LMI TECHNOLOGIES

FOCALSPEC LINE CONFOCAL SENSORS
LCI1220 & LCI1620

USER GUIDE
Version 1.2

Copyright

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Version history

Version	Status	Date	Author	Comments
1.2	Approved	27.2.2020	Kalistaja David	A note added to 5 Connecting to PC. Aligned spec terminology with datasheet / LMI.
1.1	Approved	22.1.2020	David	Rebranding
1.0	Approved	30.9.2019	Esa Kalistaja	First version

CONTENTS

1 About this Document

This document is user guide of sensors LCI1220 and LCI1620. Sensors LCI401, LCI1200, LCI1201 and LCI1600 are covered by separate guide. FocalSpec Software Development Kit (FSSDK) and the API documentation can be found after FSSDK installation from folder: C:\Focalspec\FocalSpec Software Development Kit\Manual.

2 Safety Information

This chapter contains important safety information for installing and using the LCI sensors.

- **Note!** Read this document carefully before use.
- **Note!** Keep this document for future reference.
- **Note!** Original instructions. The original language is English.

2.1 Safety Notes

This document uses safety notes as follows:

- **Note!** Notes are tips, shortcuts or alternative approaches to the task at hand. Ignoring a note should have no negative consequences.
- **Caution!** A Caution statement alerts you to situations that can be potentially hazardous to you or cause damage to hardware, firmware, software, or data.
- **Warning!** A Warning statement indicates conditions or situations that can be potentially lethal or extremely hazardous to you. Safety labels are also attached directly to products to warn of these conditions or situations.

2.2 Warnings

- **Caution!** Do not remove any safety devices or open the cover. Risk of injuries and insecure operation. The warranty is void if the cover is opened.
- **Caution!** Do not look directly into the light source. Light radiation may damage your eyes.
- **Caution!** This is a high-precision optical instrument. Protect the device from dust and moisture and avoid subjecting it to shocks and strong forces.
- **Caution!** Before using the sensor for the first time, check the sensor for transport damage. If the sensor is damaged, contact support. See *Support*.
- **Warning!** Use only qualified personnel for the installation of all electrical supplies and fixtures, and make sure that all installations adhere to local regulations and safety standards.

2.3 Proper Use

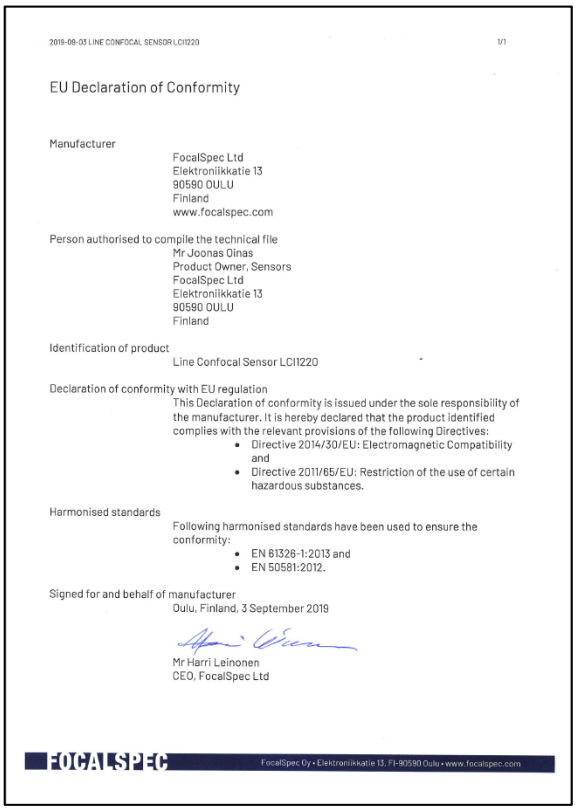
The LCI sensor is designed for the use in industrial areas. The sensor is used for optical measurements, such as 3D topography, dimensions and distances measurements, measuring the tomography of transparent materials, surface micro profile measurements, and film thickness measurements.

Only use the sensor in such a way that, in the case of malfunction or failure, personnel or machinery are not endangered.

Ambient temperature range: +15 ºC … +35 ºC.

2.4 CE Marking

The manufacturer has confirmed that these products comply with the essential requirements of the applicable EC Directive, based on the following specifications.



2019-09-03 LINE CONFOCAL SENSOR LCI1220 1/1

EU Declaration of Conformity

Manufacturer
FocalSpec Ltd
Elektroniikkatie 13
90590 OULU
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www.focalspec.com

Person authorised to compile the technical file
Mr Joonas Oinas
Product Owner, Sensors
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Finland

Identification of product
Line Confocal Sensor LCI1220

Declaration of conformity with EU regulation
This Declaration of conformity is issued under the sole responsibility of the manufacturer. It is hereby declared that the product identified complies with the relevant provisions of the following Directives:
- Directive 2014/30/EU: Electromagnetic Compatibility and
- Directive 2011/65/EU: Restriction of the use of certain hazardous substances.

Harmonised standards
Following harmonised standards have been used to ensure the conformity:
- EN 61326-1:2013 and
- EN 50581:2012.

Signed for and behalf of manufacturer
Oulu, Finland, 3 September 2019

Mr Harri Leinonen
CEO, FocalSpec Ltd

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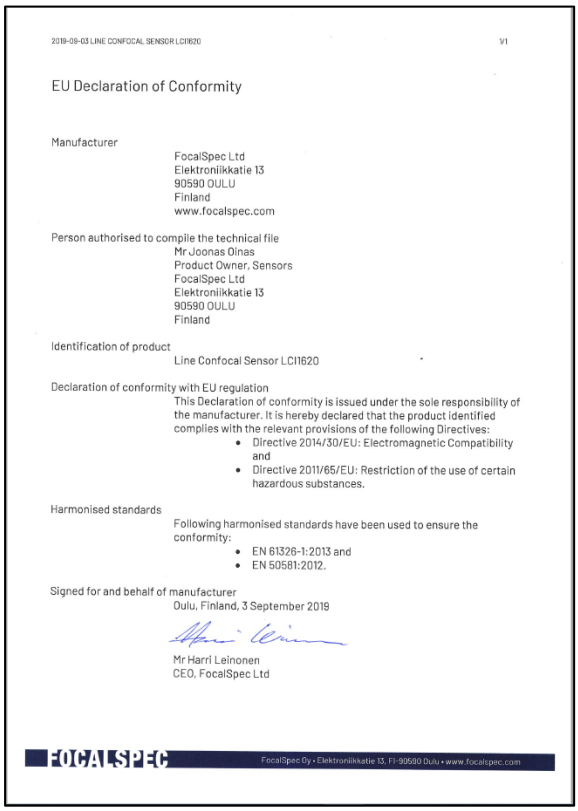

2019-09-03 LINE CONFOCAL SENSOR LCI1620 1/1

EU Declaration of Conformity

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FocalSpec Ltd
Elektroniikkatie 13
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3 Technical Data

Table 1. Technical data for the sensors

	LCI 1220	LCI 1620	
Field of view	11.6	17.0	mm
X resolution	6.7	9.9	µm
Z repeatability*	0.19	0.25	µm
Stand-off distance	20.6	64.00	mm
Measurement range	3.00	5.50	mm
Measurement speed at measurement range	3000	3000	Hz
Max measurement speed**	16000	11000	Hz
Number of points / profiles	1728	1728	
Max slope of objects +/-	20.0	13.5	deg
Dimensions	416x354x91	432x358x113	mm
Weight	19	21	kg
Level of protection (EN 80529)	IP55	IP30	

* Z repeatability is the standard deviation of Z measurements using the FocalSpec target at the specified reference distance

** Maximum speed is maximum frequency to measure region of interest (ROI) with the depth 0.4 mm on full field of view

4 Delivery Contents

Sensor delivery content includes:

- ✓ FocalSpec LCI sensor
- ✓ PushPull type 4-pin power cable (5 m)
- ✓ PushPull type 10-pin signal cable (5 m)
- ✓ Push Pull type optical cable (5 m) with two SFP+ modules
- ✓ USB drive:
  - Software Development Kit (FSSDK) installer
  - LCI1220 and 1620 user guide
  - Sensor 3D CAD STEP files
  - Sensor mounting drawings

Reference measurement sample is an optional sales item, and not included in the standard delivery content.

