JAI®

See the possibilities

User's Manual

LQ-050CL

RGB Color & NIR
4CCD Line Scan Camera

Notice

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Warranty

For information about the warranty, please contact your factory representative.

Certifications

CE compliance

As defined by the Directive 2004/108/EC of the European Parliament and of the Council, EMC (Electromagnetic compatibility), JAI Ltd., Japan declares that LQ-050CL complies with the following provisions applying to its standards.
EN 61000-6-3 (Generic emission standard part 1)
EN 61000-6-2 (Generic immunity standard part 1)
IEC61000-4-2(Electrostatic discharge immunity test)

FCC

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules.   These limits are designed to provide reasonable protection against harmful interference in a residential installation.   This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
-    Reorient or relocate the receiving antenna.
-    Increase the separation between the equipment and receiver.
-    Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-    Consult the dealer or an experienced radio/TV technician for help.

Warning
Changes or modifications to this unit not expressly approved by the party responsible for FCC compliance could void the user's authority to operate the equipment.

Supplement

The following statement is related to the regulation on " Measures for the Administration of the control of Pollution by Electronic Information Products " , known as " China RoHS ". The table shows contained Hazardous Substances in this camera.

🄵 mark shows that the environment-friendly use period of contained Hazardous Substances is 15 years.

重要注意事项

有毒，有害物质或元素名称及含量表

根据中华人民共和国信息产业部『电子信息产品污染控制管理办法』，本产品《 有毒，有害物质或元素名称及含量表 》如下.

部件名称	有毒有害物质或元素					
	铅 （Pb）	汞 （Hg）	镉 （Cd）	六价铬 （Cr(Ⅵ)）	多溴联苯 （PPB）	多溴二苯醚 （PBDE）
棱镜	✕	○	○	○	○	○
光学滤色镜	✕	○	✕	○	○	○
镜头座	✕	○	○	○	○	○
连接插头	✕	○	○	○	○	○
电路板	✕	○	○	○	○	○

○：表示该有毒有害物质在该部件所有均质材料中的含量均在SJ/T11363−2006规定的限量要求以下。
×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出SJ/T11363−2006规定的限量要求。
（企业可在此处、根据实际情况对上表中打 "×" 的技术原因进行进一步说明。）

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电子信息产品中含有的有毒有害物质或元素在正常使用的条件下不会发生外泄或突变、电子信息产品用户使用该电子信息产品不会对环境造成严重污染或对基人身、财产造成严重损害的期限。
数字「15」为期限15年。

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1. General

The LQ-050CL is a 4CCD line scan camera using four 512 pixel line sensors mounted on a prism, for the R, G,B and NIR channels. It operates with a 40 MHz pixel clock, resulting in a maximum line rate of 70,922 lines per second.
The camera outputs digital data in 4 x 8 bits or 4 x 10 bits format via Camera Link. The camera is configured by software through the serial communication port of the Camera Link interface, or via RS-232C through a 12-pin Hirose connector.
The camera accepts M52 mount or F-mount lens.

The LQ-050CL is a suitable camera for various applications such as inspection of fruits, vegetables ,circuits boards or electronic/mechanical parts, as the NIR image can catch scratches or blemishes on object surfaces which the RGB color image cannot find.

The latest version of the operation manual can be downloaded from www.jai.com .
The latest camera control tool for the LQ-050CL can be downloaded from www.jai.com .

For camera revision history, please contact your local JAI distributor

2. Camera nomenclature
The standard camera composition consists of the camera main body and sensor protection cap.

The camera is available in the following versions:
LQ-050CL
Where L stands for "Line sensor, Q stands for "Quad CCD", 50 represents the resolution "500 pixels", and CL stands for "CameraLink™" interface.

3. Main features
- 4CCD line scan camera with 512 pixel resolution
- Dichroic beam splitter prism to separate R,G,B and NIR wavelengths
- 70,922 lines per second scan rate
- 40 MHz pixel clock
- 4 x 8 bits or 4 x 10 bits output through Camera Link interface
- Flat-field correction. Two point pixel-by-pixel compensation on each R,G,B and NIR channels
- Master gain control in the range of -3dB to +12dB with a fine gain control
- Flat Shading correction and Color Shading Compensation
- One-push auto white balance
- Binning function to increase sensitivity
- Gamma correction using LUT(Look Up Table)
- Auto reset function
- Noise reduction function
- Test pattern generator(color bar, gray, white) for set-up and trouble shooting
- Electronic shutter (for selected modes)
- Short ASCII commands set-up via RS 232C or Camera Link
- M52 mount or F mount selectable
- Setup by Windows XP/Vista/7 software

About M52 mount: LQ-050CL employs a new M52 mount as the standard. This mount is recommended in the lens guide line for machine vision applications which is set by Japan Industrial Imaging Association in corporation with AIA and EMVA. The title of the guideline is "JIIA LER 004-2010 Recommended Mechanical Interfaces Applied for Each Image Size Classification" and issued on March 10th, 2010.

4. Locations and functions
4.1. Locations and functions
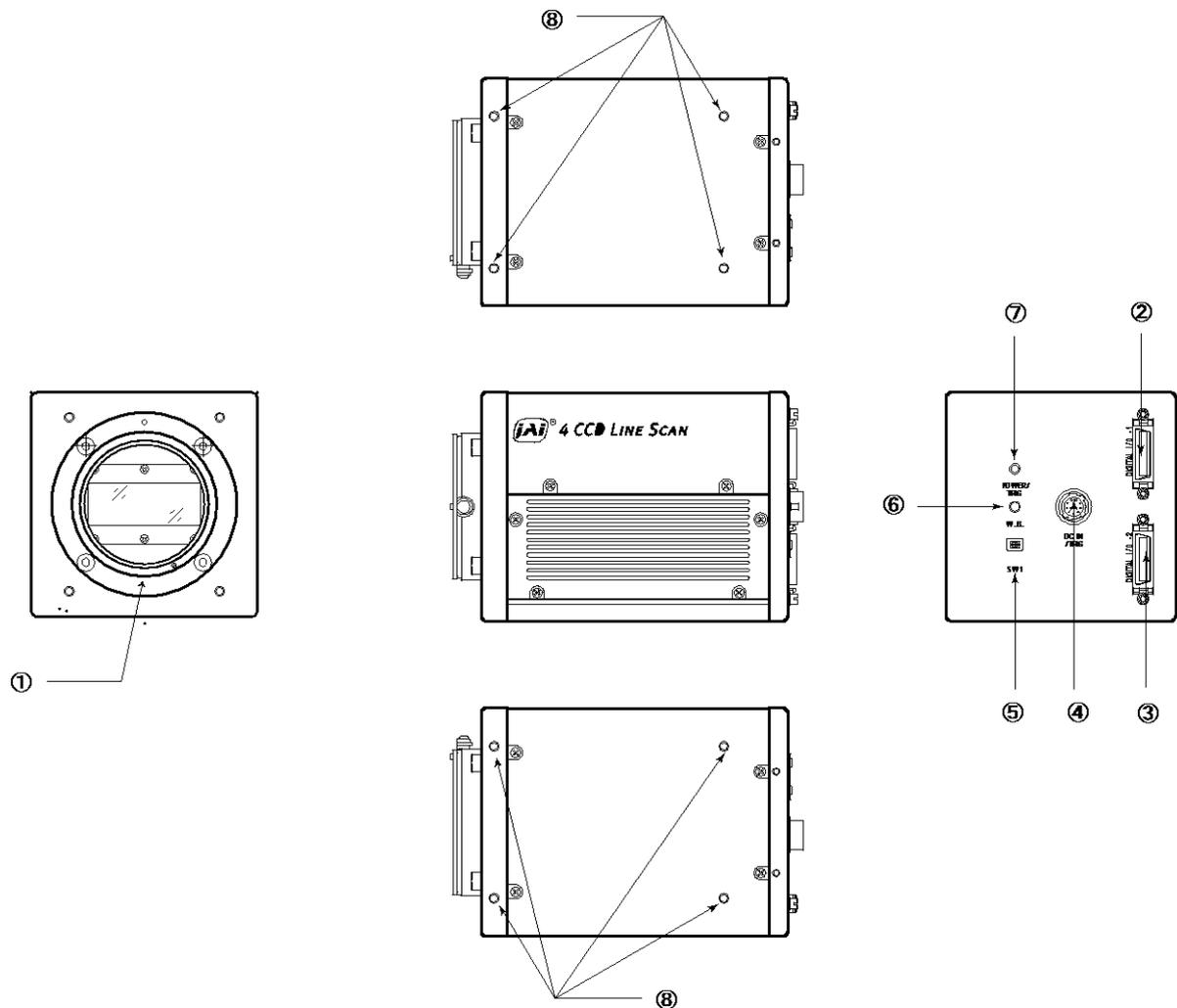
Fig. 1   Location of external features

1   Lens mount   M52 mount (*1)Note)
2   Camera Link part 1   base connector (1) (*2)Note)
3   Camera Link part2   medium connector (2) (*2)Note)
4   12-pin Hirose connector   DC +12, External trigger and RS-232C
5   DIP switch   SW-1 (refer to chapter 4.2 for the details)
6   Button   For one-push auto white balance
7   LED indicator   Power, trigger input and operation indications
8   Camera mounting holes   8 x M4, depth 6mmmm (*3) Note)

*1) Note: Rear protrusion on M52 mount lens must be less than 13mm.
*2) Note: When a CameraLink[TM] cable is connected to the camera, please do not excessively tighten
            screws by using a driver.   The CameraLink receptacle on the camera might be damaged.
            For security, the strength to tighten screws is less than 0.291 Newton meter (Nm). Tightening
            by hand is sufficient in order to achieve this.
*3) Note: The depth of mounting hole is 5.5mm . If the longer screws than 6mm are used,
            they may damage the circuit board inside.

4.2. Rear Panel
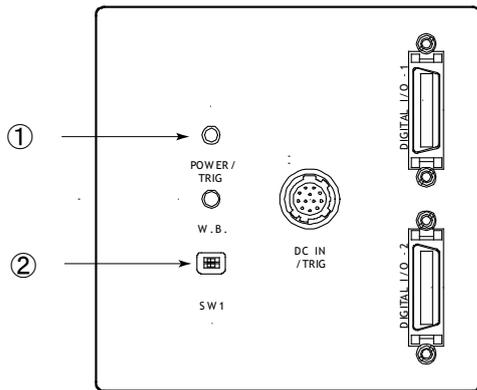
Fig2. Rear panel

① **LED**

● **Green (Steady)**
Operating, but not receiving external trigger input

✴ **Green (Flashing)**
Operating and receiving external trigger input.
Note that the flashing frequency does not correspond to the frequency of the trigger signal. The flashing does not occur in the No-Shutter internal and Shutter-Select internal modes.

● **Orange**
Initializing and cannot operate
1) Initializing for approx. 800ms
2) One-push auto white balance is engaged.

② **DIP switch**

SW-1 function

No	Function	Settings	
		ON	**OFF**
1	Serial communication	Hirose 12Pin	**Camera link (CC1)**
2	Termination of External trigger	75 Ω	**TTL**

Note: Factory default settings for both functions are "OFF".
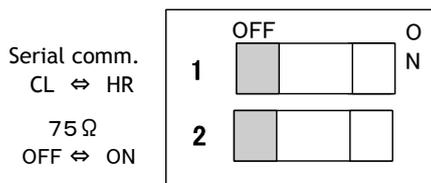
Fig.3 DIP switch

5. Connectors and pin assignment

5.1. 12-Pin Connector (Hirose)

Type: HR10A-10R-12PB-01 Hirose (Male)
Use the part number HR10A-10P-12S for the cable side
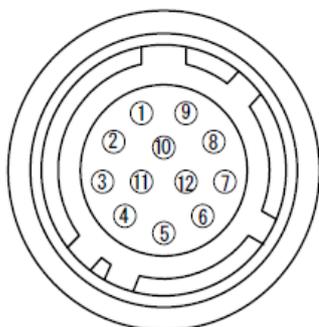
Pin No.	Signal	Remarks
1	GND	
2	DC in	+12V to +24V
3	GND	
4	Reserved	Do not connect
5	GND	
6	RxD in	RS-232C
7	TxD out	RS-232C
8	GND	
9	XEEN out	
10	Trigger in	TI=1, or set TI=0 for input via CL
11	DC in	+12V to +24V
12	GND	

Fig. 4   12-pin Hirose connector

Note: Applicable connector

No.	Manufacturer	Type	Note
Camera side	HIROSE	HR10A-10R-12PB(71)	
Cable side	HIROSE	HR-10A-10P-12S	Plug

5.2. Digital Output / Interface Connectors for CameraLink™
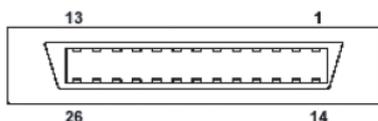
Type: 26P MRD Connector   3M 10226-1A10JL

Fig. 5   Camera Link connector

This camera can be used with all Camera Link products that comply with the AIA Camera Link standard. Cables, transmission systems and frame grabbers/acquisition boards that do not comply with the Camera Link standard may work with this camera, but JAI Camera Solutions cannot be held responsible for loss in performance or damage of equipment, including the camera.

Connector 1 (32Bit, 40 Bit)

Pin No	In/Out	Name	Note
1,14		Shield	GND
2(-),15(+)	O	TxOUT0	Data out
3(-),16(+)	O	TxOUT1	
4(-),17(+)	O	TxOUT2	
5(-),18(+)	O	TxClk	Clock for CL
6(-),19(+)	O	TxOUT3	Data out
7(+),20(-)	I	SerTC (RxD)	LVDS Serial Control
8(-),21(+)	O	SerTFG (TxD)	
9(-),22(+)	I	CC1 (Trigger)	Trigger
10(+),23(-)	I	CC2(Reserved)	
11,24		N.C	
12,25		N.C	
13,26		Shield	GND

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Connector 2 (Used only for 4 x 10 Bit output)

Pin No	In/Out	Name	Note
1,14		Shield	GND
2(-),15(+)	O	TxOUT0	
3(-),16(+)	O	TxOUT1	Data out
4(-),17(+)	O	TxOUT2	
5(-),18(+)	O	TxClk	Clock for CL
6(-),19(+)	O	TxOUT3	Data out
7(+),20(-)		N.C	
8(-),21(+)		N.C	
9(-),22(+)		N.C	
10(+),23(-)		N.C	
11,24		N.C	
12,25		N.C	
13,26		Shield	GND

Note: Applicable cable

No.	Manufacturer	Type	Note
Camera side	3M	10226-1A10PL	
Cable Ass7y	3M	14B26-SZLB-xxx-0LC	Standard

1) xxx shows the length of the cable. Applicable length is 0.5m to 10m.
2) Cables which are do not comply with CameraLink^{TM} Specifications,
14B26-SZ3B-xxx-03C(small diameter cable) and 14SZ3B-xxx-04C(High-Flex cable)
can be used but the capable length is limited.

5.3. Input and output circuits

5.3.1 Trigger input
The External Trigger signal can be applied either through the Camera Link connector or at pin 10 of the 12-pin Hirose connector. The command to change this setting is TI (Trigger Input). TI=0 for Camera Link connector (factory default) and TI=1 for 12-pin Hirose connector. The input via the 12-pin Hirose connector is AC coupled.
To allow long pulses, which may be required when using the Pulse Width Control (PWC) trigger mode, the input
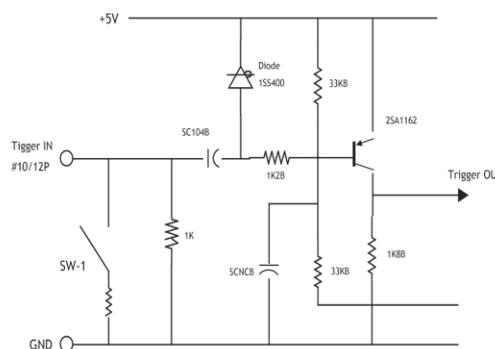
Fig. 6   Trigger input (12-pin Hirose)

circuit is designed as a flip-flop circuit. The leading and trailing edges of the trigger pulse activate the circuit.
The trigger input polarity can be changed by the command TP. At the 12-pin Hirose connector the External Trigger input is 4V ± 2V (TTL). It can be changed to 75 ohm termination by a DIP switch setting (SW 1).

