is not recommended to use the maximum cable length possible as depicted in the manual, the camera will still operate fully in such cases. In the market these days there can be found many different varieties of cables; Some for Camera Link “Base” only, some for “Medium” etc.

We recommend that you choose the correct cable for the appropriate operational specification of your cameras output and ensure that this cable is preferably within but not over the maximum guaranteed length as detailed in the individual cameras manual.

3.2 Input / Output Connectors and Indicator

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

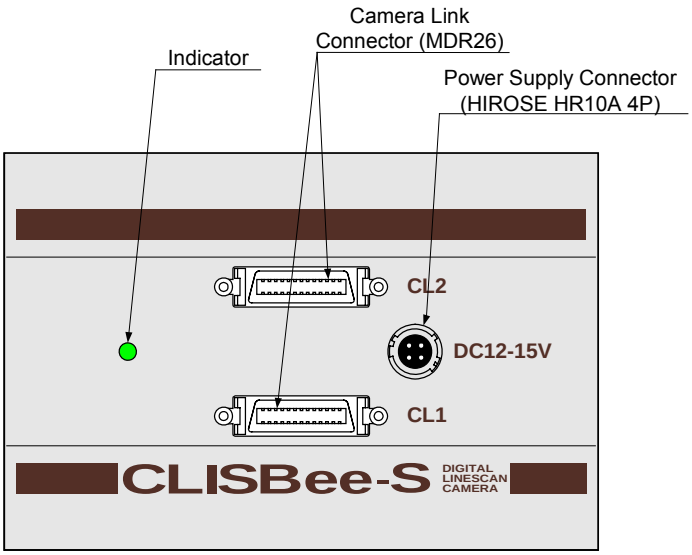


Figure 3-2-1 Input/Output Connectors and Indicator

3.3 Connectors・Pin Assignments・Cables

This camera adopts Full Configuration of Camera Link interface standards. Figure 3-3 shows the interface for the camera and a typical implementation for the frame grabber interface.

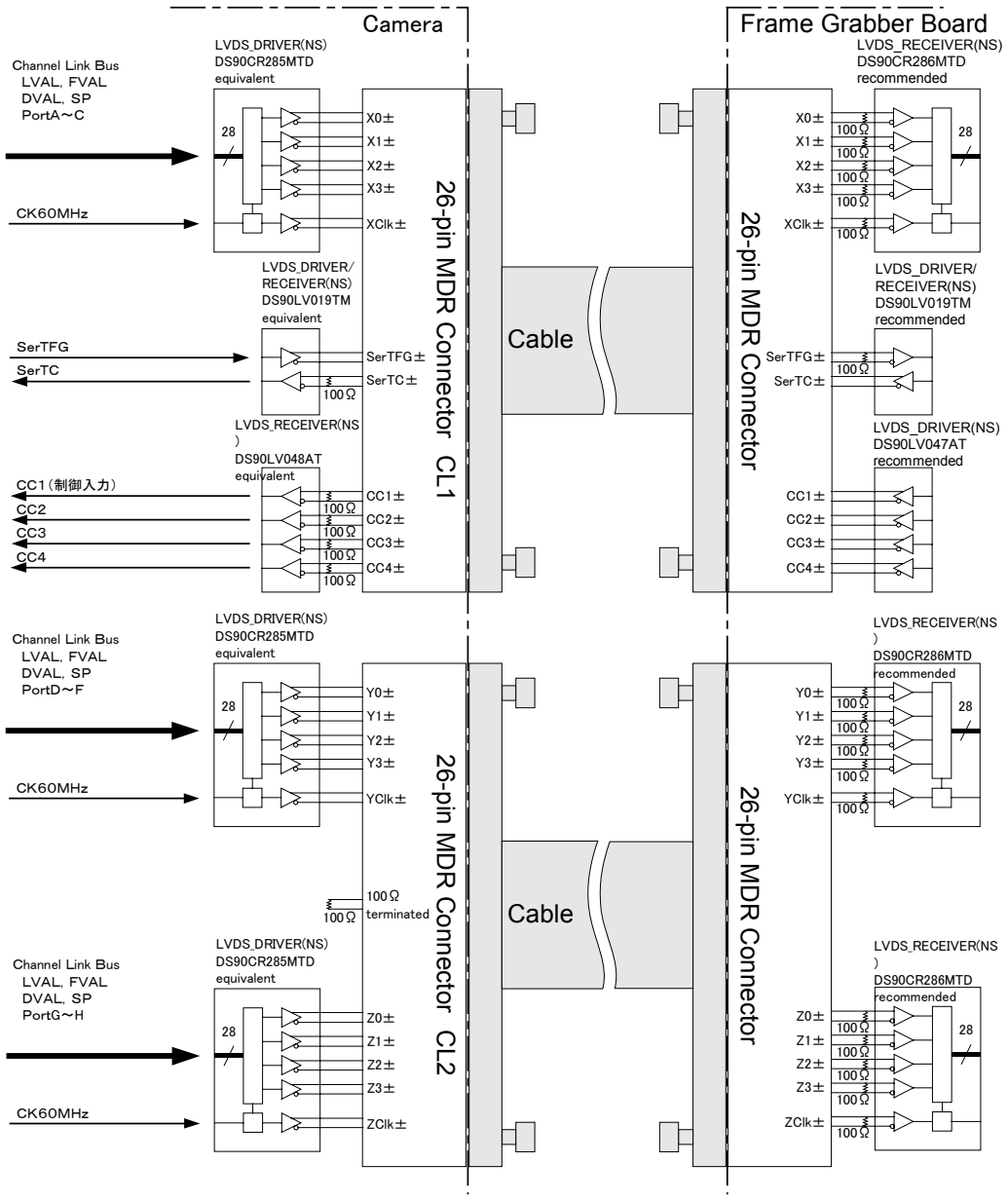


Figure 3-3-1 Camera / Frame Grabber Interface

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

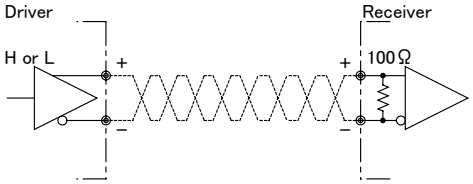


Figure 3-3-2 Circuit of LVDS

The camera has 26-pin MDR connectors for control signals of Camera Link, data signals and serial communications. The camera also has a 4-pin HIROSE connector for power supply.

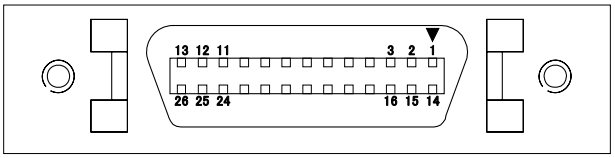


Figure 3-3-3 Camera Link Connector

- Half pitch (miniature half ribbon) shape
- Locking screw (UNC #4-40) type

Table 3-3-1 Camera Link Connector (26-pin MDR Connector) pin assignments

CL1 (Base Configuration)

No	NAME	No	NAME	I/O
1	Inner Shield	14	Inner Shield	
2	X0-	15	X0+	Out
3	X1-	16	X1+	Out
4	X2-	17	X2+	Out
5	Xclk-	18	Xclk+	Out
6	X3-	19	X3+	Out
7	SerTC+	20	SerTC-	In
8	SerTFG-	21	SerTFG+	Out
9	CC1-	22	CC1+	In
10	CC2+	23	CC2-	In
11	CC3-	24	CC3+	In
12	CC4+	25	CC4-	In
13	Inner Shield	26	Inner Shield	

CL2 (Full Configuration)

No	NAME	No	NAME	I/O
1	Inner Shield	14	Inner Shield	
2	Y0-	15	Y0+	Out
3	Y1-	16	Y1+	Out
4	Y2-	17	Y2+	Out
5	Yclk-	18	Yclk+	Out
6	Y3-	19	Y3+	Out
7	100Ω terminated	20	100Ω terminated	
8	Z0-	21	Z0+	Out
9	Z1-	22	Z1+	Out
10	Z2-	23	Z2+	Out
11	Zclk-	24	Zclk+	Out
12	Z3-	25	Z3+	Out
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- : Not in use (LVDS)
  CC4+,CC4- : Not in use (LVDS)

- Camera Link compatible cable

  3M: 14B26 – SZLB – xxx - 0LC by or equivalent

- To avoid uncoupling of the cable connectors during power on, make sure to clamp them with the locking screws.
- Do not unplug the cables while power is being supplied to the camera.
  The pin assignment of the power supply connector is shown below.

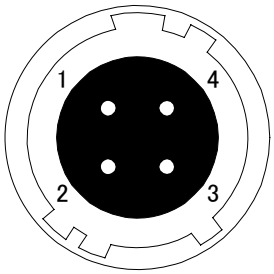


Figure 3-3-4 Power Supply Connector (HIROSE : HR10A - 7P- 4S)

- Round shape push-pull lock type

Table 3-3-2 Pin Assignment of Power Supply Connector

No	NAME	Color of Cable
1	12 -15V	White
2	12 -15V	Red
3	GND	Green
4	GND	Black

3.4 Power Supply

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

- When selecting a power source, choose one with the capacity to allow for in-rush current. (15W or more recommended)
- Insert the cable plug securely until it locks into position. This is to prevent the connector from coming loose during power transmission.
  - Acceptable Cable (Acceptable plug):DGPS -10 (HIROSE : HR10A -7P - 4S)
  - Power supply voltage: DC+12 -15V (+/-5%)
  - Consumption Current (rated): DC+12V : 500mA
  - LED lamp illuminates when +12V to +15V power is being supplied to the camera.
- 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.

4 Camera Control

The camera can be controlled through the serial communication. Two methods can be used to change the camera's parameters. The first approach is to change parameters using CLISBeeCtrl(Camera control software). (See "8 CLISBeeCtrl".) Or you can also change the parameters directly from your application by using binary read/write commands to set values in the camera register.

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 1 CMD CR
- Format 2 CMD□VAL1 CR
- Format 3 CMD□VAL1□VAL2 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, maximum 5 digits)

<Example>
gax;0 CR

4.1.3 Camera Sending Message (PC Receiving Message)

- Format 1 >R CR >[SB] CR EOT
- Format 2 (for “sta” command) >OK CR >[MEM] CR >sta CR EOT

> : Results start text (0×3E)
R: Camera receive command analyzed results
[SB] : Camera receive command send back
[MEM] : Memory data readout value
CR: Separated text (0×0D)
EOT: Send command all text End text (0×04)

<Example>
>OK CR >gax 0 CR EOT

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
VAL ERR!	Parameter accepted was outside of specified
MEM ERR!	Memory error

4.1.4 Camera Control Commands

Table 4-2 shows the list of Camera Control Commands.

Table 4-2 List of Camera Control Commands

Control Item	CMD	VAL1	VAL2	Control Description
Analog Gain	gax	0 to 20		x1.00...x11.22(1.06dB/step)
Digital Gain	gdx	0 to 511		x1...x2(x0.003906/step)
Digital Offset	odx	-15 to 15		-15...15(1DN/step at8bit) -60...60(4DN/step at10bit)
Exposure Mode	inm	0 /1/2		Free Run / Ext Edge / Ext Level
Programmable Exposure Time	int	1 to 11	61 to 1023	27.1 to 931157.33 μs Dividing / Counter
Output Signal Setting 1	voa	0	0	VAL1:8bit (8bitFix), VAL2:0 (Fixed)
Output Signal Setting 2	voc	0 /1		Linear /Log
Memory Initializing	rst			Reset to factory settings
Memory Load	rfd			Readout setup data in memory
Memory Save	sav			Store present setup data in memory
Test Pattern	tpn	0 /1		OFF/ON
Pixel Correction Data Save	wht			Store pixel correction data in memory
Pixel Correction Setting	shc	0/1/2	0 to 1023	0:Correction OFF /1:Factory white correction /2:Arbitrary white correction, Correction level (8-bit)
Exposure-Readout Time	pad	0 to 50		0 - 45511μs
Operation Status Readout	sta			Returns the current camera settings.
Scanning Direction	rev	0 /1		0 : Forward / 1 : Reverse

Programmable Exposure Time＝VAL2÷{36,000,000÷(16 x 2 ^ VAL1)}

Exposure-Readout Time＝VAL1÷{36,000,000÷(16 x 2 ^ VAL1*)}

(VAL*: Dividing of Programmable Exposure Time)

4.1.5 Memory Setup Values (Factory Settings)

The memory setup values (factory settings) are shown in Table 4-3.

