Operating Manual

ibeo LUX 2010® Laserscanner

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Version History

Date	Version	Changes
30.04.2012	1.0	Initial release
18.07.2012	1.1	CAN Data Parser adapted
13.02.2014	1.2	CAN Cable/Connection/Integration description added
28.02.2014	1.3	Deleted old ILV introduction
04.04.2014	1.4	Corrected Vertical FOV Drawing
15.04.2014	1.5	Cleaned data type reference
07.07.2014	1.6	Added optional Tracking Box

About this document

Please read this chapter carefully before working with the documentation and the ibeo LUX 2010®.

Principle of the document

This operating manual (OM) contains all information required for transport, storage, mounting, installation, commissioning, and operation. The operating manual is a part of the technical documentation of the ibeo LUX 2010®.
This operating manual does not include instructions for operation of the vehicle into which the ibeo LUX 2010® *is integrated. For information about that, refer to the operating manual of the vehicle.*
This operating manual shall help you to avoid improper use. Strict adherence to the instructions given in this operating manual ensures the function of the ibeo LUX 2010®. *Therefore always keep this operating manual in the vehicle.*

Target group

This operating manual is written for trained and qualified staff who will integrate, commission or configure the ibeo LUX 2010® *into a vehicle.*
The following conventions apply in this operating manual:

- *The text uses abbreviations. In each chapter, abbreviations appearing the first time are explained. The abbreviation is written in parenthesis behind the term.*
  Example: Operating Manual (OM)
- The pages of each chapter are numbered subsequently.
- Tables and figures are numbered consecutively within each chapter.
- Links in the text lead you to supplementary or more detailed information. Links to the figures are structured as follows:
  4-1/2
  item number
  consecutive number of the figure
  chapter number

In chapter 2 Safety, page 2-1, you find general safety notes about possible dangers when operating the ibeo LUX 2010®. Additionally, specific safety notes are printed directly before instructions which, if not followed properly, could result in danger for persons or the vehicle.
This OM is subject to changes. If the ibeo LUX 2010® is changed as a result of technical advancement, you must include the additional or changed pages at the corresponding place.

Symbols and notes

This operating manual uses different symbols for notes on safety and information.
The notes on safety include the source of the danger, possible or probable results as well as means to stop the hazard.

	DANGER
	This symbol indicates an immediate danger which could lead to severe bodily harm or to death.

	WARNING
	This symbol indicates a possible danger which could lead to severe bodily harm.

	CAUTION
	This symbol indicates a possible danger which could lead to bodily harm.

	CAUTION
	This symbol indicates a possible danger which could lead to property damage.

	NOTE
	This symbol indicates special information about key functions or special usage tips which shall help you to use all functions optimally.

Terms and definitions

Operator

The operator uses the ibeo LUX 2010® as owner or hirer. He is responsible for
- proper operation of the ibeo LUX 2010®,
- intended use of the ibeo LUX 2010®,
- the appointment of suitable trained staff to mount, install, configure, adjust, commission and clean the ibeo LUX 2010®.

Trained staff

Trained staff has undergone a specific training and is thus able to perform the assigned tasks and to detect possible dangers. The trained staff must be qualified for handling
- mechanic and electric assemblies
- control and feedback control systems.

Additionally the trained staff must know the applicable regulations, accident prevention regulations and the specific operating conditions. Responsible for the required training is the operator, who has to determine the suitability of the trained staff. Trained staff mount, install, configure, commission, adjust, and clean the ibeo LUX 2010®.

Administrator

An administrator is a specifically trained employee of the customer or an accordingly qualified employee of ibeo. An administrator can access all software functions. The administrator may
- open, delete or lock user accounts,
- change the configuration of the ibeo LUX 2010®,
- reset the devices connected to the ibeo LUX 2010®,
- launch or shut down the software of the ibeo LUX 2010®.
- update new software for the ibeo LUX 2010®.

An administrator has the highest rank of permissions in the user administration.

Manufacturer

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Warranty

The ibeo LUX 2010® has not yet been constructed according to all required legal requirements and safety-related rules. It is not yet state-of-the-art nor does it fulfill the requirements of the EC conformity.

CAUTION

The ibeo LUX 2010® including its software and the OM are still in the development and prototype state. Therefore, its usage is limited to test purposes only.

In case of using the ibeo LUX 2010® and its connected components and software for other purposes than the intended use, ibeo will not assume any responsibility nor be liable to third parties; this applies to direct, indirect or exceeding damages, accidental damages or consequential damages.
These include
The ibeo LUX 2010® is

- not used as intended,
- not used according to the instructions in this OM,
- modified in terms of construction or functions without written consent by ibeo,
- equipped with spare parts not delivered or approved in writing by ibeo,
- repaired improperly,
- repaired by trained staff not authorized in writing by ibeo,
- damaged by an "act of God".

Ibeo does not assume any liability for external devices connected to the system which cause faults and thus damages.

Safety

Intended Use

The Laserscanner ibeo LUX 2010® serves for detecting and identifying objects around a vehicle under a specific angle. It is integrated into the vehicle, for further information refer to chapter 14 Technical data, page 14-1.
The area for intended use is the area of the vehicle.

	NOTE
☞	*Any other use is only permitted after consulting Ibeo.*

Improper use

Every use other those listed above is considered improper. Ibeo is not liable for damages to persons and property resulting from such improper use.

General notes on safety

The ibeo LUX 2010® can cause danger for persons and property if handled or used improperly. Therefore the operator must ensure that every person working with the ibeo LUX 2010® has read and understood this OM.
For installation and usage of the ibeo LUX 2010® as well as for commissioning and regular technical inspection, national/international legal requirements apply.
The operator of a vehicle equipped with an ibeo LUX 2010® is responsible for consulting the responsible authorities about applicable safety rules and regulations, and adhere to them.
The notes, especially the inspection notes of this operating manual (e.g. usage, mounting, installation or integration into the vehicle control system) must be observed.
Adhere to the following safety notes in order to prevent dangers for persons and/or property:

- The operator must ensure by suitable instructions and inspections that the ibeo LUX 2010® is always clean.
- Additionally, the local safety and accident prevention regulations apply for operating the ibeo LUX 2010®.
- A defect of the control functions can cause danger for human life or property damage at the ibeo LUX 2010®.

Laser class

The ibeo LUX 2010® fulfills the requirements of laser class 1 of the European laser standard EN 60825-1: 2007-10.
The ibeo LUX 2010® is equipped with a safety device that interrupts the laser emission in case of a failure of the scan mechanism.

Operation

The operator must

- provide a permanently perfect operating state of the ibeo LUX 2010®,
- take measures for antistatic protection,
- make sure that only trained staff modifies the ibeo LUX 2010®.

The trained staff must report any relevant modifications in the functional sequence of the ibeo LUX 2010® immediately to the operator.

Disposal

The ibeo LUX 2010® is designed to burden the environment as little as possible and to consume a minimum of energy and resources.

Product overview

System variants

Depending on usage and purpose, the ibeo LUX 2010® can build a system in combination with different components. This user manual describes only the system of standard individual components
The ibeo LUX 2010® is operated by itself, without further processing components.
This system is reduced to the basic required components and uses a LUX standard connecting cable. It serves for applications which use an Ethernet connection as only interface.

System of standard individual components

The system of standard individual components is used if an Ethernet connection shall serve as only interface.

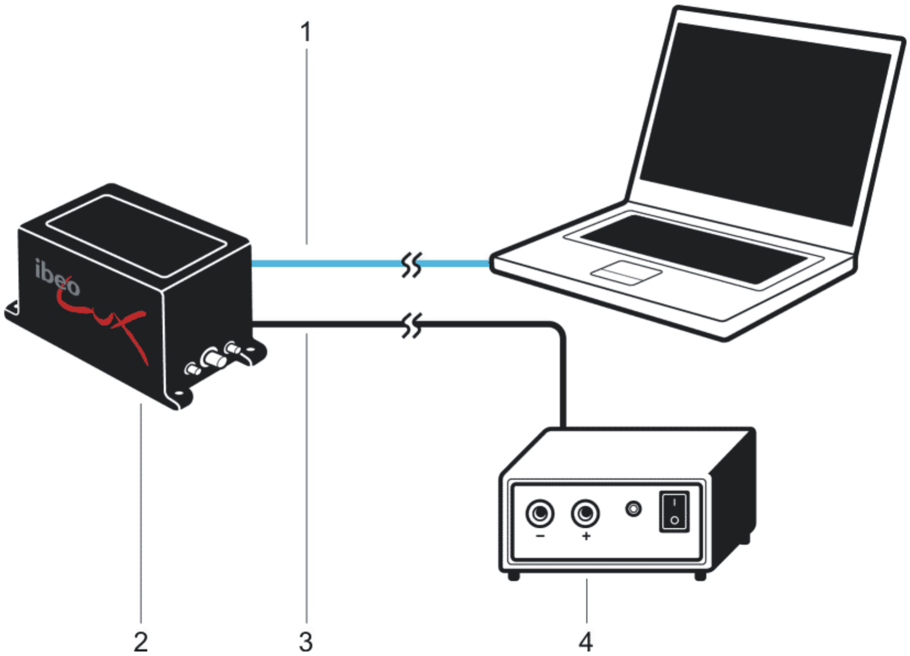


Figure 3-1: System of standard individual components

1	Ethernet connection to network or PC	3	Supply line
2	ibeo LUX 2010®	4	Power supply

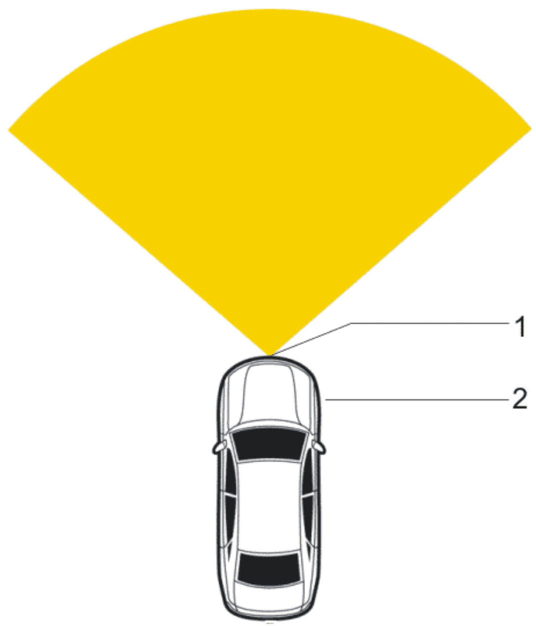


Figure 3-2: ibeo LUX 2010® with standard components integrated in a vehicle

Figure 3-2 illustrates an example for using the ibeo LUX 2010® (3-2/1) in the front area of a vehicle (3-2/2).

Components

ibeo LUX 2010®

Function

The function of the ibeo LUX 2010® bases on a process to detect the surrounding of the sensor and/or the objects located within the field of view.
For this purpose, laser beams are sent from the ibeo LUX 2010® over four levels and measure the distance and the direction (the angle in relation to the ibeo LUX 2010®) of the objects.
This yields the position of the object in the sensor or vehicle coordinate system.
The resulting profiles of the different levels are called scans, see chapter 4 Scan and object data, page 4-1.
The ibeo LUX 2010® provides two different kinds of information:

- Scan data (for all scan frequencies)
- Object data (for the scan frequency of 12.5 Hz)

The scan data are the initial information, i. e. information in which area of the field of view of the ibeo LUX 2010® the transmitted pulse has been reflected.
The data contain exact angle information (horizontal and vertical), a distance value and information about the pulse width of the reflected pulse.
Scan data are only provided via Ethernet because of their details representation and thus the very extensive amount of data.
The object data provide information on a higher level. The information is issued as a set of objects to which certain properties like size, position, speed and type can be assigned. These data can be sent via the interface CAN (3-1/7) and/or the interface Ethernet (3-1/6) and can be reused, if necessary, see chapter 3.3 Interfaces page 3-14.
To transform scan data into object data, different processes are performed in the ibeo LUX 2010®.
For a detailed description see chapter 4 Scan and object data, page 4-1.
The ibeo LUX 2010® is pre-configured by default, however, the customer can adjust some parameters, see chapter 7 Configuration, page 7-1.

Measuring process and measuring properties

The ibeo LUX 2010® is a measuring instrument basing on Light Detection And Ranging (LIDAR) technology, i. e. the ibeo LUX 2010® detects objects and their distance by means of laser beams.
It scans the surroundings with several rotating laser beams, receives the echoes with a photo diode receiver, processes the data by means of a time of flight calculation and issues the processed data via the interfaces Ethernet and/or CAN.
By the permanent rotation of the mirror in connection with the laser beam, it is possible to build a complete profile of the surroundings within the working range of the ibeo LUX 2010®. The scan data of the ibeo LUX 2010® consist of the distance, the angle and the echo pulse width.
The measurement properties base on

- time-of-flight measurement,
- multi-layer technology,
- multi-target capability,
- the working range and the relation of angle to range
- the angle resolution and the scan frequency.

Time-of-flight measurement

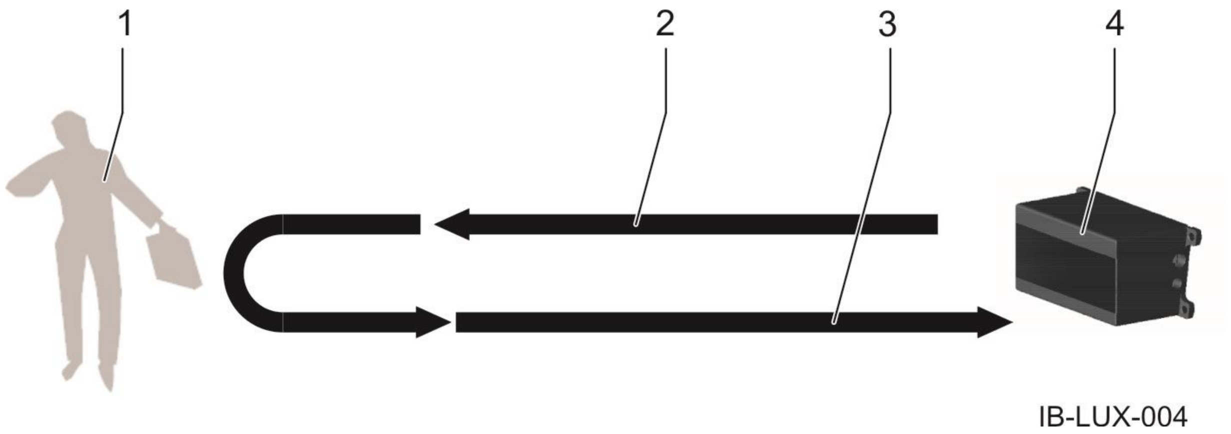


Figure 3-3: Principle of time-of-flight measurement

1	Object	3	Laser pulse, reflected
2	Laser pulse, transmitted	4	ibeo LUX 2010®

The laser pulses (3-3/2) transmitted by the ibeo LUX 2010® (3-3/4) are reflected by the objects (3-3/1) in the surrounding area.
The ibeo LUX 2010® gathers the reflection of the laser pulse (3-3/3), processes the information, and sends the data to the customer via Ethernet/CAN.
The distance is calculated from the time-of-flight of the laser pulse and the speed of light.
The rotating mirror deflects the laser pulses. The angular position of the mirror during deflection yields the direction of the detected object.
The combination of these values builds the basis for a complete profile of the surroundings in the working range of the ibeo LUX 2010®.

Multi-layer technology

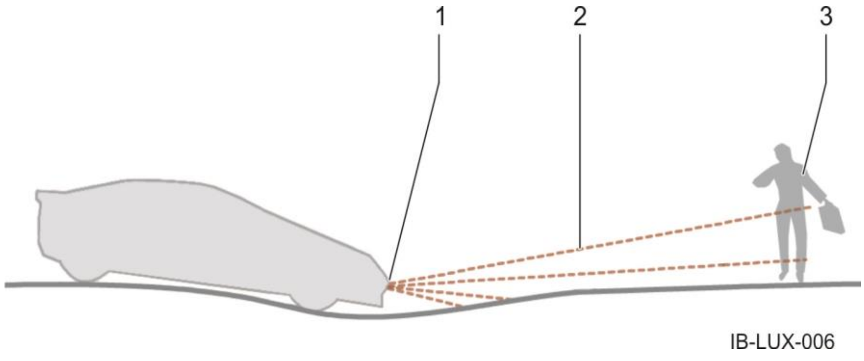


Figure 3-4: Principle of multi-layer technology

1	ibeo LUX 2010®
2	Scan level
3	Object

The multi-layer technology of the ibeo LUX 2010® allows for pitch angle compensation by means of four scan levels (3-4/2) with different vertical angles of the vehicle.
This enables the ibeo LUX 2010® (3-4/1) to detect the object (3-4/3) better, also if the vehicle is e. g. accelerating or braking.

