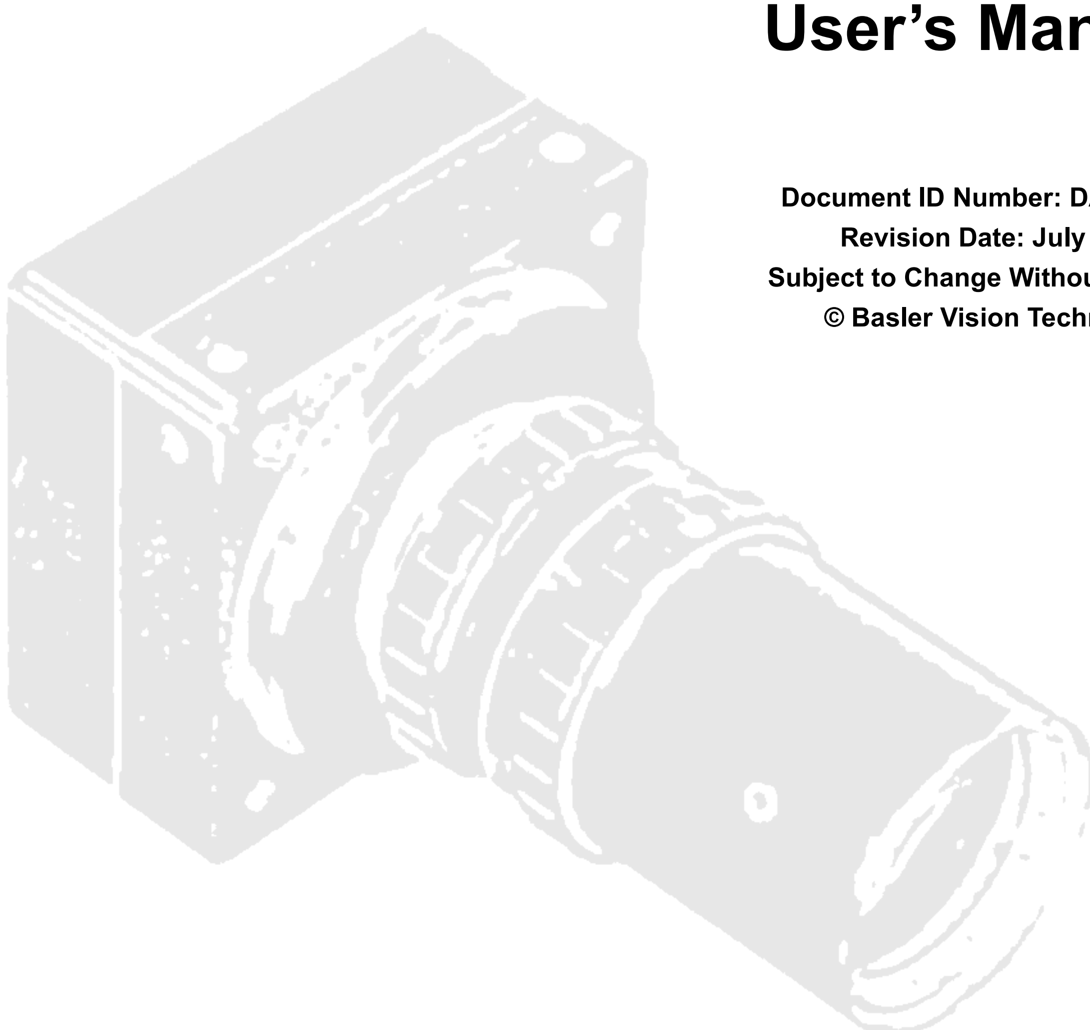
# BASLER L100b Series

# User's Manual



**Document ID Number: DA039803**
**Revision Date: July 13, 2001**
**Subject to Change Without Notice**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### For customers in the U.S.A.

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

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment.

The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

### For customers in Canada

This apparatus complies with the Class A limits for radio noise emissions set out in Radio Interference Regulations.

### Pour utilisateurs au Canada

Cet appareil est conforme aux normes Classe A pour bruits radioélectriques, spécifiées dans le Règlement sur le brouillage radioélectrique.

### Life Support Applications

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Basler customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Basler for any damages resulting from such improper use or sale.

### Warranty Note

Do not open the housing of the camera. The warranty becomes void if the housing is opened.

# Table of Contents

# 1 Introduction

**L100b** series line scan cameras are versatile cameras designed for industrial use. Superb image sensing features are combined with a robust, high precision manufactured housing.

Important features are:

- High sensitivity
- Anti-blooming
- Electronic exposure time control
- High signal-to-noise ratio
- Single or dual video data output
- Programmable via an RS-232 serial port
- Industrial housing manufactured with high planar, parallel and angular precision
- Super compact size

## 1.1 Camera Versions

**L100b** series line scan cameras are available in different versions; the version depends on the pixel clock speed. Each version of the camera is available with a 1024 or a 2048 pixel sensor.

Throughout the manual, the camera will be called the **L100b**. Passages that are only valid for a specific version will be so indicated.

| Camera Version | Pixel Clock (single output mode) | Pixel Clock (dual output mode) |
|---|---|---|
| **L101b** | 20 MHz | 20 MHz |
| **L103b** | 40 MHz | 20 MHz |
| **L104b** | 62.5 MHz | 31.25 MHz |

Table 1-1: Versions of the **L100b** Series Camera

# 1.2 Performance Specifications

| Specifications | L101b | L103b | L104b |
|---|---|---|---|
| Sensor | 1024 pixel or 2048 pixel linear CCD | | |
| Pixel Size | 10 µm x 10 µm (10 µm pitch) | | |
| Fill Factor | 100% | | |
| Spectral Response | 300 - 1000 nm, peak at 700 nm (See Figure 1-1) | | |
| Anti-blooming | 1:100 or better | | |
| Fixed Pattern Noise | ± 1 Gray Value | | |
| Photo Resp. Non-uniformity | ± 5% typical | | |
| Pixel Clock Speed<br>Single Output Modes:<br>Dual Output Modes: | <br>20 MHz<br>20 MHz | <br>40 MHz<br>20 MHz | <br>62.5 MHz<br>31.25 MHz |
| Maximum Line Rate<br>1024 Pixel Cameras:<br>2048 Pixel Cameras: | <br>18.6 kHz<br>9.5 kHz | <br>37.4 kHz<br>19.1 kHz | <br>58.5 kHz<br>29.2 kHz |
| Minimum Line Rate | 1 kHz | | |
| Pixel Depth | Programmable 8 bit or 10 bit | | |
| Video Output Type | Channel Link LVDS (RS-644 LVDS when the camera is used with the optional Basler Interface Converter) | | |
| Video Output Formats | Single 8 Bit, Single 10 Bit, Dual 8 Bit, or Dual 10 Bit | | |
| Synchronization | Via external ExSync signal or free-run | | |
| Exposure Time Control | Edge-controlled, level-controlled, or programmable | | |
| Gain and Offset | Programmable via a serial link | | |
| Connector | One, 26 pin, high-density, D-Sub plug | | |
| Power Requirements | 12 VDC ± 10%<br>max 6 W | 12 VDC ± 10%<br>max 8 W | 12 VDC ± 10%<br>max 10 W |
| Lens Adapters | 1024 Pixel Cameras: C-mount or F-mount<br>2048 Pixel Cameras: F-mount | | |
| Housing Size (L x W x H) | without lens adapter: 38.1mm x 62 mm x 62 mm<br>with C-Mount Adapter: 40.6 mm x 62 mm x 62 mm<br>with F-mount adapter: 69.6 mm x 62 mm x 62 mm | | |
| Weight | without lens adapter: ~ 160 g<br>with C-mount adapter: ~ 200 g<br>with F-mount adapter: ~ 270 g | | |
| Conformity | CE, FCC | | |

Table 1-2: L100b Series Performance Specifications

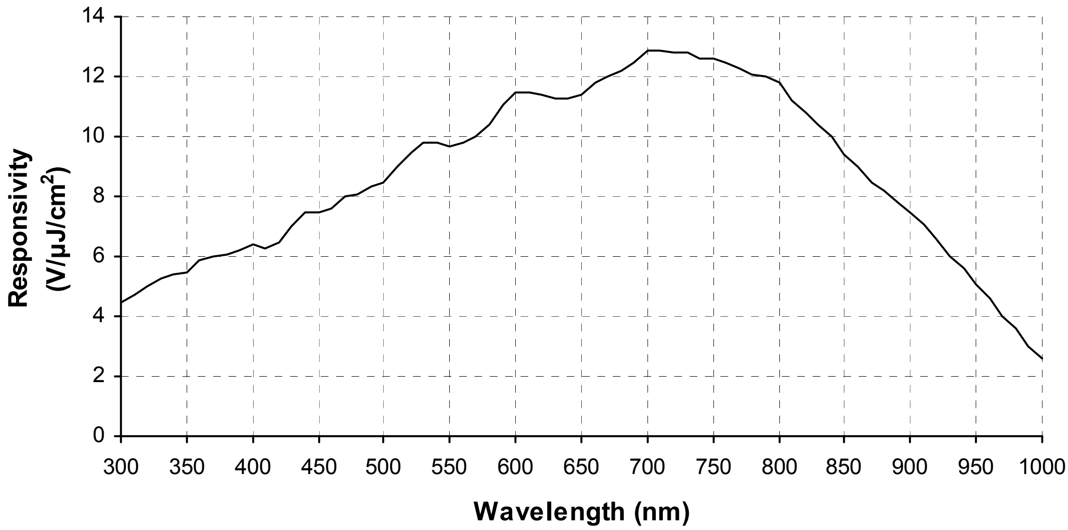



Figure 1-1: Responsivity for **L100b** Series Cameras

# 1.3 Environmental Requirements

## 1.3.1 Temperature and Humidity

| | |
|---|---|
| Housing temperature during operation: | 0° C ... + 50° C (+ 32° F ... + 122° F) |
| Humidity during operation: | 20% ... 80%, relative, non-condensing |

## 1.3.2 Ventilation

Allow sufficient air circulation around the camera to prevent internal heat build-up in your system and to keep the camera housing temperature during operation below 50° C. Provide additional cooling such as fans or heat sinks if necessary.

**Warning!**

Without sufficient cooling, the camera can get hot enough during operation to cause burning when touched.

# 1.4 Precautions

### Power

**Caution!**

Be sure that all power to your system is switched off before you make or break connections to the camera. Making or breaking connections when power is on can result in damage to the camera.

### Read the manual

Read the manual carefully before using the camera.

### Keep foreign matter outside of the camera

Do not open the casing. Touching internal components may damage them.

Be careful not to allow liquid, flammable, or metallic material inside the camera housing. If operated with any foreign matter inside, the camera may fail or cause a fire.

### Electromagnetic Fields

Do not operate the camera in the vicinity of strong electromagnetic fields. Avoid electrostatic charging.

### Transporting

Only transport the camera in its original packaging. Do not discard the packaging.

### Cleaning

Avoid cleaning the surface of the CCD sensor if possible. If you must clean it, use a soft, lint free cloth dampened with a small quantity of pure alcohol. Do not use methylated alcohol.
Because electrostatic discharge can damage the CCD sensor, you must use a cloth that will not generate static during cleaning (cotton is a good choice).

To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains, use a soft cloth dampened with a small quantity of neutral detergent, then wipe dry.

Do not use volatile solvents such as benzine and thinners; they can damage the surface finish.

# 2 Camera Interface

## 2.1 Connections

### 2.1.1 General Description

**L100b** series cameras are interfaced to external circuitry via a single, high density, 26 pin D-Sub plug located on the back of the camera. Figure 2-1 shows the plug and the two status LEDs which indicate signal integrity and power OK.

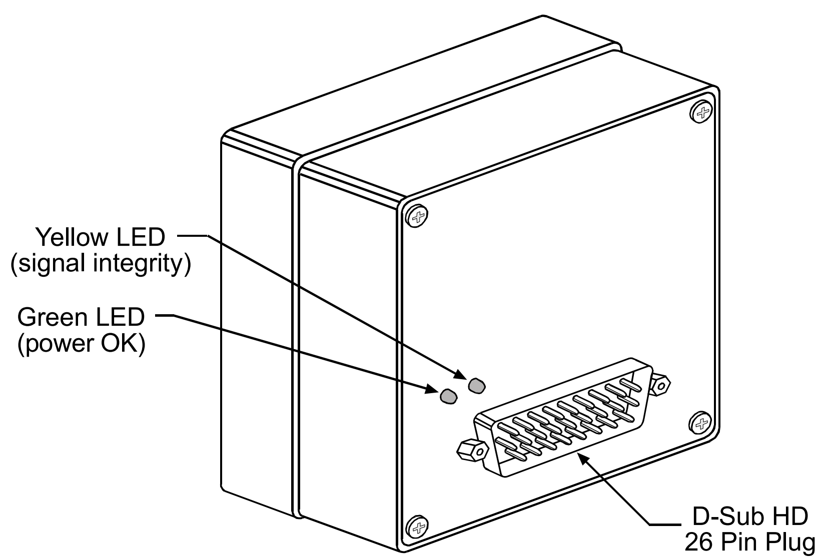



Figure 2-1: **L100b** Connector and LEDs

## 2.1.2 Pin Assignments

The pin assignments for the D-Sub HD 26 plug used to interface video data, control signals, and power are shown in Table 2-1.

| Pin Number | Signal Name | Direction | Level | Function |
|---|---|---|---|---|
| 1, 9, 18, 19, 25, 26 [1] | DC Gnd | Input | Ground | DC Ground |
| 2, 20 [2] | +12 VDC | Input | 12 VDC ± 10% | DC Power |
| 22 | RxD | Input | RS-232 | RS-232 Serial Communication Data Receive |
| 24 | TxD | Output | RS-232 | RS-232 Serial Communication Data Transmit |
| 21, 23[1] | Signal Gnd | Input | Ground | Signal Ground |
| 11 | ExSync+ | Input | RS-644 LVDS | External Trigger |
| 10 | ExSync- | | | |
| 13 | Reserved+ | Input | RS-644 LVDS | Reserved LVDS Input |
| 12 | Reserved- | | | |
| 17 | TxClkOut+ | Output | Channel Link LVDS | Transmit Clock from Channel Link Transmitter |
| 16 | TxClkOut- | | | |
| 8 | TxDataOut3+ | Output | Channel Link LVDS | Data from Channel Link Transmitter |
| 7 | TxDataOut3- | | | |
| 6 | TxDataOut2+ | Output | Channel Link LVDS | Data from Channel Link Transmitter |
| 5 | TxDataOut2- | | | |
| 15 | TxDataOut1+ | Output | Channel Link LVDS | Data from Channel Link Transmitter |
| 14 | TxDataOut1- | | | |
| 4 | TxDataOut0+ | Output | Channel Link LVDS | Data from Channel Link Transmitter |
| 3 | TxDataOut0- | | | |

[1] Pins 1, 9, 18, 19, 25, 26, 21 and 23 are all tied together inside of the camera.

[2] Pins 2 and 20 are tied together inside of the camera.

Table 2-1: **L100b** Pin Assignments for the D-Sub HD 26-pin Plug

> The camera housing is not grounded and is electrically isolated from the circuit boards inside of the camera.
>
> The camera has no reverse power protection. Therefore, always observe the polarity as indicated in Table 2-1.
>
> The camera has no overvoltage protection. Therefore, always observe the power requirements as described in Section 2.6.

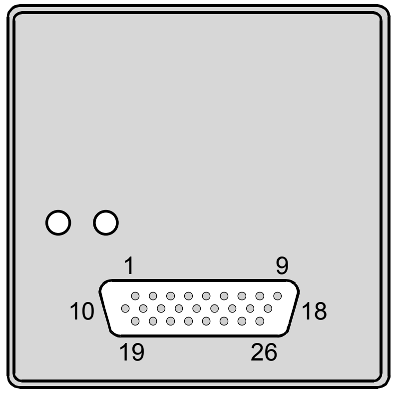



Figure 2-2: L100b Pin Numbering

### 2.1.3 Plug Source Information

At the time this manual was published, Basler's sources for the 26 pin, high density plug used on the camera are FCT Electronic (Part CT15-26P1-L228) and AMP (Part HDP-22 Size-2 26-Position). We will use plugs from either of these suppliers or the equivalent.

## 2.2 Cable Specification

The cable between the camera and the frame grabber must meet the specifications shown in Table 2-2.

| Characteristic | Specification |
|---|---|
| Maximum Length | 10 m* |
| Individually Shielded Twisted Pair Characteristic Impedance | 100 ± 10 Ω |
| Conductor Size | 28 AWG Stranded |

*The maximum cable length was tested with a Sumitomo IEE6-99135 cable. It will decrease when used in an area with severe ambient electromagnetic interference.

Table 2-2: Cable Specifications

# 2.3 Input Signals

The ExSync input signal can be used to control the **L100b**. ExSync is an LVDS signal as specified for RS-644. Section 2.3.1 describes the function of the ExSync signal.

## 2.3.1 ExSync: Controls Line Readout and Exposure Time

The camera can be programmed to function under the control of an externally generated sync signal (ExSync) in one of three exposure time control modes. In these modes, edge-controlled, level-controlled and programmable, the ExSync signal is used to control exposure time and line read out. For more detailed information on the three modes, see Section 3.2.

ExSync can be a periodic or non-periodic function. The frequency of the ExSync signal determines the camera’s line rate. Note that ExSync is edge sensitive and therefore must toggle. Minimum high time for the ExSync signal is 62.5 ns.

The **L100b** uses a National Semiconductor DS90LV048A differential line receiver to receive the ExSync input signals. A detailed spec sheet for this device is available at the National Semiconductor web site (www.national.com).

Figure 2-3 shows a basic schematic for the input stage of the **L100b**.

**RS-644/RS-422 Compatibility**

The input voltage tolerance for the RS-644 receiver used in the **L100b** Series cameras is 0.0 V to 3.9 V. On typical RS-422 transmitters, the output voltage can range as high as 4.0 V. As you see, the output voltage of a typical RS-422 transmitter can exceed the input voltage tolerance of the RS-644 receiver in the **L100b** Series cameras. Therefore, RS-422 signals should not be input directly into the **L100b** Series cameras.

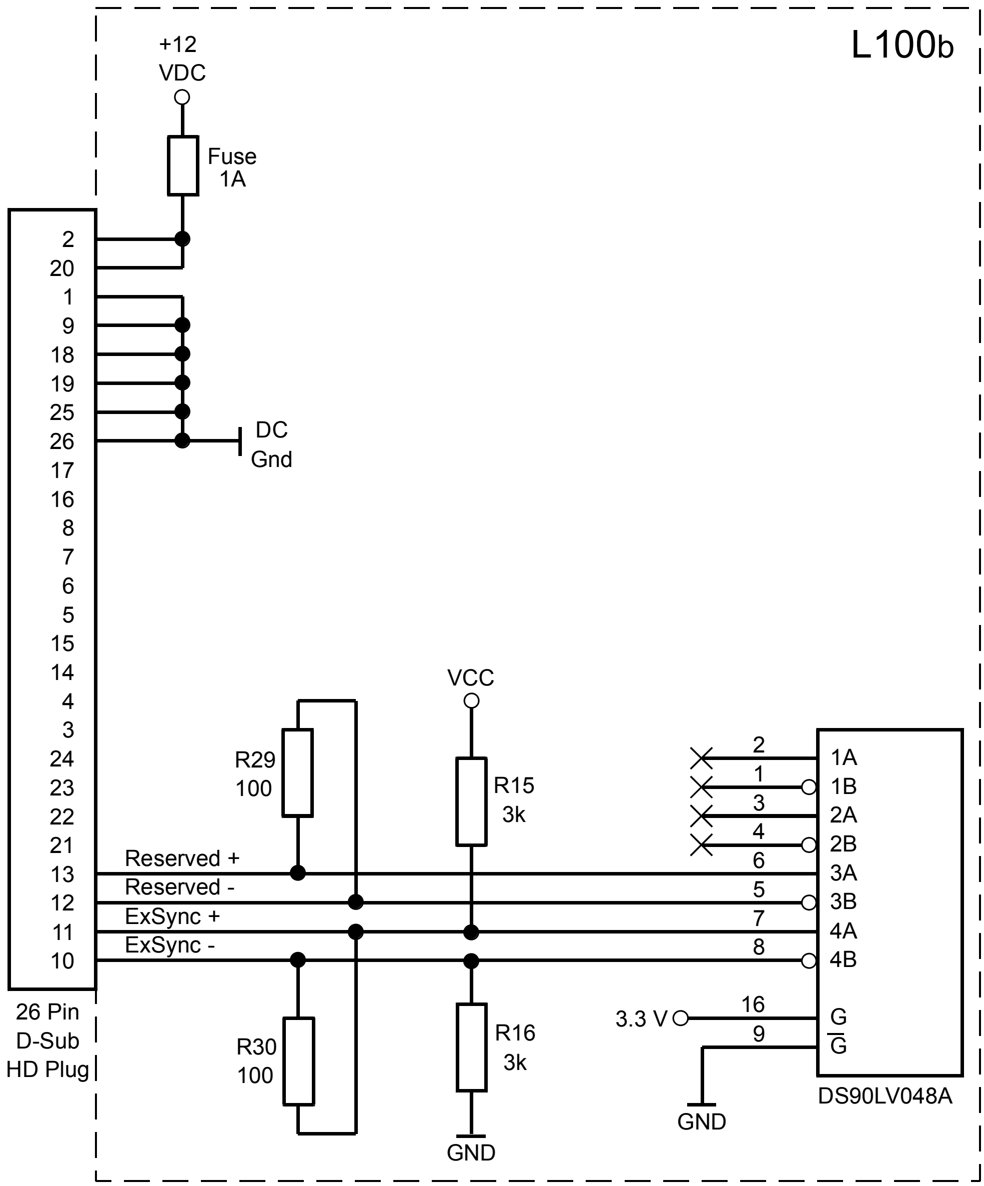



Figure 2-3: **L100b** DC Power and RS-644 Input Connections

# 2.4 Output Signals

Data is output from the **L100b** using Channel Link LVDS technology.

## 2.4.1 Channel Link Basics

Channel Link is an LVDS (Low Voltage Differential Signaling) technology for transmitting digital data. Channel Link uses a parallel-to-serial transmitter and a serial-to parallel receiver to transmit data at rates up to 1.8 Gbps.

As shown in Figure 2-4, the Channel Link Transmitter converts 28 bits of CMOS/TTL data into four LVDS data streams. A phase-locked pixel clock is transmitted in parallel with the data streams over a fifth LVDS link. With each cycle of the pixel clock, 28 bits of input data are sampled and transmitted. The Channel Link receiver converts the data streams back into 28 bits of CMOS/TTL data.

Channel Link was developed by National Semiconductor and is a registered trademark of that company.

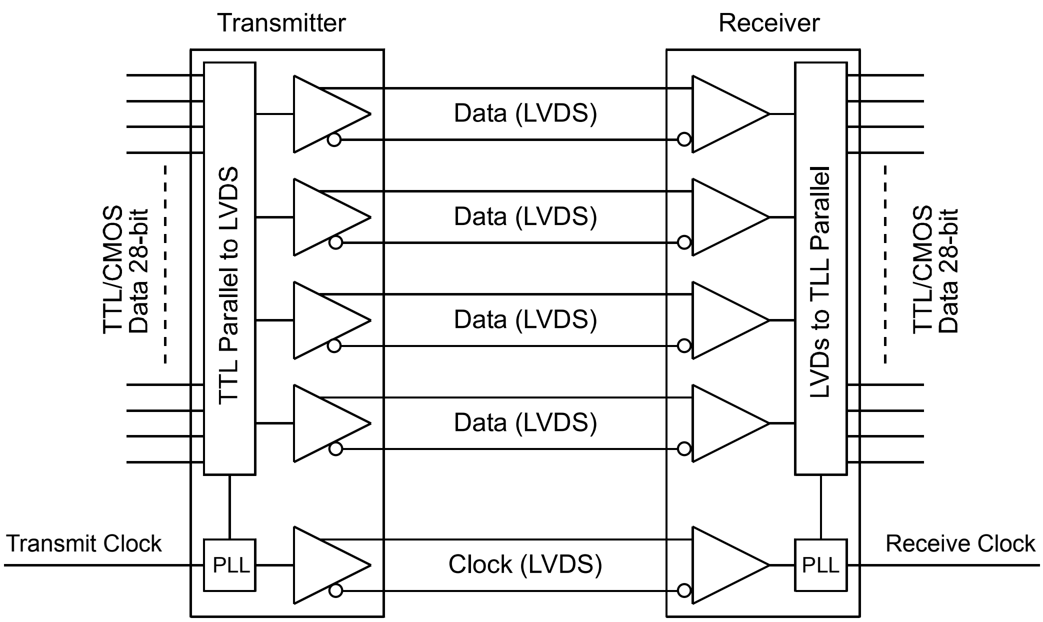



Figure 2-4: Channel Link Block Diagram

## 2.4.2 Channel Link Implementation in the L100b

The L100b uses a National Semiconductor DS90C383 as a Channel Link transmitter. For a Channel Link receiver, we recommend that you use the National Semiconductor DS90CF386, the National Semiconductor DS90CR288 or an equivalent. Detailed data sheets for these components are available at the National Semiconductor web site (www.national.com). The data sheets contain all of the information that you need to implement Channel Link, including application notes.

The schematic in Figure 2-5 shows the configuration of the output from the Channel Link transmitter on the L100b and a typical implementation for the Channel Link receiver on a frame grabber. During normal operation, 28 bits of TTL data are input to the transmitter on TX inputs 0 through 27 and the pixel clock is input on TxCLKIN. After transmission, the 28 bits appear as TTL signals on the corresponding RX outputs of the receiver.

> Note that the timing used for sampling the data at the Channel Link receiver in the frame grabber varies from device to device. On some receivers, TTL data must be sampled on the rising edge of the receive clock, and on others, it must be sampled on the falling edge. Also, some devices are available which allow you to select either rising edge or falling edge sampling. Please consult the data sheet for the receiver that you are using for specific timing information.

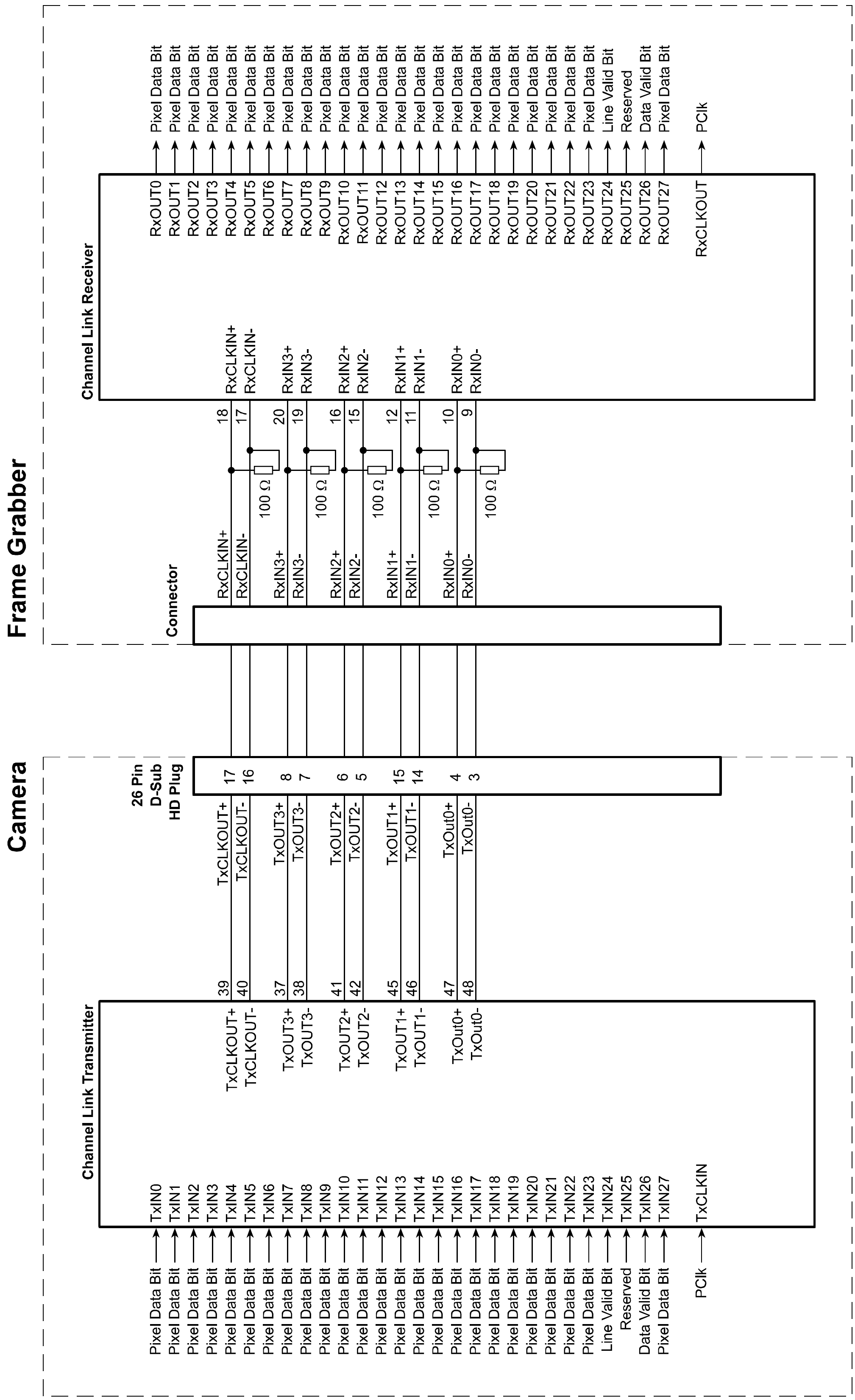



Figure 2-5: **L100b** Channel Link Outputs / Typical Frame Grabber Implementation

## 2.4.3 Pixel Clock

As shown in Figure 2-5 and in Table 2-3, the pixel clock is assigned to the TxClkIn (transmit clock) pin of the Channel Link transmitter. The pixel clock is used to time the sampling and transmission of pixel data as shown in Figures 2-6 through 2-11. The Channel Link transmitter used in **L100b** cameras requires pixel data to be sampled and transmitted on the falling edge of the clock.