Table 4-3 Memory Setup Values (Factory Settings)

Control Item	CMD	VAL1	VAL2	Control Description
Analog Gain	gax	0		x1(0dB)
Digital Gain	gdx	0		x1
Digital Offset	odx	0		0DN(8bit)
Exposure Mode	inm	0		Free Run
Programmable Exposure Time	int	1	61	27.1μs (Dividing=1、Counter=61)
Output Signal Setting 1	voa	0	0	8bit, 8192pixels
Output Signal Setting 2	voc	0		Linear
Test Pattern	tpn	0		OFF
Pixel Correction Setting	shc	1	900	Factory White Correction Correction Level 900DN(10bit)
Exposure-Readout Time	pad	0		0μs
Scanning Direction	rev	0		Forward : 0

4.2 Details on Commands

4.2.1 Setting Analog Gain

Sets analog gain in 21 steps between x1 and x11.2. (See Table 4-9)

- Format 2 CMD□VAL1 CR
- CMD gax
- VAL 0 (x1) to 20 (x11.2)

<Example>

gax□5 CR (Setting analog gain 5(x1.84))
>OK
>gax 5

4.2.2 Setting Digital Gain

Sets digital gain in 512 steps between x1 and x2.

- Format 2 CMD□VAL1 CR
- CMD gdx
- VAL 0(x1) to 511(x2)

<Example>

gdx□255 CR (Setting digital gain 255(1023/(1023-255)=x1.33))
>OK
>gdx 5

4.2.3 Setting Digital Offset

Sets digital offset -15 to +15(8bit:1DN/Step)

- Format 2 CMD□VAL1 CR
- CMD odx
- VAL -15 to 15

<Example>

odx□5 CR (Setting digital offset 5(8-bit))
>OK
>odx 5

4.2.4 Setting Exposure Mode

Sets the exposure mode.

- Format 2 CMD□VAL1 CR
- CMD inm
- VAL 0,1,2

<Example>

inm□0 CR (Setting the exposure mode free run)
>OK
>inm 0

4.2.5 Setting Exposure Time

Sets the exposure time.

- Format 3 CMD□VAL1□VAL2 CR
- CMD int
- VAL1 0 to 11 (Setting Dividing)
- VAL2 61 to 1023 (Setting Counter value)

<Example>

int□0□120 CR (Setting exposure time 48μs)
>OK
>int 1,120

4.2.6 Setting Output Signals 1 (Setting Data Format)

Sets the data format of output signals.

- Format 3 CMD□VAL1□VAL2 CR
- CMD voa
- VAL1 0 (8bit fixed)
- VAL2 0 (fixed)

<Example>

voa□0□0 CR (8bit output)
>OK
>voa 0,0

4.2.7 Setting Output Signals 2 (Setting Linear / Log)

Sets the data format of output signals.

- Format 3 CMD□VAL1 CR
- CMD voc
- VAL 0,1 (0:linear output / 1:log output)

<Example>

voc□0 CR (linear output)
>OK
>voc 0

4.2.8 Memory Initializing (Initializing Camera Settings)

Reset the flash memory to the factory default.

- Format 1 CMD CR
- CMD rst

<Example>

rst CR
>OK
>Type=XCM8040SAT8
>Ver.=2.66_0x4948
>Serial=0
>check_code = 20070615
>gax 0
>gdx 0
>odx 0
>inm 0
>int 1,31
>cka 0
>voa 0,0
>voc 0
>tpn 0
>shc 1,900
>pad 0
>rev 0
>rst

4.2.9 Memory Load

Reads out the camera settings from the flash memory.

- Format 1 CMD CR
- CMD rfd

<Example>

rfd CR
>OK
>Type=XCM8040 SAT8
>Ver.= 2.66_0x4948
>Serial=0
>check_code = 20070615

>gax 0
>gdx 0
>odx 0
>inm 0
>int 0,31
>cka 0
>voa 0,0
>voc 0
>tpn 0
>shc 1,900
>pad 0
>rev 0
>rfd

4.2.10 Memory Save

Stores the current camera settings in the flash memory.

- Format 1 CMD CR
- CMD sav

<Example>

sav CR
>OK
>sav

4.2.11 Generating Test Pattern

Generates test pattern.

- Format 2 CMD□VAL1 CR
- CMD tpn
- VAL 0,1 (0:Image data, 1: Test pattern)

<Example>

tpn□1 CR (Generating test pattern)
>OK
>tpn 1

4.2.12 Saving Pixel Correction Data

Acquires the current pixel correction data and saves it in the flash memory. One correction data can be saved at each step of analog gain.

- Format 1 CMD CR
- CMD wht

<Example>

wht CR
>OK
>wht

4.2.13 Setting Pixel Correction

Sets pixel correction.

- Format 3 CMD□VAL1□VAL2 CR
- CMD shc
- VAL1 0,1,2 (0:Correction OFF /1:Factory white correction /2:Arbitrary white correction)
- VAL2 0 to 1023 (Setting correction level: 8bit)

<Example>

shc□1□900 CR (for Factory white correction, Correction level 900DN
>OK
>shc 1,900

4.2.14 Setting Exposure Time - Readout Time

Prolongs the line period without changing the exposure time.

- Format 2 CMD□VAL1 CR
- CMD pad
- VAL1 0 to 50 (0 to 45511μs)

<Example>

pad□10 CR
>OK
>pad 10

The increment of the line period depends on the exposure time setting command VAL1 in “int”. For example, if VAL1 (in “int”)=1 and VAL1 (in “pad”)=1, the increment is 13.9ns x 2 x 16 x 2=0.890μs. If VAL1 (in “int”) = 3 and VAL1 (in “pad”)=1, the increment is 13.9ns x 2 x 16 x (2 x 2 x 2)=3.56μs. And if VAL1 (in “int”)=5 and VAL1 (in “pad”)=1, the increment is 13.9ns x 2 x 16 x (2 x 2 x 2 x 2 x 2)= 14.2μs.

4.2.15 Returning the Cameras Settings to the its original status

Returns the current camera settings.

- Format 1 CMD CR
- CMD sta

<Example>

sta CR
>OK
>Type=XCM8040SAT8
>Ver.=2.66_0x4948
>Serial=0
>check_code = 20070615
>gax 0
>gdx 0
>odx 0
>inm 0
>int 1,31
>cka 0
>voa 0,0
>voc 0
>tpn 0
>shc 1,900
>pad 0
>rev 0
>sta

4.2.16 Setting the Pixel Readout Direction

Sets the pixel readout direction.

- Format 2 : CMD□VAL1 CR
- CMD : rev
- VAL1 : 0,1 (0:Forward, 1:Reverse)

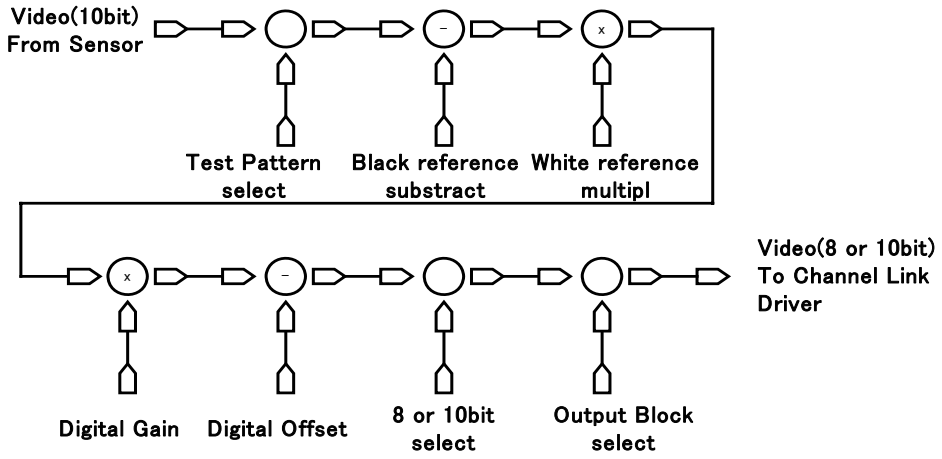
<Example>

rev□1 CR (Reverse)
>OK
>rev 1

4.3 Digital Processing flow in FPGA

The digital processing flow in FPGA is shown below.

FPGA Processing block diagram



In Test Pattern mode, Black / White reference and Digital Gain /Offset will be skipped.

Figure 4-3-1 FPGA Processing Block Diagram

4.4 Startup

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

The startup procedure is as follows.

(1) The camera hardware initializes.

(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.

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).

- The number of times the flash memory can be rewritten will vary depending on actual operational conditions. 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.

◆ If the camera power is disconnected while rewriting the memory, the whole data saved in the memory will be deleted.

As it takes several seconds to rewrite the memory, do not disconnect power supply before receiving the answer from the camera.

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)

◆ When changing the factory setting exposure mode, be sure to send the control input signal (CC1). If you do not send CC1 or sending control input signals are out of the designated range, you cannot get images and cannot change the settings. See 4.8.2 and 4.8.3.

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 Serial Communication Settings

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

4.7 Video Output Format

The camera outputs 8-bit digital data through 8 taps.

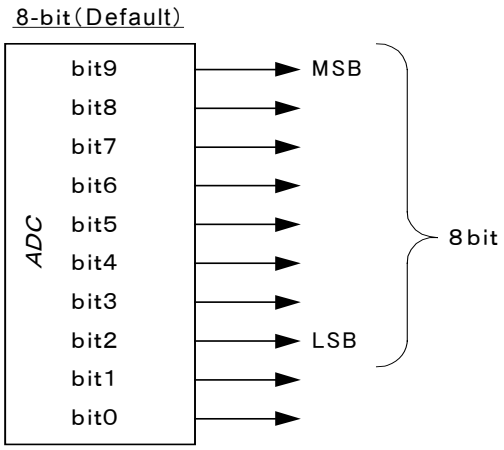
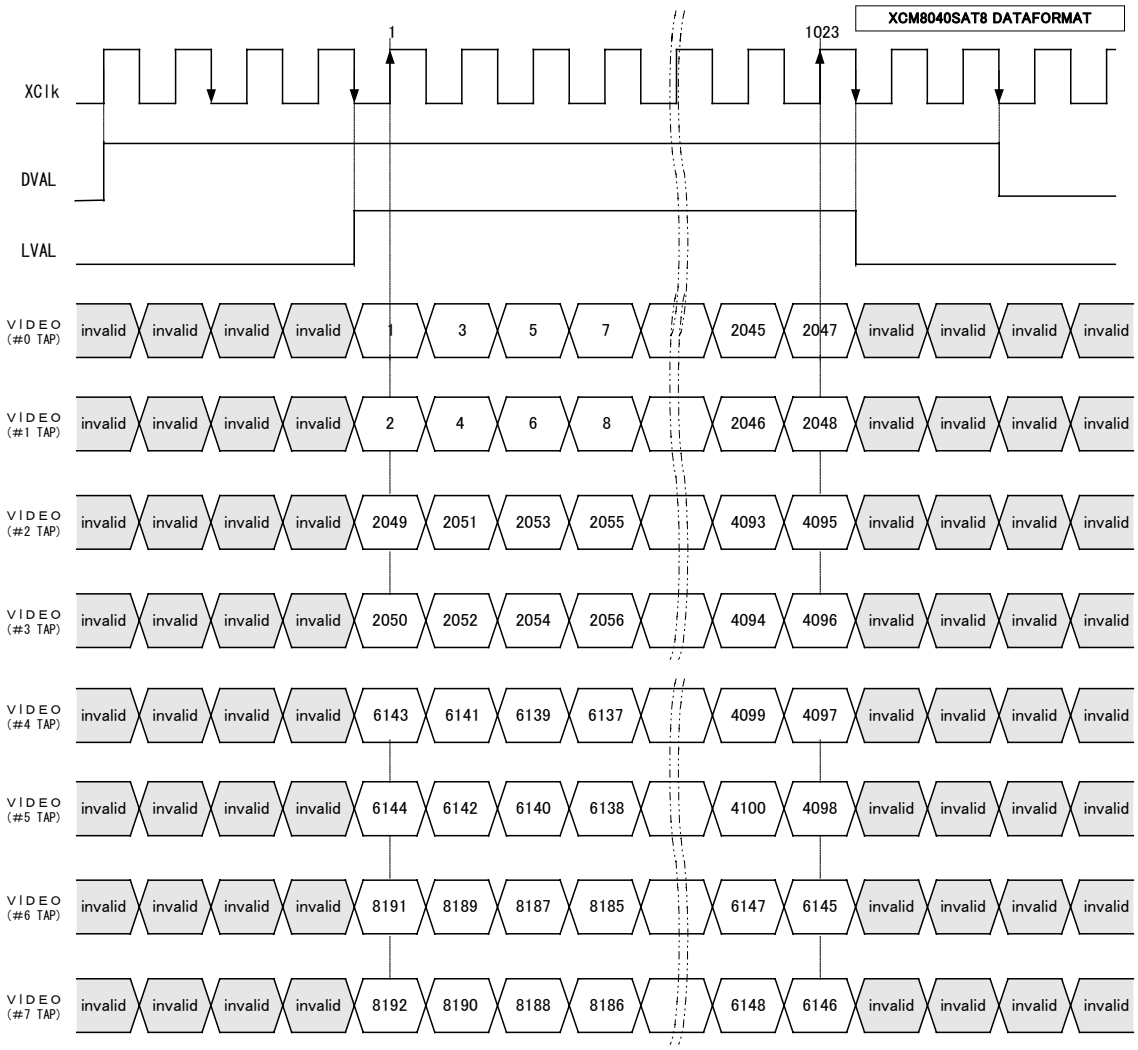


Figure 4-7-1 Pin Assignments of Digital Data

.