5.3.2   EEN / XEEN output (Exposure ENable)
This output corresponds to the exposure (accumulation) time of the camera. It works together with all operation modes. It is, however, not active when the test pattern function is enabled.
The EEN signal is available at the Camera Link connector and at the 12-pin Hirose connector at the same time.
At the Camera Link connector this signal has positive logic.
At pin 9 of the 12-pin Hirose connector the signal has negative logic, and is therefore named XEEN.
The output circuit is a 75 ohm complementary emitter follower. The circuit is powered from the 5V supply, resulting in an

output level of more than 4V. It is not terminated.
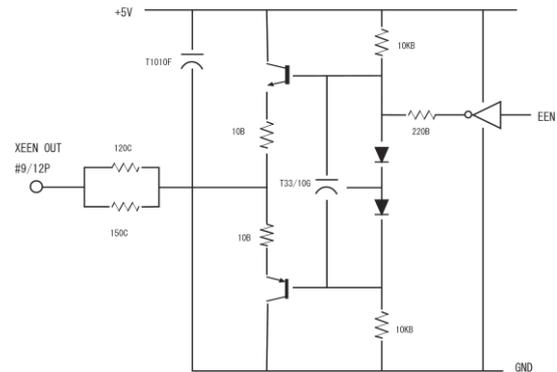
Fig. 7   XEEN Circuit (12-pin Hirose)

5.3.3 Camera Link Interface (Bit allocation)
The LQ-050CL follows the Camera Link standard in all respects.

Port/Signal	8bitx4 output	10bitx4 output	Connector	Pin Name
Port A0	Out1_D0	Out1_D0	1	Tx0
Port A1	Out1_D1	Out1_D1	1	Tx1
Port A2	Out1_D2	Out1_D2	1	Tx2
Port A3	Out1_D3	Out1_D3	1	Tx3
Port A4	Out1_D4	Out1_D4	1	Tx4
Port A5	Out1_D5	Out1_D5	1	Tx6
Port A6	Out1_D6	Out1_D6	1	Tx27
Port A7	Out1_D7	Out1_D7	1	Tx5
Port B0	Out2_D0	Out1_D8	1	Tx7
Port B1	Out2_D1	Out1_D9	1	Tx8
Port B2	Out2_D2	×	1	Tx9
Port B3	Out2_D3	×	1	Tx12
Port B4	Out2_D4	Out2_D8	1	Tx13
Port B5	Out2_D5	Out2_D9	1	Tx14
Port B6	Out2_D6	×	1	Tx10
Port B7	Out2_D7	×	1	Tx11
Port C0	Out3_D0	Out2_D0	1	Tx15
Port C1	Out3_D1	Out2_D1	1	Tx18
Port C2	Out3_D2	Out2_D2	1	Tx19
Port C3	Out3_D3	Out2_D3	1	Tx20
Port C4	Out3_D4	Out2_D4	1	Tx21
Port C5	Out3_D5	Out2_D5	1	Tx22
Port C6	Out3_D6	Out2_D6	1	Tx16
Port C7	Out3_D7	Out2_D7	1	Tx17
Port D0	Out4_D0	Out4_D0	2	Tx0
Port D1	Out4_D1	Out4_D1	2	Tx1
Port D2	Out4_D2	Out4_D2	2	Tx2
Port D3	Out4_D3	Out4_D3	2	Tx3
Port D4	Out4_D4	Out4_D4	2	Tx4
Port D5	Out4_D5	Out4_D5	2	Tx6
Port D6	Out4_D6	Out4_D6	2	Tx27
Port D7	Out4_D7	Out4_D7	2	Tx5
Port E0	×	Out3_D0	2	Tx7
Port E1	×	Out3_D1	2	Tx8
Port E2	×	Out3_D2	2	Tx9
Port E3	×	Out3_D3	2	Tx12
Port E4	×	Out3_D4	2	Tx13
Port E5	×	Out3_D5	2	Tx14
Port E6	×	Out3_D6	2	Tx10
Port E7	×	Out3_D7	2	Tx11
Port F0	×	Out3_D8	2	Tx15
Port F1	×	Out3_D9	2	Tx18
Port F2	×	×	2	Tx19
Port F3	×	×	2	Tx20
Port F4	×	Out4_D8	2	Tx21
Port F5	×	Out4_D9	2	Tx22
Port F6	×	×	2	Tx16
Port F7	×	×	2	Tx17
LVAL 1			1	Tx24
FVAL 1			1	Tx25
LVAL 2			2	Tx24
FVAL 2			2	Tx25
DVAL			1	Tx26
DVAL			2	Tx26
EEN			1	Tx23
EEN			2	Tx23

Note: LVAL 1 &2 and DVAL 1&2 are the same signal.
As the LQ-050CL is a line sensor camera, FVAL is always LOW.

5.3.4 Camera link output port

LQ-050CL handles R,G,B and NIR channels. The output ports for 8-bit and 10-bit are different.

8 bit output

Input signal   Camera link output

RED	→	Out1	Camera Link 1 Port a－c
GREEN	→	Out2	
BLUE	→	Out3	
Near IR	→	Out4	Camera Link 2 Port d－f
		Out5	
		Out6	

10 bit output

Input signal   Camera link output

RED	→	Out1	Camera Link 1 Port a－c
GREEN	↘	Out2	
BLUE	↗	Out3	Camera Link 2 Port d－f
Near IR	→	Out4	
		~~Out5~~	
		~~Out6~~	
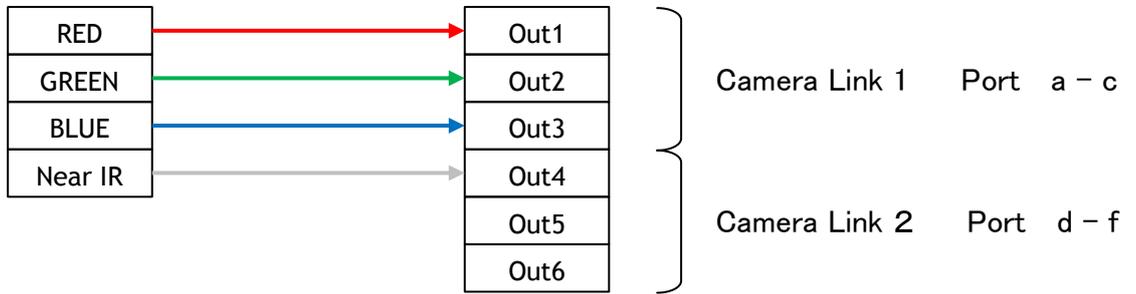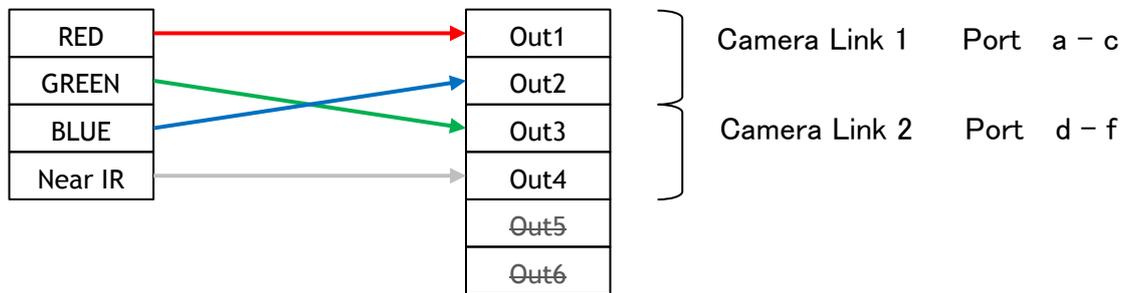
5.3.5 Bit allocation of the output video

CCD out	Digital 8Bit (LSB)	Digital 10Bit (LSB)
Black	8	32
200mV	222	890
230mV	255	1023
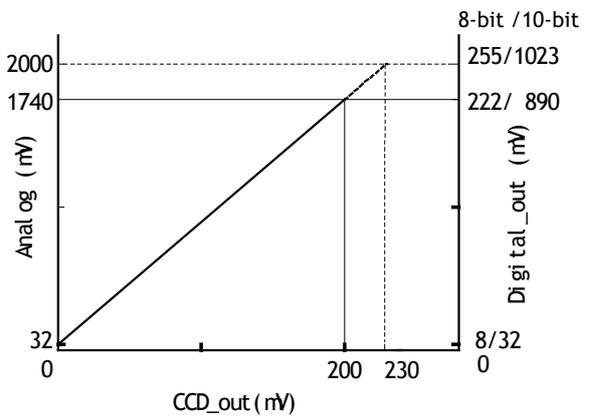
Fig.8   Video output

6.   Functions and Operation
6.1.   Basic functions
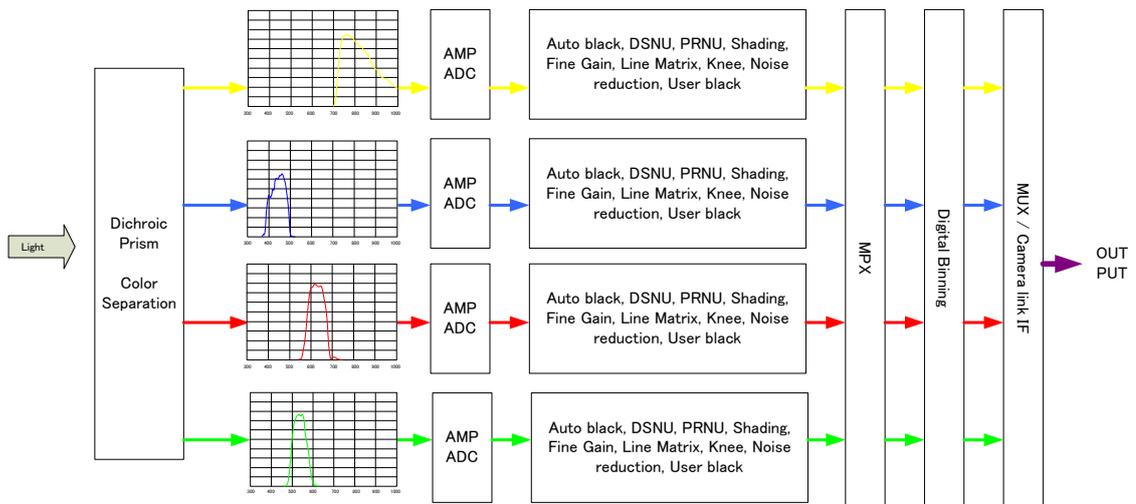
Fig.9   Signals flow

The LQ-050CL uses four high-performance CCD line scan image sensors mounted on a prism block. During exposure, the incoming light is converted to electrons (electric charge) in the
photodiodes (active pixels). The transfer gate controls the transfer of charge from photodiodes to the shift register. Activating the transfer gate terminates the exposure cycle, transfers the charge to the Horizontal Shift Register (2-phase buried channel CCD shift register) and starts a new exposure cycle. The line is subsequently read out in a single
sequence starting with pixel 1.

The exposure time is normally the same as the cycle time (in No-Shutter mode). By using the
Exposure Control Gate (in Shutter-Select or Pulse Width Control trigger modes) the exposure time can be individually set to be shorter than the cycle time (the inverse of line rate). This also allows a fixed exposure time, independent of the line rate. In the LQ-050CL
the exposure time can be set individually for all four channels.

OB : Optical Black Pixels
TP : Transition Pixels
AP : Active Pixels
Iso : Isolation Stages
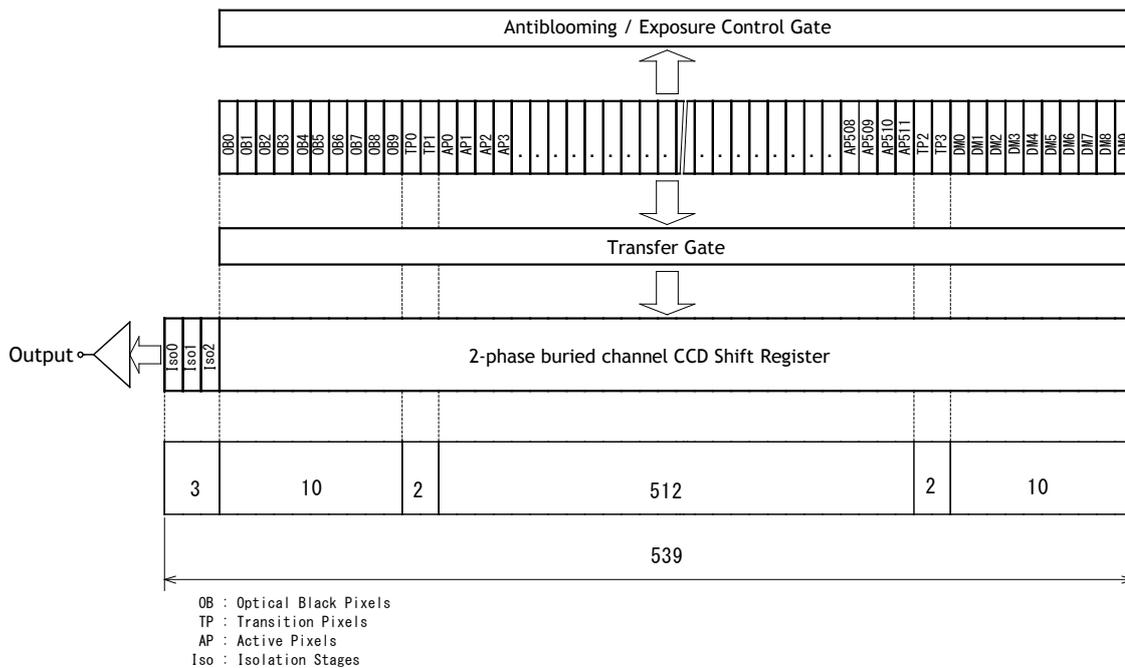
Note: The actual 1 line output from the camera is 564 clocks including additional dummy 25 clocks.

Fig.10   Sensor layout

6.2.   Operating mode

The LQ-050CL has three operating modes. They are No-Shutter mode, Shutter-Select mode and PWC (Pulse Width Control) mode.

The following chapters explain the details of these three modes. The output detail is shown below and is common with all modes.

DM : Dummy Pixels
OB : Optical Black Pixels
TP : Transition Pixels
AP : Active Pixels
Iso : Isolation Stages
LVAL : Line Valid
DVAL : Data Valid

1CLK=25ns
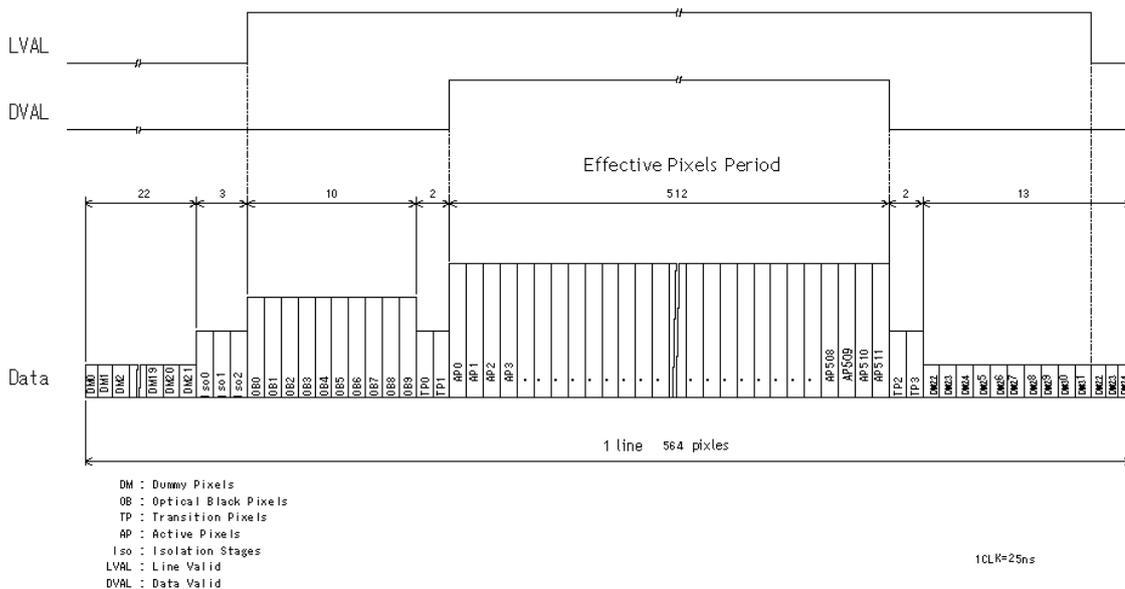
Fig.11   Video output timing

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6.2.1 No-Shutter mode with internal trigger

In this mode the camera does not accept an external trigger signal, as the line rate is generated from an internal clock (user programmable, command LR). The exposure time is directly proportional to the line rate (T_{exp} = 1/line rate). This mode is used when there is no external trigger signal available, and the speed of the object is fixed or can be pre-determined.