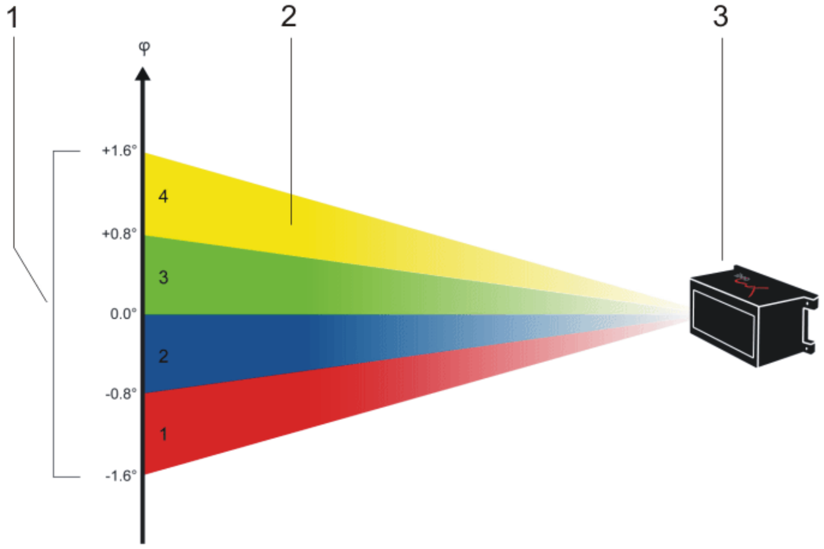


Figure 3-5: Scan level

1	Vertical opening angle (φ)	3	ibeo LUX 2010®
2	Scan level		

The photo diode receiver of the ibeo LUX 2010® (3-5/3) consists of four independent receivers arranged in a line. These four receivers enable the multi-layer technology.
One receiver is assigned to each level, which divides the vertical opening angle (3-5/1) into four scan levels (3-5/2). These four scan levels are scanned interlaced. This means that the combination of two levels is always scanned simultaneously (first e. g. the yellow and the green level, then the blue and the red level), compare Figure 3-7.

Multi-target capability

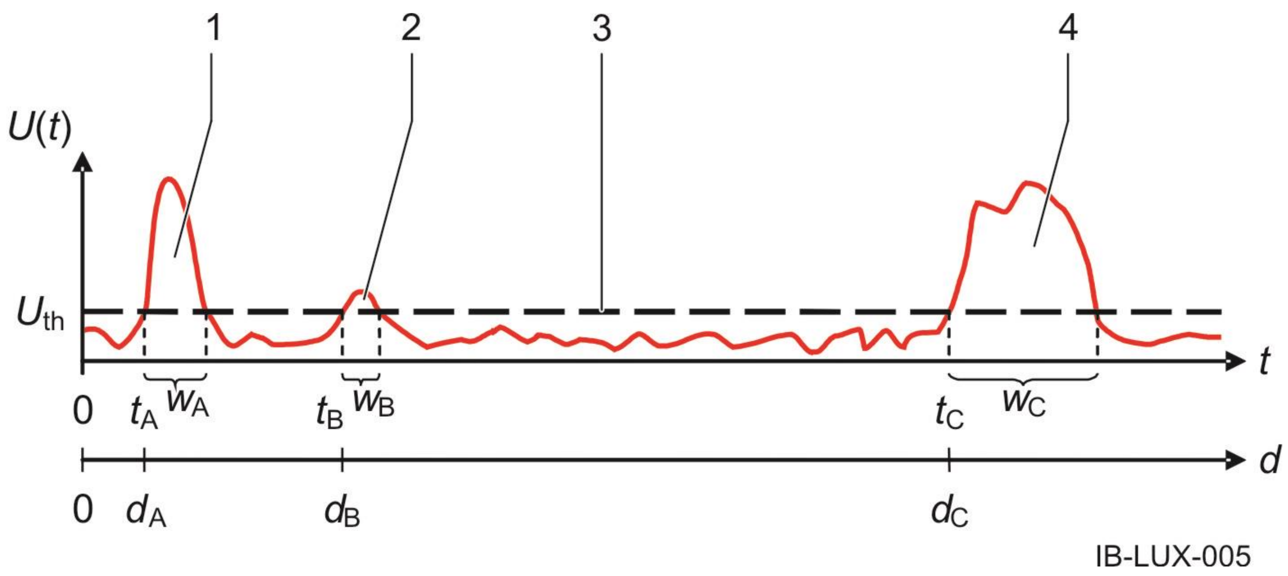


Figure 3-6: Multi-target capability

1	Example: echo of a window pane	V(t)	Output voltage
2	Example: echo of a rain drop	t	Time
3	Threshold voltage	d	distance
4	Example: echo of an object	W	echo pulse width
		A	Window pane
		B	Rain drop
		C	Object
		U_{th}	Threshold voltage

The ibeo LUX 2010® is capable of processing multiple targets.
Thus, it can gather and evaluate up to three echoes per transmitted laser pulse.
Once the echo reaches the photo diode receiver of the ibeo LUX 2010®, the received intensity is transformed into a voltage.
The example in figure 3-6 shows that a reflected echo of a window pane (3-6/1) yields a very high voltage over a short period of time.
The echo of a rain drop, however, yields a very low voltage (3-6/2) over a short period of time.
The echo of an object (3-6/4) yields a high voltage over a longer period.
All three echoes are generated by reflections of a single transmitted pulse.
The threshold voltage V_{th} separates the system noise from the relevant echoes. This threshold value prevents to interpret system noise as an object.
The ibeo LUX 2010® uses the two threshold passages to analyze the echo pulse widths $w_{A/B/C}$.
In this way the ibeo LUX 2010® is able to gather up to three echoes for each of the four scan levels. By default the attribution of scan level and echo is as follows:

Level	Echo 1	Echo 2	Echo 3
4 -yellow			
3- green			
2 - blue			
1 - red			

Table 3-1: Naming convention (colors see figure 3-5)

Color hues visualize the levels and color saturation of the echoes. Table 3-1 lists the specified naming conventions for the levels and their preset colors used for the visualization.

Example for a case with three echoes, see figure 3-6

If a laser beam hits a window pane, for example, a part of the light is reflected and triggers a measurement (echo 1).

Most of the light passes the window pane and might hit a rain drop which then again reflects a part of the light (echo 2).

The remaining light is then reflected by an object, which then results in the third measurement value (echo 3).

Angle resolution differing by sector

The angle resolution can be set to differing by sector. This can be set only at a scan frequency of 12.5 Hz.
The angle resolution differing by sector depends on the requirements of use in the vehicle.
The focus of the angle resolution is in an area of ±10 ° (3-7/1) around the direction of travel, referred to as central area.
The direction of travel is defined as the x-axis of vehicles.
The central area is characterized by a high angular resolution in order to gain good measuring results, e.g. for ACC (Adaptive Cruise Control) even over larger distances with multiple measuring data per object.
A slightly lesser angle resolution is applied in the medium area (3-7/2) of ±(30° to 10°) around the x-axis.
The lateral area between +50° to +30° and -30° to -60° (3-7/3) for objects on the side has a smaller angle resolution because the objects in that area are less relevant.

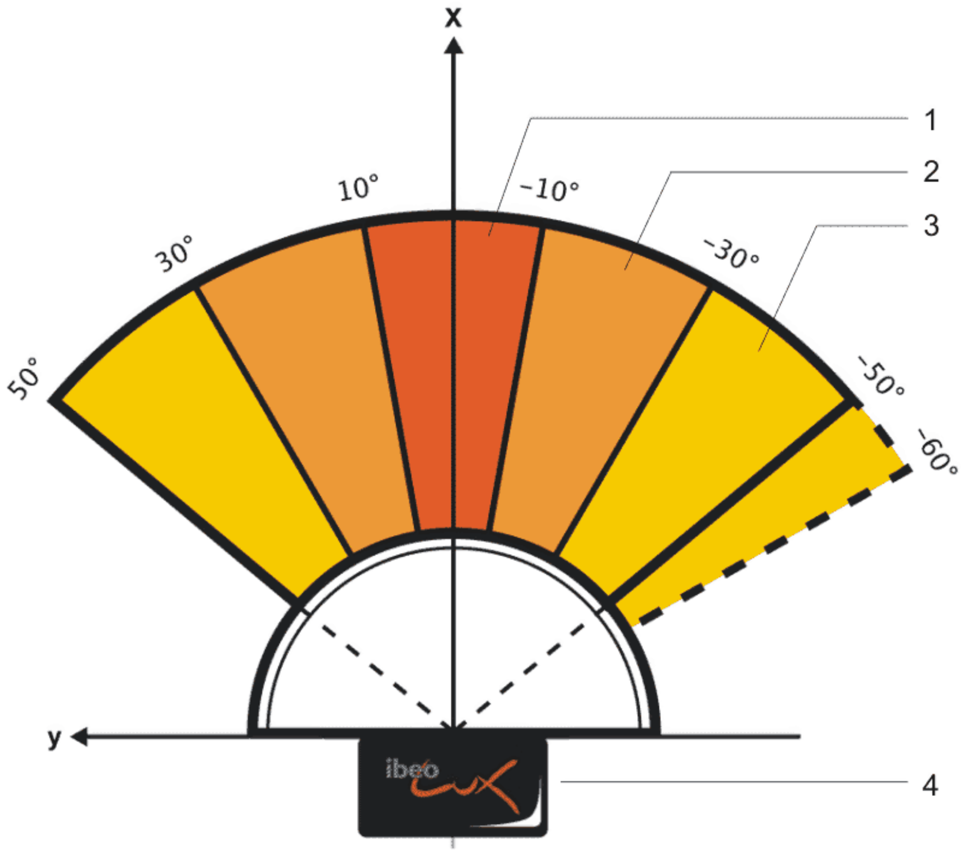


Figure 3-7: Angle resolution differing by sector

1	central range	3	lateral range
2	medium range	4	ibeo LUX 2010®

With the angle resolution differing by sector the sectors have the following resolution.

angle resolution	Scan frequency 12.5 Hz
central range	0.125°
medium range	0.25°
lateral range	0.5°

Constant angle resolution

The angle resolution can be set to constant angle resolution. This can be set at each valid frequency (12.5 Hz, 25 Hz and 50 Hz).

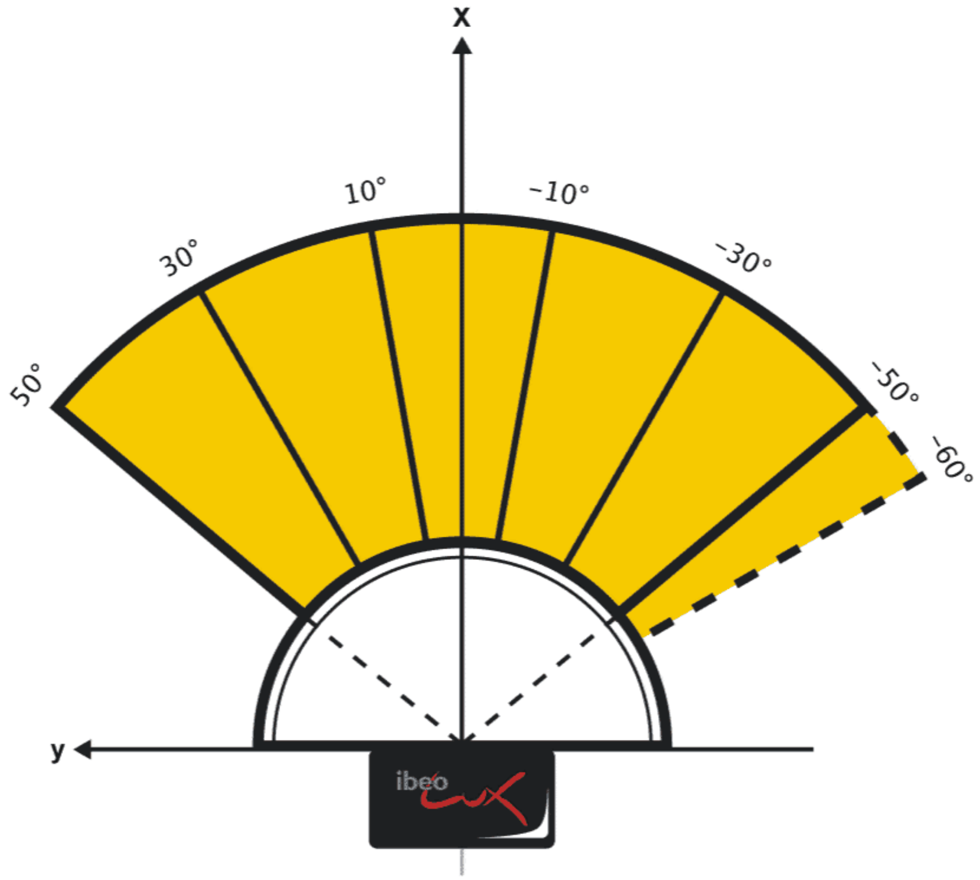


Figure 3-8: Scan frequency 12.5 Hz, constant angle resolution of 0.25°

With the constant angle resolution the sector has the following resolution.

angle resolution	Scan frequency 12.5 Hz	Scan frequency 25 Hz	Scan frequency 50 Hz
main range	0.25°	0.25°	0.5°

Working range and relation of angle to range

Due to the optical design of the ibeo LUX 2010®, the working range depends on the angle, refer to *Figure 3-9*. The measurement range depends on the optical design and inhibits a dependency on the scan angle. *Figure 3-9* and the *Table 3-2* illustrate the range over scan angle with regard to a target with 10% remission. The scan points are assigned dependent on the scan angular.

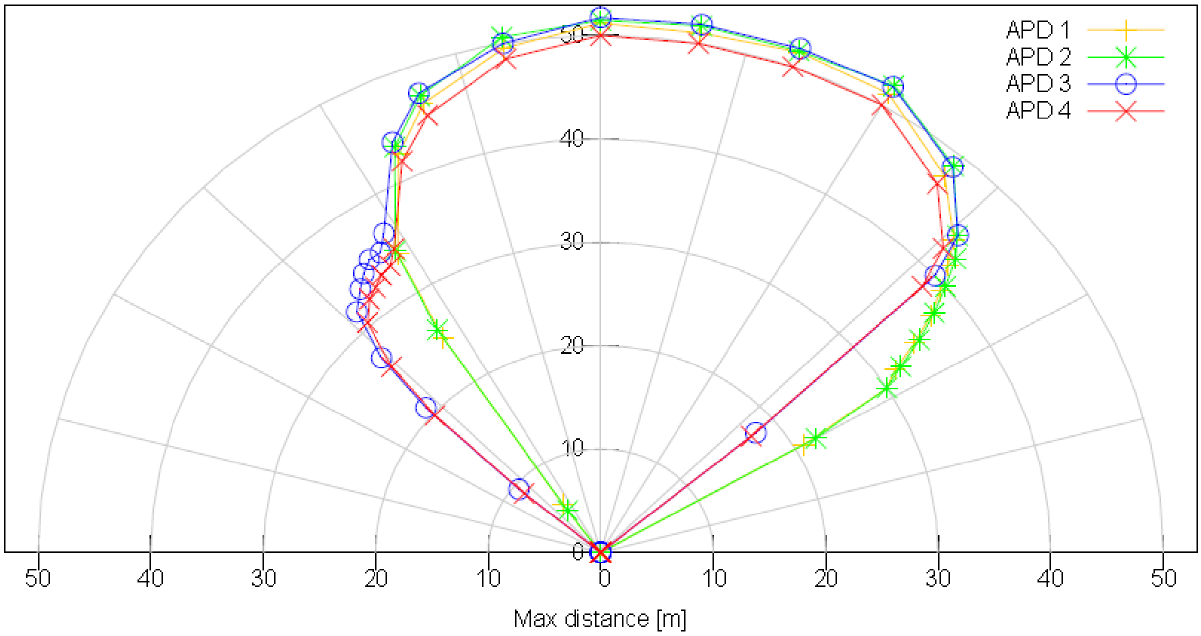


Figure 3-9: Measurement range dependent on the scan angular to a target with 10 % remission

The table below contains the related measurement values of one exemplary ibeo LUX Laserscanner of *Figure 3-9* for all four scan levels.

scan angular [°]	level 1 [m]	level 2 [m]	level 3 [m]	level 4 [m]
52	0,0	0,0	0,0	0,0
50	8,9	9,5	0,0	0,0
48	19,8	20,9	0,0	0,0
46	25,8	27,1	0,0	0,0
43	30,4	31,8	0,0	0,0
40	32,0	33,3	0,0	0,0
38	32,5	34,2	0,0	0,0
36	33,1	35,0	5,0	5,7
34	33,4	35,0	25,9	25,0
32	34,6	36,4	34,4	34,1
25	41,8	43,8	43,3	42,5
20	45,0	47,3	47,0	46,2
10	48,5	50,0	50,6	49,5
0	50,0	51,7	51,5	51,2
-10	50,0	51,8	51,7	51,0
-20	50,0	51,9	51,6	51,5
-30	50,0	52,0	52,1	51,2
-40	46,6	48,7	48,8	47,6
-46	42,3	44,2	44,1	43,6
-48	38,4	40,0	42,5	41,5
-50	17,5	18,0	40,0	39,5
-52	0,0	0,0	37,6	37,2
-54	0,0	0,0	35,0	34,5
-56	0,0	0,0	32,2	31,6
-58	0,0	0,0	30,0	30,0
-60	0,0	0,0	22,1	20,8
-62	0,0	0,0	0,0	0,0

Table 3-2: Measurement values of Figure 3-9

The optic design of the ibeo LUX 2010® is the reason for the central working range and the lateral working ranges of the sensor as shown in the figure below.