Video output phase of the camera is shown below.



◆ FVAL = 0 (low level) fixed

Figure 4-7-2 Video Output Phase of the Camera

4.8 Exposure Mode and Timing Chart

The camera has three exposure modes. The overview of each mode and the timing are as follows.

4.8.1 Free Run Exposure Mode (Programming time setting)

In free-run exposure mode, the camera generates its own internal control signal based on two programmable parameters, exposure time and readout time.

Table 4-8-1-1 Programmable Exposure Time

		8040SAT8
p	Programmable exposure time	27.1～931157.33
r	Readout time	25.6

(unit: μs)

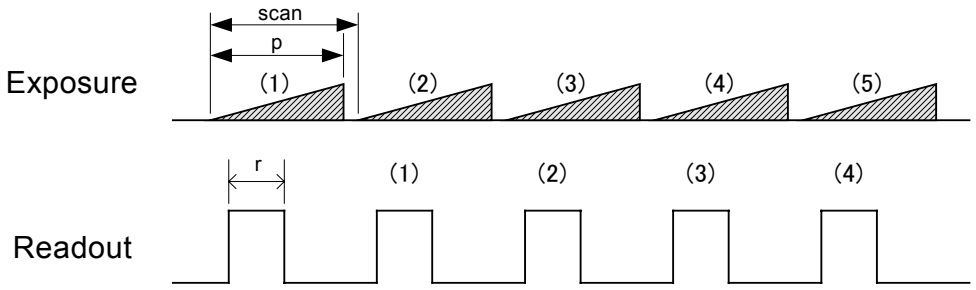


Figure 4-8-1-1 Free Run Exposure Mode

◆ The data of Exposure (1) is read out at Readout (1)

4.8.2 External Trigger Exposure Mode (Trigger Edge)

In external trigger exposure mode (Trigger Edge), the exposure time is determined by the setting for the line period parameter, each exposure starts with the rising edge and the line period is determined by the time from rising edge to rising edge of the internal control signal. The range of programmable exposure time, the timing chart of the exposure and the readout are shown below.

Table 4-8-2-1 Programmable Exposure Time

		8040SAT8
p	Programmable exposure time	27.1～931157.33
r	Readout time	25.6
a	Trigger pulse Htime	≧1.6
b	Trigger pulse Ltime	≧2.7
c	Trigger pulse cycle	≧29.8

（単位：μs）

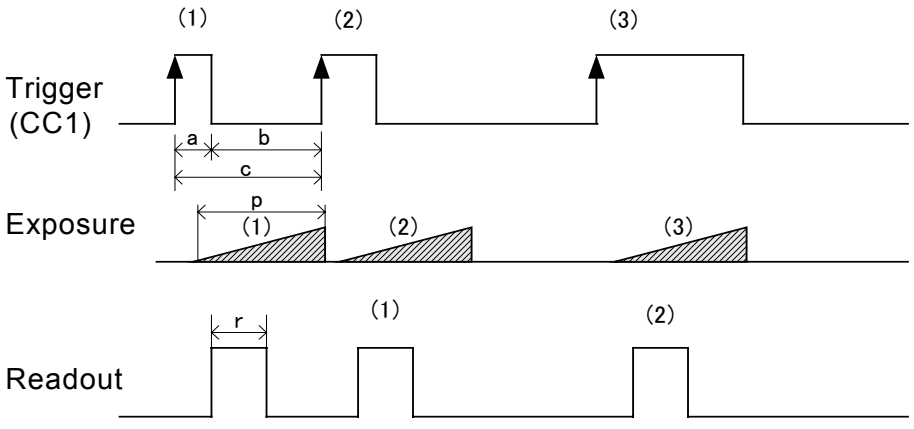


Figure 4-8-2-1 External Trigger (Trigger Edge) Exposure Mode

◆ The data of Exposure (1) is read out at Readout (1)

4.8.3 External Trigger Exposure Mode (Trigger Level)

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

Table 4-8-3-1 Programmable Exposure Time

		8040SAT8
r	Readout time	25.6
a	Trigger pulse Htime	≧28.0
b	Trigger pulse Ltime	≧1.6
c	Trigger pulse cycle	≧29.8

（単位：μs）

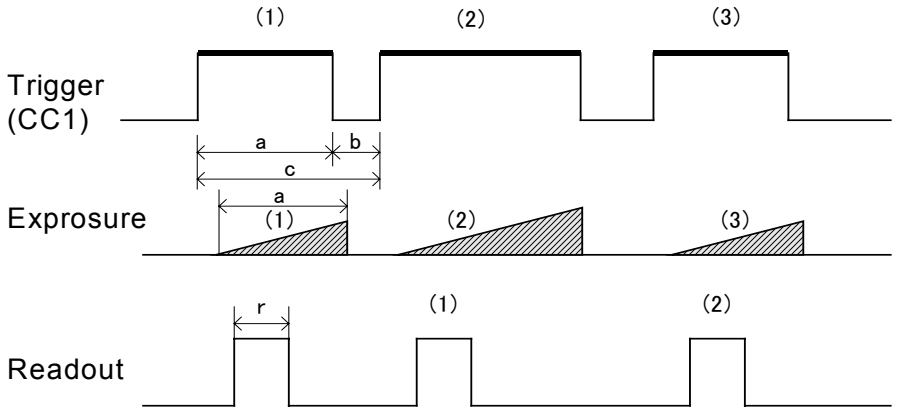


Figure 4-8-3-1 External Trigger (Trigger Level) Exposure Mode

◆ The data of Exposure (1) is read out at Readout (1)

4.9 Setting Offset

In the diagram below, the horizontal axis indicates the volume of light and vertical axis indicates the output.

Fs shows the output at saturation. Dd shows the output at darkness. (Both Fs and Dd are digital.) Se shows for the saturation current, or the amount of exposure when the output saturates.

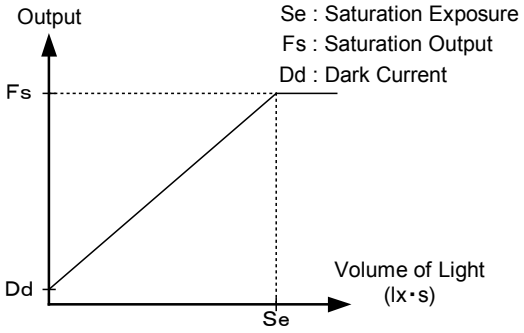


Figure 4-9-1 Saturation Exposure and Dark Current Output

By setting the offset, you can set the Y-intercept arbitrarily. DF shows the digital offset value. The gradients of lines do not change.

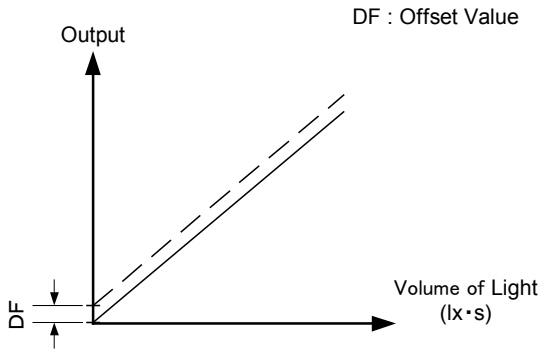


Figure 4-9-2 Offset Adjustment

◆ Adjust gain and offset to meet your system's requirements.

4.10 Setting Gain

The camera can adjust the analog gain (x1 to X11.2 in 21 steps) and the digital gain. As the diagram below indicates, increasing the gain setting increases the slope of the camera's response curve and results in a higher camera output for a given amount of light.

Analog gain can be changed by sending the ”gax” command.

Digital gain can be changed by sending the “gdx” command.

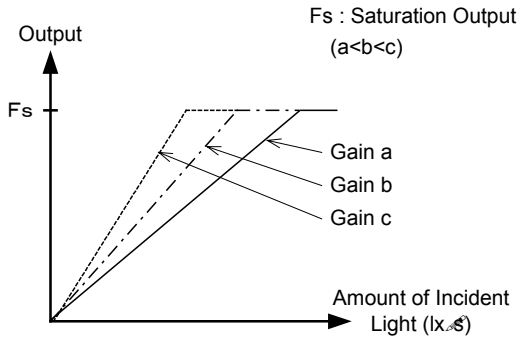


Figure 4-10-1 PGA Gain Adjustment

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

Gain-Sensitivity is shown below.

Table 4-10-1 Gain-Sensitivity

	Analog Amplifier		Sensitivity (V/lx̣s)
1	x1.00	0.00dB	70
2	x1.13	1.06dB	79
3	x1.28	2.12dB	89
4	x1.44	3.18dB	101
5	x1.63	4.24dB	114
6	x1.84	5.30dB	129
7	x2.08	6.36dB	146
8	x2.29	7.20dB	160
9	x2.59	8.26dB	181
10	x2.92	9.32dB	205
11	x3.31	10.40dB	232

	Analog Amplifier		Sensitivity (V/lx̣s)
12	x3.74	11.46dB	262
13	x4.23	12.52dB	296
14	x4.78	13.58dB	334
15	x5.40	14.64dB	378
16	x6.10	15.70dB	427
17	x6.89	16.76dB	482
18	x7.78	17.82dB	545
19	x8.79	18.88dB	615
20	x9.93	19.94dB	695
21	x11.22	20.64dB	785

Digital gain x1, Pixel correction: default, (Factory white correction data, Correction level 900DN)

You can choose between Linear or Log mode for the cameras output A/D Characteristics by sending the “voc” command. The characteristics are shown below.

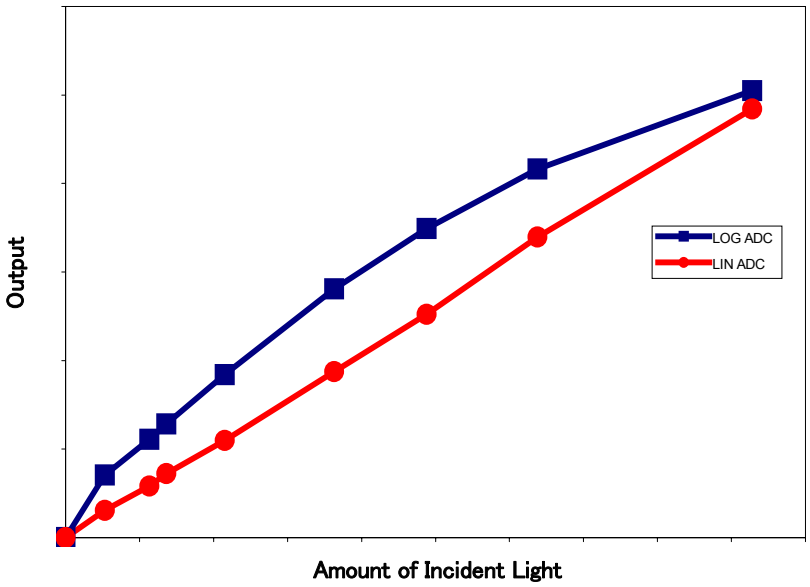


Figure 4-10-2 A/D Characteristics

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.

