User’s Manual

Triple-IN GmbH
Experts in Laser Distance Measurement

INvention
INnovation
INterfacing

PS Lightweight Laser Scanner

Triple-IN | Poppenbütteler Bogen 64 | D-22399 Hamburg

Content

1 About this document

Triple-IN's PS Lightweight is for UAV integration, survey equipment integration, industrial applications, security and surveying.

- Up to 300 m Range,
- 1.67 mrad laser spot divergence in scan direction,
- 60 kHz Pulse repetition rate,
- up to 4 selectable Echoes
- IP65 cover
- Laser class 1 Eyesafe,
- PPS/NMEA time synchronization,
- 1 kg Weight
- Application Programmable Unit

This document describes the PS Lightweight. It is related to the:

```
PS Lightweight Laser Scanner
Order number SR-LWXX-110D-P3
PS Firmware Version 3.06.xx.xx
```

This User Manual is part of a set of documents:

Manual	Targeted persons	Content
User's Manual	Technical personnel	Transport, mounting and installation Wiring and maintenance Operating means, system configuration Technical data
Programmer's Manual	Software developers	Data formats Commands and responses
APU Developer's Manual	Software developers	Developer environment setup Specific APU features

If you or your colleagues have any comments on this manual, we would be grateful to hear from you. Please write to:

Triple-IN GmbH
Poppenbütteler Bogen 64
D-22399 Hamburg - Germany
Telefon +49(0)40 50091998
Mail info@triple-in.de

2 Safety Instructions

Caution!

Before using the PS Lightweight, the user manual must be read, and all the instructions must be carefully observed.

Warning!

The PS Lightweight must be installed, configured and serviced by qualified personnel only.
National and international rules and regulations must be applied according to the field of application and usage.
PS Lightweight cannot be used as a safety device.

Warning!

Risk of eye injury!
Measurement Laser is a laser class 1 product. Emits invisible light (905 nm). Do not look directly into the laser beam!
Red laser marker is a laser class 2 product. Emits visible light (635 to 678 nm). Do not look directly into the laser beam!

Warning!

Electric shock risk!
Device contains high voltage components!
Connect and disconnect electrical linkages only under de-energized conditions.

2.1 Limited warranty

Triple-IN's General Condition of Sales grants limited warranty for defects in material or workmanship in the PS Lightweight.

Caution!

The limited warranty does not cover:

- **Any problem that is caused by accident, abuse, neglect, shock, electrostatic discharge, degaussing, heat or humidity beyond product specifications, improper installation, operation, maintenance or modification;**
- **Any use contrary to the instructions in this and other related manuals;**
- **Lost firmware passwords;**
- **Malfunctions caused by other equipment;**
- **Damage resulting during shipment.**
  Claim must be presented and examined by the shipper.
- **Damages resulting from modifications or alterations to the product in any way, including any alterations or removal of its identification marks and labels.**

2.2 Handling precautions

PS Lightweight is a sensitive optical instrument. Such equipment must be handled with special care to protect the sensors from possible damage.

Caution!

Don't exert any pressure on the device.
Do not open the device.

3 Triple-IN's KEM Time-of-Flight Technology

The technological basis for the Triple-IN's PS Lightweight is "Time-of-Flight" (ToF): the travel time of light emitted by a laser diode to natural surface.
Triple-IN's KEM method ("kontinuierliche Event Messung", "Continuous Event Measurement) improves this well-known technology:

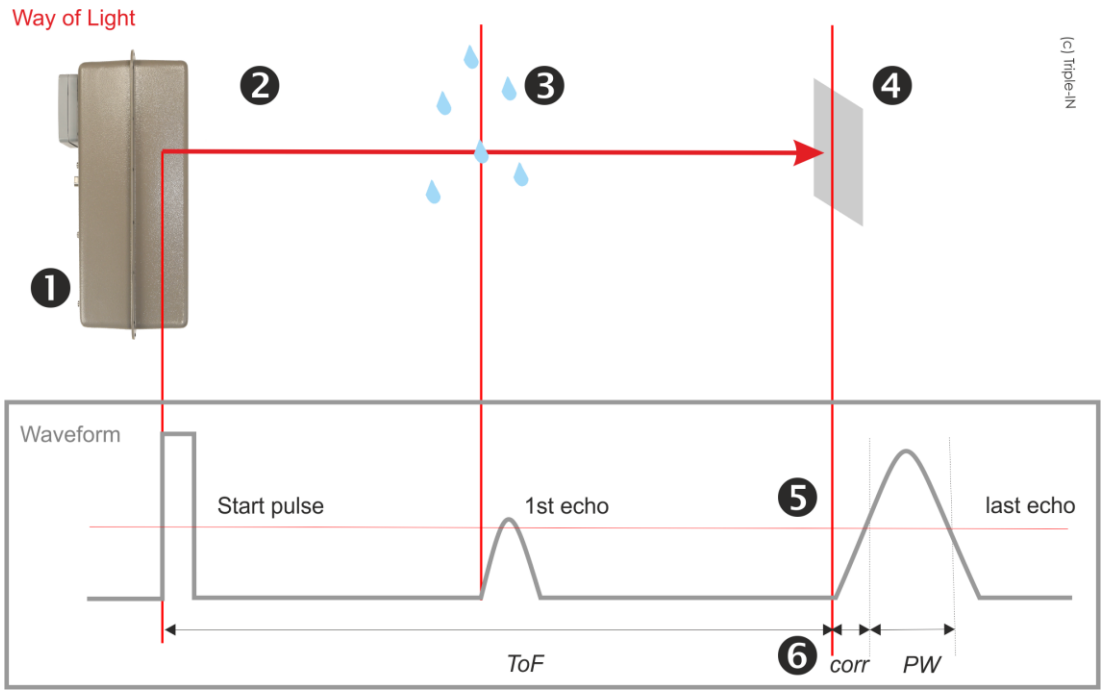


Figure 1: Principle of operation

1. The angle encoder triggers the laser diode in regular angle steps. The laser diode emits an infrared laser beam, defining the reference "Start pulse" which marks the beginning of the time-of-flight measurement.
2. The mirror, which is connected to the angle encoder, reflects the laser beam in certain directions. An even scan area is formed by the rotation of the mirror.
3. The laser beam is reflected by natural surfaces. Several echoes can be the result of window panes, rain drops, snowflakes and similar objects which reflect parts of the laser pulse's energy. This effect is called "multi-echo". PS Lightweight can record the results of up to 4 echoes for each laser beam.
4. The echo signal varies depending on the surface reflectivity and the distance to the object. The echo signal will be detected as soon as it passes a receiver threshold. The sensor measures the time-of-flight and the pulse width of the echo signal.

5. The KEM technology applies various corrections to compensate deviations from the echo signal strength.
6. The result is an accurate time-of-flight measurement, independently of the temperature, reflectivity, and target distance.
   The distance to the target is calculated by

```
D = ToF * c / 2 – corr
```

with the following variables:

```
D    = distance
ToF  = measured time-of-flight
C    = speed of light in ambient atmosphere
corr = echo signal corrections
```

3.1 Laser Spot Size and Sigma Diagrams

The next diagrams are drawn using data collected by a sensor model PS Lightweight.

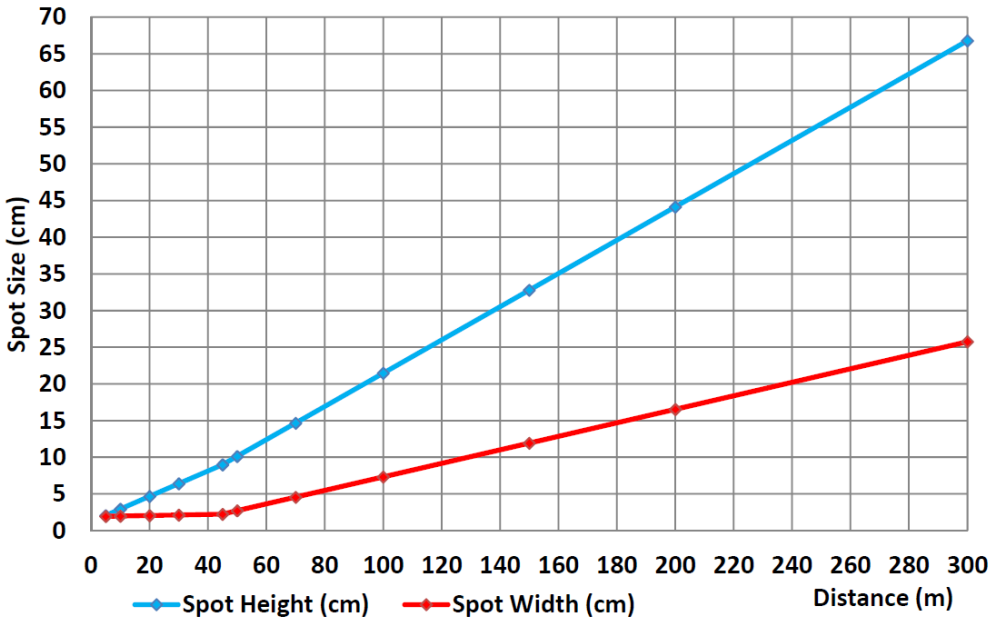


Figure 2: Spot size as function of distance

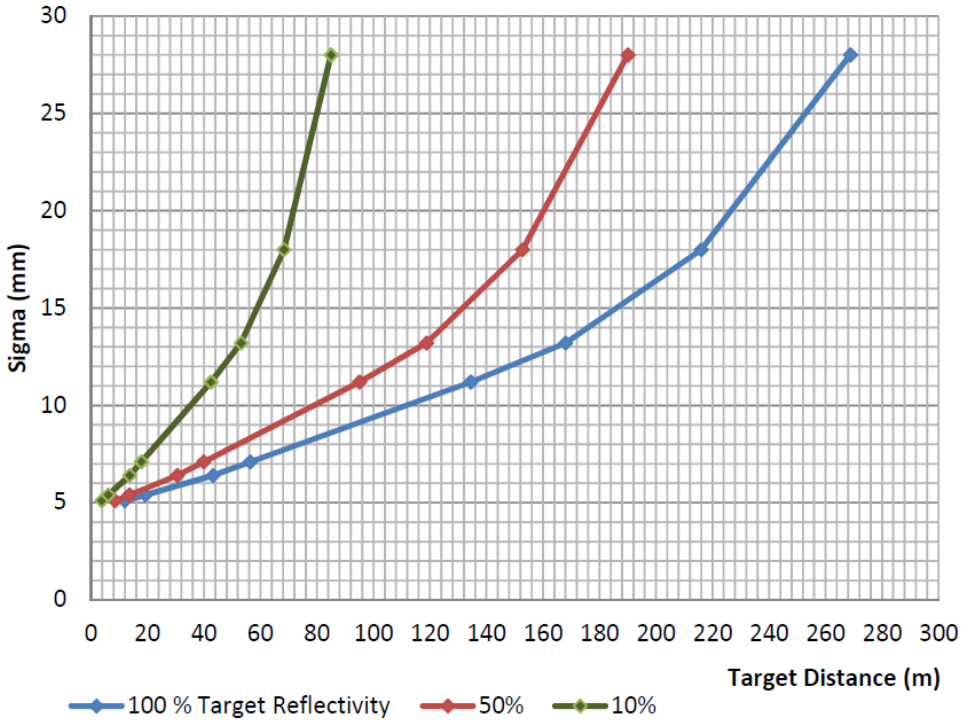


Figure 3: Sigma as function of distance

4 Operating features

4.1 System parts

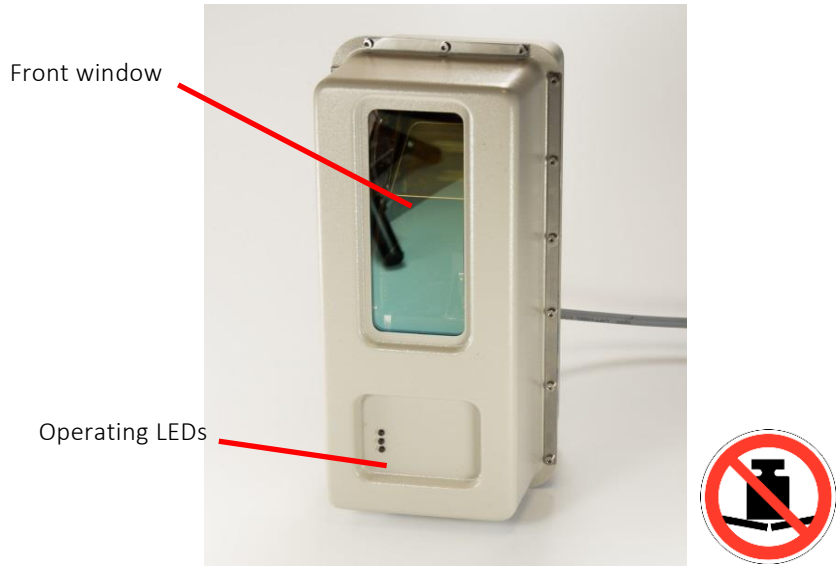


Figure 4: Front side view

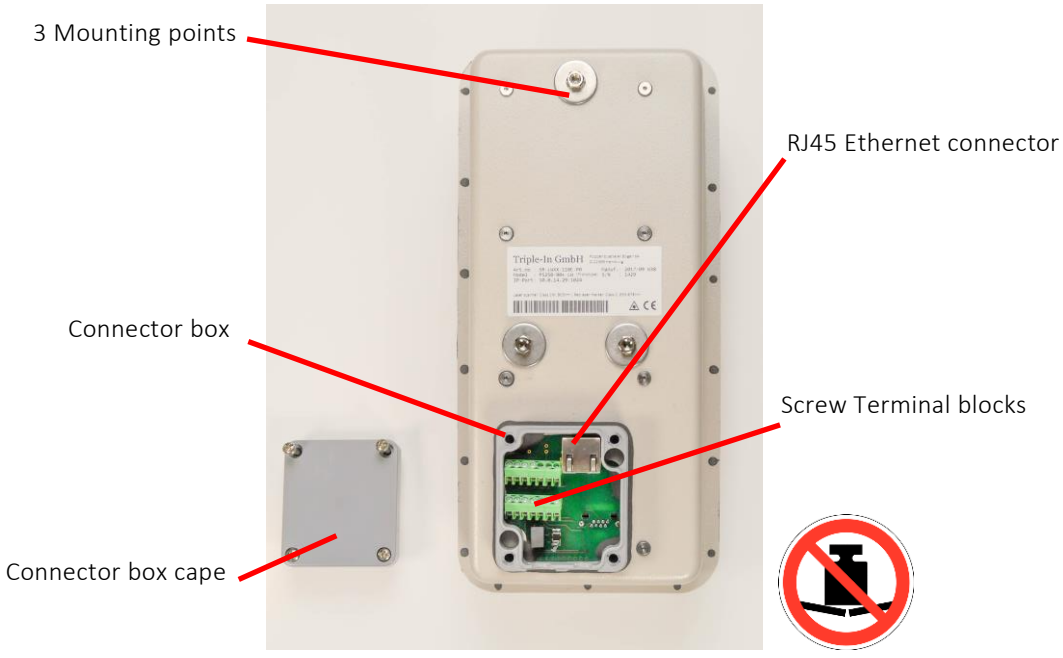


Figure 5: Rear side view

Measurement Laser

Emits a 905 nm invisible laser beam.