The frequency of the pixel clock varies depending on the camera model and on the output mode of the camera. The available output modes are explained in detail in Sections 2.4.7.1 through 2.4.7.3.

> Note that the timing used for sampling the data at the Channel Link receiver in the frame grabber varies from device to device. On some receivers, data must be sampled on the rising edge of the pixel clock (receive clock), and on others, it must be sampled on the falling edge. Also, some devices are available which allow you to select either rising edge or falling edge sampling. Please consult the data sheet for the receiver that you are using for specific timing information.

## 2.4.4 Line Valid Bit

As shown in Figures 2-6 through 2-11, the line valid bit indicates that a valid line is being transmitted. Pixel data is only valid when this bit is high.

## 2.4.5 Data Valid Bit

When the **L101b** is operating in Dual 10 Bit or Dual 8 Bit output mode, valid pixel data is only transmitted on every other cycle of the pixel clock. The data valid bit is used to identify the cycles where valid pixel data is transmitted (see Section 2.4.7.2).

When the **L101b** is operating in Dual 10 Bit or Dual 8 Bit output mode, pixel data is only valid when the line valid bit and the data valid bit are both high.

## 2.4.6 Video Data

Table 2-3 lists the assignment of pixel data bits to the input pins on the Channel Link transmitter in the camera and the corresponding output pins on the Channel Link receiver in the frame grabber. As shown in the table, the bit assignments for pixel data varies depending on the output mode setting of the camera. The available output modes are explained in more detail in Sections 2.4.7.1 through 2.4.7.3.

Table 2-3 also shows the assignment for the line valid bit, the data valid bit and the pixel clock. These assignments are constant for all output modes.

| Camera | Frame Grabber | Single 10 Bit Output Mode | Single 8 Bit Output Mode | Dual 10 Bit Output Mode | Dual 8 Bit Output Mode |
|---|---|---|---|---|---|
| TxIN0 | RxOUT0 | Pixel Bit 0 | Pixel Bit 0 | Odd Pixel Bit 0 | Odd Pixel Bit 0 |
| TxIN1 | RxOUT1 | Pixel Bit 1 | Pixel Bit 1 | Odd Pixel Bit 1 | Odd Pixel Bit 1 |
| TxIN2 | RxOUT2 | Pixel Bit 2 | Pixel Bit 2 | Odd Pixel Bit 2 | Odd Pixel Bit 2 |
| TxIN3 | RxOUT3 | Pixel Bit 3 | Pixel Bit 3 | Odd Pixel Bit 3 | Odd Pixel Bit 3 |
| TxIN4 | RxOUT4 | Pixel Bit 4 | Pixel Bit 4 | Odd Pixel Bit 4 | Odd Pixel Bit 4 |
| TxIN5 | RxOUT5 | Pixel Bit 7 | Pixel Bit 7 (MSB) | Odd Pixel Bit 7 | Odd Pixel Bit 7 (MSB) |
| TxIN6 | RxOUT6 | Pixel Bit 5 | Pixel Bit 5 | Odd Pixel Bit 5 | Odd Pixel Bit 5 |
| TxIN7 | RxOUT7 | Pixel Bit 8 | Reserved | Odd Pixel Bit 8 | Even Pixel Bit 0 |
| TxIN8 | RxOUT8 | Pixel Bit 9 (MSB) | Reserved | Odd Pixel Bit 9 (MSB) | Even Pixel Bit 1 |
| TxIN9 | RxOUT9 | Reserved | Reserved | Reserved | Even Pixel Bit 2 |
| TxIN10 | RxOUT10 | Reserved | Reserved | Reserved | Even Pixel Bit 6 |
| TxIN11 | RxOUT11 | Reserved | Reserved | Reserved | Even Pixel Bit 7 (MSB) |
| TxIN12 | RxOUT12 | Reserved | Reserved | Reserved | Even Pixel Bit 3 |
| TxIN13 | RxOUT13 | Reserved | Reserved | Even Pixel Bit 8 | Even Pixel Bit 4 |
| TxIN14 | RxOUT14 | Reserved | Reserved | Even Pixel Bit 9 (MSB) | Even Pixel Bit 5 |
| TxIN15 | RxOUT15 | Reserved | Reserved | Even Pixel Bit 0 | Reserved |
| TxIN16 | RxOUT16 | Reserved | Reserved | Even Pixel Bit 6 | Reserved |
| TxIN17 | RxOUT17 | Reserved | Reserved | Even Pixel Bit 7 | Reserved |
| TxIN18 | RxOUT18 | Reserved | Reserved | Even Pixel Bit 1 | Reserved |
| TxIN19 | RxOUT19 | Reserved | Reserved | Even Pixel Bit 2 | Reserved |
| TxIN20 | RxOUT20 | Reserved | Reserved | Even Pixel Bit 3 | Reserved |
| TxIN21 | RxOUT21 | Reserved | Reserved | Even Pixel Bit 4 | Reserved |
| TxIN22 | RxOUT22 | Reserved | Reserved | Even Pixel Bit 5 | Reserved |
| TxIN23 | RxOUT23 | Reserved | Reserved | Reserved | Reserved |
| TxIN24 | RxOUT24 | Line Valid | Line Valid | Line Valid | Line Valid |
| TxIN25 | RxOUT25 | Reserved | Reserved | Reserved | Reserved |
| TxIN26 | RxOUT26 | Data Valid | Data Valid | Data Valid | Data Valid |
| TxIN27 | RxOUT27 | Pixel Bit 6 | Pixel Bit 6 | Odd Pixel Bit 6 | Odd Pixel Bit 6 |
| TxCLKIn | RxCLKOut | Pixel Clock | Pixel Clock | Pixel Clock | Pixel Clock |

Table 2-3: Bit Assignments

## 2.4.7 Video Data Output Modes

L100b series cameras can operate in Single 10 Bit, Single 8 Bit, Dual 10 Bit, or Dual 8 Bit output mode. These modes are described in detail in Sections 2.4.7.1 through 2.4.7.3.

### 2.4.7.1 Operation in Single 10 Bit or Single 8 Bit Output Mode (L101b, L103b and L104b)

In Single 10 Bit mode, the pixel clock operates at 20 / 40 / 62.5 MHz for the L101b / L103b / L104b respectively. On each clock cycle, the camera transmits 10 bits of pixel data and a line valid bit. The assignment of the bits is shown in Table 2-3.

The pixel clock is used to time data sampling and transmission. As shown in Figures 2-6 and 2-7, the camera samples and transmits data on each falling edge of the pixel clock.

The line valid bit indicates that a valid line is being transmitted. Pixel data is only valid when the line valid bit is high. The data valid bit is not used in this mode and should be ignored.

Operation in Single 8 Bit mode is similar to Single 10 Bit mode except that the two least significant bits output from each ADC are dropped and only 8 bits of data per pixel is transmitted.

| | |
|---|---|
| | The data sequence outlined below, along with Figures 2-6 and 2-7, describe what is happening at the inputs to the Channel Link transmitter in the camera.<br><br>Note that the timing used for sampling the data at the Channel Link receiver in the frame grabber varies from device to device. On some receivers, data must be sampled on the rising edge of the pixel clock (receive clock), and on others, it must be sampled on the falling edge. Also, some devices are available which allow you to select either rising edge or falling edge sampling. Please consult the data sheet for the receiver that you are using for specific timing information. |

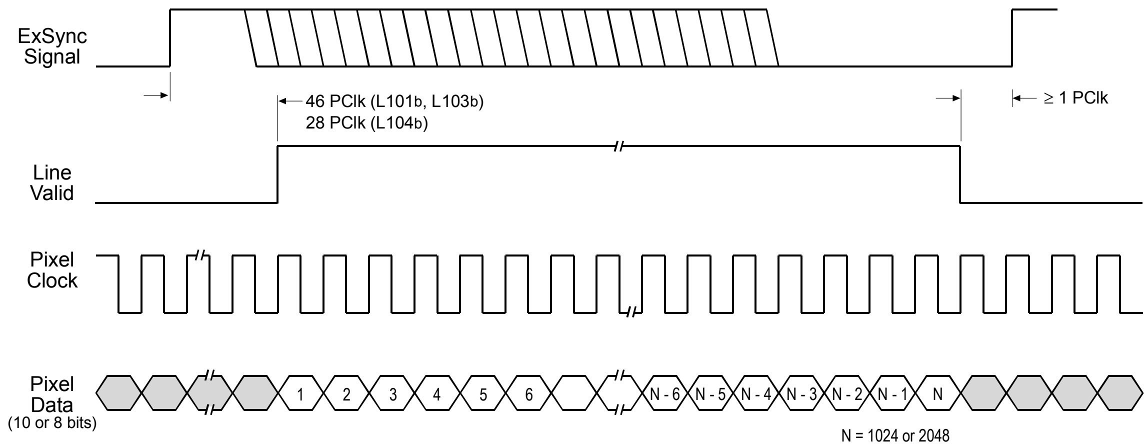
### Video Data Sequence[1]

When the camera is not transmitting valid data, the line valid bit sent on each cycle of the pixel clock will be low. Once the camera has completed line acquisition, it will begin to send valid data:

- On the pixel clock cycle where line data transmission begins, the line valid bit will become high. Ten of the bits transmitted during this clock cycle will contain the data for pixel number one.
- On the second cycle of the pixel clock, the line valid bit will be high. Ten of the bits transmitted during this clock cycle will contain the data for pixel number two.
- On the third cycle of the pixel clock, the line valid bit will be high. Ten of the bits transmitted during this clock cycle will contain the data for pixel number three.
- This pattern will continue until all of the pixel data for the line has been transmitted. (A total of 1024 cycles for cameras with a 1K sensor and 2048 cycles for cameras with a 2K sensor.)
- After all of the pixels have been transmitted, the line valid bit will become low indicating that valid line data is no longer being transmitted.

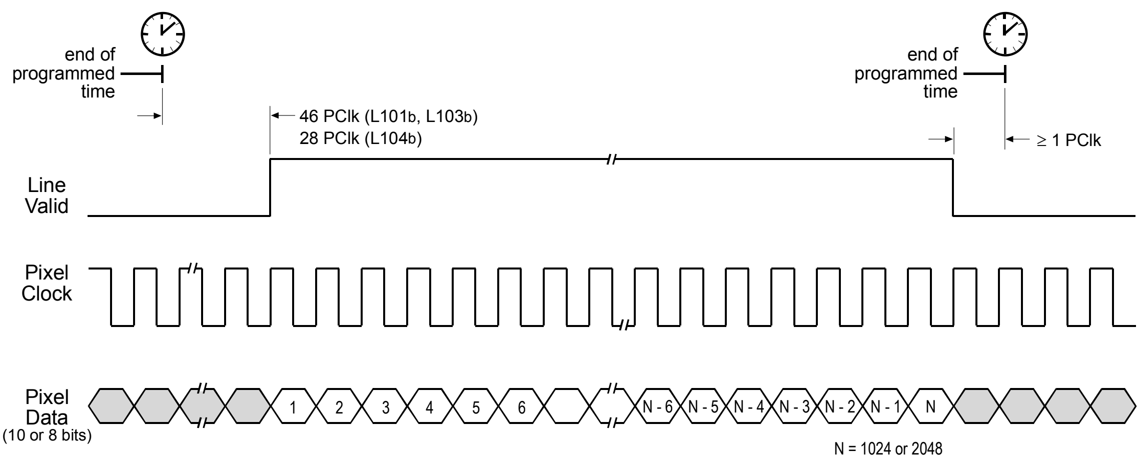
Figure 2-6 shows the data sequence when the camera is operating in edge-controlled or level-controlled exposure mode. Figure 2-7 shows the data sequence when the camera is operating in programmable exposure mode.

[1] The data sequence assumes that the camera is operating in 10 bit mode. If the camera is operating in 8 bit mode, only 8 bits of data per pixel will be transmitted.




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure 2-6: Single 10 Bit or Single 8 Bit Output Mode with Edge or Level Controlled Exposure




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure 2-7: Single 10 Bit or Single 8 Bit Output Mode with Programmable Exposure

### 2.4.7.2 Operation in Dual 10 Bit or Dual 8 Bit Output Mode (L101b only)

In Dual 10 Bit mode, the pixel clock operates at 20 MHz for the **L101b**. On every pixel clock cycle, the camera transmits a line valid bit and a data valid bit. On every other cycle of the pixel clock, the camera transmits 10 bits of data for two pixels. The assignment of the bits is shown in Table 2-3.

The pixel clock is used to time data sampling and transmission. As shown in Figures 2-8 and 2-9, the camera samples and transmits data on each falling edge of the pixel clock.

The line valid bit indicates that a valid line is being transmitted. The data valid bit indicates that valid pixel data is being transmitted. Pixel data is only valid when the line valid and data valid bits are both high.

Operation in Dual 8 Bit mode is similar to Dual 10 Bit mode except that the two least significant bits output from each ADC are dropped and only 8 bits of data per pixel is transmitted.

> The data sequence outlined below, along with Figures 2-8 and 2-9, describe what is happening at the inputs to the Channel Link transmitter in the camera.
>
> Note that the timing used for sampling the data at the Channel Link receiver in the frame grabber varies from device to device. On some receivers, data must be sampled on the rising edge of the pixel clock (receive clock), and on others, it must be sampled on the falling edge. Also, some devices are available which allow you to select either rising edge or falling edge sampling. Please consult the data sheet for the receiver that you are using for specific timing information.

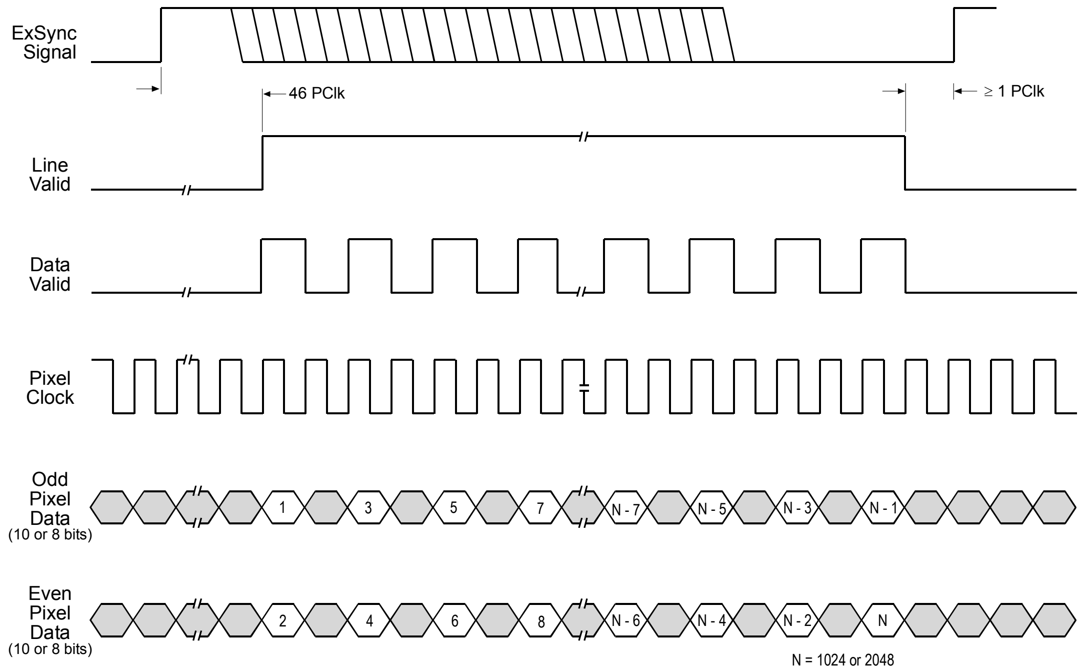
## Video Data Sequence[1]

When the camera is not transmitting valid data, the line valid bit and the data valid bit sent on each cycle of the pixel clock will be low. Once the camera has completed line acquisition, it will begin to send valid data:

- On the pixel clock cycle where line data transmission begins, the line valid bit and the data valid bit will become high. Ten of the bits transmitted during this clock cycle will contain the data for pixel number one and ten of the bits will contain data for pixel number two.
- On the second cycle of the pixel clock, the data valid bit will be low. Valid data is not transmitted during this cycle.
- On the third cycle of the pixel clock, the line valid bit and the data valid bit will be high. Ten of the bits transmitted during this clock cycle will contain the data for pixel number three and ten of the bits will contain data for pixel number four.
- On the fourth cycle of the pixel clock, the data valid bit will be low. Valid data is not transmitted during this cycle.
- This pattern will continue until all of the pixel data for the line has been transmitted. (A total of 1024 cycles for cameras with a 1K sensor and 2048 cycles for cameras with a 2K sensor.)
- After all of the pixels have been transmitted, the line valid bit will become low indicating that valid line data is no longer being transmitted.

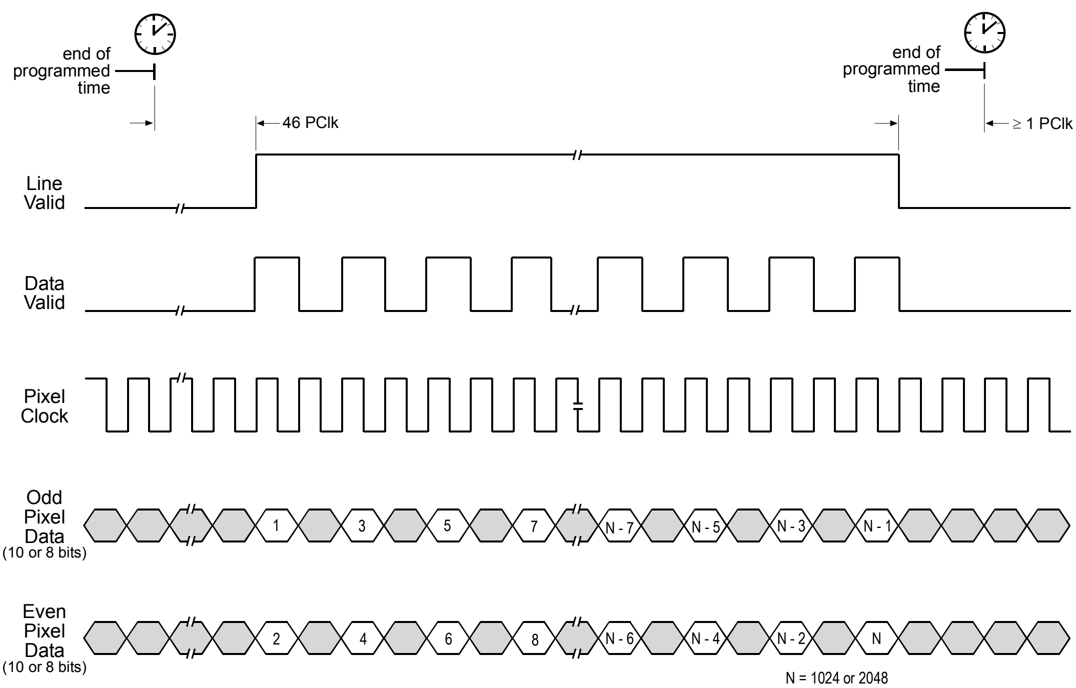
Figure 2-8 shows the data sequence when the camera is operating in edge-controlled or level-controlled exposure mode and Figure 2-9 shows the data sequence when the camera is operating in programmable exposure mode.

[1] The data sequence assumes that the camera is operating in 10 bit mode. If the camera is operating in 8 bit mode, only 8 bits of data per pixel will be transmitted.




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure 2-8: **L101b** Dual 10 or 8 Bit Output Mode with Edge or Level-controlled Exposure




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure 2-9: **L101b** Dual 10 or 8 Bit Output Mode with Programmable Exposure

### 2.4.7.3 Operation in Dual 10 Bit or Dual 8 Bit Output Mode (L103b and L104b only)

In Dual 10 Bit mode, the pixel clock operates at 20 MHz for the L103b and 31.25 MHz for the L104b. On each clock cycle, the camera transmits a line valid bit and ten bits of data for two pixels. The assignment of the bits is shown in Table 2-3.

The pixel clock is used to time data sampling and transmission. As shown in Figures 2-10 and 2-11, the camera samples and transmits data on each falling edge of the pixel clock.

The line valid bit indicates that a valid line is being transmitted. Pixel data is only valid when the line valid bit is high. The data valid bit is not used in this mode and should be ignored.

Operation in Dual 8 Bit mode is similar to Dual 10 Bit mode except that the two least significant bits output from each ADC are dropped and only 8 bits of data per pixel is transmitted.

> The data sequence outlined below, along with Figures 2-10 and 2-11, describe what is happening at the inputs to the Channel Link transmitter in the camera.
>
> Note that the timing used for sampling the data at the Channel Link receiver in the frame grabber varies from device to device. On some receivers, data must be sampled on the rising edge of the pixel clock (receive clock), and on others, it must be sampled on the falling edge. Also, some devices are available which allow you to select either rising edge or falling edge sampling. Please consult the data sheet for the receiver that you are using for specific timing information.

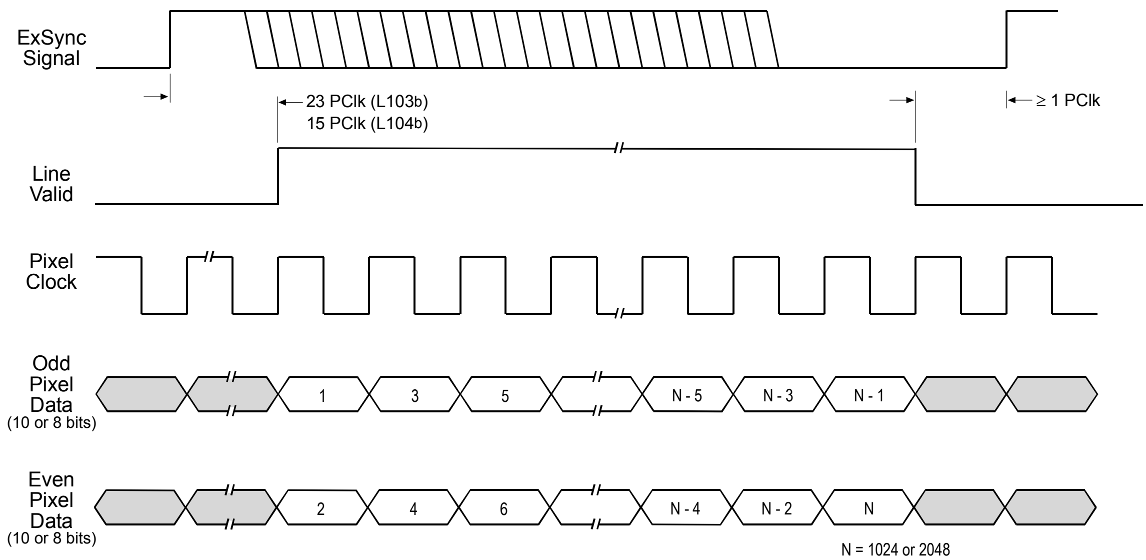
## Video Data Sequence[1]

When the camera is not transmitting valid data, the line valid bit sent on each cycle of the pixel clock will be low. Once the camera has completed line acquisition, it will begin to send valid data:

- On the pixel clock cycle where line data transmission begins, the line valid bit will become high. Ten of the bits transmitted during this clock cycle will contain the data for pixel number one and ten of the bits will contain data for pixel number two.
- On the second cycle of the pixel clock, the line valid bit will be high. Ten of the bits transmitted during this clock cycle will contain the data for pixel number three and ten of the bits will contain data for pixel number four.
- This pattern will continue until all of the pixel data for the line has been transmitted. (A total of 512 cycles for cameras with a 1K sensor and 1024 cycles for cameras with a 2K sensor.)
- After all of the pixels have been transmitted, the line valid bit will become low indicating that valid line data is no longer being transmitted.

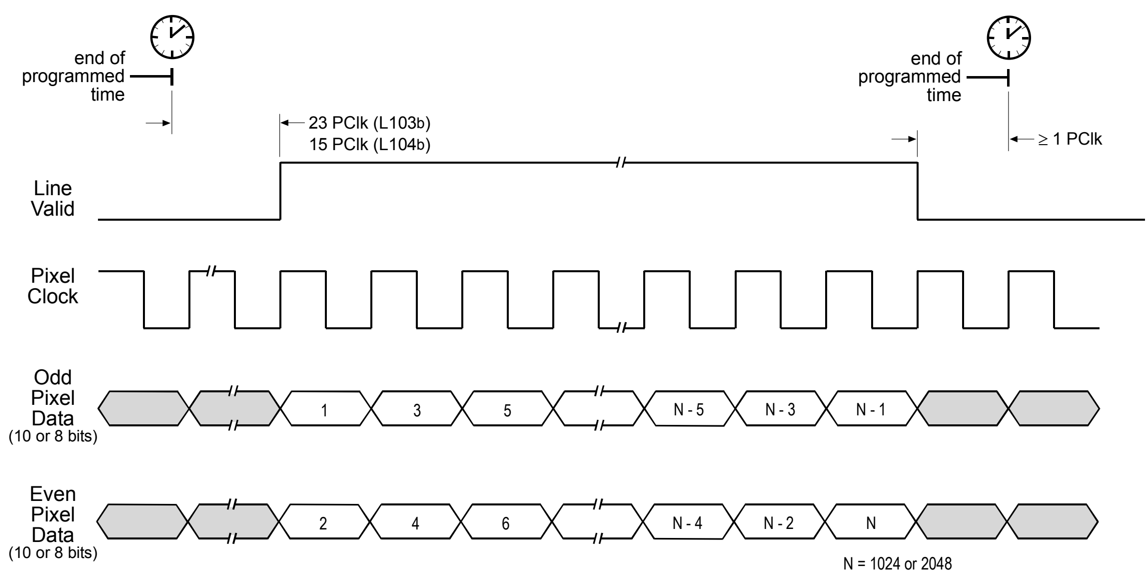
Figure 2-10 shows the data sequence when the camera is operating in edge-controlled or level-controlled exposure mode and Figure 2-11 shows the data sequence when the camera is operating in programmable exposure mode.

[1] The data sequence assumes that the camera is operating in 10 bit mode. If the camera is operating in 8 bit mode, only 8 bits of data per pixel will be transmitted.




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure 2-10: **L103b** or **L104b** Dual 10 or 8 Bit Output Mode with Edge or Level-controlled Exposure




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure 2-11: **L103b** or **L104b** Dual 10 or 8 Bit Output Mode with Programmable Exposure

# 2.5 RS-232 Serial Communication

The **L100b** is equipped for RS-232 serial communication. The RS-232 serial connection is used to issue commands to the camera for changing modes and parameters. The serial link can also be used to query the camera about its current setup.

The Basler Camera Configuration Tool is a convenient, graphical interface that can be used to change camera modes and parameters via the serial connection. The configuration tool is installed as part of the camera installation. A booklet describing how to install the configuration tool is shipped with the camera. Section 4.1 provides some basic information about the configuration tool. Detailed instructions for using the tool are included in the on-line help file that is installed with the tool.

Basler has also developed a binary command protocol that can be used to change camera modes and parameters directly from your application via the serial connection. See Section 4.2 for details on the binary command format.

## 2.5.1 Making the Serial Connection

You will use a serial port on your PC for RS-232 communication with the camera. Make sure that the following requirements are met:

- Make sure that pin 3 on the PC serial port is wired to pin 22 on the camera.
- Make sure that pin 2 on the PC serial port is wired to pin 24 on the camera.
- Make sure that pin 5 on the serial port is wired to pin 21 or 23 on the camera.
- Make sure that the port is set for 8N1 (8 data bits + no parity + 1 stop bit) and a baud rate of 9600 bps.

# 2.6 DC Power

The **L100b** requires 12 VDC (± 10%) power. The maximum power consumption is approximately 6 W / 8 W / 10 W for the **L101b** / **L103b** / **L104b** respectively. The camera has no overvoltage protection. An input voltage higher than 14 VDC will damage the camera.

Ripple must be less than 1%.

| | |
|---|---|
| ! | The camera has no reverse power protection. Therefore, always observe the polarity as indicated in Table 2-1 on page 2.<br><br>The camera has no overvoltage protection. Therefore, always observe the power requirements as described. |

# 2.7 Status LEDs

### Green LED

When the green LED on the back of the camera is not lit, it means that no voltage or a voltage below 10.4 V is present. When the green LED is lit, it means that a voltage of 10.4 V or higher is present.

The camera has no overvoltage protection. Therefore, always observe the power requirements as described in Section 2.6.

### Yellow LED

The yellow LED on the back of the camera indicates signal integrity. At power up, the LED will light for several seconds as the microprocessor in the camera boots up. If all is OK, the LED will then remain lit continuously.