Cal_bl :Output data of each pixel at perfectly dark (digital)
Cal_wh :Output data of each pixel in uniform illumination (digital)
Target-val :Target value for correction (10bit digital)
Vin :Input data (digital) Vout :Output data (digital)
The corrected data is expressed in the following equation.
Vout=(Vin-Cal_bl)xTarget_val/(Cal_wh-Cal_bl)

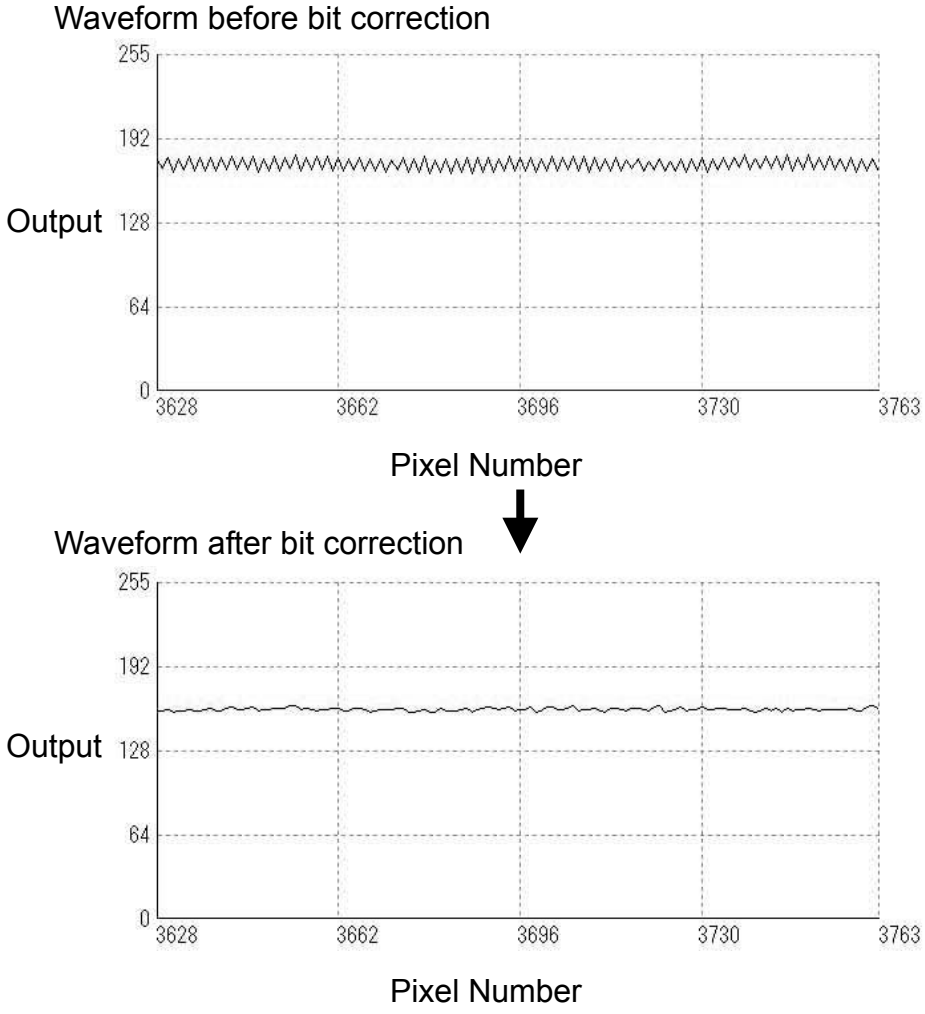


Figure 4-11-1 Waveform before and after bit correction

4.11.1 Command Settings

You can set the correction on or off, and acquire arbitrary white correction data by sending commands through serial communication,

The example of command settings

shc 0,900:	No correction
shc 1,900:	Factory white correction
shc 2,900:	Arbitrary white correction
wht:	Acquisition of arbitrary white correction data

4.11.2 How to calibrate the camera

(1) Remove the lens cap and point it at the white illumination, in order to set a uniform wave level. Then you can acquire arbitrary white correction data. With a lens, the shading by both a lens and a light source will be simultaneously corrected. At this time, please defocus a little to avoid being affected by the un-uniformity of the object.

(2) Send the “wht” command through serial communication.

(3) Confirm that the camera returns “>OK” and “>wht”. Thus arbitrary white correction data is saved and loaded to the camera.

(4) Send the “shc 2 VAL” command through serial communication. Then the arbitrary white correction will be on and set the correction level as “VAL”.

4.12 Test Pattern

This camera can generate a test pattern. Use the test pattern to verify the proper timing and connections between the camera and the frame grabber board.

The test pattern of the camera is below.

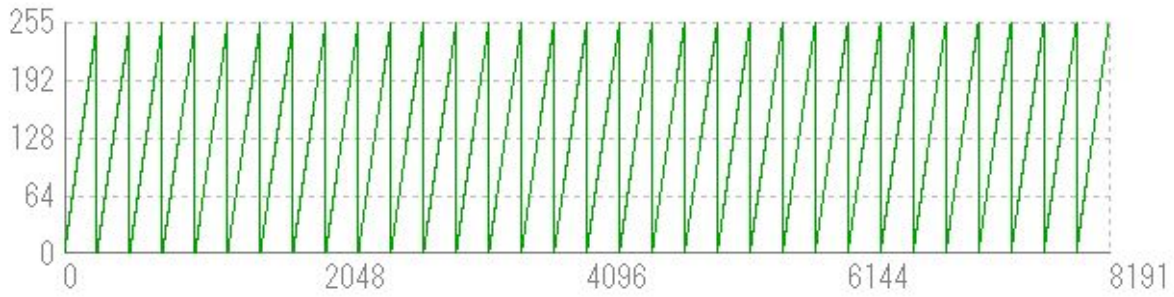


Figure 4-17 Test Pattern of the Camera

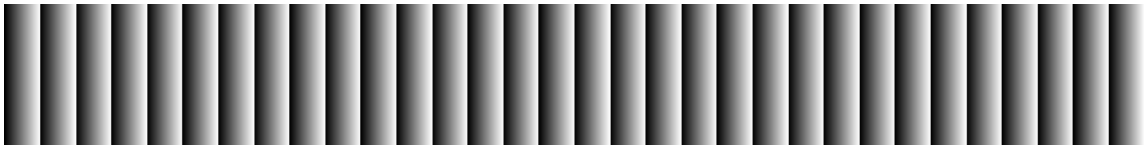


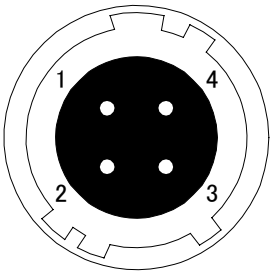
Figure 4-18 Test Image the Camera

The test pattern is a ramp from 0 to 255DN in 8-bit mode, and then it repeats itself from 0 again 32 times.

5 Confirming Camera Settings

5.1 Before Power-on

(1) Confirm the pin assignment of the power cable.



No	NAME	Color of Cable
1	12 -15V	White
2	12 -15V	Red
3	GND	Green
4	GND	Black

Figure 5-1-1 Pin Assignment of Power Cable

(2) Confirm the direction and the channel of the cables. Some Camera Link cables are directional.

- If one of the connectors says “Camera side”, connect it to the camera.

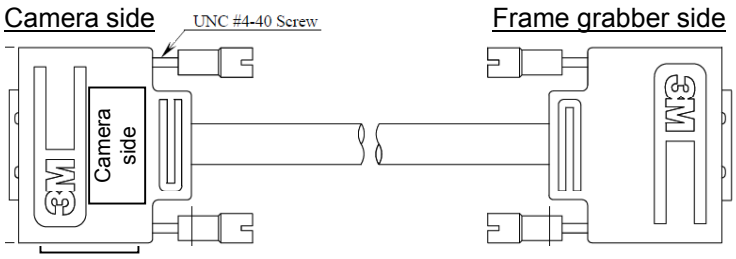


Figure 5-1-2 Connection Direction of Camera Cable

The connection channel of in case of “Solios”

CL1 = CHANNEL #0

CL2 = CHANNEL #1

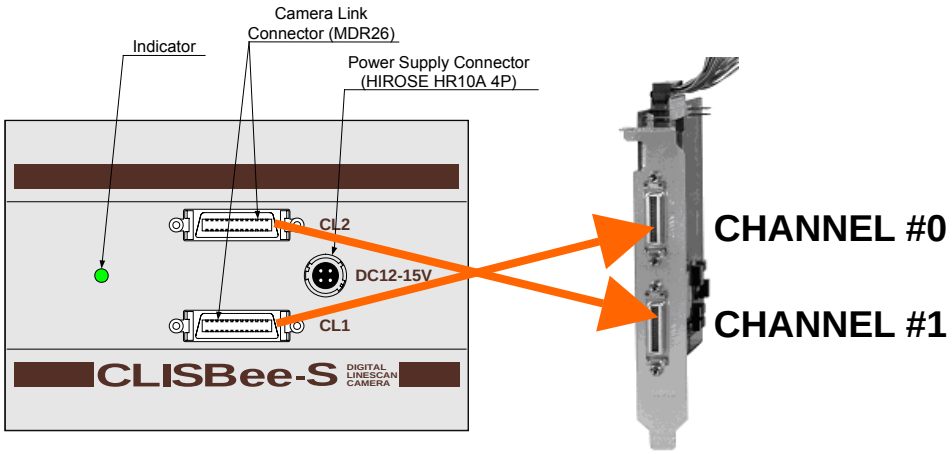


Figure 5-1-3 Channel of Camera Link Cables

5.2 After Power-on

(1) Confirm sent and received commands using the camera control utility. Launch CLISBeeCtrl, set COM port and connect. Click “Memory Dump” and wait for the response.

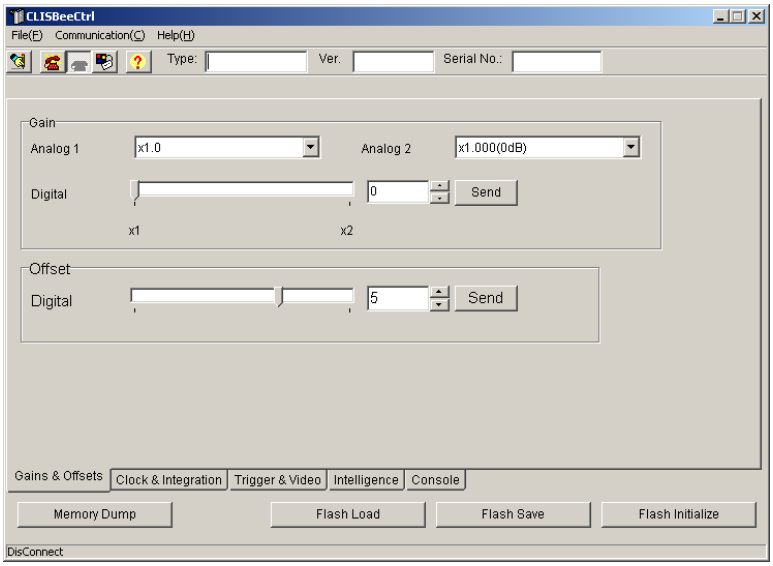


Figure 5-2-1 Confirmation of Connection

(2) Set a trigger mode and a video output mode with the camera control utility.

Example: Trigger mode = Free run
Video output mode =8bit

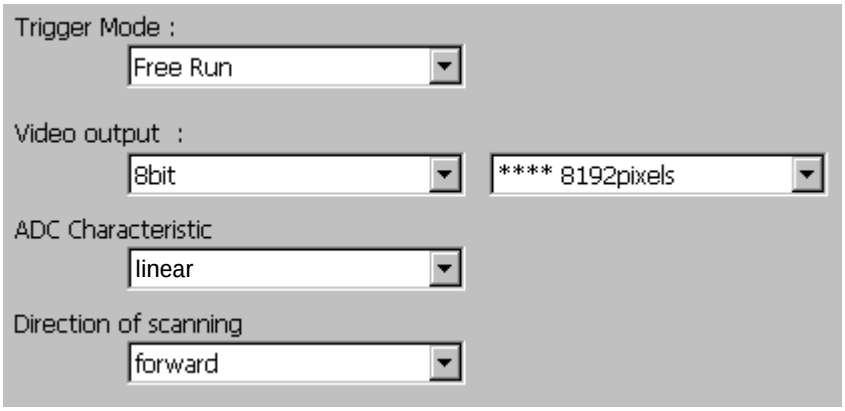


Figure 5-2-2 Exposure Mode (Trigger Mode)

◆ If you have your own application to check the images, select suitable settings.

(3) Capture images using a camera interface board utility. In case of Matrox's Solios, it is convenient to use Intellicam.