The line rate can be varied from 1 line period (L) to 1024L in 1 clock (25ns) steps (19 kHz down to 18 Hz). When using this mode, a special function called "One-push auto line rate" is available. This mode automatically maintains a constant output level by changing the line rate. The line rate is automatically adjusted in order to maintain sensitivity without reducing the S/N ratio.

To use this mode:
Set function   Trigger mode, No-Shutter   TR=0
Trigger origin, internal   TG=0
Line rate   LR=564 to 577536 clocks
(14.10µs to 14.438ms in 25ns increments)
Optional functions when using this mode:
One-push auto line rate   AR=0
Auto line rate reference   AL=0 to 1023
One-push white balance   WB
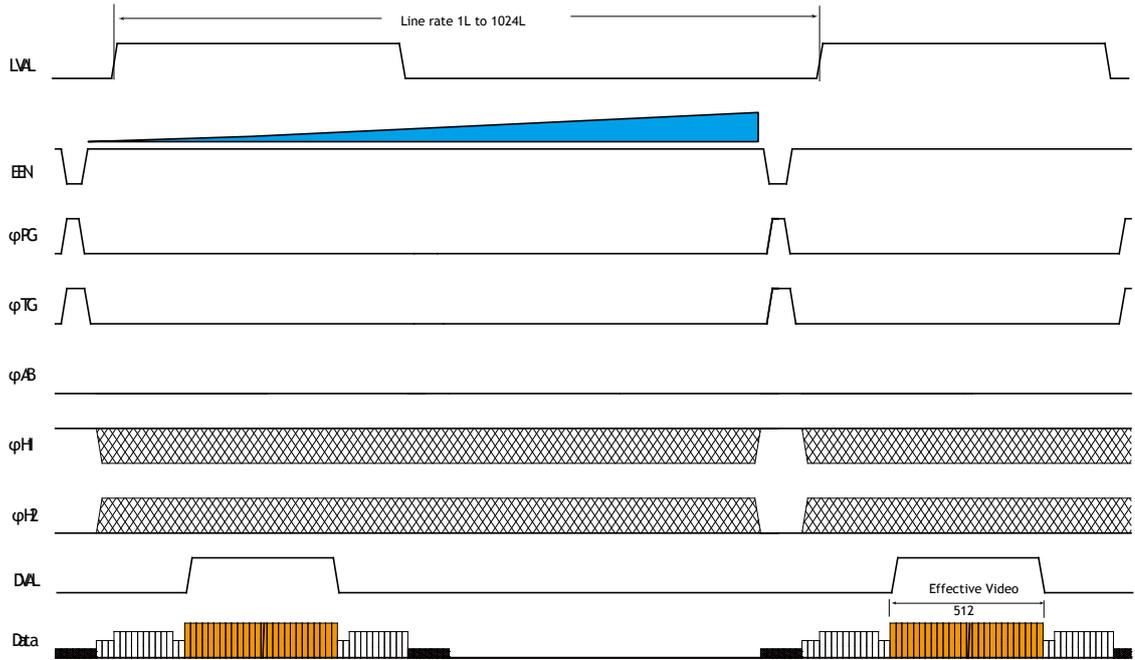
Fig.12　No-Shutter mode with internal line rate generator

Important Note
- Only gain-based one-push white balance function (WB) is available with this mode.
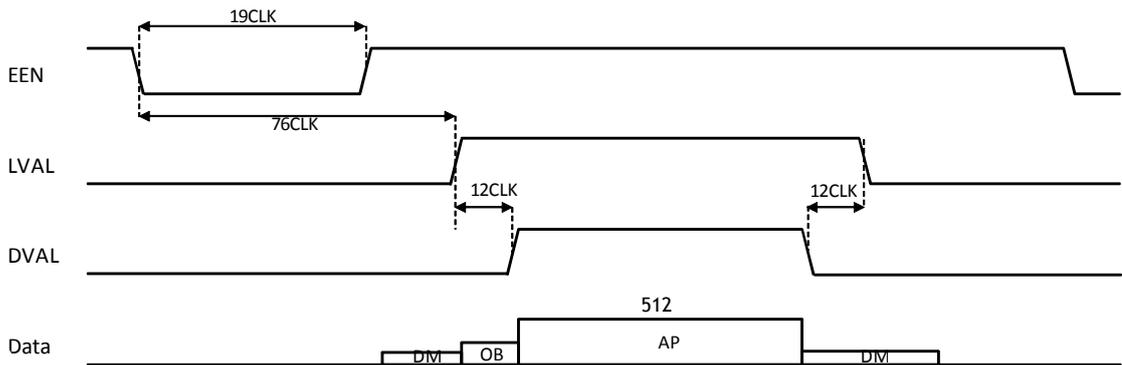
Fig.13　　Detail of No-shutter with internal line rate generator

6.2.2 No-Shutter mode with external trigger

In this mode, the exposure time is directly proportional to the line rate. The line rate is generated externally by a trigger signal. This mode is used when an external trigger signal available, e.g. from an encoder, and the scan rate can be controlled by this signal. The camera can accept an external trigger through the Camera Link connector or though the 12-pin Hirose connector.

To use this mode:

Set function	Trigger mode, No-Shutter	TR=0
	Trigger origin, external	TG=1
	Trigger input	TI=0 or 1
	Minimum Trigger Interval	14.2µs

Important note:
- When the one-push white balance has been initiated and the rear panel LED shows orange, the camera must receive continuous external trigger pulses corresponding to the frequency and duty cycle used in the application.
- Only gain-based one-push white balance function (WB) is available with this mode
- The minimum trigger interval is 14.20µs.
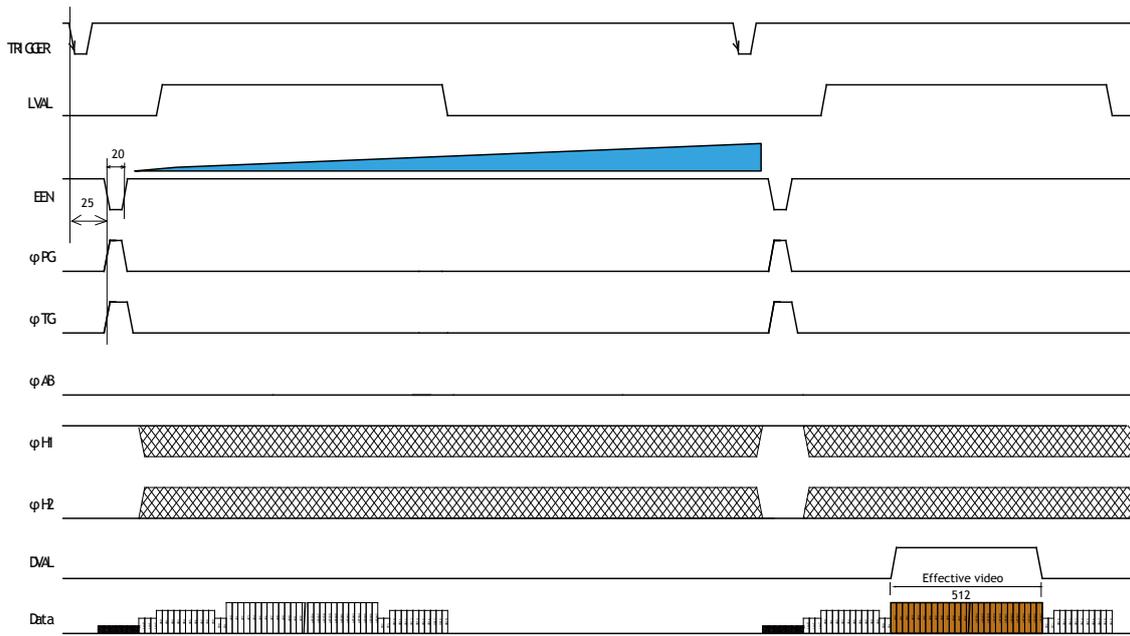
Note: If the shutter is OFF, ϕAB is not output.

Fig. 14   No-Shutter mode with external trigger
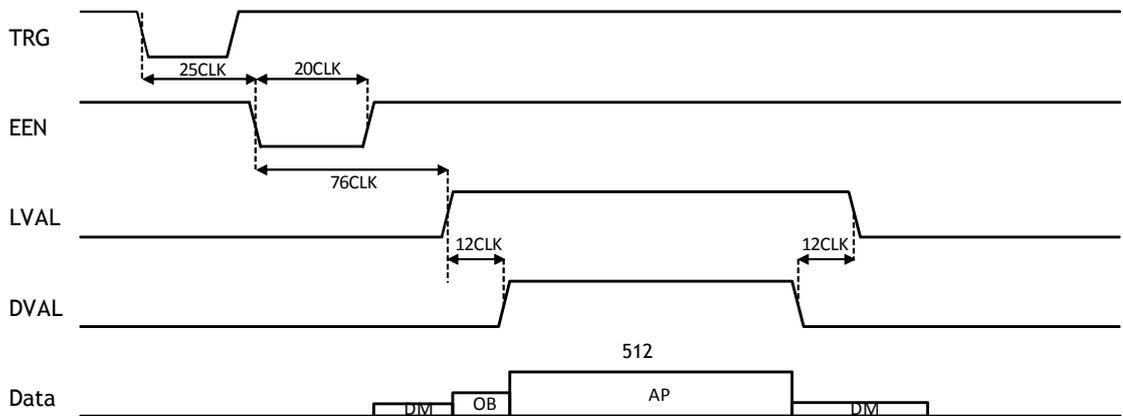
Fig.15   Detail of No-shutter with external trigger

6.2.3   Shutter-Select mode with internal trigger

This mode allows the user to have full control of the line rate and the exposure time individually, by programming separate timing generators. Subsequently, the camera does not accept an external trigger signal in this mode.

To use this mode:

Set function	Trigger mode, Shutter-Select	TR=1
	Line rate	LR=14.10µs(1L) to 14.438ms(1024L) in 1 clock(25ns) step
	Trigger origin, internal	TG=0
	Individual R, G and B exposure	EI=0(individual)
		EI=1(Interlocked with G)
	Programmable exposure	PER/PEG/PEB/PEIR=2 to {Line rate
	—	
		52clk(1.3µs)} in 1 clock(25ns) steps

Important note:

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- If using individual exposure, the EEN signal represents the channel with the longest exposure time
- The longest shutter operation is the same as the set trigger interval.
- If one-push auto white balance is used, using the shutter (command AH) or using the gain (command AW) depends on applications. If the auto white balance switch located on the rear panel is used, only the gain is effective.
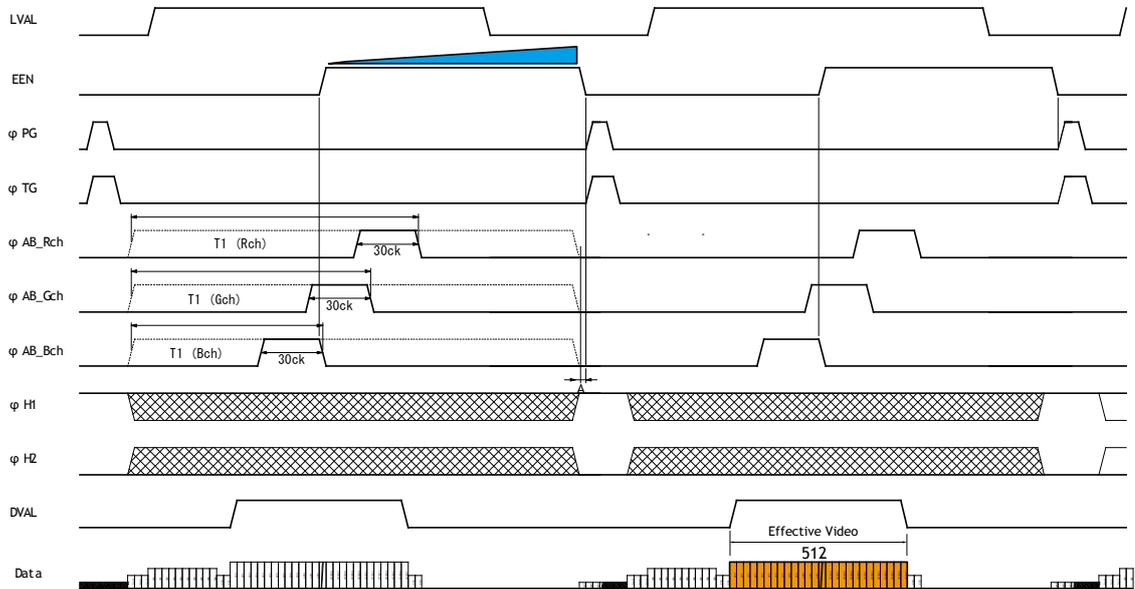
Note: Exposure time(ns) =25ns x (Repetition cycle(ck) –(T1 +21)ck)
      EEN is output in coincident with the timing of the longest exposure channel

Fig. 16   Shutter-Select mode with internal line rate generator (and individual exposure)

6.2.4   Shutter-Select mode with external trigger
This mode allows the user to have full control of the exposure time, by programming a timing generator, while the line rate is controlled by an external trigger signal. The camera can accept an external trigger through the Camera Link connector or though the 12-pin Hirose connector.

To use this mode:
Set function   Trigger   TR=1
                  Trigger origin, external   TG=1
                  Individual R, G and B exposure   EI=0(individual)
                                                   EI=1(interlocked with G)
                  Programmable exposure   PER/PEG/PEB/PEIR=2 to {trigger
                                                   Interval − 60clk(1.5µs)} in 1
                                                   clock(25ns) step (50ns to 14.438ms)

Important note:

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- If using individual exposure, the EEN signal represents the channel with the longest exposure time
- The minimum trigger interval is 14.2µs.
- If one-push auto white balance is used, using the shutter (command AH) or using the gain (Command AW) depends on applications. If the auto white balance switch located on the rear panel is used, only the gain is effective.
- When the one-push white balance has been initiated and the rear panel LED shows orange, the camera must receive continuous external trigger pulses corresponding to the frequency and duty cycle used in the application.
- The maximum trigger period is the interval of the input trigger.
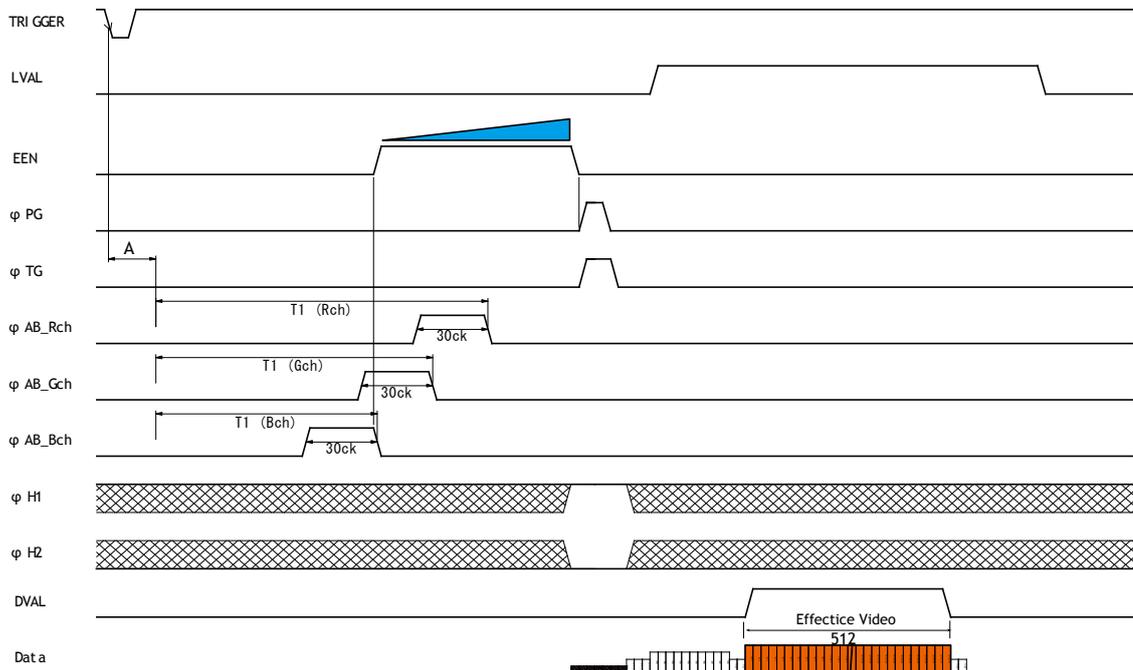
Note: "A" is less 30 clocks
      The shortest T1 is 30 clocks
      EEN is output in coincident with the timing of the longest exposure channel

Fig. 17   Shutter-Select mode with external trigger (and individual exposure)

6.2.5   Pulse Width Control (PWC) mode

In this mode, the user has full control of both the line rate and the exposure time of each line via the External Trigger input.
At the falling edge of the External Trigger signal, the exposure is initiated, and at the rising edge the exposure is terminated and read out. The camera can accept an external trigger through the Camera Link connector or though the 12-pin Hirose connector.