If an error condition is detected at any time after the microprocessor boots up, the LED will begin to blink an error code. See Section 6 for details.

# 2.8 Converting Channel Link Video Output to RS-644 with a BIC

As mentioned in Section 2.4, video data is output from the **L100b** in Channel Link LVDS format. The video output from the camera can be converted to RS-644 LVDS by using a Basler Interface Converter (BIC). The BIC is a small device which attaches to the **L100b**. For complete information on installing and using the BIC, refer to Appendix A.

# 3 Basic Operation and Features

## 3.1 Functional Description

**BASLER L100b** line scan cameras employ a CCD-sensor chip which provides features such as electronic exposure time control and anti-blooming. Exposure time is normally controlled via an external trigger (ExSync) signal. The ExSync signal facilitates periodic or non-periodic pixel readout.

When exposure is controlled by an ExSync signal, exposure time can be either edge-controlled, level-controlled, or programmable. In edge-controlled mode, charge is accumulated over the entire period of the ExSync signal and a rising edge of ExSync triggers the readout of accumulated charges from the sensor elements to the CCD shift registers. In level-controlled mode, charge is accumulated when the ExSync signal is low and a rising edge of ExSync triggers the readout. In programmable mode, exposure time can be programmed to a predetermined time period. In this case, exposure begins on the rising edge of ExSync and accumulated charges are read out when the programmed exposure time ends.

A free-run mode that allows the camera to operate without an ExSync signal is also available. In free-run mode, the camera generates its own internal control signal and the internal signal is used to control exposure and charge read out. When operating in free-run, the camera outputs lines continuously.

At readout, accumulated charges are transported from the light-sensitive sensor elements (pixels) to the CCD shift registers. The charges from the odd pixels and the charges from the even pixels are handled by separate shift registers as shown in Figure 3-1. As charges move out of the shift registers, they are converted to voltages proportional to the size of each charge. Shifting is clocked according to the camera's internal data rate.

The voltages moving out of each shift register are amplified by a Variable Gain Control (VGC) and then digitized by a ten bit, Analog to Digital converter (ADC). The digitized video data is transmitted from the camera to the frame grabber using a Channel Link transmission format (see Section 2.4 for details). The camera can transmit video at a ten bit or an eight bit depth and as a single pixel or a dual pixel stream.

For optimal digitization, gain and offset are programmable via a serial port.

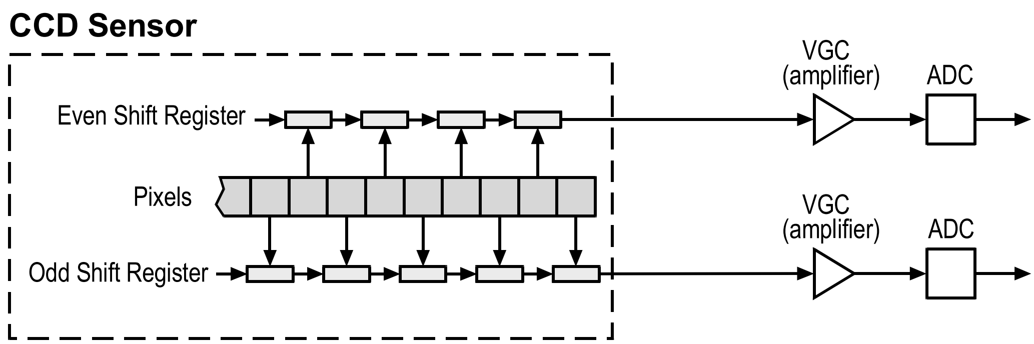



Figure 3-1: **L100b** Sensor Architecture

# 3.2 Exposure Time Control Modes

**L100b** series cameras can operate under the control of an external trigger signal (ExSync) or can operate in “free-run.” In free-run, the camera generates its own internal control signal and does not require an ExSync signal.

## 3.2.1 ExSync Controlled Operation

In ExSync operation, the camera’s line rate and exposure time are controlled by an externally generated (ExSync) signal. The ExSync signal is typically supplied to the camera by a frame grabber board. You should refer to the manual supplied with your frame grabber board to determine how to set up the ExSync signal that is being supplied to the camera.

When the camera is operating under the control of an ExSync signal, the length of the ExSync signal period determines the camera’s line rate. ExSync can be periodic or non-periodic.

When the camera is operating with an ExSync signal, it has three modes of exposure time control available: edge-controlled mode, level-controlled mode, and programmable mode.

- In **ExSync**, **edge-controlled** mode, the pixels are exposed and charge is accumulated over the full period of the ExSync signal (rising edge to rising edge). The falling edge of the ExSync signal is irrelevant. The line is read out and transferred on the rising edge of ExSync. (see Figure 3-2).

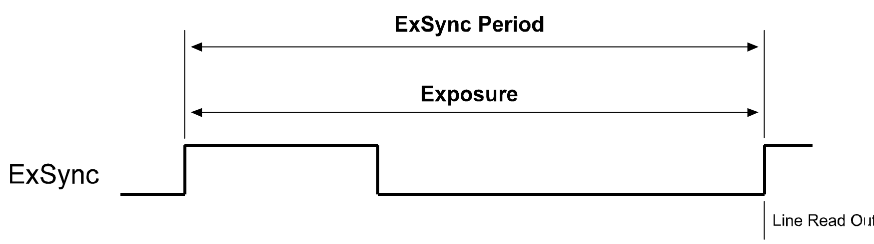



Figure 3-2: ExSync, Edge-Controlled Mode

- In **ExSync**, **level-controlled** mode, the exposure time is determined by the time between the falling edge of ExSync and the next rising edge. The pixels are exposed and charge is accumulated only when ExSync is low. The line is read out and transferred on the rising edge of the ExSync signal (see Figure 3-3).

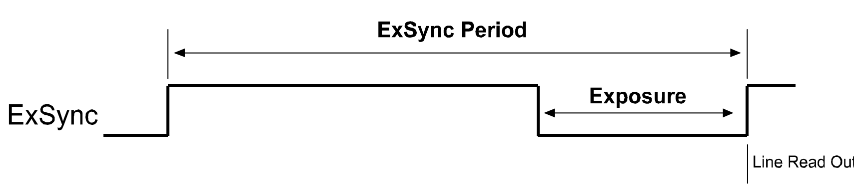



Figure 3-3: ExSync, Level-controlled Mode

- In **ExSync**, **programmable** mode, the rising edge of ExSync triggers exposure and charge accumulation for a pre-programmed period of time. The line is read out and transferred at the end of the pre-programmed period. The falling edge of ExSync is irrelevant (see Figure 3-4).

  A parameter called “Timer 1” is used to set the length of the pre-programmed exposure period.

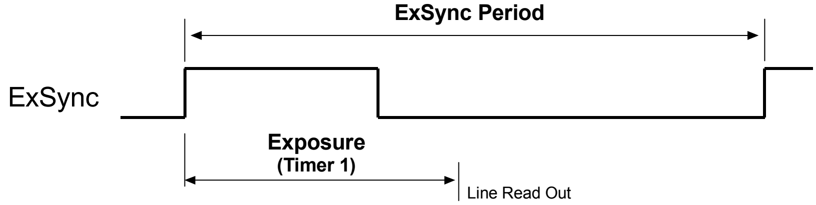



Figure 3-4: ExSync, Programmable Mode

You can set the camera to operate in one of the ExSync controlled exposure modes using either the Camera Configuration Tool (see Section 4.1) or binary commands (see Section 4.2).

With the Camera Configuration Tool, you use the Exposure Tab to set the camera for ExSync operation and to select the edge-controlled, level controlled or programmable exposure time control mode. If you select the programmable mode, you must also enter an exposure time. When you enter an exposure time, the configuration tool will automatically set the “Timer 1” parameter to the correct value.

With binary commands, you must use the Exposure Time Control Mode command to select ExSync edge-controlled, ExSync level-controlled or ExSync programmable mode. If you choose the programmable mode, you must also use the Timer 1 command to set the exposure time.

ExSync must toggle.

The minimum ExSync period for each camera version is shown in the table below:

| | **L101b** | **L103b** | **L104b** |
|---|---|---|---|
| 1024 Pixel CCD | 53.8 µs | 26.8 µs | 17.1 µs |
| 2048 Pixel CCD | 105.3 µs | 52.4 µs | 34.3 µs |

The ExSync signal must remain high for at least 62.5 ns.

There must be at least one clock cycle between the end of line transfer and readout of the next line (see Figures 2-6 and 2-7).

The minimum exposure time is 1 µs.

## 3.2.2 Free Run

In **free-run**, no ExSync signal is required. The camera generates a continuous internal control signal based on two programmable parameters: “Timer 1” and “Timer 2.” Timer 1 determines how long the internal signal will remain low and Timer 2 determines how long the signal will remain high.

When the camera is operating in free-run, the length of the control signal period determines the camera’s line rate. (The control signal period is equal to Timer 1 plus Timer 2.)

When the camera is operating in free-run, it exposes and outputs lines continuously.

In free-run, two modes of operation are available: edge-controlled and programmable.

- In **free-run**, **edge-controlled mode**, the pixels are exposed and charge is accumulated over the full period of the internal control signal (rising edge to rising edge). The falling edge of the control signal is irrelevant. The line is read out and transferred on the rising edge of the internal control signal (see Figure 3-5).

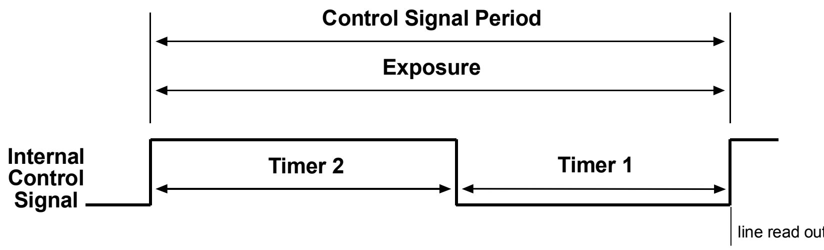



Figure 3-5: Free-run, Edge-controlled Mode

- In **free-run**, **programmable mode**, the pixels are exposed and charge is accumulated when the internal control signal is low. The line is read out and transferred on the rising edge of internal control signal (see Figure 3-6).

  In this mode, the exposure time can programmed as desired by varying the setting of the “Timer 1” parameter.

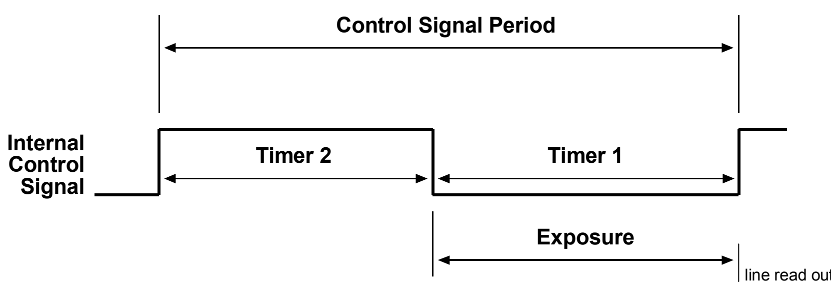



Figure 3-6: Free-run, Programmable Mode

You can set the camera to operate in free-run using either the Camera Configuration Tool (see Section 4.1) or binary commands (see Section 4.2).

With the Camera Configuration Tool, you use the Exposure Tab to set the camera for free-run and to select the edge-controlled or programmable exposure time control mode. If you choose to operate the camera in free-run, the configuration tool will require you to enter a line rate; if you are using the programmable mode, you must also enter an exposure time. The configuration tool will automatically set the Timer 1 and Timer 2 parameters based on the values that you enter on the Exposure Tab.

With binary commands you must use the Exposure Time Control Mode command to select the free-run, edge-controlled or free-run, programmable mode. You must also use the Timer 1 command to set Timer 1 and the Timer 2 command to set Timer 2.

In the free-run mode, the period of the internal control signal is equal to the sum of Timer 1 plus Timer 2. The sum of the Timer 1 setting plus the Timer 2 setting must be greater than the minimums shown in the table below.

| | L101b | L103b | L104b |
|---|---|---|---|
| 1024 Pixel CCD | 53.8 µs | 26.8 µs | 17.1 µs |
| 2048 Pixel CCD | 105.3 µs | 52.4 µs | 34.3 µs |

The minimum exposure time is 1 µs.

## 3.3 Video Data Output Modes

L100b series cameras can output video data using four different modes: Single 10 Bit mode, Single 8 Bit mode, Dual 10 Bit mode and Dual 8 Bit mode. These modes of operation are described in detail in Sections 2.4.7.1 through 2.4.7.3.

You can select the video data output mode using either the Camera Configuration Tool (see Section 4.1) or binary commands (see Section 4.2). With the Camera Configuration Tool, you use the Output Version Tab to select the data output mode and with binary commands you use the Video Data Output Mode command.

# 3.4 Gain and Offset

The pixels in the CCD sensor output voltage signals when they are exposed to light. These voltages are amplified by VGCs and transferred to ADCs where they are converted to digital output signals (see Figure 3-1).

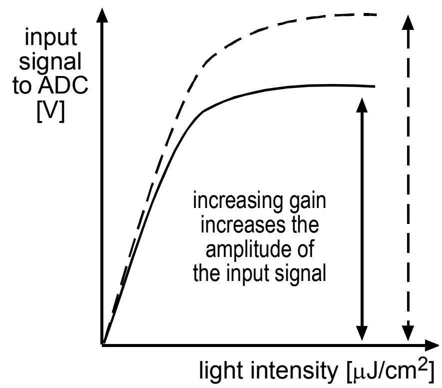



Figure 3-7: Gain

Two parameters, gain and offset are associated with each ADC. As shown in Figures 3-7 and 3-8, increasing or decreasing the gain increases or decreases the amplitude of the signal that is input to the ADC. Increasing or decreasing the offset moves the signal up or down the measurement scale but does not change the signal amplitude.

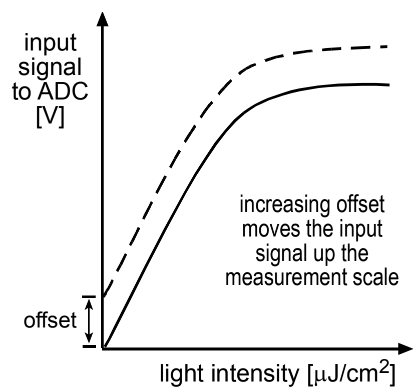



Figure 3-8: Offset

For most applications, black should have a gray value of 1 and white should have a gray value of 254 (in 8 bit output mode) or 1022 (in 10 bit output mode). Attempt to achieve this by varying exposure and illumination rather than changing the camera's gain. The default gain is the optimal operating point (low noise, good odd/even channel match) and should be used if possible.

Internally, the camera processes odd and even pixels separately in two different data channels (see Figure 3-1). Consequently, gain must be adjusted separately for the odd pixels and for the even pixels. Due to variations in the camera's electronics, a gain setting on the odd channel may produce a different output than the same gain setting on the even channel. Gain balance between the odd and even channels is important to maintain uniform output data with minimal gray value differences between odd and even pixels. See Section 3.4.1 for more detailed information on balancing the gain.

| | |
|---|---|
| ☝ | Because increasing gain increases both signal and noise, the signal to noise ratio does not change significantly when gain is increased. |

The offset is also set separately for the odd and the even channel, but the offset on the channels does not need to be balanced. An odd and even offset of, for example, 0 both produce the same output.

You can set the gain and offset using either the Camera Configuration Tool (see Section 4.1) or binary commands (see Section 4.2).

With the Camera Configuration Tool, you use the slide controls on the Gain and Offset Tab to easily adjust gain and offset.

With binary commands, you must use the Odd Pixel Gain and Even Pixel Gain commands to set the gain and the Odd Pixel Offset and Even Pixel Offset commands to set the offset.

## 3.4.1 Balancing the Gain on Odd and Even Pixels

As described on the previous page, gain alignment between the channels is important to maintain uniform output data with minimal gray value differences between odd and even pixels.

In some applications, multiple cameras are used, for example, when several line scan cameras are used next to each other to form one large image. Another example is that a camera in an existing application is replaced. In these cases, it is also necessary to balance the gain between cameras.

To meet the goals of balanced channels and comparable camera output, each Basler camera is calibrated before it leaves the factory. This calibration procedure has the following effects:

- The factory gain settings for the odd and even channels are aligned so that they equally amplify the signal and a uniform output is achieved on both channels. In addition, they are set to a low gain value to obtain an optimal operating point (low noise, good odd/even channel match)
- There are reference gain values which can be used to calculate higher or lower odd and even gain settings so that the channels remain balanced.
- All cameras have default gain settings and reference gain values which match the output of a factory master camera of the same type. This output is referred to as 0 dB. So if a camera’s gain is set to 2 dB, this means 2 dB more than the gain of the master camera.

The reference gain values can be used to calculate higher or lower gain settings that will keep the odd and even channels in balance and comparable to other cameras of the same type.

If you use the Camera Configuration Tool (see Section 4.1) to set the gain on your camera, the “auto-balance” feature on the Gain and Offset Tab will automatically use the stored reference values to keep the channels in balance.

If you use binary commands (see Section 4.2) to set the gain, you can use the reference values to calculate gain settings that will keep the channels in balance. To do this, you must select a desired gain in dB to achieve and then use the reference values along with the formula shown on the next page to calculate the required settings for the odd pixel gain and for the even pixel gain. You can then enter the calculated settings into the camera using the appropriate commands.

### 3.4.1.1 Calculating Gain Settings on the L101b and L103b with Binary Commands

Gain is adjustable and can be programmed on a decimal scale. The gain register ranges from 0 to 1023 (0x0000 to 0x03FF).

- Do not use gain settings below 90. Only the gain range from 90 to 1023 has tested and guaranteed accuracy.
- The default gain settings and the reference gain results in an amplification referred to as 0 dB.
- The gain can be adjusted in steps of 0.0354 dB.

**Sample Calculation**

Assume that you are working with an **L103b**, that you want to keep the odd pixels and the even pixels balanced, and that you want to set the gain to 2 dB.

1. To read the values that were stored during the camera's calibration procedure, use the "Read reference gain values" command (see section 4.2.7.7). For our example, we will assume that the camera returned the following reference values:

| | |
|---|---|
| *Byte 1 Low byte odd pixel reference gain after decimal point* | *0x0000* |
| *Byte 2 High byte odd pixel reference gain after decimal point* | *0x0000* |
| *Byte 3 Low byte odd pixel reference gain before decimal point* | *0x006d* |
| *Byte 4 High byte odd pixel reference gain before decimal point* | *0x0000* |
| *Byte 5 Low byte even pixel reference gain after decimal point* | *0x3333* |
| *Byte 6 High byte even pixel reference gain after decimal point* | *0x0066* |
| *Byte 7 Low byte even pixel reference gain before decimal point* | *0x006f* |
| *Byte 8 High byte even pixel reference gain before decimal point* | *0x0000* |

2. The reference values are hexadecimal. Convert them to decimal:

| | | | |
|---|---|---|---|
| *Byte 1 = 0* | *Byte 2 = 0* | *Byte 3 = 109* | *Byte 4 = 0,* |
| *Byte 5 = 13107* | *Byte 6 = 102* | *Byte 7 = 111* | *Byte 8 = 0* |

3. Use the decimal values of Byte 4 to Byte 1 to determine the odd pixel reference gain RGo:

$$RGo = (Byte\ 4 \times 256) + Byte\ 3 + \frac{Byte\ 2}{256} + \frac{Byte\ 1}{65536}$$

$$RGo = (0 \times 256) + 109 + 0 + 0$$

$$RGo = 109.00$$

4. Enter the decimal odd pixel reference gain RGo and the desired gain G into the following formula:

$$Xo = 20 \log_{10}\left[\frac{658 + RGo}{658 - RGo}\right] + G$$

G = Desired Gain in dB. Max. G = 0.0354 * (1024 - RGo)

For our example, enter RGo = 109 and G = 2:

$$Xo = 20 \log_{10}\left[\frac{658 + 109}{658 - 109}\right] + 2\ dB = 4.9$$

5. Calculate the values RGe and Xe for the even channel using the same method as in steps 1, 2, 3, and 4. Use the decimal values of Byte 8 to Byte 5 to determine the even pixel reference gain RGe. RGe is 111.60 in this example, the value for Xe is 4.93.

6. Convert the results to decimal using the appropriate formula a) or b):

| | |
|---|---|
| a) Odd pixel gain setting $= \dfrac{\left(658 \times 10^{\frac{Xo}{20}}\right) - 658}{1 + 10^{\frac{Xo}{20}}}$ | Where $G < 0.0354 * (512 - RGo)$ |
| b) Odd pixel gain setting $= \dfrac{Xo}{0.0354}$ | Where $G \geq 0.0354 * (512 - RGo)$ |

Since Xo is 4.9 and thus definitely less than 14.27, we need formula a):

a) Odd pixel gain setting $= \dfrac{\left(658 \times 10^{\frac{4.9}{20}}\right) - 658}{1 + 10^{\frac{4.9}{20}}}$

Odd pixel gain setting = 180.8. Round to 181.

7. Calculate the even gain setting in the same way. It is 184 in this example.

8. Convert the results to hexadecimal:

   Odd pixel gain setting of 181 decimal = 0x00b5

   Even pixel gain setting of 184 decimal = 0x00b8

9. Use the odd pixel gain and even pixel gain binary commands to set the odd and even gain to the calculated values.

After you use the commands to enter the calculated values, the camera will be operating at 2 dB with respect to the master camera. The odd and even pixels will be balanced.

> You may get a better odd/even match by increasing or decreasing either the odd or the even gain by one.

> Since the black level is very stable, you do not need to adjust the offset when you change the gain.

### 3.4.1.2 Calculating Gain Settings on the L104b with Binary Commands

Gain is adjustable and can be programmed on a decimal scale that ranges from 0 to 319 (0x0000 to 013F). The full scale can be used.

- The default gain settings and the reference gain results in an amplification referred to as 0 dB.
- The gain can be adjusted in steps of 0.09 dB. The change in dB settings is linear.

**Sample Calculation**

Assume that you are working with an **L104b**, that you want to keep the odd pixels and the even pixels balanced, and that you want to set the gain to 2 dB.

1. To read the values that were stored during the camera's calibration procedure, use the "Read reference gain values" command. For our example, we will assume that the camera returned the following reference values:

| | |
|---|---|
| *Byte 1 Low byte odd pixel reference gain after decimal point* | *0x0000* |
| *Byte 2 High byte odd pixel reference gain after decimal point* | *0x0000* |
| *Byte 3 Low byte odd pixel reference gain before decimal point* | *0x0014* |
| *Byte 4 High byte odd pixel reference gain before decimal point* | *0x0000* |
| *Byte 5 Low byte even pixel reference gain after decimal point* | *0x3213* |
| *Byte 6 High byte even pixel reference gain after decimal point* | *0x0064* |
| *Byte 7 Low byte even pixel reference gain before decimal point* | *0x0015* |
| *Byte 8 High byte even pixel reference gain before decimal point* | *0x0000* |

2. The reference values are hexadecimal. Convert them to decimal:

| | | | |
|---|---|---|---|
| *Byte 1 = 0* | *Byte 2 = 0* | *Byte 3 = 20* | *Byte 4 = 0,* |
| *Byte 5 = 12819* | *Byte 6 = 100* | *Byte 7 = 21* | *Byte 8 = 0* |

3. Use the decimal values of Byte 4 to Byte 1 to determine the odd pixel reference gain RGo:

$$RGo = (Byte\ 4 \times 256) + Byte\ 3 + \frac{Byte\ 2}{256} + \frac{Byte\ 1}{65536}$$

$$RGo = (0 \times 256) + 20 + 0 + 0$$

$$RGo = 20$$

4. Enter the decimal odd pixel reference gain RGo and the desired gain G into the following formula:

$$Xo = (0.094 \times RGo) + G \qquad G = \text{Desired gain in dB, Max } G = 0.094 * (1024 - RGo)$$

$$Xo = (0.094 \times 20) + 2$$

$$Xo = 3.88$$

5. Calculate the values RGe and Xe for the even channel using the same method as in steps 3 and 4. Use the decimal values of Byte 8 to Byte 5 to determine the even pixel reference gain RGe. RGe is 21.59 in this example, the value for Xe is 4.03.

6. Convert the results to decimal:

$$\text{Odd pixel gain setting} = \frac{Xo}{0.094}$$

$$\text{Odd pixel gain setting} = \frac{3.88}{0.094}$$

$$\text{Odd pixel gain setting} = 41.28$$

   Round to 41.

7. Calculate the even gain setting in the same way. It is 43 in this example.
8. Convert the results to hexadecimal:

   Odd pixel gain setting of 41 decimal = 0x0029

   Even pixel gain setting of 43 decimal = 0x002b

9. Use the odd pixel gain and even pixel gain binary commands to set the odd and even gain to the calculated values.

After you use the commands to enter the calculated values, the camera will be operating at 2 dB with respect to the reference camera. The odd and even pixels will be balanced.

You may get a better odd/even match by increasing or decreasing either the odd or the even gain by one.

Since the black level is very stable, you do not need to adjust the offset when you change the gain.

# 3.5 Digital Shift

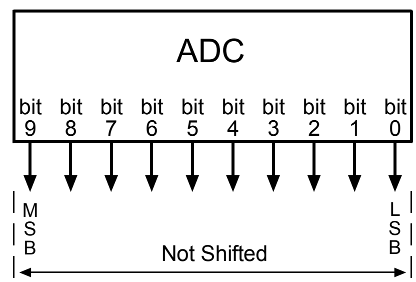
The “digital shift” feature allows you to change the group of bits that is output from each ADC. Using the digital shift feature will effectively multiply the output of the camera by 2 times, 4 times or 8 times. Section 3.5.1 describes how digital shift works when the camera is operating in a 10 bit output mode and Section 3.5.2 describes how digital shift works when the camera is operating in an 8 bit output mode.

You can set digital shift using either the Camera Configuration Tool (see Section 4.1) or binary commands (see Section 4.2). With the Camera Configuration Tool, you use the Features Tab to set digital shift and with binary commands you use the Digital Shift command.

## 3.5.1 Digital Shift in 10 bit Output Mode

### No Shift

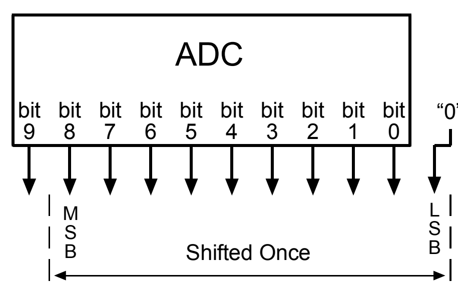
As mentioned in Section 3.1, the **L100b** uses 10 bit ADCs to digitize the output from the CCD sensor. When the camera is operating in 10 bit output mode, by default, the camera transmits the 10 bits that are output from each ADC.




### Shift Once

When the camera is set to shift once, the output from the camera will include bit 8 though bit 0 from each ADC along with a zero as an LSB.

The result of shifting once is that the output of the camera is effectively doubled. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 100. If you changed the digital shift setting to shift once, the reading would increase to 200.

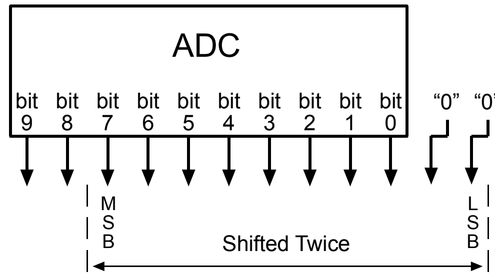



| | |
|---|---|
| | Note that if bit 9 is set to 1, all of the other bits will automatically be set to 1. This means that you should only use the shift once setting when your pixel readings in 10 bit mode with no digital shift are all below 512. |

### Shift Twice

When the camera is set to shift twice, the output from the camera will include bit 7 though bit 0 from each ADC along with two zeros as LSBs.

The result of shifting twice is that the output of the camera is effectively multiplied by four. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 100. If you changed the digital shift setting to shift twice, the reading would increase to 400.

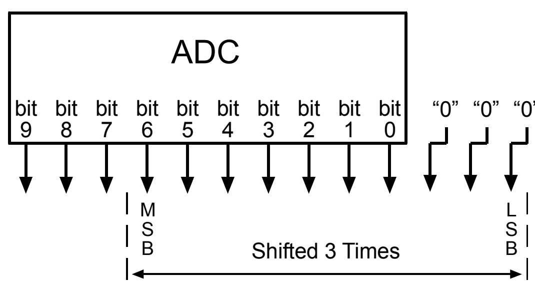



| | |
|---|---|
| | Note that if bit 9 or bit 8 is set to 1, all of the other bits will automatically be set to 1. This means that you should only use the shift twice setting when your pixel readings in 10 bit mode with no digital shift are all below 256. |

### Shift Three Times

When the camera is set to shift three times, the output from the camera will include bit 6 though bit 0 from each ADC along with three zeros as LSBs.

The result of shifting three times is that the output of the camera is effectively multiplied by eight. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 100. If you changed the digital shift setting to shift three times, the reading would increase to 800.

