OPERATING INSTRUCTIONS

Ranger3

3D vision

SICK
Sensor Intelligence.

Described product

Ranger3

Manufacturer

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Legal information

Original document

This document is an original document of SICK AG.

Contents

1 About this document

1.1 Information on the operating instructions

These operating instructions provide important information on how to use devices from SICK AG.

Prerequisites for safe work are:

- Compliance with all safety notes and handling instructions supplied.
- Compliance with local work safety regulations and general safety regulations for device applications

The operating instructions are intended to be used by qualified personnel and electrical specialists.

NOTE
Read these operating instructions carefully before starting any work on the device, in order to familiarize yourself with the device and its functions.

The instructions constitute an integral part of the product and are to be stored in the immediate vicinity of the device so they remain accessible to staff at all times. Should the device be passed on to a third party, these operating instructions should be handed over with it.

These operating instructions do not provide information on operating the machine or system in which the device is integrated. For information about this, refer to the operating instructions of the specific machine.

1.2 Explanation of symbols

Warnings and important information in this document are labeled with symbols. The warnings are introduced by signal words that indicate the extent of the danger. These warnings must be observed at all times and care must be taken to avoid accidents, personal injury, and material damage.

DANGER
... indicates a situation of imminent danger, which will lead to a fatality or serious injuries if not prevented.

WARNING
... indicates a potentially dangerous situation, which may lead to a fatality or serious injuries if not prevented.

CAUTION
... indicates a potentially dangerous situation, which may lead to minor/slight injuries if not prevented.

NOTICE
... indicates a potentially harmful situation, which may lead to material damage if not prevented.

NOTE
... highlights useful tips and recommendations as well as information for efficient and trouble-free operation.

2 Safety information

2.1 Intended use

Streaming cameras are the vision image acquisition component in a machine vision system. They make measurements on the objects that pass in front of the camera, and send the measurement results to an external processing unit for further processing. Comply with the data on the type label.

Misuse

Different or additional use is considered to be improper use. SICK AG shall not be held liable for personal injury and damage to property resulting from this.

2.2 Improper use

Any use outside of the stated areas, in particular use outside of the technical specifications and the requirements for intended use, will be deemed to be incorrect use.

- The device does not constitute a safety component in accordance with the respective applicable safety standards for machines.
- The device must not be used in explosion-hazardous areas, in corrosive environments or under extreme environmental conditions.
- Any use of accessories not specifically approved by SICK AG is at your own risk.

WARNING
Danger due to improper use!

Any improper use can result in dangerous situations.

Therefore, observe the following information:

- Device should be used only in accordance with its intended use.
- All information in these operating instructions must be strictly observed.

2.3 Limitation of liability

Applicable standards and regulations, the latest state of technological development, and our many years of knowledge and experience have all been taken into account when assembling the data and information contained in these operating instructions. The manufacturer accepts no liability for damage caused by:

- Failing to observe the operating instructions
- Incorrect use
- Use by untrained personnel
- Unauthorized conversions
- Technical modifications
- Use of unauthorized spare parts, consumables, and accessories

With special variants, where optional extras have been ordered, or owing to the latest technical changes, the actual scope of delivery may vary from the features and illustrations shown here.

2.4 Modifications and conversions

NOTICE
Modifications and conversions to the device may result in unforeseeable dangers.

Interrupting or modifying the device or SICK software will invalidate any warranty claims against SICK AG. This applies in particular to opening the housing, even as part of mounting and electrical installation.

2.5 General cybersecurity notice

Protection against cybersecurity threats requires a comprehensive and holistic cybersecurity concept that must be continuously monitored and maintained. Such a concept consists of organizational, technical, process-related, electronic and physical defense levels and sets up appropriate measures for the different types of risk. SICK's products and solutions must be regarded as an integral part of this concept.

Information on Cybersecurity can be found at: www.sick.com/psirt .

2.6 Requirements for skilled persons and operating personnel

WARNING
Risk of injury due to insufficient training.

Improper handling of the device may result in considerable personal injury and material damage.

- All work must only ever be carried out by the stipulated persons.

The operating instructions state the following qualification requirements for the various areas of work:

- **Instructed personnel** have been briefed by the operator about the tasks assigned to them and about potential dangers arising from improper action.
- **Skilled personnel** have the specialist training, skills, and experience, as well as knowledge of the relevant regulations, to be able to perform tasks delegated to them and to detect and avoid any potential dangers independently.
- **Electricians** have the specialist training, skills, and experience, as well as knowledge of the relevant standards and provisions to be able to carry out work on electrical systems and to detect and avoid any potential dangers independently. In Germany, electricians must meet the specifications of the BGV A3 Work Safety Regulations (e.g. Master Electrician). Other relevant regulations applicable in other countries must be observed.

The following qualifications are required for various activities:

Table 1: Activities and technical requirements

Activities	Qualification
Mounting, maintenance	▪ Basic practical technical training ▪ Knowledge of the current safety regulations in the workplace
Electrical installation, device replacement	▪ Practical electrical training ▪ Knowledge of current electrical safety regulations ▪ Knowledge of the operation and control of the devices in their particular application
Commissioning, configuration	▪ Basic knowledge of the Windows™ operating system in use ▪ Basic knowledge of the design and setup of the described connections and interfaces ▪ Basic knowledge of data transmission ▪ Knowledge of the programming of image-processing systems and network components

Activities	Qualification
Operation of the device for the particular application	■ Knowledge of the operation and control of the devices in their particular application ■ Knowledge of the software and hardware environment for the particular application

2.7 Operational safety and particular hazards

Please observe the safety notes and the warnings listed here and in other chapters of these operating instructions to reduce the possibility of risks to health and avoid dangerous situations.

The product is fitted with LEDs of the risk group 0. The accessible radiation from these LEDs does not pose a danger to the eyes or skin.

WARNING
Electrical voltage!
Electrical voltage can cause severe injury or death.

- Work on electrical systems must only be performed by qualified electricians.
- The power supply must be disconnected when attaching and detaching electrical connections.
- The product must only be connected to a voltage supply as set out in the requirements in the operating instructions.
- National and regional regulations must be complied with.
- Safety requirements relating to work on electrical systems must be complied with.

WARNING
Dangerous equipotential bonding currents!
Improper grounding can lead to dangerous equipotential bonding currents, which may in turn lead to dangerous voltages on metallic surfaces, such as the housing. Electrical voltage can cause severe injury or death.

- Work on electrical systems must only be performed by qualified electricians.
- Follow the notes in the operating instructions.
- Install the grounding for the product and the system in accordance with national and regional regulations.

2.8 Laser safety

Whenever a laser module is used in combination with a 3D camera, the camera is considered to be a part of a laser system. This system has to incorporate additional safety features, depending on the applicable laser class. Refer to the safety instructions of the manufacturer of the used laser module.

WARNING
When a SICK device is used in combination with a laser, all requirements for laser products and laser systems according to the laser safety standards EN/IEC 60825–1 and 21 CFR 1040.10/11 must be fulfilled.

3 Getting started

The purpose of this chapter is to quickly and easily commission and configure the product for a typical application. **Before using the product in productive operation, the complete operating instructions must have been read and understood.**

PC installation

Download the latest version of the Ranger3 Software Deployment Kit (SDK) from the SICK Support Portal, supportportal.sick.com. The SDK contains the configuration software, Ranger3 Studio.

For further information about the PC software and installation, see "Installing PC software", page 27.

Mounting the camera and the laser

Use the camera together with a line-projecting laser that illuminates the object to be measured.

- Mount the camera and the laser so that the laser illuminates the object from one direction, and the camera views the object from another direction.
- The laser line must be orthogonal to the movement direction of the object. Mount the camera so that the camera does not tilt sideways compared to the laser line.
- Make sure that the camera is properly cooled.

For further information about how to mount the camera and the laser, see "Mounting", page 18.

Connecting the camera

See figure 1 for an overview of the electrical connections for the installation.

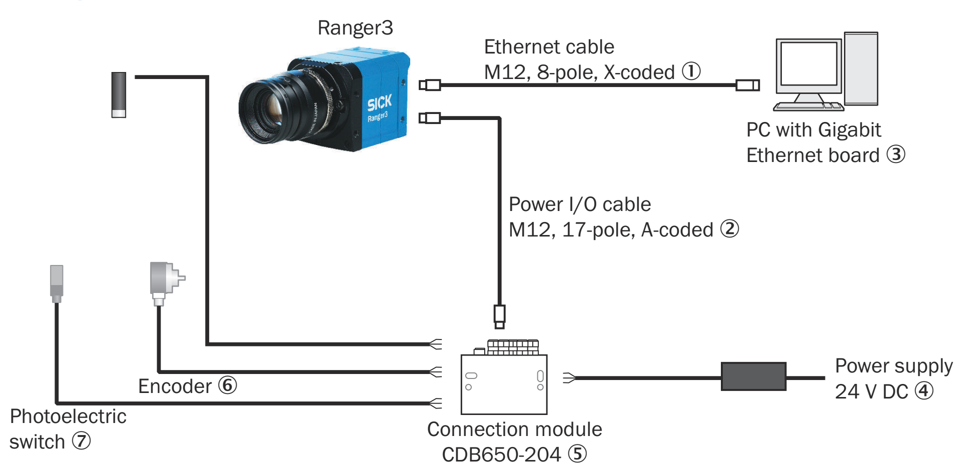


Figure 1: Electrical connections for Ranger3

① Ethernet cable, M12, 8-pole, X-coded
② Power I/O cable M12, 17-pole, A-coded
③ PC with Gigabit Ethernet board
④ Power supply 24 V DC
⑤ Connection module CDB650-204
⑥ Encoder
⑦ Photoelectric switch

For further information about the electrical installation, see "Electrical installation", page 20. The pin assignment is described in "Electrical connections", page 24.

Configuration

Before the camera can be used in a machine vision system, it must be configured. This is done by adjusting parameters in the Ranger3 Studio software until the image result is satisfactory.

See "Features", page 42 for a list of available parameters. For detailed information about how to edit the parameters in the user interface, see "Using the interface", page 61.

4 Product description

4.1 Introduction

Ranger3 is a high-speed 3D camera intended to be the vision component in a machine vision system. Ranger3 makes measurements on the objects that pass in front of the camera, and sends the measurement results to a PC for further processing. The measurements can be started and stopped from the PC, and triggered by encoders and photoelectric switches in the vision system.

The main function of Ranger3 is to measure 3D shape of objects by the use of laser line triangulation. This can be used for example for generating 3D images of the object, for size rejection or volume measurement, or for finding shape defects. In the image below, the colors represent depth.

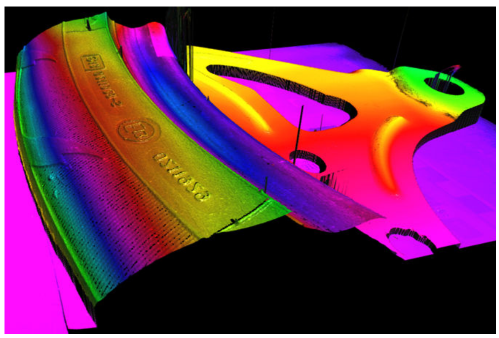


Figure 2: Example of 3D image

4.2 Measuring with a 3D camera

Each time the 3D camera makes a measurement, it measures along a cross-section of the object in front of it. The result of a measurement is a profile, containing one value for each measured point along the cross-section – for example the height of the object along its width.

For the camera to measure an entire object, the object (or the camera and lighting) must be moved so that the camera can make a series of measurements along the object. The result of such a measurement is a collection of profiles, where each profile contains the measurement of a cross-section at a certain location along the transportation direction.

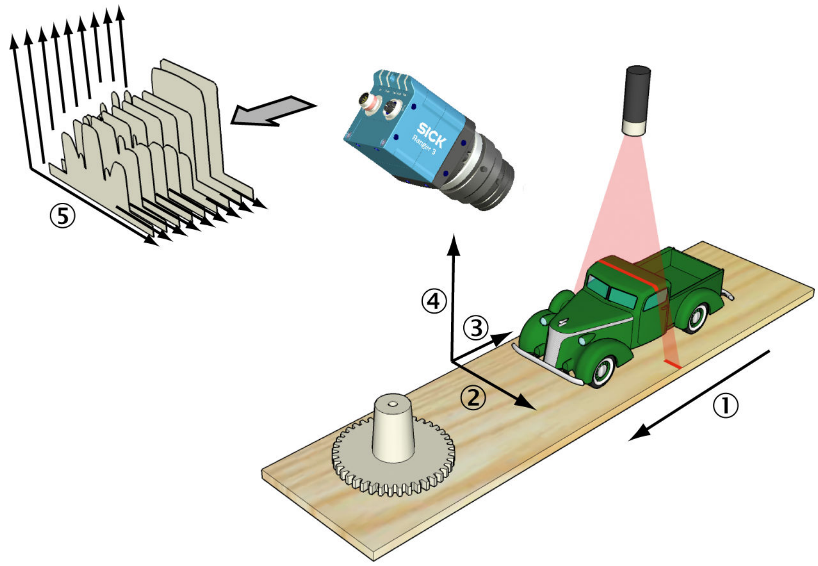


Figure 3: Measuring the range of a cross-section of an object

① Transportation direction
② X (width)
③ Y (negative transport direction)
④ Z (range)
⑤ Profiles

By default, the range measurement values from the camera are not calibrated – that is:

- X and Z (range) coordinates are represented by column and row positions on the sensor, instead of real world positions and distances.
- Y coordinates are represented for example by the sequence number of the measurement, or by the encoder value for when the profile was captured.

In a machine vision system, the Ranger3 camera acts as a data streamer. It is connected to a PC through a Gigabit Ethernet network. The camera sends the profiles to the computer, and the computer runs a custom application that retrieves the profiles and processes the measurement data in them.

Before the camera can be used in a machine vision system, the following needs to be done:

- Find the right way to mount the camera and lighting.
- Configure (and optionally calibrate) the camera to make the proper measurements.
- Write the application that retrieves and processes the profiles sent from the camera.

For more information about 3D measurements, see "Range (3D) measurement", page 89.

4.3 Hardware description

4.3.1 Sensor

The Ranger3 camera is based on a unique SICK CMOS sensor which has a 2D pixel matrix, row-parallel AD-converters, and a processor architecture that enables image processing directly on the sensor. The technology is called ROCC, which means Rapid On-Chip Calculation. For technical details, see "Technical data", page 82.

4.3.2 LED indicators

Indicator	LED	Color	Function
On	●	Green	Power ON
State	☀	Yellow	Booting (slow flashing) or firmware upgrade (fast flashing)
	●	Yellow	Idle (or acquiring single frames)
	●	Green	Continuous acquisition
	☀	Red	Thermal warning (risk of overheating)
	●	Red	The device is in rescue mode, due to software problems or overheating For more information, see "Rescue mode", page 79
Link/Data		Off	No Ethernet connection
	●	Green	Connection established, 1 gigabit/s
	☀	Green	Ethernet frames are being transmitted or received
Laser	●	Green	Digital outputs "LASER STROBE OUT" active[1]

●= illuminated, ☀= flashing

1 The **Laser** LED mirrors the behavior of the laser signal. If two lasers are connected, the **Laser** LED mirrors both laser signals using OR logic.

4.4 Standards

Ranger3 complies with the GenICam™ and the GigE Vision® standards.

4.4.1 GenICam™

GenICam™ is a standard that provides a generic programming interface for different kinds of cameras and devices. The standard is owned by EMVA (European Machine Vision Association) and consists of multiple modules. Ranger3 complies with the following modules:

GenApi	Application programming interface (API) for configuring the camera.
Standard Feature Naming Convention (SFNC)	Standardized names and types for common device features.
GenTL	Transport layer interface for grabbing images.
GenTL SFNC	Standardized names and types for transport layer interface.

For further information, see www.emva.org/standards-technology/genicam/.

4.4.2 GigE Vision®

GigE Vision® is a camera interface standard that is based on the Gigabit Ethernet communication protocol. The GigE Vision® standard is owned by AIA (Automated Imaging Association).

For further information, see https://www.visiononline.org/vision-standards.cfm.

5 Transport and storage

5.1 Transport

For your own safety, please read and observe the following notes:

NOTICE
Damage to the product due to improper transport.

- The device must be packaged for transport with protection against shock and damp.
- Recommendation: Use the original packaging as it provides the best protection.
- Transport should be performed by trained specialist staff only.
- The utmost care and attention is required at all times during unloading and transportation on company premises.
- Note the symbols on the packaging.
- Do not remove packaging until immediately before you start mounting.

5.2 Unpacking

- Before unpacking, it may be necessary to equalize the temperature to protect the device from condensation.
- Handle the device with care and protect it from mechanical damage.
- Remove the protective caps on the electrical connections immediately before connecting the connecting cable to prevent dirt and water from entering.

5.3 Transport inspection

Immediately upon receipt in Goods-in, check the delivery for completeness and for any damage that may have occurred in transit. In the case of transit damage that is visible externally, proceed as follows:

- Do not accept the delivery or only do so conditionally.
- Note the scope of damage on the transport documents or on the transport company's delivery note.
- File a complaint.

NOTE
Complaints regarding defects should be filed as soon as these are detected. Damage claims are only valid before the applicable complaint deadlines.

5.4 Storage

Store the device under the following conditions:

- Recommendation: Use the original packaging.
- Electrical connections are provided with protective caps and plugs (as they are on delivery).
- Do not store outdoors.
- Store in a dry area that is protected from dust.
- So that any residual damp can evaporate, do not package in airtight containers.
- Do not expose to any aggressive substances.
- Protect from sunlight.
- Avoid mechanical shocks.

- Storage temperature: see "Technical data", page 82.
- For storage periods of longer than 3 months, check the general condition of all components and packaging on a regular basis.

6 Mounting

6.1 Mounting instructions

- Observe the technical data.
- To prevent condensation, avoid exposing the device to rapid changes in temperature.
- The mounting site has to be designed for the weight of the device.
- It should be mounted so that it is exposed to as little shock and vibration as possible. Optional mounting accessories are available, see "Accessories", page 87.
- Protect the device from moisture, contamination, and damage.
- A sufficient level of cooling using ambient air/convection and/or heat dissipation through mechanical mounting must be ensured. Observe the permitted operating temperature, see "Technical data", page 82.

6.2 Required parts

You need the following parts to get started with Ranger3:

- Ranger3 camera.
- PC with a network interface card (NIC) that supports Gigabit Ethernet. For information about requirements, see "Recommended network card settings", page 94.
- Ethernet cable for Gigabit Ethernet, with M12 connector for the camera.
- Voltage supply.
- Line-projecting laser.

6.3 Mounting the camera

When measuring range, the camera is used together with a line-projecting laser that illuminates the cross-section of the object to be measured. The camera and the laser are mounted so that the laser illuminates the object from one direction, and the camera views the object from another direction.

The laser line must be orthogonal to the movement direction of the object. Also mount the camera so that the camera does not tilt sideways compared to the laser line, see the figure below. This makes the laser line appear along the rows of the sensor in the camera.

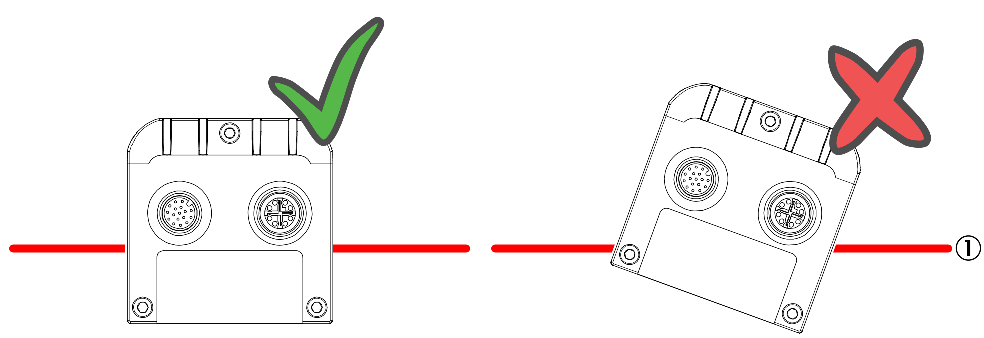


Figure 4: Correct (left) and incorrect (right) mounting of the camera

① Laser line

For best result it is important to shield out direct sunlight and other disturbing light from the field of view. It is recommended to use an optical band-pass filter to reduce ambient light.

It is also important to select a lens that is suitable for the field of view in which the camera should measure. Select a high-quality 1" C-mount lens that gives sharp images and low distortion, as this can be essential for achieving a successful vision application.

If needed, you can mount an optics protective cover that makes the camera compliant with IP65 and IP67. For available brackets, filters, lenses, and optics protective cover, see "Accessories", page 87.

Exactly how to mount the camera and the laser depends on a whole number of factors. For more information, see "Range (3D) measurement", page 89.

6.3.1 Mounting an optical filter or a Scheimpflug adapter

On delivery, there is a dummy filter in the camera to protect the sensor. When you mount an optical filter or a Scheimpflug adapter, you remove the dummy filter so that the sensor is unprotected. Make sure to be in a dust-free environment and pay special attention to cleanliness.

Mounting an optical filter

1. Use the provided tool and remove the dummy filter.
2. Mount the optical filter.

! **NOTICE**
Do not remove the dummy filter without mounting another filter.

- Using the camera without a filter can damage the sensor.
- The distance from the lens to the image sensor is adapted to the thickness of the optical filter. Without a filter, the focusing of the lens may not work properly.

7 Electrical installation

7.1 Conditions for specified enclosure rating

To ensure compliance with the IP65 and IP67 enclosure rating of the device during operation, the following requirements must be met:

- The cables plugged into the electrical M12 connections must be screwed tight.
- The optics protective hood must be screwed tightly onto the device.
- Any electrical M12 connections that are not being used must be sealed with protective plugs that are screwed tight (as in the delivery condition).

7.2 Wiring instructions

NOTE
Pre-assembled cables can be found online at:

- www.sick.com/Ranger3

NOTICE
Faults during operation and device or system defects!
Incorrect wiring may result in operational faults and defects.

- Follow the wiring notes precisely.

Observe the following safety measures:

- Standard safety requirements must be met when working in electrical systems.
- Only connect and disconnect electrical connections when there is no power to the system. Otherwise, the devices may be damaged.
- Use only shielded cables. The shield has to be terminated at both ends of the cable.
- Ensure that loose cable ends are isolated.
- Connect unused pins to GND.
- Wire cross sections of the supply cable from the customer's power system should be designed and protected in accordance with the applicable standards.
- Make sure that the Power-I/O cable is protected by a separate slow-blow fuse with a maximum rating of 2.0 A. This fuse must be located at the start of the supply circuit.
- The 24 V voltage supply must meet the requirements of SELV+LPS relating to "UL/EN60950-1:2014-08", or ES1 according to "EN/UL62368", or "CAN/CSA-C22.2 No 223-M91(R2008)-Power supplies with Extra-Low-Voltage class 2 outputs", or "UL1310 (6th Edition)-standard for class 2 power units".
- All circuits connected to the device must be designed as ES1 circuits (according to EN/UL62368) or as SELV (Safety Extra Low Voltage) circuits (according to EN/UL60950).
- Connect the connecting cables in a de-energized state. Switch on the supply voltage only after complete installation/connection of all connecting cables to the device and control system.

7.3 Prerequisites for safe operation of the device

WARNING
Risk of injury and damage caused by electrical current!
As a result of equipotential bonding currents between the device and other grounded devices in the system, faulty grounding of the device can give rise to the following dangers and faults:

- Dangerous voltages are applied to the metal housings.
- Devices will behave incorrectly or be destroyed.
- Cable shielding will be damaged by overheating and cause cable fires.

Remedial measures

- Only skilled electricians should be permitted to carry out work on the electrical system.
- If the cable insulation is damaged, disconnect the voltage supply immediately and have the damage repaired.
- Ensure that the ground potential is the same at all grounding points.
- Where local conditions do not meet the requirements for a safe earthing method, take appropriate measures (e.g., ensuring low-impedance and current-carrying equipotential bonding).

The device is connected to the peripheral devices (voltage supply, any local trigger sensor(s), system controller) via shielded cables. The cable shield – for the data cable, for example – rests against the metal housing of the device. The device can be grounded through the cable shield or through a blind tapped hole in the housing, for example.

If the peripheral devices have metal housings and the cable shields are also in contact with their housings, it is assumed that all devices involved in the installation have the **same ground potential**.

This is achieved by complying with the following conditions:

- Mounting the devices on conductive metal surfaces
- Correctly grounding the devices and metal surfaces in the system
- If necessary: low-impedance and current-carrying equipotential bonding between areas with different ground potentials

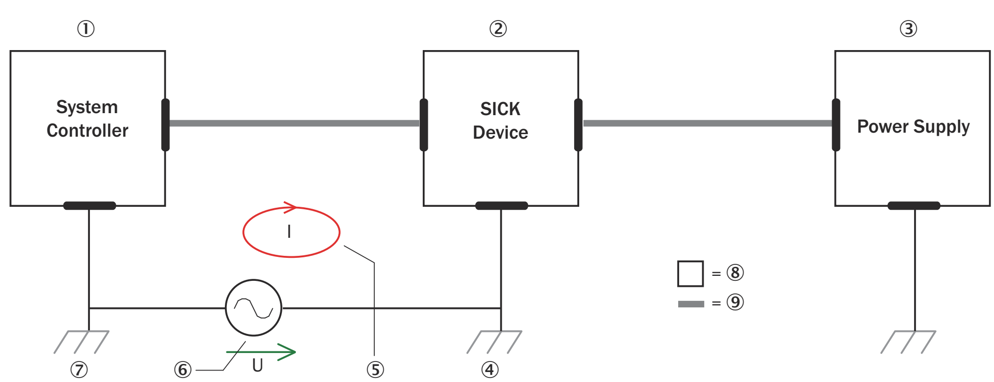


Figure 5: Example: Occurrence of equipotential bonding currents in the system configuration

① System controller
② Device
③ Voltage supply
④ Grounding point 2
⑤ Closed current loop with equalizing currents via cable shield

⑥ Ground potential difference
⑦ Grounding point 1
⑧ Metal housing
⑨ Shielded electrical cable

If these conditions are not fulfilled, equipotential bonding currents can flow along the cable shielding between the devices due to differing ground potentials and cause the hazards specified. This is, for example, possible in cases where there are devices within a widely distributed system covering several buildings.