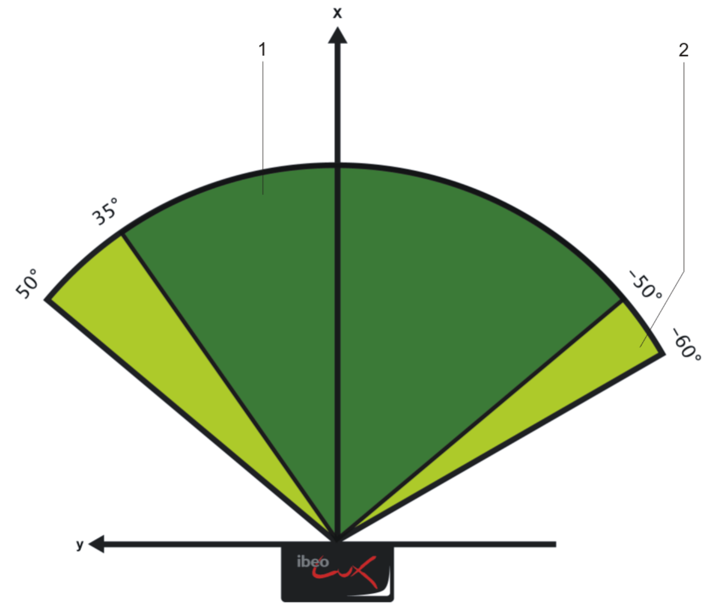


Figure 3-10: Working range

1	central working range (green)
2	lateral working range (light green)

The ibeo LUX 2010® has got a central working range of 85° for four scan levels (3-10/1). At the side the working range can be extended between +35° and +50° or -50° and -60° to 110°. The lateral working ranges (3-10/2) only provide two instead of four scan levels (refer to 3-10). The working range can be adjusted in steps by 1° by the user.

Angle resolution and scan frequency

The ibeo LUX 2010® can be operated with three different scan frequencies (12.,5 Hz, 25 Hz and 50 Hz), which allow for different settings of the angle resolution.
These parameters can be configured by the customer, see chapter 7 Configuration, page 7-1.
Two scan levels (3-5/2) each are measured and analyzed simultaneously. If an angle resolution of 0.125° is specified for a certain range, 0.125° is the distance between two scan levels (e. g. red-blue) and their partners (e. g. yellow-green). The angle for the next measurement on the same level is twice as high, in this example 0.25°.

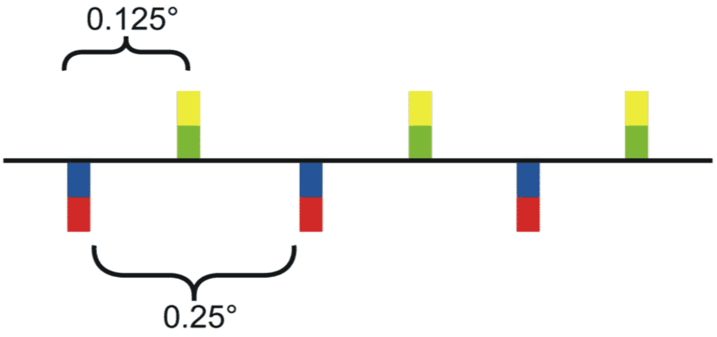


Figure 3-11: Angular resolution example (scan frequency 12.5 Hz, central range)

Divergence of the optical system

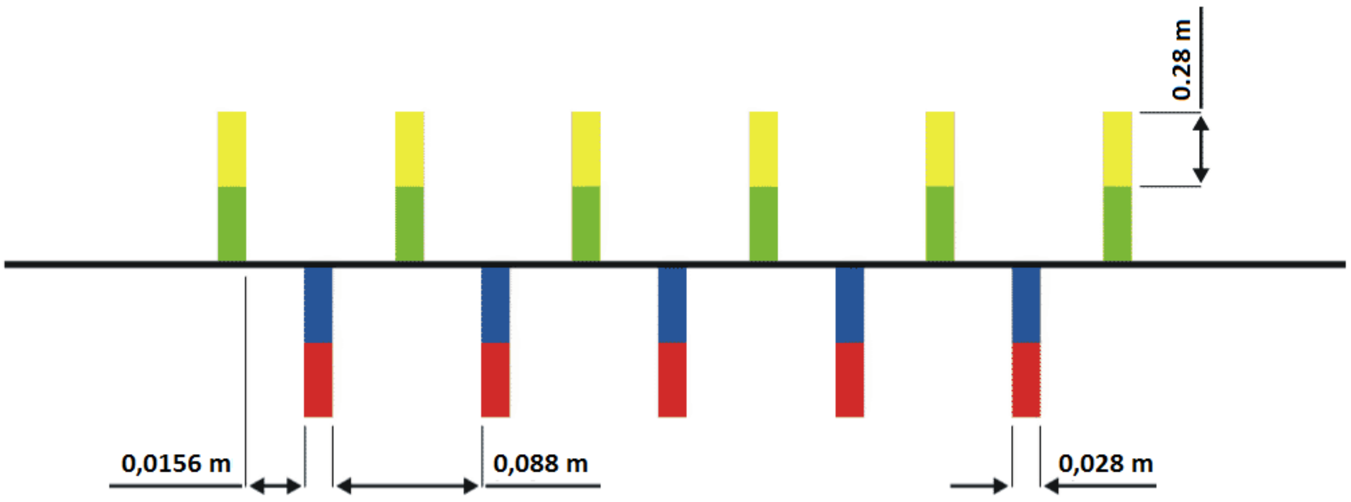


Figure 3-12: Beam size at 20 m with an angular resolution of 0.25°

Available data interfaces and data types

	CAUTION
	The bending radius of the connecting cable of the ibeo LUX 2010® must be at least 6 cm. Else the connecting cable could be damaged.

At the connecting cable of the ibeo LUX 2010®, the ibeo LUX 2010® provides the following data interfaces and data types via the interface Sensor:

- Ethernet (all data types sent are in the Ibeo LUX format)
  - Output of scan data
  - Output of object data
  - Output of warnings and fault messages
  - Reception of commands

	NOTE
	The ibeo LUX 2010® does not have a Auto-MDI(X) -function. If the scanner is directly connected to a computer, a crossover cable must be used. If it is connected to a Switch, a patch cable must be used.

- CAN
  - Output of object data
  - Output of warnings and fault messages
  - Reception of information about the vehicle's movement
  - Reception of commands
- Sync
  - Sync IN: Synchronization of the ibeo LUX 2010® to an external source
  - Sync OUT: Synchronization of an external device to the ibeo LUX 2010® or another external source
- RS232 debug
  - This interface is not in use in normal operation. It can be used if faults occur and need to be debugged.
- Voltage
  - Voltage supply 9 … 27 Volt DC

Interfaces

Interface Ethernet

	NOTE
	Make sure that the Ethernet interface of the computer you are using for receiving the Ibeo data is not blocked by other data transmissions.

The ibeo LUX 2010®, the ECU and the LUX-Switch use Ethernet interfaces with 100 MBit/s. Therefore the cables used must meet the requirements of category 5 or better.
Other components like the LUX-Connector or the LUX standard connector cable are designed accordingly.
Depending on the system configuration, the interface Ethernet provides different data types:

- Scan data (see chapter 4 Scan and object data, page 4-1)
  - ibeo LUX 2010®: data type 0x2202
- Object data (see chapter 4 Scan and object data, page 4-1)
  - ibeo LUX 2010®: data type 0x2221
- Commands and responses
  - Data types 0x2010 and 0x2020

	NOTE
	Please refer to the supplied CD-ROM regarding descriptions of the named data types, the warning and fault messages as well as the commands. *Please also refer to chapter 4 Scan and object data, page 4-1. That chapter describes the differences between the data types and their basing coordinate systems.*

Interface CAN

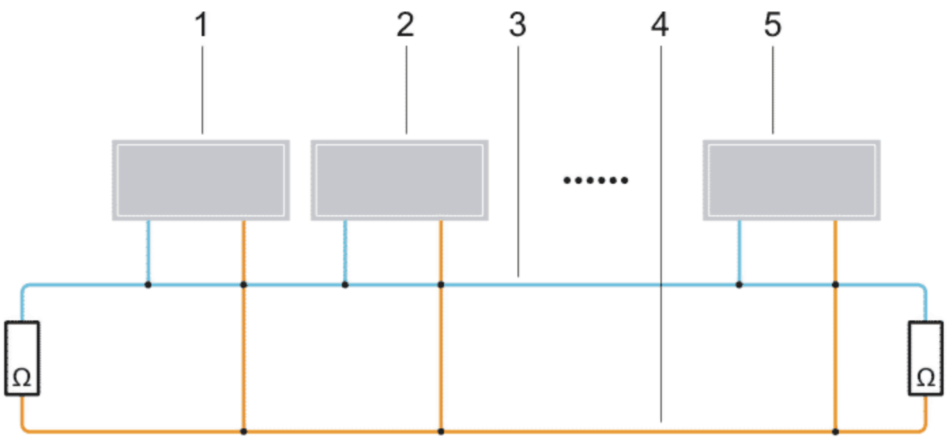


Figure 3-13: CAN bus

Description of items in figure 3-13:

1	1. Device with interface CAN	4	CAN low
2	2. Device with interface CAN	5	downstream (n.) device with interface CAN
3	CAN high	Ω	Resistor 120 Ω

	NOTE
	Make sure to design and to terminate the CAN bus correctly.

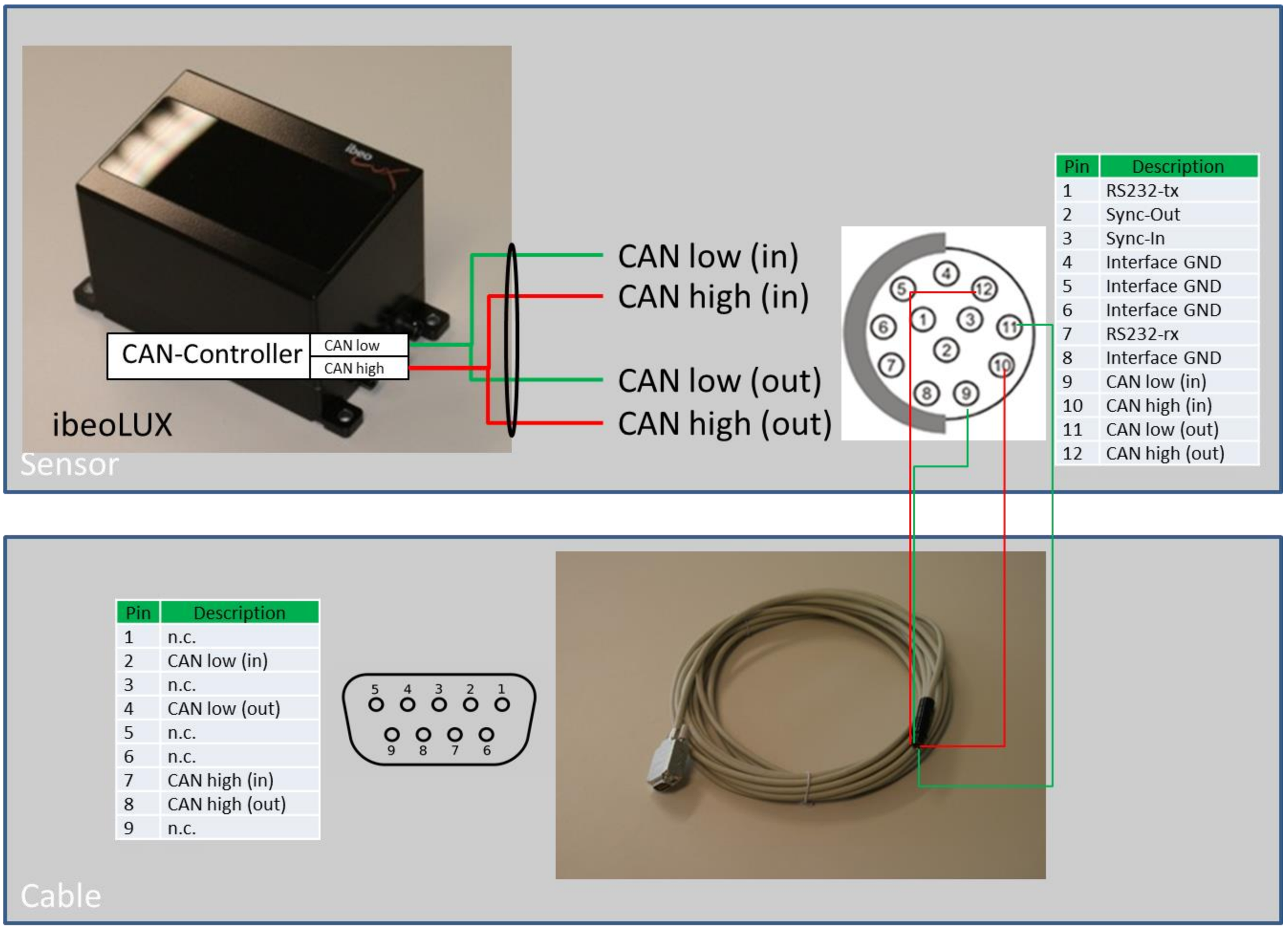
The ibeo LUX 2010® and the ECU use CAN interfaces with 500 kBit/s.
CAN participants try to establish a connection to the CAN bus over branch lines which should be as short as possible, see figure 3-13.
For CAN communication with Ibeo systems remember the following:

- Several CAN identifiers (ID) are used.
- The parametric CAN base ID (factory default: 0x500) determines the first message identifier used.
- For the transmission of object data and commands, warnings and other data types, a block of 16 IDs each is used and/or reserved. I.e. the CAN base ID 0x500 uses the entire range of 0x500 to 0x50F (including).
- The range preset via the configured CAN base ID may not contain any ID already used by another device (ibeo LUX 2010®, ECU or other bus participant).