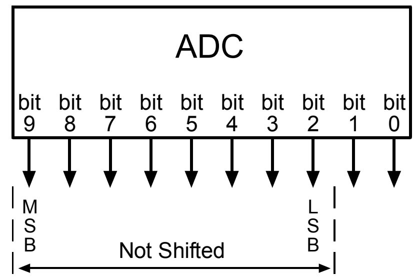



| | |
|---|---|
| | Note that if bit 9, bit 8 or bit 7 is set to 1, all of the other bits will automatically be set to 1. This means that you should only use the shift three times setting when your pixel readings in 10 bit mode with no digital shift are all below 128. |

## 3.5.2 Digital Shift in 8 bit Output Modes

### No Shift

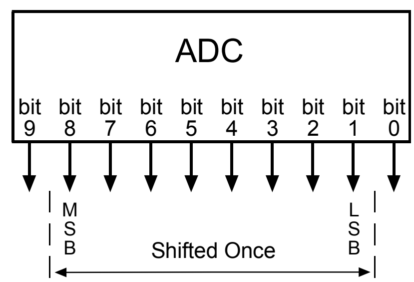
As mentioned in Section 3.1, the **L100b** uses 10 bit ADCs to digitize the output from the CCD sensor. When the camera is operating in 8 bit output mode, by default, it drops the least two significant bits from each ADC and transmits the 8 most significant bits (bit 9 through bit 2).




### Shift Once

When the camera is set to shift once, the output from the camera will include bit 8 though bit 1 from each ADC.

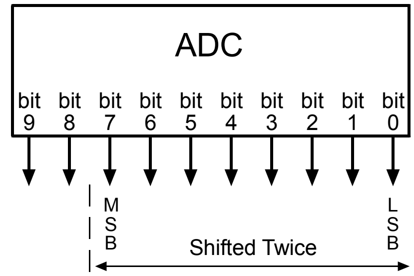
The result of shifting once is that the output of the camera is effectively doubled. For example, assume that the camera is set for no shift, that it is viewing a uniform white target and that under these conditions the reading for the brightest pixel is 20. If you changed the digital shift setting to shift once, the reading would increase to 40.




| | |
|---|---|
| | Note that if bit 9 is set to 1, all of the other bits will automatically be set to 1. This means that you should only use the shift once setting when your pixel readings in 8 bit mode with no digital shift are all below 128. |

## Shift Twice

When the camera is set to shift twice, the output from the camera will include bit 7 though bit 0 from each ADC.

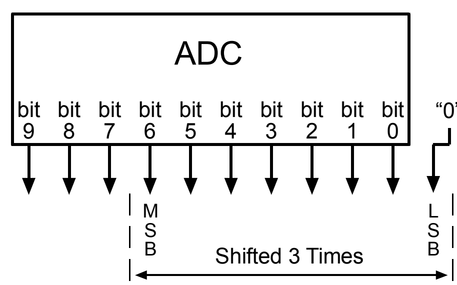



The result of shifting twice is that the output of the camera is effectively multiplied by four. For example, assume that the camera is set for no shift, that it is viewing a uniform white target, and that under these conditions the reading for the brightest pixel is 20. If you changed the digital shift setting to shift twice, the reading would increase to 80.

Note that if bit 9 or bit 8 is set to 1, all of the other bits will automatically be set to 1. This means that you should only use the shift twice setting when your pixel readings in 8 bit mode with no digital shift are all below 64.

## Shift Three Times

When the camera is set to shift three times, the output from the camera will include bit 6 though bit 0 from each ADC along with a zero as the LSB.




The result of shifting three times is that the output of the camera is effectively multiplied by eight. For example, assume that the camera is set for no shift, that it is viewing a uniform white target and that under these conditions the reading for the brightest pixel is 20. If you changed the digital shift setting to shift three times, the reading would increase to 160.

Note that if bit 9, bit 8 or bit 7 is set to 1, all of the other bits will automatically be set to 1. This means that you should only use the shift once setting when your pixel readings in 8 bit mode with no digital shift are all below 32.

## 3.5.3 Precautions When Using Digital Shift

There are several checks and precautions that you must follow before using the digital shift feature. The checks and precautions differ depending on whether you will be using the camera in 10 bit output mode or in 8 bit output mode.

**If you will be using the camera in 10 bit output mode, make this check:**

1. Use binary commands or the Output Version Tab on the configuration tool to put the camera in 10 bit output mode.
2. Use binary commands or the Features Tab to set the camera for no digital shift.
3. Check the output of the camera under your normal lighting conditions with no digital shift and note the readings for the brightest pixels.
   - If any of the readings are above 512, do not use digital shift.
   - If all of the readings are below 512, you can safely use the 2X digital shift setting.
   - If all of the readings are below 256, you can safely use the 2X or 4X digital shift setting.
   - If all of the readings are below 128, you can safely use the 2X, 4X or 8X digital shift setting.

**If you will be using the camera in 8 bit output mode, make this check:**

1. Use binary commands or the Output Version Tab on the configuration tool to put the camera in 8 bit output mode.
2. Use the binary commands or the Features Tab to set the camera for no digital shift.
3. Check the output of the camera under your normal lighting conditions with no digital shift and note the readings for the brightest pixels.
   - If any of the readings are above 128, do not use digital shift.
   - If all of the readings are below 128, you can safely use the 2X digital shift setting.
   - If all of the readings are below 64, you can safely use the 2X or 4X digital shift setting.
   - If all of the readings are below 32, you can safely use the 2X, 4X or 8X digital shift setting.

# 3.6 Area of Interest (AOI)

The area of interest feature allows you to specify a portion of the CCD array and during operation, all pixels are transferred out of the camera but only the pixel information from the specified portion is signalled as valid to the frame grabber. Pixels outside the AOI are read out but signalled as invalid to the grabber.

The size of the area of interest is defined by declaring a starting pixel and a length in pixels (see Figure 3-9). For example, if you specify the starting pixel as 10 and the length in pixels as 15, the camera will output all pixels from the array but only pixels 10 through 24 will be valid.

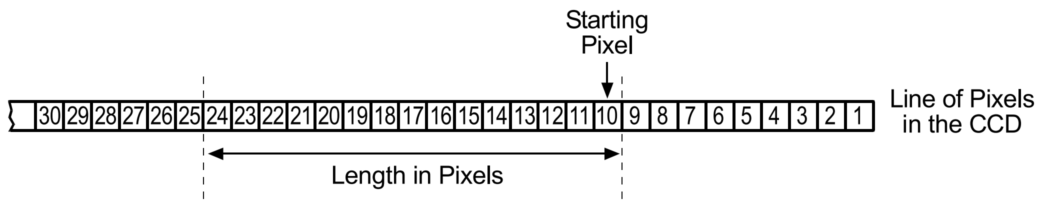



Figure 3-9: Area of Interest

The number of transferred pixels does not decrease when the area of interest feature is used.

The maximum achieveable line rate does not increase when the area of interest feature is used.

Validity of pixels is signalled using the line valid bit.

On the pixel clock cycle where AOI data transmission begins, the line valid bit will become high. For example, if you specify the starting pixel as 5, the line valid bit will become high on the clock cycle where pixel 5 is transmitted (see Figure 3-10). After all of the pixels in the AOI have been transmitted, the line valid bit will become low indicating that valid line data is no longer being transmitted.

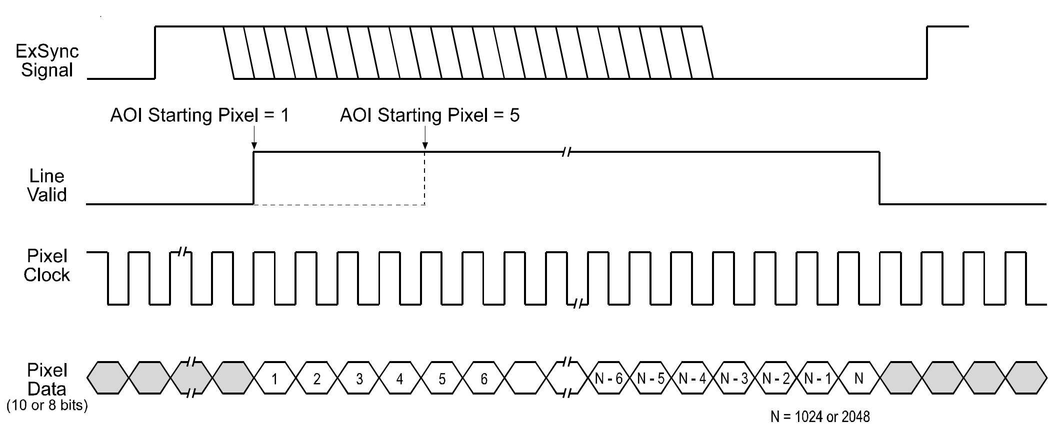



Figure 3-10: Single 10 Bit or Single 8 Bit Output Mode with Edge or Level Controlled Exposure

> If you use a frame grabber which does not take the falling edge of the line valid bit into account, you must also set the frame grabber to the number of pixels in the area of interest. For example, when you have an area of interest of 500 pixels, you must also set the grabber to 500 pixels. Otherwise, the grabber will show no effect.

| | |
|---|---|
| ☝ | In normal operation, the camera is set to use all of the pixels in the array. To use all of the pixels, the starting pixel should be set to 1 and the length in pixels to 1024 for cameras with a 1024 pixel sensor or 2048 for cameras with a 2048 pixel sensor. |

You can set the area of interest using either the Camera Configuration Tool (see Section 4.1) or binary commands (see Section 4.2). With the Camera Configuration Tool, you use the Features Tab to set the area of interest and with binary commands you use the Area of Interest Starting Pixel and Area of Interest Length in Pixel commands.

# 3.7 Test Image

The test image mode is used to check the camera's basic functionality and its ability to transmit an image via the video data cable. In test mode, the image is generated with a software program and the camera's digital devices and does not use the optics, CCD sensor, VGCs or ADCs. The test image can be used for service purposes and for failure diagnostics.

The test image is formed with an odd/even gray scale gradient that ranges from 0 to 255 and repeats every 512 pixels as shown in Figure 3-11. The odd pixel gradient starts at 0 and steps up, that is, the gray value of pixel 1 is 0, the gray value of pixel 3 is 1, the gray value of pixel 5 is 2, and so forth. The even gradient starts at 255 and steps down, that is, the gray value of pixel 2 is 255, the gray value of pixel 4 is 254, the gray value of pixel 6 is 253, and so forth.

At pixels 256 and 257, the gray value for both pixels is 128. At pixels 511 and 512, a white odd pixel is next to a black even pixel. At pixels 513 and 514, a black odd pixel is next to a white even pixel. To the human eye, the gradient appears to be a varying gray field with a white vertical line every 512 pixels.

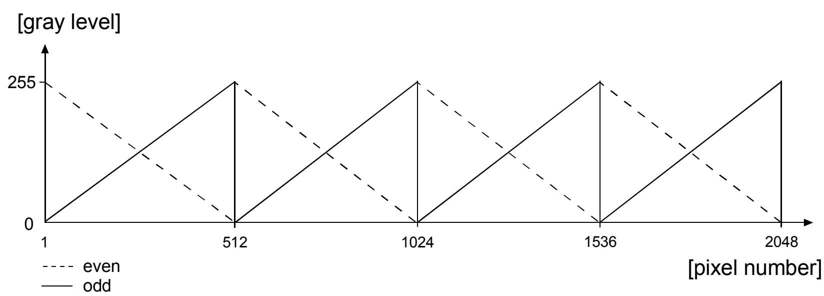



Figure 3-11: Formation of the Test Image

If the camera is set for an exposure mode that uses an ExSync signal, the ExSync signal must be present and must toggle in order to output a line on the test image. Multiple transitions of the ExSync signal will produce a two dimensional image as shown in Figure 3-12.

If the camera is set for Free-run, each cycle of the camera's internal control signal will trigger the output of a line on the test image.

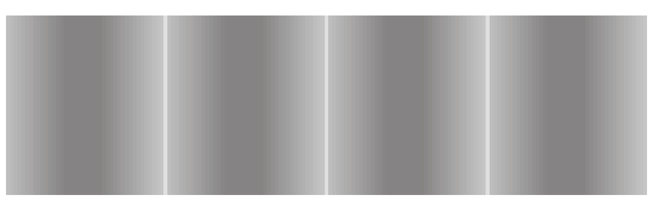


Figure 3-12: Test Image

You can use the Test Image Tab in the Camera Configuration Tool to enable and disable the test image (see Section 4.1) or use the Test Image binary command (see Section 4.2).

> When the test image is active, the gain, offset and exposure time have no effect on the image. Digital shift makes the test image appear very light, therefore, digital shift should be disabled when the test image is active.

# 3.8 Configuration Sets

The camera's adjustable parameters are stored in configuration sets and each configuration set contains all of the parameters needed to control the camera. There are three different types of configuration sets: the Work Set, the Factory Set, and User Sets.

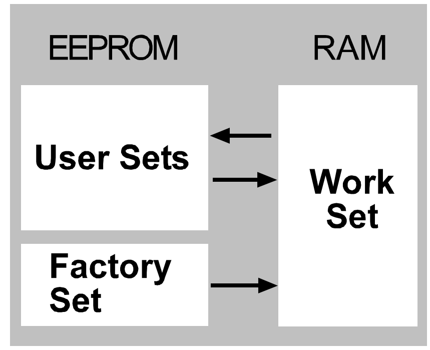



Figure 3-13: Config Sets

**Work Set**

The Work Set contains the current camera settings and thus determines the camera's present performance, that is, what your image currently looks like. The Work Set is stored in the camera RAM. The configuration parameters in the Work Set can be altered directly using the Camera Configuration Tool or using binary programming commands.

**Factory Set**

When a camera is manufactured, a test set up is performed on the camera and an optimized configuration is determined. The Factory Set contains the camera's factory optimized configuration. The Factory Set is stored in non-volatile memory on the EEPROM and can not be altered.

**User Sets**

User Sets are also stored in the non-volatile EEPROM of the camera. The camera has 15 User Sets. Each User Set initially contains factory settings but User Sets can be modified. Modification is accomplished by making changes to the Work Set and then copying the Work set into one of the User Sets. The Camera Configuration Tool or binary commands can be used to copy the Work Set into one of the User Sets.

**Startup Pointer**

When power to the camera is switched off, the Work set in the RAM is lost. At the next power on, a configuration set is automatically copied into the Work Set. The Startup Pointer is used to specify which of the configuration sets stored in the EEPROM will be copied into the Work Set at power on. The Startup Pointer is initially set so that the Factory Set is loaded into the Work Set at power on. This can be changed using the Camera Configuration Tool or binary commands. The Startup Pointer can be set to the Factory Set or to any one of the User Sets. So, for example, if the Startup Pointer is set to User Set 13, then User Set 13 will be copied into the Work Set at power on.

You can work with configuration sets and the startup pointer using either the Camera Configuration Tool (see Section 4.1) or binary commands (see Section 4.2).

With the Camera Configuration Tool, you can use the Sets Tab to copy the Work Set to a User Set, to Copy a User Set or the Factory Set to the Work Set, or to set the Startup Pointer.

With binary commands you use the Copy Work Set to User Set command, the Copy Factory Set or User Set to Work Set command, and the Select Startup Pointer command to manipulate configuration sets.

# 3.9 Camera Status

**L100b** series cameras monitor their status by performing a regular series of self checks. The current status of a camera can be viewed in several ways:

- with the Camera Configuration Tool. You can use the Status Tab (see Section 4.1 and the configuration tool's on-line help) to check a list of several possible errors and an indication of whether those errors are present.
- with binary commands. You can use the Camera Status command (see Section Figure 4.2.9) to check if the camera has detected any errors.
- by checking the yellow LED on the back of the camera. If certain error conditions are present, the yellow LED will blink (see Section 6.1).

# 4 Configuring the Camera

L100b series cameras come factory-set so that they will work properly for most applications with minor changes to the camera configuration. For normal operation, the following parameters are usually configured by the user:

- Exposure time control mode
- Exposure time (for ExSync programmable mode or free-run programmable mode)

To customize operation for your particular application, the following parameters can also be configured:

- Gain
- Offset
- Area of Interest
- Digital Shift

The camera is programmable via the serial port. Two methods can be used to change the camera's settings. The first and easier approach is to change the settings using the Camera Configuration Tool. See Section 4.1 and the configuration tool's on-line help file for instructions on using the configuration tool. You can also change the settings directly from your application using binary commands. Section 4.2 lists the commands and provides instructions for their use.

# 4.1 Configuring the Camera with the Camera Configuration Tool

The Camera Configuration Tool (CCT) is a Windows® based program used to easily change the camera's settings. The tool communicates via the serial interface and automatically generates the binary programming commands that are described in Section 4.2. For instructions on installing the tool, see the CCT installation booklet that was shipped with the camera.

This manual assumes that you are familiar with Microsoft Windows® and that you have a basic knowledge of how to use programs. If not, please refer to your Microsoft Windows® manual.

## 4.1.1 Opening the Configuration Tool

1. Make sure that the serial interface is connected to your camera and that the camera has power.
2. To start the Camera Configuration Tool, click **Start**, click **Basler Vision Technologies**, and click **Camera Config Tool** (default installation).

   If start-up was successful, the Model Tab is displayed.

   If start-up was not successful the Connection Tab or a Select Camera dialog box will appear. Refer to the CCT installation booklet that was delivered with your camera for possible causes and solutions.

## 4.1.2 Closing the Configuration Tool

Close the Configuration Tool by clicking on the [X] button in the upper right corner of the window.

## 4.1.3 Configuration Tool Basics

The RAM memory in the camera contains the set of parameters that controls the current operation of the camera. This set of parameters is known as the Work Set (see Section 3.8). The Camera Configuration Tool is used to view the present settings for the parameters in the Work Set or to change the settings. The configuration tool organizes the parameters into related groups and displays each related group on a tab. For example, the Features Tab contains all of the parameters related to the Area of Interest feature and the Digital Shift feature.

When the configuration tool is opened, it queries the camera and displays the current settings for the parameters in the Work Set.

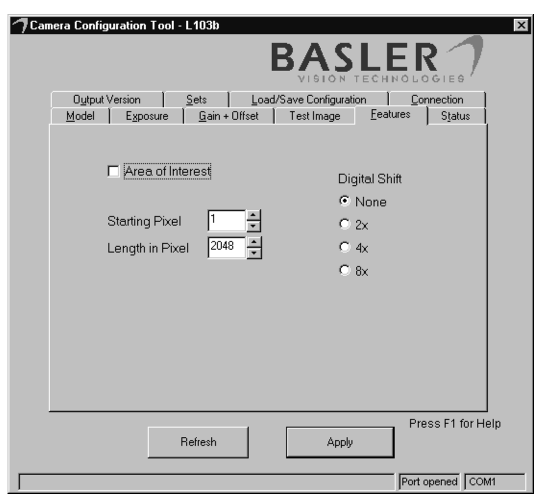



Figure 4-1: Features Tab

### Using the Refresh and Apply Buttons

Two buttons always appear at the bottom of the configuration tool window, the Refresh button and the Apply button.


Typically, if you make a change to one or more of the settings on a tab, you must click the **Apply** button for that change to be transmitted from the configuration tool to the camera's Work Set. Because the parameters in the Work Set control the current operation of the camera, when you click the Apply button, you will see an immediate change in the camera's operation.

The **Refresh** button can be used at any time to make sure that the configuration tool is displaying the current settings for the parameters in the Work Set. When you click the Refresh button, the configuration tool queries the camera to determine the current setting for each parameter in the Work Set and updates the display on each tab.

> Keep in mind that the Work Set is stored in a volatile memory. Any changes you make to the Work Set using the configuration tool will be lost when the camera is switched off. To save changes you make to the Work Set, go to the Sets Tab and save the modified Work Set into one of the camera's 15 User Sets. The User Sets are stored in non-volatile memory and will not be lost when the camera is switched off (see Section 3.8).
>
> If you want your changes to be loaded into the Work Set at the next power on, go to the Sets Tab and set the Startup Pointer to the User Set where you saved your changes.

## 4.1.4 Configuration Tool Help

The Camera Configuration Tool includes a complete on-line help file which explains how to use each tab and how the settings on each tab will effect the camera's operation. To access on-line help, press the F1 key whenever the configuration tool is active.

# 4.2 Configuring the Camera with Binary Programming Commands

Commands can be issued to the **L100b** via the RS-232 serial connection using a binary protocol. With this protocol, data is placed into a frame and sent to the camera. Once the data is received it is checked for validity. If valid, the data is extracted and the command is executed.

If the command issued to the camera was a read command, the camera will respond by placing the requested data into a frame and sending it to the host computer.

## 4.2.1 Command Frame and Response Format

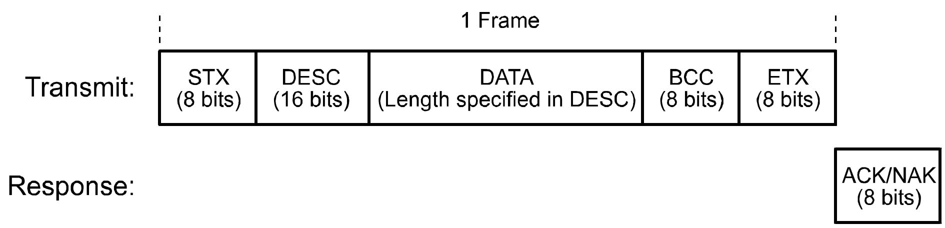



Figure 4-2: Representation of a Command Frame and Response

**STX** Identifies the start of the frame text
Size = 1 Byte
(The value of the STX byte is always 0x02)

**DESC** Descriptor
Size = 2 Bytes
The bits in the descriptor are assigned as follows:

| 8 bits | 1 bit | 7 bits |
|---|---|---|
| Command ID | Read/Write Flag ( 0 = write, 1 = read ) | Data Length (in Bytes) |

The MSB of the descriptor is on the left (highest bit of the command ID) and the LSB of the descriptor is on the right (lowest bit of the data length).

**DATA** Data field
Size = Number of bytes indicated in the Data Length portion of the descriptor.

**BCC** Block check character

Size = 1 Byte

The block check character is the exclusive-or sum (XOR sum) of the bytes in the descriptor field and the data field.

**ETX** Identifies the end of the frame text

Size = 1 Byte

(The value of the ETX byte is always 0x03)

**ACK/NAK Response** Positive frame acknowledge/negative frame acknowledge

Size = 1 byte

(The value for a positive frame acknowledgement is 0x06 and for a negative frame acknowledgement is 0x15.)

| | |
|---|---|
| ☝ | All values are formatted as little endian (Intel format). |

## 4.2.2 Error Checking

### 4.2.2.1 ACK/NAK

When the camera receives a frame, it checks the order of the bytes in the frame and checks to see if the XOR sum of the bytes in the descriptor and the data fields matches the block check character. The camera also checks to see if the number of bytes in the data field is equal to the number specified in the descriptor.

If all checks are correct, an ACK is send to the host. If any check is incorrect, a NAK is sent.

### 4.2.2.2 Time-outs

**Byte Time-out**

The camera checks the time between the receipt of each byte in the frame. If the time between any two bytes exceeds 1 second, the camera enters a “garbage state” and discards any more incoming bytes. The camera remains in this state until it sees 1.5 seconds of silence. Once the camera sees 1.5 seconds of silence, it goes into an idle state (looking for an STX).

### 4.2.2.3 Read Command

In the normal case, when a read command is sent to the camera, the camera responds with an ACK and a frame. The frame will contain the data requested in the read command.

If the camera receives a read command with an unknown command ID in the descriptor, it will respond with an ACK but will not send a frame.

If the host sends a read command and gets no ACK/NAK, the host can assume that no camera is present.

If the host sends a read command and gets an ACK/NAK but does not receive a frame within 500 ms, the host can assume that there was a problem with the read command.

### 4.2.2.4 Write Command

In the normal case, when a write command is sent to the camera, the camera responds with an ACK.

If the camera receives a write command with an unknown command ID in the descriptor, it will respond with an ACK but will not perform the write.

After a write command has been issued by the host, the host can verify the write by issuing a corresponding read command and checking that the returned data is as expected. The host can also issue a camera status read command (see Section 4.2.9) and check the returned data to see if an error condition has been detected.

> For many of the write commands listed in the Tables on pages 5-9 through 5-25, only data within a specified range or a specified group of values is valid. The camera **does not** perform a check to see if the data in the write command is within the allowed range or specified group of allowed values.

## 4.2.3 Example Commands

### 4.2.3.1 Read Command

An example of the command message used to read the camera status is:

`0x02, 0x43, 0x82, 0xC1, 0x03`

`0x02` - is the STX. The STX is always `0x02`.

`0x43` - is the first byte of the descriptor. The first byte of the descriptor is the command ID. Command IDs can be found in the tables on pages 5-9 through 5-25. If you check the table on page 5-24, you will find that the ID for the camera status read command is 0x43.

`0x82` - is the second byte of the descriptor. The MSB in this byte represents the read/write flag and since this is a read command, the bit should be set to a 1. The other seven bits of this byte represent the data size (in bytes) that will be transferred using this command. If you check the table on page 5-24, the data size for the camera status command is 2 bytes. So the arrangement of the bits in the second byte of the descriptor should be 1000 0010 which translates to 0x82.

Note that for read commands, the data size specified in the descriptor represents the number of bytes of data that you expect to see in the response. No data bytes are actually included in the read command.

`0xC1` - is the block check character (BCC). See page 5-8 for instructions on calculating a BCC.

`0x03` - is the ETX. The ETX is always 0x03.

### 4.2.3.2 Write Command

An example of the command message used to copy the Work Set into User Set 2 is:

`0x02, 0x46, 0x01, 0x02, 0x45, 0x03`

`0x02` - is the STX. The STX is always 0x02.

`0x46` - is the first byte of the descriptor. If you check the table on page 5-22, you will find that the ID for the command to copy the Work Set into a User Set is 0x46.

`0x01` - is the second byte of the descriptor. The MSB in this byte represents the read/write flag and since this is a write command, the bit should be set to a 0. The other seven bits of this byte represent the data size (in bytes) that will be transferred using this command. If you check the table on page 5-22, the data size for the copy Work Set to User Set command is 1 byte. So the arrangement of the bits in the second byte of the descriptor should be 0000 0001 which translates to 0x01.

`0x02` - is the data byte. If you check the table on page 5-22, you will find that to copy the Work Set to User Set 2, the data byte must be set to 0x02.

`0x45` - is the block check character (BCC). See page 5-8 for instructions on calculating a BCC.

`0x03` - is the ETX. The ETX is always 0x03.

### 4.2.3.3 Calculating the Block Check Character

The block check character in any L100b command is the exclusive-or sum (XOR sum) of the bytes in the descriptor and the data fields. For the write command example shown in Section 4.2.3.2, the block check character is 0x45. Let's consider how this block check character was calculated.

In this case, we must find the XOR sum of three bytes. This is done by finding the XOR sum of the first two bytes and then by taking the result and finding the XOR sum of the result plus the third byte.

Calculating XOR sums is most easily understood when numbers are shown in their binary form, so in the sample calculations shown below, the hexadecimal digits in our command have been converted to binary.

To find the XOR sum of two binary numbers, you must add the two digits in each column using the following rules:

If both digits are 0, the result is 0.

If both digits are 1, the result is 0.

If one of the digits is a 1 and the other is a 0, the result is 1.

With all of this in mind, here is how the BCC for the write command shown in Section 4.2.3.2 would be calculated:

```
0 1 0 0  0 1 1 0 = the binary representation of 0x46
0 0 0 0  0 0 0 1 = the binary representation of 0x01
0 1 0 0  0 1 1 1 = the XOR sum of the first two bytes

0 1 0 0  0 1 1 1 = The XOR sum of the first two bytes
0 0 0 0  0 0 1 0 = the binary representation of 0x02
0 1 0 0  0 1 0 1 = The XOR sum

0 1 0 0  0 1 0 1 = 0x45 = the block check character
```

## 4.2.4 Commands for Setting Camera Parameters

### 4.2.4.1 Video Data Output Mode

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set the video data output mode or to read the current video data output mode setting. See Section 2.4.7 for an explanation of the available video data output modes. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0xC0 | R/W-Flag<br>1 | Data Length<br>1 | Data<br>- |
| Response: | Cmd-ID<br>0xC0 | R/W-Flag<br>0 | Data Length<br>1 | Data<br>1 Byte |
| **Write Command:** | Cmd-ID<br>0xC0 | R/W-Flag<br>0 | Data Length<br>1 | Data<br>1 Byte |
| Response: | None | | | |
| **Data Format:** | Byte 1 | An ID that specifies the data output mode (see the table below). | | |

| ID | Output Mode |
|---|---|
| 0x00 | Single 8 Bit mode |
| 0x01 | Dual 8 Bit mode |
| 0x02 | Single 10 Bit mode |
| 0x03 | Dual 10 Bit mode |

### 4.2.4.2 Exposure Time Control Mode

**Purpose:** To set the exposure time control mode or to read the current exposure time control mode setting. See Section 3.2 for an explanation of exposure time control modes.