Receiver

Contains a receiver diode and is connected to the KEM-IC.

Measurement Processing Unit (MPU)

Contains a microcontroller and a Triple-IN KEM-IC chip to record time-of-flight events.

Application Processing Unit (APU)

It is a processing board with Linux OS, providing the Ethernet functionality and the option to run customized applications directly inside of the sensor.

Angle Encoder

It is an encoder with a resolution of 32000 coder counts.

Mirror cube

Reflects the laser beam. The 2D profile is generated due to its rotation.

Motor unit

Drives the mirror cube with a constant rotation frequency. The motor can be switched off by software.

Digital outputs

Two configurable isolated switching outputs are available, with a voltage working range from 3.3 VDC to 5 VDC.

Digital inputs

Two configurable digital inputs are available, in the same voltage range of the digital outputs. One of them can be configured to be used as a PPS (Pulse Per Second) signal for time synchronization.

4.2 Point of origin

The zero point (point of origin) is marked on the cover by a black laser marker.

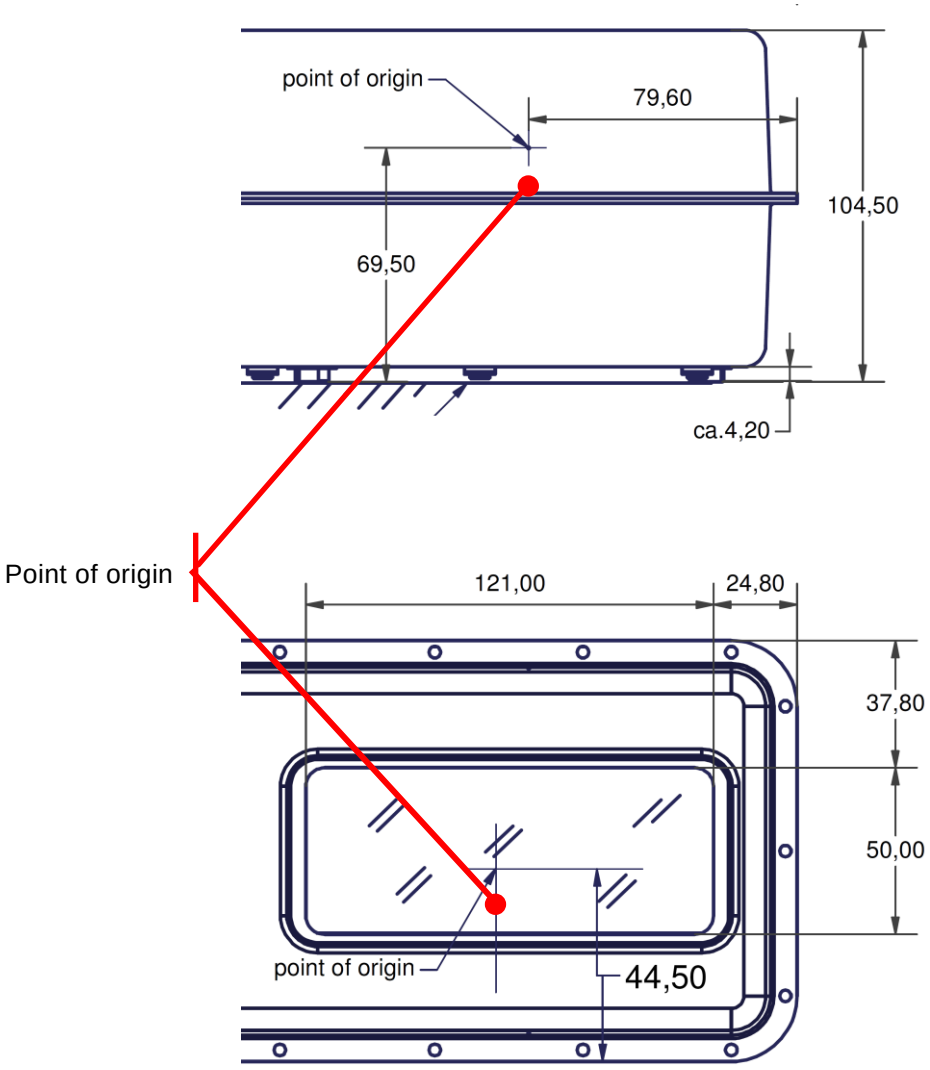


Figure 6: Measurement point of origin

4.3 Scan area

The scanner triggers 1000 laser beams on a 90° scan field, starting at 45°:

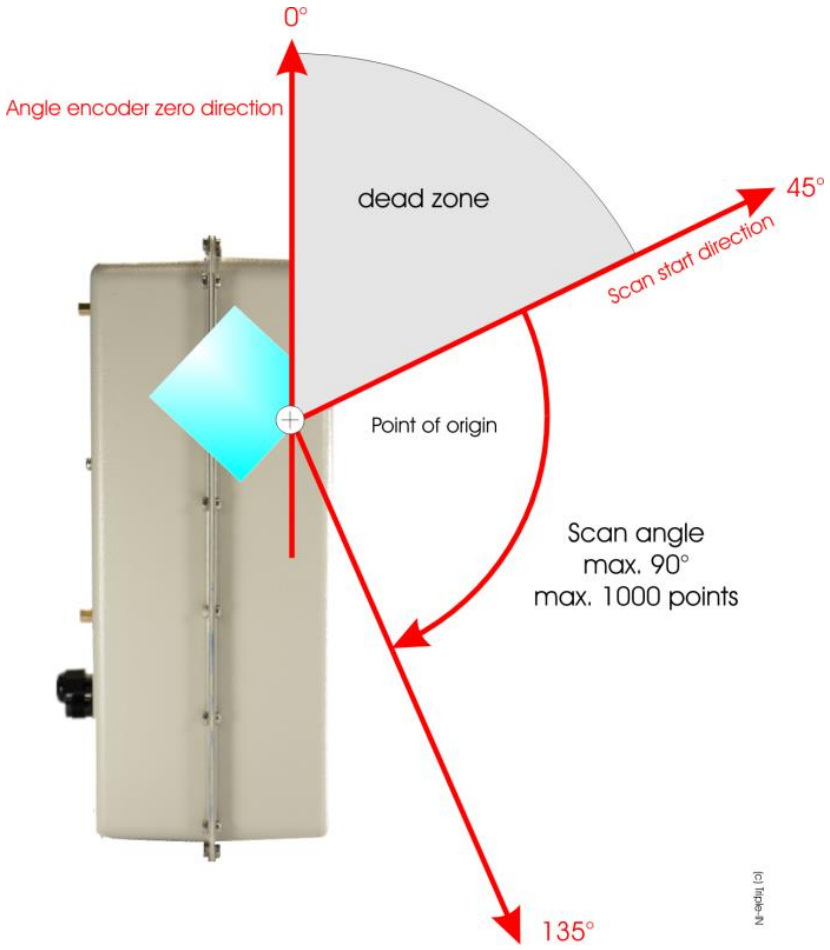


Figure 7: Scan area

- The angle measurement system is defined by a 360° circle.
- The angle encoder zero-direction is to the optical axis of the measurement laser.
- The scanner has a 45° dead zone from the top, so the scan field starts at angle encoder position 45° and ends after 90° at encoder position 135°.
- The scanner firmware handles angles as integer value in milli-degree.

The laser emits 905 nm infrared light. The laser spot size on the target surface increases with the distance.

5 Transport, installation and maintenance

5.1 General handling instructions

- Ensure during the installation that the entire system is disconnected from power supply.
- Mount the sensor at a location where the device is protected from damages, pollution and high humidity.
- Mount the PS Lightweight in a way that it is not exposed to direct sunlight.
- Route cables such that danger is excluded for persons and all cables are protected from damages.
- Do not remove the device identification label.
- Follow the safety instructions in chapter 2 Safety Instructions.

5.2 Packaging and transport

1. PS Lightweight is an optical instrument. Such equipment must be transported with special caution and sufficient packaging to protect the sensors from possible damage.
2. Use original Triple-IN packing material to transport the sensor.

Figure 8: Packaging

Caution!

Your warranty may be voided if returned sensor is received with inadequate packaging. Please always use the same package you received from Triple-IN for sending the sensor back.

3. At the time of delivery, the user should examine the shipment for loss or damage. If there is evidence of loss or damage, note it on the delivery receipt; this will be used as evidence to back up the claim. Do not use or install a defective device.

5.3 Condensation avoidance

If the PS Lightweight is suddenly brought in from the cold into a warm room, condensation may form on the optics and internal parts. To prevent condensation, first put the sensor in the transport box, then in a sealed plastic bag and let it adjust to the warmer temperature before taking it out of the bag.
If condensation forms on the sensor, do not use the sensor. This is to avoid damages to the electronics. If there is condensation, remove the power supply from the sensor, and wait until the condensation has evaporated.

5.4 Cleaning

PS Lightweight is mainly free of maintenance. The front window must be checked regularly and must be cleaned from dust and dirt.

- Use a clean and moistened cloth to clean the body.
- Use a microfiber cloth to clean the front window. Don’t put pressure on the cloth while cleaning the front window.

Caution!

Don't use abrasives, household cleaners, or other aggressive liquids.

5.5 Mechanical integration

The PS Lightweight can be fitted with three M4 socket head screws on the rear side, screw-in depth max. 4.0 mm.

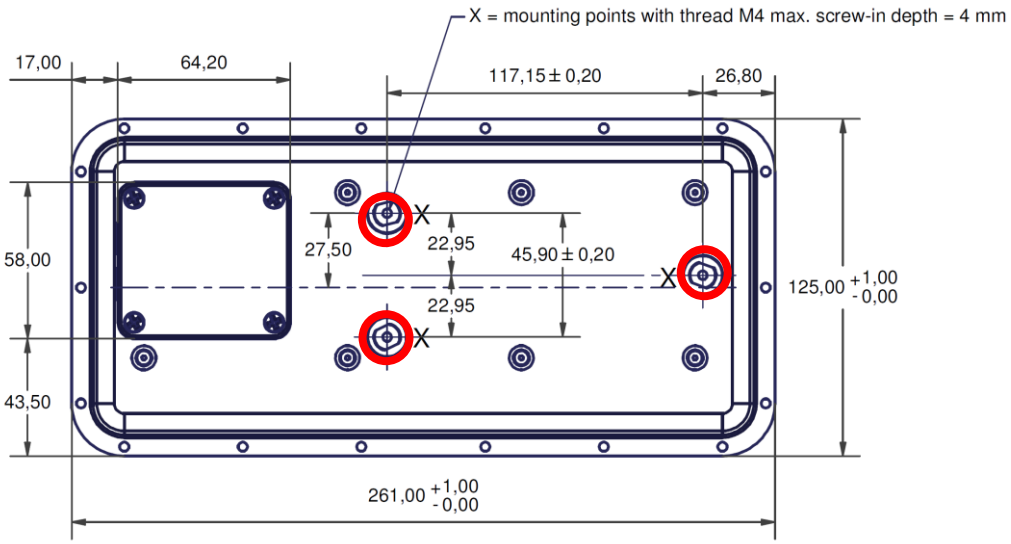


Figure 9: Mounting threads at the bottom

1. The mounting surface must be stable and warp-proof. Planarity tolerance is 0.1 mm in height.
2. Ensure that the entire system is disconnected from power supply during the installation.
3. Mount the sensor at a location where the device is protected from damages, pollution, high humidity and rapid temperature changes.
4. Mount the PS Lightweight in a way that it is not exposed to direct sunlight!
5. Route cables such that danger is excluded for persons and all cables are protected from damages.
6. Follow the safety instructions in chapter “2 Safety Instructions”.

6 Connectors

The connector box contains two screw terminals and one RJ45 Ethernet connector. The box can be opened easily by turning out the four screws.

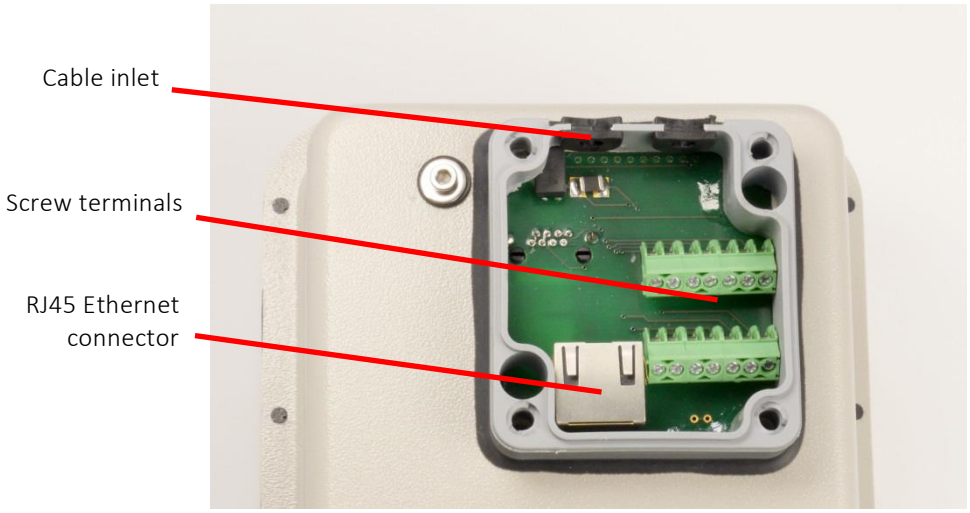


Figure 10: Connector box

Disconnect any cables from power supply.

1. Remove the plastic cap from the connector box.
2. Take the right-hand cable inlet out. Cut with a cutter a small slot into the rubber seal.
3. Run the cable for power supply, serial connectors, and digital input/outputs through the slot.
4. Attach the cable leads at the screw terminals.
5. Take the left-hand cable inlet out. Cut with a cutter a small slot into the rubber seal.
6. Run the Ethernet cable through the slot.
7. Attach the RJ45 connector.
8. Push cable inlet back into its place.
9. Check connections.
10. Close the connector box.

6.1 Screw terminal blocks

Two screw terminal blocks provide 14 connections for:

- 24 VDC power supply;
- Serial RS232 interfaces to the MPU board and the APU board;
- Two digital switching outputs;
- Two digital inputs;
- More connectors for future use. Those connectors shall not be used.

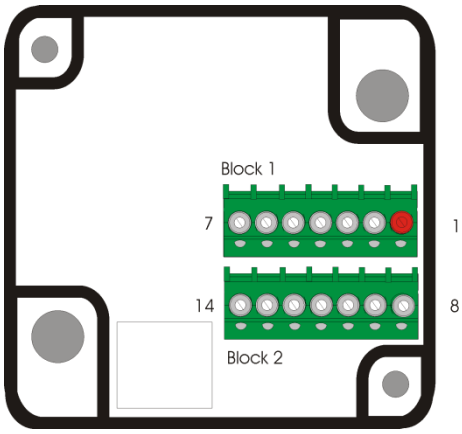


Figure 11: Position scheme of screw terminal blocks

6.1.1 Screw terminal block 1

Connector	Name	Signal	Purpose
1	STD_TXD	RS232 Measurement board transmit	Terminal mode, MPU Firmware update
2	STD_RXD	RS232 Measurement board receive	Terminal mode, MPU Firmware update
3	OUT1	Digital output 1	Digital switching output
4	OUT2	Digital output 2	Digital switching output
5	ORX	RS232 Communication board receive	Communication board firmware update
6	OTX	RS232 Communication board transmit	Communication board firmware update
7	IN1	Digital input 1	Digital input

6.1.2 Screw terminal block 2

Connector	Name	Signal	Purpose
8	IN2	Digital input 2	Digital input
9	OUT3	Do not connect	Reserved for future use.
10	OUT4	Do not connect	Reserved for future use.
11	VCC_IO	Digital output support voltage	Support voltage for the digital inputs and digital outputs
12	GND	RS232 Measurement board RS232 communication board	Common ground for RS232
13	24V DC+	Power supply	24 V supply voltage
14	24V DC-	Power supply	Ground

6.2 Connector identification

To simplify the indication given in the next paragraph, a connector will be identified by its block number followed by its connector number, separated by a colon.
For example, connector **3** on block **1** will be indicated as **1:3**.