Remedial measures

The most common solution to prevent equipotential bonding currents on cable shields is to ensure low-impedance and current-carrying equipotential bonding. If this equipotential bonding is not possible, the following solution approaches serve as a suggestion.

NOTICE
We expressly advise against opening up the cable shields. This would mean that the EMC limit values can no longer be complied with and that the safe operation of the device data interfaces can no longer be guaranteed.

Measures for widely distributed system installations

On widely distributed system installations with correspondingly large potential differences, the setting up of local islands and connecting them using commercially available **electro-optical signal isolators** is recommended. This measure achieves a high degree of resistance to electromagnetic interference.

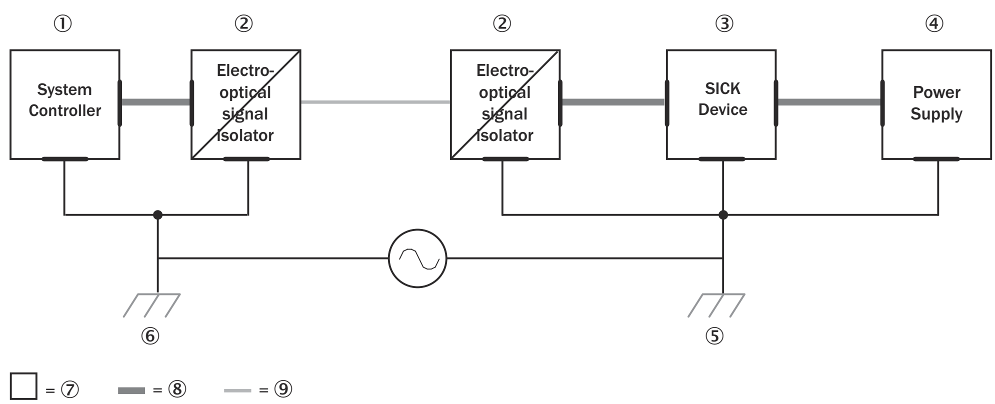


Figure 6: Example: Prevention of equipotential bonding currents in the system configuration by the use of electro-optical signal isolators

① System controller
② Electro-optical signal isolator
③ Device
④ Voltage supply
⑤ Grounding point 2
⑥ Grounding point 1
⑦ Metal housing
⑧ Shielded electrical cable
⑨ Optical fiber

The use of electro-optical signal isolators between the islands isolates the ground loop. Within the islands, a stable equipotential bonding prevents equalizing currents on the cable shields.

Measures for small system installations

For smaller installations with only slight potential differences, insulated mounting of the device and peripheral devices may be an adequate solution.

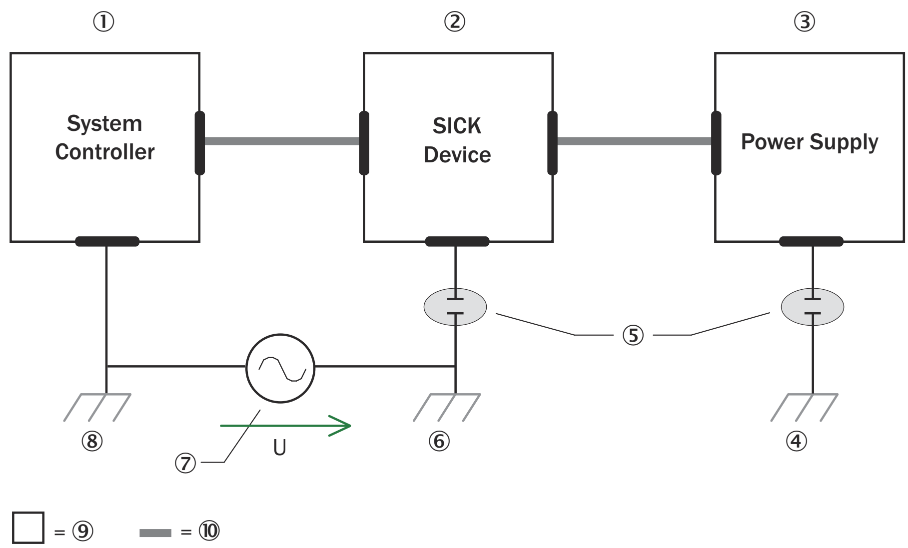


Figure 7: Example: Prevention of equipotential bonding currents in the system configuration by the insulated mounting of the device

① System controller
② Device
③ Voltage supply
④ Grounding point 3
⑤ Insulated mounting
⑥ Grounding point 2
⑦ Ground potential difference
⑧ Grounding point 1
⑨ Metal housing
⑩ Shielded electrical cable

Even in the event of large differences in the ground potential, ground loops are effectively prevented. As a result, equalizing currents can no longer flow via the cable shields and metal housing.

NOTICE
The voltage supply for the device and the connected peripheral devices must also guarantee the required level of insulation.

Under certain circumstances, a tangible potential can develop between the insulated metal housings and the local ground potential.

7.4 Connecting the camera

NOTICE

- Never connect any signals while the camera is powered.
- Never connect a powered Power-I/O terminal or powered I/O signals to a camera.

NOTICE

- Never connect a powered encoder interface unit to a camera.
- Never connect signal levels that exceed the input specification to the encoder inputs.

Failure to follow these rules can damage the camera.

NOTE
The function of the camera is not tested and guaranteed for Power I/O cables longer than 10 meters.

NOTE
Use only shielded cables. The shield has to be terminated at both ends of the cable.

There are two connectors on the back of the camera: Gigabit Ethernet (GigE) and Power I/O (see figure 8, page 24).

To prepare the camera for operation, do as follows:

1. Remove the protection caps that cover the connections for Gigabit Ethernet (GigE) and Power I/O.
2. Connect the Ethernet cable to the GigE connector on the camera. Connect the other end of the Ethernet cable to the Network Interface Card (NIC) in the PC.
3. Connect the connecting module to the Power I/O connector on the camera.
4. Connect the unpowered voltage supply to the connecting module.
5. Connect the laser to its voltage supply.
6. Switch on the power to the system.

For more information on how to connect I/O signals to the camera, see "Electrical connections", page 24.

7.5 Electrical connections

There are two connectors and four LEDs on the back plate of Ranger3.

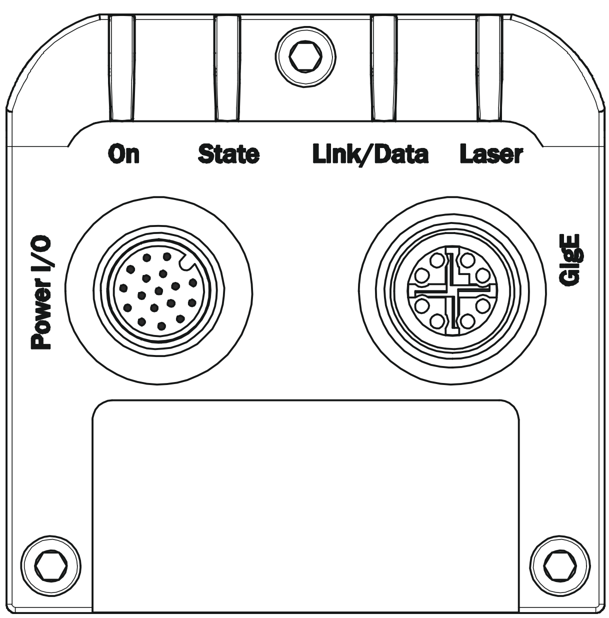
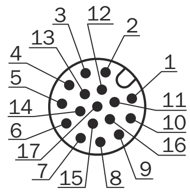


Figure 8: Back plate of the Ranger3 device

7.5.1 Power I/O connector



Pin assignment

Table 2: Power I/O connector, 17-pin

Pin	Signal	Description
1	GND	Power/signal ground
2	POWER SUPPLY	Voltage supply DC 24 V +/-20%
3	-	Not connected
4	-	Not connected
5	ENC IN A+[1]	Encoder Input A+ (5 V)/Encoder Input A (24 V) Configurable: RS-422 TTL/HTL Default: RS-422 TTL
6	ENC IN A-[1]	Encoder Input A-/Do not connect Configurable: RS-422 TTL/HTL Default: RS-422 TTL
7	-	Reserved
8	-	Reserved
9	-	Not connected
10	FRAME TRIGGER IN	24 V Frame trigger input or configurable 24 V Input/Output Default: Frame trigger input
11	ENC IN B+[1]	Encoder Input B+ (5 V)/Encoder Input B (24 V) Configurable: RS-422 TTL/HTL Default: RS-422 TTL
12	ENC IN B-[1]	Encoder Input B-/Do not connect Configurable: RS-422 TTL/HTL Default: RS-422 TTL
13	LASER STROBE OUT1[2]	5 V trigger output for Laser or Strobe
14	LASER STROBE OUT2[2]	5 V trigger output for Laser or Strobe
15	LINE TRIGGER IN[2]	24 V Line trigger input or configurable 24 V Input/Output Default: Line trigger input
16	I/O 3[2]	Encoder reset input or configurable 24 V Input/Output Default: Encoder reset
17	I/O 4[2]	Configurable 24 V Input/Output

1 Depends on the encoder type, see descriptions below
2 Not connected for article number 1083672

Notes

- Make sure, that at all times, the voltage at the I/O pins is lower or equal to the voltage at the supply pins. If not, you risk to power on the camera through the I/O pins although it is turned off (V supply = 0 V), which is strictly forbidden.
- When using a single-channel encoder, connect it to Encoder Input A+/A- (pin 5 and 6)

Encoder types

Ranger3 supports the following encoder types:

- RS-422 (5V): Two differential channels (A+/A- and B+/B-) are used as input from the encoder to the camera. The signal swing is 5 V. The maximum encoder frequency is 2 MHz.
- HTL (24 V): Two single-ended channels (A and B) are used. The signal swing is 24 V. The maximum encoder frequency is 400 kHz.

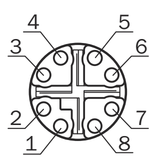
To configure the encoder type in the user interface, see "Setting the encoder type and encoder mode", page 70.

Signal levels

Table 3: Signal levels for Power I/O connector

Signal	Pins	Low	High	Remark
24 V inputs	10, 15, 16, 17	0... 9 V	12.5... V_Supply	Pulldown: 22.5 kΩ
TTL	5, 6, 11, 12	0... +0.8 V	+2 V... V_Supply	RC-termination, 112 Ω / 340 pF
24 V outputs	16, 17			Output type: Push-pull. Max output current: 100 mA
5 V outputs	13, 14			Output type: Push-pull.

7.5.2 GigE connector



Pin assignment

Table 4: GigE connector, 8-pin

Pin	Signal
1	GETH L1+
2	GETH L1-
3	GETH L2+
4	GETH L2-
5	GETH L4+
6	GETH L4-
7	GETH L3-
8	GETH L3+

8 Configuration

8.1 Software installation

8.1.1 System recommendations

The PC requirements for the vision system will depend on your application, but as a general guideline the following is recommended for minimal operation:

- Windows 7 or Windows 10, 64 bit.
- Gigabit Ethernet adapter that supports Jumbo Frames and is dedicated for camera communication, see "Recommended network card settings", page 94.

8.1.2 Network preparations

Due to the large amount of data that the camera delivers per second, it is required to connect it to the PC using a dedicated Gigabit Ethernet network, without other interfering traffic. If the PC must be connected to other equipment, for example network printers, the PC should be equipped with (at least) two network interface cards (NIC).

Multiple cameras can be connected using a NIC with multiple ports, or multiple NICs. To connect multiple cameras to a single NIC limits the maximum speed of the cameras. For best performance, connect each camera to a separate NIC.

For recommended network settings, see "Recommended network card settings", page 94.

8.1.3 Installing PC software

The latest version of the Ranger3 software deployment kit (SDK) can be downloaded from the SICK Support Portal, supportportal.sick.com.

1. Log in to the SICK Support Portal.
2. Navigate to the **Ranger3** product page.
3. Under **Releases**, click the link corresponding to the latest version of the Ranger3 SDK.
4. Download the SDK zip file.
5. Unzip the SDK and follow the instructions in the `README.txt` file.

The SDK contains the Ranger3 Studio software application, which is used for the configuration and operation procedures described in this manual. To start the application, open the **Ranger3 Studio** sub-folder and click the **Ranger3 Studio.exe** file.

8.2 Concepts

The GenICam™ standard uses "feature" as a common word for parameters, commands, and selectors.

8.2.1 Selectors

In a GenICam™ device, such as Ranger3, selectors are used to access parameters that are organized in arrays. That is, the selector acts as the index for the affected parameters. Changing the selector does not change any parameter. A parameter indexed by a selector is notated ParameterA[SelectorX].

Example: The parameter **Width[RegionSelector]** sets the width of a region. The value of **RegionSelector** decides which region that is manipulated. This means that **Width[Region1]** is the width of the region named Region1.

8.3 Configuring Ranger3

Before the camera can be used in a machine vision system, it has to be configured. This is usually done by setting up the camera in a production-like environment and evaluate different parameter settings until the result is satisfactory, see "Editing parameters", page 65.

The following can be specified when configuring the Ranger3:

Regions	Where on the sensor to measure and dimensions of the 3D output frame.
Exposure time	For how long to expose the sensor.
Triggering settings	When to make a measurement.
Component-specific settings	How to process the measurement result before sending it to the PC.

All this is specified by setting parameters in Ranger3. The parameters, as well as the selectors and commands, are organized in hierarchical groups. Each group belongs to one of the following categories[1]:

DeviceControl	Contains the features related to the control and information of the device.
ImageFormatControl	Contains the features related to the format of the acquired and transmitted images.
AcquisitionControl	Contains the features related to image acquisition, including trigger control.
DigitalIOControl	Contains the digital input and output control features.
TimerControl	Contains the Timer control features.
EncoderControl	Contains the features related to the usage of quadrature encoders.
EventControl	Contains the features related to the generation of Event notifications by the device.
FileAccessControl	Contains the File Access control features.
Scan3dControl	Contains the features related to the control of the 3D scan features.
ChunkDataControl	Contains the features related to the Chunk Data Control.
TestControl	Contains the features related to the control of the test features.
TransportLayerControl	Contains the features related to the Transport Layer Control (Gigabit Ethernet).

8.4 Regions

There are two types of regions:

Sensor regions **RegionSelector** = Region0, Region1	Defines the sensor image dimensions and readout conditions, see "Sensor regions", page 29.
Extraction regions **RegionSelector** = Scan3dExtraction1	Defines the processing and formatting conditions of the generated 3D linescan output data, see "Extraction regions", page 29.

It is possible to define multiple regions for both 2D and 3D. In different device versions different number of sensor and extraction regions are possible. Typically, you use at least one sensor region for imaging and one sensor and extraction region pair for 3D profiling purposes. You use the selector **RegionSelector** to select the region you want to view and manipulate parameters from, see "Selectors", page 27.

1) According to GenICam™ SFNC version 2.4.

8.4.1 Sensor regions

Data from the sensor is used as standard 2D image output and as input to the calculation of the 3D data. The sensor region that is used when viewing the 2D intensity image (**Region0**) and the sensor region used as input to the processing module (**Region1**) are defined independently of each other.

The sensor region defines which area of the sensor to use. Using a smaller region on the sensor enables measurements at a higher rate. The region is specified by the parameters **OffsetX**, **OffsetY**, **Width**, and **Height** as shown in the figure below. The resulting image generated by the device will have **Width** times **Height** pixels. **OffsetX** and **OffsetY** are given with respect to the upper left corner of the image area. This corner has the coordinates (0,0) in the imager (x, y) coordinate system. All measures are given in pixels.

NOTE
In GenICam™ devices, such as Ranger3, imager coordinates are defined as (x,y). In more general terms, image sensor coordinates are usually defined as (u,v), see "Sensor coordinate system", page 93.

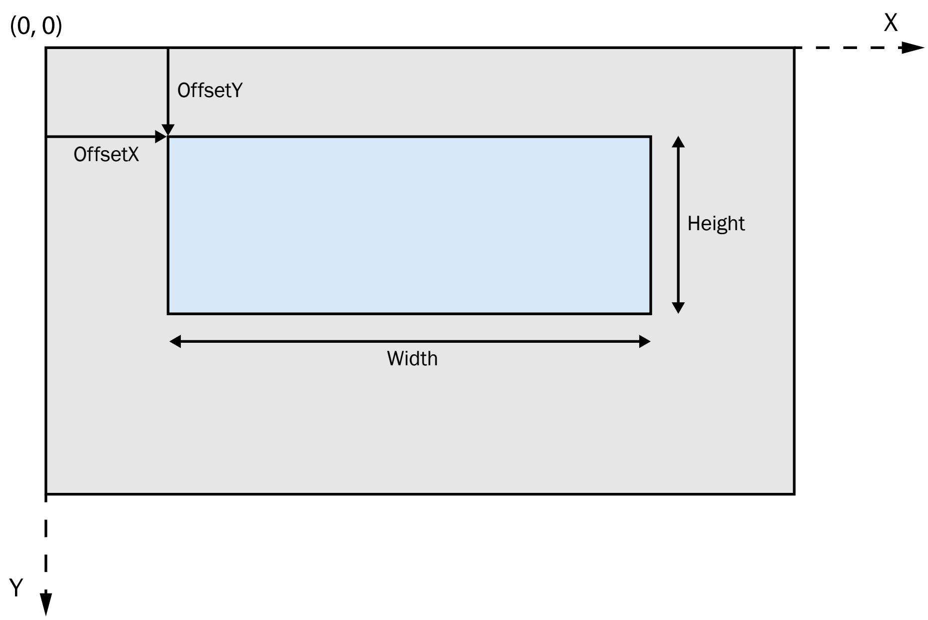


Figure 9: Image area and 2D region

The 2D intensity image is based on the sensor region **Region0**, see the figure below.

Figure 10: 2D image

8.4.2 Extraction regions

The extraction region (**Scan3dExtraction1**) uses input from a sensor region (**Region1**). Together with a processing module, the extraction region defines the processing and formatting conditions of the generated 3D linescan output data.

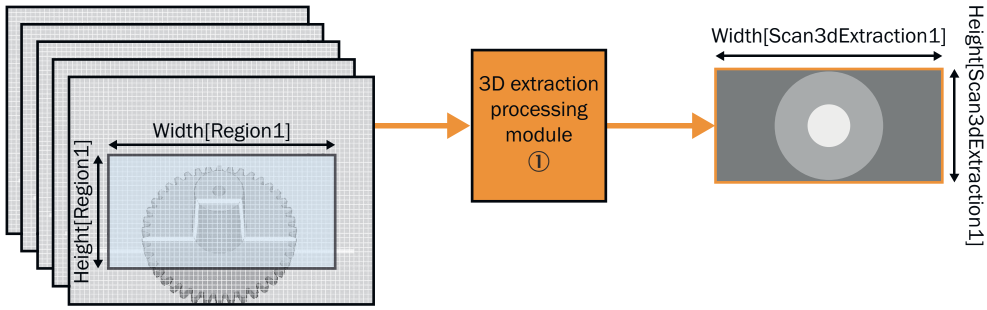


Figure 11: 3D image

① 3D extraction processing module

In Linescan 3D mode, the **Height** and **Width** parameters of the region **Scan3dExtraction1** define the dimensions of the 3D extraction output frame. Typically, the **Width** parameter of an extraction region is locked to the same value as the **Width** of the source region on the sensor.

To get a 3D image, several 2D images are required. Each 2D image corresponds to one profile, see "Measuring with a 3D camera", page 13. The 2D sensor images are transformed into lines in the 3D extraction output frame. Each line in the frame corresponds to one 2D image. This means that the **Height** value of the frame tells how many 2D images that are used to generate the resulting 3D image. The 3D image has **Width** times **Height** pixels.

The **RangeAxis** parameter defines how the lines in the 3D extraction output frame are visualized. The parameter is set to **Reversed** by default, which means that high values in the range data correspond to low values on the imager Y axis. If the parameter is set to **Standard**, high range values correspond to high values on the imager Y axis and the visualized 3D object appears upside down. See figure 12 and figure 13 for examples.

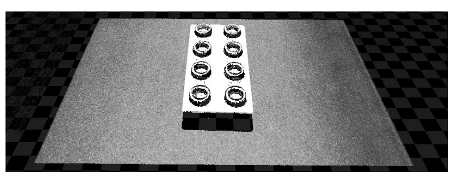


*Figure 12: **RangeAxis** set to **Reversed***

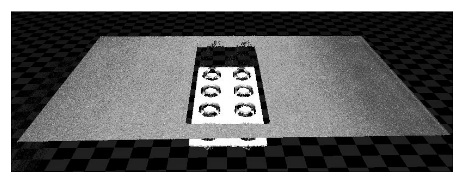


*Figure 13: **RangeAxis** set to **Standard***

8.4.3 Device scan type

The camera can be configured to output either the raw data from the image sensor or the 3D profile data. In the user interface, you select **Image** to see the raw sensor data as a 2D image or **Data collection** to get the 3D profile data, see "Workflow steps", page 57.

The camera uses the parameter **DeviceScanType** to control if 2D images or 3D profiles are acquired. This parameter is set when you select **Image** or **Data collection.** Setting the **DeviceScanType** automatically sets the relevant features for the correct mode, as described below.

Image

DeviceScanType is set to **Areascan.**

The following settings are done automatically:

RegionMode[Region0] = On
RegionMode[Region1] = Off
RegionMode[Scan3dExtraction] = Off

Data collection

DeviceScanType is set to **Linescan3d**.

The following settings are done automatically:

RegionMode[Region0] = Off
RegionMode[Region1] = On
RegionMode[Scan3dExtraction] = On

8.4.4 Maximum buffer size

The maximum size for an image buffer to be sent from Ranger3 to the host PC is around 40 MB, and the maximum supported buffer height is 16383 profiles. The limit is due to the limited GigE Vision retransmission buffer memory in the device.

The maximum buffer height (**Height[Scan3dExtraction1]**) depends on the data format, the region width (**Width[Region1]**) and the number of enabled components (e.g. reflectance, see "Reflectance", page 34). For example: With default settings, the maximum **Height** is about 11000 profiles. When reflectance is enabled, the maximum **Height** decreases to about 7000 profiles.

If the buffer size is maximized, the camera may block user actions that further increase the size. Examles of such actions are:

- Enabling another component, such as reflectance
- Increasing the bit-depth of a pixel format
- Increasing the region width

The user must decrease the buffer size to make the blocked actions available again. This is done by changing the data format, decreasing the region width or decreasing the number of enabled components.

8.5 Exposure time and measurement speed

Once the height of the sensor region is set, there are two other parameters that affect the line rate of the camera:

AcquisitionLineRate	The rate at which the lines in a frame are captured (Hz). Only applicable when the camera is in free-running mode.
ExposureTime	The time (µs) during which the sensor region is exposed.

The exposure time and the line rate are inter-dependent. The maximum exposure time cannot be longer than the time between two profiles, minus about three microseconds that are needed for readout and reset.

NOTE
The maximum exposure time and the maximum line rate are stored as floating point values and rounding-off effects may make it impossible to set the exact value returned by the GUI. The maximum deviation is 0.01 µs for the exposure time and 0.01 Hz for the line rate.

8.6 Laser strobe output signals

The camera has two laser strobe output signals, **LASER STROBE OUT1** and **LASER STROBE OUT2**, see "Electrical connections", page 24. These signals are individually controlled and can be used to control two separate lasers. You can use the signal to turn the laser on only when it is needed, for example when two separate cameras and lasers are used at the same time.

In the figure below, the laser is turned on slightly before the sensor exposure time starts. The reason for this is to allow turn-on time. When the exposure is finished, the laser is turned off.

The **LineStart** trigger signal from the encoder is used as a reference. The **TimerDelay** parameter sets the delay time (t1-t0) from the **LineStart** signal (t0) until the laser is turned on. The **TimerDuration** parameter defines for how long the laser is on. When **TriggerSelector** is set to **ExposureStart**, the **TriggerDelay** parameter sets the delay time (t2-t0) from the **LineStart** signal until the exposure starts.

The maximum time (in seconds) between two **LineStart** signals is 1/(maximum **AcquisitionLineRate**). The higher the line rate, the shorter the cycle time.

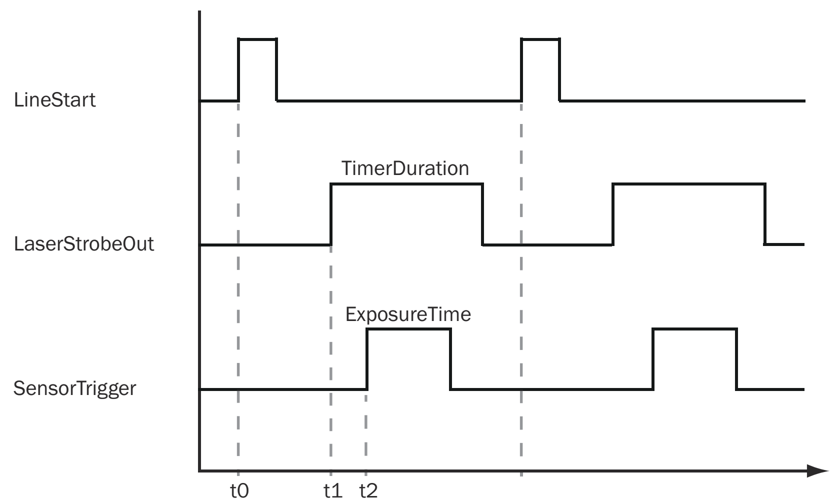


Figure 14: Laser is on only during exposure

8.7 Range (3D) measurements

8.7.1 Laser impact position on the sensor

The basic function of the 3D measurements is to compute the impact position of the laser line for all columns of the selected region of interest (ROI). The light intensity distribution from the laser line along a sensor column across the laser line can be described as in the figure below.