5 Connecting to PC

10 Gbit connection with SFP+ interface is needed to enable the high-speed data transmission.

The recommended network adapter is Intel Ethernet Converged Network Adapter X520 either two port DA2 or four port DA4 model.

Figure 1. Example of two port Intel Ethernet Converged Network Adapter X520 DA2

Windows 10 64-bit is the recommended operating systems, but sensors work also with Windows 7.

- **Note!** Disable PC power save mode to ensure uninterrupted connection to sensor.

6 Installation and Mounting

3D CAD STEP as well as high-resolution versions of the drawings below are included in the USB drive folder “hardware”. The position and orientation of the optical profile is shown in an enlarged detail image for each model. The X, Y, Z origin in each STEP file is placed into the middle of the optical profile.

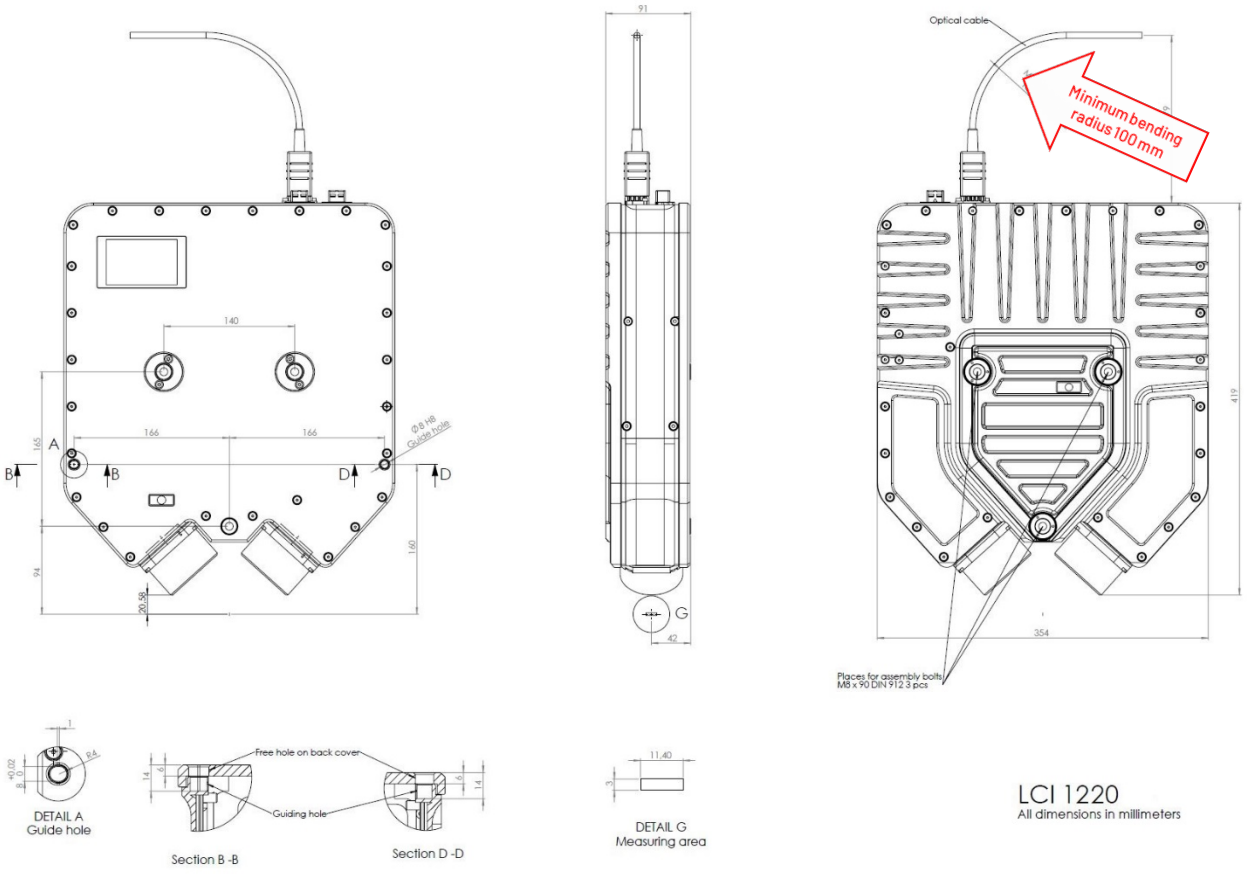


Figure 2. Installation and mounting of LCI1220.

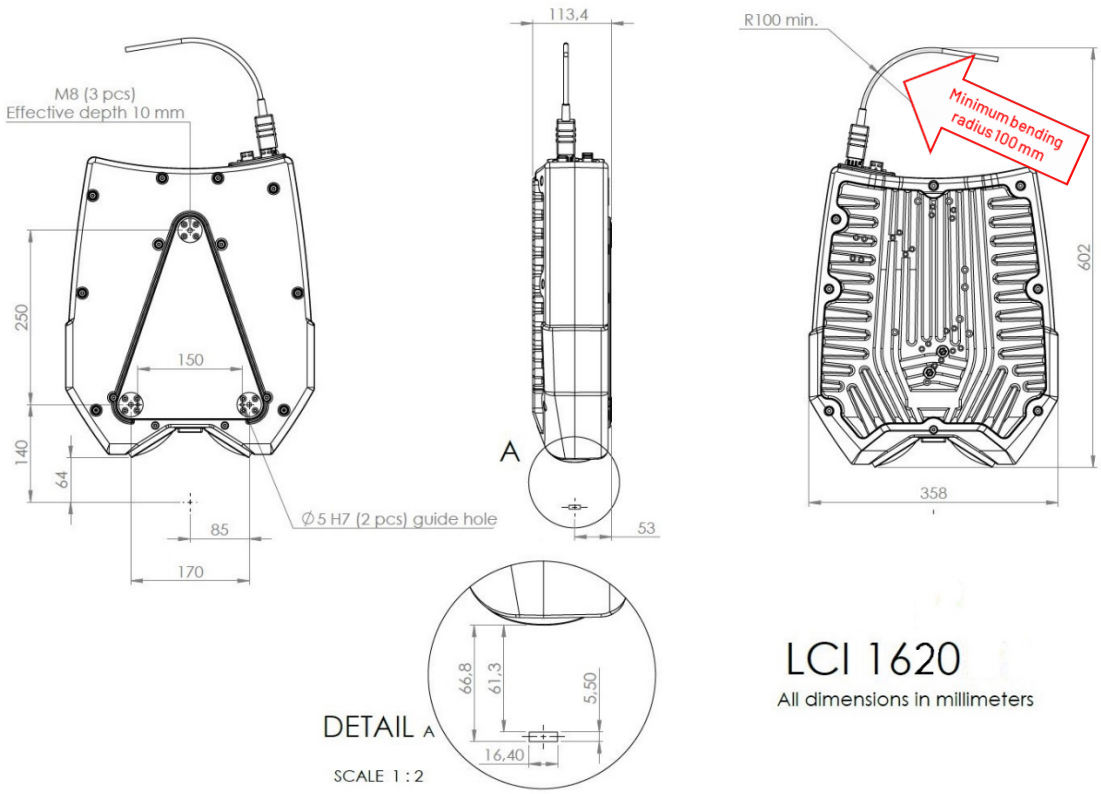


Figure 3. Installation and mounting of LCI1620.

7 Handling Optical Cable and SFP+ Modules

IMPORTANT – FRAGILE

Minimum bending radius of optical cable is 100 mm. Don't bend cable more than this. This applies to the whole length of the cable and it is especially important to pay attention to computer end of the cable as it is more flexible.