**Type:** This is a read or write command.

| | | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|---|
| **Read Command:** | | 0xA0 | 1 | 1 | - |
| | Response: | 0xA0 | 0 | 1 | 1 Byte |
| **Write Command:** | | 0xA0 | 0 | 1 | 1 Byte |
| | Response: | None | | | |

**Data Format:** Byte 1 — An ID that specifies the exposure mode (see the table below).

| ID | Exposure Time Control Mode |
|---|---|
| 0x00 | Free-run, Programmable |
| 0x02 | Free-run, Edge-controlled |
| 0x04 | ExSync, Level-controlled |
| 0x05 | ExSync, Programmable |
| 0x06 | ExSync, Edge-controlled |

### 4.2.4.3 Timer 1

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set Timer 1 or to read the current Timer 1 setting. Timer 1 is used when the camera is operating in ExSync programmable mode or in free-run mode. See Section 3.2 for details. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0xA6 | R/W-Flag<br>1 | Data Length<br>3 | Data<br>- |
| Response: | Cmd-ID<br>0xA6 | R/W-Flag<br>0 | Data Length<br>3 | Data<br>3 Bytes |
| **Write Command:** | Cmd-ID<br>0xA6 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>3 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of the Timer 1 setting | | |
| | Byte 2 | Mid byte of the Timer 1 setting | | |
| | Byte 3 | High byte of the Timer 1 setting | | |
| **Data Range:** | The timer 1 setting can range from 0x000001 to 0xFFFFFF µs. | | | |

### 4.2.4.4 Timer 2

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set Timer 2 or read the current Timer 2 setting. Timer 2 is used when the camera is operating in free-run mode. See Section 3.2 for details. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0xA7 | R/W-Flag<br>1 | Data Length<br>3 | Data<br>- |
| Response: | Cmd-ID<br>0xA7 | R/W-Flag<br>0 | Data Length<br>3 | Data<br>3 Bytes |
| **Write Command:** | Cmd-ID<br>0xA7 | R/W-Flag<br>0 | Data Length<br>3 | Data<br>3 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of the Timer 2 setting | | |
| | Byte 2 | Mid byte of the Timer 2 setting | | |
| | Byte 3 | High byte of the Timer 2 setting | | |
| **Data Range:** | The timer 2 setting can range from 0x000001 to 0xFFFFFF µs. | | | |

### 4.2.4.5 Digital Shift

**Purpose:** To enable or disable digital shift. See Section 3.5 for an explanation of digital shift.

**Type:** This is a read or write command.

| | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|
| **Read Command:** | 0xA5 | 1 | 1 | - |
| Response: | 0xA5 | 0 | 1 | 1 Byte |
| **Write Command:** | 0xA5 | 0 | 1 | 1 Byte |
| Response: | None | | | |

**Data Format:** Byte 1 — An ID that specifies the digital shift status (see the table below).

| ID | Digital Shift | |
|---|---|---|
| 0x00 | No digital shift | |
| 0x01 | Digital shift once | (multiplies output 2X) |
| 0x02 | Digital shift twice | (multiplies output 4X) |
| 0x03 | Digital shift by three | (multiplies output 8X) |

See Section 3.5.3 for precautions that you must consider when using digital shift.

#### 4.2.4.6 Area of Interest Starting Pixel

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set the starting pixel for the Area of Interest or to read the current starting pixel setting. See Section 3.6 for details. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0xA9 | R/W-Flag<br>1 | Data Length<br>2 | Data<br>- |
| Response: | Cmd-ID<br>0xA9 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| **Write Command:** | Cmd-ID<br>0xA9 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of the starting pixel setting | | |
| | Byte 2 | High byte of the starting pixel setting | | |
| **Data Range:** | 1K sensors: 0x0000 to 0x03FF<br>2K sensors: 0x0000 to 0x07FF<br>(When using binary commands, the **starting pixel = n +1** where n is the setting made using this binary command.<br>For example, if you wish to define pixel 100 as starting pixel, set 99 with the help of this command.) | | | |

#### 4.2.4.7 Area of Interest Length in Pixels

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set the length in pixels for the Area of Interest or to read the current length setting. See Section 3.6 for details. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0xAB | R/W-Flag<br>1 | Data Length<br>2 | Data<br>- |
| Response: | Cmd-ID<br>0xAB | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| **Write Command:** | Cmd-ID<br>0xAB | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of the length in pixel setting | | |
| | Byte 2 | High byte of the length in pixel setting | | |
| **Data Range:** | 1K sensors: 0x0001 to 0x0400<br>2K sensors: 0x0001 to 0x0800 | | | |

#### 4.2.4.8 Odd Pixel Gain

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set the gain for the odd pixels or to read the current odd pixel gain setting. See Section 3.4 for more information on gain. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0x80 | R/W-Flag<br>1 | Data Length<br>2 | Data<br>- |
| Response: | Cmd-ID<br>0x80 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| **Write Command:** | Cmd-ID<br>0x80 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of odd pixel gain setting | | |
| | Byte 2 | High byte of odd pixel gain setting | | |
| **Data Range:** | L101b, L103b: | 0x0000 to 0x03FF | | |
| | L104b: | 0x0000 to 0x013F | | |

#### 4.2.4.9 Odd Pixel Offset

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set the offset for the odd pixels or to read the current odd pixel offset setting. See Section 3.4 for more information on offset. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0x84 | R/W-Flag<br>1 | Data Length<br>2 | Data<br>- |
| Response: | Cmd-ID<br>0x84 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| **Write Command:** | Cmd-ID<br>0x84 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of odd pixel offset setting | | |
| | Byte 2 | High byte of odd pixel offset setting | | |
| **Data Range:** | L101b, L103b: | 0x0000 to 0x00FF | | |
| | L104b: | 0x0000 to 0x03FF | | |

### 4.2.4.10 Even Pixel Gain

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set the gain for the even pixels or to read the current even pixel gain setting. See Section 3.4 for more information on gain. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0x82 | R/W-Flag<br>1 | Data Length<br>2 | Data<br>- |
| Response: | Cmd-ID<br>0x82 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| **Write Command:** | Cmd-ID<br>0x82 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of even pixel gain setting | | |
| | Byte 2 | High byte of even pixel gain setting | | |
| **Data Range:** | L101b, L103b: | 0x0000 to 0x03FF | | |
| | L104b: | 0x0000 to 0x013F | | |

### 4.2.4.11 Even Pixel Offset

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To set the offset for the even pixels or to read the current even pixel offset setting. See Section 3.4 for more information on offset. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0x86 | R/W-Flag<br>1 | Data Length<br>2 | Data<br>- |
| Response: | Cmd-ID<br>0x86 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| **Write Command:** | Cmd-ID<br>0x86 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>2 Bytes |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte of even pixel offset setting | | |
| | Byte 2 | High byte of even pixel offset setting | | |
| **Data Range:** | L101b, L103b: | 0x0000 to 0x00FF | | |
| | L104b: | 0x0000 to 0x03FF | | |

## 4.2.5 Test Image Command

| | | | | |
|---|---|---|---|---|
| **Purpose:** | To enable or disable a test image. See Section 3.7 for an explanation of the available test images. | | | |
| **Type:** | This is a read or write command. | | | |
| **Read Command:** | Cmd-ID<br>0xA1 | R/W-Flag<br>1 | Data Length<br>1 | Data<br>- |
| Response: | Cmd-ID<br>0xA1 | R/W-Flag<br>0 | Data Length<br>1 | Data<br>1 Bytes |
| **Write Command:** | Cmd-ID<br>0xA1 | R/W-Flag<br>0 | Data Length<br>1 | Data<br>1 Byte |
| Response: | None | | | |
| **Data Format:** | Byte 1 | An ID that specifies the test image (see the table below). | | |

| ID | Test Image |
|---|---|
| 0x00 | No test image |
| 0x01 | Test Image (gray gradient) |

## 4.2.6 Camera Reset Command

| | | | | |
|---|---|---|---|---|
| **Purpose:** | Initiates a camera reset. The behavior is similar to a power up reset. | | | |
| **Type:** | This is a write only command. | | | |
| **Write Command:** | Cmd-ID<br>0x42 | R/W-Flag<br>0 | Data Length<br>2 | Data<br>0x07, 0xCF |
| Response: | None | | | |
| **Data Format:** | Byte 1 | Low byte | 0x07 is always used | |
| | Byte 2 | High byte | 0xCF is always used | |

## 4.2.7 Query Commands

### 4.2.7.1 Read Microcontroller Firmware Version

| | | | | |
|---|---|---|---|---|
| **Purpose:** To read the microcontroller firmware version | | | | |
| **Type:** This is a read only command. | | | | |
| **Read Command:** | Cmd-ID<br>0x40 | R/W-Flag<br>1 | Data Length<br>3 | Data<br>- |
| Response: | Cmd-ID<br>0x40 | R/W-Flag<br>0 | Data Length<br>3 | Data<br>3 Bytes |
| **Data Format:** | Byte 1 | Low byte of firmware version | | BCD coded |
| | Byte 2 | High byte of firmware version | | BCD coded |
| | Byte 3 | Protocol Version | | |

### 4.2.7.2 Read FPGA Firmware Version

| | | | | |
|---|---|---|---|---|
| **Purpose:** To read the FPGA firmware version | | | | |
| **Type:** This is a read only command. | | | | |
| **Read Command:** | Cmd-ID<br>0x41 | R/W-Flag<br>1 | Data Length<br>3 | Data<br>- |
| Response: | Cmd-ID<br>0x41 | R/W-Flag<br>0 | Data Length<br>3 | Data<br>3 Bytes |
| **Data Format:** | Byte 1 | Low byte of firmware version | | BCD coded |
| | Byte 2 | High byte of firmware version | | BCD coded |
| | Byte 3 | undefined - 0x00 is always used | | |

### 4.2.7.3 Read Vendor Information

| | | | | |
|---|---|---|---|---|
| **Purpose:** To read the camera vendor's name. | | | | |
| **Type:** This is a read only command. | | | | |
| **Read Command:** | Cmd-ID<br>0x01 | R/W-Flag<br>1 | Data Length<br>16 | Data<br>- |
| Response: | Cmd-ID<br>0x01 | R/W-Flag<br>0 | Data Length<br>16 | Data<br>16 Bytes |
| **Data Format:** | Zero terminated string if less than 16 bytes are needed for the vendor information. Unterminated string if all 16 bytes are needed. | | | |

### 4.2.7.4 Read Model Information

| | | | | |
|---|---|---|---|---|
| **Purpose:** To read the camera's model number. | | | | |
| **Type:** This is a read only command. | | | | |
| **Read Command:** | Cmd-ID<br>0x02 | R/W-Flag<br>1 | Data Length<br>16 | Data<br>- |
| Response: | Cmd-ID<br>0x02 | R/W-Flag<br>0 | Data Length<br>16 | Data<br>16 Bytes |
| **Data Format:** | Zero terminated string if less than 16 bytes are needed for the model information. Unterminated string if all 16 bytes are needed. | | | |

### 4.2.7.5 Read Product ID

| | | | | |
|---|---|---|---|---|
| **Purpose:** To read the camera's product ID number. | | | | |
| **Type:** This is a read only command. | | | | |
| **Read Command:** | Cmd-ID<br>0x03 | R/W-Flag<br>1 | Data Length<br>16 | Data<br>- |
| Response: | Cmd-ID<br>0x03 | R/W-Flag<br>0 | Data Length<br>16 | Data<br>16 Bytes |
| **Data Format:** | Zero terminated string if less than 16 bytes are needed for the product ID information. Unterminated string if all 16 bytes are needed. | | | |

### 4.2.7.6 Read Serial Number

| | | | | |
|---|---|---|---|---|
| **Purpose:** To read the camera's serial number. | | | | |
| **Type:** This is a read only command. | | | | |
| **Read Command:** | Cmd-ID<br>0x04 | R/W-Flag<br>1 | Data Length<br>16 | Data<br>- |
| Response: | Cmd-ID<br>0x04 | R/W-Flag<br>0 | Data Length<br>16 | Data<br>16 Bytes |
| **Data Format:** | Zero terminated string if less than 16 bytes are needed for the serial number information. Unterminated string if all 16 bytes are needed. | | | |

#### 4.2.7.7 Read Reference Gain Values

**Purpose:** To read the reference gain values that are determined during the camera's factory calibration procedure (see Section 3.4.1 on how to use the reference gain values).

**Type:** This is a read only command.

| | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|
| **Read Command:** | 0x08 | 1 | 8 | - |
| Response: | 0x08 | 0 | 8 | 8 Bytes |

**Data Format:** Each reference gain is stored as a 16 Bits followed by a decimal point followed by 16 more Bits:

$$\text{Reference Gain} = \text{High Byte b.d.p.} \times 256 + \text{Low Byte b.d.p.} + \frac{\text{High Byte a.d.p.}}{256} + \frac{\text{Low Byte a.d.p.}}{65536}$$

b.d.p.: before decimal point
a.d.p.: after decimal point

For example:

$$\text{Odd pixel reference gain} = \text{Byte 4} \times 256 + \text{Byte 3} + \frac{\text{Byte 2}}{256} + \frac{\text{Byte 1}}{65536}$$

| **Byte** | **Even/odd reference gain** | **Position before/ after decimal point** | **High/Low byte** |
|---|---|---|---|
| Byte 1 | odd | after | low byte |
| Byte 2 | odd | after | high byte |
| Byte 3 | odd | before | low byte |
| Byte 4 | odd | before | high byte |
| Byte 5 | even | after | low byte |
| Byte 6 | even | after | high byte |
| Byte 7 | even | before | low byte |
| Byte 8 | even | before | high byte |

## 4.2.8 Commands for Manipulating Configuration Sets

### 4.2.8.1 Copy the Factory Set or the User Set into the Work Set

**Purpose:** To copy the Factory Set or one of the 15 User Sets into the Work Set. See Section 3.8 for an explanation of configuration sets.

The write command will cause the selected set to be copied into the Work Set and the set will become active immediately.

The read command returns the ID of the set that was last copied into the Work Set. (If nothing has been copied to the Work Set since the last power up or reset, the read command will return the ID for “no active set.” This condition indicates that no valid Factory Set or User Sets were found. It will also cause the yellow LED on the back of the camera to show six pulses.)

**Type:** This is a read or write command.

| | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|
| **Read Command:** | 0x45 | 1 | 1 | - |
| Response: | 0x45 | 0 | 1 | 1 Byte |
| **Write Command:** | 0x45 | 0 | 1 | 1 Byte |
| Response: | None | | | |

**Data Format:** Byte 1 — An ID that specifies the set. (see the table below).

| Set ID | Set |
|---|---|
| 0x00 | Factory Set |
| 0x01 | User Set 1 |
| 0x02 | User Set 2 |
| 0x03 | User Set 3 |
| 0x04 | User Set 4 |
| 0x05 | User Set 5 |
| 0x06 | User Set 6 |
| 0x07 | User Set 7 |
| 0x08 | User Set 8 |
| 0x09 | User Set 9 |
| 0x0A | User Set 10 |
| 0x0B | User Set 11 |
| 0x0C | User Set 12 |
| 0x0D | User Set 13 |
| 0x0E | User Set 14 |
| 0x0F | User Set 15 |
| 0xFF | No active set |

### 4.2.8.2 Copy the Work Set into a User Set

**Purpose:** To copy the Work Set into one of the 15 User Sets. See Section 3.8 for an explanation of configuration sets.

**Type:** This is a write only command.

**Write Command:**

| | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|
| | 0x46 | 0 | 1 | 1 Byte |
| Response: | None | | | |

**Data Format:** Byte 1 — An ID that specifies the user set. (see the table below).

| Set ID | Set |
|---|---|
| 0x01 | User Set 1 |
| 0x02 | User Set 2 |
| 0x03 | User Set 3 |
| 0x04 | User Set 4 |
| 0x05 | User Set 5 |
| 0x06 | User Set 6 |
| 0x07 | User Set 7 |
| 0x08 | User Set 8 |
| 0x09 | User Set 9 |
| 0x0A | User Set 10 |
| 0x0B | User Set 11 |
| 0x0C | User Set 12 |
| 0x0D | User Set 13 |
| 0x0E | User Set 14 |
| 0x0F | User Set 15 |

### 4.2.8.3 Select the Startup Pointer

**Purpose:** The Startup Pointer is used to tag the configuration set that will be copied into the Work Set at power on (see Section 3.8).

The write command is used to set the Startup Pointer to the Factory Set or to one of the User Sets.

The read command returns the Set ID for the current setting.

**Type:** This is a read or write command.

| | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|
| **Read Command:** | 0x47 | 1 | 1 | - |
| Response: | 0x47 | 0 | 1 | 1 Byte |
| **Write Command:** | 0x47 | 0 | 1 | 1 Byte |
| Response: | None | | | |

**Data Format:** Byte 1 — An ID that specifies the set. (see the table below).

| Set ID | Set |
|---|---|
| 0x00 | Factory Set |
| 0x01 | User Set 1 |
| 0x02 | User Set 2 |
| 0x03 | User Set 3 |
| 0x04 | User Set 4 |
| 0x05 | User Set 5 |
| 0x06 | User Set 6 |
| 0x07 | User Set 7 |
| 0x08 | User Set 8 |
| 0x09 | User Set 9 |
| 0x0A | User Set 10 |
| 0x0B | User Set 11 |
| 0x0C | User Set 12 |
| 0x0D | User Set 13 |
| 0x0E | User Set 14 |
| 0x0F | User Set 15 |

### 4.2.9 Camera Status Command

| | |
|---|---|
| **Purpose:** | The camera has been programmed to detect several error conditions. When an error condition is detected, a flag is set. The status command allows you to read the error flags. |
| **Type:** | This is a read only command. |

| | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|
| **Read Command:** | 0x43 | 1 | 2 | - |
| Response: | 0x43 | 0 | 2 | 2 Bytes |

**Data Format:**

Byte 1 — Each bit specifies an error condition (see table below). If a bit is set to 1, the error condition assigned to that bit is present. If the bit is set to 0, the error is not present.

Byte 2 — Each bit specifies an error condition (see table below). If a bit is set to 1, the error condition assigned to that bit is present. If the bit is set to 0, the error is not present.

| **Byte 1** | |
|---|---|
| Bit 0 | No ExSync signal in the last 5 seconds |
| Bit 1 | A reset has occurred. |
| Bit 2 | The camera is unlocked |
| Bit 3 | Reserved |
| Bit 4 | Unknown command ID specified in a read or write command |
| Bit 5 | A read or write command could not be executed; access denied |
| Bit 6 | The length member of the last command does not match the defined length |
| Bit 7 | Parameter error (currently has no meaning - reserved for future use) |

| **Byte 2** | |
|---|---|
| Bit 0 | FPGA; general error |
| Bit 1 | FPGA; no FPGA firmware available |
| Bit 2 | No FPGA/ADC command list available |
| Bit 3 | Error in FPGA/ADC command list item |
| Bit 4 | User set is erroneous |
| Bit 5 | Factory set is erroneous |
| Bit 6 | EEPROM checksum error (this is a checksum used to determine if the contents of the EEPROM are valid) |
| Bit 7 | No EEPROM command list available |

## 4.2.10 Bitrate Command

**Purpose:** To set the bitrate of the serial communications link. The bitrate is changed immediately after the successful receipt of this command. (The default bitrate is 9600.)

**Type:** This is a write only command.

| **Write Command:** | Cmd-ID | R/W-Flag | Data Length | Data |
|---|---|---|---|---|
| | 0x44 | 0 | 4 | 4 Bytes |
| Response: | None | | | |

**Data Format:**

| | |
|---|---|
| Byte 1 | An ID that specifies the bitrate (see table below). |
| Byte 2 | undefined - always write 0x00 |
| Byte 3 | undefined - always write 0x00 |
| Byte 4 | undefined - always write 0x00 |

| ID | Bitrate |
|---|---|
| 0x12 | 4800 |
| 0x13 | 9600 |
| 0x14 | 14400 |
| 0x15 | 19200 |
| 0x17 | 38400 |
| 0x19 | 57600 |
| 0x1A | 76800 |
| 0x1B | 115200 |

When changing the bitrate for serial communication, use the following procedure:

1. Issue the write command with the new bitrate.
2. Wait one second.
3. Change the bitrate on the serial port that the camera is connected to.
4. Restart the PC and the camera.
5. Resume communication.

# 5 Mechanical Considerations

## 5.1 Camera Dimensions and Mounting Facilities

The L100b camera housing is manufactured with high precision. Planar, parallel, and angular sides guarantee precise mounting with high repeatability.

L100b series cameras are equipped with four M4 mounting holes on the front and two M4 mounting holes on each side as indicated in Figure 5-1.

**Caution!**

To avoid collecting dust on the sensor, mount a lens on the camera immediately after unpacking it.

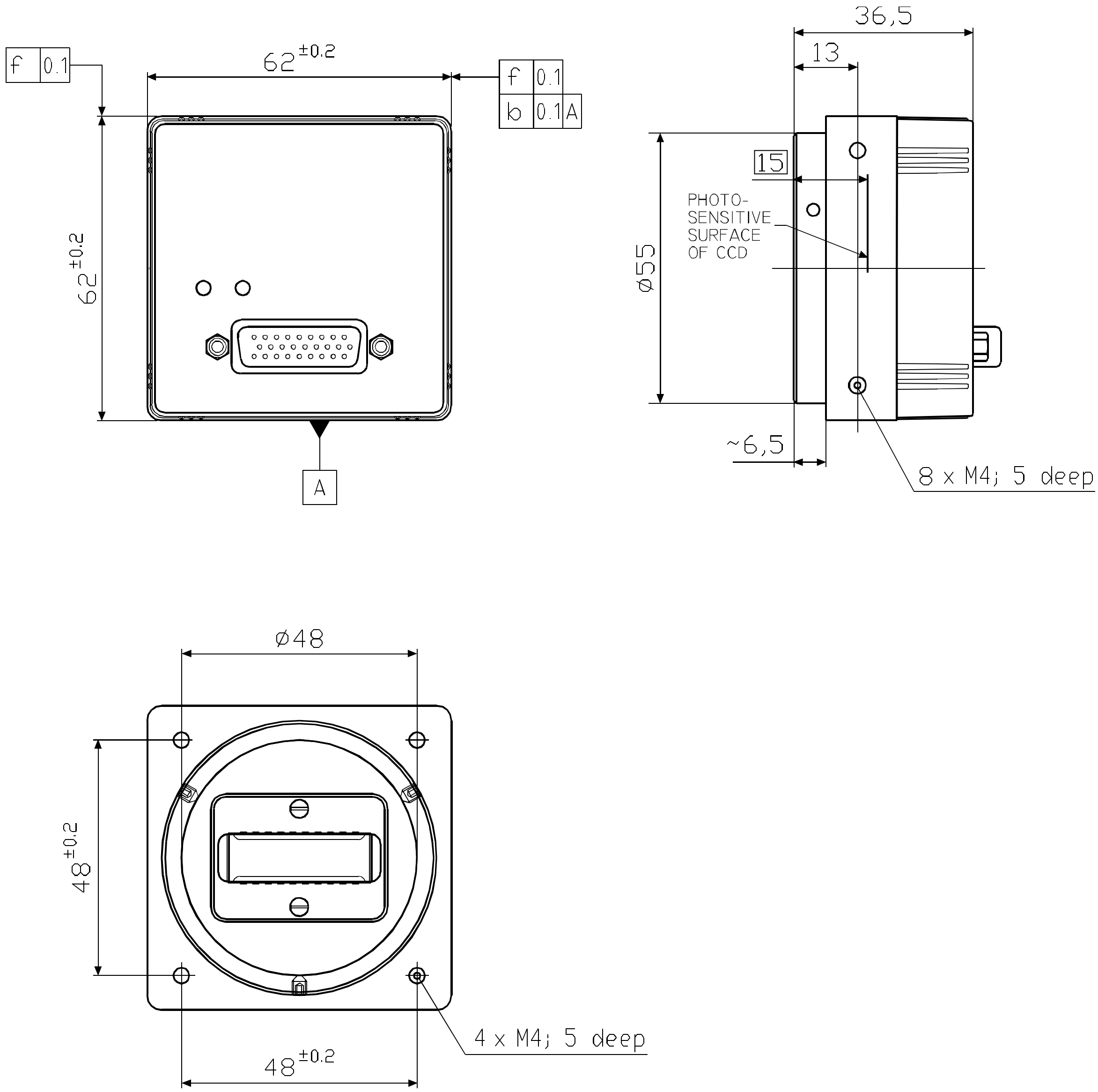



Figure 5-1: **L100b** Mechanical Dimensions (in mm)

# 5.2 C-Mount Adapter Dimensions

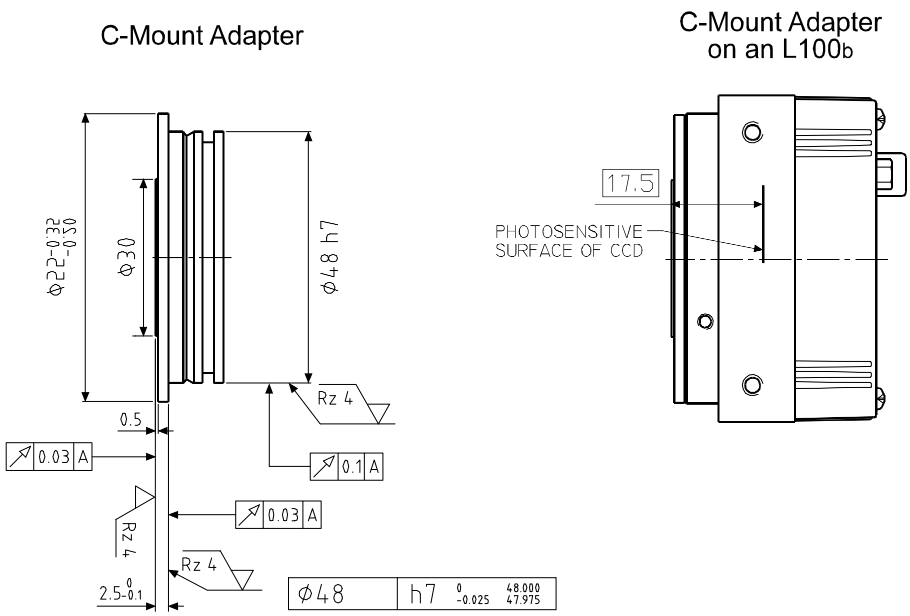



Figure 5-2: C-Mount Adapter Dimensions (in mm)

# 5.3 F-Mount Adapter Dimensions

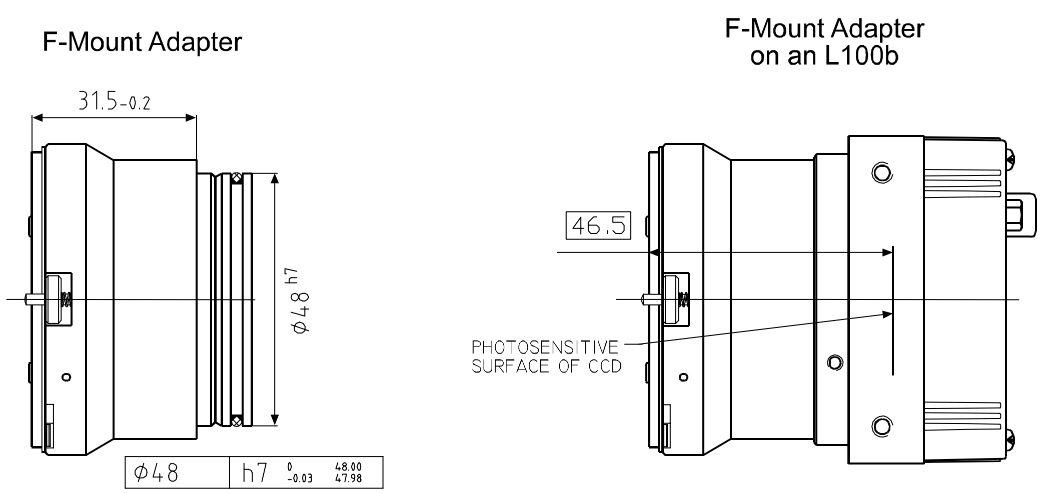
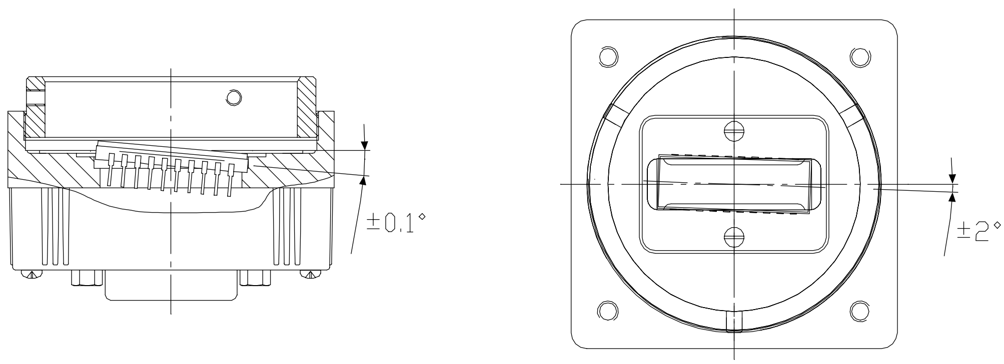



Figure 5-3: F-Mount Adapter Dimensions (in mm)

# 5.4 Positioning Accuracy of the Sensor Chip

Positioning accuracy of the sensor chip in the horizontal direction (that is, along the line of pixels) is ± 0.4 mm and in the vertical direction is ± 0.2 mm. Rotational positioning accuracy is as shown in Figure 5-4. Reference position is the center of the camera housing.

Since the translatory and rotational positioning tolerance depend on each other, the worst case of maximum rotational and horizontal/vertical mis-positioning cannot occur at the same time.




Not to scale. Not to scale.