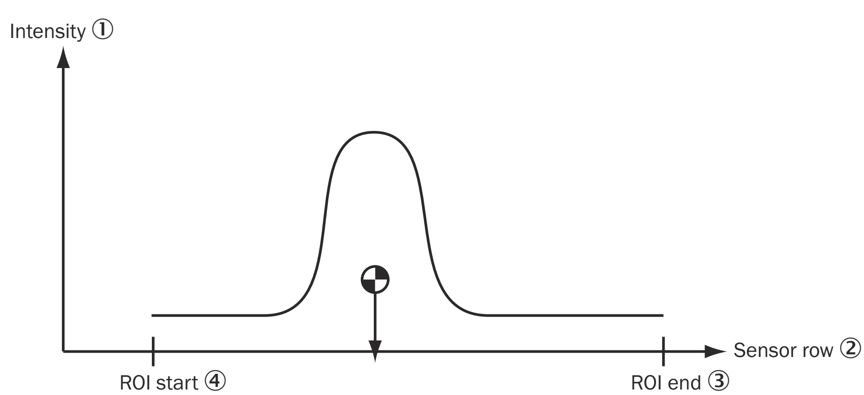


Figure 15: The impact position of the laser in one column

① Intensity

② Sensor row

③ ROI end

④ ROI start

The laser line will produce a distinct light peak distributed over a number of pixels along the sensor column. The center of this peak will be defined as the impact position of the laser line on that sensor column, which is the range value.

8.7.2 Measurement method

The default algorithm in Ranger3 is called **Hi3D**. It measures the impact position using a high-resolution peak fitting algorithm based on the pixels in a window around the extracted intensity peak position. The size of the window is set by the **WAMSize** parameter.

This method measures range with a resolution of 1/16th pixel.

8.7.3 Detection threshold

The parameter **DetectionThreshold** defines the minimum reflectance signal that can be detected as a peak position. Ideally, this parameter is set to a value that is higher than the amplitude of the noise, but still low enough to detect the laser signal, see the figure below. If **DetectionThreshold** is too low, noise will be registered as laser peaks. This will result in bad image quality. If **DetectionThreshold** is too high, not all laser peaks will be registered. This will result in an image where some parts are missing.

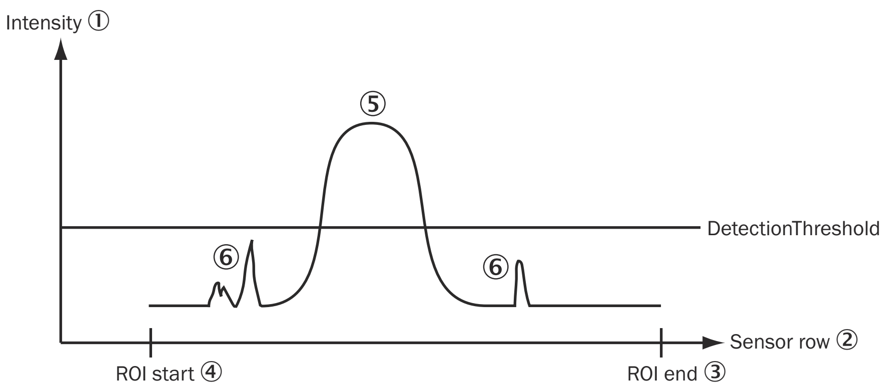


Figure 16: Analog signal with noise

① Intensity

② Sensor row

③ ROI end

④ ROI start

⑤ Detected peak

⑥ Not detected peaks

8.7.4 3D data formats

The 3D data is delivered with 4 subpixel bits resolution. The data can be represented with 12 or 16 bits. 12 bits allows a higher scan rate given the limitations of the Gigabit Ethernet link. For 12 bits a maximum region height of 256 rows can be represented. Any data outside of this is clipped/limited to the maximum value.

The pixel value 0 is dedicated to represent missing data, i.e. that no valid peak was found. This means that the lowest value possible is 0.0625 (1/16th).

The coordinate system of the data is independent of the region position. That is, the value 0.0625 always represents a position 1/16th of a pixel from the start of the region. If a buffer is saved to file, the offsetY information is stored in the XML description so that the actual position on the sensor can be calculated.

According to the GenICam™ and GigE Vision® standards, 3D data should be represented using coordinate pixel formats. For Ranger3, these formats are **Coord3d_C12p** and **Coord3d_16**. To allow a receiver that is not compatible with those new formats, the binary compatible grayscale formats **mono_12p** and **mono_16** can be used.

8.8 Additional components

8.8.1 Reflectance

The reflectance values along the laser line can be collected in parallel to the 3D data. The reflectance values are saved as an 8-bit grayscale image, with one value corresponding to each point in the range dataset.

For information about how to enable reflectance measurements, see "Enabling reflectance measurements", page 67.

8.8.2 Scatter

The scatter component measures the intensity of the laser signal in defined parts of the Window Around Maximum (WAM). The scatter signal can be explained as the amount of scattered light received in a sampling window at a distance from the peak laser position.

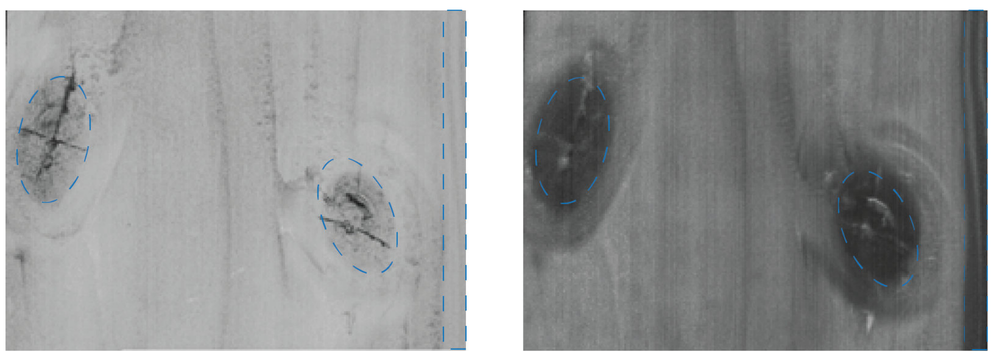


Figure 17: Wooden board displayed with reflectance (left) and scatter (right). The knots and the blue-stained right edge of the board (denoted in blue) appear dark in the scatter image.

Scatter measurements can distinguish material effects, which is useful for organic matters such as wood (wood fibers transmit light along their growth direction, and knots and rot affect this property) and meat (fat, bone and meat have different scattering properties). In some cases, scattering can reveal sub-surface effects like delamination or the content of cavities beneath a surface.

The default pixel format for scatter is 16 bits. This is due to the large dynamic range of the scatter signal, which sums up to 29 individual 8-bit pixel values.

Basic scatter parameters

The scatter component measures the amount of light received in a defined sampling window, which is part of the extracted 31-row WAM window. The amount of light is added for all rows in the sampling window to get the total scattering value. The sampling window is defined by the following parameters:

- **ScatterWidth:** The number of rows to sum scatter data from.
- **ScatterOffset:** The distance (number of pixels) from the laser peak position to the row where the first scatter measurement is made. The offset can be set to 0, which means that an odd number of rows is used for summing the scatter data.

figure 18 illustrates two cases of symmetric sampling, with low scatter to the left and high scatter to the right. The **ScatterOffset** and **ScatterWidth** are denoted in the figure.

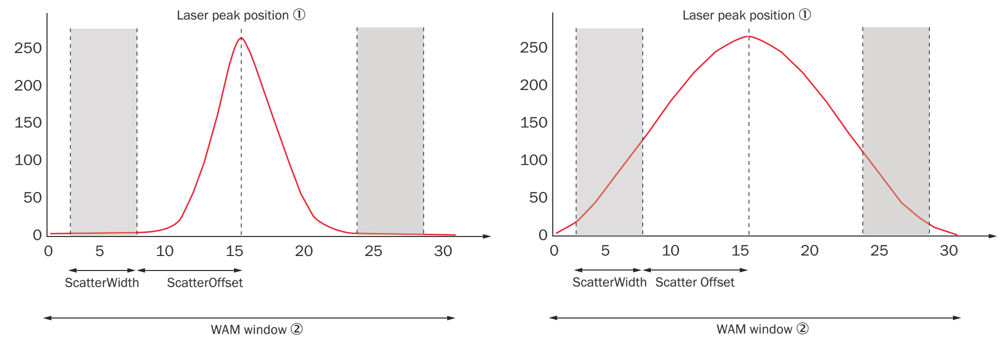


Figure 18: Examples of low scatter symmetric sampling (left) and high scatter symmetric sampling (right). The red line illustrates the laser signal in the extracted WAM window. The sampling window is shown in gray.

① Laser peak position

② WAM window

Advanced scatter parameters

The scatter sampling mode is defined by the **ScatterMode** parameter. The following options are available:

- **SymmetricSideBand**: Sampling is done on both sides of the peak, as illustrated in figure 18.
- **FrontSideBand**: Sampling is done on rows in front of the peak in the readout, as illustrated in figure 19.
- **BackSideBand**: Sampling is done on the back side of the peak in the readout.

The WAM window is centered around the global maximum. If the image is saturated, the WAM window is centered around the first saturated pixel. For general cases, such as figure 18, it is recommended to use symmetric sampling to avoid saturated pixels in the scatter data.

If the peak signal is saturated on one side, as in figure 19, **FrontSideBand** sampling can be used to avoid the effects of saturation. Alternatively, **BackSideBand** sampling can be used for an approximation of the signal saturation level.

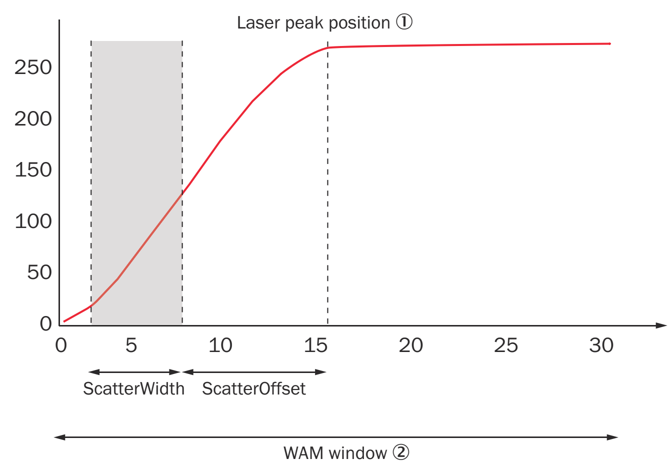


*Figure 19: Example of **FrontSideBand** scatter sampling. The sampling window is shown in gray.*

① Laser peak position

② WAM window

Scatter dynamic range tuning

The Ranger3 camera has built-in configurable dynamic range reduction from 16 to 8 bits. The dynamic range reduction reduces the bandwidth of the camera and adjusts the contrast of the scattering data.

When reducing the dynamic range, the first step is an initial tuning to set the following parameter values:

- **ScatterReductionLowerLimit:** The signal level to map to dark (value = 0)
- **ScatterReductionUpperLimit:** The signal level to map to bright (value = 255)

Between the set limits, the signal level is estimated by a linear model or by a non-linear model with one or two knee-points. The non-linear models allow approximation of the gamma correction curve, which mimics the manner in which humans perceive light and color. The knee-points are set as a percentage of the signal range.

figure 20 illustrates the input to output conversion for different dynamic range reduction models. The two-knee model gives the most accurate approximation of the gamma correction curve.

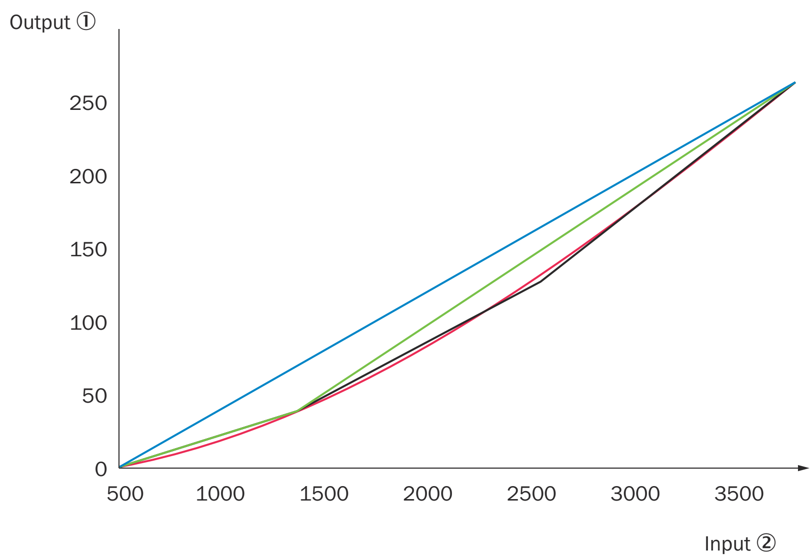


Figure 20: Illustration of input (horizontal axis) to output (vertical axis) conversion using 16 to 8-bit dynamic range reduction. The input signal is mapped to 0-255. A linear model (blue), a non-linear model with one knee-point (green) and a non-linear model with two knee-points (black) are used to approximate a gamma correction curve with gamma = 0.7 (red)

① Output

② Input

8.9 High dynamic range (HDR) imaging

Ranger3 supports high dynamic range (HDR) imaging, which increases the sensor's ability to adequately reproduce both bright and dark areas in a scene. HDR is suitable for improving the localization of the laser line when acquiring images containing both dark and bright materials, such as bright objects towards a dark background or dark objects with bright prints.

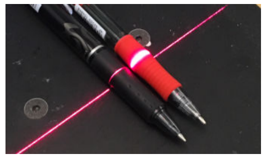


Figure 21: Acquisition of profiles

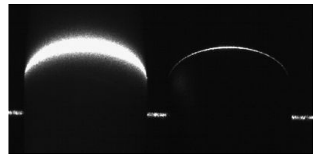


Figure 22: Resulting profile, linear (non-HDR) mode

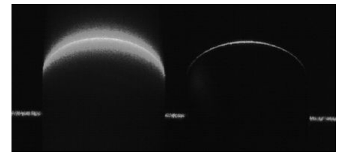


Figure 23: Resulting profile, HDR mode

Ranger3 uses an HDR principle called multiple-slope with one knee-point, which means that the normal linear relationship between the received light and the resulting pixel value (reflectance) is broken into two linear segments. The result is a compressed light-to-pixel value characteristic for high light intensities, according to figure 24.

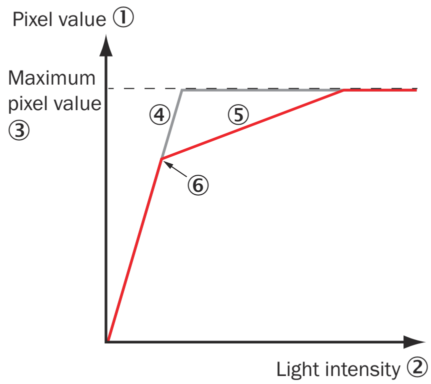


Figure 24: HDR multiple-slope principle

①	Pixel value
②	Light intensity
③	Maximum pixel value
④	Linear (non-HDR) mode
⑤	HDR mode
⑥	Knee-point

The knee-point position and the slope after the knee-point are controllable by the **Multi-SlopeMode** parameter in the camera. There are three pre-defined parameter settings (soft, medium and aggressive) which correspond to different amounts of compression. These settings result in a dynamic range increase of approximately 2, 6 and 15, respectively. See figure 25.

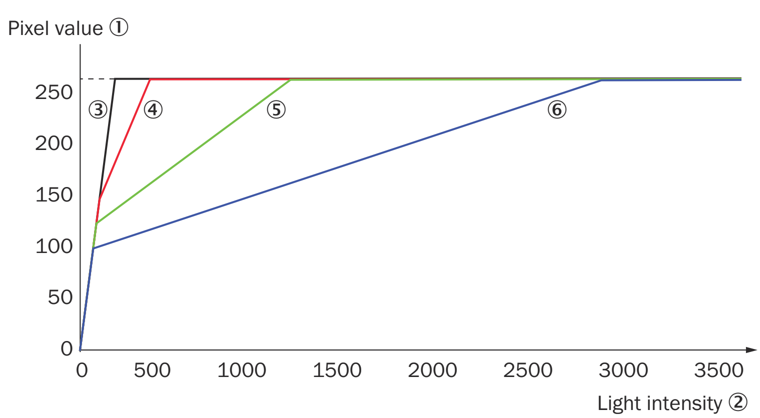


Figure 25: HDR settings for Ranger3

①	Pixel value
②	Light intensity
③	Linear (non-HDR) mode

④ Soft pre-set
⑤ Medium pre-set
⑥ Aggressive pre-set

In HDR mode, the sensor readout must be finished before a new exposure can start. The minimum cycle time is the sum of the exposure time and the readout time. In linear mode, the sensor readout and a new exposure can be done in parallel.

For example: If the readout time is 33 µs and the exposure time is 30 µ, the total cycle time is 33 µs for linear mode and 63 µs for HDR.

For information about how to enable HDR imaging for Ranger3, see "Enabling HDR imaging", page 69.

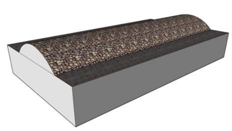
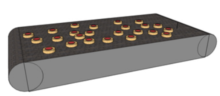
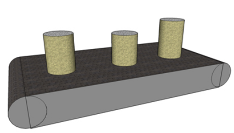
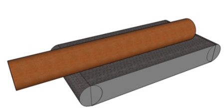
8.10 Triggering

Triggering is used to control the initiation and rate of data acquisition. Different triggering concepts and modes are presented below.

See "Setting triggering parameters", page 69 for information about how to activate triggering and set the parameters in the user interface.

8.10.1 3D triggering concepts

Different application types require different triggering concepts. Below is a table of the most common triggering situations.

	**Continuous flow**	No photoelectric switch is used. Profiles are sent continuously to the PC, typically arranged in frames of at least a few hundred profiles. Examples: Crushed stone, grain, sawdust.
	**Continuous flow of discrete objects**	No photoelectric switch is used. Profiles are sent continuously to the PC, typically arranged in frames of at least a few hundred lines. The resulting image buffers in the PC can be analyzed in a rolling buffer fashion, ensuring that all objects are analyzed completely. Example: Cookies.
	**Shorter objects of equal length**	A photoelectric switch is used. One image per object. Examples: Bottles, automotive parts, mobile phones.
	**Longer objects of variable size**	A photoelectric switch is used. Acquire profiles as long as the object remains in front of the camera. Several sub-images can be stitched together in the PC. Examples: Logs, fish, postal packages.

8.10.2 Triggering modes

There are different ways to trigger the camera to acquire frames and profiles. You can use an external signal to trigger each frame or each single profile. The camera can also be configured to acquire frames or profiles with regular time intervals, without an external trigger signal.

Note that when the camera acquires 2D images, a frame is the same thing as a complete 2D image. When the camera acquires 3D images, each frame is a set of profiles. This means that the acquisition of profiles and the Line triggering concept are only applicable for 3D images, while the 2D image triggering concept is only relevant for 2D images.

Frame triggering The camera will acquire frames based on an external input signal, for example from a photoelectric switch.
The acquisition of profiles can either be free-running or triggered by an input signal, as described in the sections **Free-running** and **Line triggering** below.

Line triggering The camera will acquire each profile based on an external input signal. There are two possibilities:

- Connect an external input signal to the line trigger input of the device.
- Use an encoder for line triggering. In that case, pulses are received on the encoder inputs. The distance between two profiles is determined by the number of pulses received.

Triggering each profile from an encoder will keep the object proportions if the object motion, tracked by the encoder, changes. Four-phase encoders also allow tracking different motion patterns, see "Triggering using an encoder", page 39. The motion pattern is defined by the **EncoderOutputMode** parameter.
When you use the line trigger input, each pulse on the line trigger input triggers one profile. Profiles are triggered when the object is moving either backward or forward. The **EncoderOutputMode** parameter is not used.

Free-running The camera will acquire 2D images (in Areascan mode) or profiles (in Linescan3D mode) with a regular time interval. In Areascan mode the time interval is controlled by the **AcquisitionFrameRate** parameter and in Linescan3D mode by the **AcquisitionLineRate** parameter.
When the acquisition of profiles is free-running, the distance between two profiles varies if the speed of the object is not constant. This may distort the image. To avoid distortion, you can use an encoder and record the counter value for each profile. This information makes it possible to calculate a correct image.

2D image triggering The camera will acquire 2D images based on external pulses on the encoder inputs.
The use of a four-phase encoder allows tracking of different motion patterns. The principles for motion tracking during 2D image triggering are the same as for line triggering, see "Triggering using an encoder", page 39.

8.10.3 Triggering using an encoder

When you use an encoder for triggering, the camera counts the number of pulses received on the encoder inputs using an internal counter. When the specified number of pulses has been received, a profile or a 2D image is triggered and the camera resets the triggering condition counter.

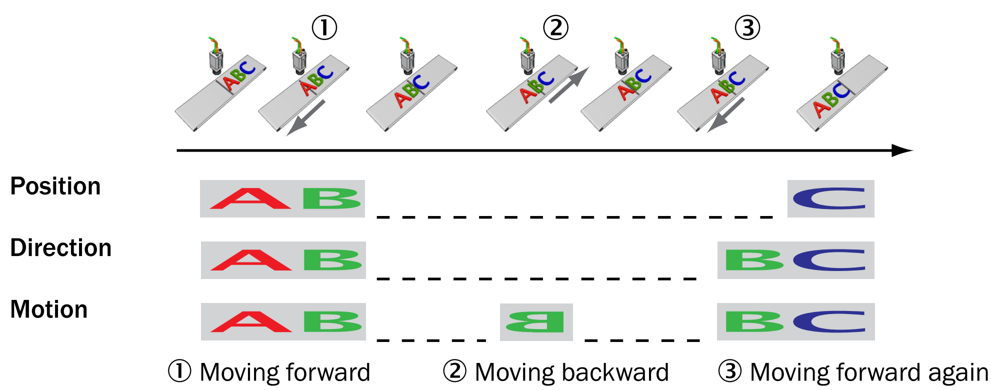
Four-phase (dual-channel) encoder

The default definition of a pulse is a full four-phase cycle on the encoder inputs. This gives a pulse counter that is robust to jitter and noise on the inputs. It is also possible to use a high-resolution encoder pulse counting mode, where each flank on an encoder input is counted. In this mode, a 4-times higher resolution is achieved, but in Direction and Motion modes (see below) jitter on the input may lead to unwanted triggering.

A four-phase encoder can handle movements in both directions (forward and backward). The camera can be configured to react to the pulses in different ways, resulting in different ways to trigger profiles. The different line triggering modes are illustrated below.

Mode	Parameter	Description
Position	**EncoderOutputMode** = PositionUp or PositionDown	The encoder triggers a profile for each object position. If the object has moved backward, no profiles are triggered until the object has moved (at least) an equal distance forward. PositionUp: "Forward" is defined as the positive direction. PositionDown: "Forward" is defined as the negative direction.
Direction	**EncoderOutputMode** = DirectionUp or DirectionDown	The encoder triggers profiles when the object is moving forward. If the object has moved backward, new profiles will be triggered as soon as the object moves forward again. DirectionUp: "Forward" is defined as the positive direction. DirectionDown: "Forward" is defined as the negative direction.
Motion	**EncoderOutputMode** = Motion	The encoder triggers profiles when the object is moving either backward or forward.

Table 5: Triggering modes



Single-channel encoder

A single-channel encoder uses only one encoder channel. The input from the encoder to the camera is a differential signal, and a profile is triggered each time the signal goes high.

When a single-channel encoder is used, the camera cannot differentiate between forward and backward movement. The single-channel encoder mode (**EncoderMode** = SingleChannel) is therefore only visible and selectable when the **EncoderOutputMode** (see table 5) is set to Motion.

State diagrams and trigger points

The encoder states and the possible transitions for a dual-channel encoder and a single-channel encoder are shown in figure 26. The trigger point depends on the type of encoder used:

- Dual-channel encoder, forward direction: The trigger point occurs when channel B goes from 1 to 0. See figure A.
- Dual-channel encoder, backward direction: The trigger point occurs when channel A goes from 1 to 0. See figure B.
- Single-channel encoder: The trigger point occurs when channel A goes from 0 to 1. See figure C.
- High-resolution encoder: The trigger point occurs for every single rising or falling edge on any channel.

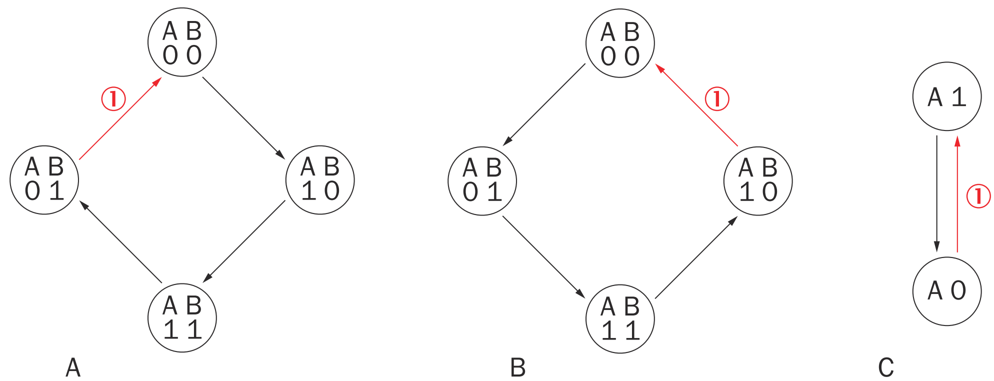


Figure 26: Encoder states and possible transitions

① Trigger point

8.10.4 Frame triggering

The Frame trigger input is used to trigger the camera to start to acquire profiles when the object passes a photoelectric switch. If the same photoelectric switch is connected to several cameras then synchronization at the microsecond level can be achieved.

When using the Frame trigger input, the **Height[Scan3dExtraction1]** parameter specifies the number of profiles that the camera acquires after the Frame trigger signal goes high. After the specified number of profiles, the camera will either idle or continue to acquire another series of profiles, depending on the state of the Frame trigger signal and the settings of the acquisition control parameters. See the table and the figure below.

Parameter settings	
TriggerSelector = FrameStart **TriggerMode[TriggerSelector]** = Off	• The camera acquires profiles continuously.
TriggerSelector = FrameStart **TriggerMode[TriggerSelector]** = On	• The acquisition of a new series of profiles (that is, capturing of a new frame) starts each time the Frame trigger input has a high level as input. • Multiple Frame trigger signals are ignored until all profiles (as specified by **Height[Scan3dExtraction1]**) have been acquired. • Note that for the very first profile the camera requires not only a high level but also a rising edge.

The system adapts the buffer height for the frame grabber and the camera to the **Height[Scan3dExtraction1]** parameter to keep the image synchronized and receive a full image after the image capture is completed. To avoid unnecessary CPU load, set the **Height[Scan3dExtraction1]** parameter to no less than 100 pixels.