Never touch optical cable fiber ends with bare hands or let the fiber ends touch anything else but cleaning equipment.

Never put anything inside the optical fiber slots of the SFP+ module.

7.1 General Instructions

1. When storing optical cables and SFP+ modules, make sure the protective caps are attached.
2. When the cables and SFP+ modules are in use, store the protective caps in an airtight plastic bag.
3. Never touch the cable ends with anything other than the cleaning cloth.
4. If a cleanroom is available, it's recommended to install SFP+ modules to cable in there.
5. Preferably wear cloth gloves when handling cable connectors.
6. Make sure the minimum bending radius of cable bend is about 100 mm (Figure 3). Don't let the cable bend more than this. This applies to the whole length of the cable and it is especially important to pay attention to computer end of the cable as it is more flexible.

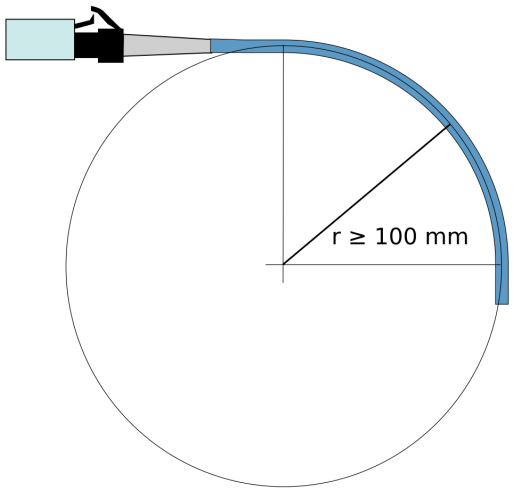
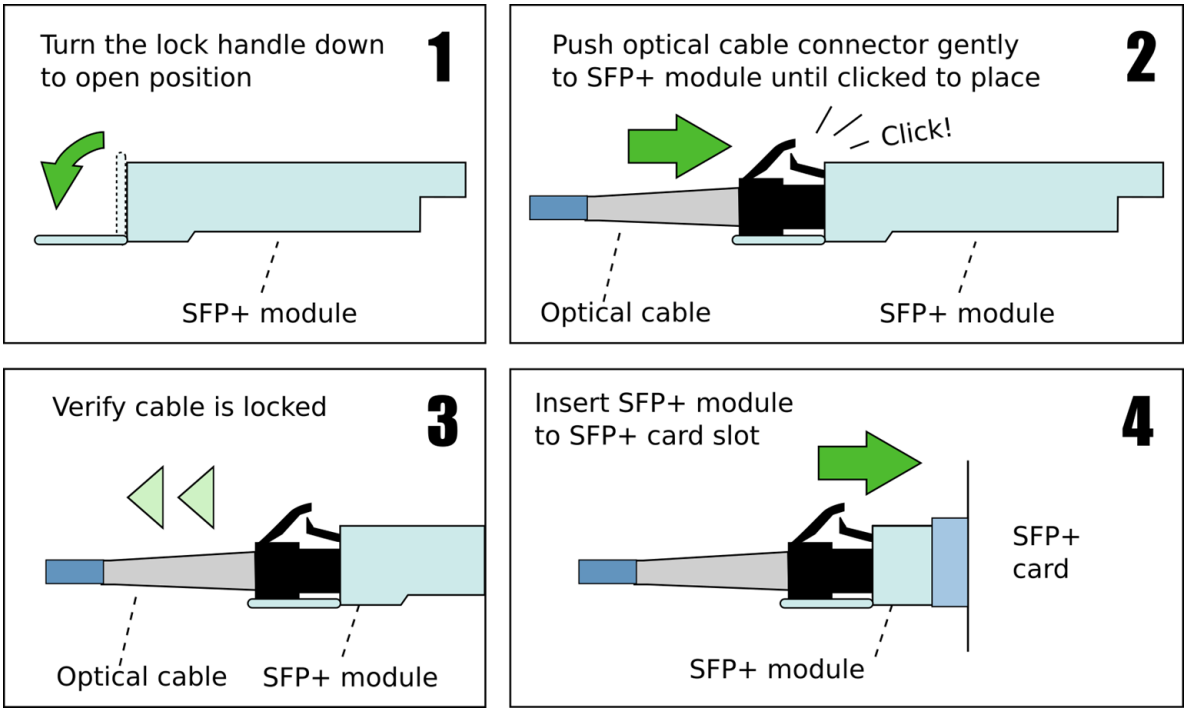


Figure 4: Minimum bending radius of the optical cable is 100 mm

7.2 Installing SFP+ Module and Optical Cable



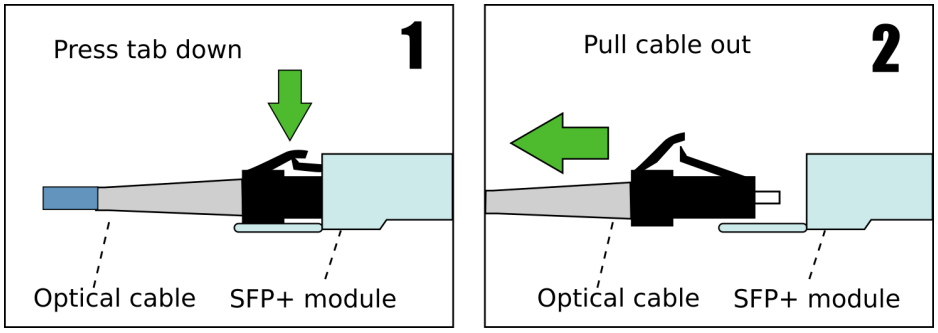
Steps to install the optical cable and SFP+ module:

1. Remove protective plug from SFP+ module.
2. Remove protective caps from the other end of the optical cable. Be sure not to touch the optical fiber ends with anything.
3. Push the lock handle down on the SFP+ module (step 1). This is the open position. This is done because the SFP+ module might be used with some SFP+ slots which

have a lock. Having the lock readily in the open position enables quick and easy attaching of the SFP+ module.

4. Carefully insert the cable connector to SFP+ module. Push the connector gently until it locks in place (step 2). Usually there is an audible “click” when the connector locks in place. Make sure the lock handle has remained in the open position.
5. Verify that connector is locked to the SFP+ module by pulling very gently on the cable: it must not be loose (step 3). If it is loose and detaches from the SFP+ module, repeat by pushing the connector to the SFP+ module until it locks into place.
6. Insert SFP+ module to the SFP+ card at PC (step 4). Make sure the SFP+ module is positioned in the correct way.
   - CORRECT: There should be a slight resistance when pushing the SFP+ module the correct way, as the connector in the SFP+ module slides into the connector at SFP+ slot side. The SFP+ module should not come out very easily.
   - INCORRECT: If the SFP+ module is inserted in incorrect way, there is no resistance. The SFP+ module slides out very easily.
7. Insert the quick connector of the optical cable to the sensor.

7.3 Detaching SFP+ Module from Optical Cable



Steps to detach SFP+ module from optical cable:

1. Press the lock tab down in optical cable connector (step 1).
2. Pull the cable out of SFP+ module (step 2).
3. Place protective caps on the optical cable connector and SFP+ module.

8 Electrical Connections

LCI1220 and LCI1620 sensors are powered by using a PushPull type 4-pin cable with Harting Power connector. For input signals which can be used for synchronization purposes 10-pin PushPull type cables with Harting Signal Connectors is used. The sensor communicates with PC via Optical cable with SFP+ 10G transceiver modules.