Figure 5-4: Rotational Positioning Accuracy

# 6 Troubleshooting

## 6.1 Fault Finding Using Camera LEDs

### 6.1.1 Yellow LED

**L100b** series cameras regularly perform self tests. Detected errors are signaled by blinking of the yellow LED on the back of the camera. The number of pulses indicate the detected error. If several error states are present, the LED outputs the error codes in succession.

See Table 6-1 for the description of the pulses and the error states.

| LED | Description |
|---|---|
| On<br>Continuous | The camera is OK. |
| 3 pulses | ExSync has not changed state for 5 seconds or longer. If you are not supplying an ExSync signal to the camera, this is a normal condition and should be ignored. Otherwise check the cable and the ExSync generating device. |
| 5 pulses | The Work Set could not be stored into a User set.<br>Please contact Basler support. |
| 6 pulses | A User Set or the Factory Set could not be loaded into the Work Set.<br>Please contact Basler support. |
| 7 pulses | A valid list of commands was not available.<br>Please contact Basler support. |
| 8 pulses | The FPGA could not be configured. Please contact Basler Support |

Table 6-1: Camera Status Indicators

### 6.1.2 Green LED

When the green LED on the back of the camera is not lit, it means that no power is present. When the green LED is lit, it means that power is present.

Keep in mind that the circuit used to light the green LED does not perform a range check. If power is present but it is out of range, the LED may be lit but the camera will not operate properly.

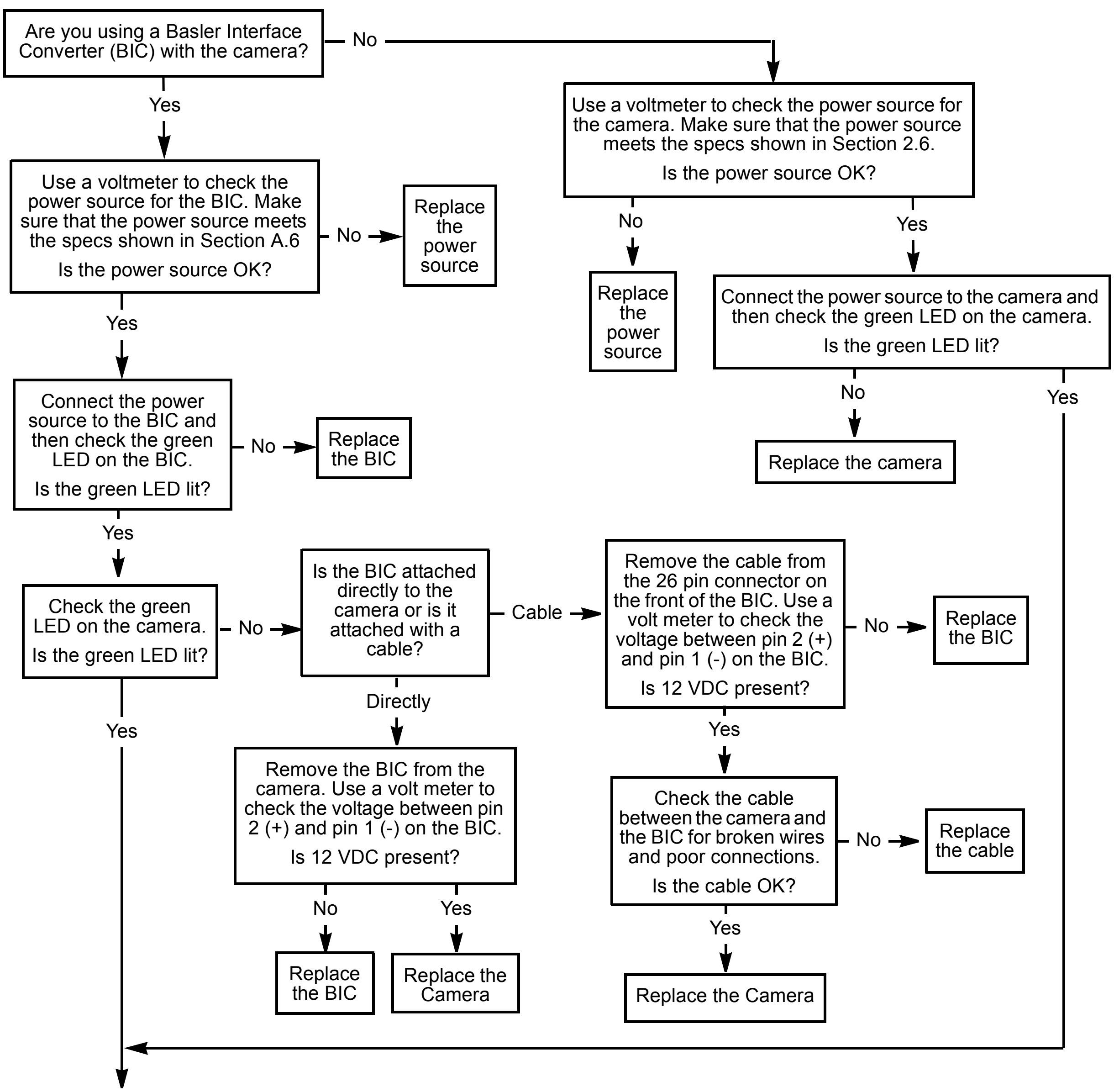
# 6.2 Troubleshooting Charts

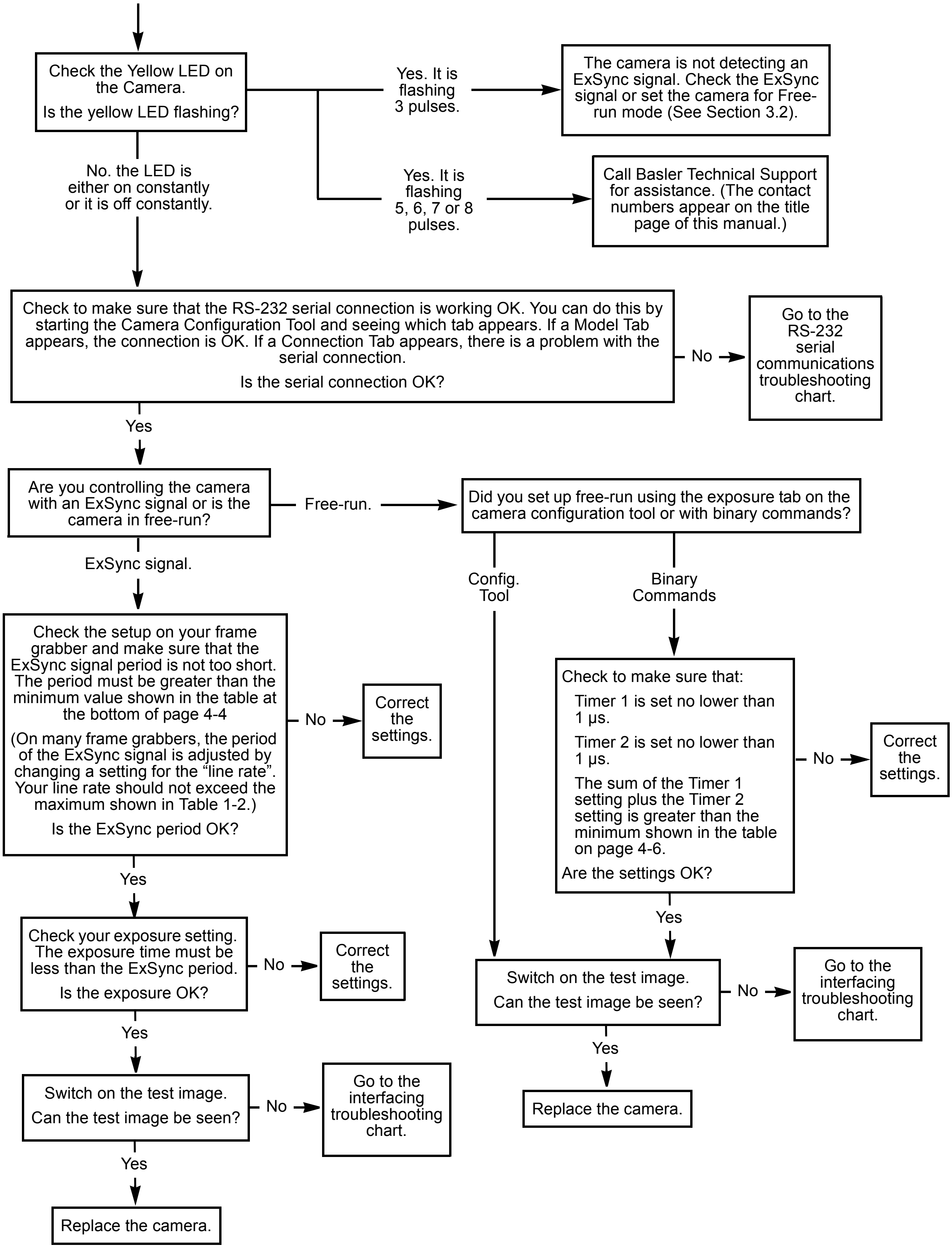
The following pages contain several troubleshooting charts which can help you find the cause of problems that users sometimes encounter. The charts assume that you are familiar with the camera's features and settings and with the settings for your frame grabber. If you are not, we suggest that you review the manuals for your camera and frame grabber before you troubleshoot a problem.

## 6.2.1 No Image

Use this chart if you see no image at all when you attempt to capture an image with your frame grabber (in this situation, you will usually get a message from the frame grabber such as "time-out"). If you see a poor quality image, a completely black image, or a completely white image, use the chart in Section 6.2.2.

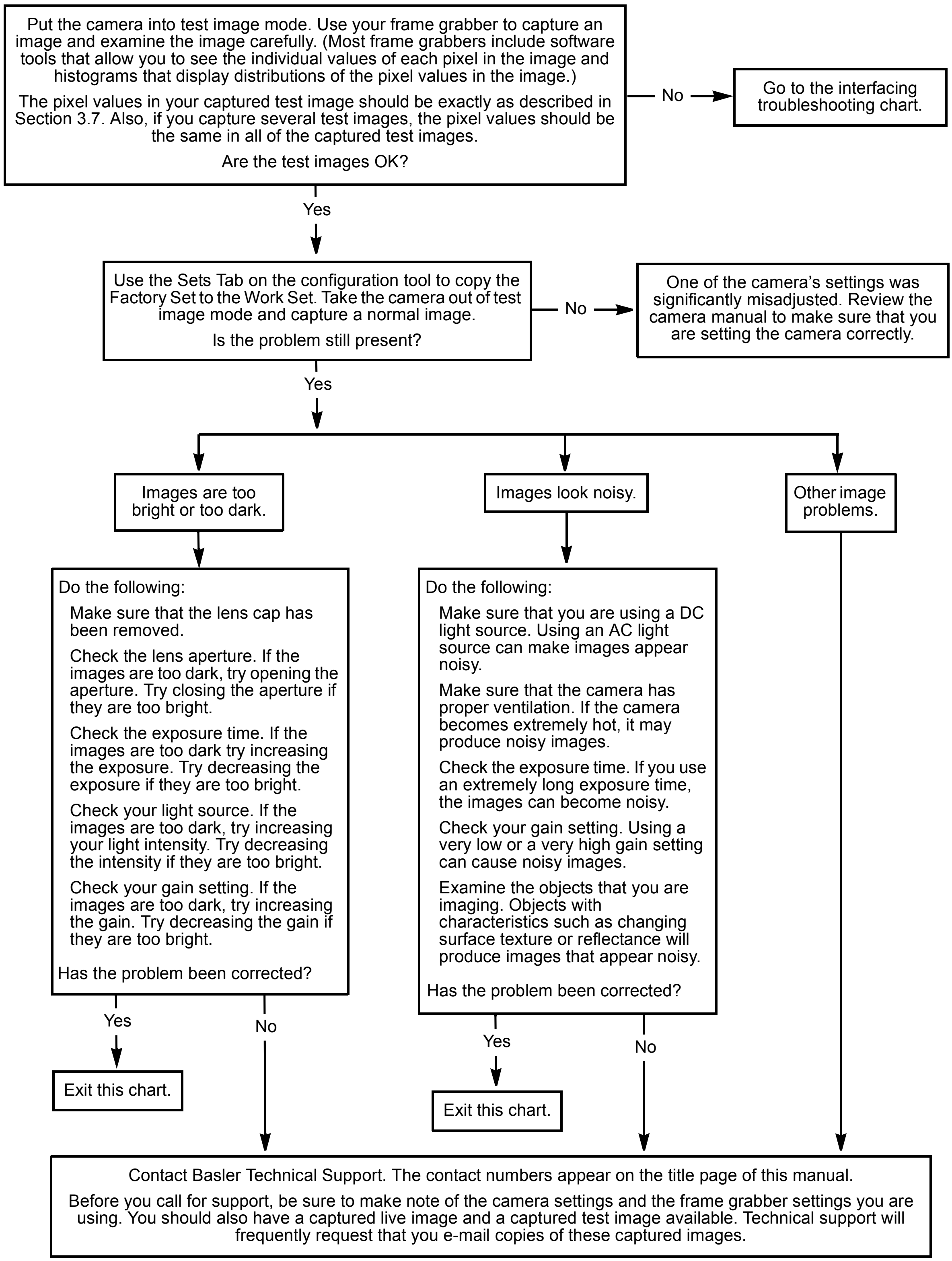
**Always switch off power to the system before making or breaking any connection.**




Check the Yellow LED on the Camera.
Is the yellow LED flashing?
Yes. It is flashing 3 pulses.
The camera is not detecting an ExSync signal. Check the ExSync signal or set the camera for Free-run mode (See Section 3.2).
Yes. It is flashing 5, 6, 7 or 8 pulses.
Call Basler Technical Support for assistance. (The contact numbers appear on the title page of this manual.)
No. the LED is either on constantly or it is off constantly.
Check to make sure that the RS-232 serial connection is working OK. You can do this by starting the Camera Configuration Tool and seeing which tab appears. If a Model Tab appears, the connection is OK. If a Connection Tab appears, there is a problem with the serial connection.
Is the serial connection OK?
No
Go to the RS-232 serial communications troubleshooting chart.
Yes
Are you controlling the camera with an ExSync signal or is the camera in free-run?
Free-run.
Did you set up free-run using the exposure tab on the camera configuration tool or with binary commands?
Config. Tool
Binary Commands
ExSync signal.
Check the setup on your frame grabber and make sure that the ExSync signal period is not too short. The period must be greater than the minimum value shown in the table at the bottom of page 4-4
(On many frame grabbers, the period of the ExSync signal is adjusted by changing a setting for the “line rate”. Your line rate should not exceed the maximum shown in Table 1-2.)
Is the ExSync period OK?
No
Correct the settings.
Check to make sure that:
Timer 1 is set no lower than 1 µs.
Timer 2 is set no lower than 1 µs.
The sum of the Timer 1 setting plus the Timer 2 setting is greater than the minimum shown in the table on page 4-6.
Are the settings OK?
No
Correct the settings.
Yes
Check your exposure setting. The exposure time must be less than the ExSync period.
Is the exposure OK?
No
Correct the settings.
Yes
Switch on the test image.
Can the test image be seen?
No
Go to the interfacing troubleshooting chart.
Yes
Replace the camera.
Switch on the test image.
Can the test image be seen?
No
Go to the interfacing troubleshooting chart.
Yes
Replace the camera.

## 6.2.2 Poor Quality Image

Use this chart if the image is poor quality, is completely white, or is completely black. If you get no image at all when you attempt to capture an image with the frame grabber, use the chart that appears in Section 6.2.1.

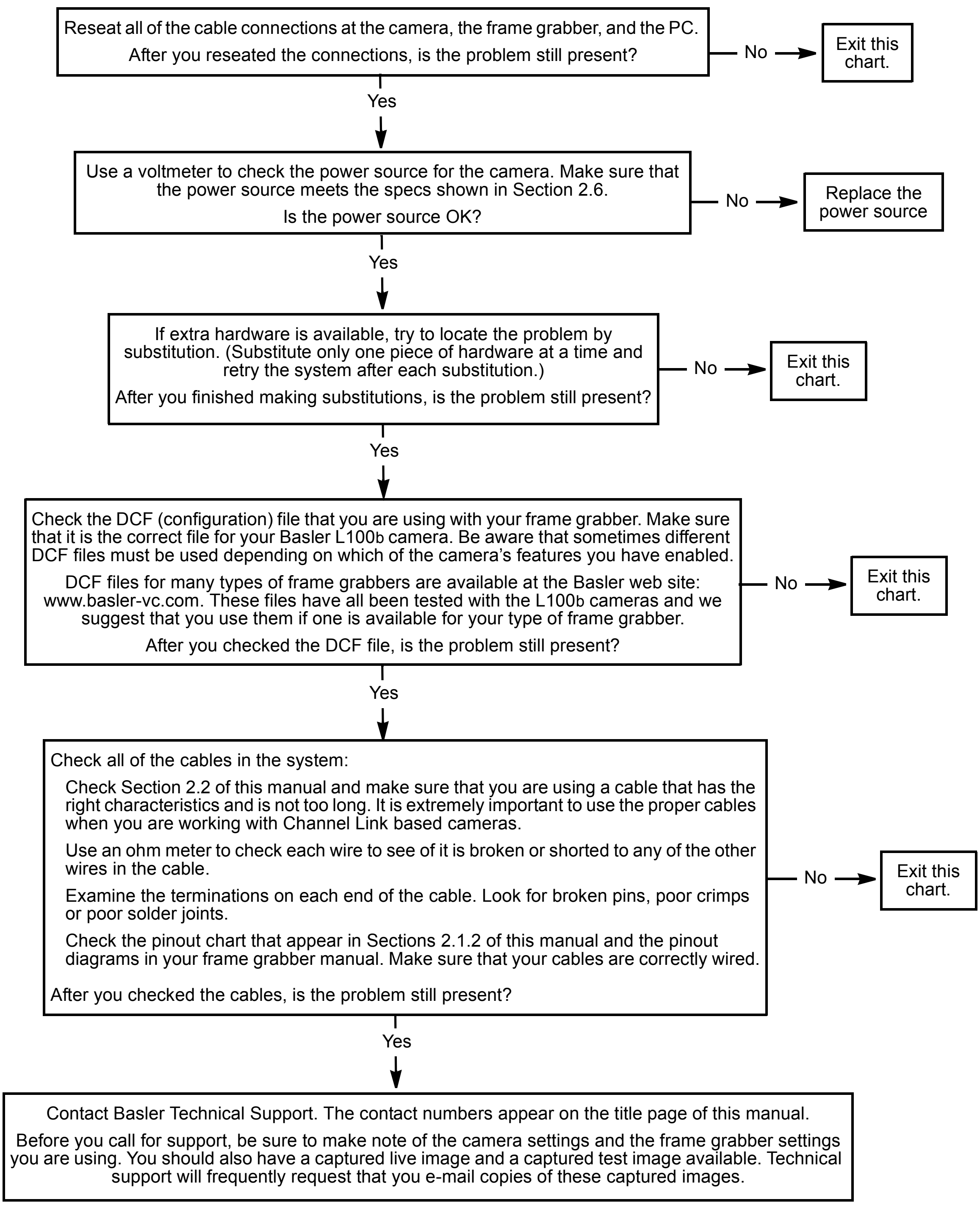


### 6.2.3 Interfacing

Use the interfacing troubleshooting charts if you think that there is a problem with the cables between your devices or if you have been directed here from another chart. Go to Chart A if you are using the camera without a Basler Interface Converter (BIC) and use Chart B if you are using the camera with a BIC.

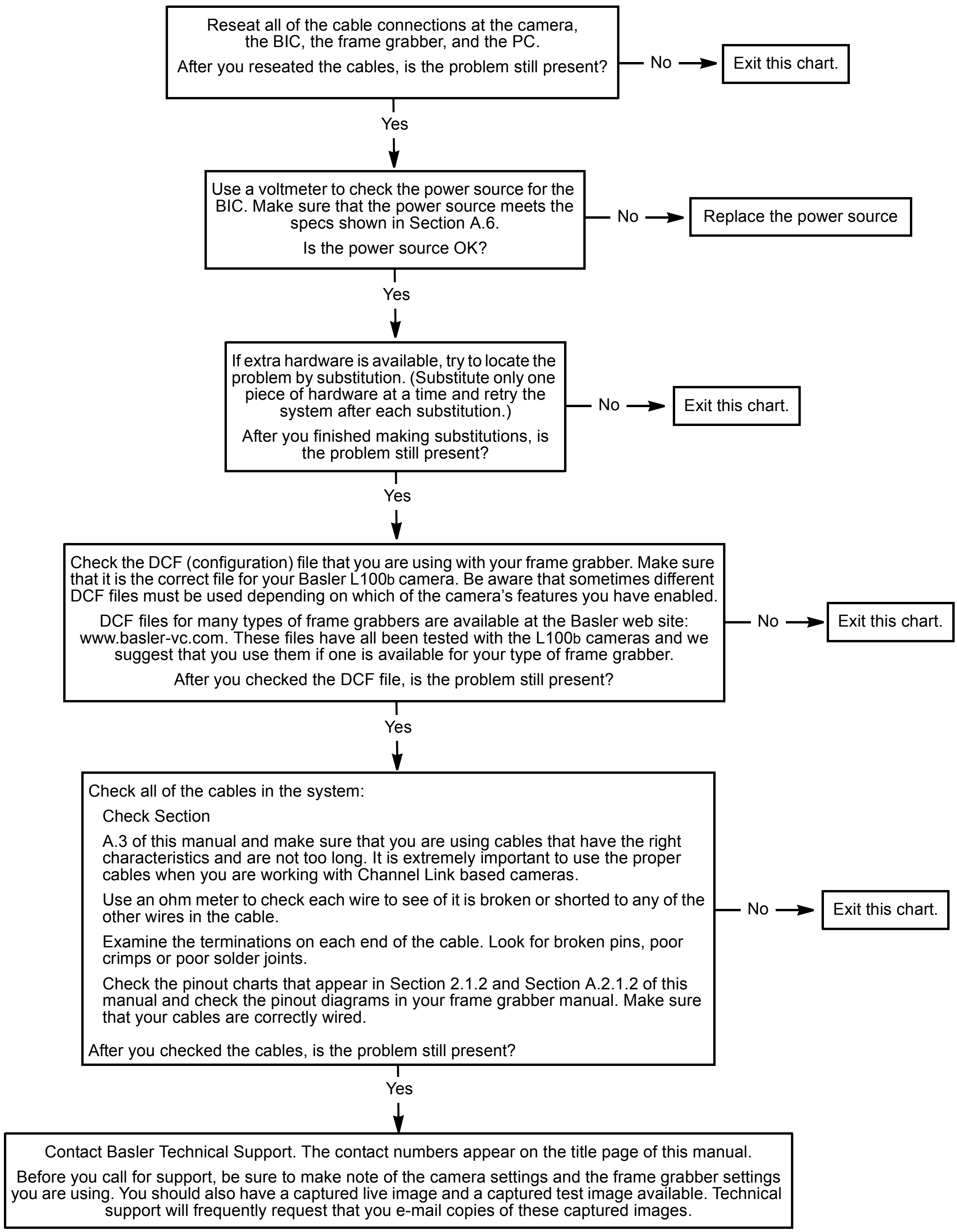
#### Interfacing Chart A (without a BIC)

**Always switch off power to the system before making or breaking any connection**



## Interfacing Chart B (with a BIC)

**Always switch off power to the system before making or breaking any connection.**

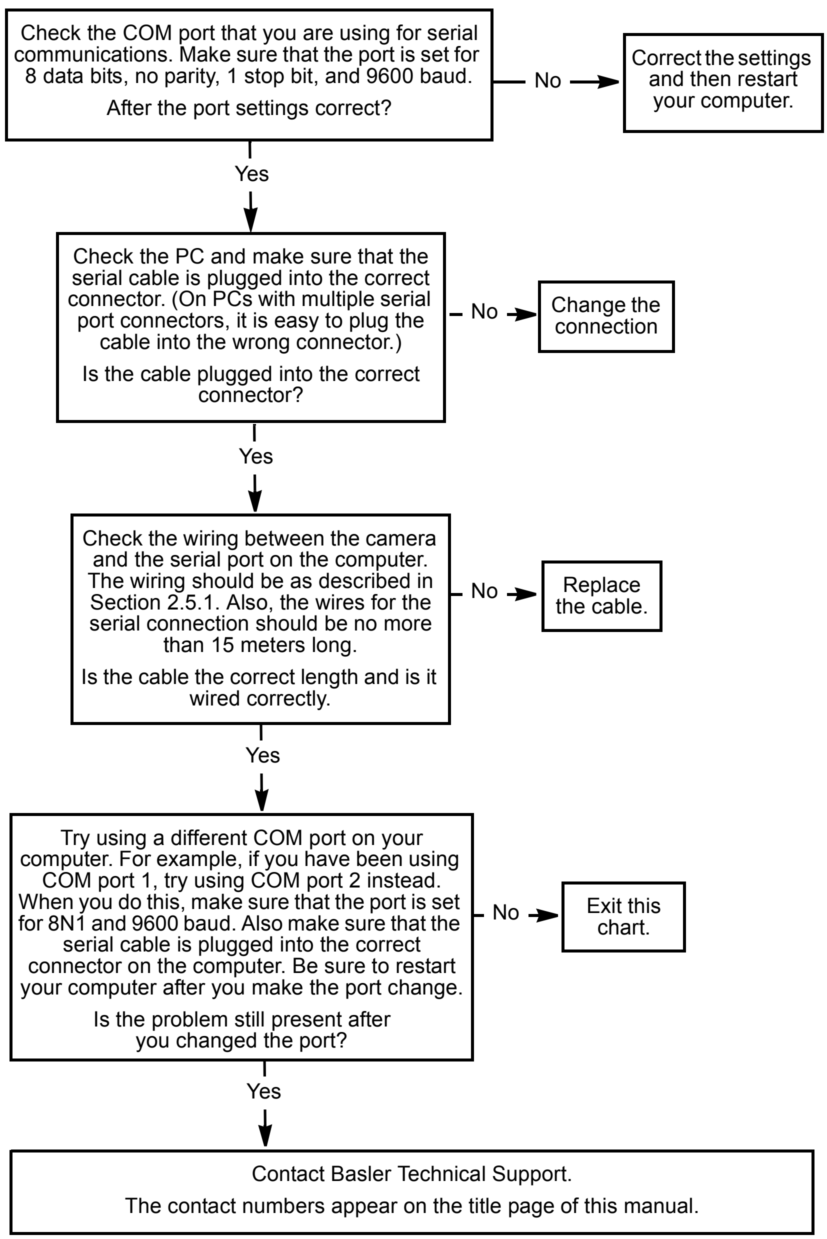


## 6.2.4 RS-232 Serial Communication

Use the serial communication troubleshooting charts if you think that there is a problem with RS-232 serial communication or if you have been directed here from another chart. Go to Chart A if you are using the camera without a Basler Interface Converter (BIC) and go to Chart B if you are using the camera with a BIC.

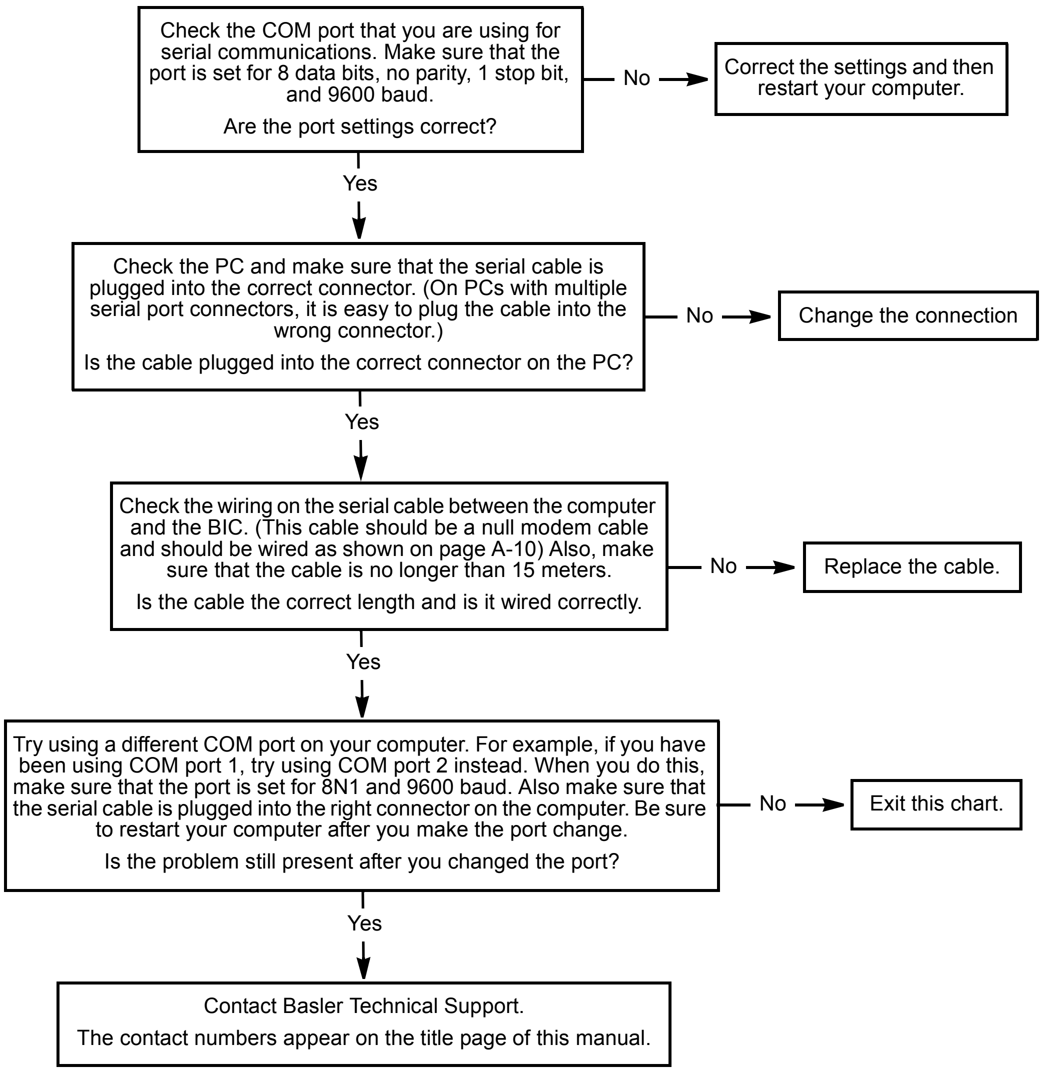
### Serial Communication Chart A (without a BIC)

**Always switch off power to the system before making or breaking any connection.**



## Serial Communication Chart B (with a BIC)

**Always switch off power to the system before making or breaking any connection.**



# Appendix A
# Using the Camera with a BIC

## A.1 Introduction

As mentioned in Section 2.4, video data is output from **L100b** series cameras in a Channel Link LVDS format. The video output from the camera can be converted to LVDS as specified for RS-644 by using a Basler Interface Converter (BIC). The BIC is a small device that attaches to the **L100b**.