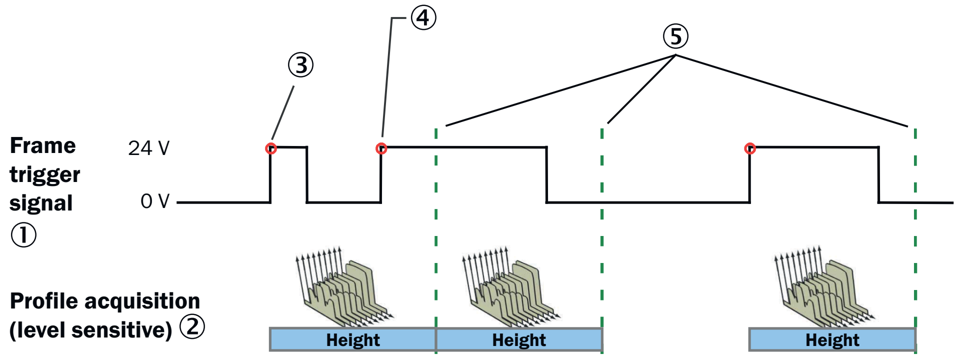


Figure 27: Timing diagram for Frame trigger signal

① Frame trigger signal
② Profile acquisition (level sensitive)
③ Frame trigger signal rising edge. Acquisition of profiles starts.
④ Frame trigger signal rising edge. Ignored.
⑤ Acquisition complete. Interpretation of Frame trigger signal.

8.11 Chunk data

Chunk data are tagged blocks of data, that are sent together with the image data. In Ranger3, chunk data are used to add encoder data to the image data. Each buffer contains, in addition to the image data, a chunk of meta data. The following meta data are available for each buffer:

- The value of the encoder counter for each line in the buffer.
- The time stamp for each line in the buffer.
- The height of the buffer.
- The width of the buffer.

8.12 Features

The features that are used for Ranger3 are listed in the following sections (see "Concepts", page 27 for a definition of a feature). Most of the features comply with GenICam™ SFNC. There are also some custom features that are described in separate tables.

The "Type" column defines the data type for a feature. GenICam defines a number of interface classes for SFNC features, where each interface class corresponds to a data type. For example, the interface class "IBoolean" corresponds to the data type "boolean".

The "Visibility" column defines which user that sees a feature in the parameter editor, see "Parameter editor", page 56. Note that the visibility level of some standard features has been adjusted compared to the recommended setting.

The "Access" column defines if the feature is readable ("R"), writeable ("W"), or both ("RW"). "R(W)" means that for some selector values the feature is both read- and writeable, but for other selector values it is just readable. In some cases, the read- and writability of a certain parameter depends on the model and version of the device.

For further information, including detailed descriptions of the standard parameters, see www.emva.org/standards-technology/genicam/.

NOTE
There are parameter dependencies both within and between the feature groups, which means that changing the value of one parameter might also change the value of others.
Examples:

- The maximum **AcquisitionLineRate** value depends on the **Height** value (a larger number of rows gives a lower maximum speed).
- The maximum **ExposureTime** value depends on the **AcquisitionLineRate** value (see "Exposure time and measurement speed", page 31).

8.12.1 Device control

Table 6: Device control standard SFNC selector

Selector	Type	Description	Visibility
DeviceTemperatureSelector	enum	Selects the location within the device, where the temperature will be measured. Values: Sensor, SensorBoard, MainBoard, ZpmSoc, Zpm1, Zpm2, Zpm3, Zpm4, Filter	Beginner

Table 7: Device control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
DeviceScanType	enum	Scan type of the sensor of the device. Ranger3 uses this parameter to control if 2D images (Areascan) or 3D profiles (Linescan3D) are acquired. Changing the **DeviceScanType** automatically sets the relevant device features for the selected mode. see "Device scan type", page 30 for details. Values: Areascan Linescan3d	Expert	R(W)
DeviceVendorName	string	Name of the manufacturer of the device.	Expert	R
DeviceModelName	string	Model of the device.	Expert	R
DeviceVersion	string	Version of the device. Used to note hardware version.	Expert	R
DeviceFirmwareVersion	string	Version of the firmware in the device.	Expert	R
DeviceManufacturerInfo	string	Manufacturer information about the device.	Expert	R
DeviceSerialNumber	string	Device's serial number.	Expert	R
DeviceUserID	string	User-programmable device identifier.	Beginner	RW
DeviceSFNCVersionMajor	int	Major version of the Standard Features Naming Convention that was used to create the device's GenICam XML.	Expert	R
DeviceSFNCVersionMinor	int	Minor version of the Standard Features Naming Convention that was used to create the device's GenICam XML.	Expert	R
DeviceSFNCVersionSubMinor	int	Sub minor version of Standard Features Naming Convention that was used to create the device's GenICam XML.	Expert	R
DeviceTLType	enum	Transport Layer type of the device. Values: GigEVision	Expert	R
DeviceTLVersionMajor	int	Major version of the Transport Layer of the device.	Expert	R
DeviceTLVersionMinor	int	Minor version of the Transport Layer of the device.	Expert	R

Parameter	Type	Description	Visibility	Access
DeviceTLVersionSubMinor	int	Sub minor version of the Transport Layer of the device.	Expert	R
DeviceLinkThroughputLimit	int	Limits the maximum bandwidth of the data that will be streamed out by the device on the selected Link.	Guru	RW
DeviceLinkHeartbeatTimeout	int	Controls the current heartbeat timeout of the specific link. A high link heartbeat timeout can be useful when debugging PC application code. The time (in ms) is the timeout before the device returns the Access Status to "Open" and disconnects from the current host.	Guru	RW
DeviceRegistersValid	bool	Returns if the current register set is valid and consistent. Updated after the **DeviceRegistersStreamingEnd** command.	Expert	R
DeviceTemperature[DeviceTemperatureSelector]	float	Device temperature in degrees Celsius (C).	Beginner	R

Table 8: Device control custom parameters

Parameter	Type	Description	Visibility	Access
DeviceRegistersStreamingActive	bool	True if a registers streaming session is active.	Guru	R
DeviceTemperatureMin	int	The minimum temperature ever in degrees Celsius (C) measured at the location selected by DeviceTemperatureSelector.	Beginner	RO
DeviceTemperatureMax	int	The maximum temperature ever in degrees Celsius (C) measured at the location selected by DeviceTemperatureSelector.	Beginner	RO
DeviceCurrentBootPath	enum	The booted software path, i.e., bootloader, kernel, application etc. Primary is the normal path and Secondary is used for rescue purposes if the primary path fails. Values: Primary Secondary	Expert	R
DeviceNextBootPath	enum	The boot path that will be used after the next soft reset[1]. This is normally set to secondary to boot the rescue version of the system if an unexpected reset occurs. Values: Unknown Primary Secondary	Guru	R
DeviceBootCount	int	Accumulated number of times the device has been booted.	Beginner	RO
DeviceOperationTime	int	Accumulated operation time of the device, in seconds.	Beginner	RO

1 A soft reset is an unwanted re-boot of the device.

Table 9: Device control standard SFNC commands

Command	Description	Visibility	Access
DeviceReset	Resets the device to its power up state.	Guru	RW
DeviceRegistersStreamingStart	Prepare the device for registers streaming without checking for consistency. DeviceRegistersStreaming is used when loading and saving a device's configuration to/from file on the host.	Guru	W

Command	Description	Visibility	Access
DeviceRegistersStreamingEnd	Announce the end of registers streaming. After this command **DeviceRegistersValid** is updated to reflect the status of the device settings.	Guru	W

8.12.2 Image format control

Table 10: Image format control standard SFNC selectors

Selector	Type	Description	Visibility
RegionSelector	enum	Selects the Region of interest to control. Values: Region0 Region1 Scan3dExtraction1	Beginner
ComponentSelector	enum	Selects a component to activate/deactivate its data streaming. Values: Intensity, Range, Reflectance, Scatter	Expert

Table 11: Image format control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
ExposureTime[RegionSelector][1]	float	Sets the Exposure time (in µs).	Beginner	R(W)
Width[RegionSelector]	int	Width of the image provided by the device (in pixels).	Beginner	R(W)
Height[RegionSelector]	int	Height of the image provided by the device (in pixels).	Beginner	R(W)
OffsetX[RegionSelector]	int	Horizontal offset from the origin to the region of interest (in pixels).	Beginner	R(W)
OffsetY[RegionSelector]	int	Vertical offset from the origin to the region of interest (in pixels).	Beginner	R(W)
RegionMode[RegionSelector]	enum	Controls if the selected region of interest is active and streaming. Values: Off On	Expert	R
ComponentEnable[RegionSelector][ComponentSelector]	bool	Controls if the selected component streaming is active.	Expert	RW
PixelFormat[RegionSelector][ComponentSelector]	enum	Format of the pixels provided by the device. Values: Mono8, Coord3D_C8, Mono12p, Mono16, Coord3d_C16	Expert	R(W)
TestPattern[RegionSelector][ComponentSelector]	enum	Selects the type of test pattern that is generated by the device as image source. Values: Off GreyHorizontalRampMoving	Expert	R(W)
RegionIDValue[RegionSelector]	int	The unique identifier value corresponding to the Region.	Expert	R
ComponentIDValue[ComponentSelector]	int	The unique identifier value corresponding to the selected Component type.	Expert	R

1 According to GeniCam™ SFNC, the **ExposureTime** parameter belongs to the **AcquisitionControl** category. Here it is moved to the **ImageFormatControl** category because it is selected by the **RegionSelector** parameter.

Table 12: Image format control custom parameter

Parameter	Description	Visibility	Access
RegionDescription[RegionSelector]	Describes the usage of a specific region in the device.	Beginner	R

8.12.3 Scan 3D control

Table 13: Scan 3D control standard SFNC selector

Selector	Type	Description	Visibility
Scan3dExtractionSelector	enum	Selects the 3DExtraction processing module to control (if multiple ones are present). Value: Scan3dExtraction1	Beginner
Scan3dCoordinateSelector[Scan3dExtractionSelector]	enum	Values: CoordinateA CoordinateB CoordinateC	Guru

Table 14: Scan 3D control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
Scan3dExtractionSource[Scan3dExtractionSelector]	enum	Selects the sensor's data source region for 3D Extraction module. This is hardcoded to a specific sensor region for each extraction module. Value: Region1	Expert	R
Scan3dExtractionMethod[Scan3dExtractionSelector]	enum	Selects the method for extracting 3D from the input sensor data. Value: Hi3D	Expert	R(W)
Scan3dInvalidDataFlag[Scan3dCoordinateSelector]	bool	Enables the definition of a non-valid flag value in the data stream.	Guru	R
Scan3dInvalidDataValue[Scan3dCoordinateSelector]	float	Value which identifies a non-valid pixel if **Scan3dInvalidDataFlag** is enabled.	Guru	R
Scan3dOutputMode[Scan3dExtractionSelector]	enum	Value: UncalibratedC	Guru	RW
Scan3dCoordinateSystem[Scan3dExtractionSelector]	enum	Value: Cartesian	Guru	R
Scan3dDistanceUnit[Scan3dExtractionSelector]	enum	Value: Pixel	Guru	R
Scan3dCoordinateScale[Scan3dCoordinateSelector]	float		Guru	R
Scan3dCoordinateOffset[Scan3dCoordinateSelector]	float		Guru	R
Scan3dAxisMin[Scan3dCoordinateSelector]	float	Minimum valid transmitted coordinate value of the selected axis.	Guru	R
Scan3dAxisMax[Scan3dCoordinateSelector]	float	Maximum valid transmitted coordinate value of the selected axis.	Guru	R

Table 15: Scan 3D control custom parameters

Parameter	Type	Description	Visibility	Access
WAMSize[Scan3dExtractionSelector]	enum	Size of Window Around Maximum (WAM) for high-resolution peak fitting. Adapt to the laser peak width on the sensor. Values: Small: size 7 pixels, peak width 2-4 pixels Normal: size 15 pixels, peak width 3-8 pixels (default) Large: size 31 pixels, peak width 7-15 pixels	Beginner	RW
DetectionThreshold[Scan3dExtractionSelector]	int	Minimum reflectance signal that can be detected as a peak position. A higher value reduces detectability of weak peaks (reflections on dark material) and a lower value increases the risk of detected noise peaks. Values 0-255. Default value 20.	Beginner	RW
SearchMode3D[Scan3dExtractionSelector]	enum	What peak type(s) to search for. Values: GlobalMax FirstLocalMax	Expert	RW
SearchDirection[Scan3dExtractionSelector]	enum	In FirstLocalMax this defines "first" or "last" peak in Region. Values: Standard (increasing rows) Reverse	Expert	RW
RangeAxis[Scan3dExtractionSelector]	enum	Defines the direction of the Z-axis when visualizing 3D data. Values: Standard Reverse	Expert	RW
ReflectanceFilter	bool	Speckle reduction smoothing of reflectance.	Guru	RW
ScatterMode[Scan3dExtractionSelector]	enum	Mode for laser scatter, both sides, front (lower rows), back (higher rows) Values: SymmetricSideBand FrontSideBand BackSideBand	Expert	RW
ScatterOffset[Scan3dExtractionSelector]	int	Distance in pixels from the center of the window to start of scatter measurement. A distance of 0 includes the center pixel.	Beginner	RW
ScatterWidth[Scan3dExtractionSelector]	int	Number of pixels to add in scatter measurement side band.	Beginner	RW
ScatterReductionCurve[Scan3dExtractionSelector]	enum	Select mode for reducing scatter values from 16 to 8 bits. Values: Linear OneKnee TwoKnees	Guru	RW
ScatterReductionLowerLimit[Scan3dExtractionSelector]	int	Scatter values below this value will be clipped to zero.	Guru	RW
ScatterReductionUpperLimit[Scan3dExtractionSelector]	int	Scatter values above this value will be clipped to 255.	Guru	RW
ScatterReductionKnee1Input[Scan3dExtractionSelector]	int	Input coordinate of the first knee, expressed as a percentage of the specified input range.	Guru	RW

Parameter	Type	Description	Visibility	Access
ScatterReductionKnee1Output[Scan3dExtractionSelector]	int	Output coordinate of the first knee, expressed as a percentage of the output range.	Guru	RW
ScatterReductionKnee2Input[Scan3dExtractionSelector]	int	Input coordinate of the second knee, expressed as a percentage of the specified input range.	Guru	RW
ScatterReductionKnee2Output[Scan3dExtractionSelector]	int	Output coordinate of the second knee, expressed as a percentage of the output range.	Guru	RW

8.12.4 Acquisition control

Table 16: Acquisition control standard SFNC selector

Selector	Type	Description	Visibility
TriggerSelector	enum	Selects the type of trigger to configure. Value: LineStart FrameStart ExposureStart AreaScanFrameStart	Beginner

Table 17: Acquisition control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
AcquisitionMode	enum	Sets the acquisition mode of the device. Values: SingleFrame Continuous	Beginner	RW
AcquisitionFrameRate	float	Controls the acquisition rate (in Hertz) at which the frames are captured. Valid if **DeviceScanType** is Areascan.	Beginner	R(W)
AcquisitionLineRate	float	Controls the rate (in Hertz) at which the lines in a frame are captured. Valid if **DeviceScanType** is Linescan3D and no external line trigger is active.	Beginner	R(W)
TriggerMode[TriggerSelector]	enum	Controls if the selected trigger is active. Values: On Off	Beginner	RW
TriggerSource[TriggerSelector]	enum	Specifies the internal signal or physical input line to use as the trigger source. The selected trigger must have its **TriggerMode** set to On. Values: Encoder, FrameTriggerInput, LineStart, LineTriggerInput	Beginner	R
TriggerActivation[TriggerSelector]	enum	Specifies the activation mode of the trigger. Values: RisingEdge LevelHigh	Beginner	R(W)
TriggerDelay	float	Specifies the delay (in microseconds) to apply after the trigger reception before activating it.	Beginner	RW
MultiSlopeMode[TriggerSelector]	enum	Increases the dynamic range Values: Off, PresetSoft, PresetMedium, PresetAggressive	Expert	RW

Parameter	Type	Description	Visibility	Access
MultiSlopeKneePointCount	int	The number of knee-points as well as the number of additional exposure slopes used for multi-slope exposure.	Expert	RW

Table 18: Acquisition control standard SFNC commands

Command	Description	Visibility	Access
AcquisitionStart	Starts the acquisition of the device.	Beginner	R(W)
AcquisitionStop	Stops the acquisition of the device at the end of the current frame.	Beginner	RW

8.12.5 Digital I/O control

Table 19: Digital I/O control standard SFNC selector

Selector	Type	Description	Visibility
LineSelector	enum	Selects the physical line (or pin) of the external device connector or the virtual line of the transport layer to configure. Values: FrameTriggerInput, LaserStrobe1Output, LaserStrobe2Output, EncoderAInput, EncoderBInput	Expert

Table 20: Digital I/O control standard SFNC parameter

Parameter	Type	Description	Visibility	Access
LineStatus[LineSelector]	bool	Returns the current status of the selected input or output line.	Expert	R
LineMode[LineSelector]	enum	Controls if the physical Line is used to Input or Output a signal. Values: Input Output	Expert	R
LineSource[LineSelector]	enum	Selects which internal acquisition or I/O source signal to output on the selected Line. **LineMode** must be Output. Values: Off LaserStrobe1Timer LaserStrobe2Timer	Expert	R
LineInverter[LineSelector]	bool	Controls the inversion of the selected input or output line. The line signal is inverted if checked (i.e. set to true).	Expert	RW
LineFormat[LineSelector]	enum	Controls the current electrical format of the selected physical input or output Line. For encoder Lines: RS422 corresponds to differential 5V (TTL) logic mode. Line24V corresponds to single-ended 24V (HTL) logic mode. Since encoder input B uses the same signal level as encoder input A, EncoderBInput is automatically changed when EncoderAInput is changed, and vice versa. Values: RS422 Line24V	Expert	RW

8.12.6 Timer control

Table 21: Test control standard SFNC selector

Selector	Type	Description	Visibility
TimerSelector	enum	Select the laser or sensor trigger output to configure. Values: LaserStrobe1Timer LaserStrobe2Timer	Expert

Table 22: Test control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
TimerDuration[TimerSelector]	float	Sets the duration (in microseconds) of the Timer pulse.	Expert	RW
TimerDelay[TimerSelector]	float	Sets the duration (in microseconds) of the delay to apply at the reception of an internal trigger before starting the Timer. The maximum value depends on **AcquisitionLineRate**.	Expert	RW
TimerTriggerSource[TimerSelector]	enum	Selects the source of the trigger to start the Timer. Values: Off, LineTrigger, GPIO, PulseGenerator	Expert	RW

8.12.7 Encoder control

Table 23: Encoder control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
EncoderResolution	float	Defines the resolution of one encoder tick in the used coordinate system.	Beginner	RW
EncoderMode	enum	FourPhase mode is the standard encoder mode where the EncoderValue increments on each full four phase sequence which supresses jitter. Values: FourPhase HighResolution SingleChannel	Expert	RW
EncoderDivider	int	Sets how many encoder increment/decrements that are needed to generate an encoder output pulse signal.	Beginner	RW
EncoderOutputMode	enum	Selects the conditions for the encoder interface to generate a valid encoder output signal. Values: PositionUp, PositionDown, DirectionUp, DirectionDown, Motion	Expert	RW
EncoderValue	int	Reads the current value of the position counter of the selected encoder.	Expert	R
EncoderResetSource	enum	Selects the signals that will be the source to reset the Encoder. Value: Off	Expert	RW
EncoderResetActivation	enum	Selects the Activation mode of the Encoder Reset Source signal. Value: RisingEdge	Expert	RW

Table 24: Encoder control standard SFNC command

Command	Description	Visibility	Access
EncoderReset	Resets the EncoderValue of the selected Encoder. The Encoder starts counting events immediately after the reset. EncoderReset can be used to reset the Encoder independently from the EncoderResetSource.	Expert	W

8.12.8 Event control

Table 25: Event control standard SFNC selector

Selector	Type	Description	Visibility
EventSelector	enum	Selects which Event to signal to the host application. Value: LogMessage	Expert

Table 26: Event control standard SFNC parameter

Parameter	Type	Description	Visibility	Access
EventNotification[EventSelector]	enum	Activate or deactivate the notification to the host application of the occurrence of the selected Event. Values: Off: The selected Event notification is disabled. On: The selected Event notification is enabled.	Expert	RW

8.12.9 User Set control

Table 27: User Set control standard SFNC selector

Selector	Type	Description	Visibility
UserSetSelector	enum	Selects the feature User Set to load, save or configure. Default User Set is read-only and cannot be modified. Values: Default, UserSet1, UserSet2, UserSet3, UserSet4, UserSet5	Beginner

Table 28: User Set control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
UserSetDefault[UserSetSelector]	enum	Selects the feature User Set to load and make active by default when the device is reset. Values: Default, UserSet1, UserSet2, UserSet3, UserSet4, UserSet5	Beginner	RW

Table 29: User Set control custom parameters

Parameter	Type	Description	Visibility	Access
UserSetDescription[UserSetSelector]	string	Description of the content of a User Set.	Beginner	RW
UserSetFirmwareVersion[UserSetSelector]	string	The firmware version for which the configuration was created. It is only possible to load user sets that are created for the currently running firmware version.	Beginner	R

Table 30: User Set control standard SFNC commands

Command	Description	Visibility	Access
UserSetLoad[UserSetSelector]	Loads the User Set specified by **UserSetSelector** from the device's non-volatile memory and makes it active.	Beginner	RW
UserSetSave[UserSetSelector]	Saves the User Set specified by UserSetSelector to the non-volatile memory of the device.	Beginner	RW

8.12.10 File access control

Normally, the user must not edit these features. They are only used for firmware update.

Table 31: File access control standard SFNC selectors

Selector	Type	Description	Visibility
FileSelector	enum	Selects the target file in the device. Values: Testfile, Update, CurrentLog, AllCrashLogs, FirmwareUpdateLog	Guru
FileOperationSelector	enum	Selects the target operation for the selected file in the device. Values: Open, Close, Write, Read, Delete	Guru

Table 32: File access control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
FileAccessOffset[FileSelector][FileOperationSelector]	int	Controls the Offset of the mapping between the device file storage and the FileAccessBuffer.	Guru	RW
FileAccessLength[FileSelector][FileOperationSelector]	int	Controls the Length of the mapping between the device file storage and the FileAccessBuffer.	Guru	RW
FileOperationStatus[FileSelector][FileOperationSelector]	enum	File operation execution status. Values: Success Failure	Guru	R
FileOperationResult[FileSelector][FileOperationSelector]	int	File operation result. For Read or Write operations, the number of successfully read/written bytes is returned.	Guru	R
FileOpenMode[FileSelector]	enum	Selects the access mode in which a file is opened in the device. Values: Read Write ReadWrite	Guru	RW
FileSize[FileSelector]	int	The size of the selected file, in bytes.	Guru	RW

Table 33: File access control standard SFNC commands

Command	Description	Visibility	Access
FileOperationExecute[FileSelector][FileOperationSelector]	Executes the operation selected by FileOperationSelector on the selected file.	Guru	RW

8.12.11 Chunk data control

Table 34: Chunk data control standard SFNC parameter

Parameter	Type	Description	Visibility	Access
ChunkModeActive	bool	Activates the inclusion of Chunk data in the payload of the image.	Beginner	RW

8.12.12 Test control

Normally, the user must not edit this feature. It is only intended for standard compliance testing.

Table 35: Test control standard SFNC command

Command	Description	Visibility	Access
TestEventGenerate	Generates a Test Event. Used for GenICam standard compliance event testing.	Guru	RW
TestPayloadFormatMode	This feature allows setting a device in test mode and to output a specific payload formatting for validation of data streaming.	Guru	R
TestPayloadType	This feature selects the payload type the device will use for streaming when the TestPayloadFormatMode feature is active.	Guru	R

8.12.13 Transport layer control

Normally, the user must not edit these features. Changing them can cause errors.

Table 36: Transport layer control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
PayloadSize	int	Provides the number of bytes transferred for each image or chunk on the stream channel.	Expert	R

8.12.13.1 GigEVision

Normally, the user must not edit these features. Changing them can cause errors.