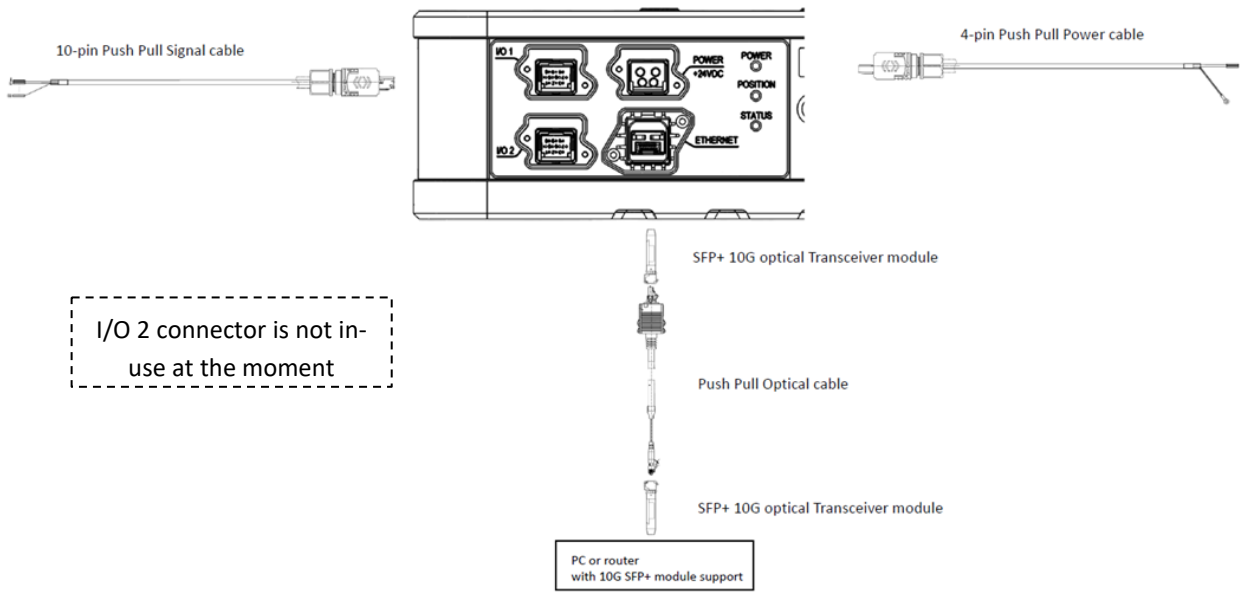


Figure 5. Electrical connections

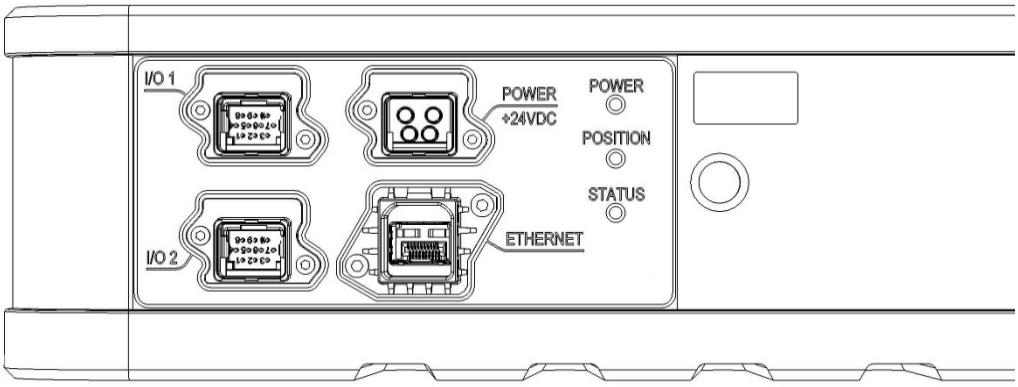


Figure 6. Electrical connections for LCI1220 (I/O 2 connector is not in-use at the moment)

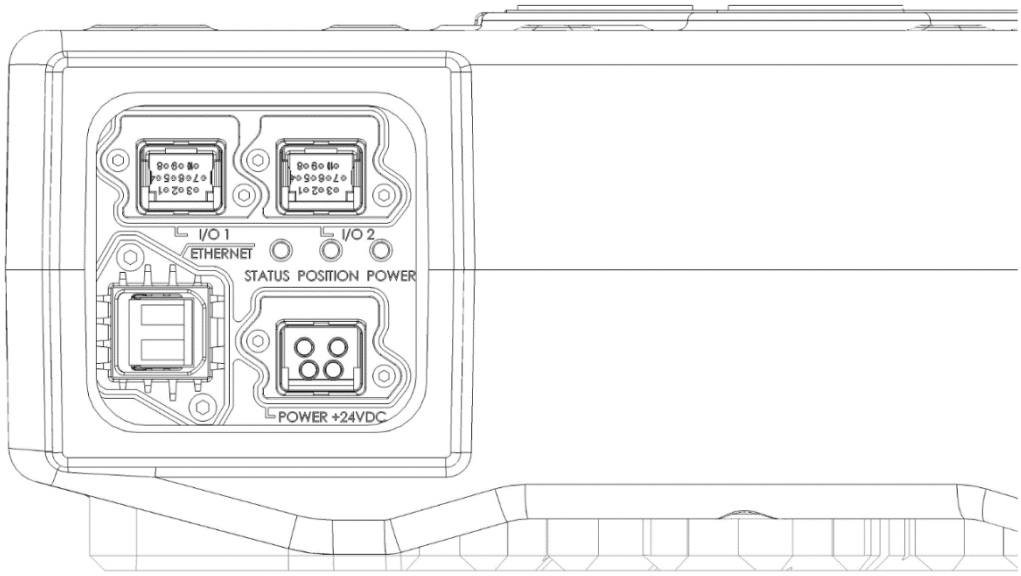


Figure 7. Electrical connections for LCI1620 (I/O 2 connector is not in-use at the moment)

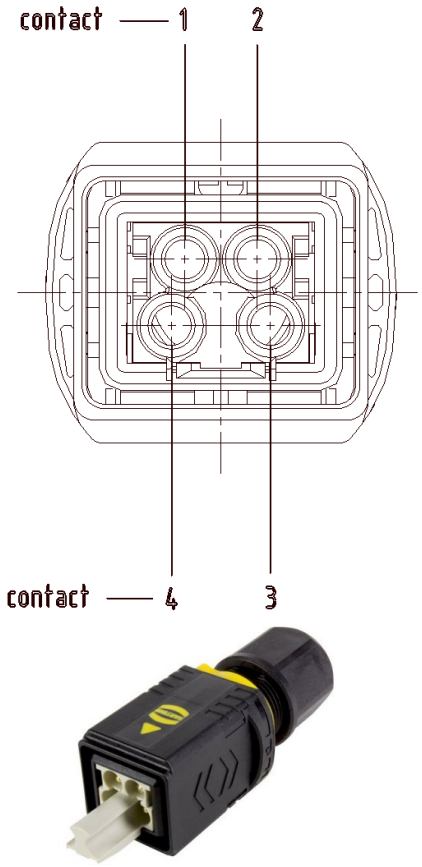
There are three indicator LEDs next to the connectors on the connector panel.
The status LED turns red if the sensor is not connected to a PC or a router. Blue means SW is booting up, whereas a green light indicates that the connection is established. The status LED blinks green when Ethernet packets are sent or received.
The position LED helps the user to find the correct distance to the target to measure. A green light is shown when target is in the measurement range. A blue light is shown when target is at the edge of the measurement range. A red light is shown when the sensor detects ambient light. This can be caused by incorrect illumination settings.
Power LED indicates with green light that power is ON and supply voltage level is in correct range. Red indicates that supply power is over the correct supply range and then the device will not power up.