6.3 Connecting 24VDC Power Supply

Power supply lines are connected to the screw terminal block connector **2:13** (positive supply voltage) and connector **2:14** (ground).

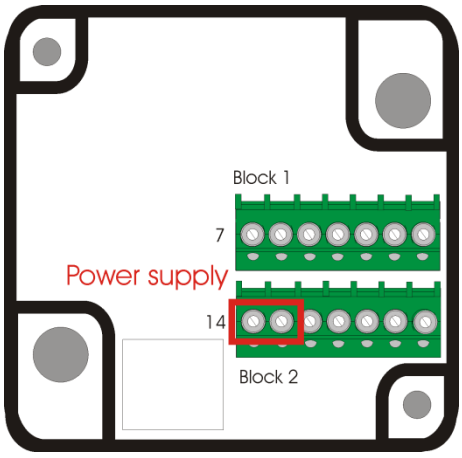


Figure 12: Power supply connectors

Connector	Name	Signal
2:14	CHG GND	24v Ground
2:13	24V DC+	Power supply 24 Volt DC

Warning!

Use correct power supply:
24 Volt DC +/- 10%
0.33 Ampere
8 Watt.

6.4 Ethernet connector

The sensor is connected to the Ethernet with a standard RJ45 connector, located in the connector box.

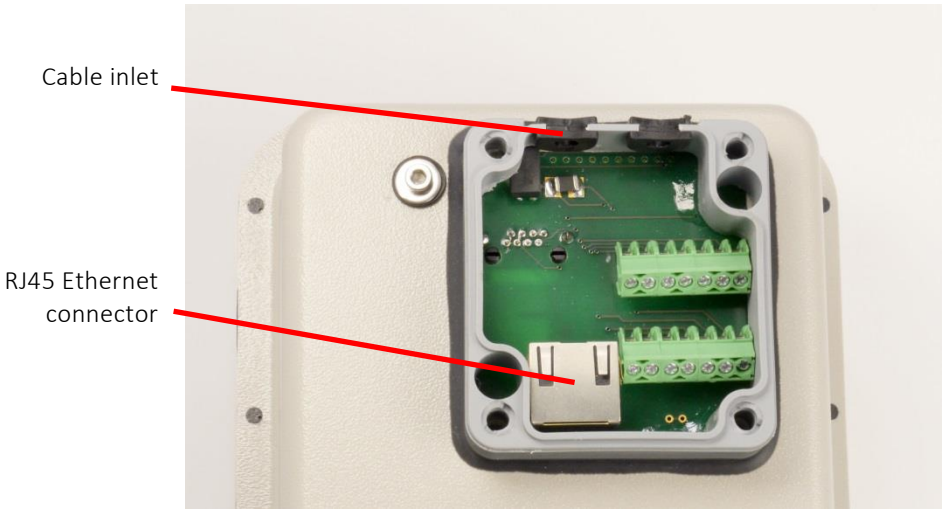


Figure 13: Ethernet cable connector

Warning!

Risk of damages by water:
Protection class IP65 is only reached by occupied cable inlets.

6.5 Wiring the MPU RS232 Serial Interface

The screw terminal blocks include an RS232 connection to the MPU.
The RS232 interface to the MPU is used for system configuration, e.g. to setup the network parameter.
PS Lightweight is classified as Data Terminal Equipment (DTE). According to the standard, PS Lightweight shall be equipped with male connectors.
A “null modem cable” consisting only of transmit data, receive data, and ground, is commonly used since the full facilities of RS232 are not required.
A DSUB9 connector must connect the following leads:

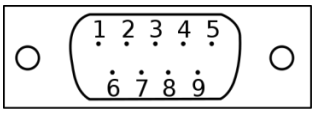


Figure 14: MPU DSUB9 male DTE pin layout (socket view)

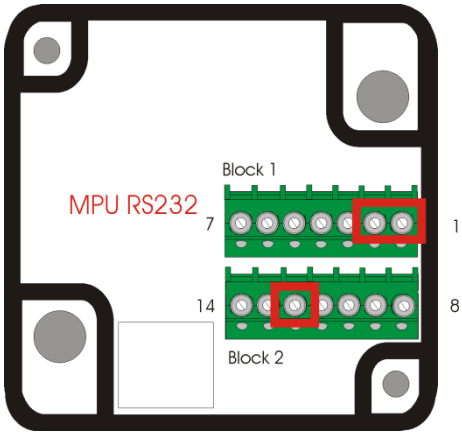


Figure 15: MPU RS232 connectors

DSUB9 pin	Connector	Name	Signal
3	1:1	STD_TXD	RS232 MPU transmit
2	1:2	STD_RXD	RS232 MPU receive
5	2:12	GND	Common ground

6.6 Wiring the APU RS232 Serial Interface

The screw terminal blocks include an RS232 connection to the the APU.
The APU provides the Ethernet interface. The RS232 interface is only used as a console access to the Linux system **OR** as GNSS connection.

PS Lightweight is classified as Data Terminal Equipment (DTE). According to the standard, PS Lightweight shall be equipped with male connectors. A “null modem cable” consisting only of transmit data, receive data, and ground, is commonly used since the full facilities of RS232 are not required.

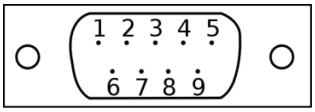


Figure 16: APU DSUB9 male DTE pin layout (socket view)

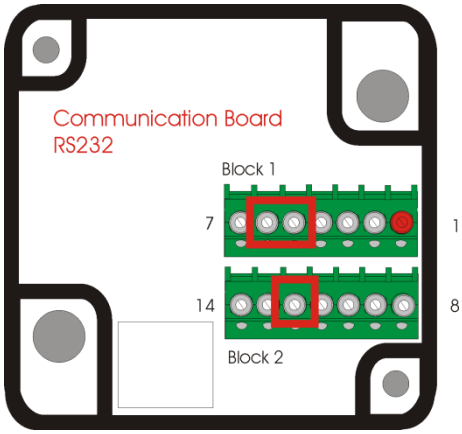


Figure 17: APU RS232 connectors

DSUB9 pin	Connector	Name	Signal
2	1:5	ORX	RS232 Communication board receive
3	1:6	OTX	RS232 Communication board transmit
5	2:12	GND	Common ground

6.7 Wiring Digital Outputs

PS Lightweight Laser scanners have two digital outputs, called OUT1 and OUT2. These outputs can be programmed for different purposes.

- Maximum output current is 50 mA;
- Maximum voltage to be applied is 5 V;
- Output residual voltage is < 1 V;
- Power supply range at VCC_IO is 3.3 to 5 VDC (+/- 10%).

Connector	Name	Signal	Purpose
3	OUT1	Digital output 1	Digital switching output
4	OUT2	Digital output 2	Digital switching output
11	VCC_IO	Digital output support voltage	Support voltage for the digital inputs and digital outputs
14	24V DC-	Power supply	Ground

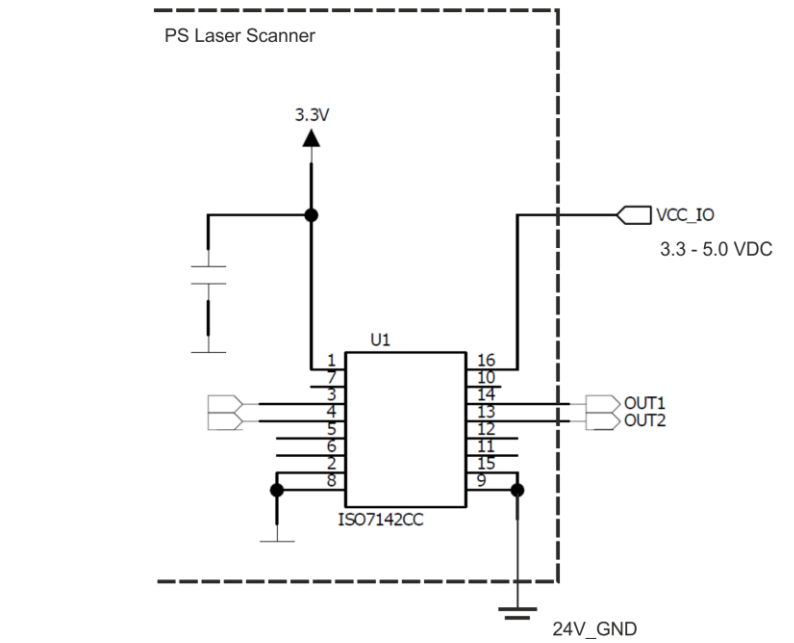


Figure 18: Digital outputs wiring scheme

6.8 Wiring Digital Inputs

PS Lightweight Laser scanners have two digital inputs, called IN1 and IN2. These inputs can be programmed for different purposes.

- Inputs are TTL;
- Maximum voltage to be applied is 5 V;
- Output residual voltage is < 1 V;
- Power supply range at VCC_IO is 3.3 to 5 VDC (+/- 10%).

Connector	Name	Signal	Purpose
7	IN1	Digital input 1	Digital input
8	IN2	Digital input 2	Digital input
11	VCC_IO	Digital output support voltage	Support voltage for the digital inputs and digital outputs

Connector	Name	Signal	Purpose
14	24V DC-	Power supply	Ground

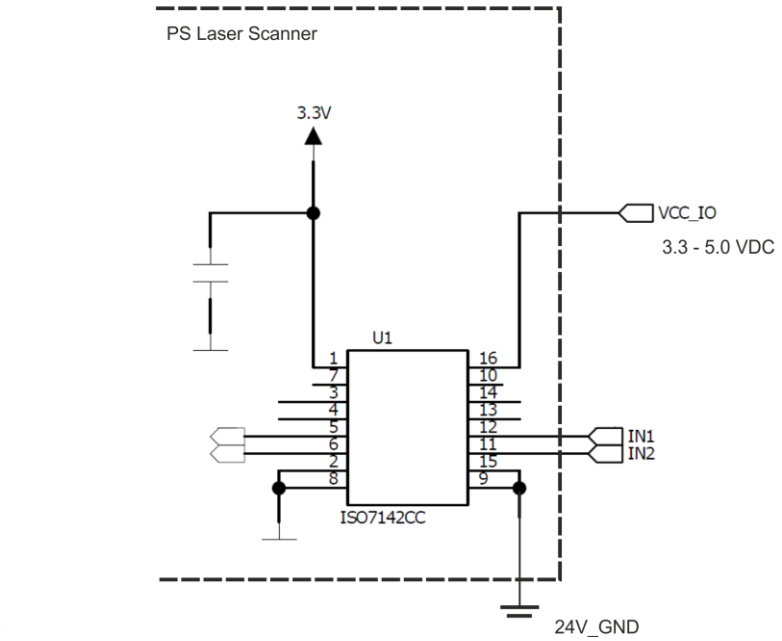


Figure 19: Digital inputs wiring scheme

6.9 Connecting a GNSS/PPS Module

The PS Lightweight Laser Scanner supports Pulses-per-second PPS signals from common GNSS receivers. The connection is made by a RS232 and one digital input.

1. Connect the GNSS RS232 with the APU RS232 wires at the Terminal block (see chapter “6.6 Wiring the APU RS232 Serial Interface”).
2. Connect the digital PPS output with one of the digital inputs.
   Note that the PPS signal must be TTL.
3. Apply 5VDC supply voltage at port VCC_IO.
4. Configurate the user settings “Digital input function”, and “GNSS/PPS”.
   Refer to chapter “Setting into operation”.

6.10 Multifunction cable for PS Lightweight

The Developer Kit for PS Lightweight provides a cable for serial connection and power supply.

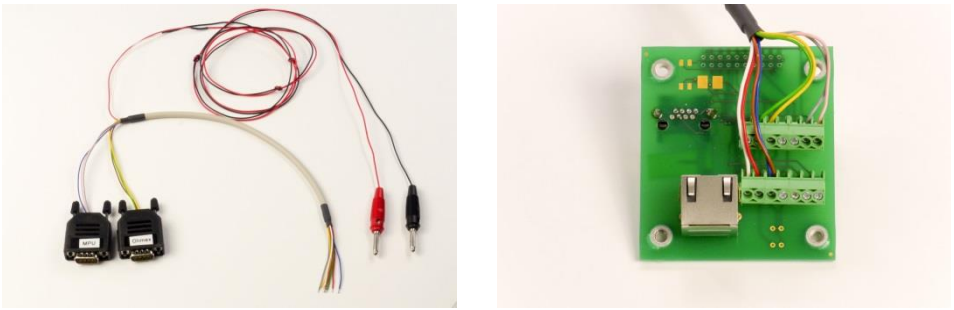


Figure 20: Multifunction cable and connection example

The open ends of the Multifunction cable must be connected to the screw terminal following the following table.

Colour	Connector	Name	Signal
Pink	1:1	STD_TXD	RS232 Measurement board transmit
Grey	1:2	STD_RXD	RS232 Measurement board receive
Yellow	1:5	ORX	RS232 Communication board receive
Green	1:6	OTX	RS232 Communication board transmit
Brown / Blue	2:12	GND	RS232 Measurement board RS232 communication board
Red	2:13	24V DC+	Power supply
White	2:14	24V DC-	Power supply

7 Microsoft Windows Software Tools

7.1 TeraTerm for the RS232 Serial Interface

TeraTerm is a very suitable program for the so-called Terminal Mode of the PS Lightweight. TeraTerm (author: T. Teranishi) is a free software terminal emulator and serial communication program for Windows.
Any other terminal program will be suitable as well.

1. Download TeraTerm from Triple-IN's web server.
2. Run the TeraTerm program installer.
3. Connect the EDM via a RS232 connection, using either a generic COM port or an USB-to-serial adapter.
4. Open TeraTerm and navigate to "`Setup > Serial port...`"
5. Choose the correct COM port.
6. Set the baud rate to 115200, 8 data bits, no parity, 1 stop bit, no flow control.

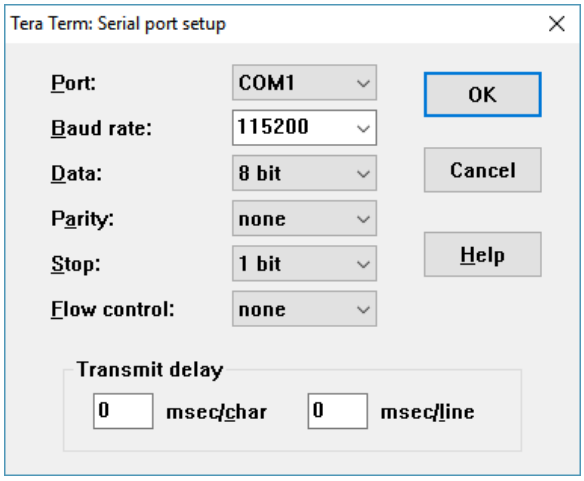


Figure 21: TeraTerm Serial Port setup dialog

7. Close the setup dialog.
8. If you want to store these settings for future use, go to "`Setup > Save setup…`"
9. Navigate to the TeraTerm installation directory and store the setup in TERATERM.INI.