Table 37: GigEVision control standard SFNC parameters

Parameter	Type	Description	Visibility	Access
GevMCPHostPort	int	Controls the port to which the device must send messages.	Guru	R
GevMCDA	int	Controls the destination IP address for the message channel.	Guru	R
GevMCTT	int	Provides the transmission timeout value in milliseconds.	Guru	R
GevMCRC	int	Controls the number of retransmissions allowed when a message channel message times out.	Guru	R
GevMC SP	int	Indicates the source port for the message channel.	Guru	R
GevSCPHostPort	int	Controls the port of the selected channel to which a GVSP transmitter must send data stream or the port fromwhich a GVSP receiver may receive data stream.	Guru	R
GevSCPSPacketSize	int	Specifies the stream packet size, in bytes, to send on the selected channel for a GVSPtransmitter (set by negotiation between the device and PC during connection) or specifies the maximum packet size supported by a GVSP receiver.	Expert	R
GevSCPD	int	Controls the delay (in GEV timestamp counter unit) to insert between each packet for this stream channel. This feature can be used as a crude flow-control mechanism if the application or the network infrastructure cannot keep up with the packets coming from the device.	Expert	RW
GevSCDA	int	Controls the destination IP address of the selected stream channel to which a GVSP transmitter must send data stream or the destination IP address from which a GVSP receiver may receive data stream.	Guru	R
GevSCSP	int	Indicates the source port of the stream channel.	Guru	R
MultiPartSupport	bool	Manual Enable/Disable of multipart-configuration bit (25) in SCCFGx register for testing.	Guru	RW

Parameter	Type	Description	Visibility	Access
GevMACAddress	int	MAC address of the logical link.	Expert	R
GevCurrentIPConfigurationPersistent IP	bool	Controls whether the PersistentIP configuration scheme is activated on the given logical link.	Expert	R
GevCurrentIPConfigurationDHCP	bool	Controls whether the DHCP IP configuration scheme is activated on the given logical link. The device falls back to Link Local Address in case no DHCP response is received after several timed out requests.	Expert	RW
GevCurrentIPConfigurationLLA	bool	Controls whether the Link Local Address IP configuration scheme is activated on the given logical link.	Expert	R
GevCurrentIPAddress	int	Reports the IP address for the given logical link.	Expert	R
GevCurrentSubnetMask	int	Reports the subnet mask of the given logical link.	Expert	R
GevCurrentDefaultGateway	int	Reports the default gateway IP address to be used on the given logical link.	Expert	R
GevPersistentIPAddress	int	Controls the Persistent IP address for this logical link. It is only used when the device boots with the Persistent IP configuration scheme.	Expert	RW
GevPersistentSubnetMask	int	Controls the Persistent subnet mask associated with the Persistent IP address on this logical link. It is only used when the device boots with the Persistent IP configuration scheme.	Expert	RW
GevPersistentDefaultGateway	int	Controls the persistent default gateway for this logical link. It is only used when the device boots with the Persistent IP configuration scheme.	Expert	RW
GevTimestampTickFrequency	int	The timestamp tick frequency in Hz. Used for timestamping frames, chunks and events.	Expert	R
GevDiscoveryAckDelay	int	Indicates the maximum randomized delay the device will wait to acknowledge a discovery command.	Expert	R

Table 38: GigEVision control custom commands

Command	Description	Visibility	Access
GevNetworkInterfaceReconfigure	Reconfigures the network interface according to the settings made. If the settings have changed the connection will be lost to the device and it may get a new IP address.	Expert	RW

8.12.14 Firmware update

Table 39: Firmware update custom parameters

Parameter	Type	Description	Visibility	Access
FirmwareUpdateProgress	enum	The current state of the firmware update process.	Guru	R
FirmwareUpdateScriptProgress	float	Estimated progress of update script. 0.00 means not started, 1.00 means finished.	Guru	R
FirmwareUpdateScriptRemainingTime	int	Estimated time left of the firmware update script.	Guru	R

9 Operation

9.1 Description of the graphical user interface

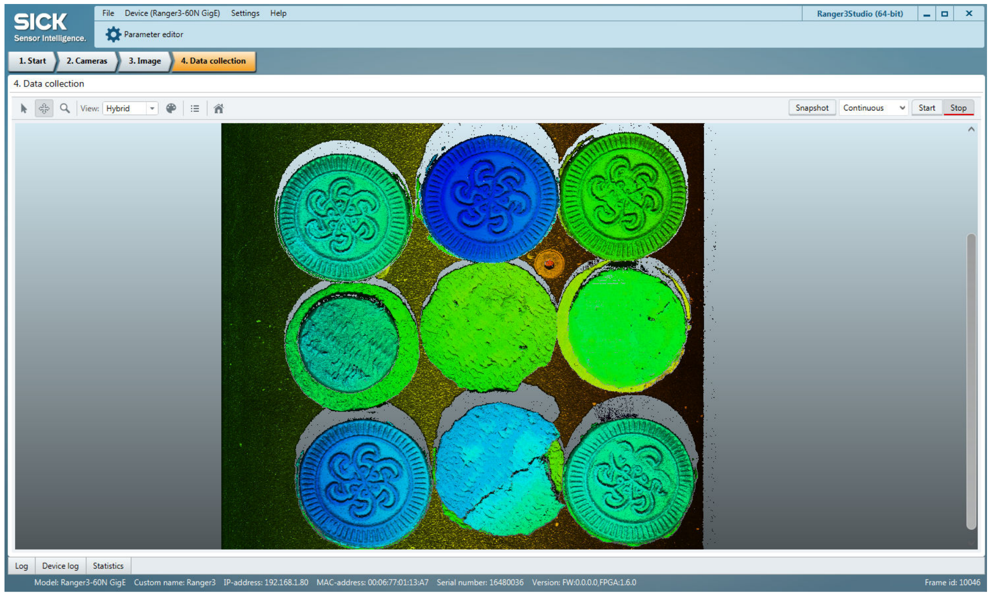


Figure 28: Graphical user interface

The Ranger3 Studio application is part of the Ranger3 SDK (see "Installing PC software", page 27). You use its graphical user interface (GUI) to configure camera parameters and evaluate the measurement results. It is also useful when you mount the camera and laser, and adjust focus and aperture.

The GUI offers different ways to visualize the data. You can also store data to file for later use. You can change the settings for the camera and instantly see how the changes affect the measurement result. The GUI is therefore useful for finding the best parameter settings for a certain application.

Once the camera has been set up to deliver measurement data that meets the requirements, the settings can be saved in a parameter file on the PC.

9.1.1 Menus

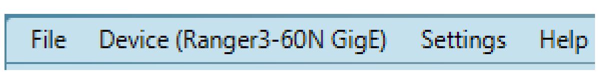


Figure 29: Menus

Four menus are available.

The **File** menu includes the following alternatives:

- **Import configuration**
- **Export configuration**
- **Load buffer from file**
- **Save buffer to file**
- **Exit**

The **Device** menu includes the following alternatives:

- **Parameter editor**
- **Save device log**
- **Save crash logs**

- **Save firmware update log**
- **Firmware update**

The **Settings** menu includes the following alternative:

- **Show partial images**

The **Help** menu includes the following alternative:

- **About**

9.1.2 Parameter editor

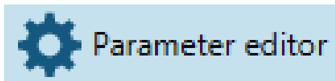


*Figure 30: **Parameter editor** button*

Click the **Parameter editor** button in the user interface to open the Parameter editor. The Parameter editor contains all the features that are available in the camera, sorted by category (see "Features", page 42 for a full list of categories and features). To search for a feature in the Parameter editor, use the search field in the upper left corner.

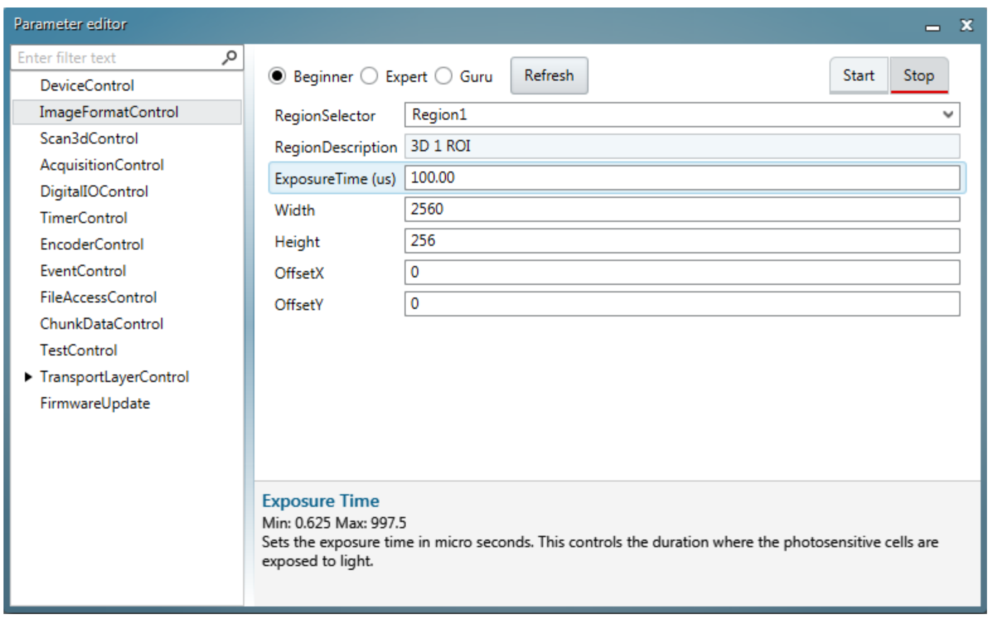


Figure 31: Parameter editor

Visibility options

The visibility options **Beginner**, **Expert**, and **Guru** define which features that are shown in the Parameter editor. They are described in the table below.

Table 40: Visibility options

Beginner	Basic features that are enough to operate the camera.
Expert	In addition to the basic features, also features that require a more in-depth knowledge of the camera functionality.
Guru	All features that are available in the camera. This includes advanced features that can bring the camera into a state where it will not work properly anymore.

Editing parameter values

Editable parameters have white input fields. Click an input field to edit its value. For non-editable parameters, the input fields are inactivated and displayed in gray.

Most input fields are locked during image acquisition, which means that the parameter values cannot be changed. When hovering over a locked input field, a warning message appears. Click a locked input field to unlock it and stop the image acquisition.

Starting and stopping the image acquisition

The **Start** and **Stop** buttons in the Parameter editor start and stop the image acquisition. Use these buttons to control the image acquisition directly from the Parameter editor during parameter adjustment.

9.1.3 Workflow steps

Figure 32: Workflow steps

The following workflow steps are available:

Start

In this step, you see the last connected device and reconnect to it.

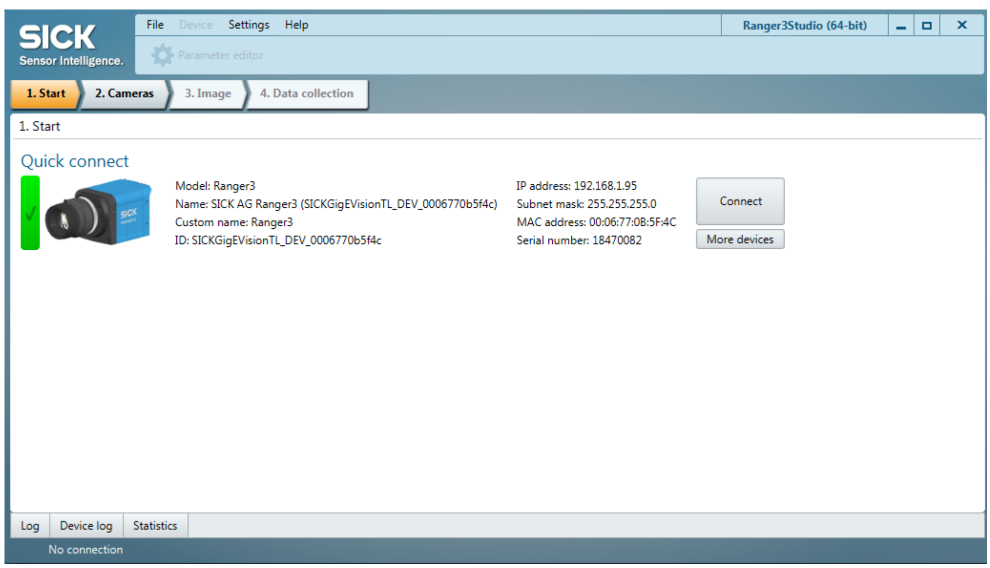


*Figure 33: Workflow step **Start***

Cameras

In this step, you search the network and see a list of all devices that are available. You can select a device and connect or disconnect to it.

It is also possible to reconfigure the camera IP settings. This is useful for example when you want to connect to a camera that is not on the same subnet as the NIC, see "Recommended network card settings", page 94. Then you have to reconfigure the camera to the same subnet, before you can connect to it.

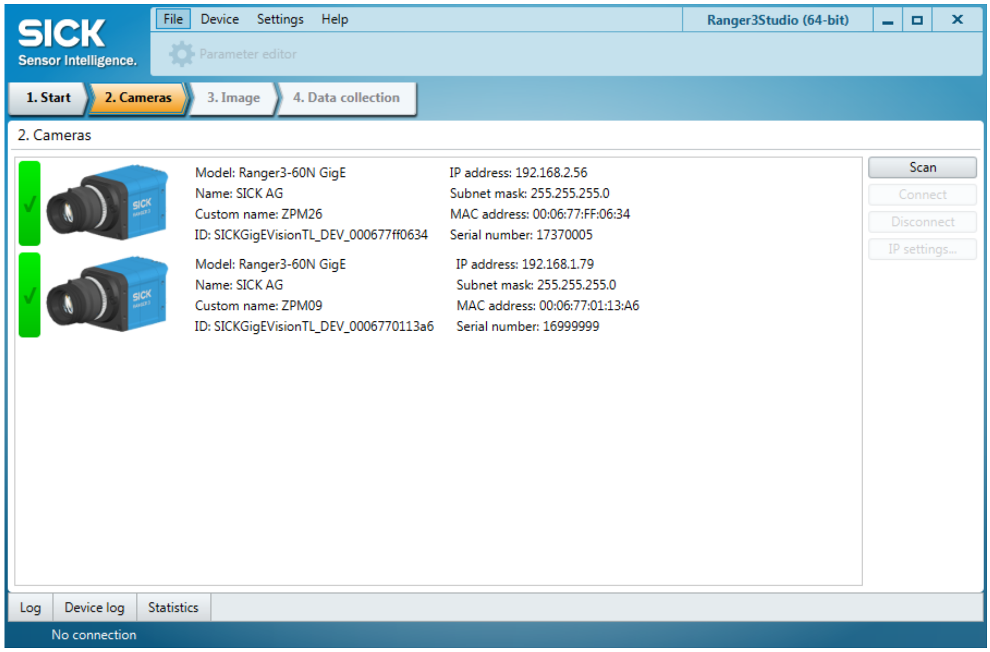


Figure 34: Workflow step ***Cameras***

Image

Here you view the 2D image data. This is what the camera sees when it is used as an ordinary camera.

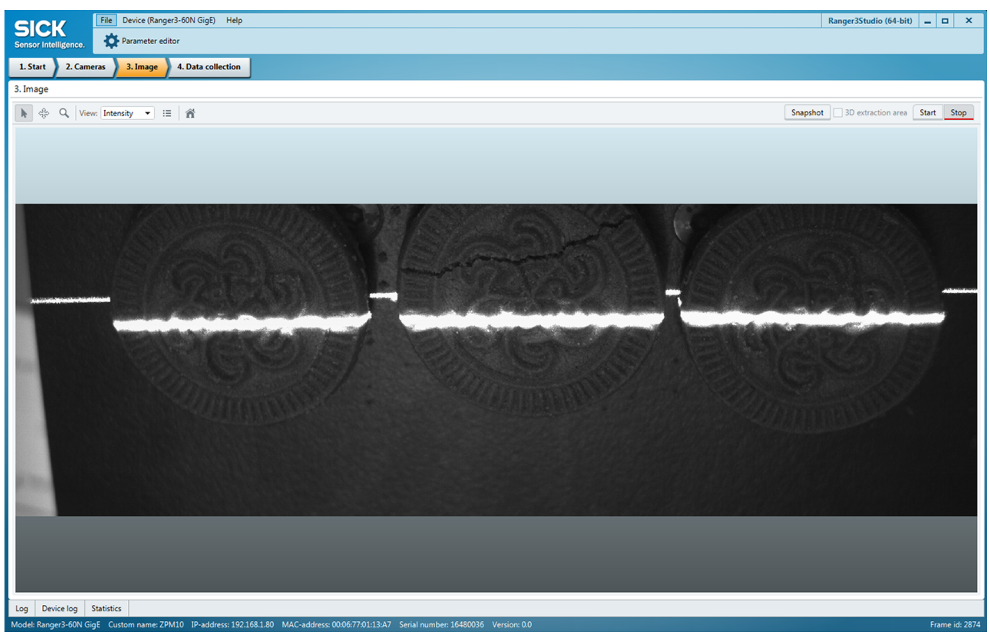


Figure 35: Workflow step ***Image***

Data collection

Here you view the 3D image that is the result of using the laser triangulation (linescan3D) mode.

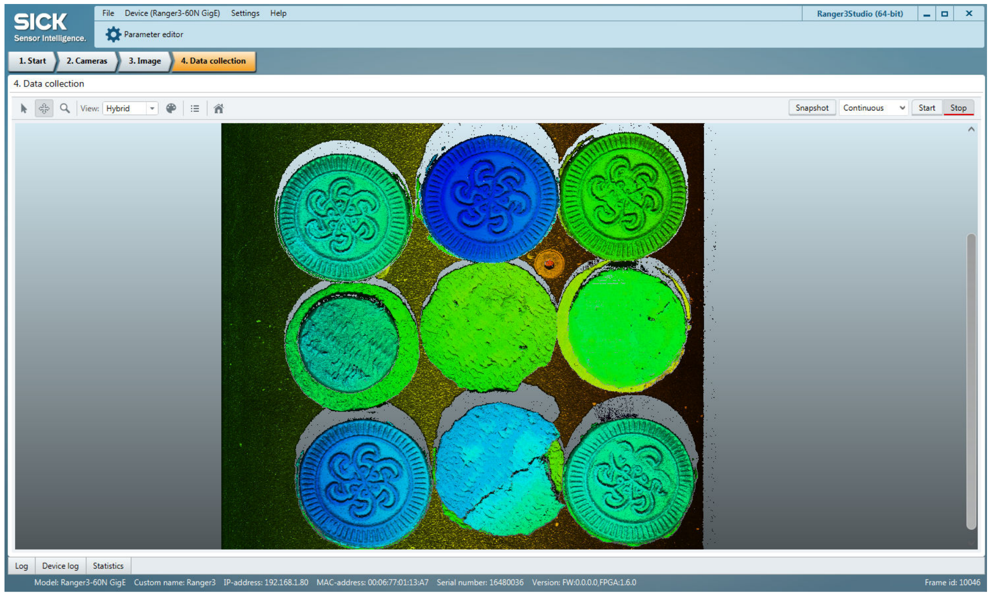
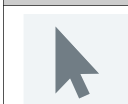
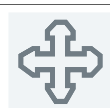
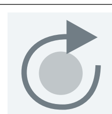


Figure 36: Workflow step ***Data collection***

9.1.4 Image handling controls

Use the image handling controls to manipulate regions and perspective when viewing images. As an alternative to the buttons, you can use a mouse with a scroll wheel, as described below.

Button	Name	Description
	Select	Click and drag to change the size and position of the image. Shortcut command: **Ctrl+Q**.
	Move	Click and drag to move the image. Shortcut command: **Ctrl+W**. **Shift+** press and hold the mouse scroll wheel.
	Rotate	Click and drag to rotate the image. Shortcut command: **Ctrl+E**. Press and hold the mouse scroll wheel.
	Zoom	Click and drag upwards to zoom in and downwards to zoom out. Shortcut command: **Ctrl+R**. Rotate the mouse scroll wheel.

3D navigation control

Use the 3D navigation control in the lower left corner of the image viewer to switch between different viewing angles:

- Click an arrowhead (X, Y or Z) to view a 2D projection of the object.
- Click the same arrowhead twice to flip the 2D projection (for example, to switch between the top and bottom view for the Z-axis).
- Press Home to restore the original viewing position.

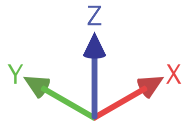


Figure 37: 3D navigation control

9.1.4.1 Pointer information

If you use the Select image handling control and move the mouse pointer over the image area, some information is shown. For a 2D image, the coordinates and the intensity value of each point are displayed. This information is useful for example when you set the height of a region, see "Setting sensor region", page 66. For a 3D image, the coordinates, the sensor row, and the encoder counter value of each point are displayed.

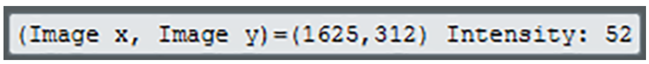
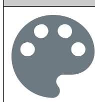


Figure 38: Pointer information (2D image)

9.1.5 Image view options

Button	Name	Description
	Color	View image in color (various options) or grayscale.
	Options	Contains options for **Color Range**, **Surface** and **Points**, as described in this manual.
	Home	Restore default settings for position and zoom.

9.1.6 Log and statistics tabs

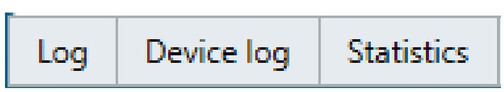


Figure 39: Log and statistics tabs

At the bottom of the main window, there are three tabs where log messages and statistics are available.

Log and Device log

The **Log** tab contains messages from the GUI, and the **Device log** tab contains messages from the device.

The system assigns each log message a level, either **SEVERE**, **WARNING**, **INFO** or **FINE**.

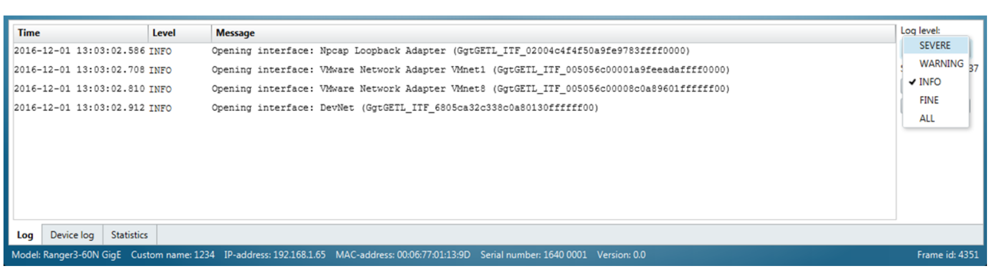


*Figure 40: **Log** tab*

Statistics

The **Statistics** tab contains network statistics, such as lost data.

*Figure 41: **Statistics** tab*

9.1.7 General information

At the bottom of the screen, the following information is shown:

- Model of the device
- Name of the device (**DeviceUserID**)
- IP address of the device
- MAC address of the device
- Serial number of the device
- Software version
- Frame ID of the image that is currently displayed.

NOTE
The frame ID is reset each time the camera is re-started.

9.2 Using the interface

9.2.1 Connecting and getting a 2D image

Workflow step: **Start**

The last connected device is displayed in the 'Quick connect' list together with a bar indicating the device status:


Device is available (or already connected).


Device is available, but the IP settings need to be modified.


Device is already in use.

1. If the suggested device is correct and available, click **Connect.**
2. If the suggested device is not correct or if the IP settings need to be modified,
   a) Click **More devices** to go to the **Cameras** workflow step.
   b) Click **Scan** to see all devices that are available on the network.
   c) Select the correct device.
   d) If needed, click **IP settings** and edit the non-persistent IP settings of the device, see "Editing IP settings", page 62.
   e) Click **Connect.**

✓ When the device is connected, the **Image** workflow step is displayed and the **Parameter editor** opens.

3. In the **Image** workflow step, click **Start** to view the 2D images and the laser line.

9.2.1.1 Editing IP settings

Before you connect to the camera, you can set non-persistent IP address, subnet mask, and gateway. These settings will be lost if the camera is restarted.

When you have connected to the camera, you can edit the corresponding parameters to make the settings persistent, that is, save them in the camera's flash memory.

Non-persistent IP settings

Workflow step: **Cameras**

1. Select the correct camera and click **IP settings**.

✓ A new window opens.

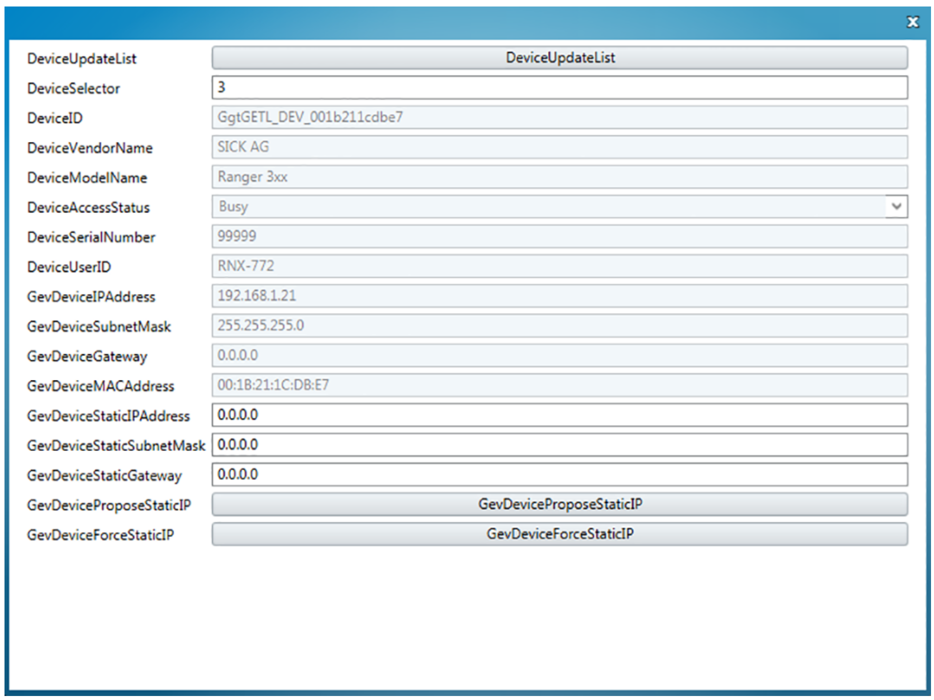


Figure 42: IP settings

2. To get suggested IP settings from the system, click **GevDeviceProposeIP**.
3. If needed, edit the suggested settings.
4. To save the IP settings, click **GevDeviceForceIP**.
5. Close the window.
6. To update the IP settings and the device status, click **Scan**.

Persistent IP-settings

Workflow step: **Image**, **Data collection**

1. Open the Parameter editor and go to the **TransportLayerControl** category.
2. In the **GigE vision** sub-category, select the **GevCurrentIPConfigurationPersistent IP** check box and then edit the **GevPersistentIPAddress**, **GevPersistentSubnetMask**, and **GevPersistentDefaultGateway** parameters.
3. Restart the camera to apply the updated parameters.

9.2.2 Adjusting focus

Workflow step: **Image**

When the camera is connected, look at the 2D image and the laser line and do the following adjustments:

1. If needed, adjust the tilt of the camera so that the laser line is horizontal in the image.
   This is to make sure that the laser line appears along the sensor in the camera.
2. Turn the focus ring of the camera until the image is focused.
3. If needed, adjust the focus of the laser according to the instructions of the laser manufacturer.

9.2.3 Recording images

Workflow step: **Image**, **Data collection**

Use the **Record** function in the user interface to record 2D or 3D buffers. When recording is active, each acquired buffer is streamed to the connected PC and saved in a selected target folder.

NOTE
The **Record** button is automatically released when the image acquisition stops.

1. Click the correct workflow step: **Image** for recording of 2D buffers, **Data collection** for recording of 3D buffers.
2. Click the **File** button above the image viewer.
3. In the dialog box that appears, select a target folder and a file name. The file name will be used as a prefix for each saved file.
4. Click **Save** to close the dialog box.
5. Click **Record** to activate image recording.
6. Click **Start** to start the image acquisition.

✓ Each acquired buffer is saved in the selected target folder on the PC.

9.2.4 Loading and saving parameter files

Workflow step: **Start**, **Cameras**, **Image**, **Data collection**

Loading

To load a .csv file with pre-defined parameter settings, do as follows:

1. In the **File** menu, select **Import configuration**.
2. Find and select the parameter file and click **Open**.

✓ The parameter settings are loaded.