To use this mode:
Set function   Trigger mode, PWC   TR=2

Important Note:
- Possible pulse width:
  TTL input via 12P   14.2µs (TTL interface)
  Camera link input   14.2µs (CameraLink interface)
- One-push white balance by gain setting only.
- The trigger interval is more than (Exposure period + 52.6µs).

- When the one-push white balance has been initiated and the rear panel LED shows orange, the camera must receive continuous external trigger pulses corresponding to the frequency and duty cycle used in the application.

A	B	C
Less 30 clocks	30 clocks	Less 10 clocks
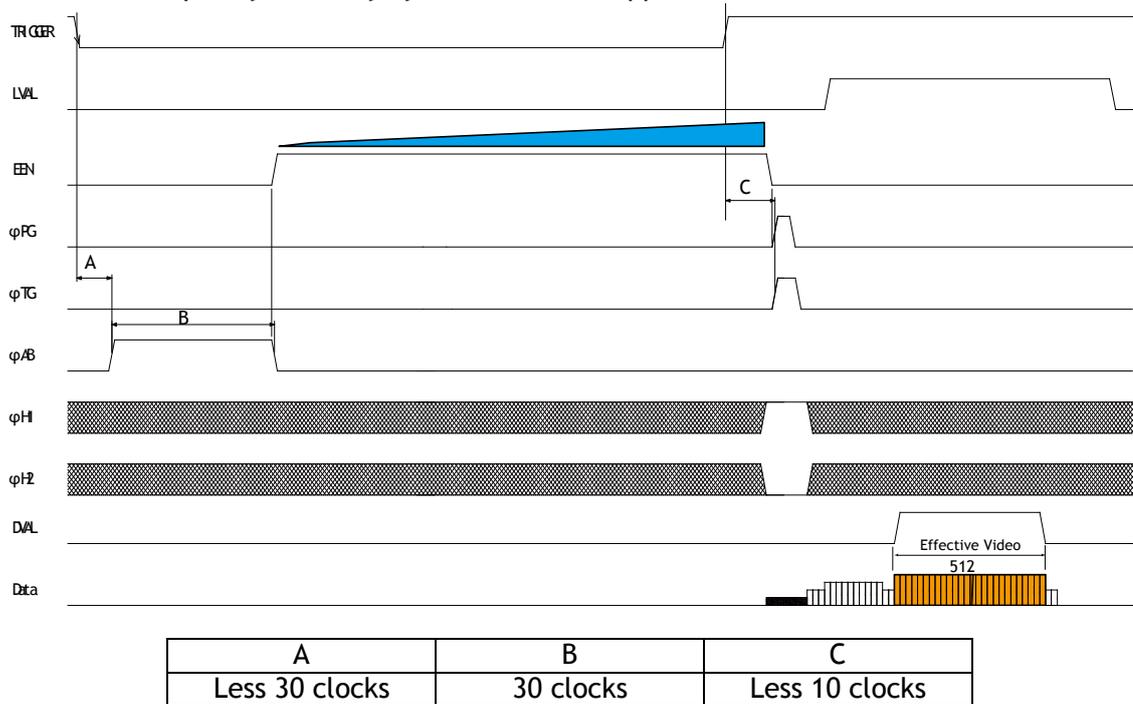
Fig. 18   Pulse Width Control mode

6.3.   Scan rate and exposure time range

6.3.1   Minimum cycle time of external trigger

Mode	Minimum trigger cycle
No-Shutter	C1+14.10μs
Shutter-Select	C1+14.10μs
PWC	Exposure + C2

C1 =0.1μs; C2= 14.20μs

6.3.2   Minimum trigger pulse width.

Mode	Via Camera Link	Via Hirose 12-pin
No-Shutter	500ns	5 μs
Shutter-Select	500ns	5 μs
PWC	14.20μs	14.20μs

6.3.3   Compatibility of trigger modes and functions

Mode	Trigger	Binning	Pixel gain & black correction	Shading correction	One-Push WB		Gain & black level ctr.	Trigger interval variable (Accumu. variable)	Program exposure time
					Gain	Shutter			
No-Shutter	Internal	Yes	Yes	Yes	Yes	No	Yes	Yes(*1)	No
	External	Yes	Yes	Yes	Yes	No	Yes	Yes(*1)	No
Shutter-Select	Internal	Yes	Yes	Yes	Yes	Yes	Yes	Yes(*2)	Yes
	External	Yes	Yes	Yes	Yes	Yes	Yes	Yes(*2)	Yes
PWC	External	Yes	Yes	Yes	Yes	No	Yes	No	No

*1: The accumulation period is equal to the trigger interval.
*2: The accumulation period is the setting value for accumulation but the longest period is the trigger interval.

6.3.4   Trigger modes and auto white balance modes matrix table

	Trigger	Control		
		Manual	One push gain	One push shutter
No-Shutter	Internal	Only gain	yes	No
	External	Only gain	yes	No
Shutter Select	Internal	yes	yes	yes
	External	yes	yes	yes
PWC	Internal	Only gain	yes	No

7. Functions listed alphabetically by command acronyms

7.1 Command <u>AHRS</u> – Request Status After One-Push AWB
This command returns the status of the one-push AWB function, with the following parameters:
0=AWB not completed yet
1=Succeeded
2=Error1: Green image too bright
3=Error2: Green image too dark
4=Error3: Timeout occurred

7.2 Command <u>AL</u> – Automatic Line Rate Reference Level
This command is a target of luminance level when command AR is activated.

Settings:	0 to 1023 (for both 8-bit and 10-bit)
Applicable modes:	No-Shutter with internal trigger
	Shutter Select with internal trigger
Associated functions:	Command AR

7.3 Command <u>AR</u> – Automatic Line Rate Setting
The line rate can be adjusted from 1L to 1024L. This function will calculate and set the line rate of the camera based on the Automatic Line Rate Reference Level (as set in command AL) and the scene illumination. Please note that the aspect ratio of the scanned object will change as the line rate is changed.

Settings:	0 (activate automatic process)
Applicable modes:	No-Shutter with internal trigger
	Shutter-Select with internal trigger
Associated functions:	Command AL

Note
• The data can be stored in the camera memory for next start up.

7.4 Command <u>ARST</u> – Auto Reset Mode
This function enables/disables the Auto Reset mode, which prevents offset rising in special case where line triggers are not received for long periods of time.

Settings 0 (off) and 1 (on).   Factory default is 0 (off).

In this mode, when a trigger pulse does not occur after more than 53ms, the LQ-050CL automatically returns to the internal trigger mode with the line rate of approx. 14.1µsec. In this time, the camera operates by the internal trigger, and if the external trigger is input, the video is immediately output. In the Shutter-Select mode, the exposure starts immediately   after the trigger is input and the camera outputs the video. In the No-Shutter mode, the exposure will start immediately after the trigger is input, but the video output is available after the second trigger pulse is input.   In this ARST mode, DVAL, EEN and Video OUTPUT are disabled in order to prevent charges due to dark current from building up in the sensor during standby periods and only LVAL is output

.

7.5   Command <u>AH</u> - Activate One-Push Auto White Balance (AWB) - Shutter

By sending this command via the serial communication, the ***shutter based*** One-Push AWB function is activated. The white balance function takes approximately 3 seconds to complete. During this time the rear panel LED will show orange.
This function operates in two steps. First the red-to-green channel difference and the blue-to-green channel difference are calculated separately. Then the exposure time of the blue and red channels are automatically adjusted, to obtain the same output level on all three channels.

Settings: 0 = activate automatic process
Applicable modes: Shutter-Select mode only
Associated functions: Command WB

Note:
- When color temperature of illumination exceeds the range of adjustment, proper white balance may not be obtained.
- The data can be stored in camera memory for use at next start up.
- This function can work in external trigger mode.
- The S/N ratio of the output will remain constant for all channels

7.6   Command <u>AW</u> – Activate One-Push Auto White Balance (AWB) - Gain

By sending this command via the serial communication, the ***gain based*** One-Push AWB function is activated. This function can also be initiated by pressing the rear panel button. The white balance function takes approximately 3 seconds to complete. During this time the rear panel LED will show orange.
This function operates in two steps. First the red-to-green channel difference and the blue-to-green channel difference are calculated separately. Then the gain of the blue and red channels are automatically adjusted, to obtain the same output level on all three channels.

Settings: 0 = activate automatic process
Applicable modes: All
Associated functions: Command WB
                                Rear panel one-push WB button.

Note:
- When color temperature of illumination exceeds the range of adjustment, proper white balance may not be obtained.
- The data can be stored in camera memory for use at next start up.
- This function can work in external trigger mode.
- The S/N ratio of the output will change as a result of this function.

7.7   Command <u>BA</u> – Bit Allocation

This function lets the user select whether the video data is presented as 4 x 8 (32)-bit or 4 x 10 (40)-bit in the Camera Link output. The internal processing in the camera is based on a 12-bit A/D signal. The 32-bit and 40-bit function removes the least significant bits from the 12-bit signal.

Settings: 0=8-bit, 1=10-bit
Applicable modes: All

7.8 Command <u>BI</u> – Binning (horizontal only)

This function reduces the number of pixels to 256 without affecting the line rate. Two adjacent pixels are combined at the output stage and read out as one pixel. Sensitivity is doubled as a result of binning.

Settings: 1=binning on, 0=binning off
Applicable modes: All

Note
- Setting data is stored in camera memory for use at next start up
- This function is available for all modes.

7.9 Command <u>BL</u> – Master Black Level

This command is a global black level adjustment for all channels. There are two adjustment ways, one is "Master Tracking" and the other is "Individual". The adjustable range for master black is 0 LSB to 255 LSB. The LQ-050CL has an automatic black level clamp function. This circuit is an analog circuit and after the signal level of dummy pixels is clamped at the constant level, it is digitized and the OB level is clamped at 32 LSB (8 LSB) in the digital clamp circuit. This function is always operating.
The number in the parenthesis is for 8bit.

Master Mode :   Master(G): 0 to 255LSB (10-bit output)

Individual Mode :   G ch : 0 to 255LSB (10-bit output)

Associated functions: Commands BLR, BLB, BLIR

7.10 Commands <u>BLR</u> , <u>BLB</u> and <u>BLIR</u> – Black Level Red, Blue and NIR

In conjunction with Command BL, these commands allow individual setting of the black level in all channels.

Master Mode :   -128 to 127 LSB (10-bit output)
          BLR,BLB and BLIR can be set from -128LSB to 127LSB at the setting value of the master gain. In this case, total range should be within 0LSB to 255LSB.
          For instance, it the master is set at 100, BLR, BLB and BLIR can be set from -100 to 127LSB.

Individual Mode   0 to 255LSB (10-bit output)

Associated functions: Command BL

7.11 Command <u>BLM</u> - Black Level Mode

Select the black level adjustment method

Settings   0=Master tracking
          1=Individual (Factory default)

7.12 Command <u>EI</u> – Interlocked R, G, B & NIR Exposure

When this function enabled (interlocked), exposure time for all four channels is selected by setting the green channel and the red, blue and NIR channels will track.
To obtain white balance, adjust red and blue channels, PER and PEB. It is thereafter possible to adjust overall exposure time by using the command PEG. The red and blue channels will track the green channel proportionally, thus maintaining white balance settings.

Settings:	0= OFF (independent R, G,B and NIR settings)
	1= R, B and NIR channel interlocked with G
Setting range:	50ns to {Line rate — 52clk(1.3µs)} (Individual R,G,B & NIR) in 25ns(1 clock) step
Associated functions:	Commands PER, PEG, PEB and PEIR – Programmable Exposure
Applicable modes:	Shutter-Select mode only (Internal and external)

Note: The LQ-050CL has a priority for the line rate setting. If the exposure is use around the longest exposure speed which is nearly equal to the trigger cycle, please note the followings.
1. Shutter select mode in the internal trigger
    The maximum shutter speed is the setting line rate minus 52clk(1.3µs).
2. Shutter select mode in the external trigger
    The maximum shutter speed is the provided trigger cycle minus 60 clocks (1.5µs) .

7.13 Command <u>GA</u> – Master Gain Level

This function is a global gain adjustment for all channels. There are two ways to adjust gain, one is "Master Tracking" and the other is "Individual". Command GM selects a required mode. The gain setting is done in the analog domain where 1LSB equals 0.03dB.

Master Mode:	Master(G): -123 to 429(-3dB to +12dB)	
Individual Mode:	G:	-363 to 660 (-9dB to +18dB)

Associated functions:	Commands GAR, GAB, GAIR - Gain level red, blue, and NIR.

Note: The adjustment range is available under 7800K light. If light with a color temperature other than 7800K is used, the adjustable range might be limited.

7.14 Commands <u>GAR, GAB</u> and <u>GAIR</u> – Gain Level Red, Blue and NIR.

In conjunction with the Command GA, this function allows the individual setting of gain for all channels, or it can be used for fine adjustment after one push white balance is executed. It is important to note that increasing the gain will lead to an increased noise level and reduced S/N-Ratio. 1LSB equals 0.03dB.

Master Mode:	-231 to 231 (-6dB to +6dB)
Individual Mode:	-363 to 660 (-9dB to +18dB)

Associated function:	Command GA – Master gain level
Applicable modes:	All modes

Note
- Setting data is stored in camera memory for use at next start up
- The adjustment range is available under 7800K light. If light with a color temperature other than 7800K is used, the adjustable range might be limited.

7.15 Commands GAR2 , GAG2, GAB2 and GAIR2 – Fine Gain (R,G, B and NIR)
Fine gain can be digitally controlled.

Settings: 6554 to9830
                              x0.969 (6554/8192) to x1.03(9830/8192) (R,G,B and NIR)

7.16 Command GM - Gain Mode
Selects gain mode.

Settings: 0=Master Tracking
                              1=Individual (Factory default)

7.17 Command LR - Line Rate (Scan Rate)
This function is used only when there is not an external trigger pulse (e.g. from an encoder) available. It allows the user to program the line rate, in order to match the speed of the object being scanned. In the No-Shutter mode, the exposure time is directly proportional to the line rate (T_{exp} = 1/line rate)

Settings: 567 to 577536 clocks, in 1 clock(25ns) increments
                              14.10µs(1L) to 14.438ms(1024L)
Associated functions: Trigger origin, TG=0
Applicable modes: No-Shutter with internal trigger   (TR=0)
                              Shutter-Select with internal trigger   (TR=1)

Note
- The data can be stored in the camera memory for next start up.
- **It is recommended to use 52.5µs to 2ms of line rate because the black level is stable in this range.**

7.18 Command LUTC - LUT Control
The LQ-050CL has an internal LUT(Look Up Table) for setting gamma. Command LUTC selects gamma OFF, Gamma 0.45 or LUT.

Settings: 0 = Off
                              1 = 0.45
                              2 = User

γ=0.45
In this mode, R,G,B and NIR have the same characteristics for gamma.