Table 2. Indicator LEDs

	Green	Green blinking	BLUE		Red
Status LED	Client connected	Ethernet packets are sent or received	SFP not ready	SFP ready Sensor ready for connection	Connection lost
Position LED	Target is in the measurement range (correct distance to target)	-	Target is at the edge of the measurement range	-	Peak amount exceeds warning limit
Power LED	Power is ON and supply voltage level is in correct range	-	-	-	1. Power supply voltage level is over correct supply range and device will not power up. 2. Overload condition

9 Input and Output Description

Table 3. Power cable pinout



Pin	Color	Name	Description
1		24VDC	24 V (21 V – 28 V) / 2.3 A
2		24VDC	
3		GND	Power Ground
4	Red ring Terminal	Cable Shield	Cable shield (connect to system GND)

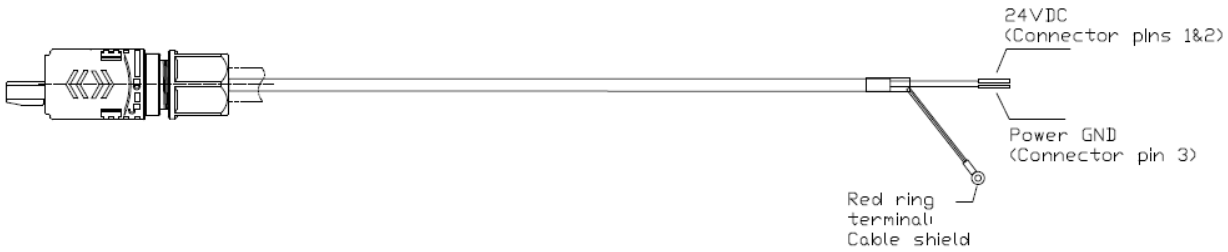
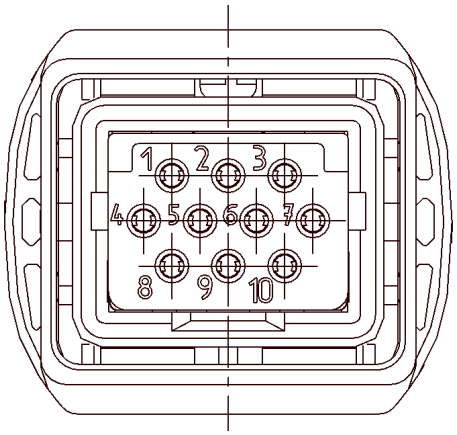


Figure 8. Power cable

NOTE 1: Connect the power cable ring terminal to system GND

Table 4. Signal cable pinout (pins 5 to 7 not in use till later SW update)



I/O 1 PINOUT

Pin	Color	Name	Description
1	White	Input GND	Common ground for inputs
2	Brown	Input 1	Input 1 (5V & 24 V, default encoder A input)
3	Green	Input 2	Input 2 (5V & 24 V, default encoder disable-input)
~~4~~	Yellow	Input 3	Input 3 (5V & 24 V, default zero input)
~~5~~	~~Grey~~	~~Input 4~~	~~Input 4 (5V & 24 V)~~
~~6~~	~~Pink~~	~~Input 5~~	~~Input 5 (5V & 24 V)~~
~~7~~	~~Blue~~	~~Input 6~~	~~Input 6 (5V & 24 V)~~
8	Red	Output 1	24 V Output 1 (250 mA)
9	Black	Output 2	24 V Output 2 (250 mA)
10	Violet	GND	Digital GND (for Output use)

Figure 9. Signal cable

Table 5. Input / Output parameter values.

Input / Output Parameter	Value
Sensor Power supply voltage (recommended)	24VDC
Power supply unit requirements (PSU):	24VDC@4A
Input signal voltage (operating range)	3.5V - 26V
Input signal Maximum pulse rate	150 kHz
Input signal current Min	2.7 mA
Input signal current Max	15 mA
Output signal current Max (2 output pins)	250 mA