Saving

To save the current parameter settings, do as follows:

1. In the **File** menu, select **Export configuration**.
2. Find a place to store the file, name it, and click **Save**.

✓ The parameter settings are saved as a .csv file.

9.2.5 Saving and loading a User File

It is possible to store an arbitrary file called a User File on the device. A User File can have any file extension and a maximum size of 100.000 bytes. A stored User File can be downloaded from the device to a PC.

NOTE

- When saving a User File to the device, the original file name and file extension are lost. The file is named "UserFile" on the device.
- If the selected file is too large, no data will be written to the device.

To save a User File from a PC to the device:

1. Connect the PC to the camera.
2. On the **Device** menu in the GUI, click **Device Files...**
✓ The **Device Files** window opens.
3. On the **UserFile** row, click **Send to camera**.
4. In the file selection dialogue that appears, select a file and click **Open**.
✓ The file is now stored on the device.

To download a User File from the device to a PC:

1. Connect the PC to the camera.
2. On the **Device** menu, click **Device Files...**
✓ The **Device Files** window opens.
3. On the **UserFile** row, click **Retrieve from camera**.
4. In the "Save as..." dialogue that appears, select a file name and a file extension.
5. Select a directory on the PC and click **Save**.
✓ The file is now stored on the device.

9.2.6 Booting the device using a User Set

A User Set contains a full set of parameter values that can be used for booting the camera. Up to five User Sets can be stored on the device.

The device can be programmed to boot from either one of the stored User Sets, or from the built-in **Default** parameter values. If no User Set is selected, the **Default** option is used.

To save a User Set:

1. Connect to the camera.
2. Open the Parameter editor.
3. Edit the parameter values for the User Set.
4. Select the **User Set Control** category.
5. In the **User Set Selector** list, select a User Set to use for storing the current parameter values.
6. Optionally, enter a description of the User Set in the **User Set Description** field.
7. Click **UserSetSave** to store the current parameter values in the selected User Set.

To boot from a User Set:

1. In the Parameter editor, select the **User Set Control** category.
2. In the **User Set Default** list, select the User Set that you want the device to boot from.
✓ Next time the device boots, it will use the parameter values in the selected User Set.

To load a User Set:

1. In the Parameter editor, select the **User Set Control** category.
2. In the **User Set Selector** list, select a User Set.
3. Click **UserSetLoad**.
✓ The parameters in the selected User Set are now used on the device.

Migrating a User Set

Since the set of available camera parameters often changes when the camera firmware is updated, a User Set is only valid for the firmware version that was used when creating the User Set.

After each firmware update, follow the steps below to migrate the stored User Sets to the current firmware version:

1. On the **Device** menu, click **Migrate User Sets**.
✓ The **User Set migration** window opens. If the **Migrate to current firmware** button is enabled for a User Set, it means that the current firmware version is different from the one that was used to create the User Set.
2. Click **Migrate to current firmware** to migrate the User Set to the current firmware version.

9.2.7 Editing parameters

Workflow step: **Image**, **Data collection**

When you adjust the parameters, you look at the 2D or 3D image to see the result. You can take a snapshot after each adjustment and compare the images to find the best configuration. You cannot edit the parameters while the camera is acquiring data.

1. Click **Stop** to stop the acquiring of data.
2. If the parameter editor is not already open, click **Parameter editor** to open it.
3. In the left part of the **Parameter editor** window, select the category that the parameter belongs to.
✓ The parameters of the selected category are displayed in the right part of the window.
4. If the parameter you want to edit is not shown, select **Expert** or **Guru** to make more parameters visible, see "Parameter editor", page 56.

NOTICE
If you edit parameters that have visibility **Expert** or **Guru**, you can make the system work incorrectly. Always make sure that you have the right knowledge before you make any changes.

5. Select the parameter.
✓ A description of the parameter is shown in the lower part of the window.
6. Depending on type of parameter, type or select the new value.
✓ The new value is saved automatically when you leave the input field or press Enter on your keyboard.
7. Click **Start** to start the data collection.
8. To take a snapshot of the currently displayed image and display it in a separate window, click **Snapshot**.

9.2.7.1 Setting exposure time

Workflow step: **Image**

1. In the **Parameter editor**, set **RegionSelector** to Region0.
2. Look at the 2D image and the laser line and adjust the **ExposureTime** parameter until the laser line is imaged as a narrow bright stripe and the background is not visible, see the figure in the middle below.

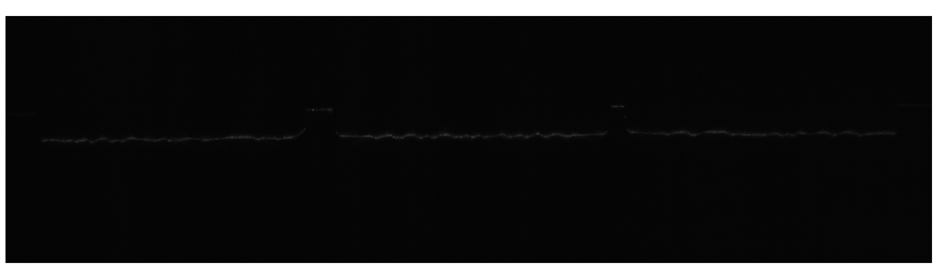


Figure 43: Too short exposure time: Laser line hardly visible.

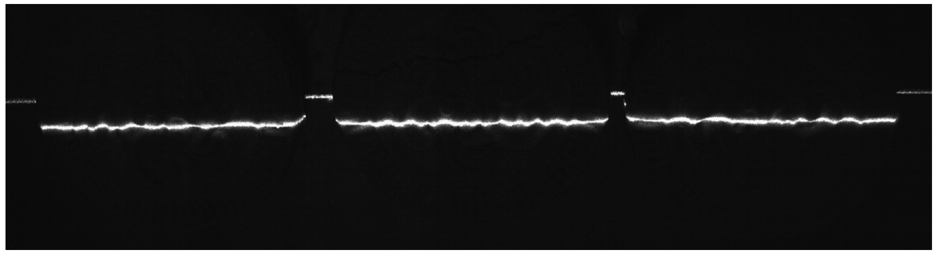


Figure 44: Normal exposure time: Laser line bright but not saturated. No background visible.

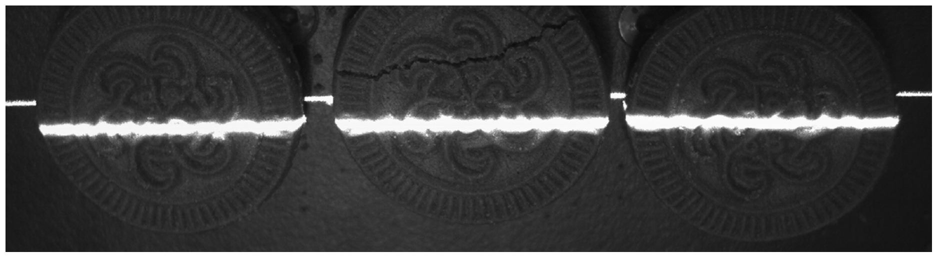


Figure 45: Too long exposure time: Laser line wide and saturated. The background is visible.

3. Set **RegionSelector** to Region1.
4. Set the **ExposureTime** parameter to the same value as for Region0.

✓ This will give the 3D acquisition the same exposure time as the 2D image.

NOTE
If reflectance measurements are enabled, the exposure time can also be adjusted using a reflectance image as reference. For details, see "Setting exposure time using reflectance", page 68.

9.2.7.2 Setting the **DetectionThreshold** parameter

Workflow step: **Data collection**

Prerequisites: Focus and exposure time have been adjusted for best image quality.

1. Turn the laser off.
2. Click **Start** to start the collection of 3D image data.

✓ Since the laser is turned off, only noise will be visible in the image.

3. Open the **Parameter editor** and select the **Scan3dControl** category.
4. Take a snapshot of the 3D image and adjust the **DetectionThreshold** parameter in the following way:
   - If there is much noise in the image, increase the **DetectionThreshold** value.
   - If there is no noise in the image, decrease the **DetectionThreshold** value.
5. Repeat the previous step until **DetectionThreshold** has a low value without excessive visible noise.
6. Turn the laser on.

9.2.7.3 Setting sensor region

Workflow step: **Image**

To adjust the height and position of the sensor region that is used to generate the 3D image data (**Region1**, see "Extraction regions", page 29), follow the steps below.

NOTE
For best image quality, make sure that the whole width of the laser line is within the region.

1. Select the **Show active sensor area** checkbox in the **Settings** section in the right part of the GUI.
✓ A blue overlay appears in the 2D image (see figure 46). The overlay represents the parts of the image to be excluded from the generation of 3D image data. The remaining dark area is the extraction area (corresponding to **Region1**).

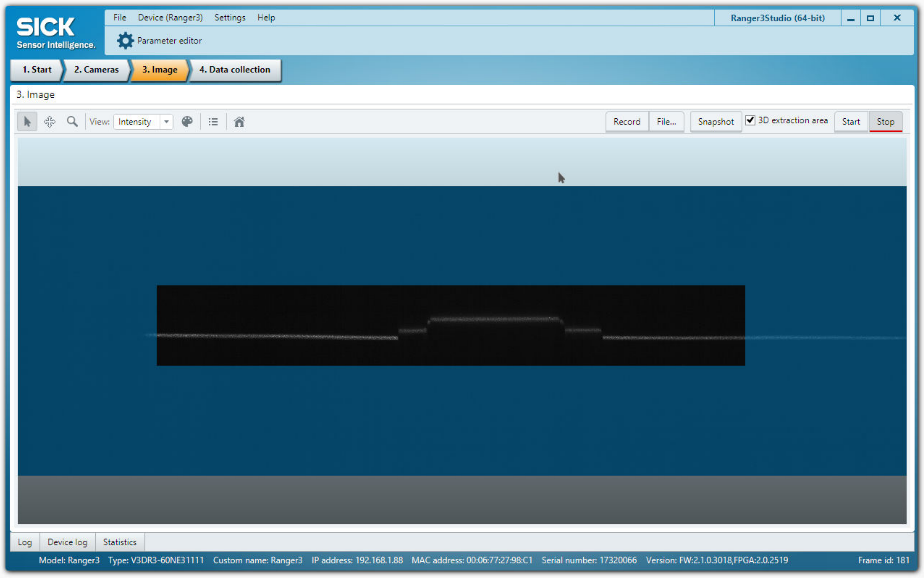


Figure 46: 2D image with blue overlay

2. Hover over the extraction area to highlight its handles.
3. Click and drag the handles to change the dimensions and offset for **Region1**:
   - Click and drag the middle handle to adjust the **OffsetY** and **OffsetX** parameters.
   - Click and drag the side handles to adjust the **Height** and **Width** parameters.

When a handle is moved, the corresponding parameter values in the Parameter editor are automatically updated. As an alternative to moving the handles, the parameter values can be changed directly in the Parameter editor.

Increasing the number of rows

The camera acquires 12-bits data as default, which means that the maximum height of Region1 is 256 rows. To increase the maximum number of rows, you must switch to 16-bits data, according to the steps below:

1. In the Parameter editor, set **RegionSelector** to Scan3dExtraction1.
2. Set **ComponentSelector** to Range.
3. Set **PixelFormat** to Coord3D_C16.

9.2.7.4 Enabling reflectance measurements

Workflow step: **Data collection**

To enable collection of laser reflectance values in addition to the range data, follow the steps below.

1. Open the **Parameter editor** and select the **ImageFormatControl** category.
2. Set **RegionSelector** to Scan3dExtraction1.
3. Set **ComponentSelector** to Reflectance.
4. Select the **Component Enable** checkbox.

To view the image with laser reflectance, select **Reflectance** or **Reflectance (Hybrid)** from the **View** list. see "View modes", page 72 for details.

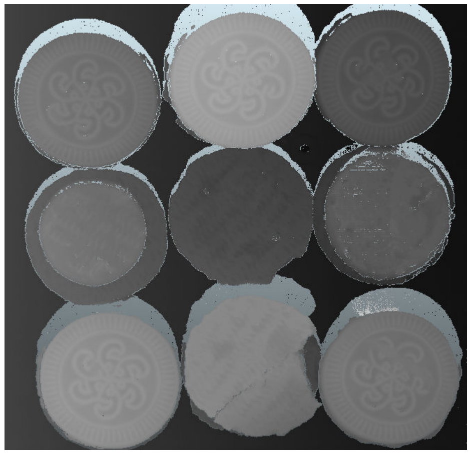


Figure 47: 3D image, no laser reflectance

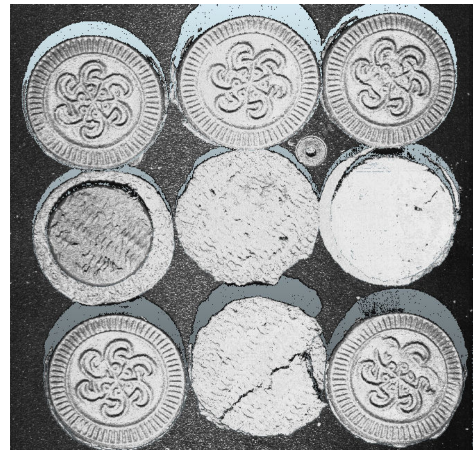


Figure 48: 3D image with laser reflectance

9.2.7.4.1 Setting exposure time using reflectance

Use the reflectance image as an indicator when adjusting the exposure time:

- If the exposure time is too low, the objects in the reflectance image contain dark regions or regions with missing data. See figure 49.
- If the exposure time is too high, the objects contain bright saturated areas and artifacts. See figure 51.

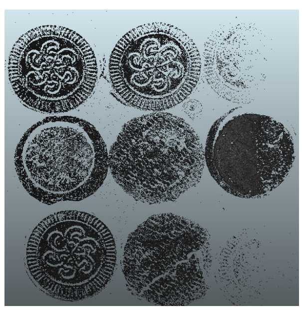


Figure 49: Low exposure time

Figure 50: Normal exposure time

Figure 51: High exposure time

9.2.7.5 Enabling scatter measurements

Workflow step: **Data collection**

To enable scatter measurements in addition to the range data, follow the steps below:

1. Open the Parameter editor and select the **ImageFormatControl** category.
2. Set **RegionSelector** to **Scan3dExtraction1**.
3. Set **ComponentSelector** to **Scatter**.
4. Select the **Component Enable** checkbox.

To edit the parameter values for the scatter measurements:

1. Select the **Scan3dControl** category.
2. Edit the relevant scatter parameters, which all have the prefix "**Scatter**". For more information about each parameter, see "Scatter", page 34.

NOTE
In the **Image** workflow step, select the **Simulate scatter window** checkbox to visualize the scatter profile for each column along the laser line. The visualization function can be used to evaluate the effect of each scatter parameter on the scatter data. See "Visualizing 2D data", page 70 for details.

9.2.7.6 Enabling HDR imaging

Workflow step: **Image**, **Data collection**

To enable HDR imaging:

1. Open the **Parameter editor** and select the **AcquisitionControl** category.
2. Set **MultiSlopeMode** to PresetSoft, PresetMedium or PresetAggressive.
   - PresetSoft increases the dynamic range by a factor ~2.
   - PresetMedium increases the dynamic range by a factor ~6.
   - PresetAggressive increases the dynamic range by a factor ~15.

NOTE
Using HDR affects the maximum exposure time:

- In Areascan (2D) mode, the maximum exposure time for PresetSoft, PresetMedium and PresetAggressive is about 16, 40 and 100 ms, respectively.
- In Linescan (3D) mode, the maximum exposure time for PresetSoft, PresetMedium and PresetAggressive is about 4,10 and 26 ms, respectively.

9.2.7.7 Setting triggering parameters

Workflow step: **Image**, **Data collection**

Open the **Parameter editor** and go to the **AcquisitionControl** category to adjust the triggering settings. For information about the triggering concepts, see "Triggering modes", page 38.

Enabling frame triggering:

1. Set the **TriggerSelector** parameter to **FrameStart**.
2. Set the **TriggerMode** parameter to **On**.

✓ The camera will acquire frames based on the triggering source specified by the **TriggerActivation** parameter.

3. Follow the steps in the **Enabling line triggering** section below to acquire profiles based on encoder input or line trigger signal input, or in the **Enabling free-running** section to acquire profiles with a regular time interval.

Enabling line triggering:

1. Set the **TriggerSelector** parameter to **LineStart**.
2. Set the **TriggerMode** parameter to **On**.
3. Set the **TriggerSource** parameter:
   - To acquire profiles based on encoder input, select **Encoder**.
   - To acquire profiles based on the line trigger input signal, select **LineTriggerInput**.

NOTE
When acquiring profiles based on the line trigger input signal, the time from line trigger to exposure start is 3 - 5 microseconds even if **TriggerDelay** is set to 0. The delay is due to debounce and deglitch filtering on the line trigger input.

Enabling free-running:

1. Set the **TriggerSelector** parameter to **LineStart**.
2. Set the **TriggerMode** parameter to **Off** to acquire profiles with a regular time interval.

3. To set the acquisition rate:
   - For 3D images, adjust the **AcquisitionLineRate** parameter.
   - For 2D images, adjust the **AcquisitionFrameRate** parameter.

Enabling 2D image triggering:
1. Set the **TriggerSelector** parameter to **AreascanFrameStart**.
2. Set the **TriggerMode** parameter to **On**.

For 2D image triggering, the encoder input is always used as trigger source (**Trigger-Source** = **Encoder**).

9.2.7.8 Setting the encoder type and encoder mode

Workflow step: **Data collection**

The **Expert** visibility option is required to change the below encoder settings in the Parameter editor.

Setting the encoder type

Set the encoder type in the GUI so that it matches the physical encoder that is used for the camera setup (RS-422 or HTL). For information about the encoder types, see "Power I/O connector", page 25.

NOTICE
- If the camera is programmed to use an RS-422 (5V) encoder, and an HTL (24V) encoder is connected, warnings are printed in the GUI log window. The camera is protected by protection circuits. Encoder pulses may be registered but the setup is not recommended.
- If the camera is programmed to use an HTL (24V) encoder, and an RS-422 (5V) encoder is connected, no warnings are printed in the GUI and no encoder pulses are registered.

To set the encoder type:
1. Open the Parameter editor.
2. Click the **Digital IO Control** category.
3. Set the **Line Selector** to **EncoderAInput**.
4. Set the **Line Format** to the correct encoder type. The **Line24V** option represents HTL.

Since encoder input B uses the same signal level as encoder input A, **EncoderBInput** is automatically changed when **EncoderAInput** is changed, and vice versa.

Setting the encoder mode

Follow the steps below to set the encoder mode (four-phase or high-resolution). For more information about the encoder modes, see "Triggering using an encoder", page 39.

NOTE
High-resolution encoder mode works with both RS-422 (5V) and HTL (24V) encoders.

1. Open the Parameter editor.
2. Click the **Encoder Control** category.
3. Set the **Encoder Mode** to the desired encoder mode.

9.2.8 Visualizing 2D data

The **Settings** section in the **Image** workflow step contains visualization options for the acquired 2D image data. The **Settings** section is located to the right of the image viewer in the GUI.

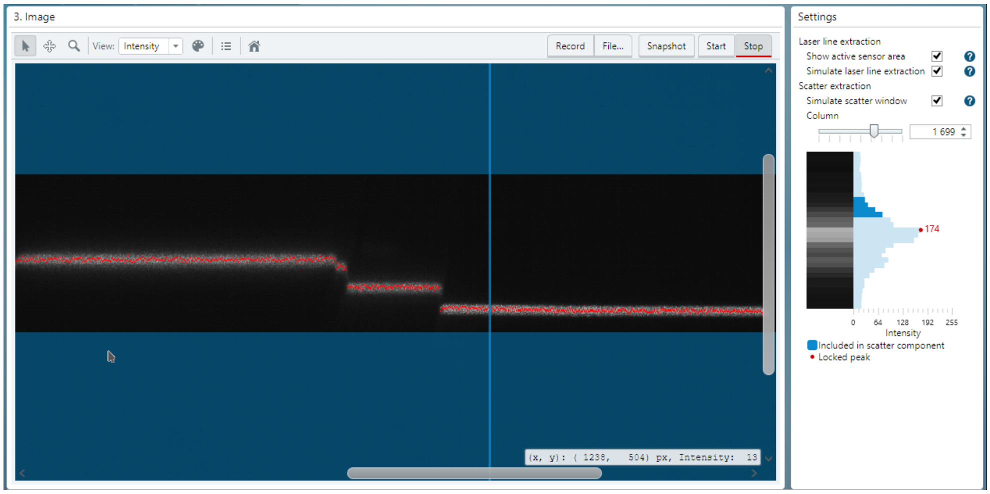


*Figure 52: Settings for the **Image** workflow step. The black region is the active sensor area. The red line represents the extracted laser line. The vertical blue line represents the sensor column for which the scatter data is visualized.*

Show active sensor area

Select the **Show active sensor area** checkbox to visualize the active area on the sensor. When the checkbox is selected, a blue overlay appears in the 2D image (see figure 52). The overlay represents the parts of the image to be excluded from the generation of 3D image data. The remaining dark area is the active sensor area (corresponding to **Region1**).

Simulate laser line extraction

Select the **Simulate laser line extraction** checkbox to visualize an approximation of the extracted laser line. The visualization shows where the laser line is detected in the active sensor area, which is useful for tuning laser line extraction parameters such as the **DetectionThreshold**, **PeakThreshold**, **WAMSize**, and **SearchDirection**.

Simulate scatter window

Select the **Simulate scatter window** checkbox to visualize the scatter data to be extracted, based on the current values for the **ScatterOffset**, **ScatterWidth**, and **ScatterMode** parameters. The visualization is useful for evaluating the effect of a parameter change on the scatter data. To enable scatter measurements, see "Enabling scatter measurements", page 68.

The vertical blue line in the image viewer (see figure 52) represents the sensor column for which the scatter data is visualized. Click and move the line, or change the **Column** value in the **Settings** section, to select a different sensor column.

9.2.9 Collecting 3D data

Workflow step: **Data collection**

1. Click **Start** to start the collection of 3D image data.
2. To adjust the number of profiles in each grabbed 3D image, set **RegionSelector** to **Scan3dExtraction1** and edit the **Height** parameter.
3. To take a snapshot of the 3D image, click **Snapshot**.

✓ The **Evaluation view** window opens and shows a 3D view of the image.

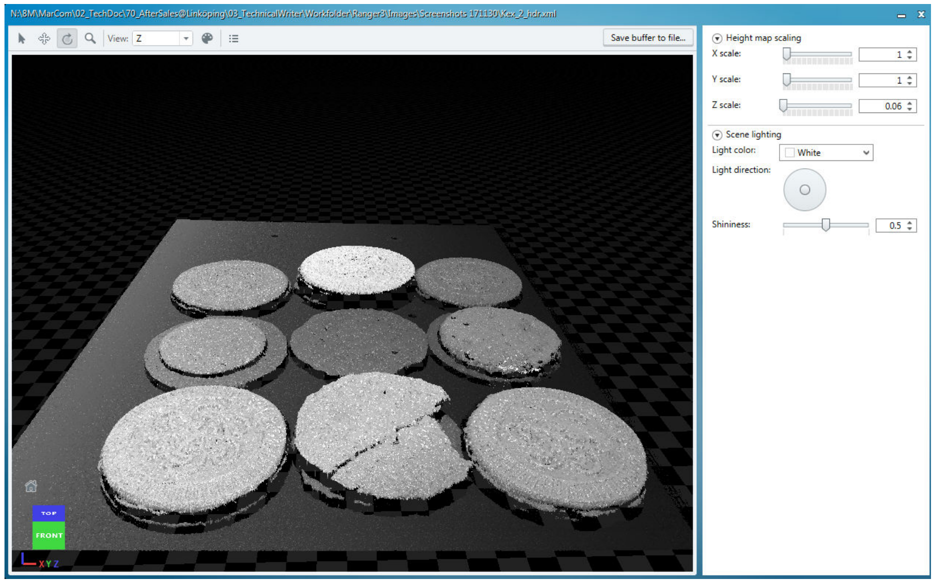


*Figure 53: **Evaluation view** window*

4. Use the image handling controls to move, rotate, and zoom while you inspect the image, see "Image handling controls", page 59.
5. Use the **View** drop-down menu to select view mode, see "View modes", page 72.
6. To change the color range, click the Options button and select **Color range**, see "Color range", page 73.
7. To select data presentation, click the Options button and select **Surface** or **Points**, see "Data presentation", page 74.
8. To adjust the proportions of the data, use the sliders in the GUI, see "Height map scaling", page 75.
9. To adjust the scene lighting, use the menus and sliders in the GUI, see "Light control", page 75.

9.2.10 Visualizing 3D data

9.2.10.1 View modes

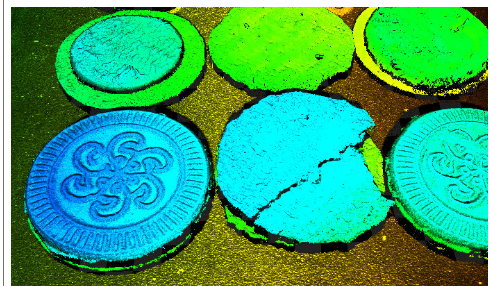
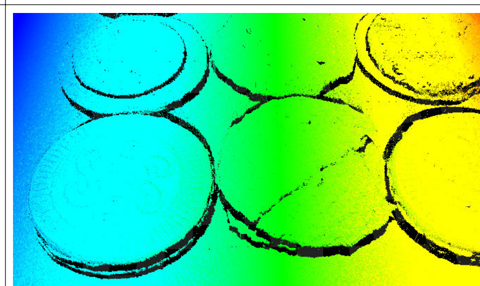
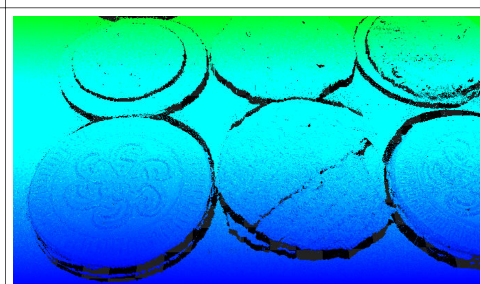
View mode for 2D images

For 2D images, **Intensity** is the only available view mode. In this mode, color is proportional to the intensity values of the pixels.