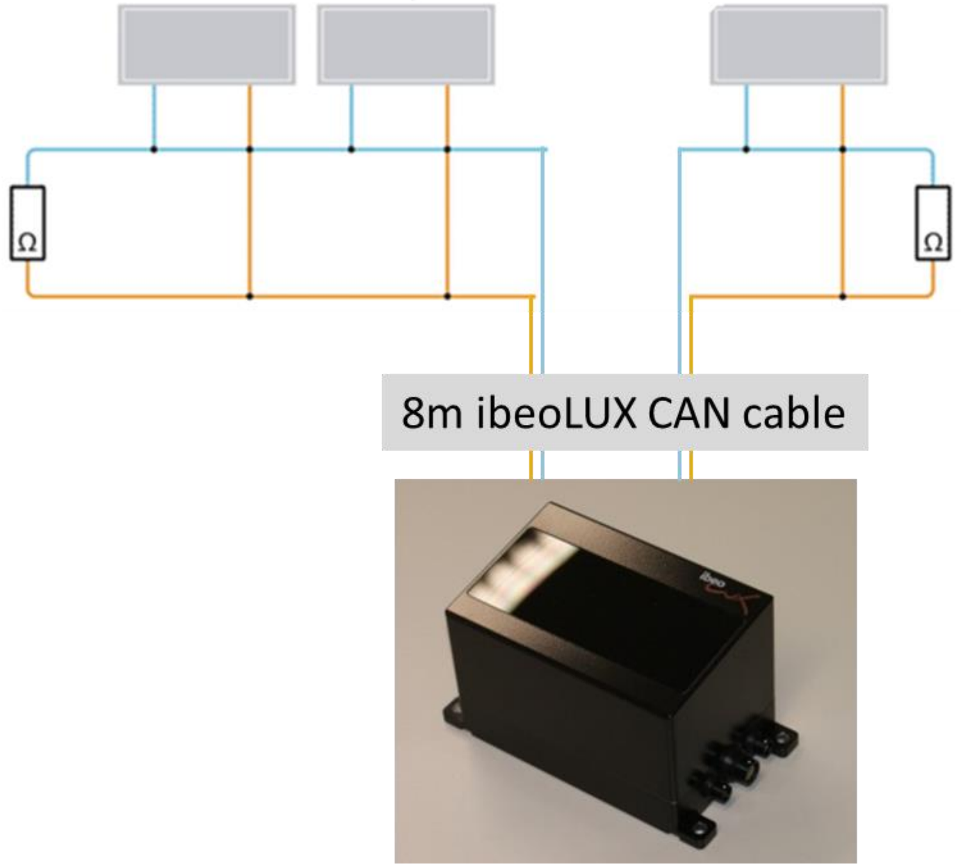
The interface CAN provides the following data types:

- Object data (see chapter 4 Scan and object data, page 4-1 and chapter 7 Configuration, page 7-1)
- Warnings and fault messages
- Commands and responses

Please have a look to the following drawing.



Be aware that the Sensor has one CAN-Controller but a CAN in and a CAN out connection, that is internally connected. So pins for CAN high in and CAN high out is physically connected as well as CAN low in and CAN low out.
This is especially interesting if you have long cables from the main CAN harness of your vehicle to the ibeoLUX, e.g. using the 8m ibeo CAN cable.
Recommended integration into the vehicle CAN bus as shown in the following drawing.



NOTE
For details about the messages and the transmission protocol refer to the special document in the provided CD-ROM.

ibeo LUX CAN Data Parser

The ibeoLUX comprises a CAN interface, which is also used to receive vehicle data in addition to the transmission of object data (see chapter 4 Scan and object data, page 4-1).
This information is utilized to calculate the own movement of the vehicle the ibeo LUX 2010® is attached to and to gather the dynamic object information (absolute speed of the objects) see chapter 4.3 Step 3, object formation, page 4-5.
The following types of information on a vehicle’s own movement are received via CAN:

1. Vehicle velocity
2. Vehicle yaw rate
3. Steering wheel angle

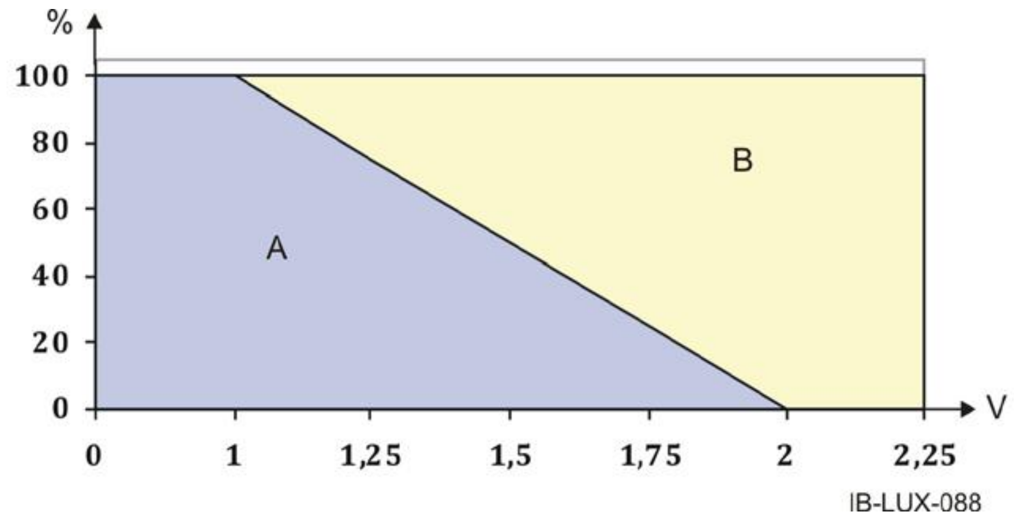


Figure 3-14: Absolute vehicle speed

A	Share steering wheel angle in %	V	Absolute vehicle speed in m/s
B	Share yaw rate in %		

Steering wheel angle (3-14/B) and yaw rate (3-14/A) are used for the calculation of vehicle turning (e. g. during cornering) Both items are taken into account in the calculation weighted depending on speed.

Configuration

As the vehicle data are transmitted in different CAN message formats depending on the respective vehicle and system, the ibeo LUX 2010® contains a configurable CAN data parser, which provides information for decoding the information on the vehicle's own movement from the CAN messages.

3.4.1.1 Structure of a CAN message

A CAN message consist of 8 bytes with 8 bits each. Refer to Figure 3- in the “Big Endian Byte Order (BE)“ the count starts from byte 7 with bit 0 and if the “Little Endian Byte Order (LE)“ is used, byte 0 starts with bit 0 and ends with bit 7. Analogously to this byte 1 starts with bit 8 and ends with bit 15.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	7	6	5	4	3	2	1	0
Byte 1	15	14	13	12	11	10	9	8
Byte 2	23	22	21	20	19	18	17	16
Byte 3	31	30	29	28	27	26	25	24
Byte 4	39	38	37	36	35	34	33	32
Byte 5	47	46	45	44	43	42	41	40
Byte 6	55	54	53	52	51	50	49	48
Byte 7	63	62	61	60	59	58	57	56

IB-LUX-089

Figure 5-25: Example of a CAN message, Little Endian

If the “Little Endian Byte Order (LE)“ is used, byte 0 starts with bit 0 and ends with bit 7. Analogously to this byte 1 starts with bit 8 and ends with bit 15.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	63	62	61	60	59	58	57	56
Byte 1	55	54	53	52	51	50	49	48
Byte 2	47	46	45	44	43	42	41	40
Byte 3	39	38	37	36	35	34	33	32
Byte 4	31	30	29	28	27	26	25	24
Byte 5	23	22	21	20	19	18	17	16
Byte 6	15	14	13	12	11	10	9	8
Byte 7	7	6	5	4	3	2	1	0

IB-LUX-090

Figure 5-26: Example of a CAN message, Big Endian

In “Big Endian Byte Order (BE)“ the count starts from byte 7 with bit 0.

```
sending order:
      |------------------------------------------------------------
      |  BYTE0  |  BYTE1  |  BYTE2  |  BYTE3  |  BYTE4  |  BYTE5  |  BYTE6  |  BYTE7  |
      |------------------------------------------------------------
      |->                          (sending order)                          ->|
      |------------------------------------------------------------
      |


big endian bit-numbering:
      |-------------------------------------------------------------------------------------------------------------------------------------|
      |        BYTE0          |        BYTE1          |        BYTE2          |        BYTE3          |        BYTE4          |        BYTE5          |        BYTE6          |        BYTE7          |
      |-------------------------------------------------------------------------------------------------------------------------------------|
      |                       |                       |                       |                       |                       |                       |                       |                       |
Bit8: | 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0|
Bit64:|63 62 61 60 59 58 57 56|55 54 53 52 51 50 49 48|47 46 45 44 43 42 41 40|39 38 37 36 35 34 33 32|31 30 29 28 27 26 25 24|23 22 21 20 19 18 17 16|15 14 13 12 11 10  9  8| 7  6  5  4  3  2  1  0|
data: |       msb                                                                                                                                         lsb             |
      |-------------------------------------------------------------------------------------------------------------------------------------|
      |


little endian bit-numbering:
      |-------------------------------------------------------------------------------------------------------------------|-----------------------|
      |        BYTE0          |        BYTE1          |        BYTE2          |        BYTE3          |        BYTE4          |        BYTE5          |        BYTE6          |        BYTE7          |
      |-------------------------------------------------------------------------------------------------------------------|-----------------------|
      |                       |                       |                       |                       |                       |                       |                       |                       |
Bit8: | 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0| 7  6  5  4  3  2  1  0|
Bit64:| 7  6  5  4  3  2  1  0|15 14 13 12 11 10  9  8|23 22 21 20 19 18 17 16|31 30 29 28 27 26 25 24|39 38 37 36 35 34 33 32|47 46 45 44 43 42 41 40|55 54 53 52 51 50 49 48|63 62 61 60 59 58 57 56|
data: |       lsb                                                                                                                                         msb             |
      |-------------------------------------------------------------------------------------------------------------------------------------|
      |
```

Figure 3-27: CAN message, Little and Big Endian Byte Order

Settings of the ibeoLUX CAN data parser

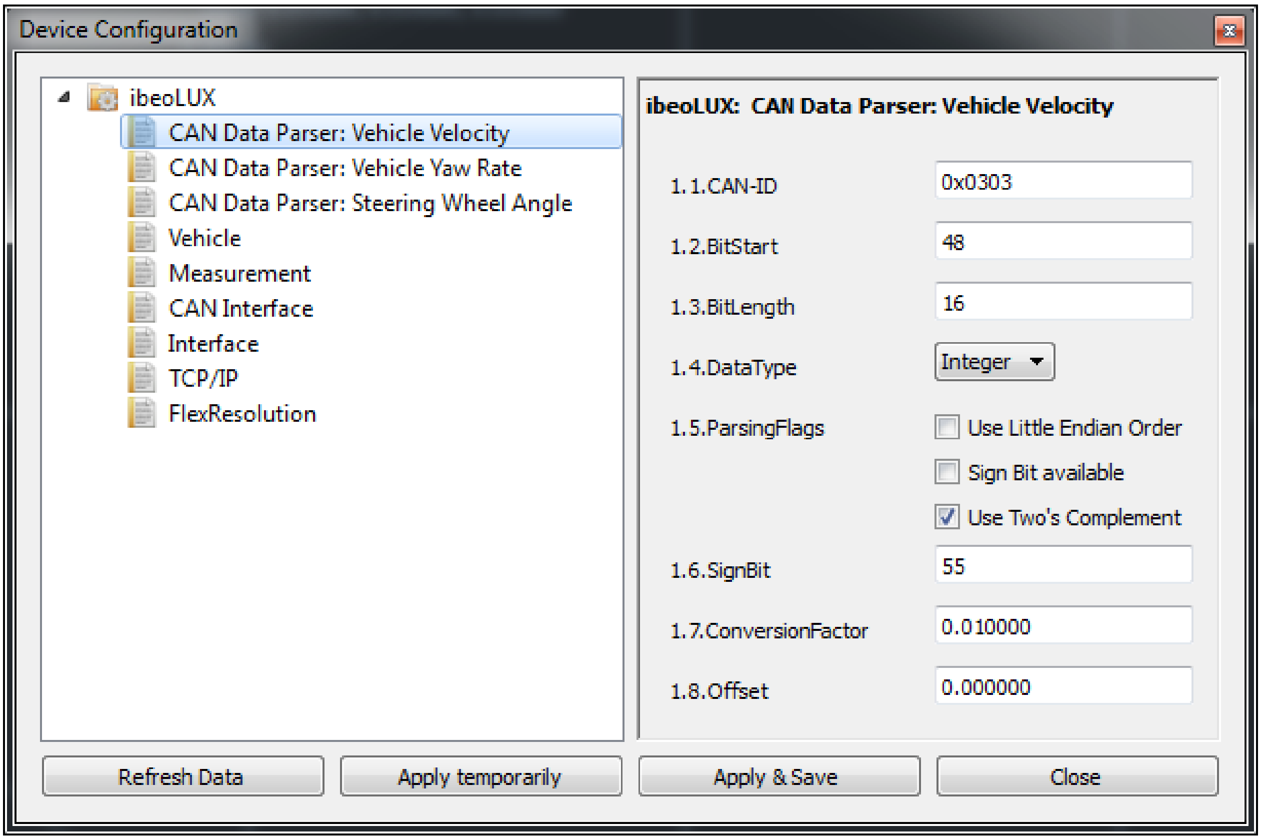


Figure 3-28: LUX CAN Data Parser

According to the types of information on a vehicle's own movement the dialog box contains three blocks. Each of these blocks contains the parameters, how the ibeo LUX 2010® interprets the CAN messages.
In the dialog window LUX CAN Data Parser you can set the following parameters:

1. CAN-ID:
   ID of the CAN message to be received (0x000 … 0x7FF).
   Only standard CAN-IDs are supported.
2. BitStart:
   First bit occupied by the value to be transmitted.
   Example : (BE) StartBit = 48,.
3. BitLength:
   Number of bits occupied by the value to be transmitted.
   Examples: BitLength = 16.
   If a sign bit is used, it is not included in the length.
4. DataType:
   Integer
5. ParsingFlags:
   with the following options:
   - Use Little Endian Byte Order
     Use of the Little Endian Byte Order
     If this option is not selected, the Big Endian Byte Order is used.
   - Sign Bit available
     Availability of a sign bit.
     This option must be activated, if the following option (Two'sComplements) is set.
   - Use Two´sComplements
     Use of the two's complement for decoding/encoding negative values.
     If this option has not been selected, the one's complement is used for decoding negative values, if a sign bit is available.
6. SignBit:
   Number of the sign bit used for decoding/encoding.
   This is irrelevant, if no sign bit is available or the corresponding option is disabled.

7. ConversionFactor:
Conversion factor (32-bit Float) for the conversion into a target unit of the vehicle data for the ibeo LUX 2010®. The data are read in according to the above configuration as an integer value and multiplied by the conversion factor.
This factor must be selected such that the value is converted into the unit expected by the ibeo LUX 2010®:
- cm/s for the speed value
- 1/10000 rad/s for the yaw rate
- 1/1000 rad for the steering wheel angle

Since firmware version 2.5.00 and ILV version 1.9.4 the CAN Data Parser expects SI units.
In this the possible range of values after conversion into the ibeo LUX 2010® is -32768 … 32767 in the respective unit stated above.

	NOTE
☞	*Make sure that the transmitted values are always within the indicated range!*

Interface RS232

The ibeo LUX 2010® and the ECU each comprise one interface RS232, using a baud rate of 57600 (8 data bits, no parity, 1 stop bit, no flow control) as per factory default.
These interfaces are not in use in normal operation.
With the ibeo LUX 2010®, the interface RS232 can be used for service purposes, if required.
With the ECU, this interface can be used to connect optional external devices (e. g. GPS).
Interface sync
Several ibeo LUX 2010® can be synchronized with each other and with external devices (e. g. camera). That means, each ibeo LUX 2010® scans a certain angle position at a certain point of time (synchronization signal). This angle position can be configured for every ibeo LUX 2010®, see chapter 7 Configuration, page 7-1.
It is also possible to synchronize external devices via an Ibeo system.
The ibeo LUX 2010® detect a valid synchronization signal automatically once it is applied. In every case, a signal is issued or transmitted. It is even possible to use the synchronization input and output simultaneously.

Interface voltage

The interface Voltage serves for supplying the individual components of the system and the ibeo LUX 2010® with voltage, see chapter 14 Technical data, page 14-1.

Scan and object data

	DANGER
	With incorrect mounting position, the calculation of object speed can be incorrect or objects can even be missed. Applications working with these object data may not function properly.