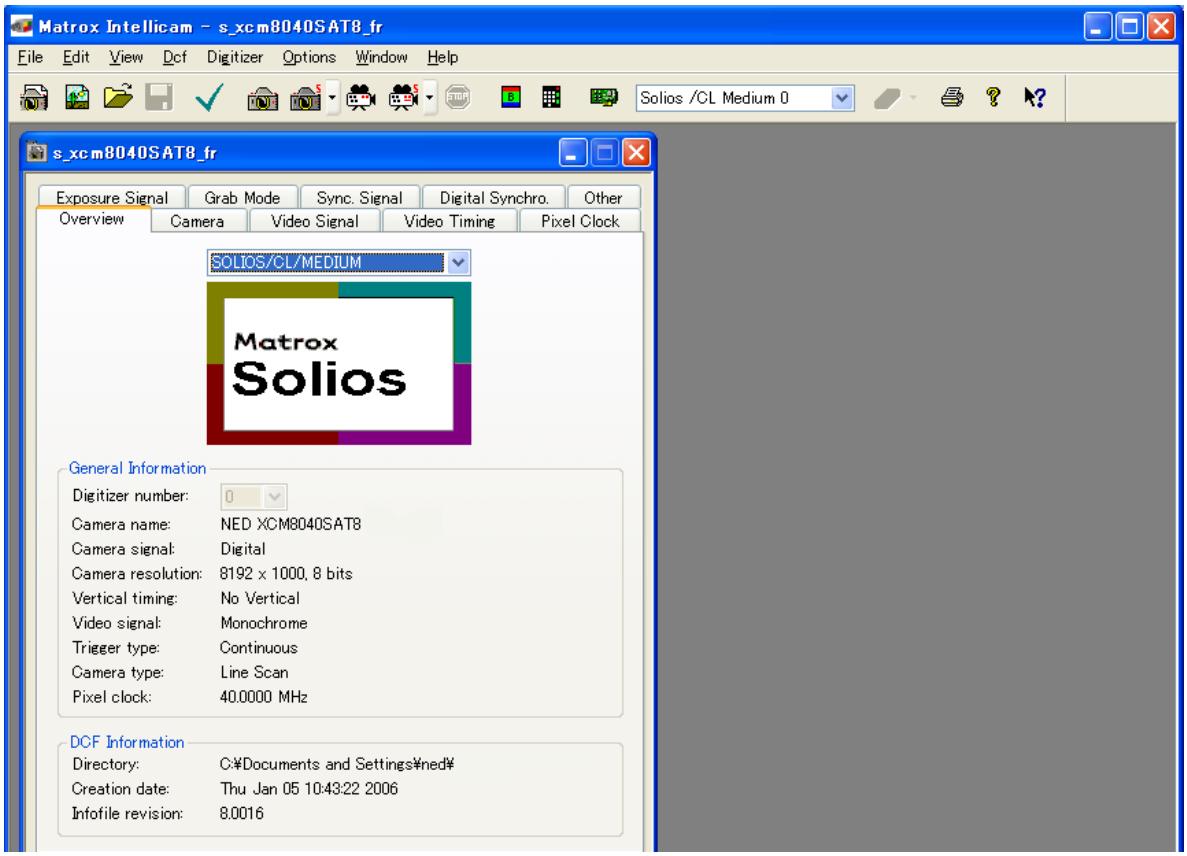


Figure 5-2-3 Solios Window

5.3 In Operation

(1) Does acquisition time out error occur?

<Cause>

<1> Captured images are too heavy.

If there are many filtering processes, the assignments to the driver may be insufficient.

<2> The cables are detached from the connector

Ensure that the power cable and Camera Link cables are connected to the camera correctly.

<3> Camera Link cables come under the influence of noise when the cables are laid near a light source inverter line or a power line. The personal computer in use may be reset.

(2) Are there dark lines in the direction of vertical scanning on the image?

<Cause>

<1> Dust on the sensor window

Dust may come on the sensor window from the inside or the outside of the camera. Remove the dust with air or a lens cleaner.

6 Sensor Handling Instructions

6.1 Electrostatic Discharge and the Sensor

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

6.2 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.

6.3 Cleaning the Sensor Window

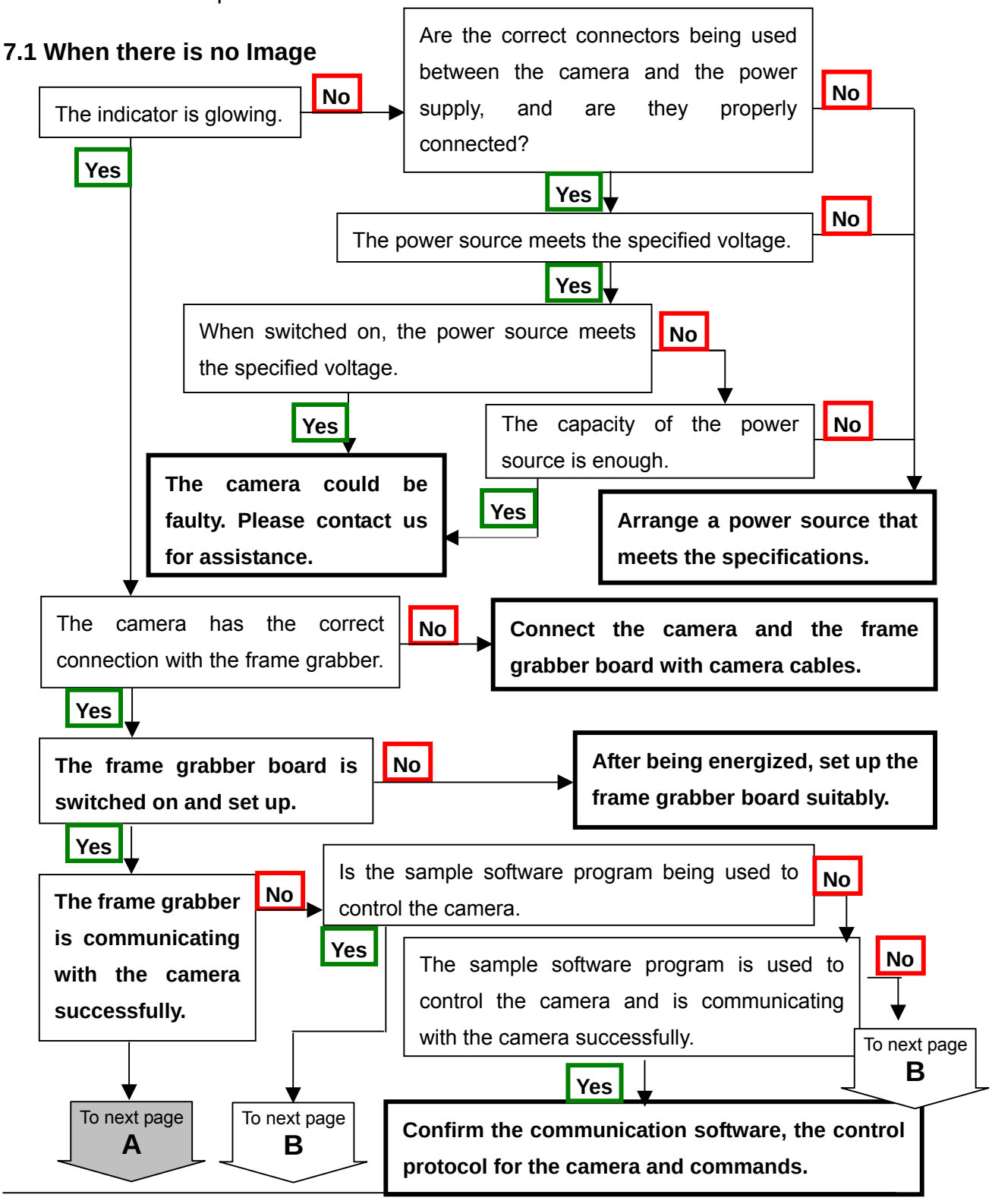
Dust: Can usually be removed by blowing the window surface using a compressed air blower.

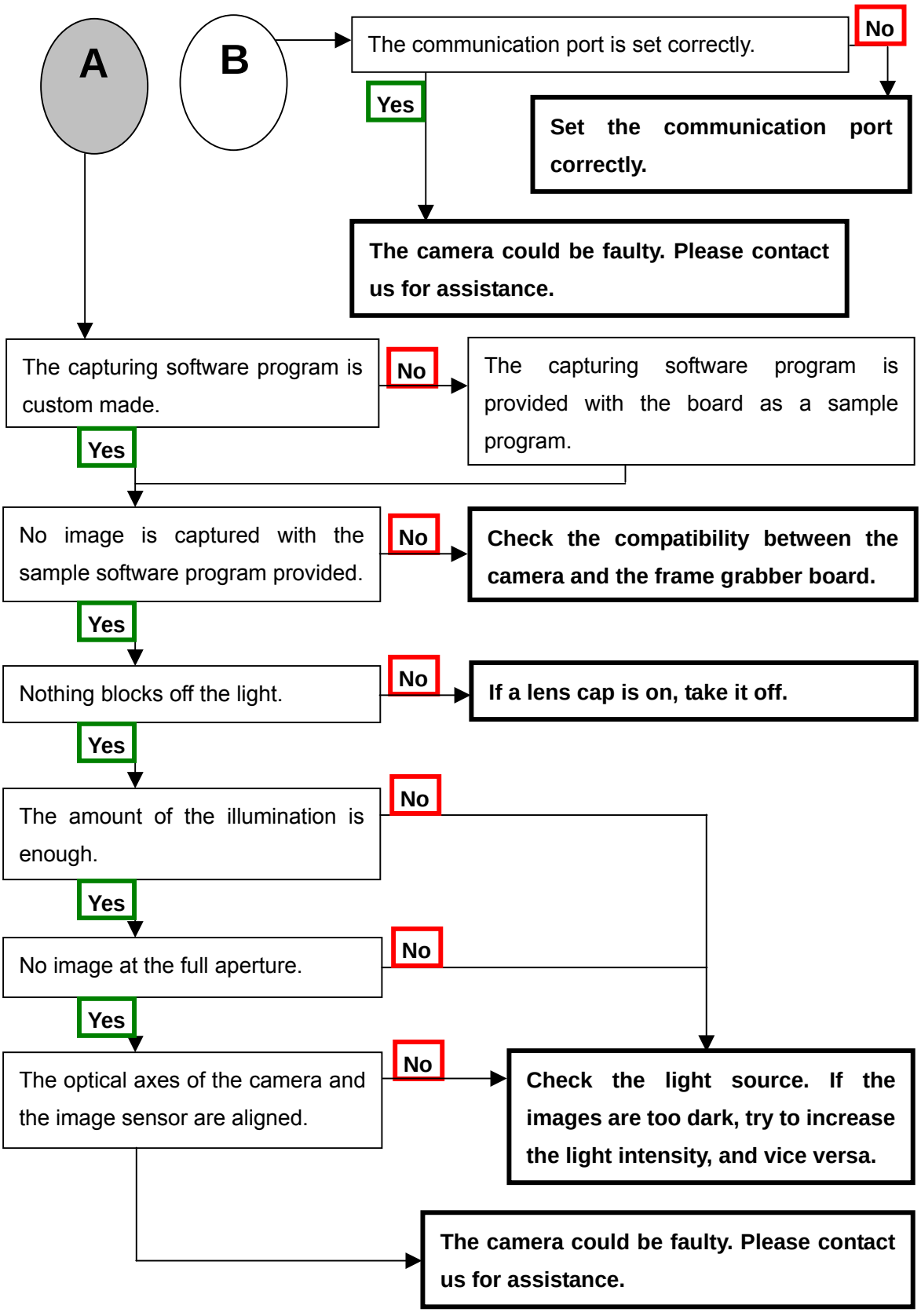
Oil: Wipe the window with a lint-free cloth wiper moistened with ethyl alcohol carefully and slowly.