View modes for 3D images

When you view a 3D image, you can select different ways to color it. The following view modes are available:

View mode	Description	Example
Intensity	Color is proportional to the reflectance values along the laser line. Suitable to show the surface details of an object, such as a print.	

View mode	Description	Example
Hybrid	Color hue is proportional to depth (z-coordinate), color brightness is proportional to the laser reflectance. Suitable to show large variations in depth together with surface details.	
Normals	Color is proportional to the orientation of the surface normal vector. Suitable to show small variations in depth.	
X	Color is proportional to x-coordinate.	
Y	Color is proportional to y-coordinate.	
Z	Color is proportional to depth (z-coordinate). Suitable to show large variations in depth.	

9.2.10.2 Color range

When you adjust the color range, you adjust the interval that will be colored in the image. As default, the available color spectrum covers the whole range between the minimum and the maximum value of the data. If your object is small, or if you want to study a part of the object in detail, you can make the interval smaller. This means that the whole color spectrum is spread over a smaller interval, and it will be easier to see small variations in depth.

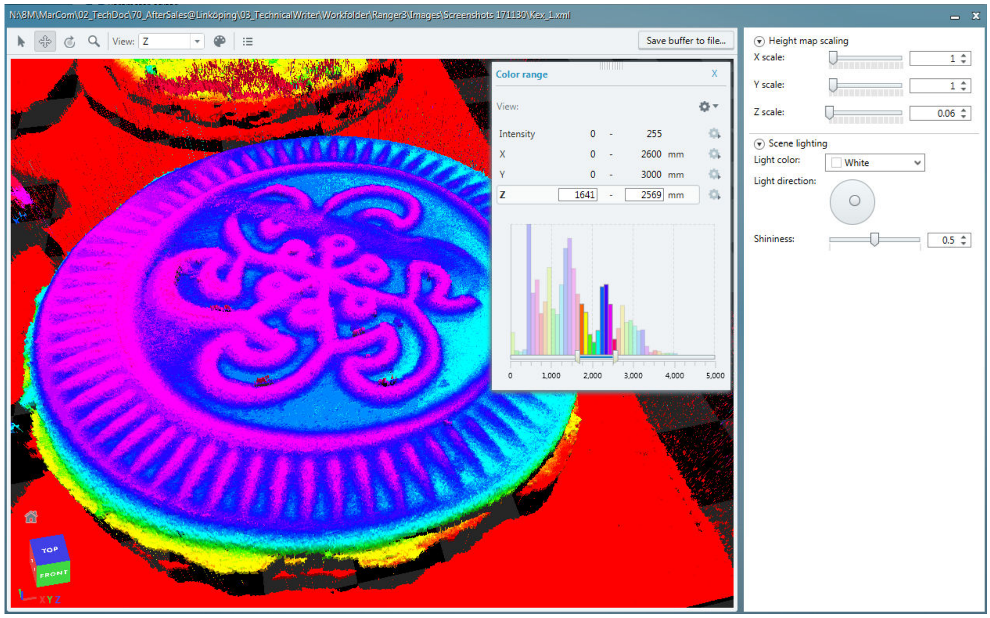


Figure 54: Narrow color range

1. To adjust the color range, either type the new values or use the slider at the bottom of the window.
2. To select color or black and white, click the Settings symbol.

9.2.10.3 Data presentation

Using the Options button, you can select different ways to present the image data.

1. To view the data as a continuous surface, select **Surface**.

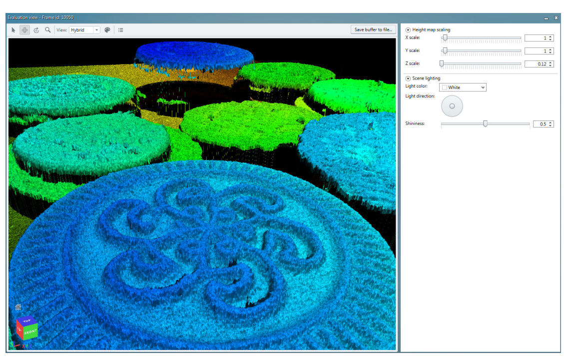


Figure 55: Data presentation ***Surface***

2. To view the data as a point cloud, select **Points** and use the slider to set the size of the points.

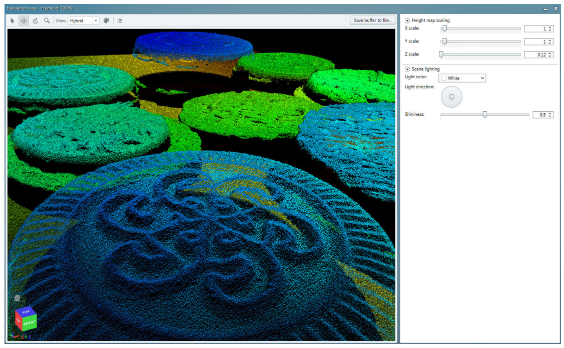


Figure 56: Data presentation ***Points****, small points*

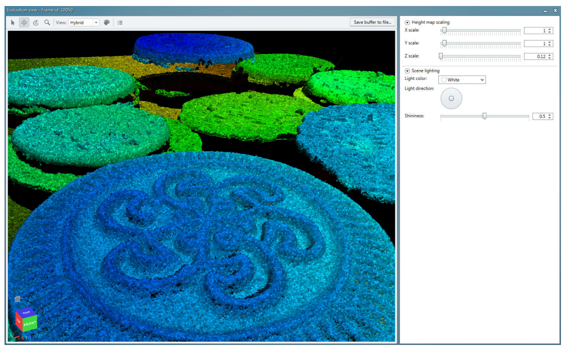


Figure 57: Data presentation ***Points****, larger points*

9.2.10.4 Height map scaling

In the **Height map scaling** section, you can change the proportions of your data by scaling the different axes. The default value is 1 for the X and Y axes, and 0.0625 (corresponding to 1/16th) for the Z axis.

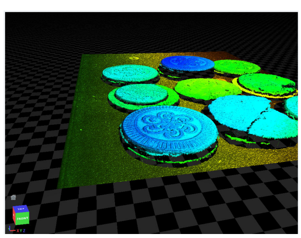


Figure 58: No scaling

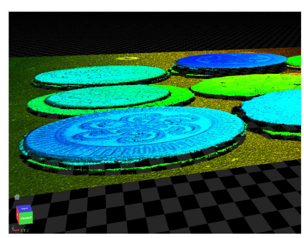


Figure 59: Scaling of X-axis

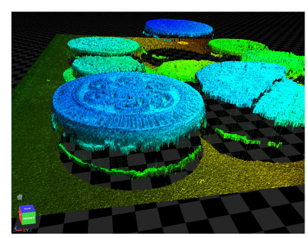


Figure 60: Scaling of Z-axis

9.2.10.5 Light control

In the **Scene lighting** section, you can select lighting effects for the dataset.

- Use the **Light color** list to change the lighting color. All colors in the RGB spectrum are available.
- Use the **Light direction** graph to adjust the position of the scene lighting effect.
- Use the **Shininess** slider to adjust the shining effect.

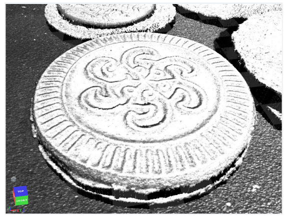


Figure 61: Bright light, centered

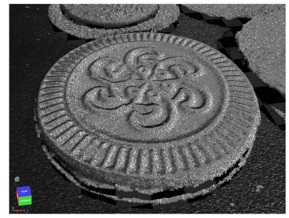


Figure 62: Bright light from right side

Figure 63: Brown light, centered

9.2.11 Loading and saving image buffers

Workflow step: **Image**, **Data collection**

When you save a 2D or 3D buffer, two separate files are created:

- A binary file that contains the image data.
- An XML file that describes the binary file.

In the **Image** workflow step, the currently displayed 2D image is saved. In the **Data collection** workflow step, the complete buffer of the currently displayed image is saved. This applies also if you have zoomed in so that only a part of the image is shown in the window.

Save buffer when the data collection is stopped

1. In the **File** menu, select **Save buffer to file.**

Save buffer while still collecting data

1. Click **Snapshot.**
2. Click **Save buffer to file.**

Record buffers during the data collection

When recording is active, each acquired buffer is streamed to the connected PC and saved in a selected target folder.

NOTE
The recording is automatically stopped when the image acquisition stops.

1. Click the correct workflow step: **Image** for recording of 2D buffers, **Data collection** for recording of 3D buffers.
2. Click **File.**
3. In the dialog box that appears, select a target folder and a file name. The file name will be used as a prefix for each saved file.
4. Click **Save** to close the dialog box.
5. Click **Record** to activate recording.
6. Click **Start** to start the image acquisition.

✓ Each acquired buffer is saved in the selected target folder on the PC.

Loading image data

To load saved image data:
1. In the **File** menu, select **Load buffer from file.**
2. Click the XML file describing the image data.

✓ The **Evaluation view** window opens and the image data is displayed.

9.2.12 Handling log messages

1. Select which log you want to study:
   a) To handle log messages from the GUI, click **Log**.
   b) To handle log messages from the device, click **Device log**.
2. In the **Log level** drop-down list, select which type of log messages you want to see. You see log messages on the selected level and the levels above it. For example, if you select **WARNING**, only log messages on level **SEVERE** and **WARNING** will be shown.
3. To manually save the data as a log file, click **Save to file**.
✓ All log messages are saved, also the messages that have a lower log level than the one selected above.
4. To delete all log messages, click **Clear**.

The log messages are always automatically saved as a java log, but when you use the **Save to file** button, the saved log will have a different format and you can select the file location.

9.2.13 Updating firmware

Follow the steps below to update the camera's firmware:

1. In the **Device** menu, select **Firmware update**.
2. Find and select the firmware file and click **Open**.
✓ The **Firmware updater** window opens and the firmware update starts automatically.

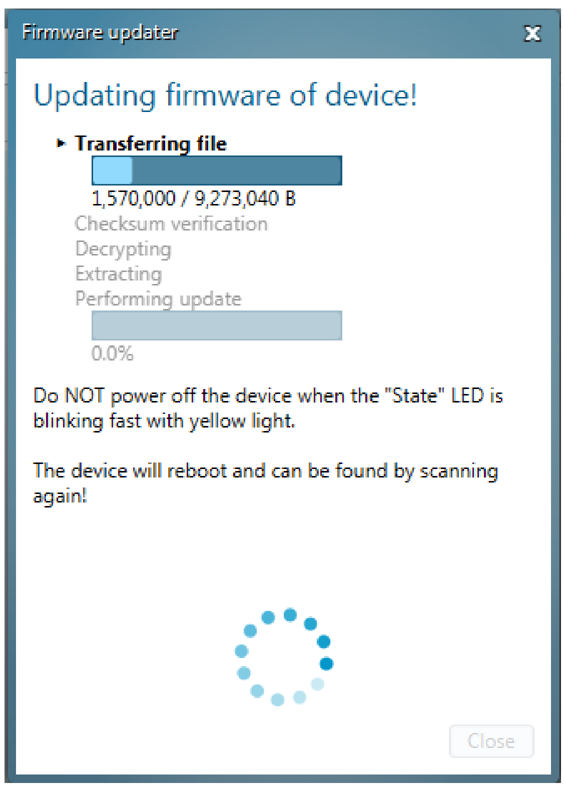


*Figure 64: **Firmware updater** window*

✓ When the update is finished, the device re-starts automatically.
3. Click **Close**.
4. Reconnect to the device, see "Connecting and getting a 2D image", page 61.

10 Maintenance

WARNING
Risk of injury due to optical radiation in connection with external laser devices

- The risk of injury depends on the laser used: Observe warning signs and operating instructions of the laser device!
- Before doing cleaning or maintenance work: Switch off device laser and take suitable protective measures.

10.1 Maintenance plan

NOTE
No maintenance is required to ensure compliance with the LED risk group.

Table 41: Maintenance plan

Maintenance work	Interval	To be carried out by
Cleaning the housing	Cleaning interval depends on ambient conditions and climate.	Specialist
Check screw connections and plug connectors	Interval depends on the place of use, ambient conditions, or operational regulations. Recommended: At least every 6 months.	Specialist
Check that the unused connections are sealed with protective caps or plugs	Interval depends on ambient conditions and climate. Recommended: At least every 6 months.	Specialist

10.2 Cleaning

NOTICE
Equipment damage due to improper cleaning.
Improper cleaning may result in equipment damage.

- Only use recommended cleaning agents.
- Never use sharp objects for cleaning.

▶ Clean the housing with a soft cloth, dry or dampened with a mild water-diluted cleaning agent without powder additives.

11 Troubleshooting

11.1 Over triggering

When you use Ranger3 with an external line trigger source it is possible to overtrig the camera. This means that a new trigger arrives before the sensor can acquire new data. When configuring Ranger3, the max value of the **AcquisitionLineRate** parameter indicates how fast the camera can be triggered. If the trig rate exceeds this, an overtrig occurs.

When a single overtrig occurs, the triggering of the profile is delayed until the sensor is ready. If several overtrigs occur before the sensor is ready, only the first overtrig will cause a trig, and the others will be discarded. The camera will signal an error of class SEVERE with the text "IRQ 9 Sensor overtrig or Internal Scheduling error". This is also followed later by INFO messages giving details of the error. The details can be logged for further error analysis by technical support but contain no further user information.

If overtrig occurs when it is not expected there might be noise on the trigger inputs.

11.2 Encoder line trigger setup tips

In the **DigitalIOControl** section the **LineStatus** parameter can be used to pull the status of the digital inputs for the encoder and the frame trigger. This makes it possible to see if the inputs are switching as expected.

In the **EncoderControl** section the **EncoderValue** parameter can be used to see how the encoder input signals are counted by the camera. The **EncoderReset** command will reset the counter to 0.

11.3 Network card settings

For problems related to the network card settings, see "Recommended network card settings", page 94.

11.4 Rescue mode

If the State LED on the device turns red, it means that the device has entered rescue mode and does not allow any data acquisition. There are two possible reasons:

- The device has discovered a problem with the installed application firmware.
- The device is overheated.

In Ranger3 Studio, select **Save last crash log** from the **Device** menu to export a log file with details about the error that put the device into rescue mode.

To exit rescue mode, try one of the following options:

- Disconnect and then re-connect the power to the device.
- In the **Parameter editor**, select the **DeviceControl** category and click **DeviceReset**. The button is only visible if the visibility is set to **Guru**.
- Upload new valid firmware, see "Updating firmware", page 77.

! **NOTICE**
If the device enters rescue mode at multiple occasions and the reason is unknown, please contact the SICK support.

11.5 Repairs

Repair work on the device may only be performed by qualified and authorized personnel from SICK AG. Interruptions or modifications to the device by the customer will invalidate any warranty claims against SICK AG.

11.6 Returns

- ▶ Do not dispatch devices to the SICK Service department without consultation.
- ▶ The device must be sent in the original packaging or an equivalent padded packaging.

NOTE
To enable efficient processing and allow us to determine the cause quickly, please include the following when making a return:

- Details of the contact person
- Description of the application
- Description of the fault that occurred

12 Decommissioning

12.1 Disposal

Any device which can no longer be used must be disposed of in an environmentally friendly manner in accordance with the applicable country-specific waste disposal regulations. Do not dispose of the product along with household waste.

NOTICE
Danger to the environment due to improper disposal of the device.

Disposing of devices improperly may cause damage to the environment.

Therefore, observe the following information:

- Always observe the valid regulations on environmental protection.
- Separate the recyclable materials by type and place them in recycling containers.

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13 Technical data

NOTE
The relevant online data sheet for your product, including technical data, dimensional drawing, and connection diagrams can be downloaded, saved, and printed from the Internet:

- www.sick.com/Ranger3

13.1 Product data

Device type	Ranger3-60	Ranger3-40	Ranger3-30
Device type code	V3DR3-60NE31111	V3DR3-40NE31111	V3DR3-30NE31111
Part number	1091560	1105757	1109564

13.2 Features

Product	Ranger3-60	Ranger3-40	Ranger3-30
Task	Positioning, Inspection, Measuring		
Technology	3D by Laser triangulation		
Example field of view	Free of choice by lens selection		
Data synchronization	Free running / Encoder triggered / Externally triggered		
3D measurements	Yes		
Reflectance measurements	Yes		
Exposure modes	Linear / HDR		
ProFlex-Front	Yes		

13.3 Performance

Product	Ranger3-60	Ranger3-40	Ranger3-30
Image sensor	SICK CMOS with ROCC technology		
Active imager size	15360 µm (H) × 4992 µm (V)	15360 µm (H) × 4992 µm (V)	9216 µm (H) × 4992 µm (V)
Sensor resolution	2560 px x 832 px	2560 px x 832 px	1536 px x 832 px
Pixel size	6 µm x 6 µm		
Scan/frame rate	46000 3D profiles/s	20000 3D profiles/s	20000 3D profiles/s
Scan/frame rate full frame	7000 3D profiles/s	2500 3D profiles/s	1500 3D profiles/s
3D height resolution	16 bits, 1/16 subpixel		
SNR_{max}	39.5 dB		
Dynamic range	50 dB		
Shutter type	Global		
Spectral range	400 nm ... 950 nm		

13.3.1 Signal range

The M30 imager has an 8-bit signal range, which means that it can deliver 0 - 255 AD units in linear or multi-slope HDR mode. The sensor contains fixed-pattern noise (FPN) correction, which removes gradients from the image data. The FPN correction causes a small reduction of the resulting signal range, and the expected useful signal range is around 240 AD units.

When the imager is saturated, residual FPN may appear.

13.3.2 Light sensitivity

The peak sensitivity is located in the interval from 600 to 650 nm.

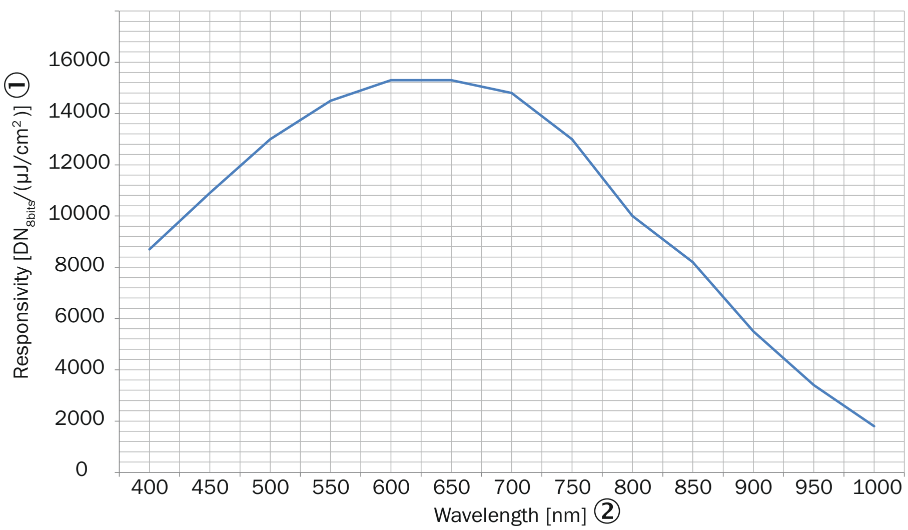


Figure 65: Spectral response for the M30 sensor

① Responsivity [DN_{8bits}/(µJ/cm^2)]

② Wavelength [nm]

13.3.3 Maximum line rate

The maximum line rate as a function of the number of used sensor rows for the Ranger3 variants is shown in figure 66.

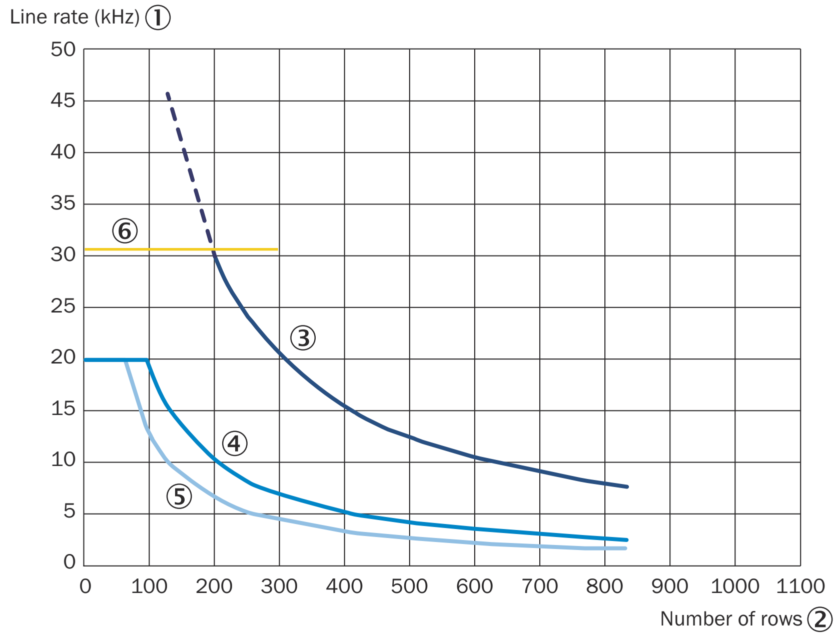


Figure 66: The maximum line rate as a function of the number of sensor rows used

① Line rate (kHz)
② Number of rows
③ Ranger3-60, 2560 columns
④ Ranger3-40, 2560 columns
⑤ Ranger3-30, 1536 columns
⑥ Bandwidth limitation for 2560 columns

13.4 Interfaces

Product	Ranger3-60	Ranger3-40	Ranger3-30
Configuration software	Ranger3 Studio		
Communication interfaces	Gigabit Ethernet/GigE Vision		
Operating system	Windows 7 or Windows 10		
Programming interface	GenAPI, GenTL		
Digital inputs	4 x HIGH = 10 V ... 28.8 V		
Digital outputs	2 x TTL level for laser strobe		
Encoder interface	RS-422 (5V level)		
External illumination control	2 x 5 V TTL		

13.5 Ambient data

Product	Ranger3-60	Ranger3-40	Ranger3-30
Shock load	15 g, 3 x 6 directions		
Vibration load	5 g, 58 Hz ... 150 Hz		
Ambient operating temperature	0 °C ... +50 °C[1]		
Ambient storage temperature	–20 °C ... +70 °C[1]		

1 Non-condensing

13.6 Mechanics and electronics

Product	Ranger3-60	Ranger3-40	Ranger3-30
Connections	Power I/O: M12, 17-pin male Gigabit Ethernet: M12 female		
Connector material	Nickel-plated brass		
Supply voltage	24 V DC +/-20%		
Power consumption	12 W		
Current consumption	Imax = 1.5 A		
Enclosure rating	IP 20		
Enclosure rating with optics protective cover	IP 65/67 (by ProFlex-Front)		
Scheimpflug adapter	Yes (by ProFlex-Front)		
Interchangeable optical fil-ter	Yes (by ProFlex-Front)		
Housing material	Aluminum		
Housing color	Blue, varnished		
Weight	330 g		
Dimensions (L x W x H)	77 mm x 55 mm x 55 mm[1]		
Optics	C-Mount, 1"[2]		

1 Only housing without lens and protective cover
2 To be ordered separately as accessory (see "Accessories", page 87)

13.7 Dimensional drawings

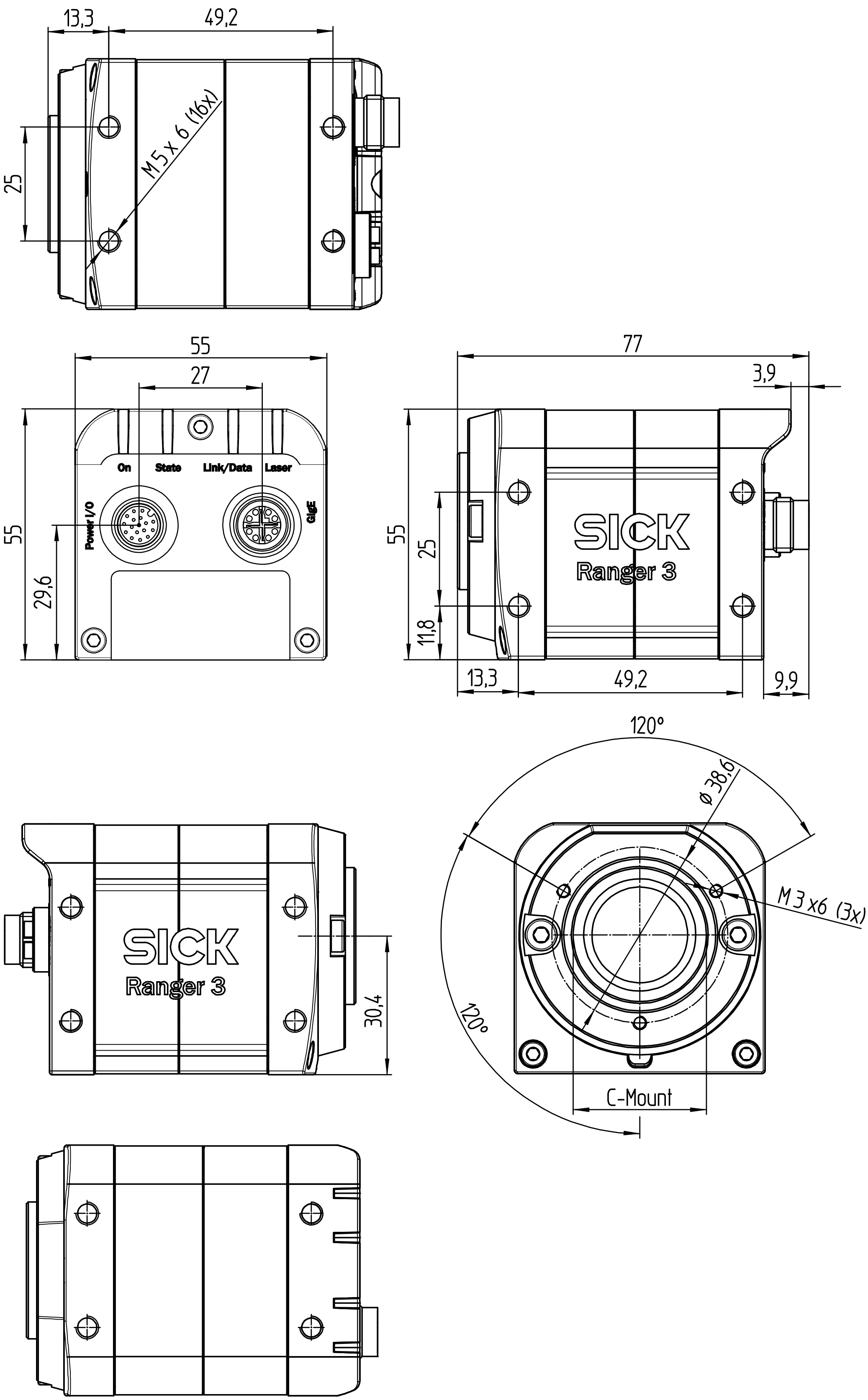


Figure 67: Ranger3 dimensions

14 Accessories

NOTE
Accessories and where applicable mounting information can be found online at:

- www.sick.com/Ranger3

15 Glossary

15.1 Terms and abbreviations

3D image	A point cloud where the object shape is represented by three coordinates.
block	In the GigE Vision transport protocol a frame is named block.
buffer	Each frame will be received in the PC as one buffer.
frame	In Areascan mode: One 2D image. In Linescan3D mode: A set of 3D profiles. Each line in the frame is created from one 2D image.
frame rate	The rate at which the frames are captured (Hz) in Areascan mode.
GUI	Graphical User Interface
height map, depth map	A frame where the values represent height or depth and not intensity.
intensity	The intensity value of the pixels in a 2D sensor image.
line	Contains one value for each measured point along a cross-section of the object. Same thing as profile.
line rate	The rate at which the lines in a frame are captured (Hz).
NIC	Network Interface Card
profile	Contains one value for each measured point along a cross-section of the object. Same thing as line.
reflectance	The reflected peak intensity of the laser line when measuring 3D profiles.
ROI	Region Of Interest
scan (verb)	To collect measurements made by the 3D camera at one point in time. That is the same thing as to capture one single profile.
SoC	System on Chip

16 Annex

16.1 Range (3D) measurement

The 3D camera measures range by using triangulation. This means that the object is illuminated with a line light from one direction, and the camera is measuring the object from another direction. The most common lighting used when measuring range is a line projecting laser.