The scanning of the surroundings of the scan in the working range of the ibeo LUX 2010® is called scan process. The total set of measured data (= scan data) of a scan process, consisting of individual scan points, are called scan.
The transmitted laser pulses are reflected by objects within the measuring range. These echo pulses are received and analyzed by the ibeo LUX 2010®. Every detected echo pulse is represented by a scan point with the following main properties:

- Position of the point
- Width of the echo pulse
- Scan level and echo number

The ibeo LUX 2010® generates a two-dimensional profile of the surroundings, with additional height information (three-dimensional information) resulting from the multi-layer technology, see figure 3-5.
This information usually only serve for adjusting the pitch movement of the vehicle to which the device is mounted, and they are used e. g. for masking the ground while the scan data are processed.
The typical representation of scan data is the bird's view, the view top view of the measuring level, which represents in a simplified way the border between the two middle scan levels.

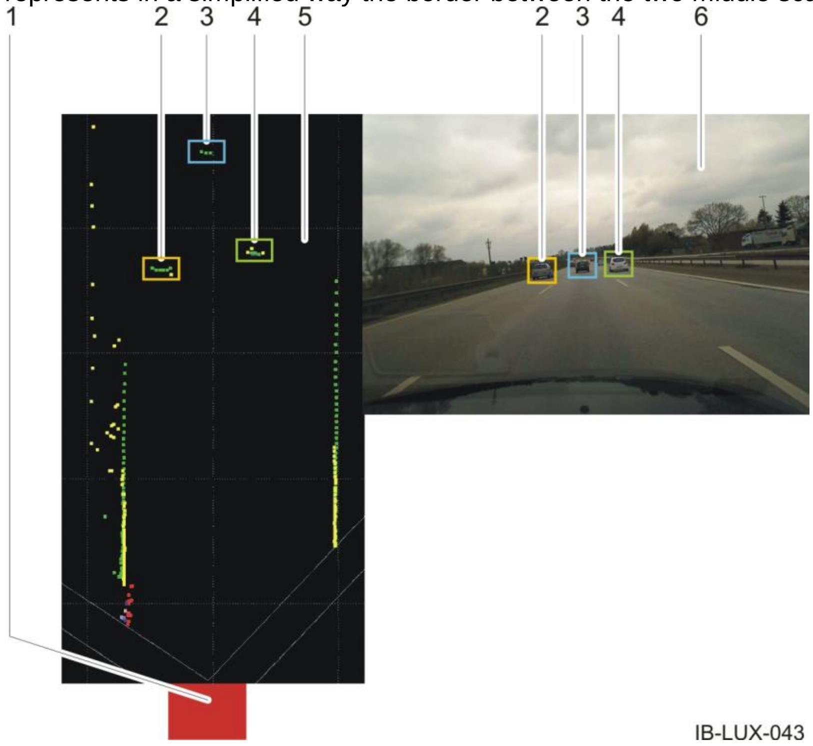


Figure 4-1: Scan data and video image

Description of items in figure 4-1:

1	ibeo LUX 2010®	4	Vehicle on the right lane
2	Vehicle on the left lane	5	Scan data image
3	Vehicle on one's own lane	6	Video image

Figure 4-1 shows a picture with excerpts from scan data (4-1/5) taken while driving on the highway. The scan points are displayed as colored dots.
In the video image (4-1/6), which shall only serve for illustration, and in the scan data image, three vehicles (4-1/2, 3 and 4) each are marked with rectangles in different colors to make them easier to assign.
In the scan data image, the roadside border lines left and right are clearly visible.
In this illustration, the colors of the points match the respective scan level, see chapter 0

Level	Echo 1	Echo 2	Echo 3
4 -yellow			
3- green			
2 - blue			
1 - red			

Table 3-1: Naming convention (colors see figure 3-5)

Color hues visualize the levels and color saturation of the echoes. Table 3-1 lists the specified naming conventions for the levels and their preset colors used for the visualization.

Example for a case with three echoes, see figure 3-6

If a laser beam hits a window pane, for example, a part of the light is reflected and triggers a measurement (echo 1).
Most of the light passes the window pane and might hit a rain drop which then again reflects a part of the light (echo 2).
The remaining light is then reflected by an object, which then results in the third measurement value (echo 3).
, page 3-7.
No processing has occurred yet.

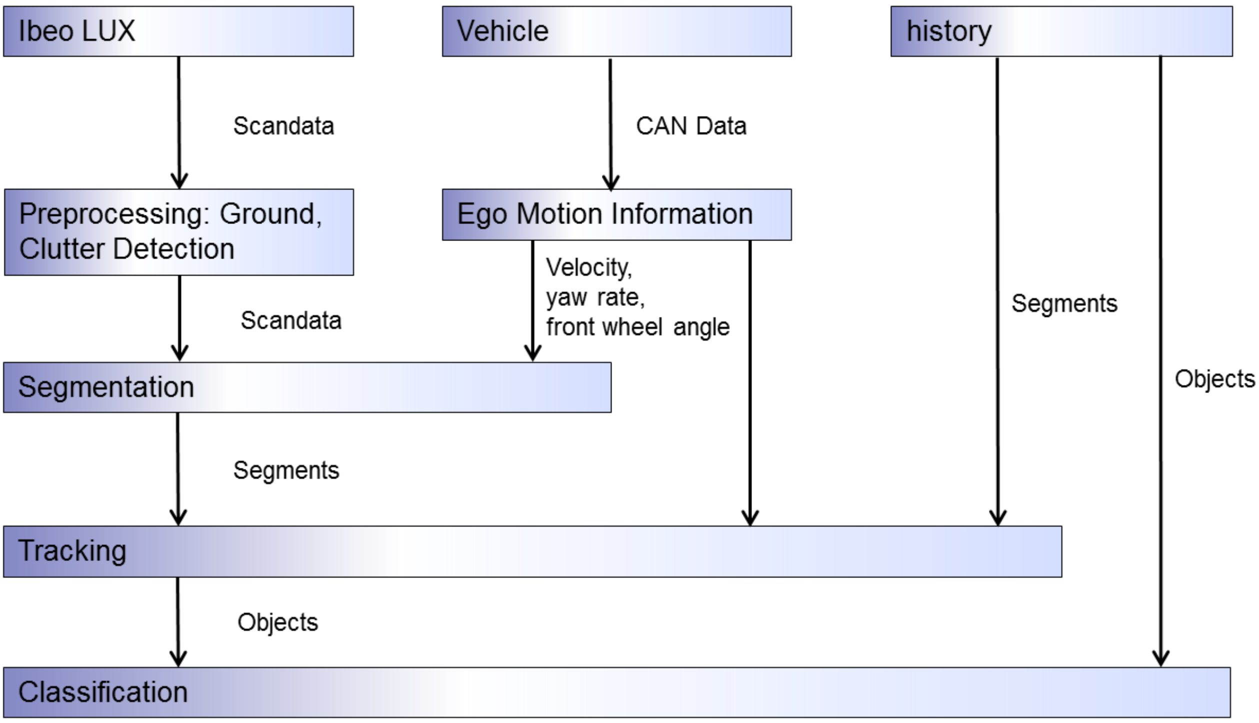
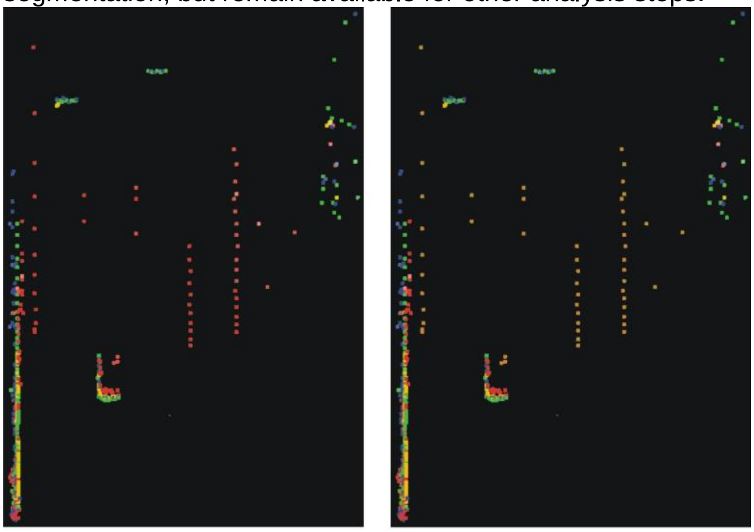


Figure 4-2: Scheme

The scheme 4-2 gives an overview of the steps from scan data processing all the way to classified objects.

Step 1, analysis of the scan data

First the scan data are analyzed. This analysis is called preprocessing.
Measured data of the ground or of atmospheric disturbances (e. g. rain) are marked. They are not used for segmentation, but remain available for other analysis steps.



IB-LUX-050

Figure 4-3: *Scan data excerpt*

Figure 4-3 shows an excerpt of scan data of a highway cruise.
In the left picture, the scan points are marked in the color of their scan level.
In the right picture, all valid points out of which objects will be built in the following processing steps are shown in red. Irrelevant points, such as measurements on the ground, are shown in brown.
Scan data are exclusively transmitted via Ethernet as data types

- 0x2202 from the ibeo LUX 2010®
- (see also the description of the Ethernet protocols to the provided CD-ROM).

Observe the following differences:

- Scan data of the ibeo LUX 2010® are issued as polar coordinates in the sensor coordinate system. They contain the complete mounting position of the ibeo LUX 2010®.
- Scan data of an ECU/ibeo API are issued as Cartesian coordinates in the reference or vehicle coordinate system.

☞	**NOTE**
	The algorithms about scan data processing assume that the ibeo LUX 2010® is aligned in parallel to a level surface. This is the basis for e. g. masking the ground.

	NOTE
☞	*Scan data are transmitted to the sensor coordinate system by the ibeo LUX 2010®. They also contain information about the configured mounting position of the ibeo LUX 2010®, which are available for all subsequent processing steps.* *ibeo API, ECU or visualization transform the scan data from the sensor coordinate system into the vehicle's coordinate system. But this only considers the rotation around the yaw angle and the translations Δx, Δy and Δz. Roll angle and pitch angle are not taken into consideration.*

Step 2, segmenting the scan data

Now the scan data are segmented. This generates segments as groups of associate scan points. The segmentation depends on the vehicle's own movement.

	NOTE
☞	*Segmentation and object formation are only available if the pitch angle and the roll angle are preset to 0° in the configuration.*

Step 3, object formation

During tracking, objects are built from the segments. In the process, the vehicles own movement and the objects of the last scan (history) are also used.
Objects have the following main properties:

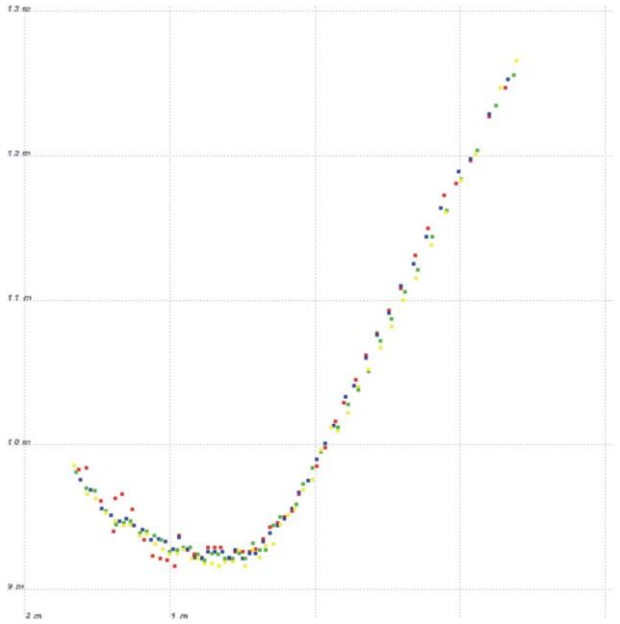
- position
- size
- outline
- speed

Different representations are available for an object:

- Object box – object position, orientation and size from the tracking
- Bounding box – object position and size basing on the scan data
- Object outline – the contour of the object as facing the ibeo LUX 2010® as a polygon, basing on scan data

Figure 4-4: Reference image

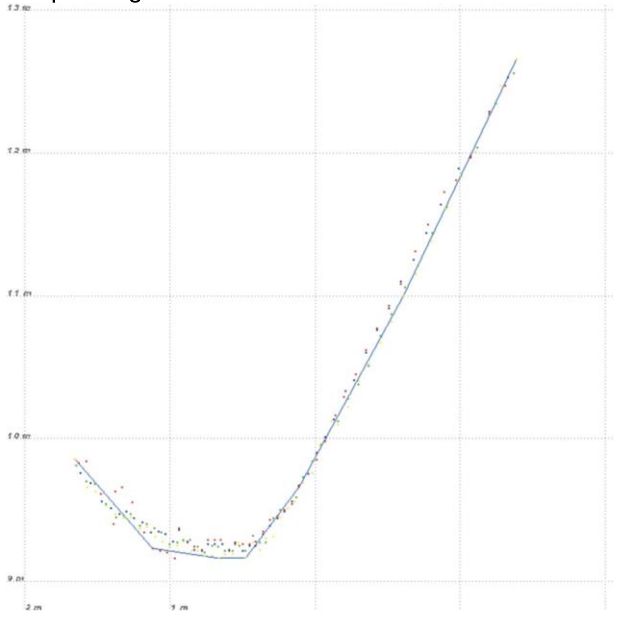
The reference image in figure 4-4 shows a moment in which a vehicle (4-4/1) passes an experimental vehicle (4-4/2) with integrated ibeo LUX 2010® at an angle. The experimental vehicle with the ibeo LUX 2010® is stationary.



IB-LUX-045

Figure 4-5: *Scan data*

An excerpt of the scan data of the ibeo LUX 2010® at this point of time is shown in figure 4-5. Only scan points of the passing vehicle are shown.



IB-LUX-046

Figure 4-6: *Object outline*

The blue line in figure 4-6 shows the outline of the object as generated from the scan points.

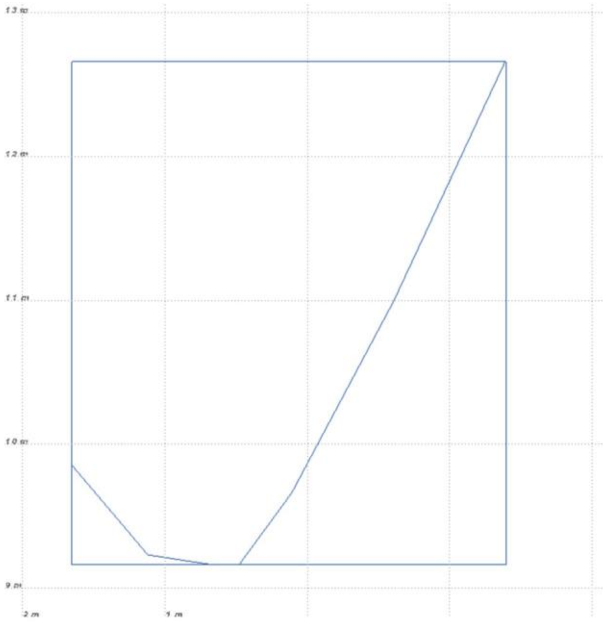

IB-LUX-047

Figure 4-7: Bounding box" of the object

The rectangle around the outline in figure 4-7 represents the bounding box of the object.

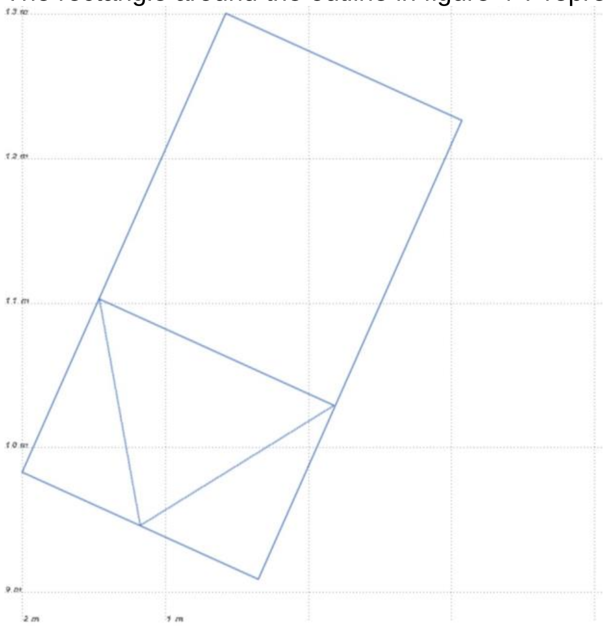

IB-LUX-048

Figure 4-8: Object box

Finally, the object box in figure 4-8 shows the filtered object information as determined during the tracking.
With the speed of the vehicle, the orientation of the object box and thus the direction of movement is displayed.
Length and width of the object also derive from the object racking. They must not match the current measured values exactly as they are filtered values.
Objects are generated from segments and tracked on a time-base. In doing so, object speeds and other object properties are determined.
The speed is issued both relative and absolute (if the vehicle's movement is available via a CAN bus):

- Absolute speed is the speed of a vehicle on the street or viewed from a stationary observer.
- Relative speed is the speed of a vehicle relative to an observer. While approaching a stationary target with a constant speed v, the corresponding object has the relative speed -v.
- Relative and absolute speed are identical as long as the own vehicle does not move.