CCD out	Analog Signal	Digital Out(32bit)	Digital Out(40bit)
Black	Setup 3.6%, 25mV	8LSB	32LSB
200mV	700mV	222LSB	890LSB
230mV ↑	800mV	255LSB	1023LSB
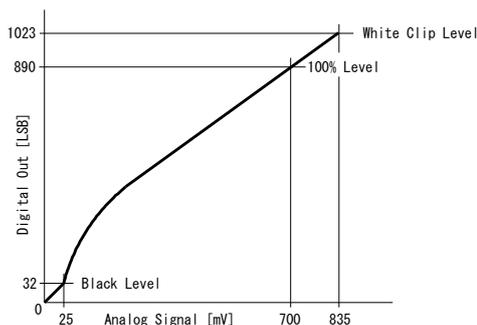
Fig.19 LUT characteristics

γ=**User**
In this mode, R,G,B or NIR can be set individually.
Settings: Range: 0 to 8191 LSB (200%)
                                      Setting point: 512

7.19.   Command <u>NR</u> - Noise Reduction

Noise levels less than 16 LSB (4LSB) which are superimposed on the video signal will be eliminated. The deterioration of spatial frequency is minimized. The improvement of signal-to-noise ratio will be 3dB as the maximum although it depends on the object.
Figure in ( ) is for 8-bit output.

Settings: 0=ON, 1=OFF

7.20   Command <u>PBC</u> – Enable Pixel Black (FPN) Correction

This command enables (or disables) the "pixel black level" correction function, which compensates for Dark Signal Non Uniformity / Fixed Pattern Noise (DSNU / FPN) for individual pixels.

Settings: 0 = Off (Deafult)
                                1 = Factory setting
                                2 = user area
Associated functions: Command PBR
Applicable modes: All

7.21.   Command <u>PBR</u> – Run Pixel Black Correction and Store to User Area

This command initiates the "pixel black level" correction function, and stores the settings in the user area.   When this function is activated, lens must be capped.

Settings: 0 = Run this function
Associated functions: Command PBC must be set to 2

Note:
- This function requires that no light reaches the image sensors. The lens must therefore be covered by a lens cap, or put the F-mount protective cover on the camera, when executing this function.
- As the black level is influenced by the exposure time (especially for long exposure times at slow scan rates) it is recommended to perform the pixel black correction at the exposure time and line rate at which the camera will be operated.

___

Principle of Pixel black level correction (DSNU / FPN correction)

Dark Signal Non-Uniformity or Fixed Pattern Noise is, as the name implies, fixed pattern on the sensor output, which is *not* dependent on the incoming light.

Before correction: dark signal non-uniformity from pixel to pixel

Subtract factor   Max

Add factor   Average

         Min
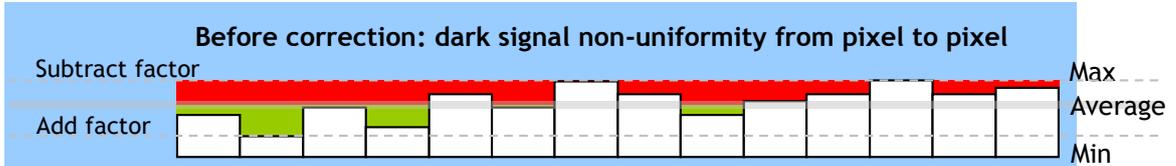
To correct for DSNU/FPN, the camera's internal correction circuit captures one or several lines of data under dark conditions (the lens *must* be covered by a lens cap), and the average across the line is calculated. Based on the average, coefficients are then generated for each individual pixel. The coefficient has the function of adding or subtracting a value to the pixel output. These coefficients are stored in a non-volatile memory, and are therefore maintained after power down.

As the dark signal is highly dependent on the exposure time, this correction must be performed under the operating conditions (exposure time and line rate) that will be used by the application.

After correction: Flat dark signal response from pixel to

         Average
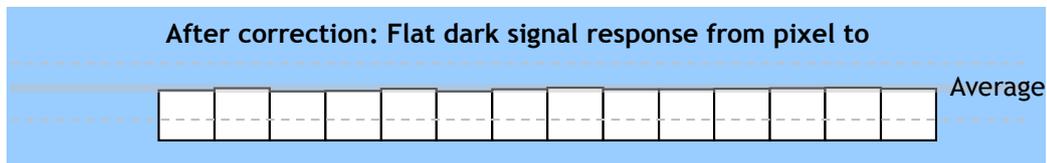
7.22. Command PBS - Request Status After Pixel Black Correction

This command returns the status of the pixel black correction, with the following parameters:

0=Not completed yet
1=Succeeded
2=Error1: Image too bright
3=Error2: Image too dark
4=Error3: Timeout occurred

7.23. Command PER,PEG,PEB and PEIR – Programmable Exposure for R,G,B,and NIR

This command allows individual setting of the exposure time for each channel. It is only valid for the Shutter-Select mode (see chapter 6.2)

Settings:	2 to 577,536 in 25ns steps
Associated functions:	EI =0 (R,G,B and NIR independent)
	EI=1 (R , B and NIR exposure interlocked with G)
Applicable modes:	Shutter-Select (internal/external trigger)

Note:
The actual exposure time (ns) is calculated as follows:
T_{exp} = 25ns x (Repetition Period (clk) – (T1 (clk) +21clk))
Where,
Repetition Period is line rate or trigger interval
T1 is programmable exposure setting value and 21clk is a fixed value.

7.24. Command <u>PGC</u> – Enable Flat-Field Correction (pixel gain)

This command enables (or disables) the "pixel gain" (flat-field) correction function, which compensates for Pixel Response Non Uniformity (PRNU) for individual pixels. The algorithm for compensation is different in No-Shutter mode and Shutter-Select mode. If the operating mode is changed, an adjustment in the selected mode must be made. The factory default is Shutter-Select mode.

Settings: 0=Off (Default)
                                   1=Factory Setting
                                   2=User area
Associated functions: Command PGR
Applicable modes: All

7.25. Command <u>PGR</u> – Pixel Gain Correction and Store in User Area

This command initiates the pixel gain correction function, and stores the settings in the user area.

Settings: 0= activate automatic process
Associated functions: Command PGC must be set to 2

Note:
- The image sensors must not be saturated when executing this function.
- When executing this function, the exposure time and line rate should be the same as when the camera is operated in the application.

Operating procedure for individual R, G and B channel shading correction:
1. Before making adjustment, approximately 30 minutes of warm up is required.
2. Make sure the output signal is not saturated (<80% of full output is recommended)
3. Set command PGC=2.
4. Set command PGR to 0 to initiate shading correction.
5. If desired, set command SDR to 0 or 1 to activate shading correction to correct the shading caused by lens or lighting. When the shading correction is performed, the flat-
   field correction must be activated before the shading correction is performed.

Principle of Pixel Gain (flat-field) correction (PRNU correction)
Pixel Response Non-Uniformity is, as the name implies, a non-uniformity of the response of each individual pixel. This means that for a fixed light level each pixel will have a slightly different output level (response).
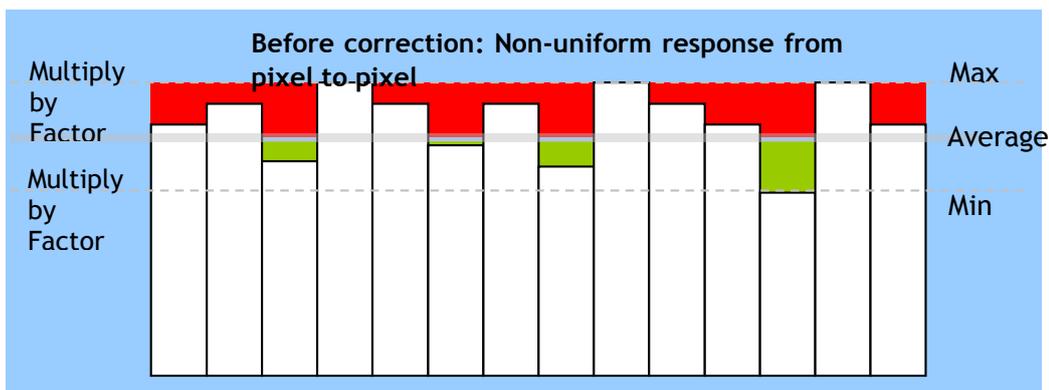
To correct for PRNU, the camera's internal correction circuit captures one or several lines of data under non-saturated illuminated conditions (not more than 80% of maximum - recommend level is half of maximum), and the average across the line is calculated. Based on this average, coefficients are then generated for each individual pixel. The coefficient has the function of multiplying the pixel output with a factor greater or less than 1. These coefficients are stored in a non-volatile memory, and are therefore maintained after power down.

After correction: flat response from pixel to pixel

Average
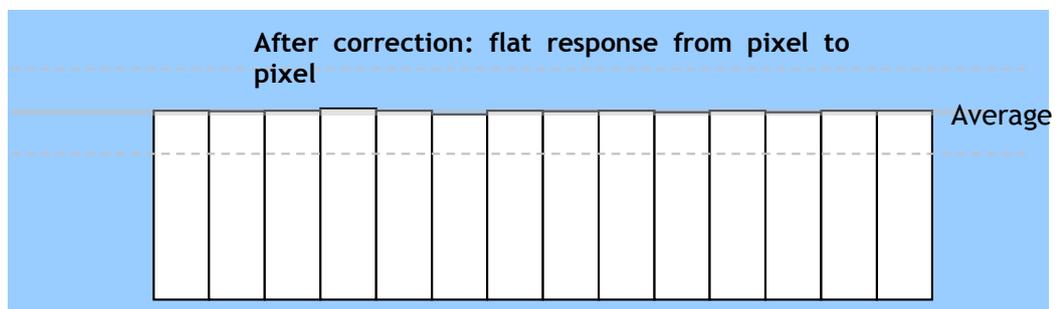
7.26. Command <u>PGS</u> - Request Status After Pixel Gain Correction
This command returns the status of the pixel gain correction, with the following parameters:
0=Not completed yet
1=Succeeded
2=Error1: Image too bright
3=Error2: Image too dark
4=Error3: Timeout occurred

7.27. Command <u>SDC</u> – Select Shading Correction Mode
This function enables (or disables) shading correction.

Settings:	0 = off (Bypass) (Default)
	1 = Factory setting
	2 = User area
Associated functions:	Commands PGR, SDR and SDS

7.28. Command <u>SDR</u> – Run Shading Correction
This function initiates automatic shading correction, and stores the result to the user area. This function should be used together with the flat-field correction (commands PGC and PGR). There are two types of shading correction: Individual R, G and B channel correction and chromatic shading correction.

JAI's measuring conditions;
Ambient temperature : 25°C
Light source   :   7800K, LED white light source
Lens used: f35mm, F2.8 lens

(A) Flat shading correction   (SDR=0)
Shading is calculated and individually compensated for R, G ,B and NIR channels respectively. The compensation range is within 30% as compare with the highest brightness in the previous line.

Individual shading correction
per channel
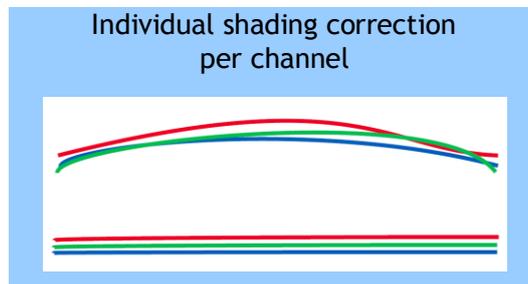
Note:
- Depending on the optics and/or illumination used together with the camera, it may not be possible to fully compensate for shading.

Operating procedure for individual R, G ,B and NIR channel shading correction:
1. Before making adjustment, approximately 30 minutes of warm up is required.
2. Make sure the output signal is not saturated (<80% of full output is recommended)
3. Set command PGC=2 and SDC=2.
4. Set command SDR to 0 to initiate shading correction.
5. If desired, set command PGR to 0 to activate flat-field (pixel gain) correction to correct for pixel response non-uniformity.
6. Again set SDR=0 after running the flat-field (pixel gain) correction

(B) Chromatic shading correction (SDR=1)
In this mode, shading correction of R ,B and NIR signals are referenced to the G signal which is the reference. When the green channel detects "undulating" or "parabolic" type shading, R and B channels are compensated to follow the same curve.

Shading correction tracking
the green channel
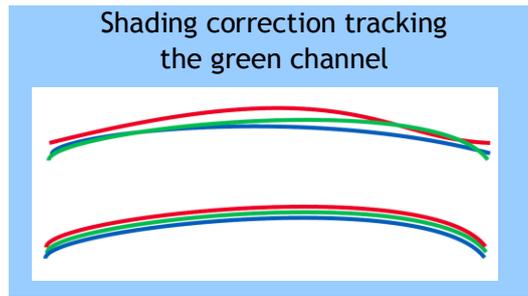
Note:
- For this function, no reference value is stored in the camera.

Operating procedure for individual R, B and NIR channel shadings correction:
1. Before making adjustment, approximately 30 minutes of warm up is required.
2. Make sure the output signal is not saturated (<80% of full output is recommended)
3. Set command PGC=2 and SDC=2.
4. Set command SDR to 1 to initiate shading correction.
5. If desired, set command PGR to 0 to activate flat-field (pixel gain) correction to correct for pixel response non-uniformity.
6. Again set SDR=1 after running the flat-field (pixel gain) correction

7.29. Command SDS – Request Status After Executing Shading Correction Command
This command returns the status of the shading correction function, with the following parameters:
0=Not completed yet
1=Succeeded
2=Error1: Image too bright
3=Error2: Image too dark
4=Error3: Timeout occurred

7.30. Command TG – Trigger Origin
Selects whether an external signal or an internal clock generator is used as a trigger source.

Settings:	0=Internal clock generator
	1=External signal
Associated commands:	TI
	TP

7.31. Command TI – Trigger Input
Selects whether the External Trigger input signal is taken from the Camera Link connector, or from the 12-pin Hirose connector.

Settings:	0=Camera Link connector
	1=12-pin Hirose connector

Important Note
The 12-pin Hirose connector trigger input can be terminated for 75 ohm. This is selected by a rear panel DIP-switch (SW1).

Serial comm.
CL ⇔ HR

75Ω
OFF ⇔ ON

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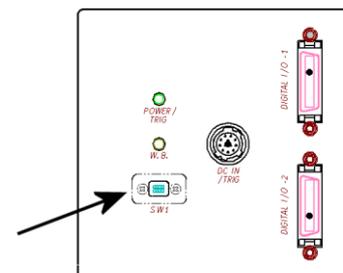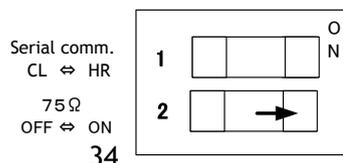
Fig.20   Rear panel

7.32.   Command <u>TP</u> – Trigger Polarity

Settings: 0=Active Low (factory default)
                             1=Active High

7.33.   Command <u>TR</u> – Trigger Mode
Selects the trigger mode of the camera. Depending on the mode used, it allows the scan rate to either be programmed by an internal timing generator or by and external trigger pulse. See chapter 6 for details on the operation modes.

Settings: 0=No-Shutter mode
                             1=Shutter-Select mode
                             2=Pulse Width Control (PWC) mode
Associated functions: Command TG (trigger origin)
                             Command TI (trigger input)
                             Command TP (trigger polarity)

7.34.   Command <u>TS</u> – Test Pattern
This allows the camera to output a number of test patterns for set-up and troubleshooting.