7 Troubleshooting

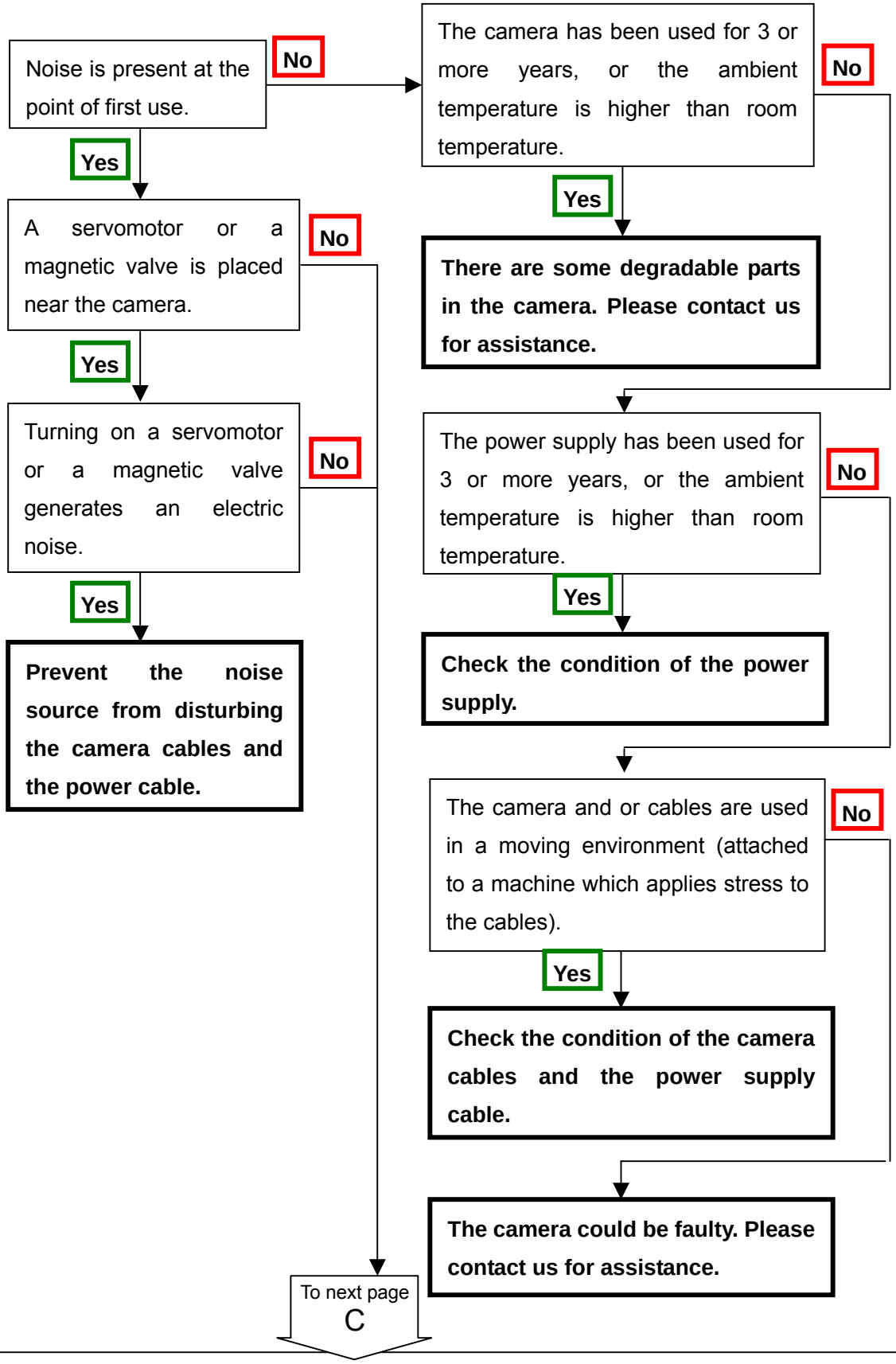
The following pages contain several troubleshooting charts that can help you find the cause of problems user sometimes encounter.

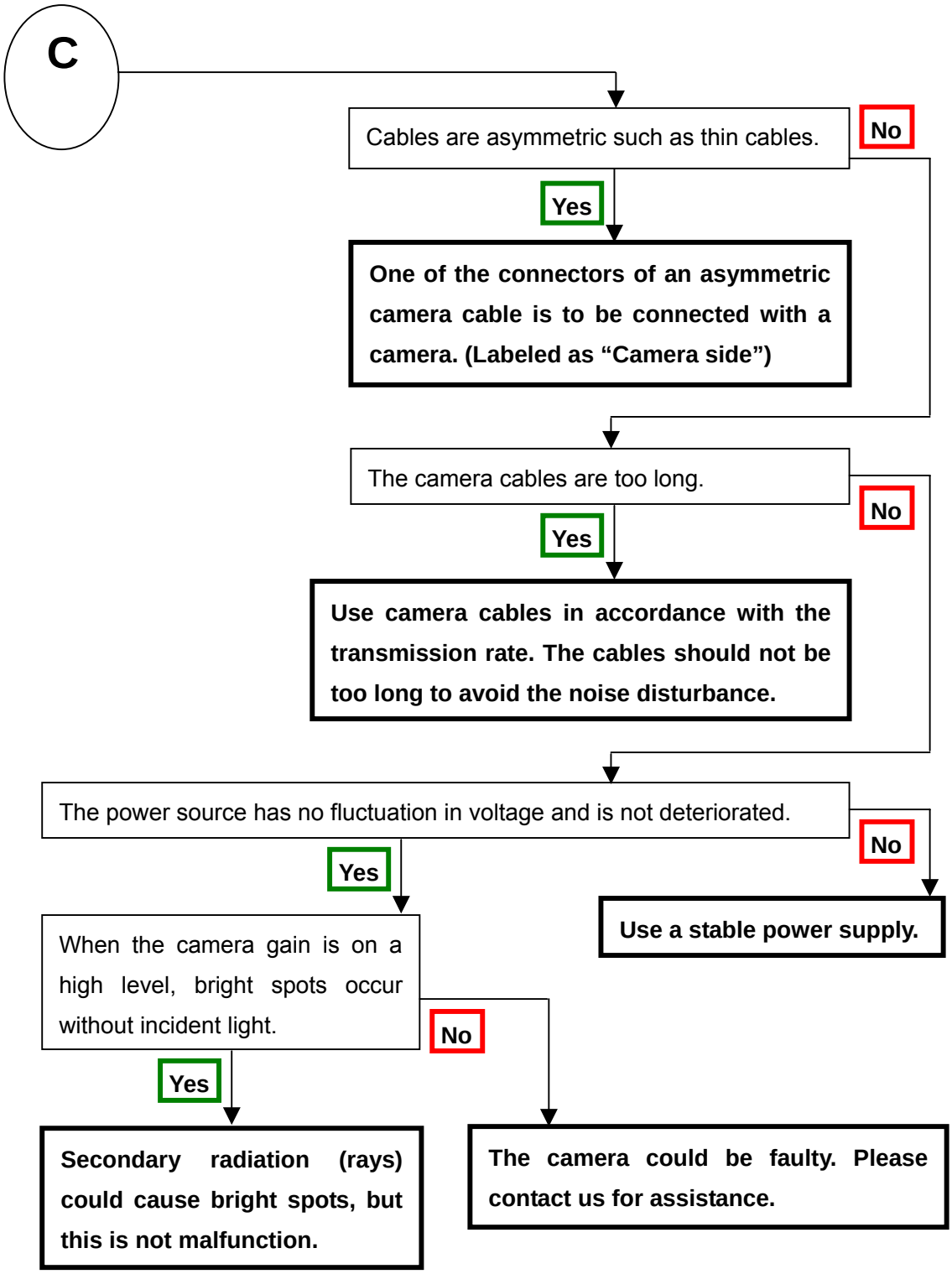
7.1 When there is no Image



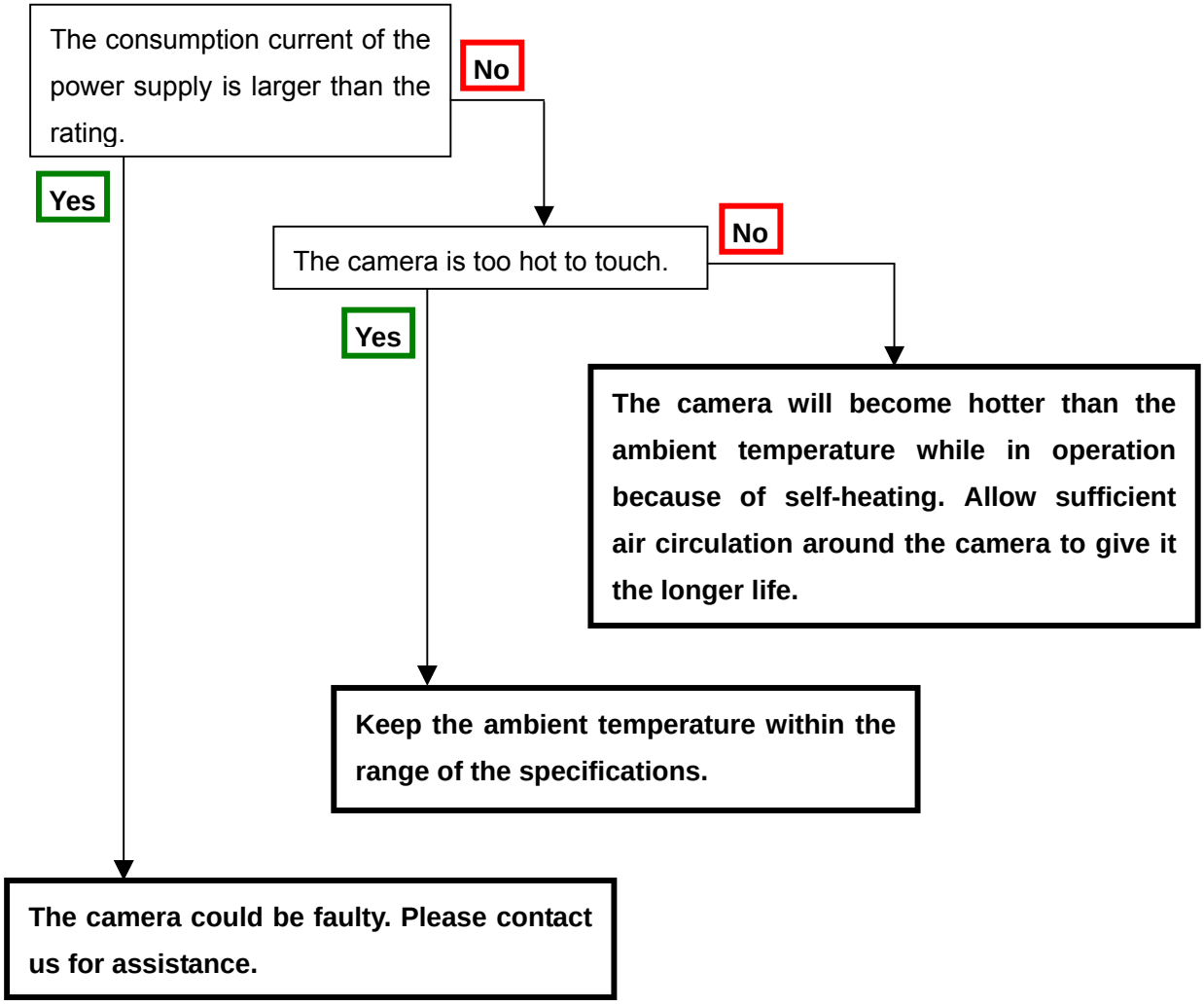

A
B
The communication port is set correctly.
No
Yes
Set the communication port correctly.
The camera could be faulty. Please contact us for assistance.
The capturing software program is custom made.
No
The capturing software program is provided with the board as a sample program.
Yes
No image is captured with the sample software program provided.
No
Check the compatibility between the camera and the frame grabber board.
Yes
Nothing blocks off the light.
No
If a lens cap is on, take it off.
Yes
The amount of the illumination is enough.
No
Yes
No image at the full aperture.
No
Yes
The optical axes of the camera and the image sensor are aligned.
No
Check the light source. If the images are too dark, try to increase the light intensity, and vice versa.
The camera could be faulty. Please contact us for assistance.

7.2 When Noise is present in the Image




C
Cables are asymmetric such as thin cables.
No
Yes
One of the connectors of an asymmetric camera cable is to be connected with a camera. (Labeled as “Camera side”)
The camera cables are too long.
No
Yes
Use camera cables in accordance with the transmission rate. The cables should not be too long to avoid the noise disturbance.
The power source has no fluctuation in voltage and is not deteriorated.
No
Yes
Use a stable power supply.
When the camera gain is on a high level, bright spots occur without incident light.
No
Yes
Secondary radiation (rays) could cause bright spots, but this is not malfunction.
The camera could be faulty. Please contact us for assistance.

7.3 When the Camera becomes hot



8 CLISBeeCtrl

8.1 Overview

The CLISBeeCtrl is the remote control software for “CLISBee*” camera using “**N**ED **C**amera **C**ontrol **P**rotocol”(NCCP) from a PC.

Connectable interfaces are following.

1) Camera Link API

2) Communication Port (COM port, RS232C)

*CLISBee is the nickname for XCM series camera.