Object speeds have an amount and an orientation, they can be divided into the x and y coordinates.

Step 4, classification

In the last processing step, the classification, the following classes are assigned to the objects, on the basis of properties and history:

- car
- cycle (motorcycle, bicycle)
- truck
- pedestrian
- unknown, large
- unknown, small

Packaging, Storage and Transport

Packaging

☞	**NOTE**
	Improper disposal of the packaging materials burdens the environment. *Dispose of the materials separately according to national and local regulations.*

ibeo LUX Single System and individual components

The ibeo LUX Single System as well as common combinations of individual components are packed in one packaging unit.
This packaging unit consists of

- an outer cardboard box,
- an inner cardboard box with the accessories,
- possibly filler material for safer transport e. g. in the inner box for the accessories, and
- a membrane pack to secure the ibeo LUX 2010® between two film layers.

Accessories include the following components which can vary according to system:

- LUX ethernet cable
- LUX power cable
- DVD with operating manual

Storage

Store the ibeo LUX 2010® dust-free, dry and protected from direct sunlight. Cover the ibeo LUX 2010® carefully.
In case of longer storage, arrange a contract of exactly defined storage conditions.
Do not remove or damage the packaging of the ibeo LUX 2010® during storage.
Make sure that the shipping locks are not removed. The shipping locks may only be removed by trained staff prior to mounting.
Avoid larger thermal fluctuation and condensation.

Storage temperature	min. -40°C max. +95°C
Relative humidity	relevant to norm EN 60068-2-30: 2005-12; audit Db variant 1

☞	**NOTE**
	for the storage of the components see chapter 14 Technical data, page 14-1.

Transport

Please note the instructions on the packing list!
Make sure that the surfaces and seals are not deformed or damaged during transport.
Make sure that the shipping locks are not removed. The shipping locks may only be removed by trained staff prior to mounting.
Check the ibeo LUX 2010® upon reception on site for outer damages. In case of damages, immediately notify
Ibeo Automotive Systems GmbH
Merkurring 60-62
D - 22143 Hamburg
Phone: +49 - (0) 40 298 676 - 0
Fax: +49 - (0) 40 298 676 - 10
E-mail: support@ibeo-as.com

Mounting and installation

DANGER

Opening the ibeo LUX 2010® is strictly forbidden.

Some parts inside the ibeo LUX 2010® are under high voltage.

DANGER

Opening the ibeo LUX 2010® is strictly forbidden.

If the housing is open, the safety of your eyes cannot be ensured because direct eye contact with the laser is possible.

CAUTION

Never operate the ibeo LUX 2010®, the ECU and the LUX-Switch beyond the prescribed voltage range, see chapter 14 Technical data, page 14-1!
Ensure the correct voltage polarity in order to avoid damages to the devices!

Check, whether all plugs (especially the plugs provided on the ibeo LUX 2010®, on the ECU or on the extension cables, respectively) are screwed on tightly. If plugs are not screwed on tightly, the connections are not waterproof and malfunctions can occur due to only partially connected contacts.

Mounting

	CAUTION
	Danger of slight hand injuries during mounting. Be very careful and wear gloves, if necessary, to avoid injuries.

	CAUTION
	Opening the ECU and/or the LUX-Switch is prohibited.

	NOTE
	When using two or more ibeo LUX 2010®, insufficient synchronization can cause malfunctions. *For information about synchronization refer to the separate document on the provided CD-ROM.*

ibeo LUX 2010®

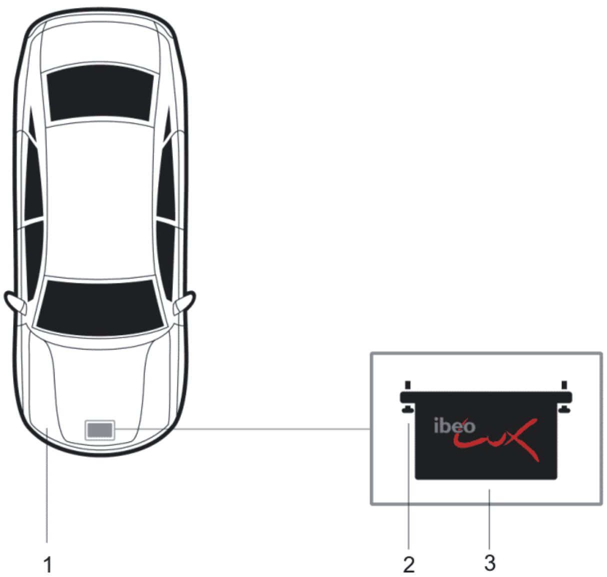


Figure 6-1: Standard installation ibeo LUX 2010®

1	Vehicle
2	Hexagon socket screw
3	ibeo LUX 2010®

By default, the ibeo LUX 2010® (6-1/3) is attached to the front area of the vehicle (6-1/1).

	NOTE
☞	*For information about other mounting options please contact Ibeo.*

Mount the ibeo LUX 2010®:

- at a height h0 of 25 to 70 cm , measured from the ground, with the label pointing upwards,

	NOTE
☞	*In case of a low mounting position, the tail of a high vehicle (e.g. truck) cannot be detected safely, as the ibeo LUX 2010® might only measure the axles.* *In such a case, the lower scan levels hit the ground early (according to the mounting angle). Thus, only three or two levels are available.*

	NOTE
☞	*Mounting must allow for later adjustment of the ibeo LUX 2010® in order to set the pitch angle in such a way that the optical axis (0° orientation, see figure 9-5) of the ibeo LUX 2010® is parallel to the ground.* *It must be possible to mount or adjust the yaw angle to the desired orientation (0°, see figure 9-6).*

- with a free field of view for the working range, see also chapter 15.3.2 Boundary conditions for integration, page 15-8
- possibly behind a pane (polycarbonate or acrylic glass) with a pane thickness of about 2 mm, which is transparent for infrared light (905 nm)

	⚠ WARNING
⚠	*An additional pane in front of the ibeo LUX 2010® can cause reflections and thus disturbances.*

	NOTE
☞	*For further information about suitable material, contact ibeo.*

Proceed as follows to mount the ibeo LUX 2010®:

1. Attach the sensor carrier at the vehicle.
2. Attach the ibeo LUX 2010® with four hexagon socket screws DIN 912 M 6x16, 16, A2 (6-1/8.8) at the sensor carrier.
3. Adjust the ibeo LUX 2010® vertically and horizontally, see chapter 0

4. Adjustment, page 9-1.

☞	**NOTE**
	You can also attach the ibeo LUX 2010® at the vehicle without a sensor carrier. *Then adjust the ibeo LUX 2010® vertically and horizontally.*

Installation

	CAUTION
	Do not lay the cables over sharp edges and make sure that the cables do not scour on sharp edges. If necessary, use an edge protection. The bending radius of the connecting cable of the ibeo LUX 2010®, of the LUX extension cable and the **LUX stand**ard connector cable must be at least 6 cm. Else the cables could be damaged.

System of standard individual components

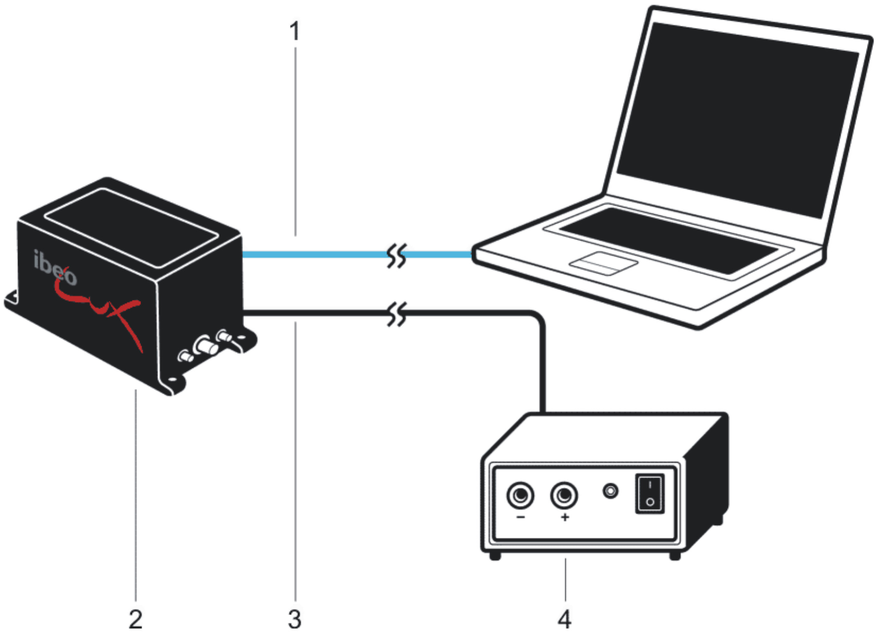


Figure6-2: System of standard individual components

Description of items in figure 6-2:

1	LUX Ethernet cable	2	ibeo LUX 2010®
3	LUX power cable	4	Power supply

Pin assignment of the interface Voltage

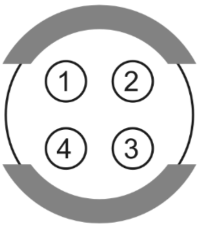


Figure 6-3: Pin assignment of the interface Voltage

Pin	Description
1	Voltage supply ground
2	Voltage supply DC 12 V
3	Voltage supply DC 12 V
4	Voltage supply ground

Table 6-1: Pin assignment of the interface voltage

Pin assignment of the interface Ethernet at the LUX standard connector cable

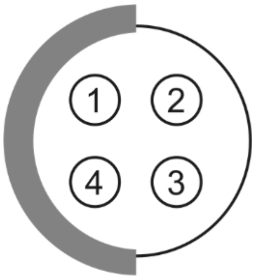


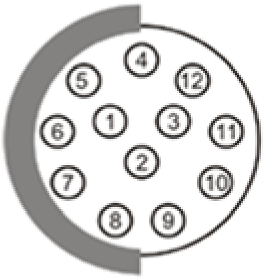
Figure 6-4: Pin assignment of the interface Voltage

Pin	Description
1	Ethernet Rx-n
2	Ethernet Tx-p
3	Ethernet Tx-n
4	Ethernet Rx-p

Table 6-2: Pin assignment of the interface voltage

This pin assignment was selected to enable a direct connection to a network participant.

Pin assignment of the extended interface at the LUX Connector



Pin	Description
1	RS232-tx
2	Sync-Out
3	Sync-In
4	Interface GND
5	Interface GND
6	Interface GND
7	RS232-rx
8	Interface GND
9	CAN low (in)
10	CAN high (in)
11	CAN low (out)
12	CAN high (out)

Table 6-3: Pin assignment of the interface voltage

Configuration

	DANGER
	Changes to the configuration can impair the safety of the system, because they impact the object tracking (number of objects, quality of the objects, etc.). After every configuration change, you must perform a safety check. If necessary, contact the ibeo service team. Ibeo does not assume any liability if a system is operated with incorrect configuration..

Ibeo delivers the systems preconfigured so that usually a first usage is possible without changing the settings.
For the extended usage of the systems it is required to configure the systems according to the requirements and the application range.
In this chapter you find the configuration of the ibeo LUX 2010® Laserscanner.

ibeo LUX 2010®

The central components of all systems build one or more ibeo LUX 2010®.
These sensors offer different setup options.
With the help of the data visualization ILV, the corresponding parameters can be viewed, modified and stored or applied temporarily or permanently in the ibeo LUX 2010®, see chapter **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**, page **Fehler! Textmarke nicht definiert.**.
If parameters are only set temporarily, the ibeo LUX 2010® uses the old, permanently set parameters at the next start (if the voltage supply has been interrupted or if the ibeo LUX 2010® has been interrupted by a reset command).

Parameters of the interfaces

The interfaces provide specific and general configuration options.

- Network
  - IP address
    Here you can modify the preset IP address and adjust it to your needs.
  - Subnet mask
    Please make sure that the selected subnet mask matches your network or the IP range used by you.
- CAN
  - Transmission rate
    A transmission rate of 500 kBit/s is typical. The transmission rate can be adjusted to your CAN bus.

☞	**NOTE**
	Please note that lower data rates also mean that less objects can be transmitted.

  - Base identifier
    The base identifier determines the ID range used by the ibeo LUX 2010®. From this base value on, a range of 16 IDs is used or reserved as working range.
  - Maximum object number
    The data rate of the CAN bus, the bus load if already present and the selected density of contour points (see section "general", page 7-2) limit the maximum possible number of objects transmitted per scan.
    A limit value defines this maximum number of transmitted objects as a parameter. Currently, the closer objects are transmitted in such a case.
  - ibeo LUX 2010®
    The ibeo LUX 2010® expects information about the vehicle's movement in a specified format, see the description of the CAN data log on the provided CD-ROM
    These data are required for tracking.
    If no information about the movement is available, warnings or fault messages are issued and no absolute object speed is available.
    In addition, the quality of these object data is not at its optimum if the ibeo LUX 2010® moves e. g. with a vehicle without information about the vehicle's movement.
- General
  - Selection which data to transmit.
  - Minimum age of the transmitted objects (in scans).
  - Maximum prediction age (number of pure predictions without measurement; in scans) of the transmitted objects.
    If this value is larger than 0, objects without current measurement values are also issued.
  - Contour point density
    Here you can select to show the densest object point or a low / high contour point density, see the section "maximum object number", page 7-2.

Parameters of the measuring process

By modifying the following parameters you can influence the measuring properties of the ibeo LUX 2010®.

- Start angle of the scan range
  The start angle of the scan range must always be larger than the end angle of the sensor coordinate system.
  The maximum value is +50°.
- End angle of the scan range
  The end angle of the scan range must always be smaller than the start angle of the sensor coordinate system.
  The minimum value is -60°.
- Scan frequency
  Scan frequencies of 12.5 Hz, 25 Hz and 50 Hz are possible, however, the available angle resolutions depend on the scan frequency, see page 3-13.
- Angle resolution
  With a scan frequency of 12.5 Hz, the angle resolution can be set to be optimized towards the front. Else the angle resolution is constant, see page 3-13.

Parameters of the mounting position and the carrier vehicle

- Mounting position of the ibeo LUX 2010® referring to the center of the back axle of the carrier vehicle
- Vehicle dimensions

Transmission of steering wheel angle into wheel angle

Commissioning

	CAUTION
	Commissioning and decommissioning of the ibeo LUX 2010® may only be performed by trained staff. Make sure to observe all national and local safety requirements. Never operate the ibeo LUX 2010®, the ECU and the LUX-Switch beyond the prescribed voltage range, see chapter 14 Technical data, page 14-1! Ensure the correct voltage polarity in order to avoid damages to the devices!
	NOTE
	This chapter describes issues that are only valid for the Windows operating system. Act accordingly for other operating system.

First steps

To ensure safety during commissioning, check the following. Every requirement must be fulfilled.

1. Check that all screw connections are tight.
2. Check if all cables are installed correctly and completely, see chapter 6.2

Installation, page 6-2.
3. Check if any cable runs around sharp edges or can scour sharp edges in case of movements. If that is the case, change the cable layout or use an edge protection around the sharp edges.
4. Check if the supply voltage is applied.

Commissioning

Quick start incl. basic configuration for an ibeo LUX Single System

1. Connect the ibeo LUX 2010® with the LUX standard connector cable or the LUX-Connector.
2. Connect the LUX standard connector cable or the LUX-Connector to the voltage supply.
3. Connect the LUX standard connector cable or the LUX-Connector with the Ethernet.
4. Switch on the voltage supply.
5. Start the computer.
6. Prepare the network interface of the computer.
   The default IP address of the ibeo LUX 2010® is 192.168.0.1 Subnetmask 255.255.255.0.