7.2 TCP/IP Manager for managing network configurations

Triple-IN recommends the open-source Freeware “TCP/IP Manager” (author: A. C. Tundrea) to prepare the computer’s network settings for PS Lightweight. With this tool, you may simply save and restore network settings for PS Lightweight and standard Windows applications in different profiles.

1. Download TCP/IP Manager from Triple-IN’s web server.
2. Run the installer resp. unpack the ZIP file.
3. Start TCP/IP Manager.
4. Select in “`TCP/IP Settings > Network connection name`” the network adapter connected with the PS Lightweight.
5. Check if “`IP address`” matches the Gateway IP address as stored in the PS Lightweight. The default Gateway address is 10.0.10.0.
6. Check if “`Subnet mask`” matches the subnet mask as stored in the PS Lightweight. The default network mask is 255.255.0.0.
7. For later use, consider “`Network profile > Create a new profile`” to save the setup.
8. Choose “`Apply Settings`”.
9. To connect a PS Lightweight with the default settings:

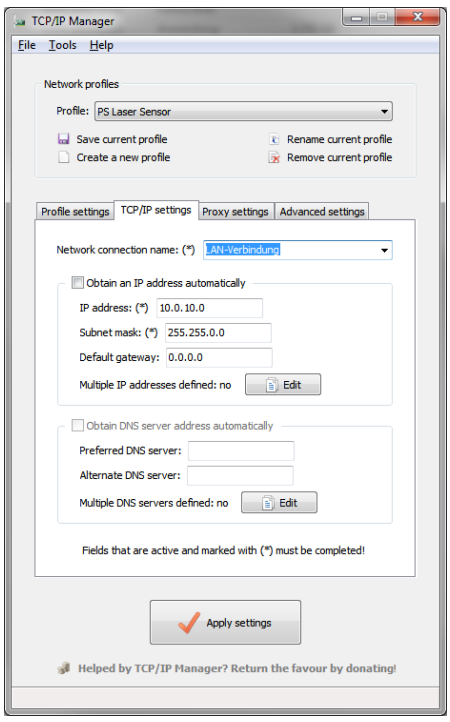


Figure 22: Network configuration with TCP/IP Manager

After disconnecting the sensor, you may use TCP/IP Manager to restore the Windows standards:

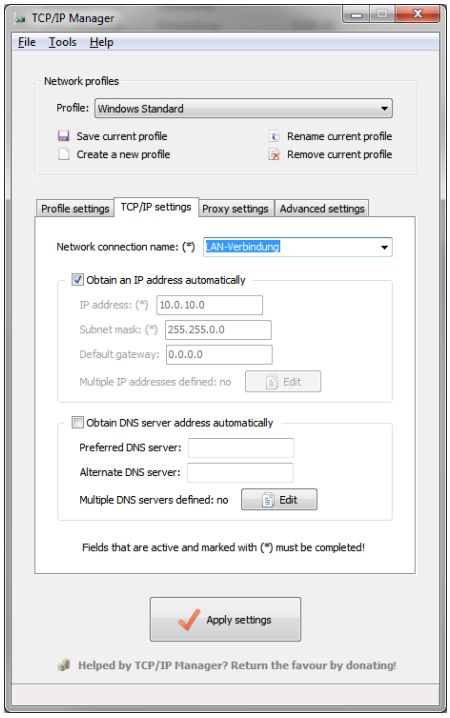


Figure 23: Restore the network configuration with TCP/IP Manager

1. Start TCP/IP Manager.
2. Select in "`TCP/IP Settings > Network connection name`" the network adapter connected with the PS Lightweight.
3. "`Obtain an IP address automatically`" should be checked.
4. For later use, consider "`Network profile > Create a new profile`" to save the setup.
5. Choose "`Apply Settings`".

7.3 Triple-IN PSControlProgram

Triple-IN's PSControlProgram is a PC application for controlling the functionality of Triple-IN Laser sensors via Ethernet connection. It makes the user able to set the user parameters of the sensor, start measurements, record the scans to files or show it on the chart or in the table.
The program is available on Triple-IN's web server.

To install the application please follow the instructions:

1. Start Windows installation program.
6. Confirm that you have administrator permissions to install the program.
7. The installer inspects the version information to use it during the installation process.
8. The product information (company, product name and version) is displayed on the screen if it's found during the analysis process.
9. Confirm installation.

A full description of the program can be found in the “PSControlProgram User’s manual”. The manual is part of the program distribution.

8 Setting into operation

8.1 Startup Procedure

To start the system:

1. Connect the control computer to the same network of the PS Lightweight.
2. Connect the power supply to the PS Lightweight.
3. After switching on the supply voltage, the scanner runs through a self-test. All LEDs are flashing. The firmware of the device checks important hardware components and parameters. Commands will respond to the control computer with a “device not ready” error.
4. The red LED is switched off after the self-test has passed successfully.

Caution!

After disconnecting the sensor from power supply, you must wait 30 seconds before turning it back on. Otherwise capacitors not being discharged could leave the sensor peripheral not fully reset.

8.2 Serial RS232 Communication

8.2.1 Setting up the serial communication

PS Lightweight has serial RS232 interfaces to connect a control computer with the MPU. The RS232 is used for the initial setup of the PS Laser scanner.
The standard communication settings are:

Parameter	Value
Baud rate	115200 bauds
Data bits	8
Parity	None
Stop bits	1
Handshake	No hardware or software handshake

The first serial interface, internally connected with the MPU, is used to program the TCP/IP connection parameters and to update the Measurement board firmware. This interface supports the so-called Terminal Mode (see next paragraph). After startup the terminal displays the sensor's serial number, IP address and self-test results.

```
PS Lightweight
[PSFirmWare; 03.06.00.00; (c) Triple-IN GmbH 2019]

SN:         1234
Local IP:   10.0.12.34:1024
Gateway IP: 10.0.10.0:1025

- Running self-test…
- Self-test done.

Type 4 x ENTER to switch to Terminal Mode
```

Figure 24: MPU start-up and self-test messages

The second serial interface is connected to the APU and is used to access the Linux console.

8.2.2 Entering the Terminal Mode

The PS Lightweight provides a Terminal Mode as an additional user interface.
This is an ASCII oriented, human-readable menu structure and user interface.
The Terminal mode is entered after the user sends 4 successive carriage return characters from a RS232 terminal console.

```
_____________________________________________________________________________

 Terminal Mode
_____________________________________________________________________________
 1 - Show user parameter
 2 - Show system health status
 3 - Network configuration ...
 4 - Restore to factory settings
 5 - Show reference tables...

 E - Edit a parameter
 S - Take a scan

 0 - Exit to Run Mode
```

Figure 25: MPU terminal mode

Caution:

The Ethernet interface is not available while the sensor operates in the Terminal Mode.

Show user parameter

Lists the parameters set by the user. With the function "Edit parameter" these values can be edited.

Show system health status

Lists the results of the self-test. See Appendix A for information about the meaning of the single statuses.

Network configuration

Changes the IP settings to standard configurations.

Restore to factory settings

This function is used to set parameters to their default values.

Caution!

“Reset to factory settings” will reset all previously modified parameter values!

Show reference tables

Displays the firmware versions and parameter code reference tables.

Edit parameters

This function is used to change any parameter. The parameter codes are needed for this. After entering the parameter code, the firmware shows the current value, the measurement unit and the valid range of values. The program then asks whether the changed parameters should be stored in the flash.

```
> E
> Enter parameter ID:
3_

> Enter parameter "Scan mode: 0=off, 1=normal, 2=fast, 3=fine":
2_
```

Figure 26: Editing a parameter in Terminal Mode

Take a scan

Starts the motor and carries out a single scan. The result is presented as CSV table. This function shall be used to check the basic functionality of the sensor.

Switch laser marker

Switches the red laser marker on and off.

8.2.3 Binary Command/Control Interface

Control computer programs, such as PSControlProgram, communicate with PS Lightweight over Ethernet or serial RS232 by use of binary commands. A full reference of the binary command/control interface can be found in the “PS Plus Programmer’s Manual”.

8.3 Ethernet connection

8.3.1 About Network settings

PS Lightweight uses the Internet Socket Interface for communications over Ethernet. The sensor socket address is a combination of the IP address (the location of the sensor) and a port (which is mapped to the application program process) into a single identity.

8.3.1.1 UDP/IP transport protocol

The UDP transport protocol can be used to send commands to the sensor, receive responses and receive the online scan stream.

8.3.1.2 TCP/IP transport protocol

The TCP transport protocol can be used to send commands to the sensor and receive responses. It is possible but not recommended to use TCP/IP to receive online scan stream.

8.3.1.3 Why choose UDP for scan data stream

TCP was designed to be reliable in data transmission. This means that, if a packet of data is not correctly (without errors) received by the destination, the sender will try to transmit it again until it is received correctly.
In a real-time system though it is more important to have always the most recent data available even if it means to have some previous data lost.
The UDP transport protocol has a lot of advantages for this purpose:

- It is stateless, suitable for very large numbers of clients. It is used for example in streaming media applications such as IPTV
- The lack of retransmission delays makes it suitable for real-time applications such as Voice over IP, online games, and many protocols built on top of the Real Time Streaming Protocol
- It works well in unidirectional communication and is suitable for broadcast information such as in many kinds of service discovery and shared information such as broadcast time or Routing Information Protocol

All these attributes (and more) made the UDP protocol the best choice to send the scan data stream to the requesting consumers.

8.3.2 Ethernet IPv4 addresses and ports to be configured

In the described communication pattern, the sensor provides some functionalities accessible through the Ethernet. Each one of these functionalities is identified as a "Service", and the control computer is the "Client".
More information can be found in the "PS Plus Programmer's Manual".

8.3.2.1 Sensor IPv4 addresses

The sensor has two different IP addresses configured and exposed to the outside:

- Predefined. Is automatically calculated from the serial number and cannot be changed. The network mask is **255.255.0.0** and it is calculated this way:

```
IP = 10.255.(serial / 100).(serial MOD 100)
```

- Custom. This address can be modified by the user. It is initially set with a default value calculated similarly to the Predefined:

```
IP = 10.0.(serial / 100).(serial MOD 100)
```

Example:

- The predefine IP address of sensor with serial number "1234" is **10.255.12.34**.

- The default IP address of the same sensor is `10.0.12.34`.

Caution!

The IP address set by the user cannot be the same as the Predefined.
The Port set by the user cannot be one of: 22, 80, 3007, 6969 and 6996.

8.3.2.2 Default client IPv4 address

The sensor has the possibility to start sending a scan data stream automatically on power on. This function is called "`AutoStart`". With AutoStart enabled, the sensor sends data to a predefined Client immediately. That predefined client is called the "`default client`". The user can define the IP address and port of the default client.

8.3.2.3 Gateway IPv4 Address

The Gateway in an Ethernet network serves the forwarding hosts to other networks when no other route specification matches the destination IP address of a packet. Often is the Gateway the router used to connect the local network with the World Wide Web.

8.3.3 Ports and Services

The sensor socket addresses are a combination of an IP address and a port (which is mapped to the application program process). Every available combination identifies a "Service".
The following are the services available by default on a sensor. As an example, we list the IP addresses for a sensor with the serial number as `1234`:

Service IP/Port	Protocol	Service	Description
10.255.12.34: 6969	TCP/IP	Scan and commands	Command communication line for configuration and online data stream
	UDP/IP	Scan and commands	Command communication line for configuration and online data stream
10.0.12.34:1024	TCP/IP	Scan and commands	Command communication line for configuration and online data stream
	UDP/IP	Scan and commands	Command communication line for configuration and online data stream
10.0.12.34:6996	UDP/IP	Announcement	A defined command sent to this channel will respond with the announcement message
10.0.12.34:3007	TCP/IP	Update	Used to send firmware updates to the sensor
10.0.12.34:22	TCP/IP	SSH	SSH access to the sensor
10.0.12.34:80	TCP/IP	Web interface	Access to the sensor web interface

8.3.4 Concurrent connections

Update and Commands TCP/IP listening Services are limited to one connection at a time. This means that if a TCP/IP Service is connected to a client, no other Client can use that service.

8.3.5 Changing the Sensor's network configuration using the RS232 Terminal Mode

The sensor IP address and the Gateway IP address can be set in the RS232 Terminal Mode with the parameters "`Sensor IPv4 address`", "`Default client IPv4 address`", "`Gateway IPv4 address`", and "`IP Subnet Mask`".
The Terminal Mode includes a function "`3 - Network configuration ...`" for a simple IP setup. The following configurations are available and can be changed individually:

```
_____________________________________________________________________
 Network configuration menu

 Sensor IPv4 address is  10.0.12.34
 Client computer IPv4 address is 10.0.10.0
 Gateway IPv4 address is 0.0.0.0
_____________________________________________________________________

 1 - Set default sensor IPv4 address
 2 - Set static sensor IPv4 address
 3 - Set private sensor address (APIPA)
 4 - Edit sensor IPv4 address
 5 - Edit client computer IPv4 address
 6 - Edit Gateway IPv4 address
 7 - Edit network mask

0 – Exit
```

Figure 27: Network configuration in Terminal Mode

- Default sensor IP address which is created in address space 10.0.x.x according to the sensor serial number.
- A static sensor IP address which is 192.168.0.10 by default.
- Private sensor IP address (APIPA) which is 169.254.0.10 by default.
  APIPA addresses are for standalone Windows computers.

These IP settings can be changed individually after the default has been set:

```
> Enter Parameter “Sensor IP Address AAA.xxx.xxx.xxx”:
192
> Enter parameter “Gateway IP Address xxx.BBB.xxx.xxx”:
168
[…]
```

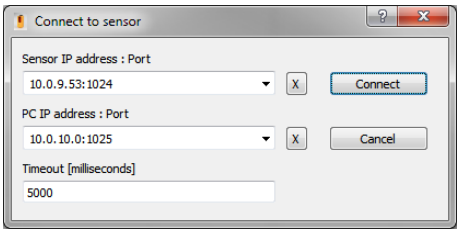
Figure 28: Network address edit in Terminal Mode

Caution

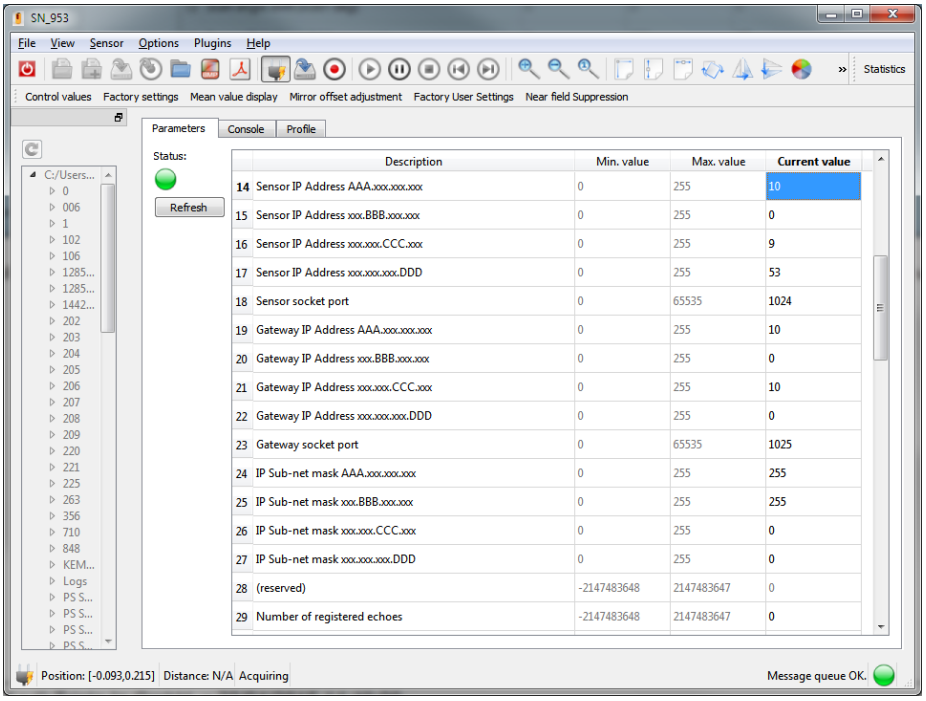
The sensor needs to be restarted after the network configuration has been changed. The Ethernet interface is disabled while the Terminal Mode is active.