Figure 10. Optical cable with SFP+ modules in both ends

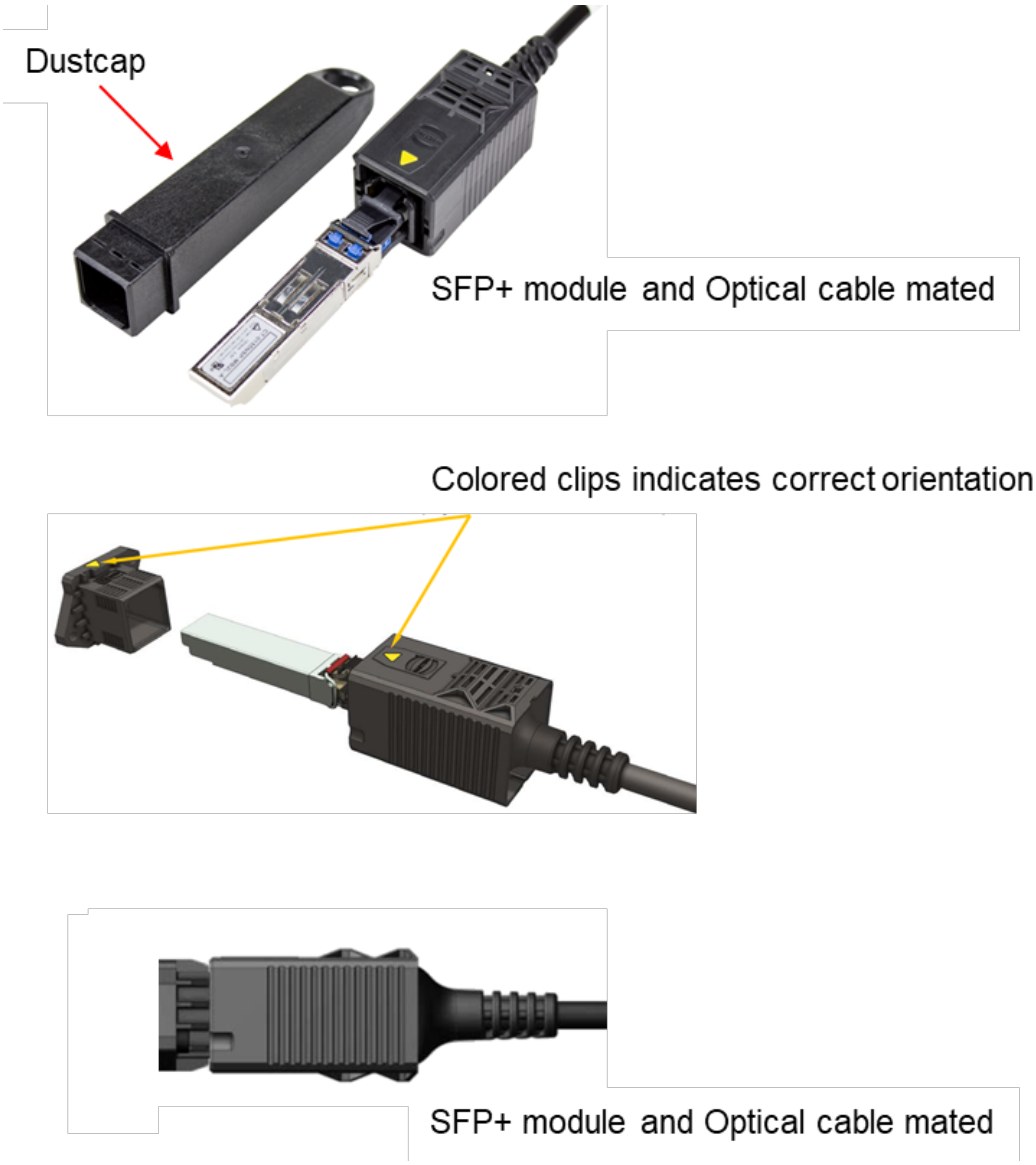


Figure 11. Optical cable SFP+ module

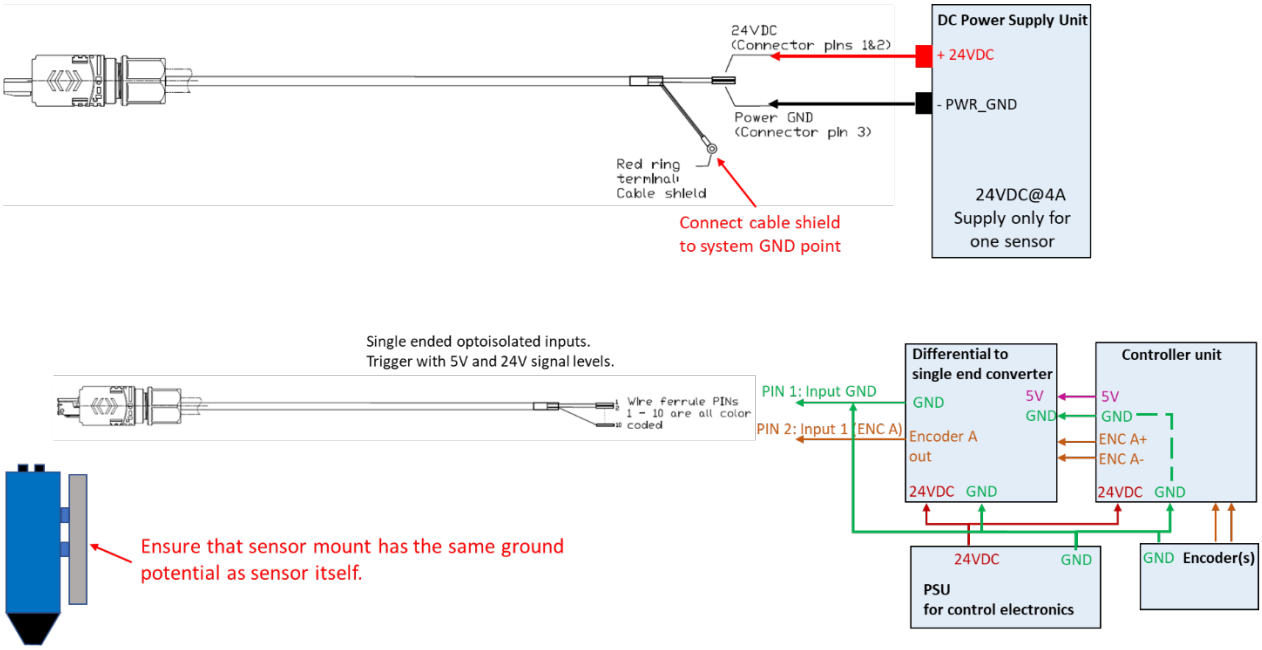


Figure 12. Example wiring for sensor connection

NOTE 1: Connect the power cable ring terminal to system GND

NOTE 2: Ensure that the sensor mount has the same ground potential as the sensor itself.

10 External Trigger Configurations

The trigger inputs can be used to synchronize the sensor with an external device. Application examples include: synchronizing the profile measurement into a certain signal of a production process or combining profiles into 3D point clouds based on the trigger index. Enabling external and internal triggering is explained in the "FocalSpec Software Development Kit". Configuring inputs is done programmatically using corresponding FSSDK parameters and values 1-4 as shown in the table below. Value 0 means not connected.

Table 8. Configuring trigger input pins

Trigger Input	FSSDK .Net parameter	FSSDK C/C++ #define	Default Value (pin)
A	SensorParameter.TriggerSource	PARAM_TRIGGER_SOURCE	1
B	SensorParameter.TriggerMinusSource	PARAM_TRIGGER_MINUS_SOURCE	0
Zero/Reset	SensorParameter.TriggerZeroSource	PARAM_TRIGGER_ZERO_SOURCE	3
Disable	SensorParameter.TriggerDisableSource	PARAM_TRIGGER_DISABLE_SOURCE	2

By default, *Input 1* is encoder channel A, *Input 2* is disable signal, *Input 3* is encoder zero/reset pulse and *Input 4* is not connected.
The sensor keeps count of the trigger location internally and embeds this information for each frame. B input of the encoder can be used as a "disable" signal. On every rising edge of the encoder input signal A, the edge is accepted as a trigger if the encoder input signal B is simultaneously at a low state. An external logic can be used to generate B signal. B signal can be used, for example, to disable measurement during a relocation of the sensor.

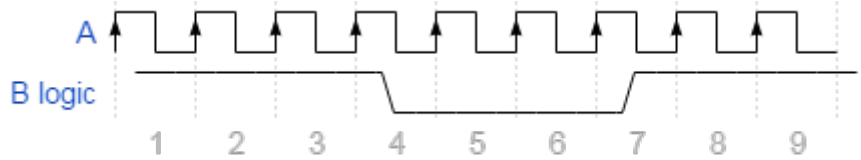


Figure 1. Forward encoding. External logic B enables trigger A at edges 5-7.

Another way of configuring the encoder inputs is shown in the figure below. Every rising edge of the A input, while the B input is in low state, increases location count. Every rising edge of the A input, while the B input is in high state, decreases location count. A rising edge of the Zero input resets the location count. This can be used, for example, to synchronize the sensor with the scanner mechanics and to compose a 3D point cloud from the individual profiles.
To measure the profile at each trigger event, input A should be used (input B is unconnected and is pulled down internally). This way every rising edge of the A signal triggers a measurement. The figure below shows the timing diagram of A and B signals when connected to a quadrature encoder. Only the *B forwards* triggers the measurement because the B channel is on low state at the moment of a rising edge of the A channel.

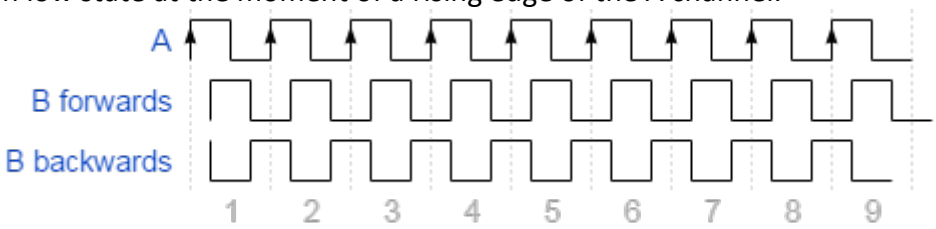


Figure 2. Timing diagram of a quadrature encoder.

11 Sensor Warming Up

Warming up the sensor is recommended prior to data acquisition in order to stabilize the sensor's capability to measure absolute Z coordinate. During the sensor's warming up there is a small variation on the absolute Z height on which the sensor sees the target surface.
The recommended warm up time is 30 minutes with 50% duty cycle. 50% duty cycle can be achieved e.g. using LED pulse width 1 ms and frequency 500 Hz.
In general, it is recommended to use relative Z coordinate for measuring rather than absolute. In relative measuring the used Z height value is the difference to the reference, not an absolute Z value. This way the set-up is less sensitive to any variation over time like vibration or ambient condition changes.

12 Preparing Measurement Setup

To ensure the most favorable measurement conditions, follow the instructions below.

- Handle the sensor with care. Neither the casing nor the lenses of the sensor must interfere with any object: only the dedicated mounting holes are to be used when installing the sensor.
- Do not hit, drop or shake the sensor. The optics may get out-of-tune if the sensor is handled improperly.
- If the sensor cannot yet be mounted into your setup, it should be laid on top of a clean, sturdy table.
- If you need to clean the lenses, please use compressed air (hand-help bottles are usually enough). If compressed air does not remove the impurity, dedicated lens cleansing liquid and cloths should be used with care.
- The target on the reference sample holder must not be touched. Keep the sample clean and if needed, use compressed air for cleaning, do not use liquid, etc.