Figure 8-1: Properties

7. Configure the network of the computer in such a way that the ibeo LUX 2010® can be reached.
   Figure 8-1 shows a dialog window to setup the network settings for a Windows operating system. If necessary, contact your system administrator.
   - Subnet mask 255.255.255.0
   - IP address range 192.168.0.2 … 192.168.0.254
   - IP addresses may only be assigned to one device within a network
   - Gateway, DNS etc. may not be modified

Figure 8-2: Optional test for the ibeo LUX 2010® or an ECU

8. Test the configuration or check all issues again. To do so, access the prompt of the system under cmd.exe.
   - Enter "ping <ibeo-LUX-IP-Address>" at the prompt:
     e. g. "ping 192.168.0.1".
   - If the ibeo LUX 2010® answers, the configuration was successful.
   - If the ibeo LUX 2010® does not answer, repeat the procedure starting with step 6.

Starting the operating mode "measuring process"

	NOTE
☞	*For further information about the operating mode "measuring process" refer to chapter* ***Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.****, page* ***Fehler! Textmarke nicht definiert.****.*

1. Start the program ILV.
2. Enter the IP address of the ibeo LUX 2010® into the input field "Scanner IP:".
3. Press the button Connect.
4. The ibeo LUX 2010® starts the operating mode "measuring process" with the default settings.
5. The scan data or the object data appear in the display area.
6. In order to finish the measurement, press the button Disconnect or the system button "Exit".

Decommissioning

	⚠ CAUTION
	Danger of slight hand injuries during decommissioning. Be very careful and wear gloves, if necessary, to avoid injuries.

Always dispose of unusable or irreparable devices according to the local waste regulations (e.g. European Waste Code 16 02 14).
Only trained staff may separate materials!
Prior to supplying the devices to environment-friendly recycling processes, you must separate the different materials of the ibeo LUX 2010®. Separate the housing from the remaining components.
We will gladly assist you in the disposal of these devices. Contact us.
Dispose of the individual materials according the applicable recycling processes.

Adjustment

	DANGER
	Never use the data from the ibeo LUX 2010® if the ibeo LUX 2010® is not or incorrectly adjusted. With incorrect mounting position, the calculation of object speed can be incorrect or objects can even be missed. Applications working with these object data may not function properly.
	CAUTION
	Danger of slight hand injuries during adjustment. Be very careful and wear gloves, if necessary, to avoid injuries.
	CAUTION
	Never operate the ibeo LUX 2010®, the ECU and the LUX-Switch beyond the prescribed voltage range, see chapter 14 Technical data, page 14-1! Ensure the correct voltage polarity in order to avoid damages to the devices!

In order to ensure proper function of the system, the ibeo LUX 2010® must be configured and adjusted after mounting.
If more than one ibeo LUX 2010® is integrated into the vehicle, perform steps 1 to 4 of the following chapters 9.2 to 9.5 for each ibeo LUX 2010® .
If an ibeo LUX 2010® is not adjusted, it must be either switched off or its scan range must be covered.

Coordinate system

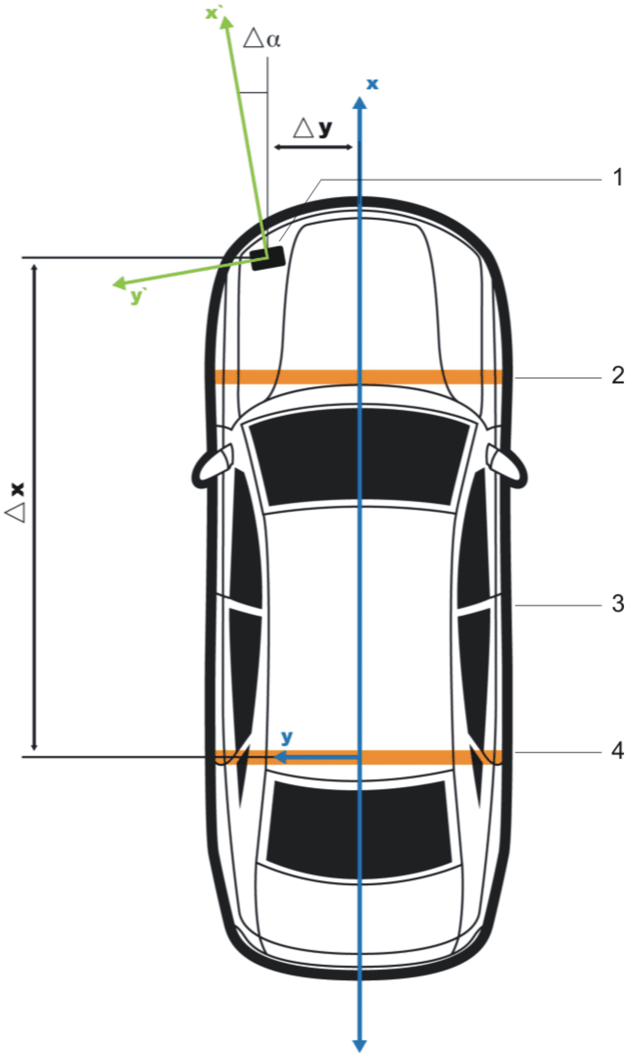


Figure 9-1: Coordinate system, view from above

1	ibeo LUX 2010®	Δα	Yaw angle
2	Front axle	Δx	Offset to the vehicle's coordinate system on the x-axis
3	Vehicle	Δy	Offset to the vehicle's coordinate system on the y-axis
4	Rear axle	x	x-axis of the vehicle's coordinate system
		y	y-axis of the vehicle's coordinate system
		x'	x-axis of the sensor's coordinate system
		y'	y-axis of the sensor's coordinate system

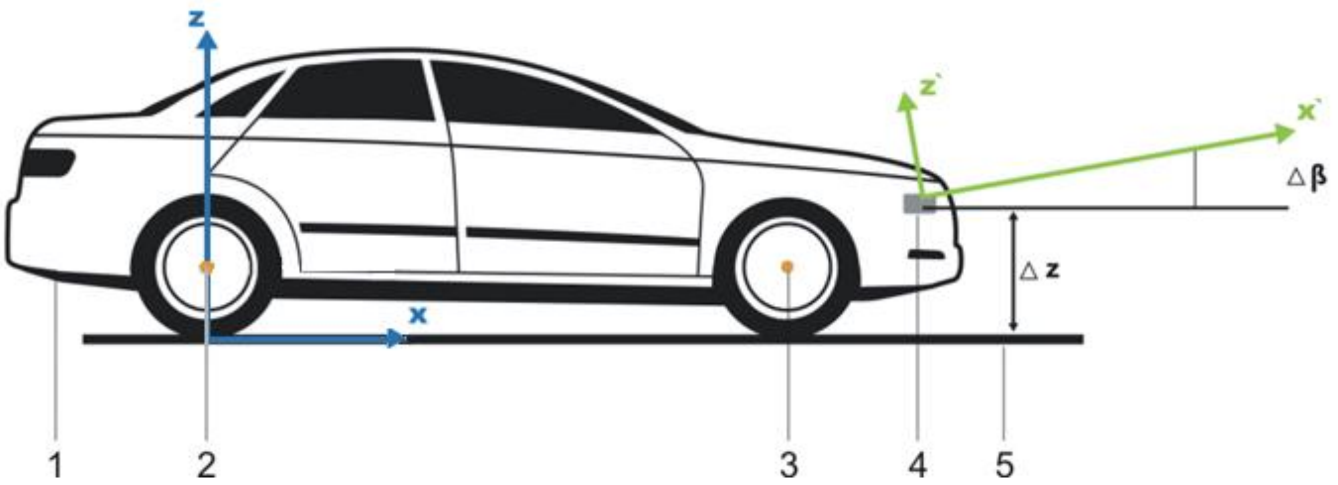


Figure 9-2: Coordinate system, side view

1	Vehicle	Δz	Offset to the underground of the z-axis
2	Rear axle	Δß	Pitch angle
3	Front axle	z	z-axis of the vehicle's coordinate system
4	ibeo LUX 2010®	z'	z-axis of the sensor's coordinate system
5	Level surface		

To calculate the movement of the vehicle, the ibeo LUX 2010® (9-1/1) requires the exact mounting position on the vehicle (9-1/3), because the object data must be transformed into the vehicle's coordinate system.
To do so, the values Δx (9-1/Δx), Δy (9-1/Δy), Δz (9-2/Δz), the yaw angle (9-1/Δα), the roll angle and the pitch angle (9-2/Δß) in the ibeo LUX 2010® must be set (configured) or the ibeo LUX 2010® must be adjusted accordingly.
The origin of the vehicle's coordinate system is always the center of the rear axle (9-1/4).
The origin of the sensor coordinate system is shown in the following figures (Figure 9-3 and Figure 9-4)

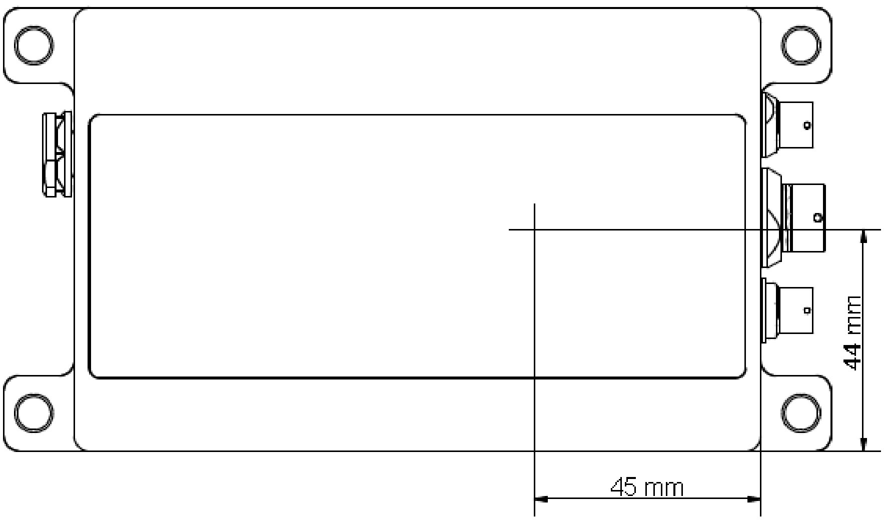


Figure 9-3: Origin of the ibeo LUX 2010®, side view

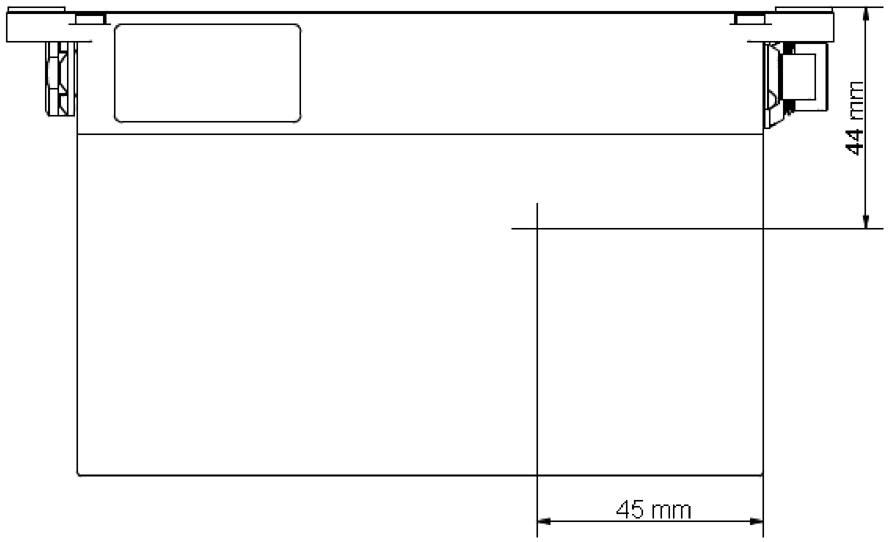


Figure 9-4: Origin of the ibeo LUX 2010®, top view

Step 1, mounting position ibeo LUX 2010®

Use a suitable measuring instrument to determine the exact mounting position of the ibeo LUX 2010® referring to the vehicle's coordinate system or accept the mounting data from the technical drawing or CAD data.
Configure the mounting position Δx, Δy, Δz of the ibeo LUX 2010® using the ILV program.

Step 2, adjusting the pitch angle

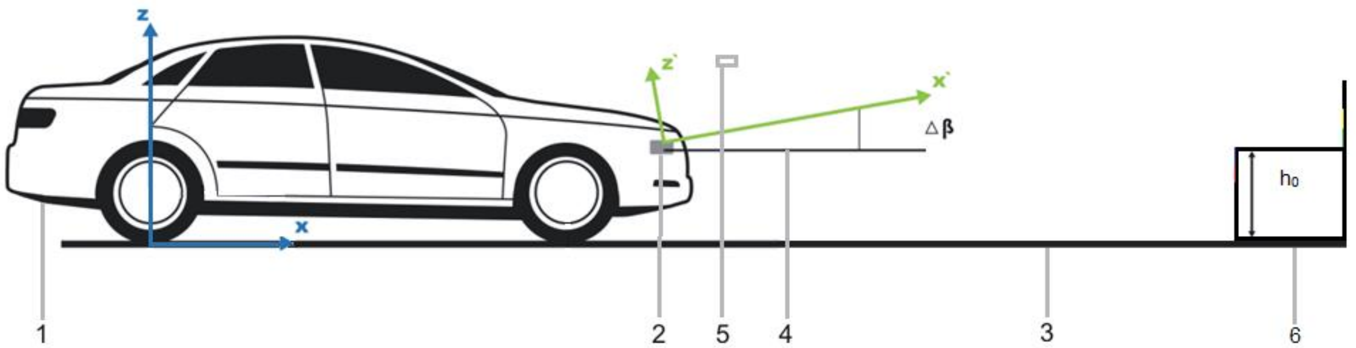


Figure 9-5: Pitch angle

1	Vehicle	5	Laser detector
2	ibeo LUX 2010®	6	Reference target
3	Level surface	h_0	Height
4	Optical axis		

Adjust the ibeo LUX 2010® (9-5/2) vertically (static pitch angle of the ibeo LUX 2010®) by aligning the optical axis (9-5/4) of the ibeo LUX 2010® parallel to a surface ground assumed as even (9-5/3).
Proceed as follows for adjustment:

1. Park the vehicle (9-5/1) on a level surface and make sure that the surface is level up to 10 m in front of the vehicle.
2. Load the vehicle as under normal conditions, e.g. with one driver and one passenger.
3. Activate the ibeo LUX 2010®. It must measure actively.
4. Measure the height h0 between the ground and the center of the ibeo LUX 2010®.
5. Perform the adjustment either with a laser detector or with the help of ILV and a reference target.

6.	7 8. NOTE
	9. If the vehicle is equipped with an automatic chassis adjustment, it must be activated. This requires the engine to be running.

Adjustment with the help of a laser detector

1. Place the laser detector (9-5/5) in a distance of 10 m in front of the ibeo LUX 2010® in 0° direction (sensor coordinate system).
2. Adjust the ibeo LUX 2010® so that the height of the beam center is identical with the height h0 directly at the ibeo LUX 2010®.
3. Repeat this process starting with step 2 for at least one other direction (e.g. 30°) in order to correct a possible roll angle/bank angle of the ibeo LUX 2010®. After this correction, the scan level should be parallel to the ground and the mirror center should be inside the scan level.

Adjustment using ILV and a reference target

1. Build a simple reference target (9-5/6) with the height h_0, e. g. a wooden block or wooden plank with a foot to make it stand upright on its own.
2. Place the reference target in a distance of 10 m in front of the ibeo LUX 2010® in 0° direction (sensor coordinate system).
3. Adjust the ibeo LUX 2010® so that the height of the beam center is identical with the height h0 directly at the ibeo LUX 2010®.
4. Adjust the ibeo LUX 2010® so that the only the lower two scan levels (predefined colors: red and blue) hit the reference target in the ILV while the upper two scan levels (green and yellow) hit the background or show no measurement at all, see figure 3-5.
5. Repeat this process starting with step 2 for at least one other direction (e.g. 30°) in order to correct a possible roll angle/bank angle of the ibeo LUX 2010®. After this correction, the scan level should be parallel to the ground and the mirror center should be inside the scan level.