8.3.6 Changing the Sensor’s network configuration using PSControlProgram

PSControlProgram is useful to change the sensors’ default network settings over Ethernet:

1. Start PSControlProgram.
2. Choose button “Connect” to connect the application with a sensor. The IP and port dialog appears on the beginning of the connection progress.
3. Enter the sensor’s standard IP address and the computer’s IP address. Note that both addresses must be part of the same network.
4. 

5. PSControlProgram network connection dialog
6. Once the connection has been made, all parameters including the network settings can be changed on the “Parameters” view.

7. 

8. PSControlProgram parameters view
9. Switch-off and restart the sensor to apply the changed network settings.

8.4 Configuration

8.4.1 Ways of configuration

You can configure the PS Lightweight in different ways:

- Using the commands “GPRM get parameter” and “SPRM set parameter” of the binary command/control interface. This way is most suitable for computer programs, such as PSControlProgram;
- Interactively using the RS232 Terminal Mode;
- Interactively using the sensor’s web interface.

8.4.2 About User Parameters

The entire sensor configuration is stored in a table of user parameters. Every parameter has a number as unique parameter identification code. The user can edit the parameter either by use of the Terminal Mode, or over RS232 and Ethernet by use of binary commands.
A list of parameters can be found in the “PS Plus Programmers Manual”.

Important

Parameter identifiers always refer to a certain firmware version. Therefore, an individual parameter reference table exists for every firmware version.
You find the description of the binary commands for the processing of the user parameters in the "PS Plus Programmer's Manual".

8.5 Taking Scans

8.5.1 Setting up the Scan Mode

With each of the scan modes, the following measurement parameters are set:

1. Scan rate: number of scans per second.
2. Scan start direction: direction of the first measurement point of a scan.
3. Scan angle: size of the scan area in degree.
4. Scan angle step: small angle between two subsequent measurement points. Defined by the scan angle size and the number of measurement points.
5. Scan Angle Shift: small angle between the start directions of subsequent scans.

The scan mode can be set with the user parameter:

```
Scan mode: 0=off, 1=normal, 2=fast, 3=fine
```

8.5.1.1 Normal scan mode

The "Normal Scan Mode" is defined by the following parameters:

- Scan start direction: min. 45°
- Scan angle: max. 90° with 1000 points.
- Scan angle step: 90°/1000 points = 0.090°
- Scan Angle Shift: Normal-Mode scans are not shifted.

8.5.1.2 Fast scan mode

To achieve an increase on the scan rate, the point density must be reduced. In "Fast Scan Mode" the point density is halved, with the scan rate doubled accordingly.

- Scan start direction: min. 45°
- Scan angle: max. 90° with 500 points.
- Scan angle step: 90°/500 points = 0.180°
- Scan Angle Shift: Fast-Mode scans are not shifted.

8.5.1.3 Fine scan mode

If the scan rate is not important but the lateral resolution is, a shift between the scans may be introduced. This leads to more “scans/profile” and consequently to a better lateral resolution with overlapping spots and a reduced profile rate. This measurement mode is called “Fine Scan Mode” and is implemented by interlacing 4 Normal scan lines with 1/4 angle shift.

- Scan start direction: min. 45°.
- Scan angle: max. 90° with 4x1000 points interlaced.
- Scan angle step: 90°/1000 points = 0.090° that will be interlaced.
- Scan Angle Shift: each scan is shifted by 0.0225°.
- Four scans can be interlaced to a single profile with 4000 points.

8.5.2 Taking scans in Terminal Mode

The Terminal Mode function “Take a scan” creates a table with the latest profile scan. The ASCII format is “comma separated” and can be easily imported into Excel or Open Office.

1. Enter the Terminal Mode
2. Open in TeraTerm “File > Log...”. Check “Plain text” and disable “Append”
3. Choose a log file name and close the dialog. TeraTerm will now record all sensor outputs.
4. Choose “S – Take a Scan”
5. Close TeraTerm
6. The log file can be opened directly with a common spread sheet program like Excel or OpenOffice Calc.

```
Scan;
_____________________________________________________________________________
    1490.489; 1st Pulse time stamp[s];
    1490.489; Last pulse Time stamp [s];
           0; UTC[s];
           0; Incremental encoder position [counts];
      45.000; Scan start direction [dg];
       0.900; Scan angle [dg];
       0.090; Scan angle step [dg];
          10; Points in scan;
           0; Master echo (0=last echo);
        31.7; Temperature [Celsius];
           3; Mirror ;


_____________________________________________________________________________
 Pulse ;  Echo ;   Direction ;    Distance ; Pulse width ;      Signal;
       ;       ;      [deg]  ;        [m]  ;       [ps]  ;
_____________________________________________________________________________
     1 ;     1 ;      45.000 ;     24.6281 ;       10343 ;         103;
     2 ;     1 ;      45.090 ;     24.6317 ;       10343 ;         103;
     3 ;     1 ;      45.180 ;     24.6410 ;       10417 ;         104;
     4 ;     1 ;      45.270 ;     24.6412 ;       10368 ;         103;
```

The header of the table contains:

- Time stamp [s]: is the time in seconds since the sensor was started
- The UTC time as provided by the GNSS, if available.
- Incremental encoder position [count]: is the count of the optional external incremental encoder.
- Profile start direction is the start direction of the profile, where 0 is upwards to the zenith.
- Scan angle: is the scanned area in degrees.
- Angle steps: give the scan resolution in degrees.
- Points in profile: give the length of the following measurements table.
- Master echo: 1 for the first echo or 0 for the last echo.
- Number of echoes: the number of echoes processed.
- Temperature: is the reading from the internal temperature sensor in Celsius degrees.

The measurements table contains:

1. Point: the number of the current point in the scan

2. Echo: the number of the evaluated echo. This value is always 1 if the Master Echo parameter has been set to “1=first echo”. The echo number varies from 1 to 4 if the Master Echo has been set to “0=last echo”.
3. Direction: direction to the target in degree.
4. Distance: distance in meters to the target surface.
5. Pulse width: echo signal pulse width in pico-seconds

8.5.3 Taking scans with Triple-IN’s PSControlProgram

Triple-IN’s PSControlProgram is a Windows application with user menu, toolbar, status line, workspace explorer bar and the data output widgets ordered in the tabs. User menu and main toolbar are providing the basic functionality for the system actions like connecting the program with a sensor, performing the scans, recording, loading or, exporting the data to “`*.csv`” files.
The program is available on Triple-IN’s web server.

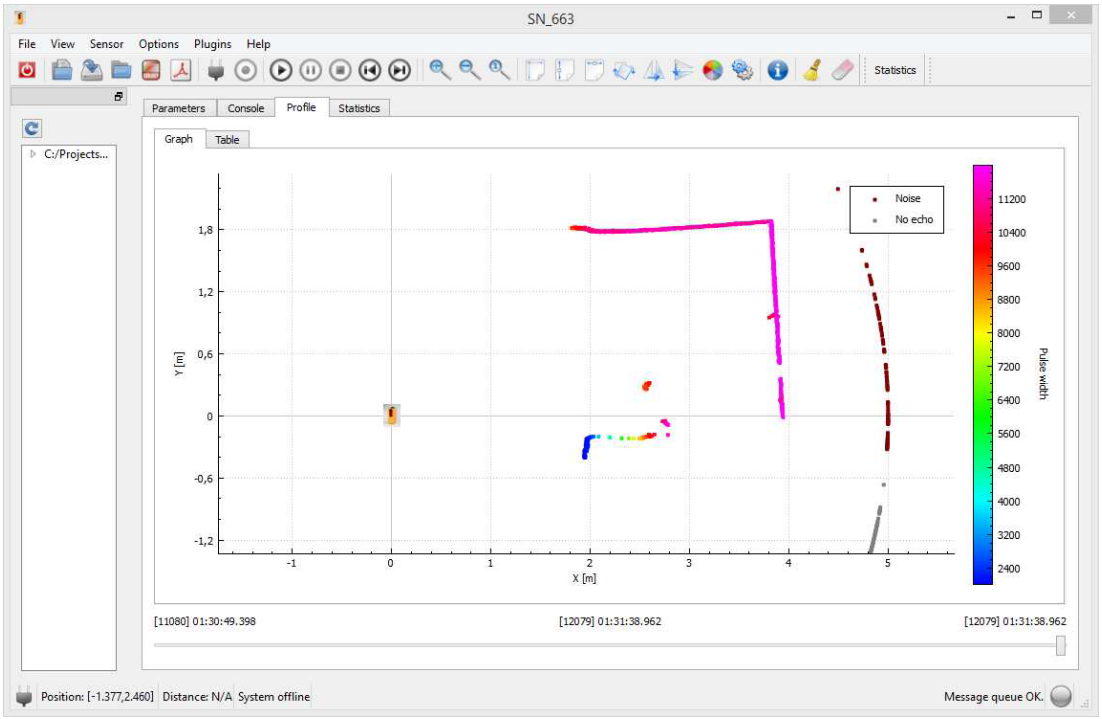


Figure 29: A scan taken with PSControlProgram

1. Connect to the PS Lightweight
2. Once online, the record button allows the user to write the scans to the binary files for later evaluation.

3. If the recording starts successfully the application starts to write the binary data to files. Every minute a new file of recorded profiles is created.
4. To easily find the files press “Open output directory” button on the toolbar and a File explorer window will be opened pointing at the correct directory.

8.6 Measurement filters

8.6.1 Near field suppression filter

The near-field suppression is used to suppress measurements to targets close to the sensor. This prevents the sensor to detect contamination of the optics.
PS Lightweight has optional, adjustable near-field suppression. This is divided up in zones, each with a width of 760 millimeter. Zone 0 defines the closest distance.
The near field suppression zone can be configured with the user parameter:

```
Near-field suppression zone, min=0
```

The current near field range can be obtained by the parameter

```
Const: Near field suppression range [0.1 mm]
```

Example:

Zone 3 has been set as near field suppression range. Any echo from a target in the range will be ignored:

```
Near_field_range = zone0 + zone1 + zone2 + zone3
```

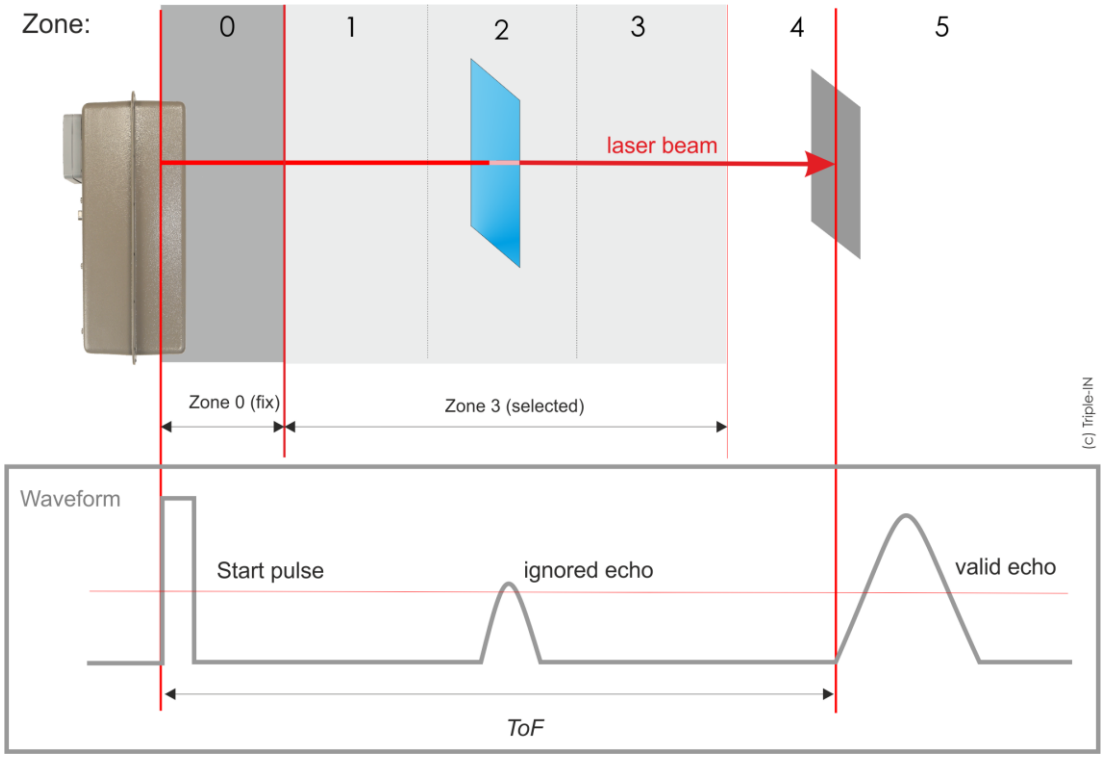


Figure 30: Near-field suppression: example with zone 3

8.6.2 Low echo filter

If the laser spot is only partly reflected by object edges, incorrect measurements may arise. A “low echo filter” removes measurements with echo signals less than 3%. To use the full range of sensitivity, the low echo filter can be disabled. The user parameter must be set to 0.

```
Low echo filter; 0=disabled, 1=enabled
```

8.6.3 High echo filter

If the laser spot is reflected by several surfaces, incorrect measurements may arise due to deformations of the echo signal. The “high echo filter” removes measurements which appear with very wide echo signal amplitudes.
The high echo filter can be disabled to allow measurements on reflectors and reflecting foil. The user parameter must be set to 0.

```
High echo filter: 0=disabled, 1=enabled
```

8.7 Master echo selection

At measuring through rain, through protection windows, or in dusty surroundings several objects may reflect the laser beam. PS Lightweight can process until 4 echoes but some of the data format can return only one or two. In those formats, the “Master Echo” identifies which echo of the 4 processed is returned.