Settings: 0=off
                             1=Color bar
   2=Gray wedge
                             3=Gray bars
   4=White (890LSB)
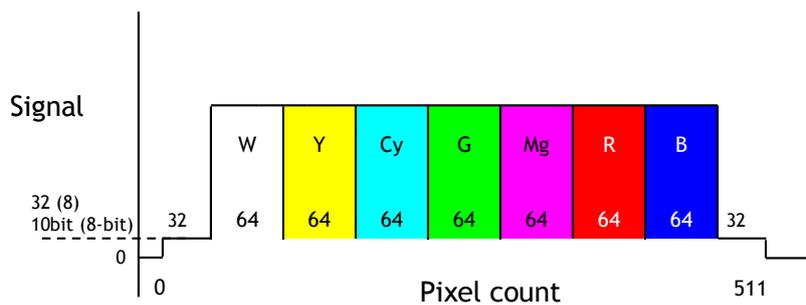

Fig. 21   Color bar test pattern
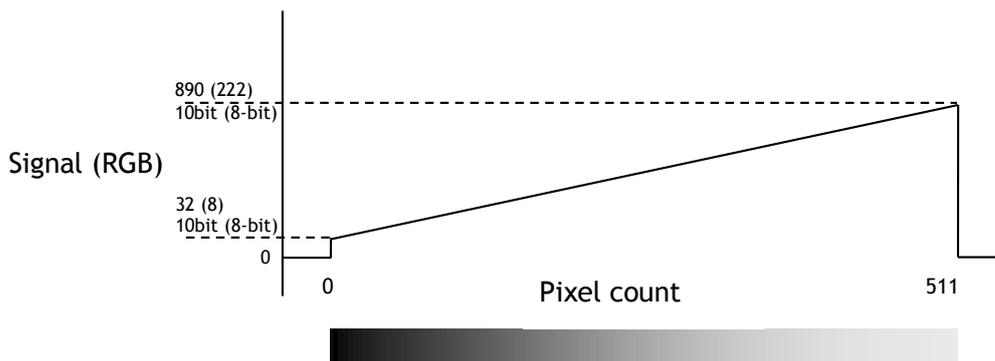
Fig. 22   Gray wedge test pattern

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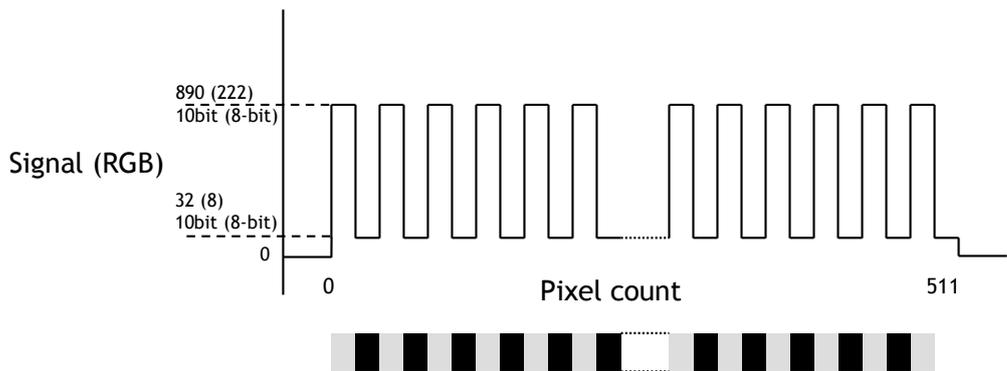
Fig. 23   Gray bars test pattern
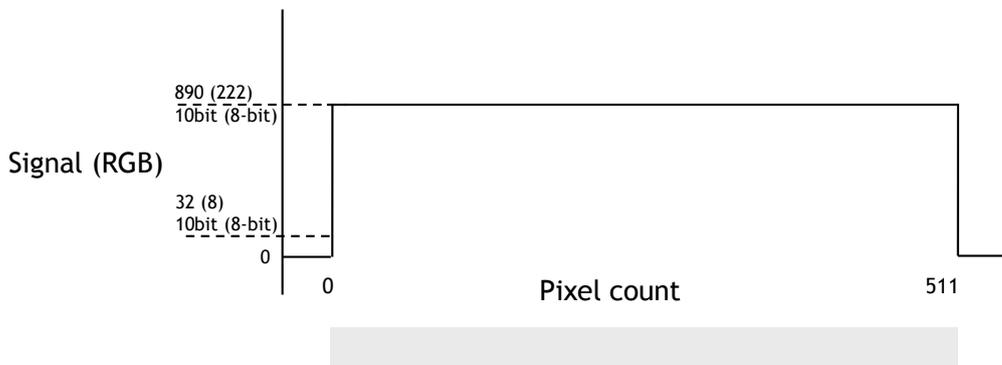
Fig. 24   White level test pattern

7.35.   Command <u>WB</u> – White Balance

The white balance function can be used for manual setting, one-push automatic white balance (AWB) and fixed color temperatures (3 selections)

Settings:	0=Manual / On-Push AWB
	1=4000K
	2=4600K
	3=5600K
Applicable modes:	All
Associated functions:	Command AW (Gain)
	Command AH (Shutter)
	Command GAR – Manual gain red channel
	Command GAB – Manual gain blue channel
Adjustment range:	One-Push AWB: -6dB to +6dB
	Manual white balance: -6dB to +6dB

Note: For precise white balance adjustment in both one-push and manual, it is required to

use　fine gain adjustment described in the chapter 7.15.

8.　Serial communication and command list
8.1.　Serial communication
The LQ-050CL can communicate by serial communication via the Camera Link connector or via RS232C in the 12-pin Hirose connector. The Baud Rate is fixed at 9600 bps. Switch SW1 at the rear panel of the camera is used to select which way the serial communication is set up.

SW1

No	Function	Setting	
		ON	**OFF (Default)**
1	Select serial communication path	Hirose 12Pin	Camera link
2	External trigger input termination	75 ohm	TTL

OFF　　　　　　ON

Serial Communication

Termination

Default setting
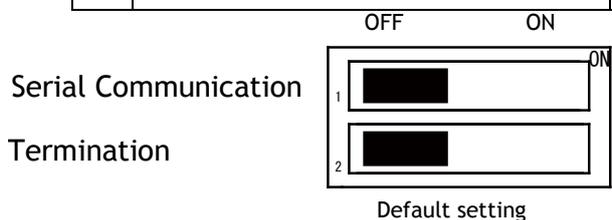
Note: HIROSE 12 Pin and Camera Link can not be used simultaneously.

Communication setting:

Baud Rate	9600
Data Length	8bit
Start Bit	1bit
Stop Bit	1bit
Parity	Non
Xon/Xoff Control	Non

```
                               ┌ 1 CD
                               ├ 4 DTR
                               └ 6 DSR    9 pin
                TXD ─────── 2 RXD         D-con
CAMERA  RXD ─────── 3 TXD                 PC COM
        GND ─────── 5 GND                 PORT
                               ┌ 7 RTS
                               └ 8 CTS
                                 9 CI
```
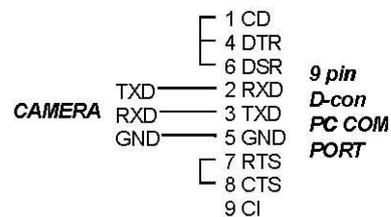
Protocol.

Transmit setting to camera:
> **NN=[Parameter]<CR><LF>**   (NN is any kind of command. Capital or small letters.)

The camera answers:
> **COMPLETE<CR><LF>**

To have all communication visible on the emulator screen, start with:
> **EB=1<CR><LF>**

The camera answers:
> **COMPLETE<CR><LF>**

Transmit request command to camera:
> **NN?<CR><LF>**   (NN is any kind of command.)

The camera answers:
> **NN=[Parameter]<CR><LF>**

Transmit the following to have the camera's actual setting:
> **ST?<CR><LF>**

The camera answers:
> A complete list of the current settings

Transmit the following to have a command list:
> **HP?<CR><LF>**

The camera answers:
> A list with all commands and possible settings

Invalid parameters send to camera: (99 is an invalid parameter)
> **SH=99<CR><LF>**

The camera answers:
> **02 Bad Parameters!!<CR><LF>**

To see firmware number.
> **VN?<CR><LF>**

To see camera ID. It shows the manufacturing lot number.
> **ID?<CR><LF>**

8.2.   Command list

	Command Name	Format	Parameter	Remarks
A – General settings and useful commands.				
EB	Echo Back	EB=[Param.]<CR><LF> EB?<CR><LF>	0=Echo off, 1=Echo on	Returns character sent to the camera. Off at power up
ST	Camera Status Request	ST?<CR><LF>		Display current settings of all functions
HP	Online Help Request	HP?<CR><LF>		Get a list of available commands
VN	Firmware Program Version Request	VN?<CR><LF>		3 digits Example: 100 = Version 1.00

PV	FPGA Program Version Request	PV?<CR><LF>		3 digits Example: 100 = Version 1.00
ID	Camera ID Request	ID?<CR><LF>		Returns the camera's ID (?). Factory setting.
MD	Model Name Request	MD?<CR><LF>		Returns the camera's model name. Factory setting.
UD	User ID	UD=[Param.]<CR><LF> UD?<CR><LF>		User definable field. Up to 16 characters.
B - Line Rate, Exposure				
LR	Line Rate	LR=[Param.]<CR><LF> LR?<CR><LF>	564 to 577536, in 25ns increments	Only valid for TG=0
AR	One-push auto line rate set	AR=[Param.]<CR><LF> AR?<CR><LF>	0=Activate one-push auto line rate set	Only valid for TR=0 and TG=0
AL	Auto line rate reference level	AL=[Param.]<CR><LF> AL?<CR><LF>	0 to 1023	Only valid for TG=0
EI	RB Exposure interlocked with G	EI=[Param.]<CR><LF> EI?<CR><LF>	0=Off (independent) 1=On (interlocked)	Only valid for TR=1
PER	Programmable Exposure - Red	PER=[Param.]<CR><LF> PER?<CR><LF>	2 to577536, in 25ns increments	Only valid for TR=1
PEG	Programmable Exposure - Green	PEG=[Param.]<CR><LF> PEG?<CR><LF>	2 to577536, in 25ns increments	Only valid for TR=1
PEB	Programmable Exposure - Blue	PEB=[Param.]<CR><LF> PEB?<CR><LF>	2 to577536, in 25ns increments	Only valid for TR=1
PEIR	Programmable Exposure - NIR	PEIR=[Param.]<CR><LF> PEIR?<CR><LF>	2 to577536, in 25ns increments	Only valid for TR=1
AH	One-push AWB shutter	AH=[Param.]<CR><LF>	0=Activate one-push AWB shutter	Only valid for TR=1
AHRS	Get status after one-push AWB shutter	AHRS?<CR><LF>	<One of following values will be replied from the camera> 0=Succeeded. 1=AWB has not been finished yet. 2=Error1. Green image was too bright. 3=Error2. Green image was too dark. 4=Error3. Timeout-error occurred.	
C - Trigger mode				
TR	Trigger Mode	TR=[Param.]<CR><LF> TR?<CR><LF>	0=No-Shutter mode 1=Shutter-Select mode 2=Pulse Width Control	

			mode	
TG	Trigger Origin	TG=[Param.]<CR><LF> TG?<CR><LF>	0=Internal 1=External	TG=0 is available when TR=0 or TR=1
TI	Trigger Input	TI=[Param.]<CR><LF> TI?<CR><LF>	0=Camera-Link 1=Hirose12pin	
TP	Trigger Polarity	TP=[Param.]<CR><LF> TP?<CR><LF>	0=Active-Low 1=Active-High	
ARST	Auto reset mode	ARST=[Param.]<CR><LF> ARST?<CR><LF>	0=OFF 1=ON	
D - Image format				
BI	Binning	BI=[Param.]<CR><LF> BI?<CR><LF>	0=Binning Off, 1=Binning On	
BA	Bit allocation	BA=[Param.]<CR><LF> BA?<CR><LF>	0=8bitx4, 1=10bitx4	
TS	Test Pattern	TS=[Param.]<CR><LF> TS?<CR><LF>	0=Off 1=Color Bar 2=Gray Pattern 1 3=Gray Pattern 2 4=White	Off at power up
E - Gain, white balance and signal settings				
GA	Gain Level - Master	GA=[Param.]<CR><LF> GA?<CR><LF>	Master Mode:-132 to 429 Individual:-363 to 660	0=0dB
GAR	Gain Level - Red	GAR=[Param.]<CR><LF> GAR?<CR><LF>	Master Mode:-231 to 231 Individual:-363 to 660	
GAB	Gain Level - Blue	GAB=[Param.]<CR><LF> GAB?<CR><LF>	Master Mode:-231 to 231 Individual:-363 to 660	
GAIR	Gain Level - Blue	GAIR=[Param.]<CR><LF> GAIR?<CR><LF>	Master Mode:-231 to 231 Individual:-363 to 660	
GM	Gain mode	BLM=[Param.]<CR><LF> BLM?<CR><LF>	0=Master Mode 1=Individual Mode	Default is 1
BL	Black Level – Master(Master Mode) Green(Individual)	BL=[Param.]<CR><LF> BL?<CR><LF>	Master Mode:0 to 255 Individual:0 to 255	
BLR	Black Level - Red	BLR=[Param.]<CR><LF> BLR?<CR><LF>	Master Mode:-128 to 127 Individual:0 to 255	
BLB	Black Level - Blue	BLB=[Param.]<CR><LF> BLB?<CR><LF>	Master Mode:-128 to 127 Individual:0 to 255	
BLIR	Black Level - NIR	BLIR=[Param.]<CR><LF> BLIR?<CR><LF>	Master Mode:-128 to 127 Individual:0 to 255	
BLM	Gain Mode	BLM=[Param.]<CR><LF> BLM?<CR><LF>	0=Master Mode 1=Individual	Default is 1
WB	White Balance	WB=[Param.]<CR><LF> WB?<CR><LF>	0=Manual/One push AWB 1=4000K 2=4600K 3=5600K	
AW	Activate One-push AWB	AW=[Param.]<CR><LF>	0=Activate one-push AWB	
AWRS	Inquire the status after	AWRS?<CR><LF>	<Camera replies > 0=AWB has not been	

	one-push AWB		finished yet. 1=Succeeded. 2=Error1. Green image was too bright. 3=Error2. Green image was too dark. 4=Error3. Timeout-error occurred.	
GAR2	Fine gain – red	GAR2=[Param.]<CR><LF> GAR2?<CR><LF>	6544 to 9830	8192=1
GAG2	Fine gain - Green	GAG2=[Param.]<CR><LF> GAG2?<CR><LF>	6544 to 9830	8192=1
GAB2	Fine gain - Blue	GAB2=[Param.]<CR><LF> GAB2?<CR><LF>	6544 to 9830	8192=1
GAIR2	Fine gain - NIR	GAIR2=[Param.]<CR><LF> GAIR2?<CR><LF>	6544 to 9830	8192=1
NR	Noise reduction	NR=[Param.]<CR><LF> NR?	0 = OFF, 1= ON	
LUTC	LUT Control	LUTC=[Param.]<CR><LF> LUTC?<CR><LF>	0 = OFF, 1= 0.45, 2=User	
LUTR	LUT data - Red	LUTR=[Param.]<CR><LF> LUTR?<CR><LF>	Data：512 Parameter：0 to 8191	Transfer by serial
LUTG	LUT data - Green	LUTG=[Param.]<CR><LF> LUTG?<CR><LF>	Data：512 Parameter：0 to 8191	Transfer by serial
LUTB	LUT data - Blue	LUTB=[Param.]<CR><LF> LUTB?<CR><LF>	Data：512 Parameter：0 to 8191	Transfer by serial
LUTIR	LUT data - NIR	LUTIR=[Param.]<CR><LF> LUTIR?<CR><LF>	Data：512 Parameter：0 to 8191	Transfer by serial

F - Shading correction, pixel gain and pixel black correction

SDC	Select shading correction mode	SDC=[Param.]<CR><LF> SDC?<CR><LF>	0=Off (Bypass) 1=Factory area 2=User area	
SDR	Run shading correction, store to user area	SDR=[Param.]<CR><LF>	0=Run flat shading correction, store to user area 1=Run color shading correction, store to user area	Store in user setting.
SDS	Inquire the status after shading correction	SDS?<CR><LF>	0=Shading correction not yet completed. 1=Succeeded. 2=Error 1 – Image too bright 3=Error 2 - Image too dark 4=Error 3 - Timeout error occurred.	
PGC	Select pixel gain correction mode	PGC=[Param.]<CR><LF> PGC?<CR><LF>	0=Off (Bypass) 1=Factory area 2=User area	

PGR	Run pixel gain correction, store to user area	PGR=[Param.]<CR><LF> PGR?<CR><LF>	0=Run pixel gain correction, store to user area	Store in user setting.
PGS	Inquire the status after pixel gain correction	PGS?<CR><LF>	0=Pixel gain correction not yet completed. 1=Succeeded 2=Error 1 – Image too bright 3=Error 2 - Image too dark 4=Error 3 - Timeout error occurred.	
PBC	Select pixel black correction mode	PBC=[Param.]<CR><LF> PBC?<CR><LF>	0=Off (Bypass) 1=Factory area 2=User area	
PBR	Run pixel black correction, store to user area	PBR=[Param.]<CR><LF> PBR?<CR><LF>	0=Run pixel black correction, store to user area	Store in user setting.
PBS	Inquire the status after pixel black correction	PBS?<CR><LF>	0=Pixel black correction has not been finished yet. 1=Succeeded. 2=Error1 - Timeout error occurred.	
G - Saving and loading data in EEPROM				
LD	Load Setttings (from Camera EEPROM)	LD=[Param.]<CR><LF>	0=Factory area 1=User area1 2=User area2	Latest used DATA AREA will become default at next power up.
SA	Save Settings (to Camera EEPROM)	SA=[Param.]<CR><LF>	1=User area1 2=User area2 Note the parameter 0 is not allowed.	
EA	EEPROM Current Area No. Request.	EA?<CR><LF>	0=Factory area 1=User area1 2=User area2	The camera returns latest used DATA AREA.