The camera analyzes the sensor images to locate the laser line in them. The higher up the laser line is found for a point along the x-axis (the width of the object), the higher up is that point on the object.

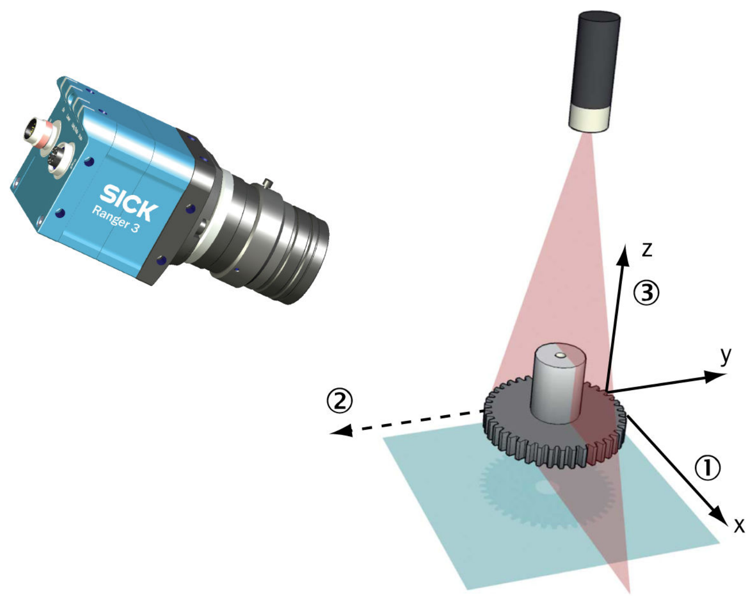


Figure 68: Coordinate system when measuring range

① Width
② Transport
③ Range

When measuring range, there are two angles that are interesting:

- The angle at which the camera is mounted.
- The angle of the incoming light (incidence).

Both angles are measured from the normal of the transport direction. The angle of the camera is measured to the optical axis of the camera – that is, the axis through the center of the lens.

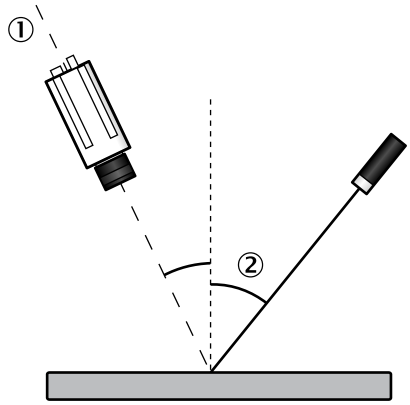


Figure 69: Angles and optical axis

① Optical axis
② Incidence angle

The following is important to get correct measurement results:

- The laser line is orthogonal to the movement direction of the object and, if possible, also aligned with the sensor rows in the camera.
- The lens is focused so that the images contain a sharp laser line.
- The laser is focused so that there is a sharp line on the objects, and the laser line cross section covers a few rows on the sensor.

16.1.1 Occlusion

Occlusion occurs when there is no laser line for the 3D camera to detect in the sensor image. Occlusion will result in missing data for the affected points in the measurement result.

There are two types of occlusion:

Camera occlusion	When the laser line is hidden from the camera by the object.
Laser occlusion	When the laser cannot properly illuminate parts of the object.

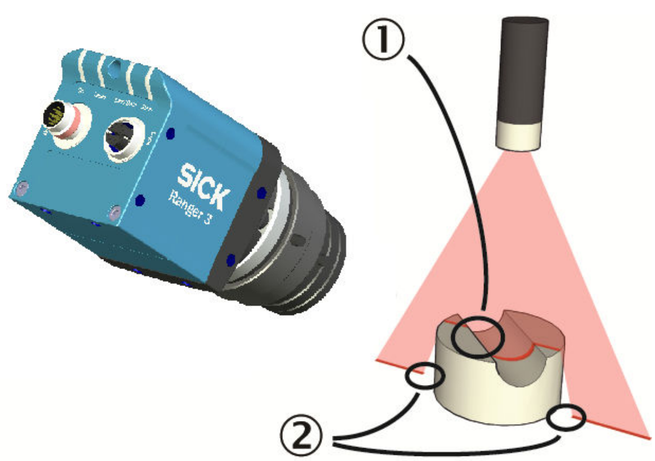


Figure 70: Different types of occlusion

① Camera occlusion
② Laser occlusion

Adjusting the angles of the camera and the laser can reduce the effects of occlusion.

If adjusting the angle is not suitable or sufficient, you can avoid laser occlusion by using multiple lasers that illuminate the objects from different angles. Camera occlusion can be avoided by using multiple cameras that view the objects from different angles.

16.1.2 Width resolution and resolution in the motion direction

In a laser triangulation system the camera placement and optics determine the width of the field-of-view (FOV). The resolution across the object (ΔX) is the FOV width divided with the number of pixels.

The resolution along the motion direction (ΔY) is a direct function of the measurement frequency and the object speed.

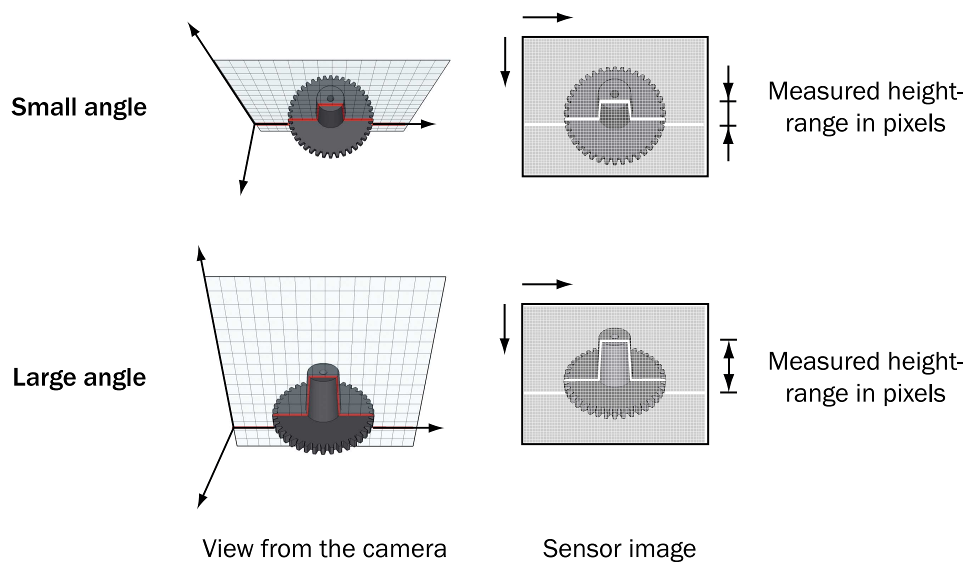
16.1.3 Height-range and height resolution

The height-range of the measurement is the distance between the highest and the lowest point that can be measured within a ROI. A large height-range means that objects that vary much in height can be measured.

The height resolution (ΔZ) is the smallest height variation that can be measured. High resolution means that small variations can be measured. But a high resolution also means that the height-range will be smaller, compared with using a lower resolution in the same ROI.

In general, the height-range and the resolution depend on the angle between the laser and the camera. If the angle is very small, the location of the laser line will not vary much in the sensor images even if the object varies a lot in height. This results in a large height-range, but low resolution.

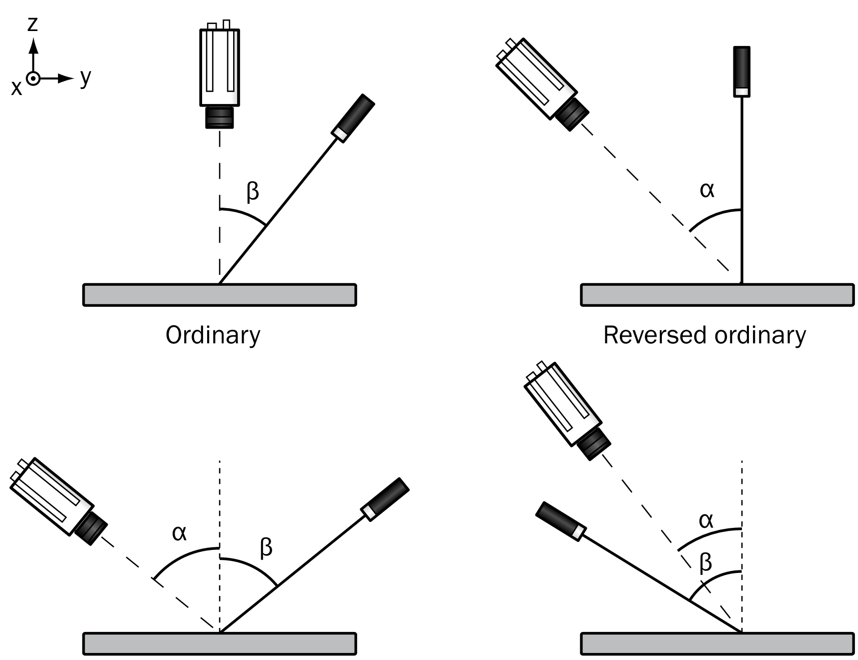
On the other hand if the angle is large, even a small variation in height would be enough to move the laser line some pixels up or down in the sensor image. This results in high resolution, but small height-range. See the figures below.



16.1.4 Main geometries

There are four main principles for mounting the camera and the laser, see below. Note that the measurements are always done in the laser plane. This means that if the laser plane and the z-axis are not parallel, the y-coordinate of each range value in a profile depends on the height. This is the case for Ordinary, Specular, and Look-away. When you use the Reversed ordinary setup, all range values in a profile correspond to the same y-coordinate.

Ordinary	The camera is mounted right above the object – perpendicular to the direction of movement – and the laser is illuminating the object from the side. This geometry gives the highest resolution when measuring range.
Reversed ordinary	As the Ordinary setup, but the placement of the laser and the camera has been switched so that the lighting is placed above the object. When measuring range, the reversed ordinary geometry gives slightly lower resolution than the ordinary geometry. It gives the least distorted depth map representation because the measurements are made in the Z plane. This is the most common geometry.
Specular	The camera and the lighting are mounted on opposite sides of the surface normal of the object. Specular geometries are useful for measuring dark or matte objects, since it requires less light than the other geometries.
Look-away	The camera and the lighting are mounted on the same side of the surface normal of the object. This geometry can be useful for avoiding unwanted reflexes but requires more light than the other methods and gives lower resolution.



As a rule of thumb, the height resolution increases with the angle between the camera and the laser, but the resolution also depends on the angle between the camera and the height direction (z-axis).

The relationship between the measured locations on the sensor and their real-world positions is typically non-linear, and only known after a calibration procedure. As a starting point, the following formulas can be used for approximating the resolution for the different geometries, in for example mm/pixel:

Geometry	Approximate range resolution
Ordinary	$\Delta Z \approx \Delta X / \tan(\beta)$
Reversed ordinary	$\Delta Z \approx \Delta X / \sin(\alpha)$

Geometry	Approximate range resolution
Specular	$\Delta Z \approx \Delta X \cdot \cos(\beta) / \sin(\alpha+\beta)$, If $\alpha = \beta$: $\Delta Z \approx \Delta X / 2 \cdot \sin(\alpha)$
Look-away	$\Delta Z \approx \Delta X \cdot \cos(\beta) / \sin(\lvert\alpha-\beta\rvert)$

where:

ΔZ = Height resolution (mm/pixel)

ΔX = Width resolution (mm/pixel)

α = Angle between camera and vertical axis (see the figures above)

β = Angle between laser and vertical axis (see the figures above)

Note that these approximations give the resolution for whole pixels. If the measurement is made with sub-pixel resolution, the resolution in the measurement is the approximated resolution divided by the sub-pixel factor. For example, if the measurement is made with the Hi3D component that has a resolution of $1/16^{th}$ pixel, the approximate resolution is $\Delta Z/16$.

16.1.5 Sensor coordinate system

Typically, the camera views the object and the laser line from above, with a certain angle between the camera and the laser, as described in this document. The sensor image has its origo in the top left corner when you view the image on screen, see the figure below. This means that the v-coordinate of a point that is close to the bottom of the screen (v_1) is greater than the v-coordinate of a point that is higher up on the screen (v_2).

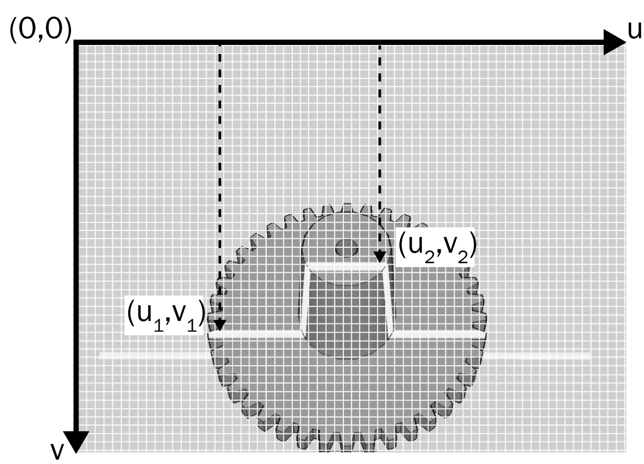


Figure 71: Sensor image and coordinate system

When the coordinates from the sensor image are used as 3D data, a high value of the v-coordinate will give a high range value.

In the coordinate system above, parts of the object that are far away from the camera will get a high range value, and parts that are close to the camera will get a low range value. That is, the range value represents distance from the camera. If you view the 3D image in a coordinate system that has its origo in the lower left corner, the 3D image will appear upside down.

NOTE

If you want the range value to represent height from a surface, rather than distance from the camera, you set the **RangeAxis** parameter to **Reverse**. see "Extraction regions", page 29. Then parts of the object that are close to the camera will get a high range value and parts that are far away from the camera will get a low range value.

16.2 Recommended network card settings

Due to the large amount of data that Ranger3 delivers per second, it is required to connect the camera(s) to the PC using a separate Gigabit Ethernet network, without other interfering traffic.

The Network interface card (NIC) must support Gigabit Ethernet, and it is recommended that the NIC supports Ethernet Jumbo frames. Ethernet Jumbo frames are frames with more than 1500 bytes of Ethernet payload. Sending and receiving Ethernet Jumbo Frames can give a performance increase due to lower PC CPU usage.

The Ranger3 camera has mainly been tested using network interface cards from Intel. See the tables below for recommended network settings. Note that the names of the settings may differ depending on NIC or driver version.

Receive buffers	
Recommended setting	512 or more
Default setting	256
Maximum setting	2048

Jumbo frames	
Recommended setting	>4200
Default setting	disabled
Maximum setting	16128

When using Jumbo frames the camera can support up to 4096 bytes of image data in each data package, which corresponds to 4200 bytes per Ethernet frame.

Camera IP settings

The GigE Vision® standard dictates that the factory default setting for devices is IP configuration using DHCP. If no DHCP server is found, the default for devices is to assign a Link-Local Address (LLA), also called a Zero Configuration IP, on the format 169.254.x.y.

It is recommended to define a persistent IP address which can be used when a device boots. Which IP configuration option that is used when a device boots is dictated by the **TransportLayerControl** parameters, see "Editing IP settings", page 62.

Ranger3 also supports setting a static IP using the GigE Vision® forceIP method. This IP address is not persistent, which means it is lost at power-off, see "Editing IP settings", page 62.

Symptoms of possible problem

Receive buffers	Symptoms of too low setting: Multiple consecutive packets are lost, e.g. 31 consecutive packets are lost. Symptoms of too high setting: Use of memory increases.
Jumbo frames	Symptoms of too low setting: The camera will use a smaller frame size, which implies higher CPU load on the PC. Symptoms of too high setting: If you use a switch that is unable to support Jumbo Frames connected between the camera and the PC, it is impossible to receive streaming data from the camera.
IP settings	If the device and the NIC is not connected to the same DHCP server, or only one end is connected to a DHCP server, the device can not assign a correct IP, see "Editing IP settings", page 62.

16.2.1 Connecting multiple cameras

When you connect multiple cameras to the PC, you get the best performance if each camera is connected to a separate NIC. The camera and the NIC must be on the same subnet. You can also connect multiple cameras to the same NIC, using a switch. In that case, both the NIC and all the cameras that are connected to it must be on the same subnet.

If the PC has multiple NICs, all the NICs must be on different subnets. The subnet is indicated by the third section of the IP address, see an example in the figure below. This figure also shows that other equipment, such as network printers, should be connected to a separate NIC.

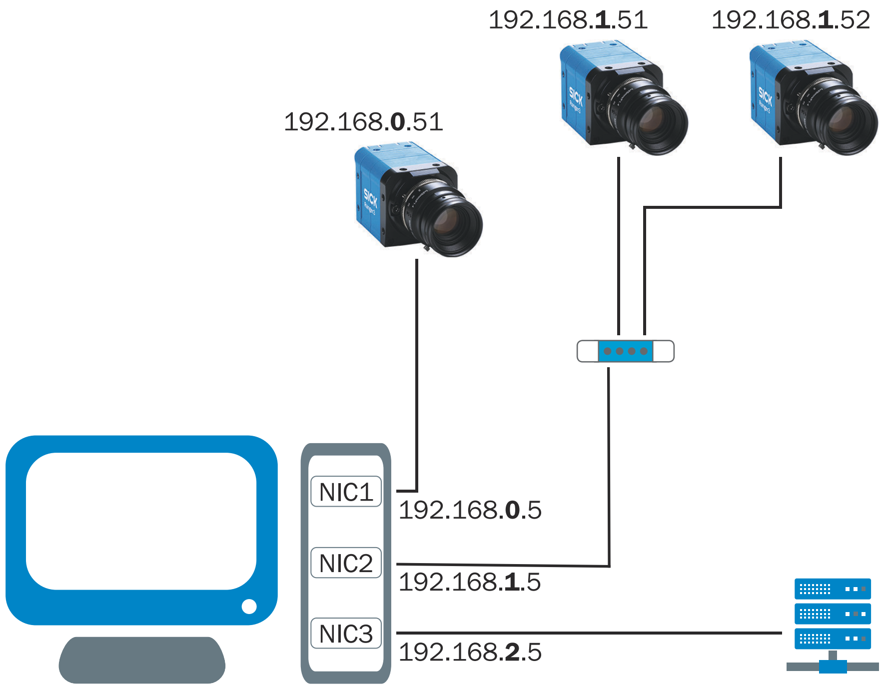


Figure 72: PC conncted to three cameras and external network, using three separate NICs and one switch

16.3 Connecting encoders

The RS-422 inputs on the camera have internal termination, which makes it possible to connect an RS-422 encoder to the camera without requiring any external termination. With this termination it is possible to directly connect up to two cameras to the same encoder.

Use an incremental encoder with two channels (A+/A- and B+/B-) and connect all four outputs. It is not possible to connect an index channel (Z) to the camera.

The example below shows a wire diagram for connecting one SICK Stegmann RS-422 encoder (DRS-60 with TTL output levels) to two cameras.

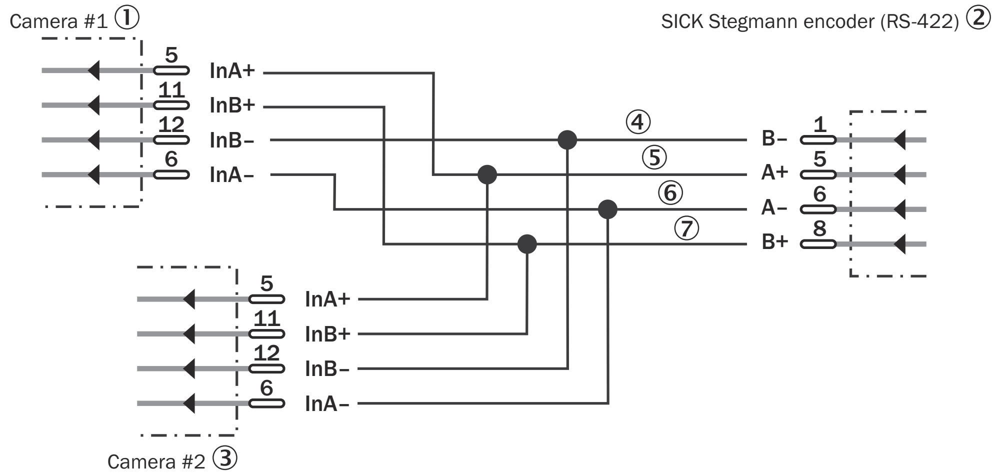


Figure 73: Wiring example

①	Camera #1
②	SICK Stegmann encoder (RS-422)
③	Camera #2
④	Phase2 RS-422-
⑤	Phase1 RS-422+
⑥	Phase1 RS-422-
⑦	Phase2 RS-422+

16.4 EU declaration of conformity / Certificates

The EU declaration of conformity and other certificates can be downloaded from the Internet at:

- www.sick.com/Ranger3

SICK uses open-source software. This software is licensed by the rights holders using the following licenses among others: the free licenses GNU General Public License (GPL Version2, GPL Version3) and GNU Lesser General Public License (LGPL), the MIT license, zLib license, and the licenses derived from the BSD license.

This program is provided for general use, but WITHOUT ANY WARRANTY OF ANY KIND. This warranty disclaimer also extends to the implicit assurance of marketability or suitability of the program for a particular purpose.

More details can be found in the GNU General Public License. View the complete license texts here: www.sick.com/licensetexts. Printed copies of the license texts are also available on request.

16.5 Scheimpflug adapters

The Scheimpflug adapters for Ranger3 make it possible to create a camera setup where the plane of focus is parallel to the laser line. This means that a subject that is not parallel to the image plane can be rendered sharply. Adapters with three different tilt angles are available, see "Accessories", page 87.

Scheimpflug adapters are based on the Scheimpflug principle, which decribes a situation where the lens plane is not parallel to the image plane of the sensor. When a line is extended from the image plane, and another is extended from the lens plane, they meet at a point through which the plane of focus also passes.

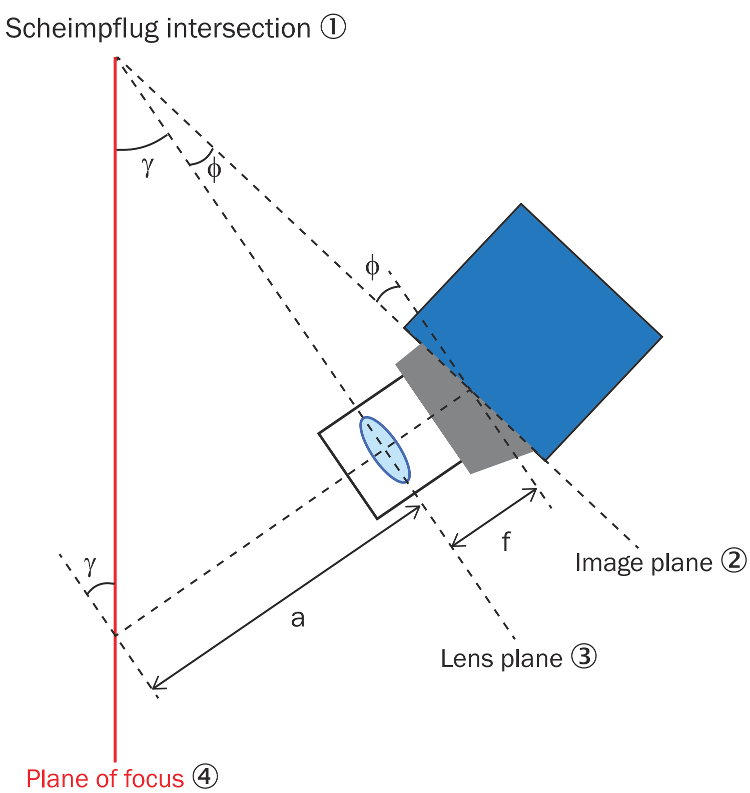


Figure 74: Using a Scheimpflug adapter (adapter shown in gray)

① Scheimpflug intersection

② Image plane
③ Lens plane
④ Plane of focus

figure 74 shows how a Scheimpflug adapter can be used to change the angle between the image plane and the lens plane so that the plane of focus is parallel to the laser line. The setup can be described with the following formula:

$$\emptyset \approx arctan\left(\frac{f \cdot tan(\gamma)}{a}\right)$$

where a is the distance between the lens plane and the plane of focus, f is the focal distance (between the lens and the camera), Ø is the tilt angle between the image plane and the lens plane and γ is the angle between the lens plane and the plane of focus.

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