### A.1.1 BIC Functional Description

As shown in the block diagram in Figure A-1, a channel link receiver in the BIC receives the output data from the camera in Channel Link LVDS format. The receiver converts the Channel Link signals to TTL level signals and passes the TTL signals to a group of RS-644 LVDS transmitters. The LVDS transmitters convert the TTL level signals to standard LVDS signals as specified for RS-644 and transmit the signals out of the BIC.

The **L100b** can accept an ExSync input signal in RS-644 LVDS format. The ExSync signal from the frame grabber is passed through the BIC to the camera using a straight through connection with no active circuitry.

Configuration commands and responses are transmitted between the camera and the host computer via an RS-232 serial connection. RS-232 commands and responses are passed through the BIC using a straight through connection with no active circuitry.

The BIC requires a 24 VDC power input. **L100b** cameras, however, require 12 VDC power. The BIC converts incomming 24 VDC to 12 VDC and supplies 12 VDC to the camera.

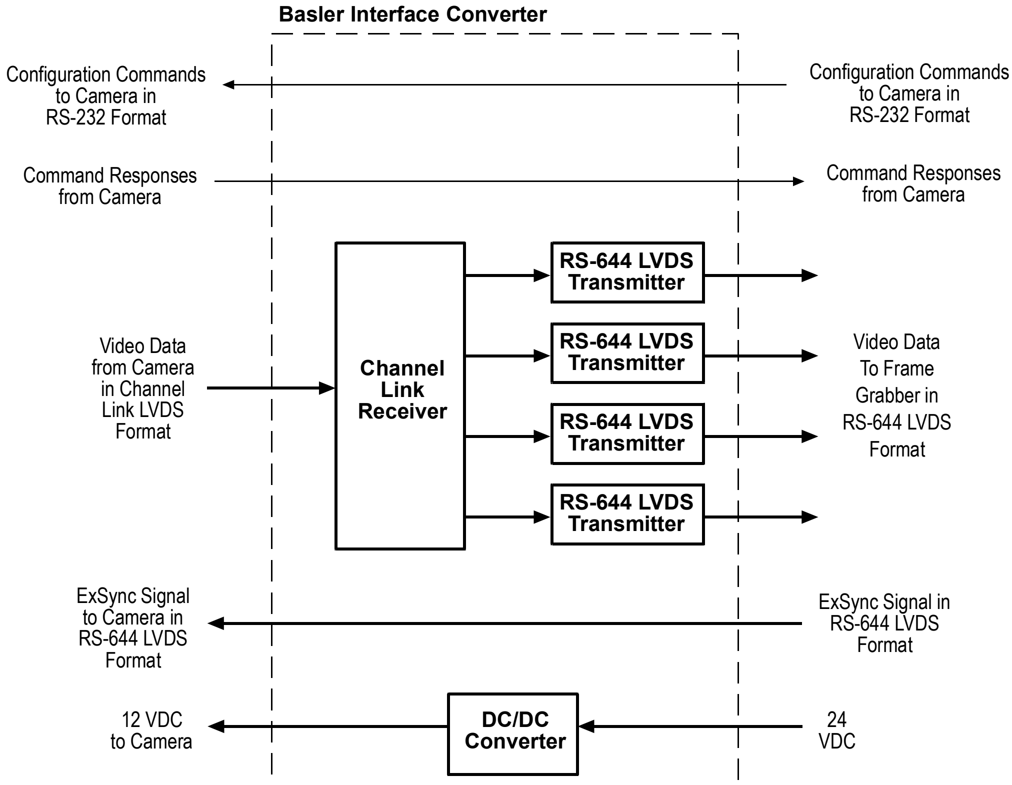



Figure A-1: BIC Block Diagram

## A.1.2 BIC Specifications

| Category | Specification |
|---|---|
| Video Input | Channel Link LVDS |
| Video Output | RS-644 LVDS |
| Power Requirements | 24 VDC (± 10%), max. 8 / 10 / 12 W (when attached to an L101b / L103b / L104b respectively) |
| Pixel Clock Speed | Depends on the version and the output mode of the attached camera (see Sections A.4.2.4 and A.4.2.5). |
| Size | 35.5 mm x 59.5 mm x 59.5 mm (L x W x H) |
| Weight | ~ 110 g |

Table A-1: BIC Specifications

## A.1.3 BIC Environmental Requirements

### A.1.3.1 Temperature and Humidity

| | |
|---|---|
| Housing temperature during operation: | 0° C ... + 50° C (+ 32° F ... + 122° F) |
| Humidity during operation: | 20% ... 80%, relative, non-condensing |

### A.1.3.2 Ventilation

Allow sufficient air circulation around the BIC to prevent internal heat build-up in your system and to keep the BIC housing temperature during operation below 50° C. Provide additional cooling such as fans or heat sinks if necessary.

**Warning!**

Without sufficient cooling the BIC can get hot enough during operation to cause burning when touched.

## A.1.4 BIC Precautions

**Power**

**Caution!**

Be sure that all power to your system is switched off before you make or break connections to the camera or the BIC. Making or breaking connections when power is on can result in damage to the camera or the BIC.

**Keep foreign matter outside of the BIC**

Do not open the housing. Touching internal components may damage them.

Be careful not to spill water or other liquids on the BIC. Do not allow flammable or metallic material inside of the housing. If used with any foreign matter inside, the BIC may fail or cause a fire.

**Electromagnetic Fields**

Do not operate the BIC in the vicinity of strong electromagnetic fields. Avoid electrostatic charging.

**Transporting**

Only transport the BIC in its original packaging. Do not discard the packaging.

**Cleaning**

To clean the surface of the BIC housing, use a soft, dry cloth. To remove severe stains, use a soft cloth dampened with a small quantity of neutral detergent, then wipe dry.

Do not use volatile solvents such as benzine and thinners; they may damage the surface finish.

# A.2 BIC Interface Description

## A.2.1 Connections

### A.2.1.1 General Description

The BIC is interfaced to external circuitry via one connector on its front and three connectors on its back. Figure A-2 shows the connector types used on the BIC and shows the location of the power indicator LED. Figure A-3 provides a general description of the function of each connector on the BIC. Figure A-4 shows how the pins in the BIC's connectors are numbered.

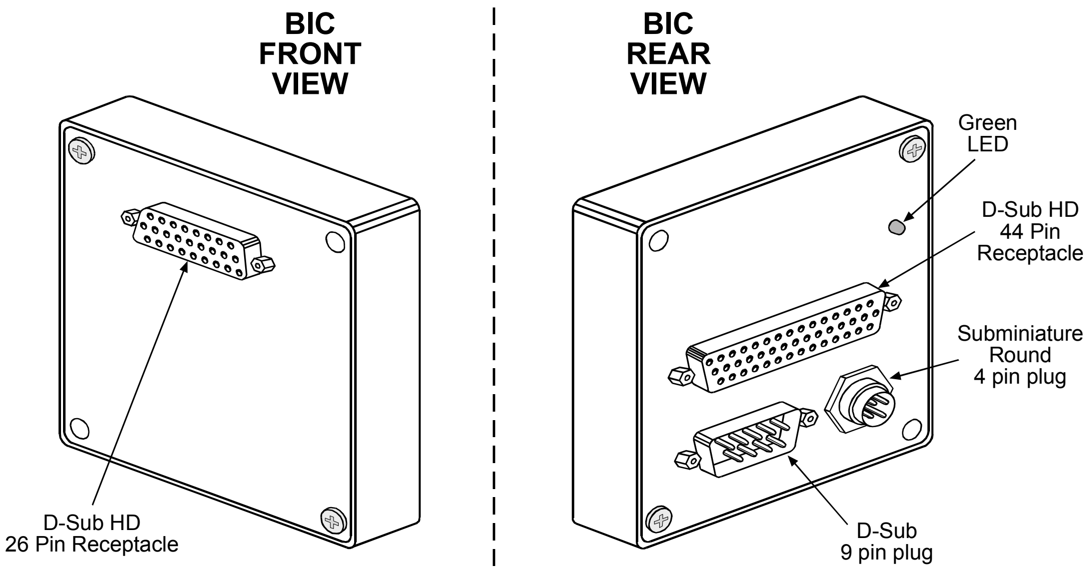



Figure A-2: BIC Connector Types

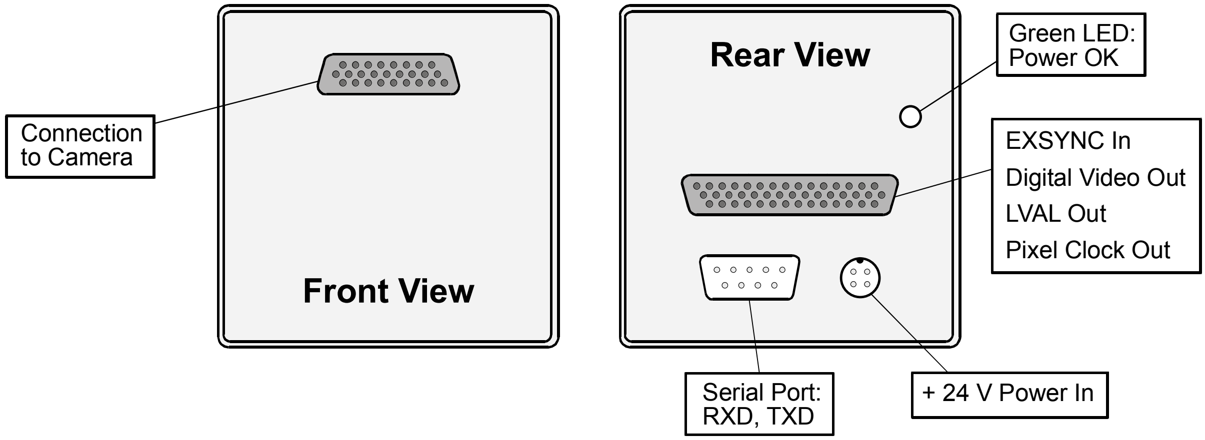



Figure A-3: BIC Connectors and Signals

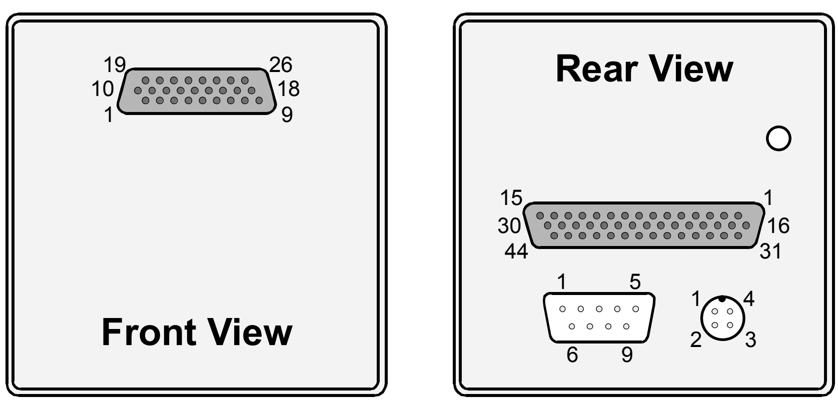



Figure A-4: BIC Pin Numbering

### A.2.1.2 Pin Assignments

The D-Sub HD 26-pin receptacle on the front of the BIC is used to interface video data and control signals with the camera. The pin assignments for the receptacle are shown in Table A-2.

| Pin Number | Signal Name | Direction | Level | Function |
|---|---|---|---|---|
| 1, 9, 18, 19, 25, 26 [1] | DC Gnd | Output | Ground | DC Ground |
| 2, 20 [2] | +12 VDC | Output | 12 VDC ± 10% | DC Power Output to the Camera |
| 22 | TxD | Output | RS-232 | RS-232 Serial Communication |
| 24 | RxD | Input | RS-232 | RS-232 Serial Communication |
| 21, 23[1] | Signal Gnd | Output | Ground | Signal Ground |
| 11 | ExSync+ | Output | RS-644 LVDS | External Trigger |
| 10 | ExSync- | | | |
| 13 | Reserved+ | Output | RS-644 LVDS | Reserved LVDS Output |
| 12 | Reserved- | | | |
| 17 | RxClkIn+ | Input | Channel Link LVDS | Receive Clock to Channel Link Receiver |
| 16 | RxClkIn- | | | |
| 8 | RxDataIn3+ | Input | Channel Link LVDS | Data to Channel Link Receiver |
| 7 | RxDataIn3- | | | |
| 6 | RxDataIn2+ | Input | Channel Link LVDS | Data to Channel Link Receiver |
| 5 | RxDataIn2- | | | |
| 15 | RxDataIn1+ | Input | Channel Link LVDS | Data to Channel Link Receiver |
| 14 | RxDataIn1- | | | |
| 4 | RxDataIn0+ | Input | Channel Link LVDS | Data to Channel Link Receiver |
| 3 | RxDataIn0- | | | |

[1] Pins 1, 9, 18, 19, 25, 26, 21 and 23 are all tied together inside of the BIC.

[2] Pins 2 and 20 are tied together inside of the BIC.

Table A-2: Pin Assignments for the D-sub HD 26-pin Receptacle

The BIC housing is not grounded and is electrically isolated from the circuit boards inside of the BIC.

The D-Sub 9-pin plug on the back of the BIC is used for RS-232 communication between the host computer and the camera. The pin assignments for the plug are shown in Table A-3.

| Pin Number | Signal Name | Direction | Level | Function |
|---|---|---|---|---|
| 1 | | | | Not Connected |
| 2 | RxD | Input | RS-232 | RS-232 Serial Communication |
| 3 | TxD | Output | RS-232 | RS-232 Serial Communication |
| 4 | | | | Tied to pin 6 internally |
| 5 | Signal Gnd | Input | Ground | Signal Ground |
| 6 | | | | Tied to pin 4 internally |
| 7 | | | | Tied to pin 8 internally |
| 8 | | | | Tied to pin 7 internally |
| 9 | | | | Not Connected |

Table A-3: Pin Assignments for the D-sub 9-pin Plug

The subminiature, round 4-pin plug on the back of the BIC is used for input power. The pin assignments for the plug are shown in Table A-4.

| Pin Number | Signal Name | Direction | Level | Function |
|---|---|---|---|---|
| 1 | DC Gnd | Input | Ground | DC Ground |
| 2 | | | | Tied to pin 1 internally |
| 3 | +24 VDC | Input | 24 VDC ± 10% | DC Power input for the BIC |
| 4 | | | | Tied to pin 3 internally |

Table A-4: Pin Assignments for the Subminiature, Round 4-pin Plug

The D-Sub HD 44-pin receptacle on the back of the BIC is used to interface video data and control signals with the frame grabber. The pin assignments for the receptacle are shown in Table A-5. As shown in the table, the assignment of pixel data varies depending on the output mode setting of the camera that is attached to the BIC.

| Pin Number | Signal Name | Direction | Level | Single 10 Bit Output Mode | Single 8 Bit Output Mode | Dual 8 Bit Output Mode |
|---|---|---|---|---|---|---|
| 1 | DOUT 0 | Output | RS-644 LVDS | Pixel Bit 0 | Pixel Bit 0 | Odd Pixel Bit 0 |
| 2 | DOUT 1 | Output | RS-644 LVDS | Pixel Bit 1 | Pixel Bit 1 | Odd Pixel Bit 1 |
| 3 | DOUT 2 | Output | RS-644 LVDS | Pixel Bit 2 | Pixel Bit 2 | Odd Pixel Bit 2 |
| 4 | DOUT 3 | Output | RS-644 LVDS | Pixel Bit 3 | Pixel Bit 3 | Odd Pixel Bit 3 |
| 5 | DOUT 4 | Output | RS-644 LVDS | Pixel Bit 4 | Pixel Bit 4 | Odd Pixel Bit 4 |
| 6 | DOUT 5 | Output | RS-644 LVDS | Pixel Bit 5 | Pixel Bit 5 | Odd Pixel Bit 5 |
| 7 | DOUT 6 | Output | RS-644 LVDS | Pixel Bit 6 | Pixel Bit 6 | Odd Pixel Bit 6 |
| 8 | DOUT 7 | Output | RS-644 LVDS | Pixel Bit 7 | Pixel Bit 7 (MSB) | Odd Pixel Bit 7 (MSB) |
| 9 | DOUT 8 | Output | RS-644 LVDS | Pixel Bit 8 | Not Used | Even Pixel Bit 0 |
| 10 | DOUT 9 | Output | RS-644 LVDS | Pixel Bit 9 (MSB) | Not Used | Even Pixel Bit 1 |
| 11 | DOUT 10 | Output | RS-644 LVDS | Not Used | Not Used | Even Pixel Bit 2 |
| 12 | DOUT 11 | Output | RS-644 LVDS | Not Used | Not Used | Even Pixel Bit 3 |
| 13 | DOUT 12 | Output | RS-644 LVDS | Not Used | Not Used | Even Pixel Bit 4 |
| 14 | DOUT 13 | Output | RS-644 LVDS | Not Used | Not Used | Even Pixel Bit 5 |
| 15 | DOUT 14 | Output | RS-644 LVDS | Not Used | Not Used | Even Pixel Bit 6 |
| 16 | /DOUT 0 | Output | RS-644 LVDS | /Pixel Bit 0 | /Pixel Bit 0 | /Odd Pixel Bit 0 |
| 17 | /DOUT 1 | Output | RS-644 LVDS | /Pixel Bit 1 | /Pixel Bit 1 | /Odd Pixel Bit 1 |
| 18 | /DOUT 2 | Output | RS-644 LVDS | /Pixel Bit 2 | /Pixel Bit 2 | /Odd Pixel Bit 2 |
| 19 | /DOUT 3 | Output | RS-644 LVDS | /Pixel Bit 3 | /Pixel Bit 3 | /Odd Pixel Bit 3 |
| 20 | /DOUT 4 | Output | RS-644 LVDS | /Pixel Bit 4 | /Pixel Bit 4 | /Odd Pixel Bit 4 |
| 21 | /DOUT 5 | Output | RS-644 LVDS | /Pixel Bit 5 | /Pixel Bit 5 | /Odd Pixel Bit 5 |
| 22 | /DOUT 6 | Output | RS-644 LVDS | /Pixel Bit 6 | /Pixel Bit 6 | /Odd Pixel Bit 6 |
| 23 | /DOUT 7 | Output | RS-644 LVDS | /Pixel Bit 7 | /Pixel Bit 7 | /Odd Pixel Bit 7 |
| 24 | /DOUT 8 | Output | RS-644 LVDS | /Pixel Bit 8 | Not Used | /Even Pixel Bit 0 |
| 25 | /DOUT 9 | Output | RS-644 LVDS | /Pixel bit 9 | Not Used | /Even Pixel Bit 1 |
| 26 | /DOUT 10 | Output | RS-644 LVDS | Not Used | Not Used | /Even Pixel Bit 2 |
| 27 | /DOUT 11 | Output | RS-644 LVDS | Not Used | Not Used | /Even Pixel Bit 3 |
| 28 | /DOUT 12 | Output | RS-644 LVDS | Not Used | Not Used | /Even Pixel Bit 4 |
| 29 | /DOUT 13 | Output | RS-644 LVDS | Not Used | Not Used | /Even Pixel Bit 5 |
| 30 | /DOUT 14 | Output | RS-644 LVDS | Not Used | Not Used | /Even Pixel Bit 6 |

Table A-5: Pin Assignments for the D-sub HD 44-pin Receptacle

| Pin Number | Signal Name | Direction | Level | Single 10 Bit Output Mode | Single 8 Bit Output Mode | Dual 8 Bit Output Mode |
|---|---|---|---|---|---|---|
| 31 | DOUT 15 | Output | RS-644 LVDS | Not Used | Not Used | Even Pixel Bit 7 (MSB) |
| 32 | /DOUT 15 | Output | RS-644 LVDS | Not Used | Not Used | /Even Pixel Bit 7 |
| 33 | LVAL | Output | RS-644 LVDS | Line Valid | Line Valid | Line Valid |
| 34 | /LVAL | Output | RS-644 LVDS | /Line Valid | /Line Valid | /Line Valid |
| 35 | PClk | Output | RS-644 LVDS | Pixel Clock | Pixel Clock | Pixel Clock |
| 36 | /PClk | Output | RS-644 LVDS | /Pixel Clock | /Pixel Clock | /Pixel Clock |
| 37 | SyncIn | Input | RS-644 LVDS | External Trigger | External Trigger | External Trigger |
| 38 | /SyncIn | Input | RS-644 LVDS | /External Trigger | /External Trigger | /External Trigger |
| 39 | Not used | | | | | |
| 40 | Not used | | | | | |
| 41 | Not Connected | | | | | |
| 42 | Not Connected | | | | | |
| 43 | Signal Gnd | Output | Ground | Signal Ground | Signal Ground | Signal Ground |
| 44 | Tied to pin 43 internally | | | | | |

/ means an inverted signal with the low signal being active

Table A-5: Pin Assignments for the D-sub HD 44-pin Receptacle

# A.3 Cable Information

## A.3.1 Channel Link Cable Between the Camera and the BIC

The BIC can be attached directly to a Channel Link based camera or a cable can be used between the camera and the BIC. In cases where a cable is used between the camera and the BIC, the cable must meet the specifications shown in Section 2.2.

## A.3.2 Video Data Cable Between the BIC and the Frame Grabber

The video data cable between the BIC and the frame grabber must be made with 28 gauge AWG twisted pair wire and have a characteristic impedance of 100 ohms.

The maximum allowed length of the cable depends on the camera model and the video data output mode that the camera is using. Maximum lengths are shown in Table A-6.

| | L101b | L103b | L104b |
|---|---|---|---|
| Single Output Modes | 20 meters | 11 meters | 5 meters |
| Dual Output Modes | 20 meters | 18 meters | 15 meters |

Table A-6: Video Data Cable Maximum Lengths

## A.3.3 RS-232 Cable Details

The RS-232 cable between the nine pin plug on the BIC and the serial port connector on the PC can be a null modem cable or a simple three wire connection as illustrated in Figure A-5.

For all L100b cameras in all operating modes, the maximum length of the RS-232 cable is 15 meters.

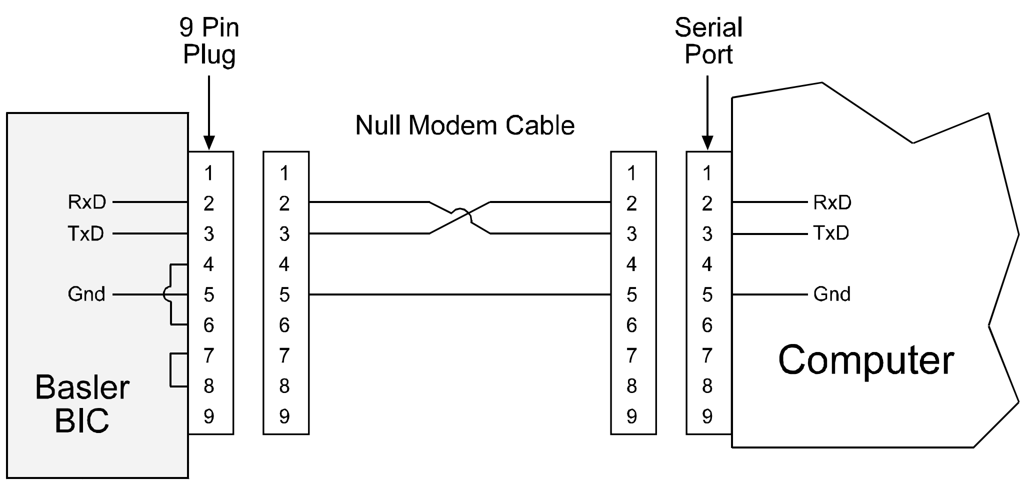



Figure A-5: BIC to PC RS-232 Interface Cable

| | |
|---|---|
| ☝ | The cable between the BIC and the PC must contain a twist so that pin 2 on the BIC connects to pin 3 on the PC and pin 3 on the BIC connects to pin 2 on the PC. |

# A.4 Video Data and Control Signals Between the BIC and the Frame Grabber

All video data and control signals transmitted between the BIC and the frame grabber use LVDS technology as specified for RS-644. Detailed information on RS-644 appears in Section A.4.3.

## A.4.1 Signals Input to the BIC by the Frame Grabber

### A.4.1.1 ExSync: Controls Line Readout and Exposure Time

The camera attached to the BIC can be programmed to function in several exposure time control modes. In some of these modes, an ExSync signal is used to control exposure time and line read out. For more detailed information on exposure control modes and the use of the ExSync signal, see Section 3.2.

ExSync can be a periodic or a non-periodic function. The frequency of the Exsync signal determines the camera's line rate.

The BIC accepts the ExSync signal from the frame grabber and passes it through to the camera using a straight through connection with no active circuitry.

## A.4.2 Signals Output from the BIC to the Frame Grabber

### A.4.2.1 LVAL: Indicates a valid Line

Line valid (LVAL) indicates a valid line of data as illustrated in Figures A-6 through A-9. Video data is valid when LVAL is High.

### A.4.2.2 Pixel Clock: Indicates a Valid Pixel

Pixel clock (PClk) indicates a valid pixel of data as illustrated in Figures A-6 through A-9. The LVAL and PClk signals are used to clock the digital video output data into external circuitry. Digital data is valid on the rising edge of the pixel clock with LVAL high.

The frequency of the pixel clock output from the BIC varies depending on the model and the output mode setting of the attached camera. See Sections A.4.2.4 and A.4.2.5 for more information.

### A.4.2.3 Video Data

The assignment of pixel data bits to the output pins of the BIC and the output sequence of the pixel data vary depending on the output mode of the attached camera. Table A-5 shows how the pixel data bits are assigned for each camera output mode. Sections A.4.2.4 and A.4.2.5 describe the data output sequence for each camera output mode.

| | |
|---|---|
| ☝ | The camera attached to the BIC **must** be set for Single 10 Bit, Single 8 Bit, or Dual 8 Bit output mode. The BIC can not accept Dual 10 Bit output from a camera. |

### A.4.2.4 BIC Operation with Attached Camera in Single 10 Bit or Single 8 Bit Output Mode

When the camera attached to the BIC is operating in Single 10 Bit output mode, the pixel clock output from the BIC will be 20 / 40 / 62.5 MHz when attached to an **L101b** / **L103b** / **L104b** respectively. On each clock cycle, the BIC will transmit 10 bits of pixel data. The assignment of the bits is shown in Table A-5.

When the camera attached to the BIC is operating in Single 8 Bit output mode, the pixel clock output from the BIC will be 20 / 40 / 62.5 MHz when attached to an **L101b** / **L103b** / **L104b** respectively. On each clock cycle, the BIC will transmit 8 bits of pixel data. (The two least significant bits output from each ADC are dropped.)