8.2 System Requirements

PC : PC/AT compatible

Operating System: Microsoft Windows 2000 or XP. (Windows Vista: not confirmed)

Free disk space: 1-2MB (It may fluctuate with the number of camera parameter files.)

Connection: Camera Link grabber board, Camera Link cables

8.3 Install

Copy the CLISBeeCtrl folder in the media (CD-ROM, etc), which our company provides, to your hard disk.

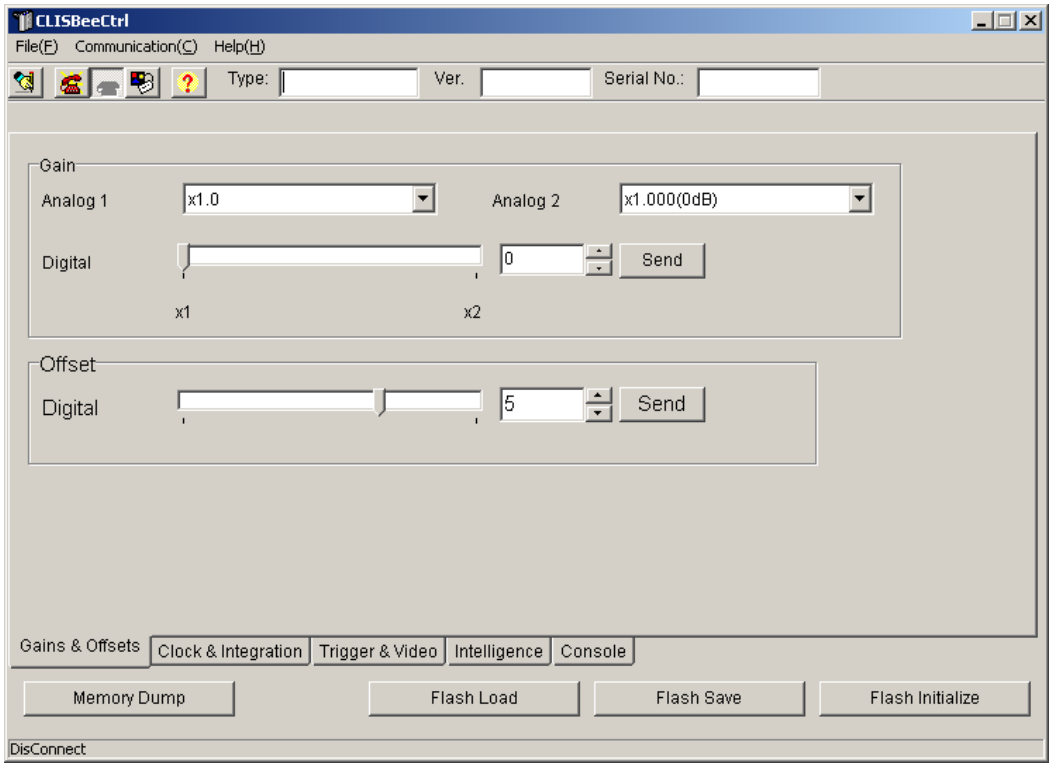
8.4 Uninstall

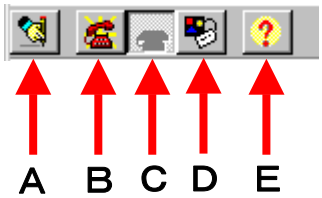
Remove the CLISBeeCtrl folder and all files in CLISBeeCtrl folder.

8.5 Operation

8.5.1 Start Program

Open Windows Explorer and Double-click the “CLISBeeCtrl.exe”.





Buttons in the tool-bar have the following functions.

A: Exporting parameters in the text file format.

B: Connection with the camera.

C: Disconnection.

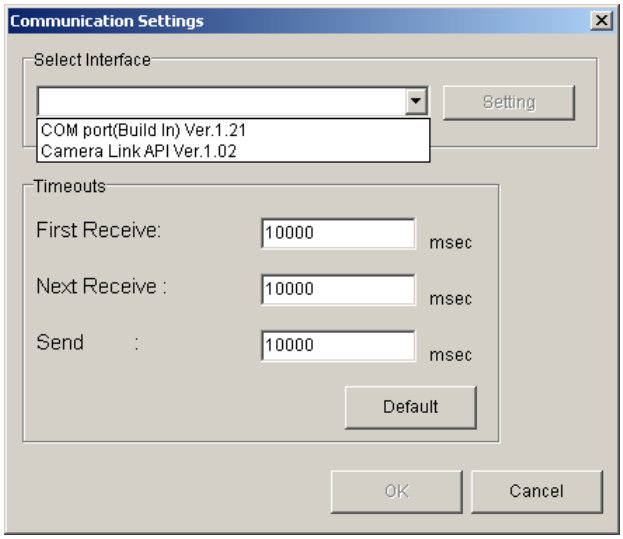
D: Setting Communication.

E: Version Information.

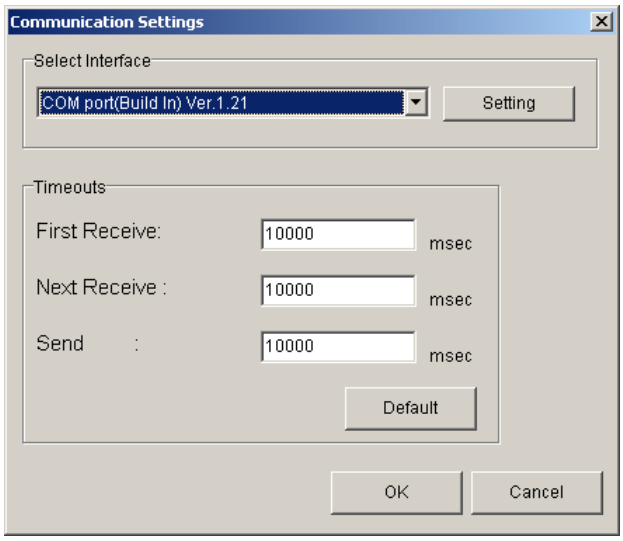
8.5.2 Selecting interface and Timeout setting

8.5.2.1.Selecting interface

1) Click button D.



2) Select the interface in Drop-down-list-box.



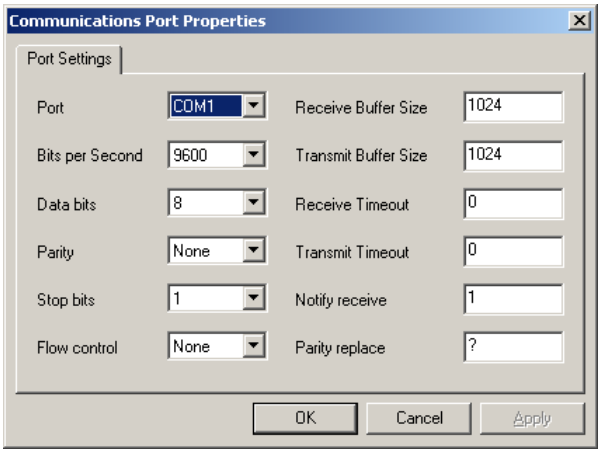
3) Click “Setting” button to set the interface. (See 8.5.2.2. and 8.5.2.3.)

4) Click “OK” button.

Click “Cancel” button when stopping setup.

Note: The camera can be used without this operation after it has been set up correctly.

8.5.2.2 Setting Communication port



1) Set up each item as follows. (NED standard)
   However, when the setup which differs to the camera to connect is shown, follow there.

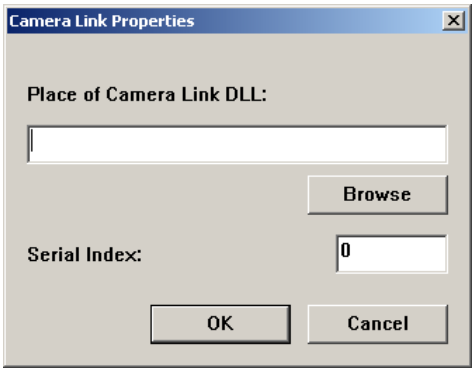
   (1) Port: Select connecting port.
   (2) Bits per Second: 9600
   (3) Data bits: 8
   (4) Parity: None
   (5) Stop bits: 1
   (6) Flow control: None

   Note: Other parameters are not used.

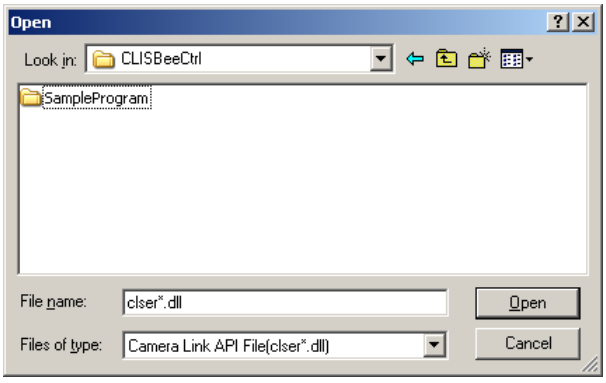
2) Click “OK” button.
   Click “Cancel” button when stopping setup.

Note: The camera can be used without this operation after it has been set up correctly.

8.5.2.3 Setting Camera Link API



1) Input the DLL file name for Camera Link API by edit-box,
Or click “Browse” button and select this file.



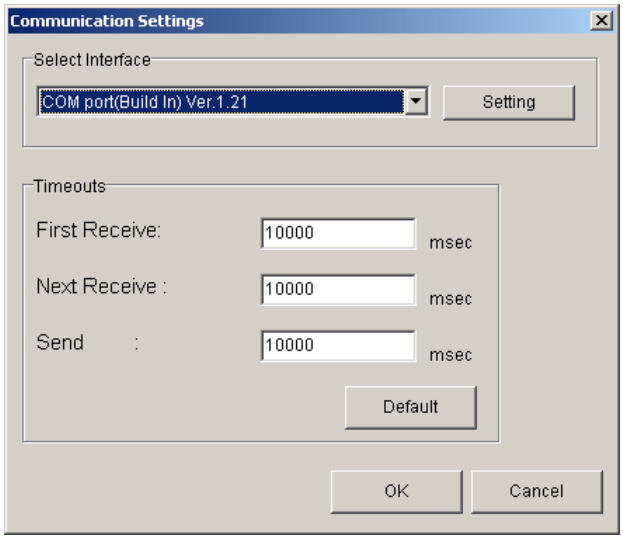
2) Input value corresponding to the position of Camera Link cable to connect, into “Serial Index” column.

3) Click “OK” button.
Click “Cancel” button when stopping setup.

Note: The camera can be used without this operation after it has been set up correctly.

Note: DLL for Camera Link API is provided by the manufacturer of the grabber board.
Some frame grabber boards are connected directly to the PC’s COM port, in this case, select interface to COM port (RS232C). Please contact the manufacturer of the grabber board for detail.

8.5.2.4 Setting Timeout



1) Input each timeout value in the edit-box.(unit :msec)

When you will click on the “Default” button, the value will be reset to the cameras default values.

The meanings of each timeout are as follows.

First Receive: The maximum time from sending a command to receiving the first data.
Next Receive: The maximum time between a letter and the next one.
Send: The maximum time until finishing sending a command.

2) Click “OK” button.

Click “Cancel” button when stopping setup.

Note: The camera can be used without this operation after it has been set up correctly.