Note: To avoid malfunction, do not attempt writing commands not shown in the above list.

9. Camera Control Tool for LQ-050CL

From www.jai.com Camera Control Tool for Windows XP/Vista/7 can be downloaded.

9.1. Software Install

Execute LQ-050CL_Ver.XXX.exe in the downloaded file.   The setup program starts and continues according to the screen instructions.

9.2. Open the Control Tool

Connect the camera to the PC on which the software is installed and set the power ON. Then select "All programs" in the Windows start menu, select "JAI A-S" and click "LQ-050CL control tool".
LQ-050CL Camera Control Tool and Communication windows will open.
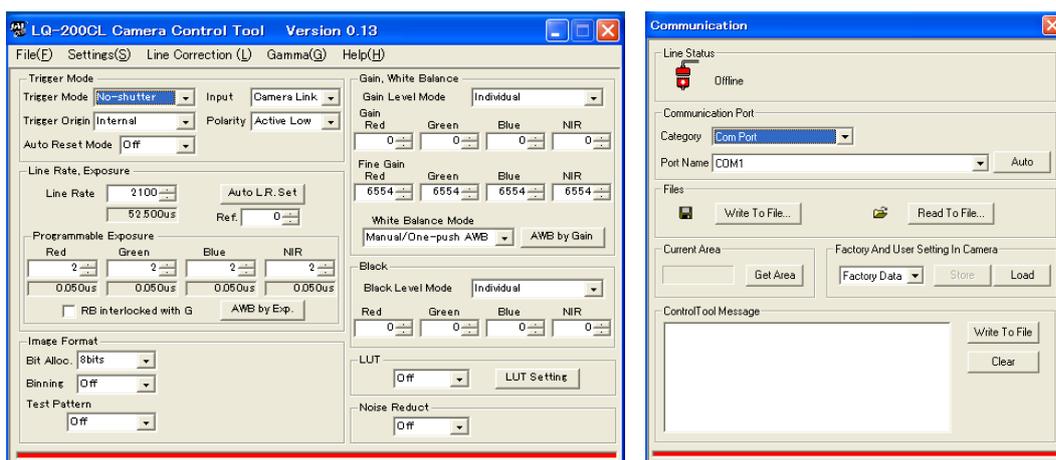
If the Communication window does not open, click "Help" in the Download menu of "Camera Control Tool" and click "Communication".

9.3. Connect a camera

If the frame grabber board is already installed in the connected PC, it will appear in the "Category" box in the "Communication port" pane. Click it if it is the appropriate one.
If the frame grabber board is not used, select the COM port to which the camera is connected, and click "OK". After the connection is established, the RED Off-line icon changes to GREEN and the RED bar in the bottom changes to GREEN.

9.4.   Camera control window

When the connection between camera and PC is completed, the camera control tool shows the current camera settings.
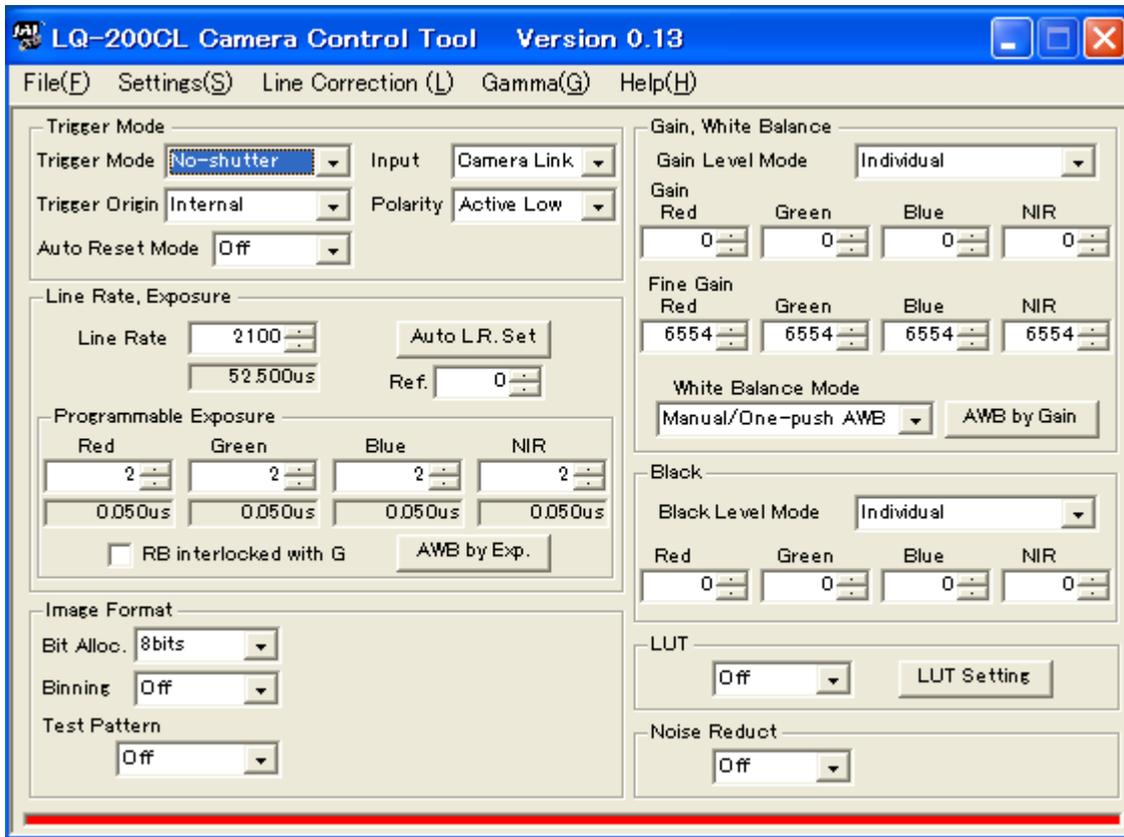

9.5.   LUT setting

Open the drop-down menu under "LUT" and click "User".

When you click "LUT setting", the following four windows for NIR, Red, Blue and Green will be opened.
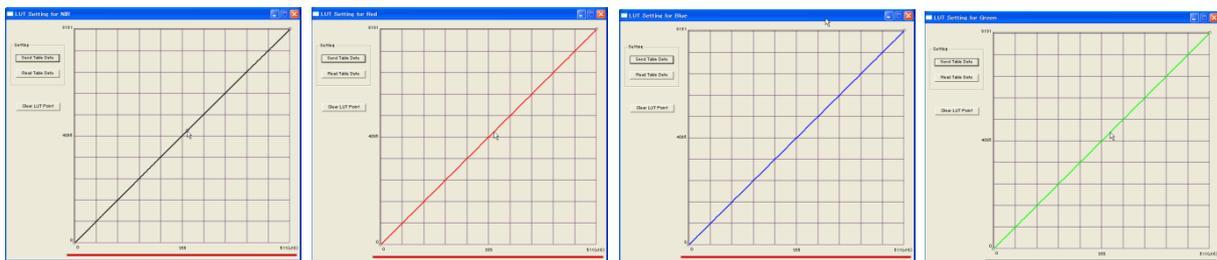
When you drag the line and move it, the required gamma characteristics can be obtained.
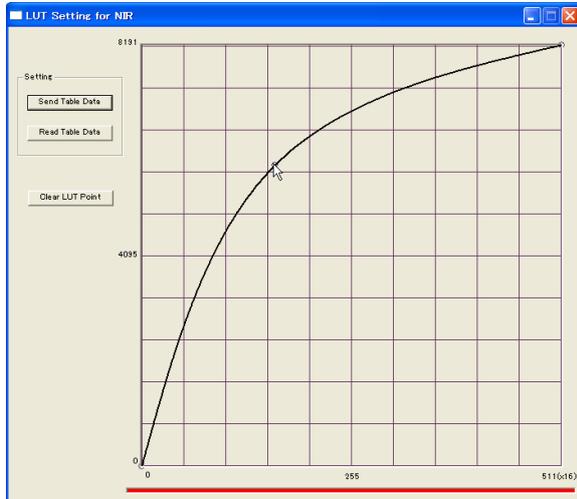

9.6. Menus
9.6.1 File menu

Open: Transfer the setting parameters in HDD or other memory devices to the camera. The extension is .cam

Save as: Store the setting parameters in HDD other memory devices. The extension is .cam.

Exit: Finish the software.

9.6.2 Settings menu
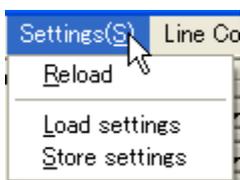
Reload: Read the setting parameters from RAM area of the camera.

Load settings: Read the setting parameters from EEPROM area of the camera.
Select from Factory, User 1 or User2.

Store settings: Read the parameters in the EEPROM area of the camera. Select from User 1 or User 2.

9.6.3 Line Correction menu
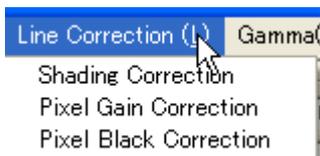
Click Line correction menu and drop-down menu will open. The setting window for shading, pixel gain and pixel black can be opened.
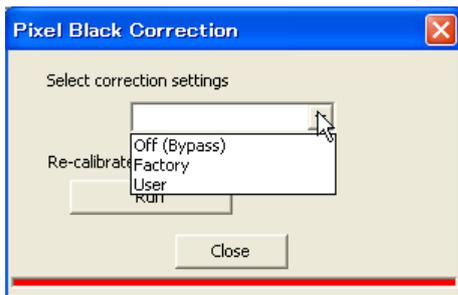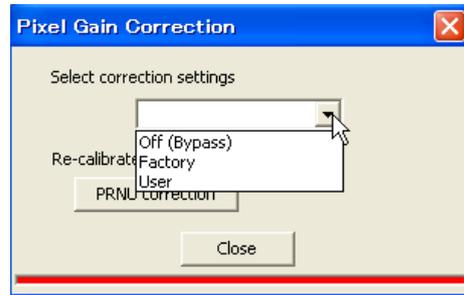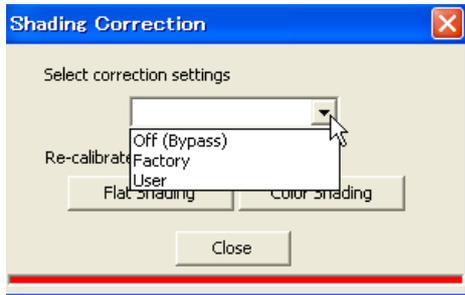
9.5.4 Gamma menu
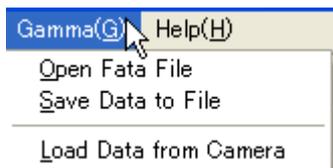
Open Data file: Transfer the LUT data stored in HDD or the other memory devices, to the Control software. The file extension is .csv.

Save Data to File: Store the LUT data set in the Control software, to HDD or other memory devices. The file extension is.csv.

Load Data from Camera: Load the LUT dataset in the camera, to the Control software. Select from User 1 or User 2.

9.5.5 Help menu

Display camera software version, model name, firmware version and camera ID.

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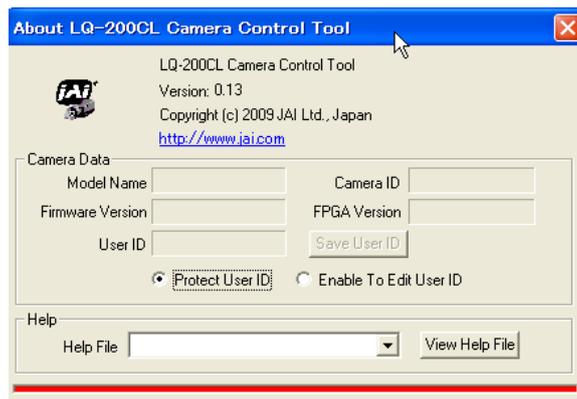
10.   External appearance and Dimensions
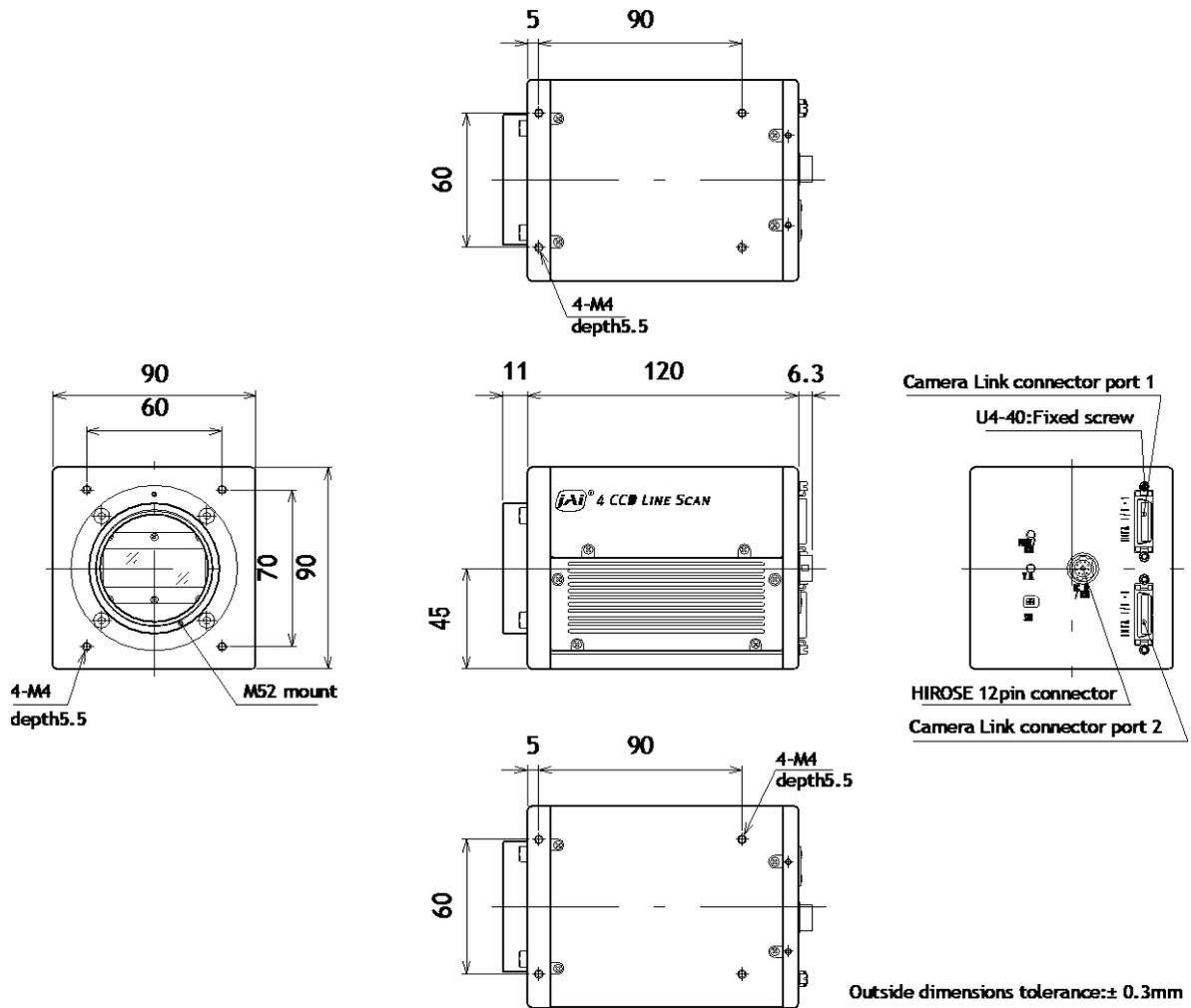
Fig.25   External Appearance and Dimensions for M52 mount

5 | 90

60

4-M4
depth 5.5

90
60

90
70
90

4-M4
depth 5.5

Nikon F-mount

11 | 120 | 6.3

jAi 4 CCD Line Scan

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Camera Link Connector Port 1

U4-40: Fixed screw

POWER /
TRIG

W.B.