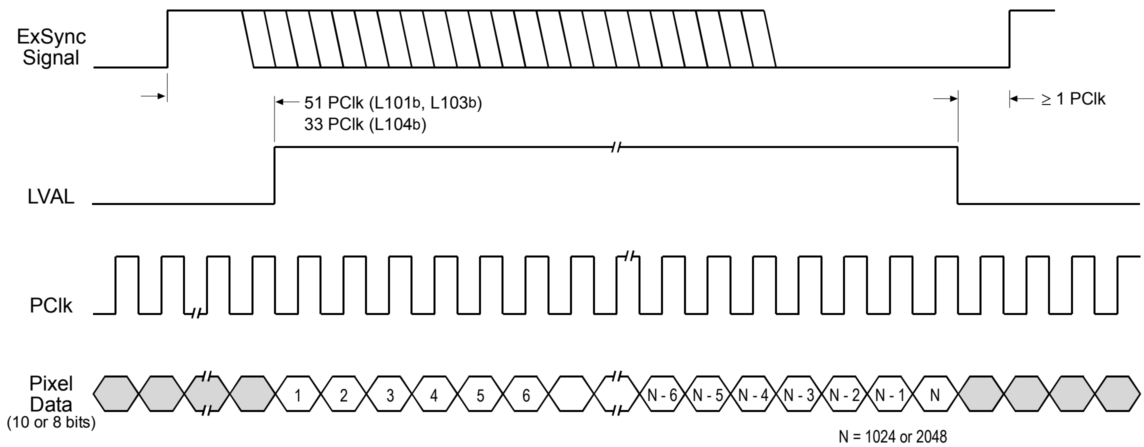
#### Video Data Sequence[1]

When the camera is not transmitting valid pixel data, the line valid signal on each cycle of the pixel clock will be low. Once the camera has completed line acquisition, it will begin to send valid data:

- On the pixel clock cycle where line data transmission begins, LVAL will become high. During this cycle, 10 bits of data for pixel one will be transmitted.
- On the second cycle of the pixel clock, LVAL will be high. During this cycle, 10 bits of data for pixel two will be transmitted.
- On the third cycle of the pixel clock, LVAL will be high. During this cycle, 10 bits of data for pixel three will be transmitted.
- This pattern will continue until all of the pixel data for the line has been transmitted. (A total of 1024 cycles for cameras with a 1K sensor and 2048 cycles for cameras with a 2K sensor.)
- After all of the pixels have been transmitted, LVAL will become low indicating that valid line data is no longer being transmitted.

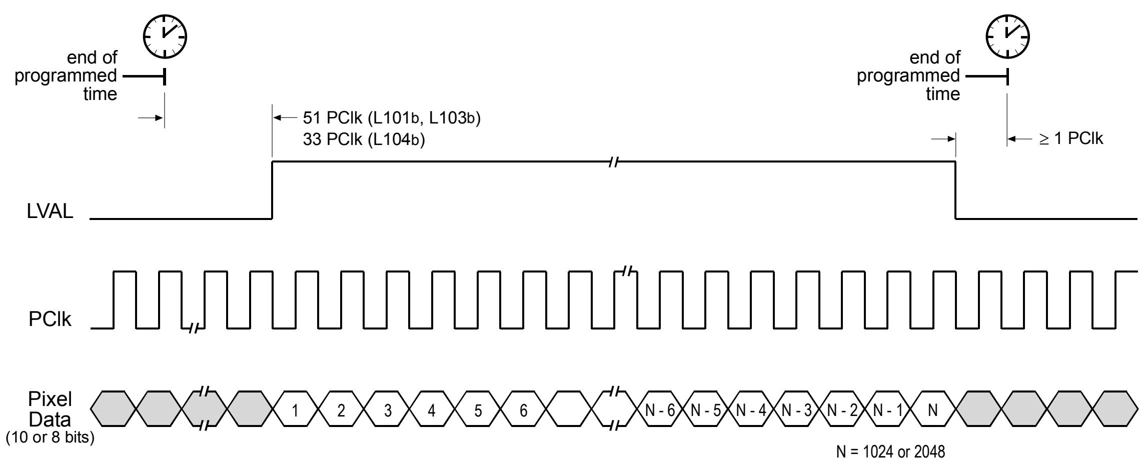
Figure A-6 shows the data sequence when the camera is operating in edge-controlled or level-controlled exposure mode. Figure A-7 shows the data sequence when the camera is operating in programmable exposure mode.

[1] The data sequence assumes that the camera attached to the BIC is operating in 10 bit mode. If the attached camera is operating in 8 bit mode, only 8 bits of data per pixel will be transmitted.




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure A-6: Single 10 Bit or Single 8 Bit Output Mode with Edge or Level Controlled Exposure




This diagram assumes that the area of interest feature is not being used. With the area of interest feature enabled, the number of pixels transferred could be smaller.

Figure A-7: Single 10 Bit or Single 8 Bit Output Mode with Programmable Exposure

### A.4.2.5 BIC Operation with Attached Camera in Dual 8 Bit Output Mode

When the camera attached to the BIC is operating in Dual 8 Bit output mode, the pixel clock output from the BIC will be 10 / 20 / 31.25 MHz when attached to a **L101b** / **L103b** / **L104b** respectively. On each clock cycle, the BIC will transmit 8 bits of data for two pixels. The assignment of the bits is shown in Table A-5.

### Video Data Sequence

When the camera is not transmitting valid data, the line valid signal on each cycle of the pixel clock will be low. Once the camera has completed line acquisition, it will begin to send valid data:

- On the pixel clock cycle where line data transmission begins, LVAL will become high. During this clock cycle, eight bits of data for pixel one and eight bits of data for pixel two will be transmitted.
- On the second cycle of the pixel clock, LVAL will be high. During this clock cycle, eight bits of data for pixel three and eight bits of data for pixel four will be transmitted.
- This pattern will continue until all of the pixel data for the line has been transmitted. (A total of 512 cycles for cameras with a 1K sensor and 1024 cycles for cameras with a 2K sensor.)
- After all of the pixels have been transmitted, LVAL will become low indicating that valid line data is no longer being transmitted.

Figure A-8 shows the data sequence when the camera is operating in edge-controlled or level-controlled exposure mode. Figure A-9 shows the data sequence when the camera is operating in programmable exposure mode.

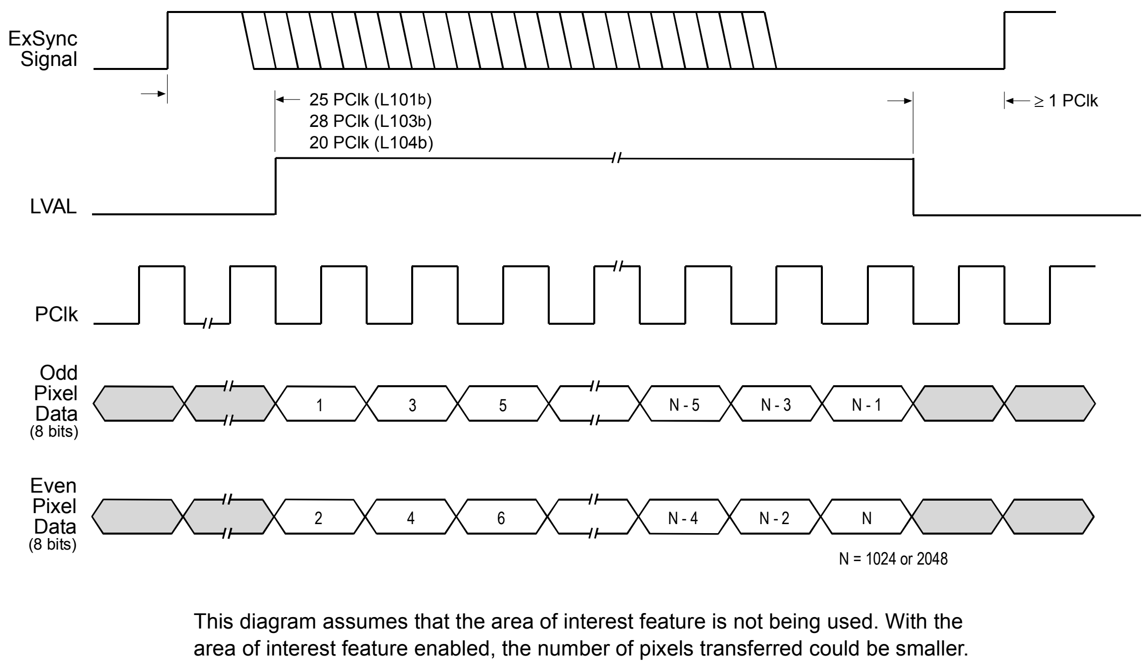



Figure A-8: Dual 8 Bit Output Mode with Edge or Level Controlled Exposure

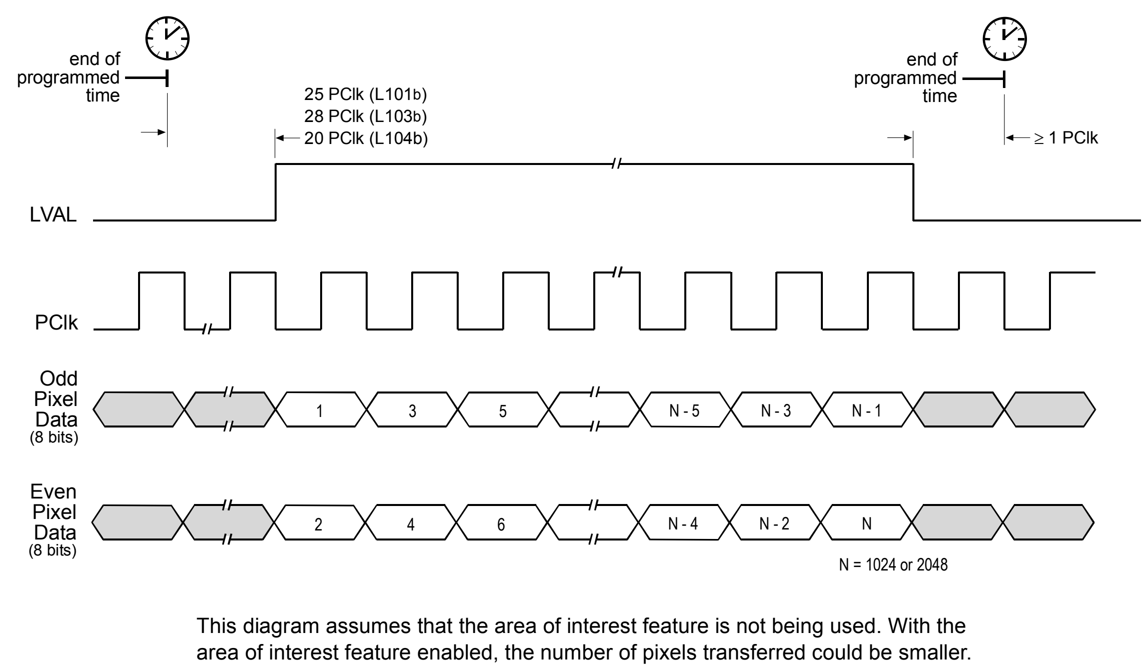



Figure A-9: Dual 8 Bit Output Mode with Programmable Exposure

## A.4.3 RS-644 LVDS Information

All video data and control signals output from the BIC and the ExSync control signal input to the BIC use LVDS technology as specified for RS-644.

As shown in Figure A-10, the BIC uses National Semiconductor DS90LV047A differential line drivers to generate the LVDS output signals DOut0 through DOut15, LValOut and PClkOut.

The ExSync control signal input to the BIC passes straight throug the BIC and into the camera. The camera uses a National Semiconductor DS90C032 differential line receiver to receive the ExSync input signal.

Detailed spec sheets for these devices are available at the National Semiconductor web site (www.national.com).

### A.4.3.1 RS-644/RS-422 Compatibility

**Outputs From the BIC**

The output voltage level for the RS-644 differential line drivers used in the BIC can range from a low of 0.90 V to a high of 1.6 V. The typical voltage swing for these devices is ± 0.31 V.

The receive threshold for typical RS-422 receivers is well within the ± 0.31 V swing generated by the RS-644 line drivers. Also, the input voltage tolerance for typical RS-422 receivers is well above the output voltage generated by the RS-644 devices. For these reasons, typical RS-422 receivers are compatible with the RS-644 signals output from the BIC.

**Inputs to the BIC**

As shown in Figure A-10, the ExSync signal input to the BIC passes directly though the BIC and on to the camera. The input voltage tolerance for the RS-644 receiver used in the camera is 0.0 V to 3.9 V.

On typical RS-422 transmitters, the output voltage can range as high as 4.0 V. As you see, the output voltage of a typical RS-422 transmitter can exceed the input voltage tolerance of the RS-644 receiver used in the camera. Therefore, RS-422 signals should not be input directly into the BIC.

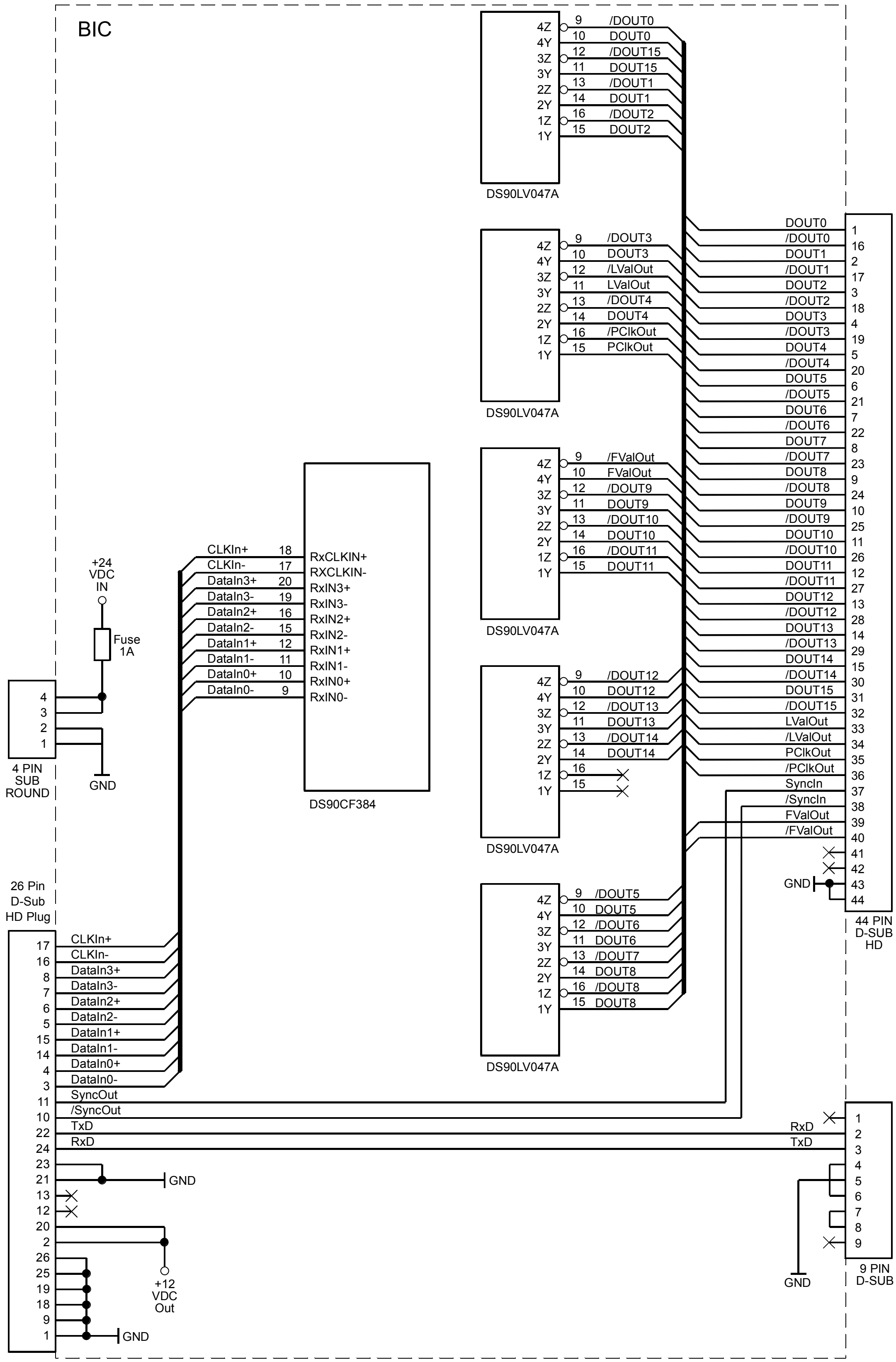



Figure A-10: BIC Power, RS-232, and Video Data Connections

# A.5 RS-232 Serial Connection

As mentioned in Section A.1.1, configuration commands and responses are transmitted between the camera and the host computer via an RS-232 serial connection. RS-232 commands and responses are passed through the BIC using a straight through connection with no active circuitry.

# A.6 Power Supply

The BIC requires a 24 VDC (± 10%) power supply. The maximum wattage required for a BIC is approximately 8 / 10 / 12 W when attached to an **L101b / L103b / L104b** respectively.

Ripple must be less than 1%.

> The BIC operates on 24 VDC, but **L100b** cameras operate on 12 VDC. The BIC will convert its 24 VDC input to 12 VDC and will supply 12 VDC to the camera.
>
> **DO NOT** apply 24 VDC to the camera.

# A.7 Status LED

**Green LED**

When the green LED on the BIC is lit, it indicates that power is being supplied to the BIC.

# A.8 Installing the Camera and the BIC

The camera and BIC can be installed in two ways: the BIC can be attached directly to the camera or the BIC can be connected to the camera with a cable. If you are installing a system with the BIC directly attached to the camera, start your installation with Section A.8.1. If you are installing a system with the BIC and camera connected with a cable, start your installation with Section A.8.2.

## A.8.1 Making Connections (BIC Directly Attached to Camera)

| | |
|---|---|
| ! | **Caution!**<br>Be sure that all power to your system is switched off before you make or break connections to the camera or the BIC. Making or breaking connections when power is on can result in damage to the camera or the BIC. |

1. Remove the six-sided standoffs on each side of the 26-pin plug on the back of the camera and on each side of the 26-pin receptacle on the front of the BIC (see Figure A-11). Replace the standoffs with pan head screws from the BIC installation kit.
2. Remove two screws from the back of the camera as shown in Figure A-11. Replace the screws with six-sided standoffs from the BIC installation kit.

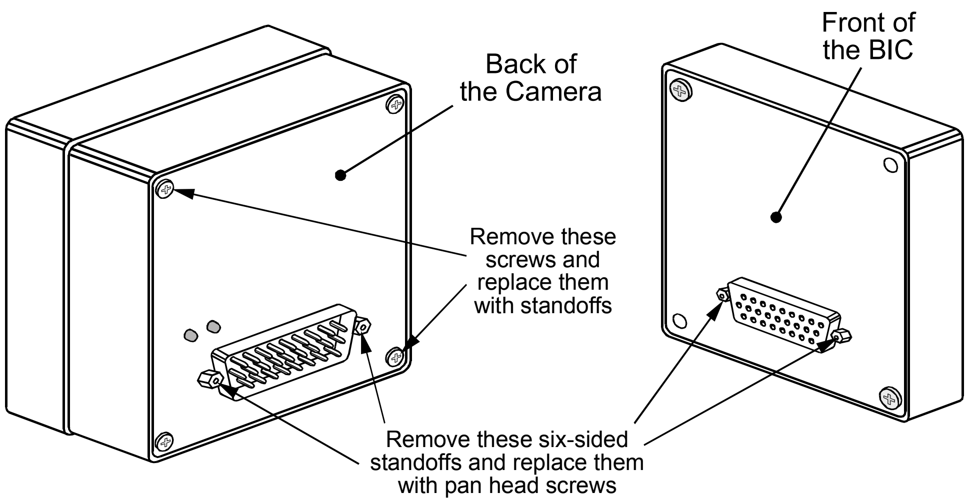



Figure A-11: Changing the Screws

3. Hold the camera and the BIC so that the 26 pin plug on the back of the camera is aligned with the 26 pin receptacle on the front of the BIC.
4. Press the camera and the BIC together.
5. Get two 20 mm long screws from the BIC installation kit. Insert the screws through the BIC (see Figure A-12) and screw them into the back of the camera. This will lock the BIC and the camera together.

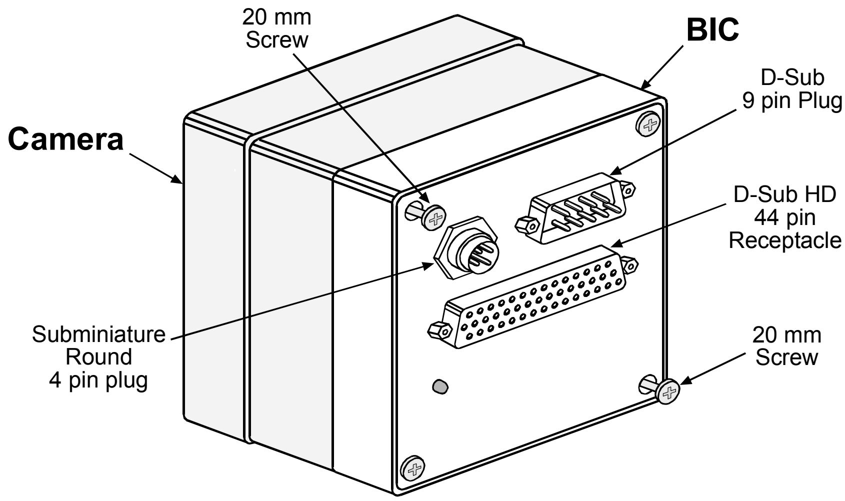



Figure A-12: BIC Mated Directly to Camera

6. Attach one end of your video data/control signal cable to the 44 pin receptacle on the BIC and the other end to your frame grabber.
7. Attach one end of a null modem cable to the nine pin plug on the BIC and the other end to a serial port on your computer.
8. Make sure that the power source you will be using to supply the BIC meets the requirements shown in Section A.6.
9. Attach the output connector from your power source to the four pin plug on the BIC.
10. Switch on the power to your system.
11. Go on to Section A.8.3 to continue the installation.

| | |
|---|---|
| ☝ | The BIC operates on 24 VDC, but **L100b** cameras operate on 12 VDC. The BIC will convert its 24 VDC input to 12 VDC and will supply 12 VDC to the camera. |

## A.8.2 Making Connections (BIC and Camera Mated with a Cable)

| | |
|---|---|
| ⚠ | **Caution!**<br>Be sure that all power to your system is switched off before you make or break connections to the camera or the BIC. Making or breaking connections when power is on can result in damage to the camera or the BIC. |

1. Connect a straight-through Channel Link Cable from the 26 pin plug on the back of the camera to the 26 pin receptacle on the front of the BIC (see Figure A-13).

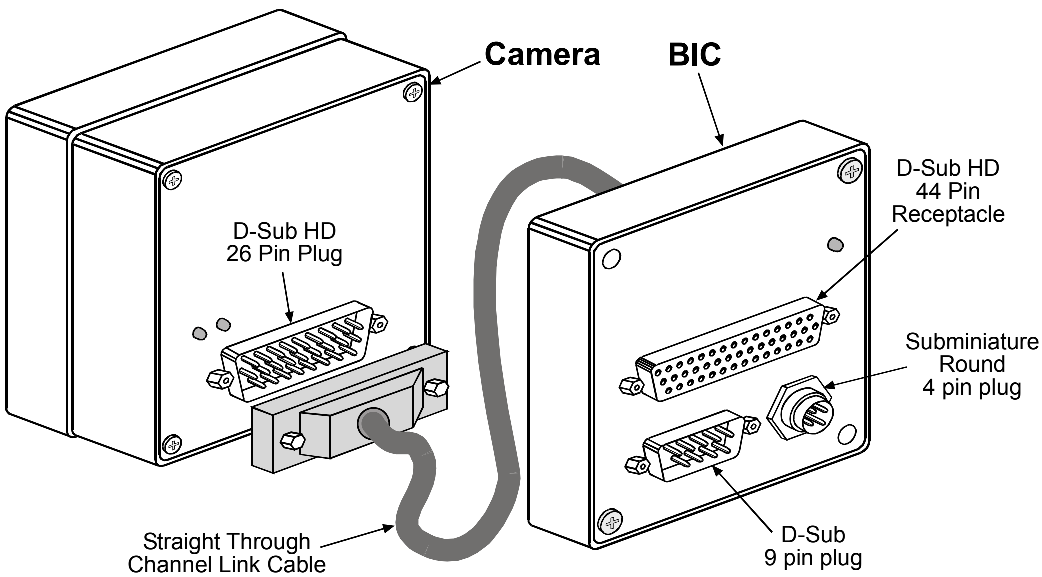



Figure A-13: Attaching a Cable to the Camera and the BIC

2. Attach one end of your video data/control signal cable to the 44 pin receptacle on the back of the BIC and the other end to your frame grabber.
3. Attach one end of a null modem cable to the nine pin plug on the back of the BIC and the other end to a serial port on your computer.
4. Make sure that the power source you will be using to supply the BIC meets the requirements shown in Section A.6.
5. Attach the output connector from your power source to the four pin plug on the BIC.
6. Switch on the power to your system.
7. Go on to Section A.8.3 to continue the installation.

| | |
|---|---|
| ☝ | The BIC operates on 24 VDC, but **L100b** cameras operate on 12 VDC. The BIC will convert its 24 VDC input to 12 VDC and will supply 12 VDC to the camera. |

## A.8.3 Setting Up the Serial Port

The RS-232 serial connection between your computer and the camera is used to issue commands to the camera for changing camera modes and parameters. In order for your camera to receive commands, it must be connected to a serial port and the serial port must be set up correctly.

Make sure that the serial port your camera is connected to has the following settings:

- 8 data bits
- no parity
- 1 stop bit
- baud rate = 9600 bps

You must use the computer's "control panel" to set up the serial port. If you are not familiar with setting up a serial port on your computer, refer to the manual or help files for your computer's operating system.

Once you have set up the serial port, go on to Section A.8.4.

## A.8.4 Installing the Camera Configuration Tool

The Camera Configuration Tool (CCT) is a Windows® based program used to easily change the camera's settings. The tool communicates with the camera via the serial connection.

For instructions on installing the tool, see the CCT installation booklet that was shipped with the camera.

## A.8.5 Next Steps

- Look at each of the Tabs in the Camera Configuration Tool and look through the on-line help included with the tool. This is a good way to familiarize yourself with the camera's features and settings.
- Read the manual for your Basler camera. You will get the most from your camera if you understand how the camera's features work and what happens when you change camera settings.
- Read the supporting material included with your frame grabber and make sure that the frame grabber is properly configured to work with your Basler camera. **In order to capture images, your frame grabber must be properly configured to work with your Basler camera.**

In addition to configuring the camera and the frame grabber, you must also set up other system components such as light sources, optics and the host computer. Only a complete, careful setup will guarantee optimum performance.

# A.9 BIC Dimensions

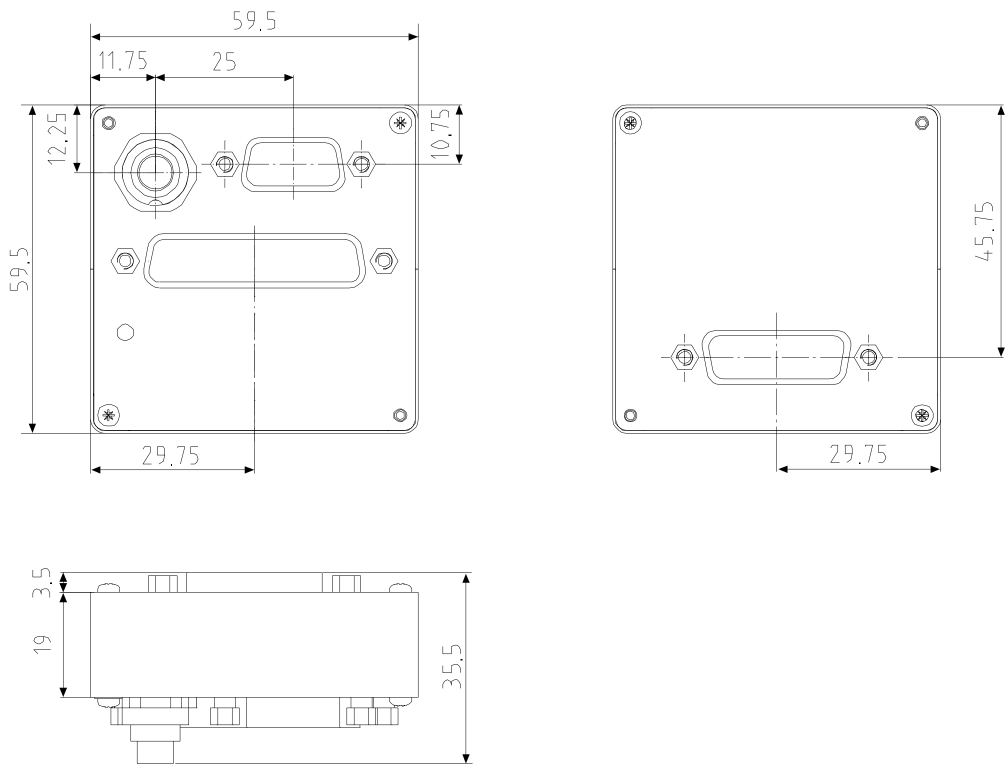



Figure A-14: BIC Dimensions (in mm)

# Revision History

| Doc. ID Number | Date | Changes |
|---|---|---|
| DA039801 | Dec. 21, 2000 | Initial release. |
| DA039802 | May 02, 2001 | The gain control of the camera has changed so that new formula are required to calculate the gain. Changed Chapters 4.4 Gain and Offset, 5.1.6 Gain and Offset Tab, and 5.2.7.7 Read Gain Reference Values.<br>Added ripple specification to Table 1-2 and Sections 2.6 , A.1.2 and A.6.<br>Added note on reverse power and overvoltage protection to Sections 2.1.2 and 2.6.<br>Added maximum cable length specification to Section 2.2.<br>Added information on absolute maximum voltage to Section 2.6.<br>**L102**b camera type is no longer built. Removed **L102**b information. |
| DA 039803 | July 13, 2001 | Removed the “Camera Installation“ section. Camera installation is described in the camera‘s Installation Guide only.<br>Removed information on camera configuration tool installation. Installation is described in the tool‘s Installation Guide only.<br>Corrected minimum line rate for the L104b to 1 kHz in Section 1.2. |

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