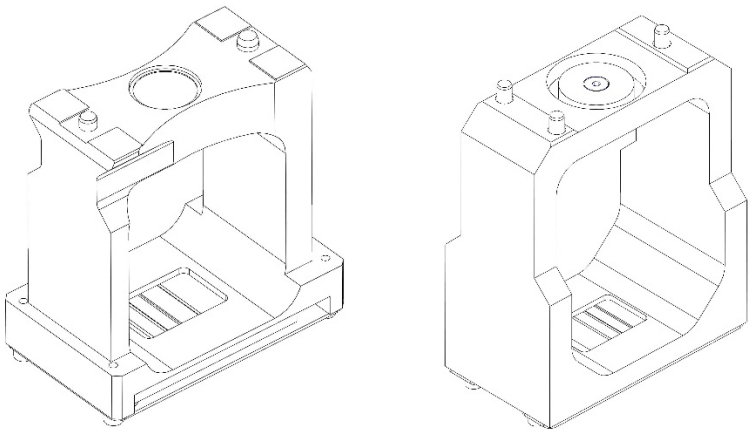
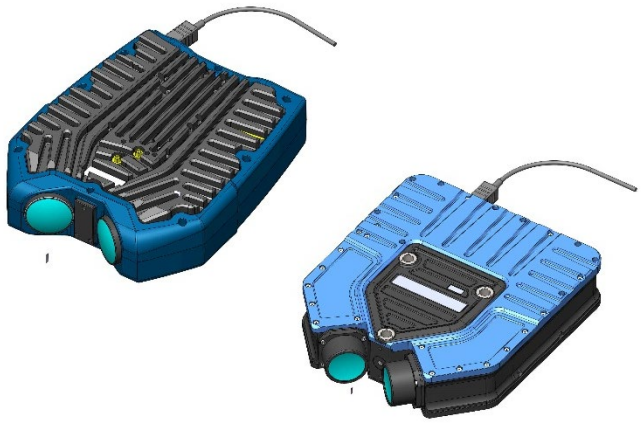
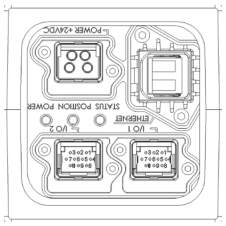
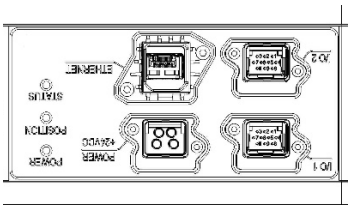
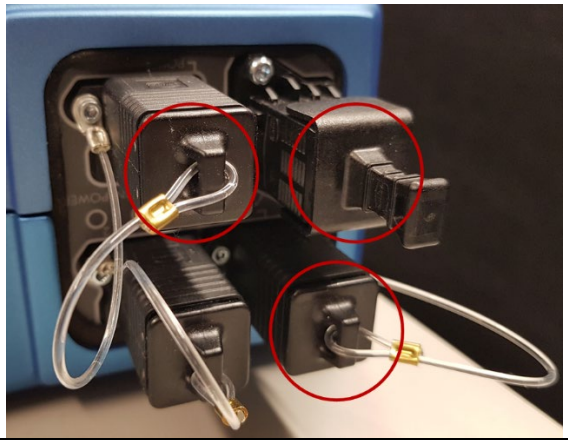
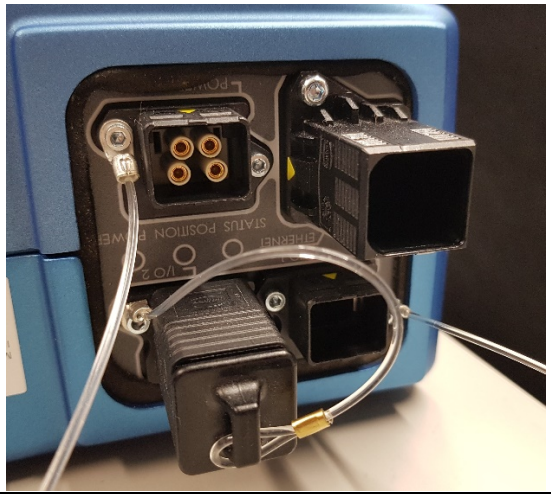
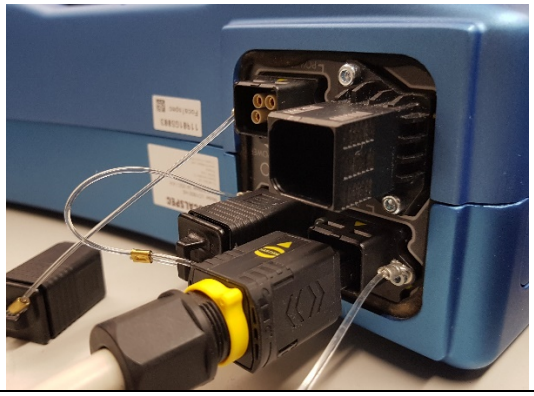


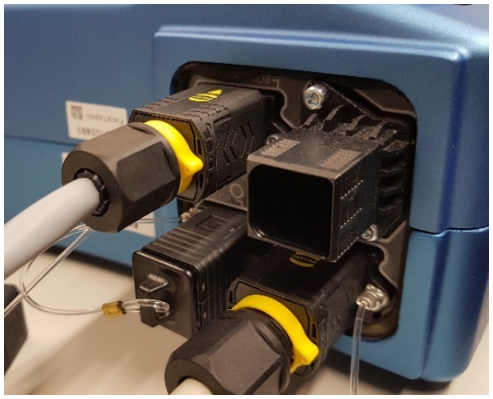
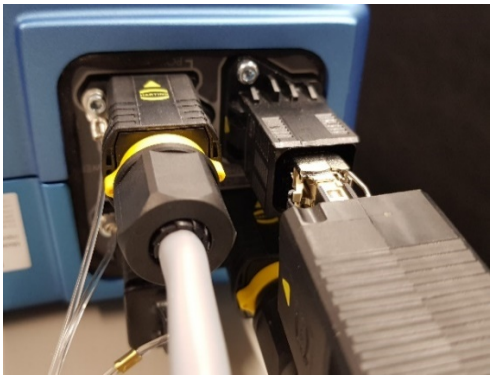
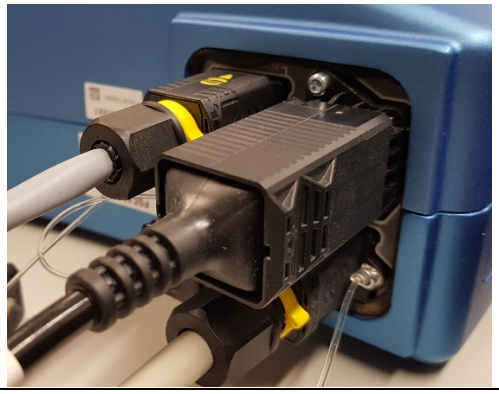
Figure 15. Reference sample holders of LCI1220 (left) and LCI1620.

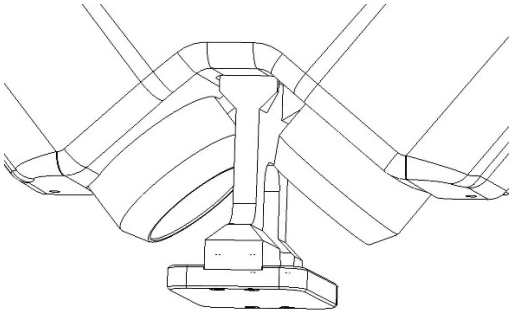
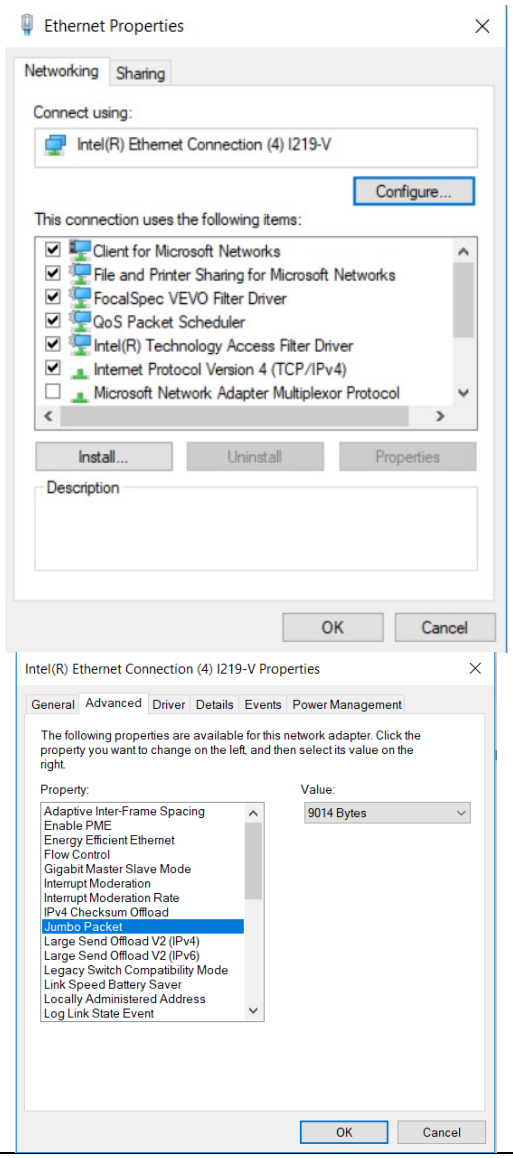
13 Getting Started