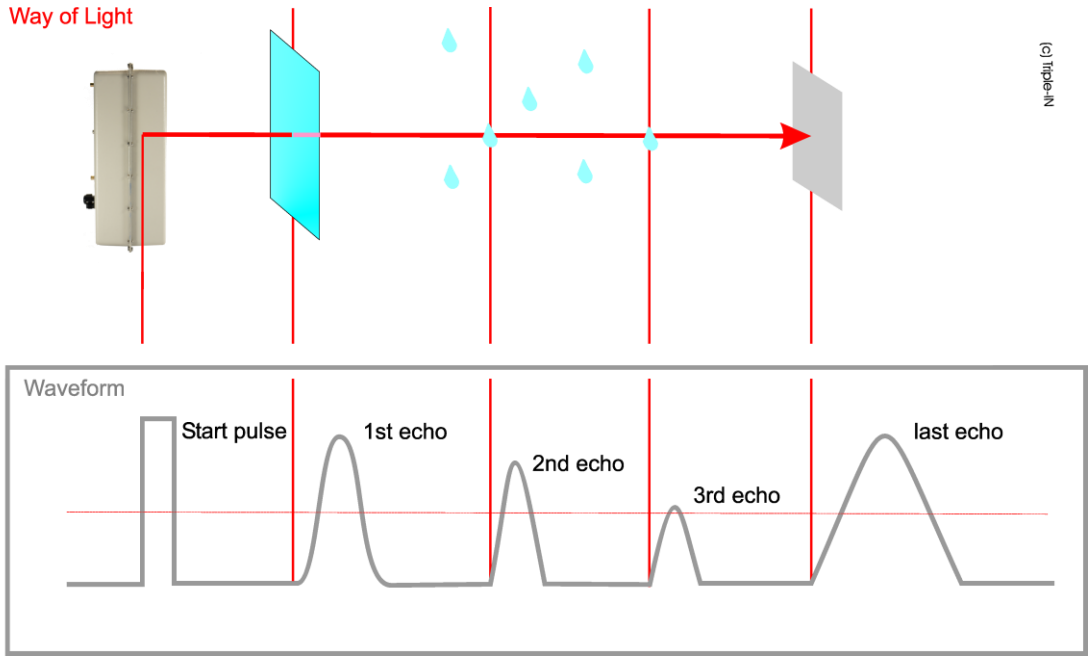


Figure 31: Figure 1Muti-echo

The user parameter “Master echo” is used for configuration:

```
Master echo: 0=last, 1-4=echo index
```

- Scans contain the first echo (closest object) if the parameter has been set to “1”.
- Scans contain the second, third or fourth echo if the parameter is set respectively to “2”, “3” or “4”.
- If the parameter is set to “0”, the last and furthest measuring is returned.

8.8 Using Digital Outputs

8.8.1 Using the digital outputs as scan synchronization signal

One single digital output can be configured to provide a scan synchronization signal. The signal is set active with the first laser pulse, and it is set inactive with the last laser pulse of a scan.
The scan synchronization signal allows an accurate synchronization with other devices, such as GNSS receivers and turn tables.
The scan synchronization signal is set active by setting the user parameter “Digital output function” to “1=sync”.

8.8.2 Using the digital outputs as pulser

User applications can set a counter value in advance to produce output signals of a specific count.
This function permits a control computer to transmit a counting stand or volume information as digital signals to another system. All digital switching outputs can be used independently. The pulser feature is set active by setting the user parameter “SW function” to “3=pulser”.
The counter value must be written into the parameter:

```
Digital output pulser setup
```

The sensor firmware copies this value, sets the parameter register back to 0, and starts the count down. After this, new counts can be added to current output by writing another counter value. Make sure that the parameter “Digital output pulser setup” has reached 0 before adding new counts.
The hold time can be defined by the user parameter:

```
SW hold time [ms]
```

The delay between counter signals can be defined by the user parameter:

```
SW delay [ms]
```

The resolution of both timing parameters is about 10 ms.

Example:

The following parameter setup:

```
53;  3; 1st Digital output function: 0=off, 1=sync, 2=switch, 3=pulser;
56; 10; 1st Digital output hold time [ms];
57; 20; 1st Digital output delay [ms];
58;  0; 1st Digital output logic: 0=normal, 1=low active;
59;  3; 2nd Digital output function: 0=off, 1=sync, 2=switch, 3=pulser;
62; 30; 2nd Digital output hold time [ms];
63; 40; 2nd Digital output delay [ms];
64;  1; 2nd Digital output logic: 0=normal, 1=low active;
```

In conjunction with the counter parameters:

```
55;  4; Temp: 1st Digital output: pulser setup;
61;  2; Temp: 2nd Digital output: pulser setup;
```

Results in the following signal pattern:

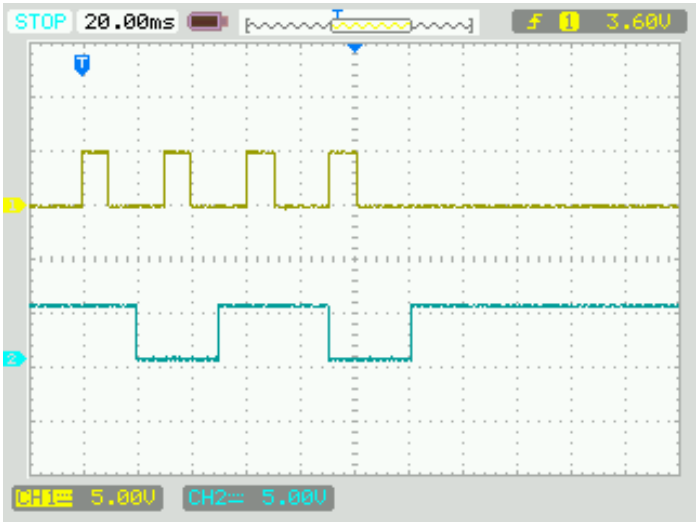


Figure 32: Digital output example signal pattern

8.9 Using digital inputs

8.9.1 Pulse per second PPS

A pulse per second (PPS) is an electrical signal that has a width of less than one second and a sharply rising or abruptly falling edge that accurately repeats once per second. PPS signals are typically provided by GNSS receivers and are used for precise timekeeping and time measurement.
PS Lightweight supports the PPS signal in the following way:

1. The internal sensor clock provides an internal counter on millisecond base.

2. Each rising edge of the PPS signal increases a full second counter and resets the millisecond counter to 0.

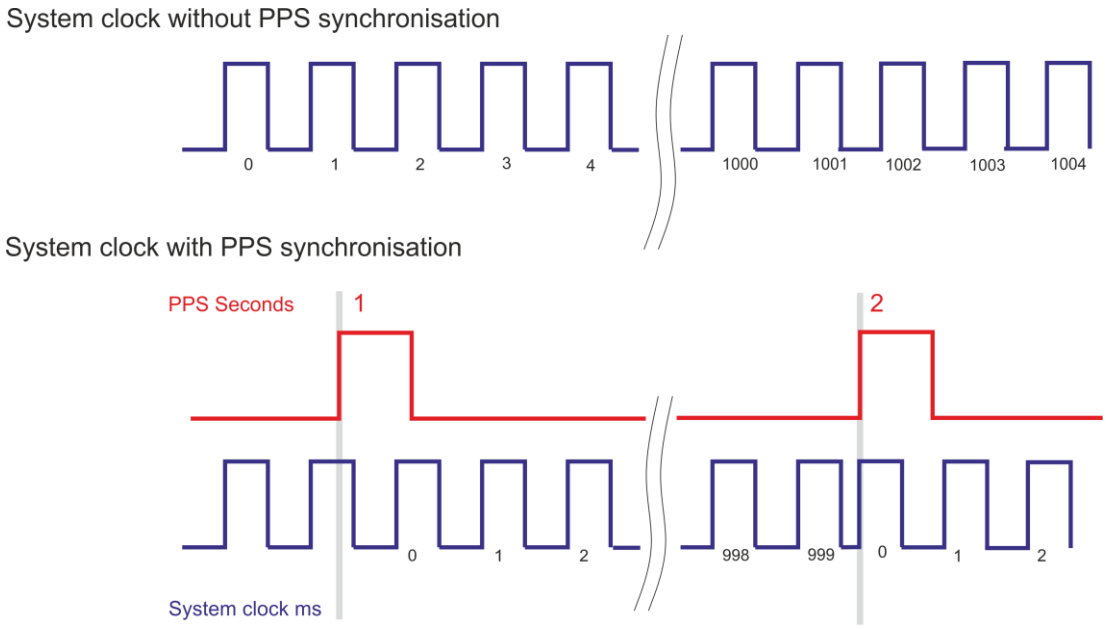


Figure 33: PPS signal

3. If the PPS signal occurs before a full sensor second, then the time stamps between PPS and sensor seconds are skipped.
4. If the PPS signal occurs after a full sensor second, time stamps may occur twice.
5. If the PPS input has been enabled, but no PPS source is connected, the internal clock continues to count milliseconds and provides the time stamp.

Only one single digital input can be used for the PPS signal. The sensor selects the first digital input defined.
The feature is set active by setting the parameter `IN function` to "`2=PPS`":

```
Digital Input function: 1=enabled, 2=PPS, 3=RTC reset
```

The current number of PPS signals received can be obtained with the temporary user parameter "Digital input status".

8.9.2 Configure PPS and GNSS

PPS source is commonly a GNSS receiver, which provides also the accurate UTC time stamp. PS Lightweight laser scanners provide a RS232 input to receive GNSS NMEA protocols.
To activate and use the UTC time, the following parameter must be set:

```
95; GNSS NMEA status: 0=off, 1=prev. PPS, 2=next PPS;
96; GNSS Receiver RS232 baudrate;
```

Parameter “95 GNSS NMEA status” defines the relation of the PPS signal with the NMEA sentence that contains the UTC timestamp:

- `1=prev`:
  PPS occurs before the related NMEA sentence. This is a kind of standard for most GNSS receivers.
- `2=next`:
  First the NMEA sentence gives the UTC, then the related PPS signal will be set.

After the connection has been made, the parameter “97 UTC Unix time stamp [s]” is updated periodically with the sensor system time. The unix time stamp is the number of seconds since the Unix Epoch on January 1st, 1970.

9 Web interface

The PS Lightweight provides a Web interface useful to check the sensor status and to make some configurations, like quick changes on user parameters.

9.1 Sensor information page

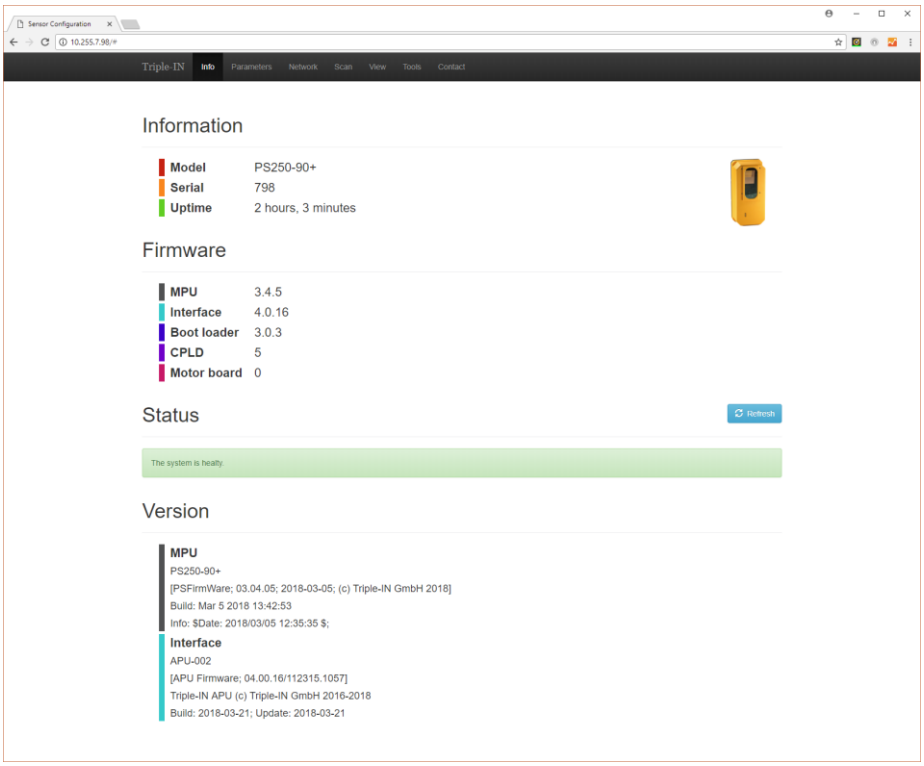


Figure 34: Web interface Info page

The Info page offers a glance on the sensor status and version. The four sections described below are available.

Information

Contains the sensor model, serial number and uptime (time since the previous power-up/restart of the APU).

Firmware

Shows the firmware version of the various sensor parts:

1. MPU, Measurement Processing Unit

2. APU, Application Processing Unit
3. Boot loader (MPU boot loader)
4. CPLD (Internal controlling circuit)
5. Motor board (vertical deflection unit motor controller)

Status

In this section are shown all the issues the sensor can incur into. See Appendix A for more information.

Version

Shows detailed version information for the MPU and for the APU.

9.2 User parameters page

In this page, all the User Parameters are shown.

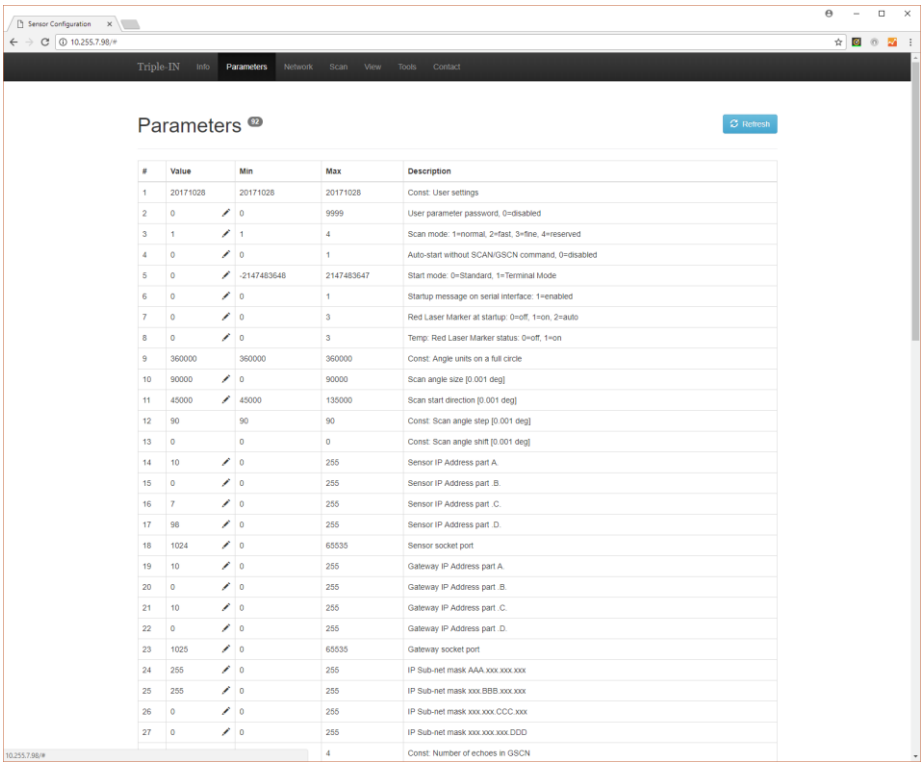


Figure 35: Web interface Parameters page

The value of editable parameters can be modified just clicking on the pencil icon placed on the right of the value.