8.5.3.Connect

Click button B. Then you can control the camera. (See “8.6.Control”)

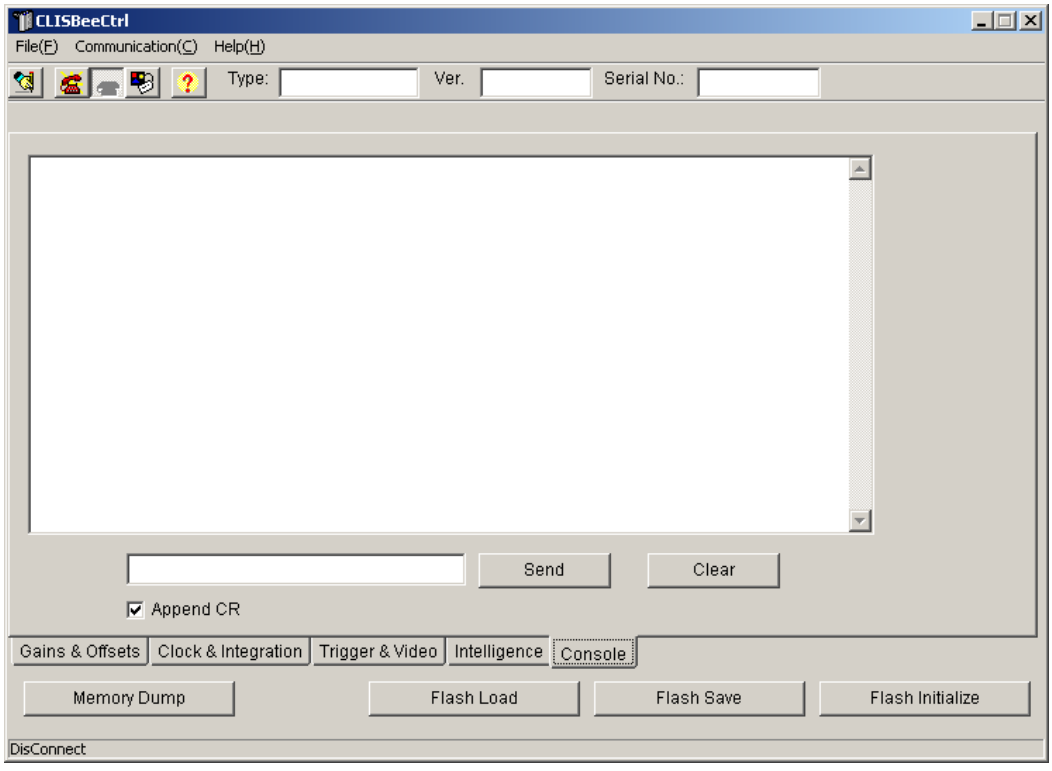
Click the “Memory Dump” button to acquire the current data of the camera.

8.5.4.Disconnect and end program

Click button C. Then click “X” button in the upper right of the window.

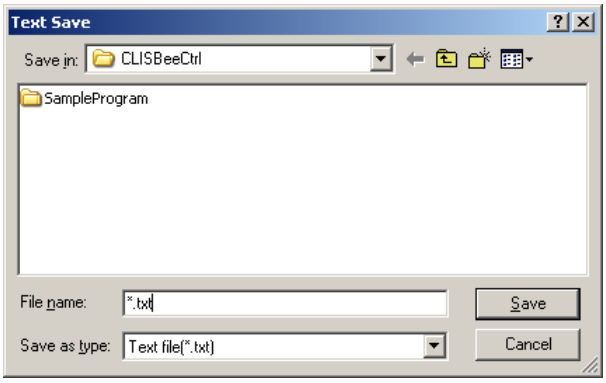
8.5.5.Check of the contents of communication

Click "Console" tag near the bottom window.



8.5.6.Export Parameters to text file

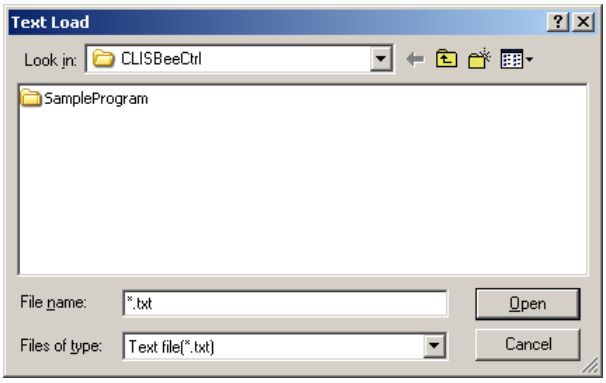
1) Click button A.



2) Input file name and click “Save” button. Present setting value of each control is saved by text format.

8.5.7.Import Parameters from text file

1) Select menu “File” – “Text Load”

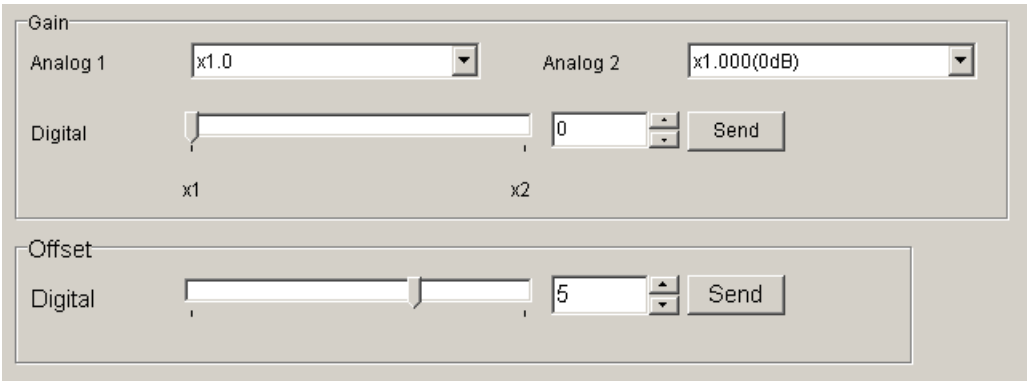


2) Input file name and click “Open” button.

Each command preserved in the text file is issued one by one.

8.6 Control

8.6.1 Gains and Offsets



< Gain >

Analog 1 / **Analog 2** :

The signal will be sent to the camera every time you make a selection from the menu in the drop-down-list-box.

Note: XCMx0x0SA does not use ‘Analog 2’.(Included to ‘Analog 1’)

Digital :

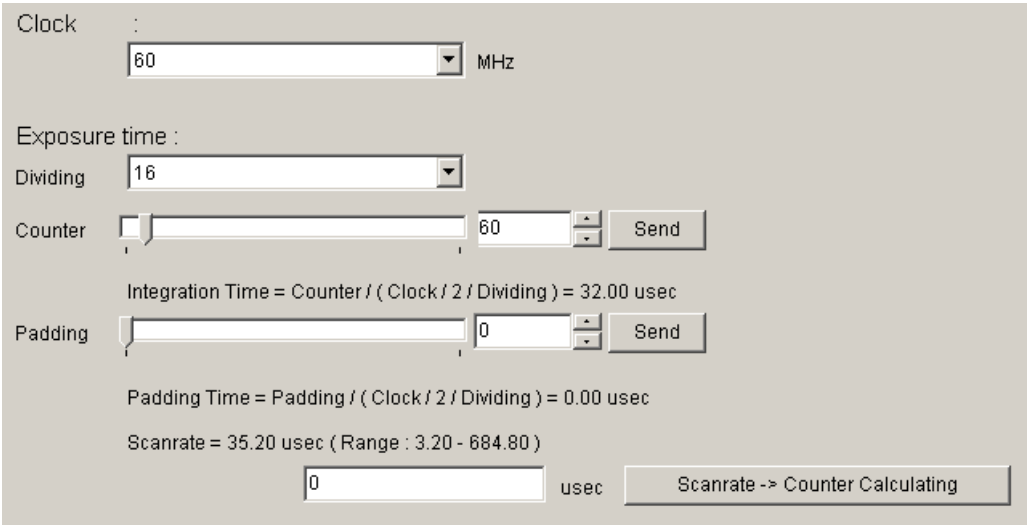
Set a value with the slider, the edit-box or the spin-button. Then, click “Send” button.

< Offset >

Digital :

Set a value with the slider, the edit-box or the spin-button. Then, click “Send” button.

8.6.2 Clock & Integration



Clock :

Shows the camera internal clock frequency.

(**Read Only**)

Dividing / **Counter** :

Setting integration time.

First, choose a dividing clock from the drop-down-list-box.

Next, set a counter value with the slider, edit-box or the spin-button. Then, click “Send” button.

Integration Time :

Shows the calculated value of integration time. (unit : μs)

Padding :

Set a value with the slider, the edit-box or the spin-button. Then, click “Send” button.

Padding Time :

Shows the calculated value of padding time. (unit : μs)

Scanrate :

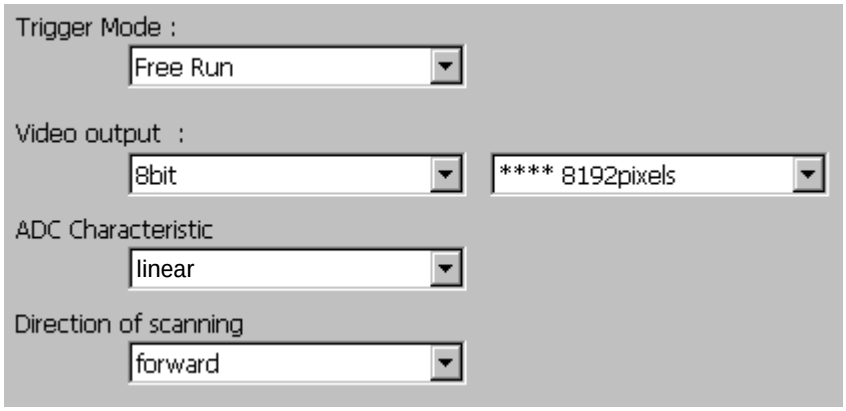
Shows the calculated value of the scan rate. (unit : μs)

Scanrate -> Counter Calculating :

Set the value in the edit-box. Then, click this button.

Put the desirable scan rate value, then the counter value will be calculated automatically with the present values of clock, dividing and padding.

8.6.3 Trigger & Video



The signal will be sent to the camera every time you make a selection from the menu in the drop-down-list-box.

Trigger Mode :

The selection of Free Run Exposure mode and External Trigger Exposure mode.

Video output :

The selection of the number of the output bit and the output block.

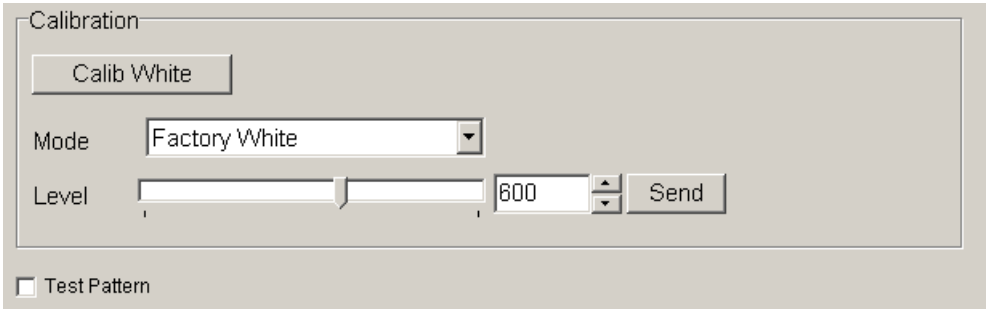
ADC Characteristic :

The selection of the A/D characteristics.

Direction of scanning :

The selection of the scan direction.

8.6.4 Intelligence



< Calibration >

Calib White :

Acquisition of white data and saving the calibration data to camera's flash memory.

Note:It takes time for processing.

Mode / **Level** :

First, choose the mode from the drop-down-list-box.

Next, set a value with the slider, the edit-box or the spin-button. Then, click "Send" button.

Test Pattern :

The signal will be sent to the camera every time you make this selection from the menu in the drop-down-list-box.

8.6.5 Memory in camera

Memory Dump :

Read the data from the camera's work memory.

Flash Load :

Loading the data from the camera's flash memory.

Flash Save :

Saving the data in the camera's flash memory.

Flash Initialize :

Initializing the camera's flash memory with the factory standard data.

Note:It takes time for saving and initializing.

8.7 Upgrade

When installing a newer / updated software version from our company,
Please perform in the following procedure.

1) Check the CLISBeeCtrl has not started.
2) Uninstall the old version software. (See “8.4.Uninstall”)
3) Install new version software. (See “8.3.Install”)

8.8 How to Program

Please refer sample programs in CLISBeeCtrl¥SampleProgram folder.

8.9 Attention on use

1) Reproducing and distributing without notice the part or all of this software and this book is prohibited..
2) Reverse engineering, decompiling, disassembling and modifying without notice the part or all of this software is prohibited..
3) The specification of this software and the contents of this book may be changed without announcement in future.

9 Others

9.1 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.

9.2 Contact for support

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Fax +81-92-451-9335

URL
http://ned-sensor.co.jp/

E-Mail
sales@ned-sensor.com

9.3 Product Support

9.3.1 Warranty card (attach a separate)

Read carefully the Warranty card, please trasure it.

9.3.2 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

(1) executing the “sta” command, or

(2) clicking “Memory Dump” button when using CLISBeeCtrl.

The example of the camera status.

```
sta CR
>OK
>Type=XCM8040SAT8
>Ver.= 2.66_0x4948
>Serial=0
>check_code = 20070615
>gax 0
>gdx 0
>odx 0
>inm 0
>int 1,31
>cka 0
>voa 0,0
>voc 0
>tpn 0
>shc 1,900
>pad 0
>rev 0
>sta
```

Revision History

Revision Number	Date	Changes
01	8 Oct. 2010	Initial release