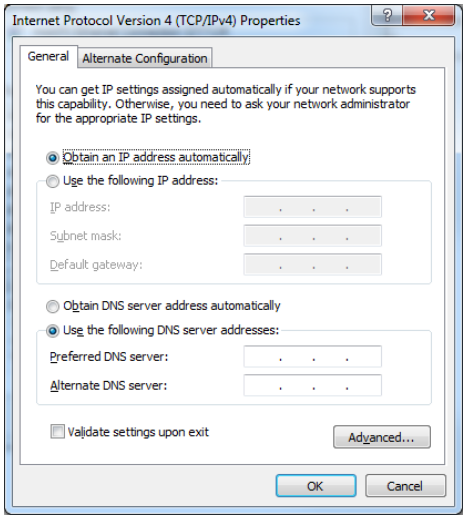
This chapter gives instructions on how to set up the system with the sensor and a PC in order to show measurement profile.

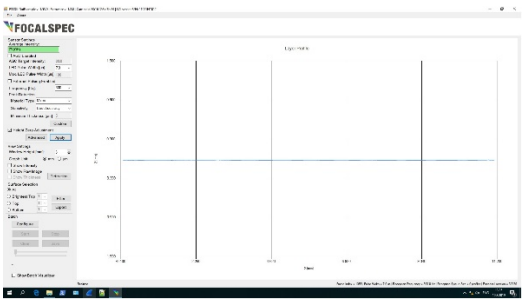
Step	Illustration		Instructions
1			Lay down the sensor carefully on a table with Focalspec label up and mounting holes down. Refer to chapter “Preparing Measurement Setup”.
2	LCI1620 	LCI1220 	Check the connector order of the sensor.

3		Remove dust caps from POWER, I/O 1 and Ethernet. Power and I/O caps are connected to sensor. Ethernet cap is loose, store it for possible future use.
4		Dust caps removed from POWER, I/O 1 and Ethernet.
5		Plug 10-pin signal connector into I/O1 port. Yellow marks indicate correct orientation.

6		Lock connector turning the yellow ring clock-wise.
7		Before connecting the power, test that power source voltage setting is the correct 24V. Plug in 4-pin power connector. Yellow marks indicate correct orientation.
8		Remove dust cap from the optical Ethernet cable end, store it for possible future use. Plug optical cable with SFP+ module into Ethernet port. Yellow marks indicate correct orientation.
9		Optical cable properly mated. Plug the SFP+ module of the optical cable's other end into computer.

10		Attach a reference sample holder on the magnet on the casing of the sensor. Do not touch the lenses or the black pipes. Power on the sensor. Sensor starting up takes about 30 seconds.
11	 	Check that Jumbo Packet setting is 9014 Bytes. 1. Click Start icon on the bottom left of the Windows task bar. 2. Select Control Panel. 3. Select Network and Sharing Center. If it is not visible, change View by to Large icons on the top right. 4. Select Change adapter settings. 5. Right-click Local Area Connection (the adapter connected to the sensor in step 3.) and select Properties. 6. Open Configure 7. Select Jumbo Packet and select 9014 Bytes 8. Click OK.

12		Make sure the network adapter of the PC to set to obtain IP address automatically: 1. Go back to Properties. 2. Double-click Internet Protocol Version 4 (TCP/IPv4) on the list. 3. Ensure Obtain an IP address automatically is selected as depicted on the left. 4. Click OK.
13		Double-click “setup.exe” on the USB drive and follow on-screen instructions to install FocalSpec Software Development Kit. If Windows asks you if you want to allow the program to make changes to the computer, select *Yes*. The installer needs this permission to add Windows Firewall rules, which allow the example application to communicate with the sensor. If you are using another firewall, allow these programs after the installer has finished: GuiExample\bin\Release\GuiExample.exe

14		When the installation is completed: Turn on the sensor power, wait until the power LED indicator is green. Start *FocalSpec GUI Example Application by* double-clicking the shortcut on desktop.
15		The application controls are explained in FocalSpec Software Development Kit (FSSDK) and the API documentation which can be found after FSSDK installation from folder: C:\Focalspec\FocalSpec Software Development Kit\Manual.

14 Troubleshooting

Q: An application cannot find any sensors. SDK function Open () returns 0 sensors.
A: Network troubleshooting checklist:

1. Check that the application binaries (.exe and vshost.exe) are allowed in firewall
    a. Both TCP and UDP must be allowed.
    b. For testing, it's best if firewall is disabled completely.
2. Verify that the sensor replies to a ping command: ping <sensorIP> (requires that sensor IP is known from the previous use)
    a. Ping packets are handled by controller platform of the sensor and they should be working whether or not the sensor controller software itself is running properly.
    b. If ping replies, the network connection is functioning.
    c. If ping doesn't reply, there is a problem in network connection.
3. Verify that network cables are properly connected.
4. Check that optical cable is not damaged. Try a different optical cable.
5. Check with Wireshark that there are DHCP and ARP packets sent by sensor during boot-up.
    a. These packets are sent by the sensor controller software.
    b. If there are no ARP packets, the cause may be one of these:
        i. Firewall is enabled.
        ii. Network cables have not been properly attached. Double-check connections.
        iii. Network devices or cables are faulty. Replace them.

Q: There is no measurement profile seen in *FocalSpec Graphical User Interface Example Application* (GuiExample).
A: Follow the check-list below:

1. Ensure the measurement target (surface) is in optical Z range and in focus. To validate this, attach the reference sample into magnetic place holder.
2. Ensure the sensor is triggering. To validate this, change *LED Pulse Width [µs]* to 100, check that *Frequency [Hz]* is set to 300 and check that there is a visible light beam on the reference sample target area.
3. If the problem still exists, proceed as follows:
    a. Close the application.
    b. Check cabling (Ethernet, power).
    c. Check firewall rules. The installer (setup.exe) automatically opens the needed rules into Windows firewall. To validate this, open Windows firewall and check that the rules are created into "Inbound Rules" with names "FocalSpec SDK GUI Example". If you have another firewall, allow *GuiExample.exe*.
    d. Check IPv4 address settings for the connected Ethernet adapter. To validate this, refer to the step 10 of chapter "Getting Started".
    e. Start the application.

f. If the problem still exists, do the following: power off the sensor, close the PC software, power on the sensor and start the PC software.

4. Change *LED Pulse Width [µs]* back to a more reasonable value. To validate, monitor *Average Intensity* text box, which indicates if *LED Pulse Width [µs]* is *too low, ok,* or *too high.*

15 Support

For further assistance, please do not hesitate to contact LMI by submitting a technical support request through https://support.lmi3d.com (recommended) or by email at support@lmi3d.com.

16 Abbreviations

CAD	Computer-aided Design
GUI	Graphical User Interface
LCI	Line Confocal Imaging
LED	Light-Emitting Diode
SDK	Software Development Kit
SFP+	Small Form-factor Pluggable Transceiver
USB	Universal Serial Bus