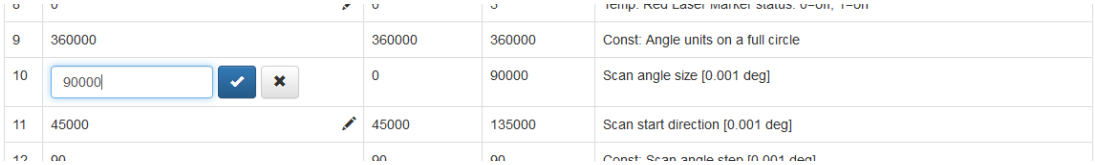


Figure 36: Changing a parameter value on the Web interface

To confirm the modified value just click on the blue button on the right. Click on the gray button to keep the previous value.

9.3 Network page

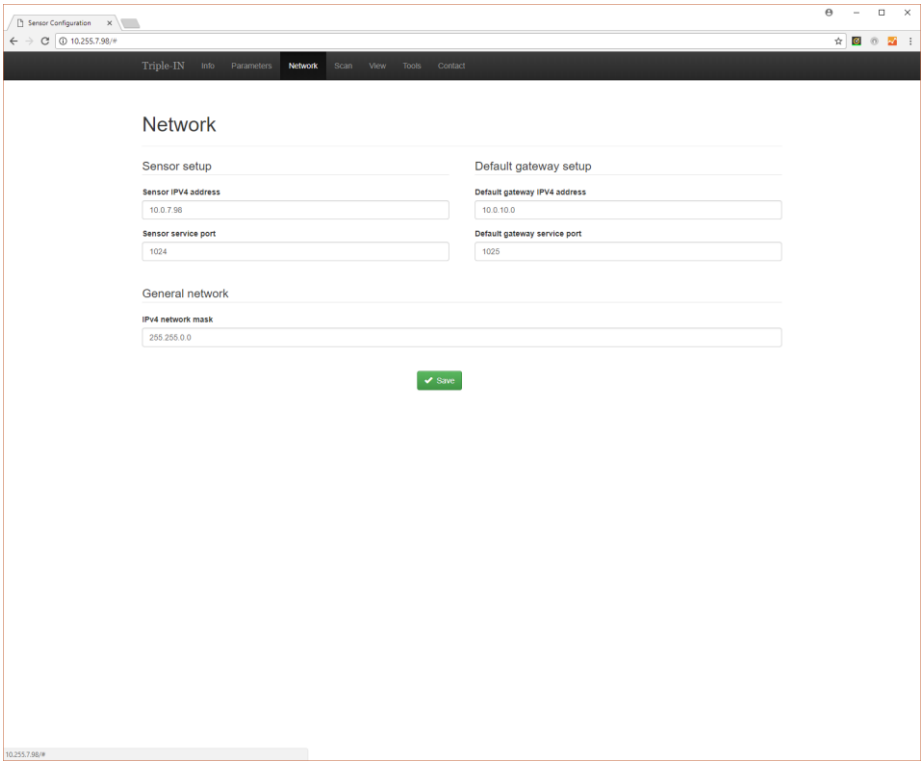


Figure 37: Web interface Network page

The Network page, offers a simple way to modify the sensor network settings. Just modify the values as needed and press on the green **Save** button.

9.4 Scan page

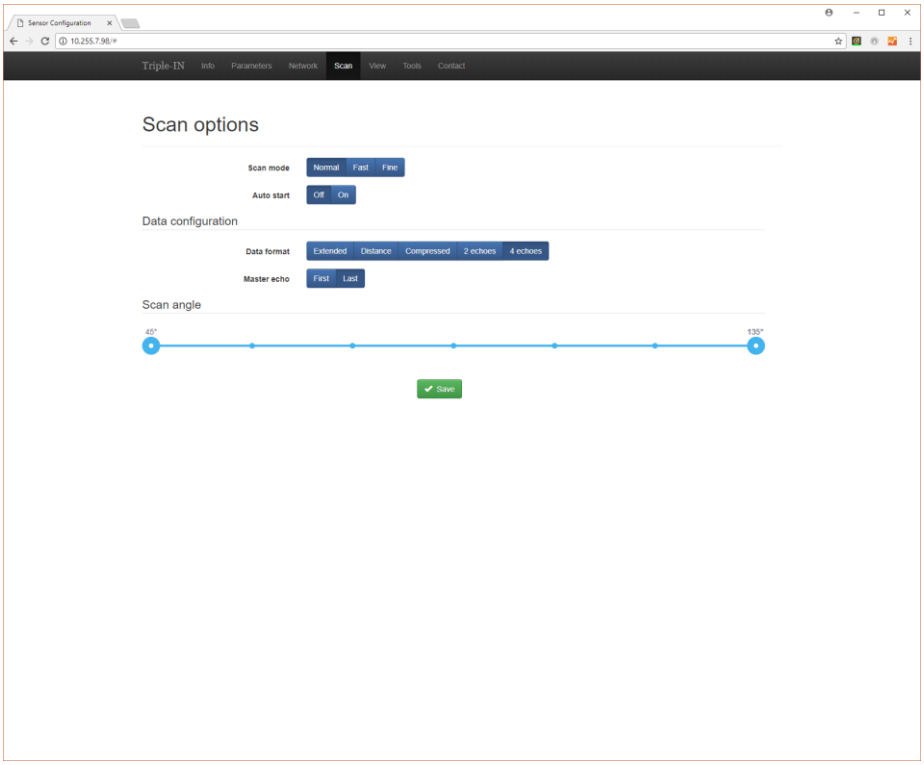


Figure 38: Web interface Scan page

In the Scan page, it is easy to modify in one shot the user parameters defining the returned scan lines.

1. Scan mode
2. Auto-start feature
3. Data format
4. Master echo
5. Scan start direction
6. Scan angle size

9.5 View page

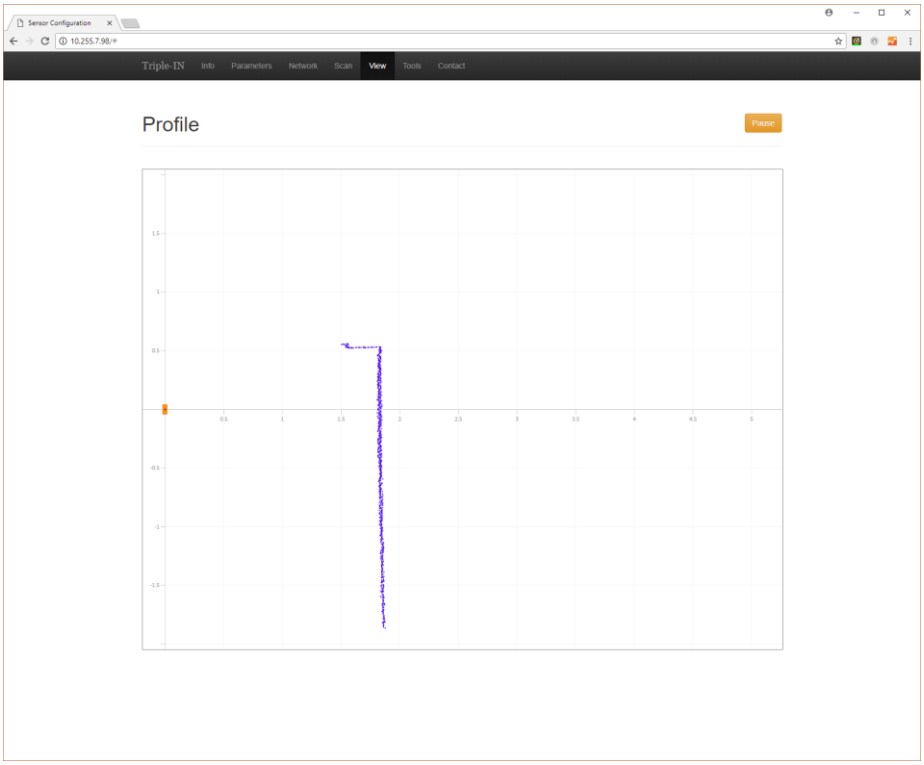


Figure 39: Web interface View page

The View page offers a preview of the scan line produced by the sensor.

Caution

The display frequency in this page is sensibly lower than the real scan frequency. Delays between the acquisition time and display time can be in the order of few seconds.

9.6 Tools page

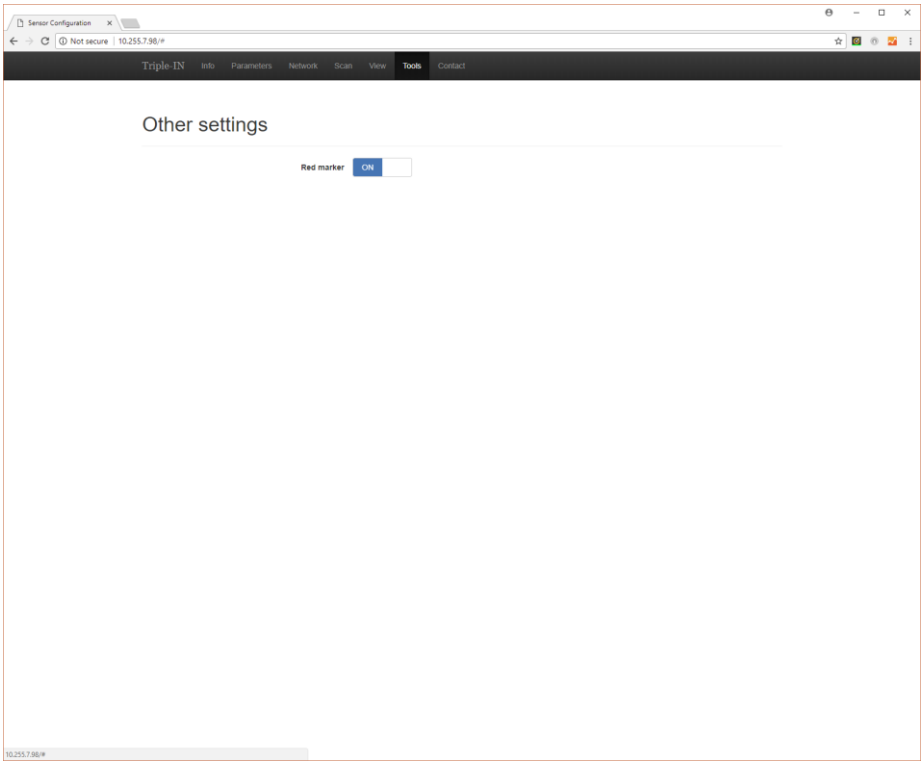


Figure 40: Web interface Tools page

This page offers the possibility to access to some special tools or settings.

9.7 Contacts page

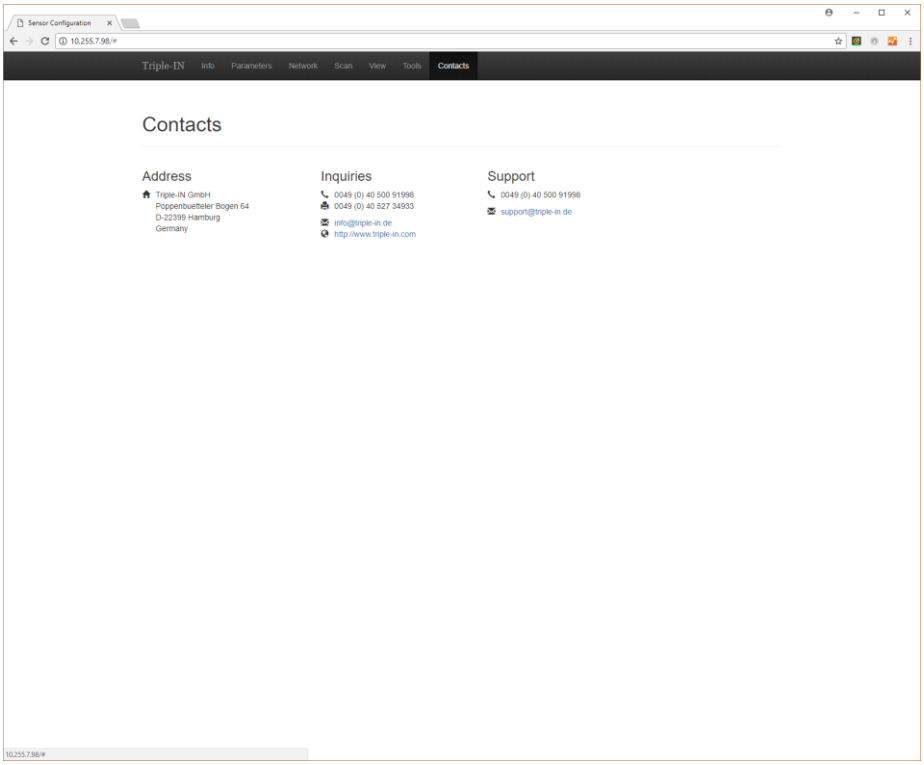


Figure 41: Web interface Contacts page

This page shows the various way to contact Triple-IN.

10 Firmware update

10.1 Updating MPU firmware

The MPU firmware of the PS Lightweight can be updated over the serial interface by use of the XMODEM protocol. The sensor supports XMODEM-CRC and XMODEM-1K variants to improve performance and transfer safety.

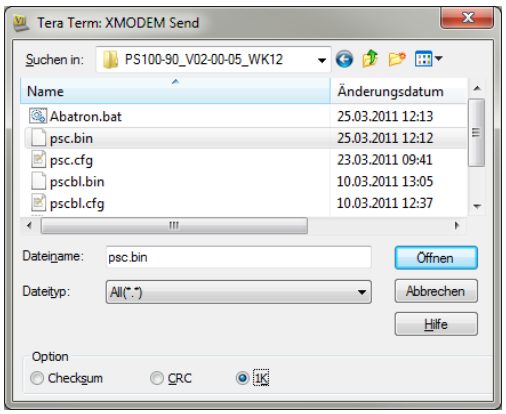
Warning!

Risk of malfunction:
Carefully read this entire instruction before you start updating your sensor.
Do not power off the sensor until the firmware is updated!

1. Download the latest firmware image from Triple-IN's Homepage.
2. Make sure that the "MPU RS232" lines of the serial interface connector are connected to the serial interface of your computer.
3. Switch the sensor **on**.
4. Start TeraTerm. Wait until the following message has appeared on the terminal:

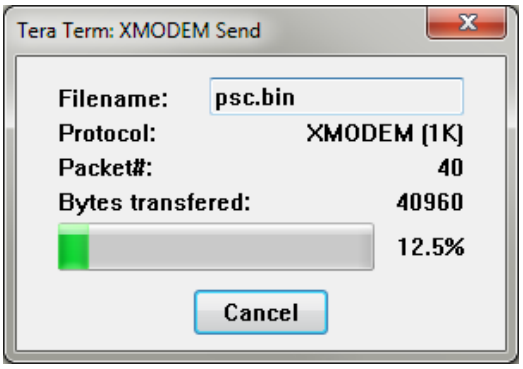
```
"Type 4 x ENTER to launch Terminal Mode"
```

5. Switch the sensor **off**.
6. Choose File > Transfer > XModem > Send...
7. Locate and single click on the required firmware binary file.
8. Select 1K from the options at the foot of the dialogue and click "Open"



9. When the XMODEM Send dialogue is displayed in TeraTerm, power the sensor on

10. Data will start transferring to the sensor. TeraTerm will display progress:



11. Once the firmware has been transferred, the sensor will update the firmware in the flash memory. This process needs about 30 seconds.

```
- new firmware; size: 328704
- unlock and erase 20 blocks from 1 to 20
- Programming from RAM 0x04001000  to ROM 0x00008000  = 164352 words
```

12. The sensor will now reboot the new firmware.

```
PS Laser Scanner
[PS Firmware; 03.06.xx; 2019-01-20; (c) Triple-IN GmbH 2018]

SN:         1234
Local IP:   10.0.12.34:1024
Gateway IP: 10.0.10.0:1025
```

For a clean restart, finally switch the sensor off and on again.