SW1

DC IN
/TRIG

HIROSE 12pin Connector

Camera Link Connector Port 2

5 | 90 | 4-M4
depth 5.5

60

Outside size tolerance : ± 0.3mm
Unit: mm
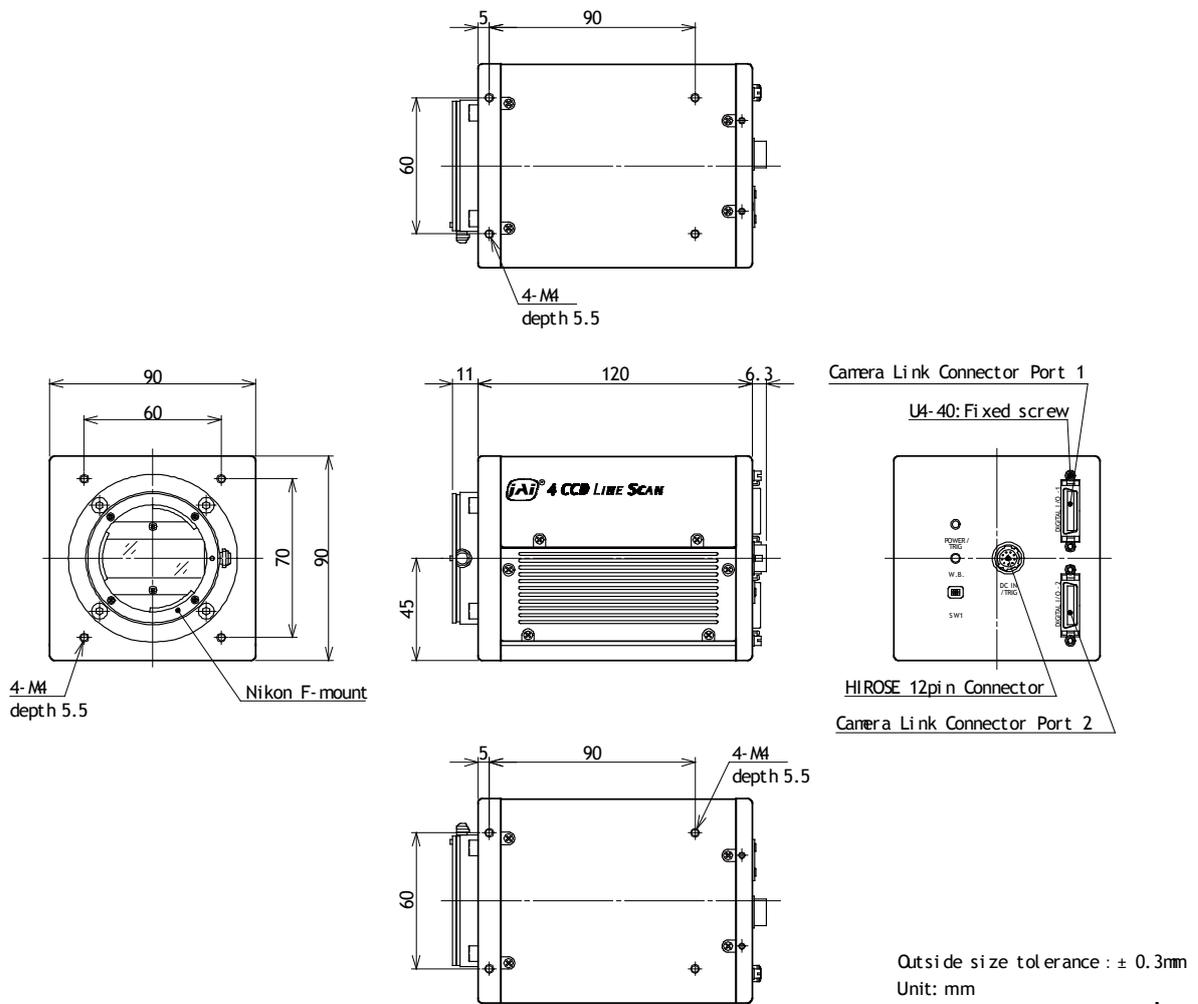
Fig.26   External Appearance and Dimensions for F mount

11.   Specifications

11.1 Typical data

Scanning system	Line Scan
Image Sensor	Effective pixels :512 pixels Pixel Size : 14.0μm × 14.0μm Effective image length : 7.168mm
Pixel clock	40.00 MHz
Total pixels per line	564 clocks
Line Rate (Standard)	14.10μs	Internal trigger	No-shutter, Shutter select
	14.20μs	External trigger	No-shutter, Shutter select, PWC
Line Frequency	70.922KHz	Internal trigger	No-shutter, Shutter select
	70.422KHz	External trigger	No-shutter, Shutter select, PWC
Sensor sensitivity	27nJ/cm^2
Sensitivity (Standard)	RGB : 2800 Lx (7800K White LED light) Conditions: Line Rate=600μs, Gain=0dB, Shutter=OFF, Lens iris=F2, 100% output) NIR : 20μW/cm^2 at 800nm
S/N	58 dB (Green channel, Gain=0dB）
Synchronization	Internal
Video output	Digital 8-Bit x 4 or 10-Bit x 4 (Camera link)
Video output format	Full resolution, Binning(Digital 2 pixels accumulation)

Gain range	Mode select:
	    Master mode : Adjust master level and match R,G,B and NIR
	                    Master(Green): -3dB to +12dB
	                    R/B/NIR : -6dB to +6dB
	    Individual : Adjust each channel individually
	                    R/G/B/NIR : -9dB to +18dB
	Fine gain (R&B): Adjustable range from x 0.8 to x 1.2

White balance	Adjustable range : 4000K to 9000K Standard color temperature : 7800K

Black level
(User setup)
	Mode select:
	    Master mode : Adjust master level and match R,G,B and NIR
	                    Master(Green): 0 to 255 LSB(10-bit output)
	                    R/B/NIR : -128 to 127 LSB (10-bit output)
	    Individual : Adjust each channel individually
	                    R/G/B/NIR : 0 to 255 LSB (10-bit output)

Line rate (Variable)	Range : 14.10μs(1L) to 14.438ms(1024L) Note: Black level stable range is 14.10μs(1L) to 2ms Adjustment increment : 25ns (1clk) This mode is available for No-shutter internal trigger and Shutter-select internal trigger modes.
Electronic shutter	Available for Shutter-Select mode Adjustable range : 50ns (2 clk) to {Line rate − 52clk(1.3μs) 50ns to 12.8μs (Note 1) Adjustment increments : 25ns (1 clk)

Binning	Horizontal
Test pattern	0: Color Bar 1: Gray 1 2: Gray 2 3: White (890 LSB)
Signal processing circuit	1. Pixel gain correction: Pixel Response Non Uniformity(PRNU),Dark Signal Non Uniformity(DSNU) 2. Shading compensation : ON / OFF Flat shading compensation, Color shading compensation 3. Color matrix : R,G,B color compensation 4. LUT/Gamma : OFF, 0.45 and User settings 5. Noise reduction: ON/OFF
Operation mode	No-Shutter	Internal trigger/External trigger
	Shutter select	Internal trigger/External trigger
	Pulse Width Control (PWC)	External trigger

Trigger input	Hirose 12-Pin : 4.0±2.0Vp-p TTL or
	Camera Link : LVDS (CC1)
	Possible to change negative Logic or positive Logic
	Minimum trigger width :
	        External trigger: more than 500ns,
	        PWC : more than 20.57μs

Sync output (open termination)	Camera Link LVAL, DVAL, EEN Hirose 12-Pin XEEN (negative logic) 4.0 Vp-p (no termination)
Communication interface	Via Camera Link connector or RS-232C (Hirose 12-Pin connector) Baud rate : 9600bps Interface is switched by SW1 located rear panel. Camera Link and Hirose 12-Pin cannot be used at the same time.
Power	DC +12V -10% to +24V +10% 975mA (internal trigger, line rate *600μs, 0dB, lens covered) 1000mA (internal trigger, line rate :600μs, max gain, saturation) The above data is for +12V input. Note: Use a power supply capable of providing more than 3A.

Lens Mount	M52 mount (Standard) or Nikon F-Mount(Optional)
	Maximum allowed rear protrusion on lenses:
	  M52 Mount : 13mm
	  Nikon F-Mount: 13 mm

Flange back	M52 Mount : 46.5mm Tolerance 0 to +0.1mm Nikon F-Mount : 46.5mm Tolerance 0 to +0.1mm
Optical axis	Center ±0.1mm (max)
Operating temperature /humidity	- 5°C to +45°C / 20 to80% (non-condensing)
Storage temperature /humidity	-25°C to +60°C, 20 to 80% (non-condensing)
Vibration	3G (20Hz to 200Hz XYZ direction)
Shock	50G
Regulation	CE (EN61000-2+EN61000-3) IEC61000-4-2 Conforming to Level 4 (Note 3) FCC Part15 Class B RoHS

Dimensions	90(W) x 90(H) x 120(D) mm (without connector and lens mount protrusion)
Weight	1050 g
Connectors	Camera Link : 10226-1A10PL x2 Hirose 12-Pin : HR10A-10R-12PB

Note 1: **This is the maximum shutter time at minimum line cycle (14.10 μs)**
Note 2: **LSB numbers shown in parentheses is for 8-bit output.**
Note 3: **This is effective only when specified connector or cable is used.**
   Refer to chapter 5. Connectors.

## 11.2   Camera Spectral sensitivity
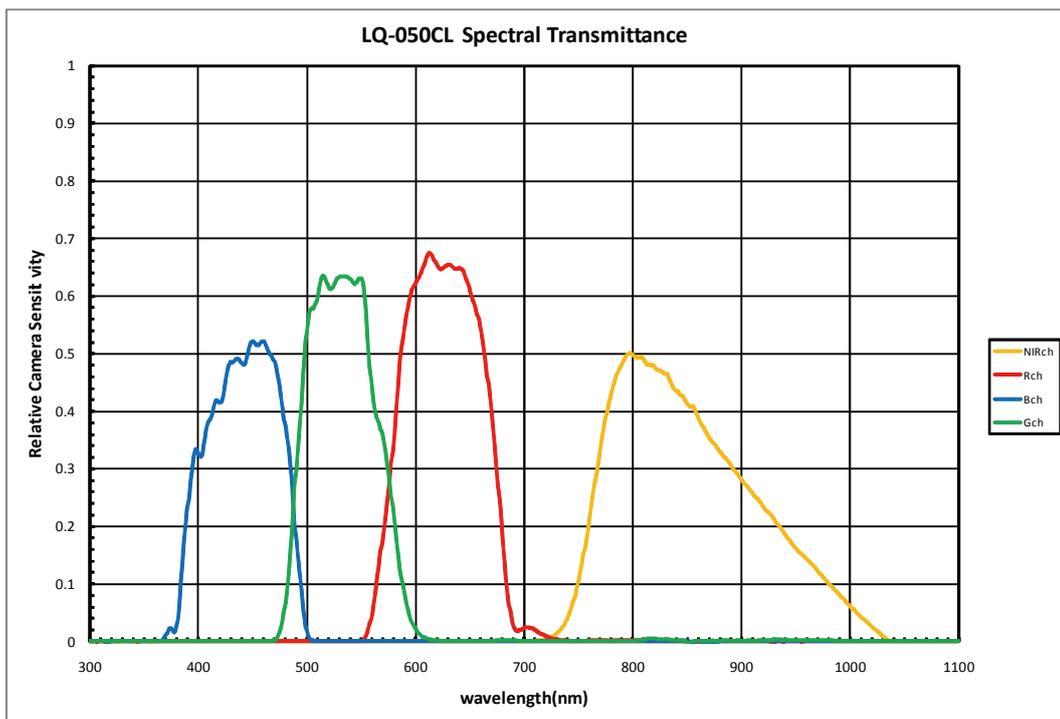
Fig. 27   Camera Spectral sensitivity

Appendix

1.   Precautions

Personnel not trained in dealing with similar electronic devices should not service this camera.
The camera contains components sensitive to electrostatic discharge. The handling of these devices should follow the requirements of electrostatic sensitive components.
Do not attempt to disassemble this camera.
Do not expose this camera to rain or moisture.
Do not face this camera towards the sun, extreme bright light or light reflecting objects.
When this camera is not in use, put the supplied lens cap on the lens mount.
Handle this camera with the maximum care.
Operate this camera only from the type of power source indicated on the camera.
Power off the camera during any modification, such as changes of jumper and switch settings.

2.   Typical Sensor Characteristics

The following effects may be observed on the video monitor screen. They do not indicate any fault of the camera, but are associated with typical sensor characteristics.

V. Aliasing
When the CCD camera captures stripes, straight lines or similar sharp patterns, jagged image on the monitor may appear.

Blemishes
All cameras are shipped without visible image sensor blemishes.
Over time some pixel defects can occur. This does not have a practical effect on the operation of the camera. These will show up as white spots (blemishes).
Exposure to cosmic rays can cause blemishes to appear on the image sensor. Please take care to avoid exposure to cosmic rays during transportation and storage. It is recommended using sea shipment instead of air flight in order to limit the influence of cosmic rays on the camera. Pixel defects/blemishes also may emerge due to prolonged operation at elevated ambient temperature, due to high gain setting, or during long time exposure. It is therefore recommended to operate the camera within its specifications.

Patterned Noise
When the sensor captures a dark object at high temperature or is used for long time integration, fixed pattern noise may appear on the video monitor screen.

3.   Caution when mounting a lens on the camera

When mounting a lens on the camera dust particles in the air may settle on the surface of the lens or the image sensor of the camera. It is therefore important to keep the protective caps on the lens and on the camera until the lens is mounted. Point the lens mount of the camera downward to prevent dust particles from landing on the optical surfaces of the camera. This work should be done in a dust free environment. Do not touch any of the optical surfaces of the camera or the lens.

4.   Caution when mounting the camera

When you mount the camera on your system, please make sure to use screws of the recommended length described in the following drawing. Longer screws may cause serious damage to the PCB inside the camera.

Camera Chassis

5.5 mm ± 0.2 mm
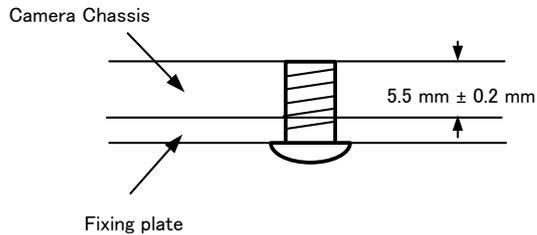
Fixing plate

Fixing the camera on the plate

If you mount the tripod mounting plate, please use the provided screws.

Camera Chassis

5.5 mm ± 0.2 mm
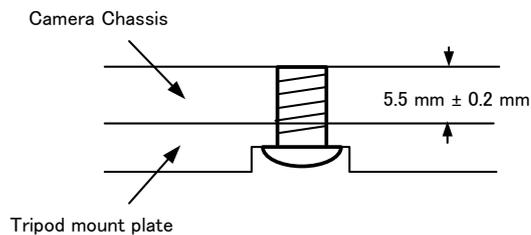
Tripod mount plate

Attaching the tripod mount

5.   Exportation

When exporting this product, please follow the export regulation of your own country.

6.   References

1. This manual and datasheet for the LQ-050CL can be downloaded from www.jai.com
2. Camera control software can be downloaded from www.jai.com

Change history

Date	Revision	Changes
May 2011	1.0	New release
Oct. 2012	1.1	Chapter 7.25 Change "flat-field" to "pixel gain"
Dec. 2014	1.2	Correct default setting for PBC, PGC and SDC

User's Record

Camera type: **LQ-050CL**

Revision: ……………..

Serial No.   ……………..

Firmware version.   ……………..

For camera revision history, please contact your local JAI distributor.

User's Mode Settings.

User's Modifications.

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