10.2 Updating APU firmware

The APU firmware of the PS Lightweight can be performed using the Ethernet connection. Download from the Triple-IN's web server the command line utility "TISendUpdate" and decompress the content of the archive. The folder directory will look like this:

```
02/06/2015  17:09           119 822 libgcc_s_dw2-1.dll
02/06/2015  17:09         1 537 038 libstdc++-6.dll
02/06/2015  17:09            80 384 libwinpthread-1.dll
06/11/2017  14:07               456 README.txt
06/11/2017  14:28         1 043 549 tisendupd.exe
```

The firmware upgrade is performed using a reserved TCP/IP connection on the port 3007. Using the tool "tisendupd.exe" the update is easy and safe. Just open a command prompt and write the command using this format:

```
tisendupd.exe –o UPDATE_FILE –a IPADDRESS[:PORT]
```

The PORT field can be omitted, and the default port will be used (3007).

```
C:\tisendupdate>tisendupd.exe -o 20180321.ttu -a 10.255.7.98
APU-002
[APU Firmware; 1.00/111B06.3315(rc2)]
Triple-IN Ethernet Updater (c) Triple-IN GmbH 2015-2017

- Connecting to: 10.255.7.98:3007 ...
  Connected!
- The device has accepted our request.
  > 256.0 KB transferred by now...
  > 512.0 KB transferred by now...
  > 768.0 KB transferred by now...
  > 1024.0 KB transferred by now...

…

  > 7.3 MB transferred by now...
  > 7.5 MB transferred by now...
  > 7.8 MB transferred by now...
  File completely sent. 7.9 MB transferred.
  The update process may take a while. Please wait...
- The device has received the update file.
- The device has checked the update file.
- The device is processing the update file.
  System is still updating. 4 minutes until timeout

…

  System is still updating. 4 minutes until timeout
- The update process is complete.
The device is updated.
Please restart it if needed!
```

As soon as the tool will finish its work, the APU will be restarted to complete the update.

11 Troubleshooting

11.1 LED indicators

The PS Lightweight supports 3 LEDs:

1. Green LED: Power indicator; blinks if the scanner is in Terminal mode.
2. Yellow LED: Measurement laser indicator.
3. Red LED: Error indicator.

LEDs can be permanently turned off with the user parameter:

```
"Front side LEDs enabled=1, disabled=0."
```

The following table shows the meaning of the different combinations of the three LEDs.

LED Status	Description	Meaning
	All LEDs off	Power off
	all LEDs are on	For about one second during power-on.
	All LEDs are blinking	Self-test is running.
	Yellow is off	Measurement laser is switched off
	Green is blinking Yellow is blinking	Starting the motor. Waiting for SCAN command.
	Green is steady on Yellow is steady on	Usual operation.
	Green is blinking	Terminal mode, waiting for user input
	Green is steady on Yellow is steady on	Terminal mode, Scan in process
	Red is steady on	System error. Check system health status.

11.2 Self-test messages and System Health status

PS Lightweight performs a self-test at startup and check various hardware components.
All LEDs are blinking during the self-test.
The result of the self-test is reported on the RS232 of the MPU board.

```
PS Lightweight
[PSFirmWare; 03.06.00.00; (c) Triple-IN GmbH 2019]

SN:         1234
Local IP:   10.0.12.34:1024
Gateway IP: 10.0.10.0:1025

- Running self-test ...
- Warning: Check Ethernet!
- Error: Measurement clock error
- Self-test done.

Type 4 x ENTER to switch to Terminal Mode
```

Figure 42: Startup message with errors and warnings

The Terminal mode provides the function “2 - Show system health status”.

```
 System Status & Self-test results;
_____________________________________________________________________
 Bit;       Result;  Message
_____________________________________________________________________
   0;           OK;  Warning: System not ready.
   1;           OK;  Warning: Scan buffer is empty.
   2;        check;  Warning: Sensor operates in Terminal Mode.
   3;     disabled;  Digital output failure!
   4;           OK;  Warning: Digital input failure!
   5;           OK;  Warning: Check external incremental encoder!
   6;           OK;  Warning: Check mirror motor!
   7;           OK;  Warning: Check angle encoder!
   8;     disabled;  Check field of view!
   9;           OK;  Warning: Temperature out of operating range!
  10;           OK;  Warning: Check Ethernet!
  11;     disabled;  (reserved)
  12;           OK;  Warning: Factory setup not complete!
  13;     disabled;  (reserved)
  14;     disabled;  (reserved)
  15;     disabled;  (reserved)
  16;     disabled;  (reserved)
  17;           OK;  Warning: Laser Power Control is switched off!
  18;           OK;  Warning: Check KEM-IC delay unit!
  19;           OK;  Error: Measurement clock error
  20;     disabled;  (reserved)
  21;     disabled;  (reserved)
  22;     disabled;  (reserved)
  23;     disabled;  (reserved)
  24;     disabled;  (reserved)
```

```
   25;        check;  Warning: Measurement laser is switched off.
   26;     disabled;  (reserved)
   27;           OK;  Warning: Measurement laser failure.
   28;           OK;  Warning: Firmware update needs factory reset.
   29;           OK;  Warning: Check Communication Board version!
```

Figure 43: System Health and Self-test bits in Terminal Mode

The following warnings can be fixed by the user:

Warning: User Parameter File was restored!

The user parameter setup got lost, probably due to a power-off while parameters were written to the internal non-volatile memory.
Enter the terminal mode and check the user parameter setup.

Error: Temperature out of operating range!

The sensor is too hot or too cold. Disconnect immediately from power supply and check the environmental conditions. Let the sensor operate only in its specified temperature range.

Warning: Check Ethernet!

Check the Ethernet connections.
Restart the sensor to apply changed IP settings.

Warning: Firmware update needs factory reset.

The firmware has been updated, but the parameter setup does not match for the new version. Restart the sensor. The sensor will ask for a parameter update.

Error: Check I/O Board version!

The MPU firmware has been updated and requires a newer version of the communication board firmware.

Warning: System needs to restart

Restart the system by power-off and power-on.

Warning!

Any other warning or error message reports a serious system defect. In this case, contact Triple-IN for a service and repair request.

12 Technical Information

12.1 Technical Data

Sensor	PS Lightweight
Article number	SR-LWXX-110D-P3
WORKING RANGE	
Maximum Range @ R = 100%, Lambertian Reflector (m)	300
Maximum Range @ R = 10%, Lambertian Reflector (m)	95
Minimum Range (m)	2.5
ACCURACY DATA	
Resolution (mm)	1
Repeatability 1 σ @ strong signal (mm)	5
Repeatability 1 σ @ weak signal (mm)	20
Accuracy (systematic error) (mm)	≤ 5
SPOT PROPERTIES	
Divergence in scan direction (°)	0.096
Divergence in scan direction (mrad)	1.67
Divergence perpendicular to scan direction (°)	0.029
Divergence perpendicular to scan direction (mrad)	0.5
Spot close to the sensor window (mm)	12 x 18
Focusing distance (m)	45
SCAN PROPERTIES	
Maximum Scan and Profile Angle	90°
Scan Mirror Type	4 Mirror Polygon
Maximum Scanning Duty Cycle	50%
OPERATIONAL MODES	
Normal Mode	
Beam Scan Angle Step (°)	0.09
Measurements in 90° Scan	1000
Scan Rate (Hz)	30
Scan Time @ 90° Scan (ms)	16.65
Overlap of Spots in Scan (°)	0.006
Fine Mode	
Beam Scan Angle Steps in Profile (°)	0.0225
Measurements in 90° Scan	1000
Scan Rate (Hz)	30
Scan Time @ 90° Scan (ms)	16.65
Scans/Profile (interlace)	4
Profile Rate (Hz)	7.5
Profile Time @ 90° Scan (ms)	134
Measurements in Profile (4 scans interlace)	4000
Overlap of Spots in Scan (°)	0.0735
Fast Mode	
Beam Scan Angle Step (°)	0.18

Measurements in 90° Scan	500
Scan Rate (Hz)	60
Scan Time @ 90° Scan (ms)	8.5
Gap between Spots in Scan (°)	0.084
MULTI-ECHO EVALUATION	
Echoes evaluated	Up to 4
Selectable echoes	From 1st to 4th or last echo
TARGET SURFACE TEMPERATURE	
Surface Temperature Range	T < 500°C
LASER DATA	
Measurement Laser	
Measurement Laser Type	Pulse Laser Diode
Wave Length (nm)	905
Safety Class; EN 60825-1; 94,96,01	1
Measurement or Pulse Rate (kHz)	Up to 60 kHz
INTERFACES	
Ethernet	TCP and UDP 100 Mb/s
RS232 for Sensor Programming	115 kBaud, 8n1
GNSS RS232	Configurable baud rate, 8n1
Digital Outputs	2 x 3.3 to 5 VDC programmable isolated switching outputs
Digital Inputs	2 x 3.3 to 5 VDC programmable isolated inputs
POWER SUPPLY	
Power Voltage	24 VDC ± 5 VDC power supply, 3.3 to 5 VDC for I/O
Direct Power Supply	Yes
Power Consumption (W)	7.5
Start-up Time (s)	< 30
SENSOR PROTECTION	
Ingress Protection	IP65
Operating Temperature Range	-10°C to +50°C
Temperature Range for Storage	-30°C to +70°C
Enclosure	Polycarbonate (aviation standard) 1.5mm, dark grey
Front Screen	AR-coated glass
Function in strong Sunshine	Ambient light control
DIMENSIONS & WEIGHT	
Height x Width x Length (mm)	261 x 125 x 100
Weight (kg)	1.2

12.2 Dimensional drawings and outlines

Caution

All drawings are without scale.

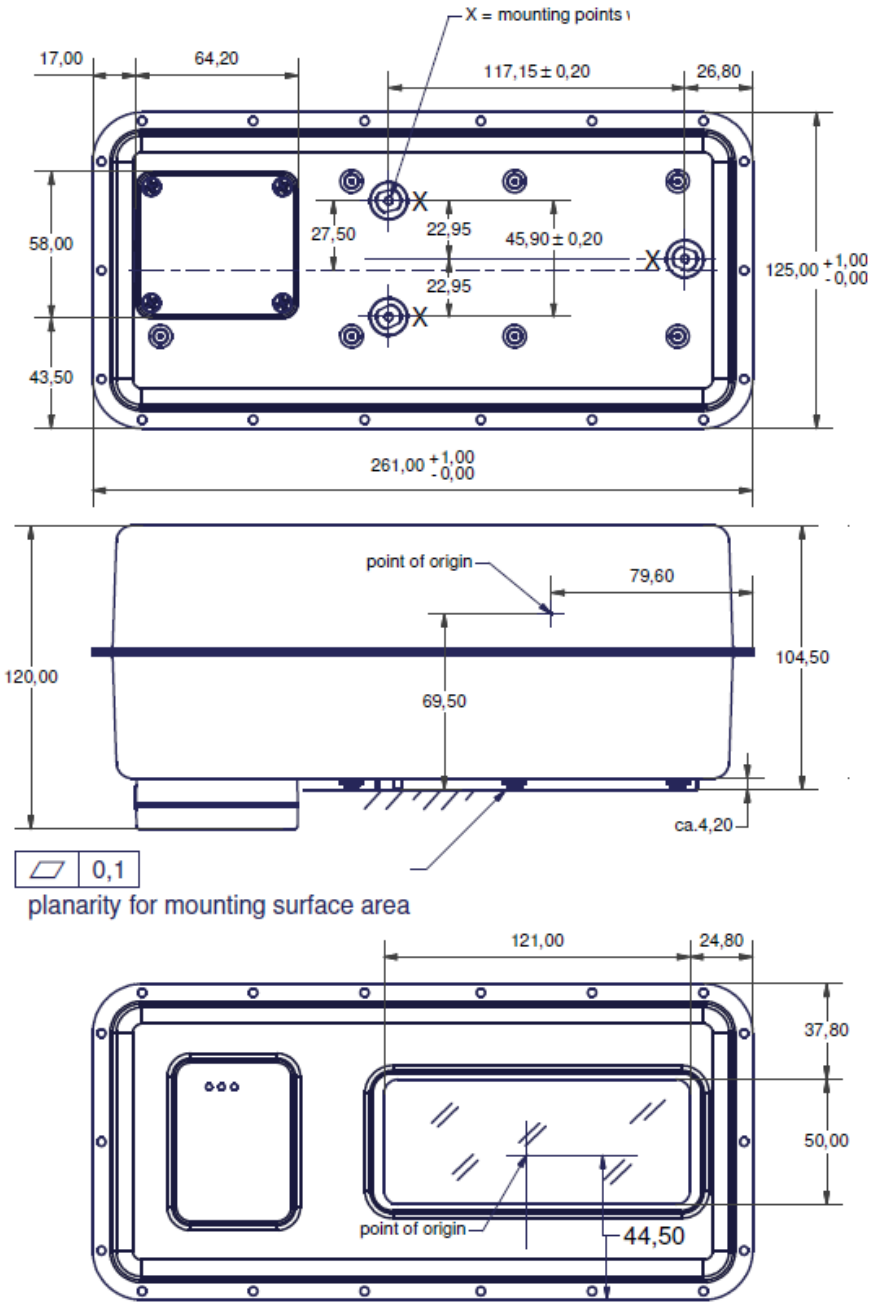
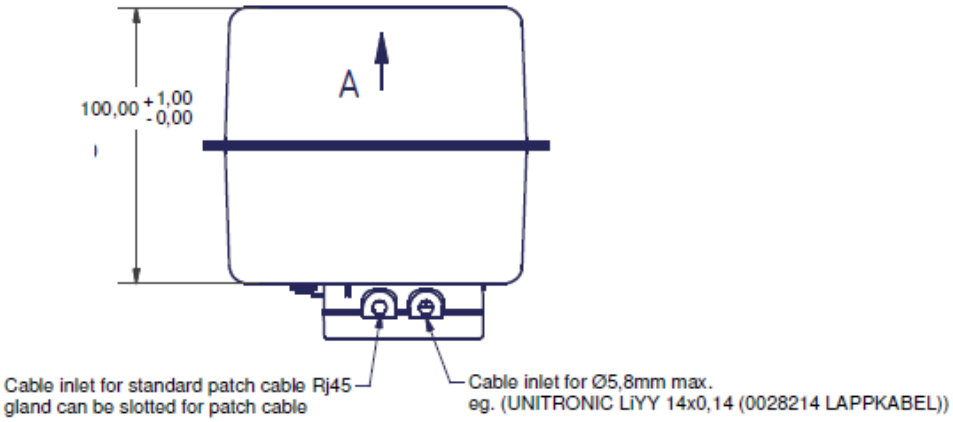


Figure 44: PS Lightweight dimensions



12.3 3D CAD Model

A 3D CAD model (STEP format) of the PS Lightweight outlines is available on demand.