Step 3, adjusting the yaw angle

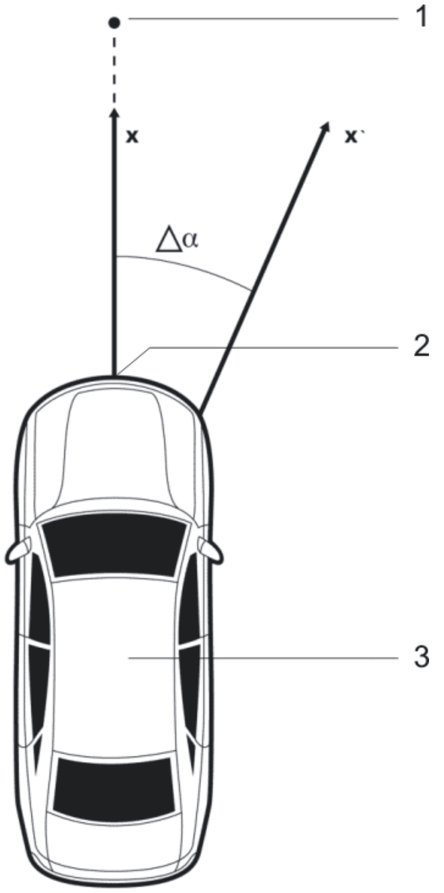


Figure 9-6: Yaw angle

1	Reference target	x	x-axis of the vehicle's coordinate system
2	ibeo LUX 2010®	x'	x-axis of the sensor's coordinate system
3	Vehicle	$\Delta\alpha$	Yaw angle

Adjust the ibeo LUX 2010® (9-6/2) horizontally (static yaw angle of the ibeo LUX 2010®) by adjusting the 0° alignment of the ibeo LUX 2010® into the desired direction (default mounting 0° direction in the vehicle's coordinate system).
Proceed as follows for adjustment:

1. Park the vehicle (9-6/3) on a level surface and make sure that the surface is level up to 10 m in front of the vehicle.
2. Place a reference target (9-6/1) (ideally a target with a height of approx. 1 m and a diameter of 15 … 20 cm) in a distance of 10 m centrally in front of the vehicle or the x-axis of the vehicle's coordinate system (9-6/x).
3. Switch on the ibeo LUX 2010® and start ILV.
4. Use the ILV to measure the yaw angle (9-6/□□) of the ibeo LUX 2010®.
   Please note that ILV considers all set offsets (apart from roll and pitch angle) and that the data are displayed in the vehicle's coordinate system.
   If the ibeo LUX 2010® is mounted with a yaw angle of -25°, as shown in figure 9-6, the target is displayed in the ILV under the angle 25°.
   Check the yaw angle adjustment of the ibeo LUX 2010® and adjust them to your requirements until the angle is correctly shown in the ILV.
5. Configure the mounting position yaw angle of the ibeo LUX 2010® in the ILV program.

☞	NOTE

	So far, no angle offset has been set in the ibeo LUX 2010®. The measured data are not yet displayed in a turned way, but may be shifted due to the offset values (step 1). Hence, measured data from the 0° direction of the sensor coordinate system are displayed in 0° direction of the ILV.

Step 4, test

Check if the reference target is transformed correctly, i. e. if 0° in the vehicle's coordinate system are displayed as 0° in the ILV.
If the reference target is transformed correctly, the adjustment of the ibeo LUX 2010® is complete.
If the reference target is not displayed correctly, repeat the steps starting with chapter 9.4 Step 3, adjusting the yaw angle, page 9-6.
If all steps have been performed correctly, the pitch angle and the roll angle both have the value 0°.

Operation

	DANGER
	With incorrect mounting position, the calculation of object speed can be incorrect or objects can even be missed. Applications working with these object data may not function properly.
	CAUTION
	Never operate the ibeo LUX 2010®, the ECU and the LUX-Switch beyond the prescribed voltage range, see chapter 14 Technical data, page 14-1! Ensure the correct voltage polarity in order to avoid damages to the devices!
	NOTE
	During operation, the requirements for the ambient conditions must be met, see chapter 14 Technical data, page 14-1.

Ibeo Tracking Box

Why Ibeo Tracking Box

The Ibeo Tracking Box provides the latest Ibeo object tracking developments. The all new Ibeo object tracking algorithms improve the environmaental description for both stationary and moving objects significantly.
This is possible due to a new high speed CPU inside the Ibeo Lux Tracking Box.
Another important feature is the easy to use and easy to install extention of the already installed single sensor system. The Tracking Box is added by connecting to the Ethernet switch the Lux is connected to.

LUX sensor tracking vs. Tracking Box tracking

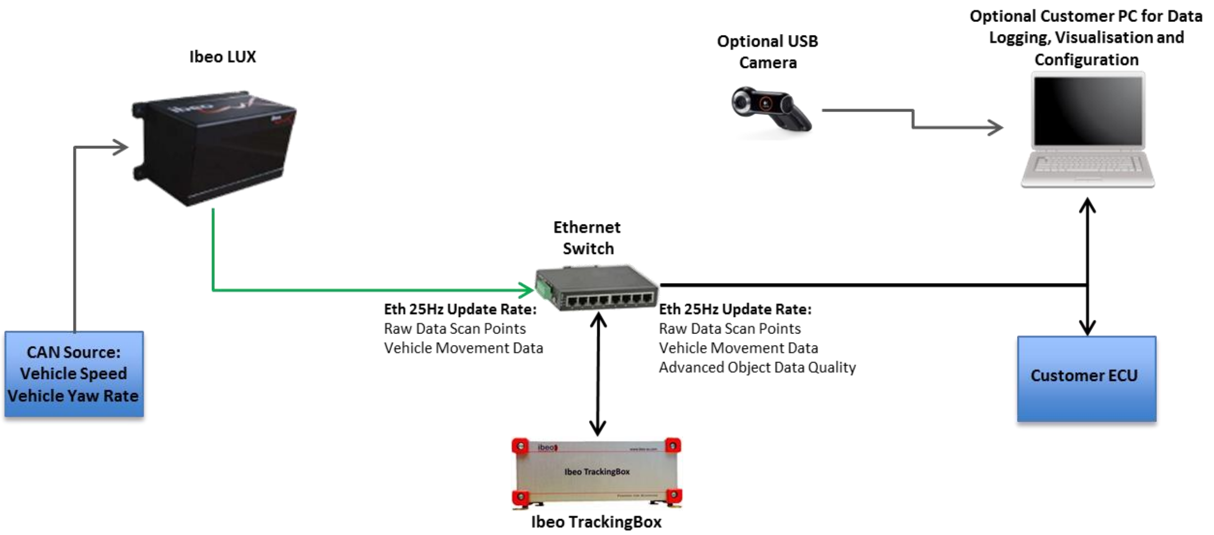
LUX Tracking	TrackingBox Tracking

• 12.5Hz object update rate
• Standard tracking performance
  • Common tracking model
  • Center of gravity based
	• 25Hz object update rate
	• Advanced tracking performance
	  • Dedicated object model for either stationary or dynamic objects
	  • Shape based

Improvements

- Improved tracked object boxes
- Improved motion estimation of dynamic tracked objects
- Improved contour representation of dynamic objects
- Improved polyline representation of stationary objects

Connection Scheme



Prerequisites

Make sure the Ibeo Lux sensor is working correctly without Ibeo TrackingBox:

1. Power supply with banana plug connectors with 12V/24V (including vehicle tolerances) and 20VA in total is available
2. Ibeo Lux sensor is connected to an Ethernet switch
3. ILV software is installed on Customer PC or notebook that is connected to the Ethernet switch
4. A physical vehicle CAN connection to a CAN bus where speed and yaw rate with an update rate >= 50Hz is available

5. Connect to the Ibeo Lux sensor with ILV software
6. The Ibeo Lux sensor is able to generate objects:
    a. Scanning frequency 12.5Hz, configure with ILV Software
    b. CAN connection to the vehicle CAN with vehicle speed and yaw rate, for testing synthetic CAN data from an auxiliary source can also be used to check for functionality before mounting to the vehicle, steering wheel angle is no longer necessary
    c. CAN interface of the Ibeo Lux sensor is correctly configured to interpret the speed and yaw rate information from the CAN bus, this can be checked in the ILV Software in the vehicle status widget.
    d. Object output is enabled, configure with ILV.
    e. Check with ILV if there is reasonable object information
7. When Ibeo Lux sensor is mounted to the vehicle configure mounting position and vehicle parameters, use ILV

Ibeo Lux sensor configuration steps before attaching the Ibeo TrackingBox using ILV:

1. Connect to Ibeo Lux sensor
2. Select LUX->Device configuration
3. Data Parser: Vehicle Velocity
4. CAN Data Parser: Vehicle Yaw Rate
5. Vehicle:
    a. AngleYaw
    b. FrontAxleToRearAxle
    c. OffsetX
    d. OffsetY
    e. OffsetZ
    f. VehicleMotionDataFlags : Enable
    g. VehicleWidth (wheel to wheel width)
6. Measurement:
    a. AngularResolutionType : constant
    b. 12.5Hz
7. Interface(enable):
    a. ETH-Scandata
    b. ETH-Objectdata
    c. ETH-Vehicledata
    d. ETH-Error/Warning
    e. ETH-CAN-Rawdata
8. Apply & Save

Check if the Ibeo Lux sensor configuration is correct in a test run without Ibeo Tracking Box:

1. Power on Ibeo Lux sensor
2. Place the Sensor in way you expect objects to be detected
3. Connect to the Sensor using ILV
4. Enable Object visualization in preferences, please refer to the ILV manual for further information
5. Check if one or more objects are available
6. Enable vehicle state view and check if CAN-Messages are available and if the CAN-Parser is configured correctly

Ibeo Tracking Box installation

Prepare Ibeo Lux sensor for Tracking Box operation

1. Connect to the Ibeo Lux sensor using ILV
2. Select LUX→ device Configuration:
    a. Change Measurement : Scan Fequency to 25Hz
    b. Disable Interface: ETH-Objectdata
3. Apply & Save

Prepare Ibeo Tracking Box

1. Connect Ibeo Tracking Box to the same Ethernet Switch the Ibeo Lux is connected to

Power on

Both devices Ibeo Lux sensor and Ibeo TrackinBox should be powered at the same time from the same source. After roughly 30s the Ibeo TrackingBox has connected and initialized the Ibeo Lux sensor. The default IP-address of the Ibeo trackingBox is set to 192.168.3.30.

The Ibeo TrackingBox will automatically connect by default to an Ibeo Lux sensor with IP-address 192.168.30.204. These Address settings can be changed after first boot.
Use ILV to connect to the Ibeo Tracking Box.

Ethernet Interface

The default Ethernet Interface of the Ibeo Tracking Box delivers following data types:

#	Description
0x2202	Raw Scan data
0x2221	Object data
0x2805	Vehicle State
0x64XX	Trace Messages

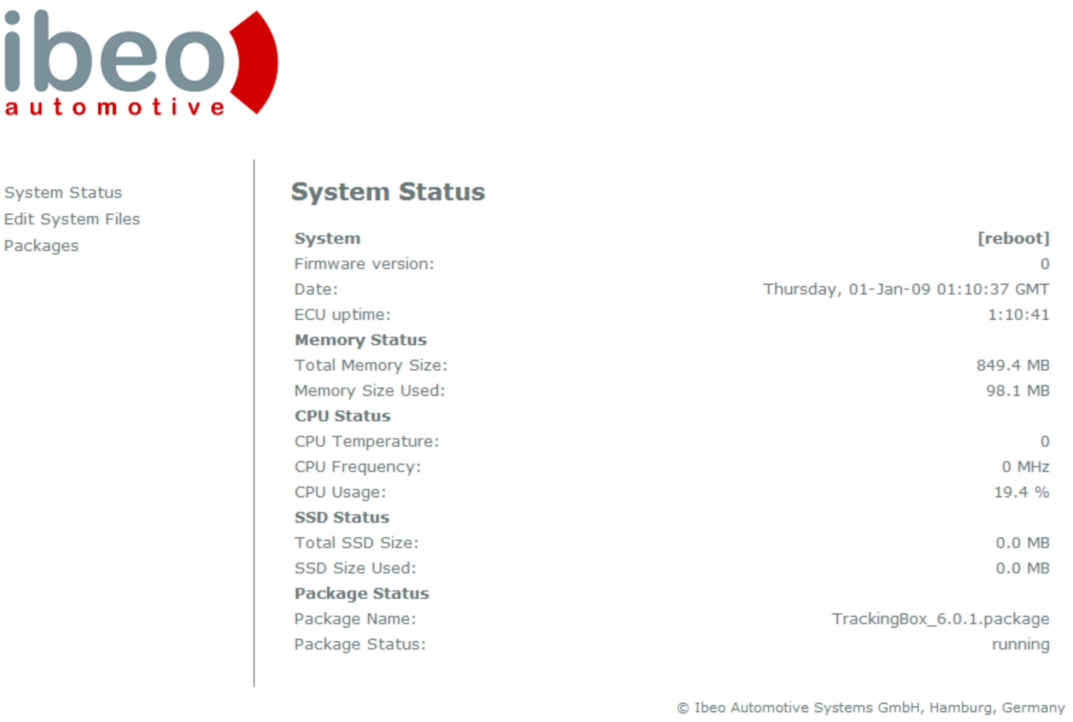
For in depth description, please refer to the Ibeo Customer Documentation Ethernet.

Configuration Options

Use your favorite Web Browser and contact http://192.168.3.30/status.php

System Status

The System Status gives brief information about the systems behavior.

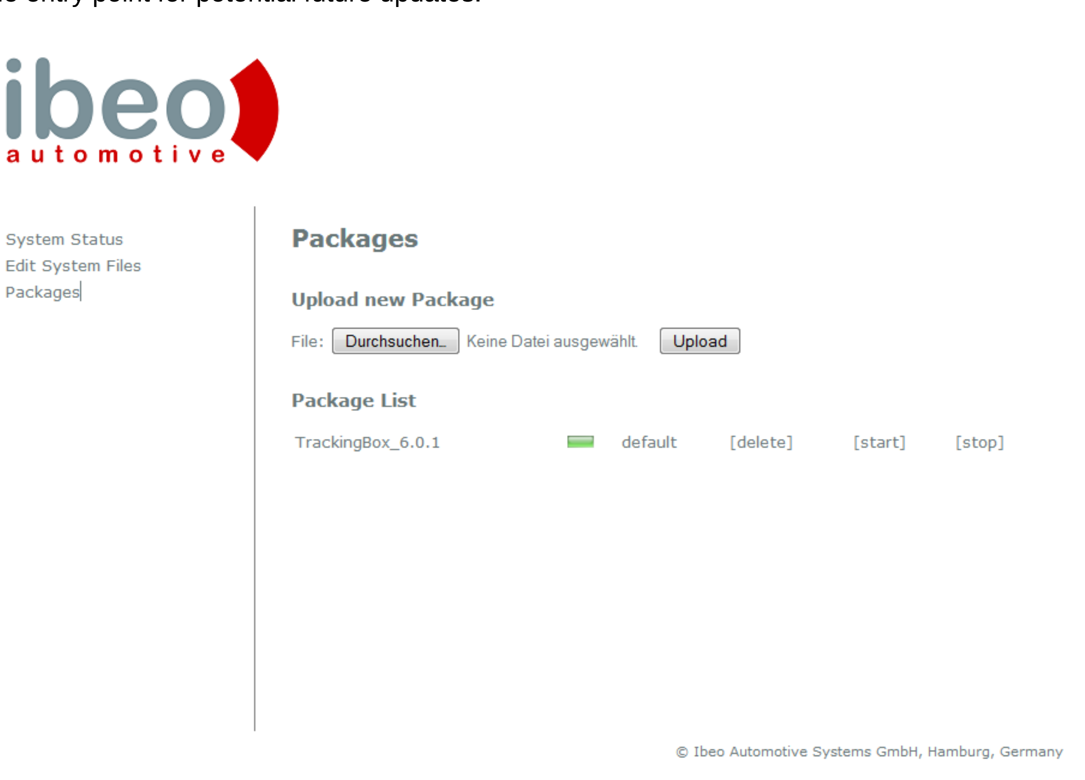


Edit System Files

The Edit System Files page enables the user to change the Ethernet configuration of the Tracking Box. Be careful when changing the settings, there is no customer option to find out forgotten Address settings.
The gateway setting is not needed.

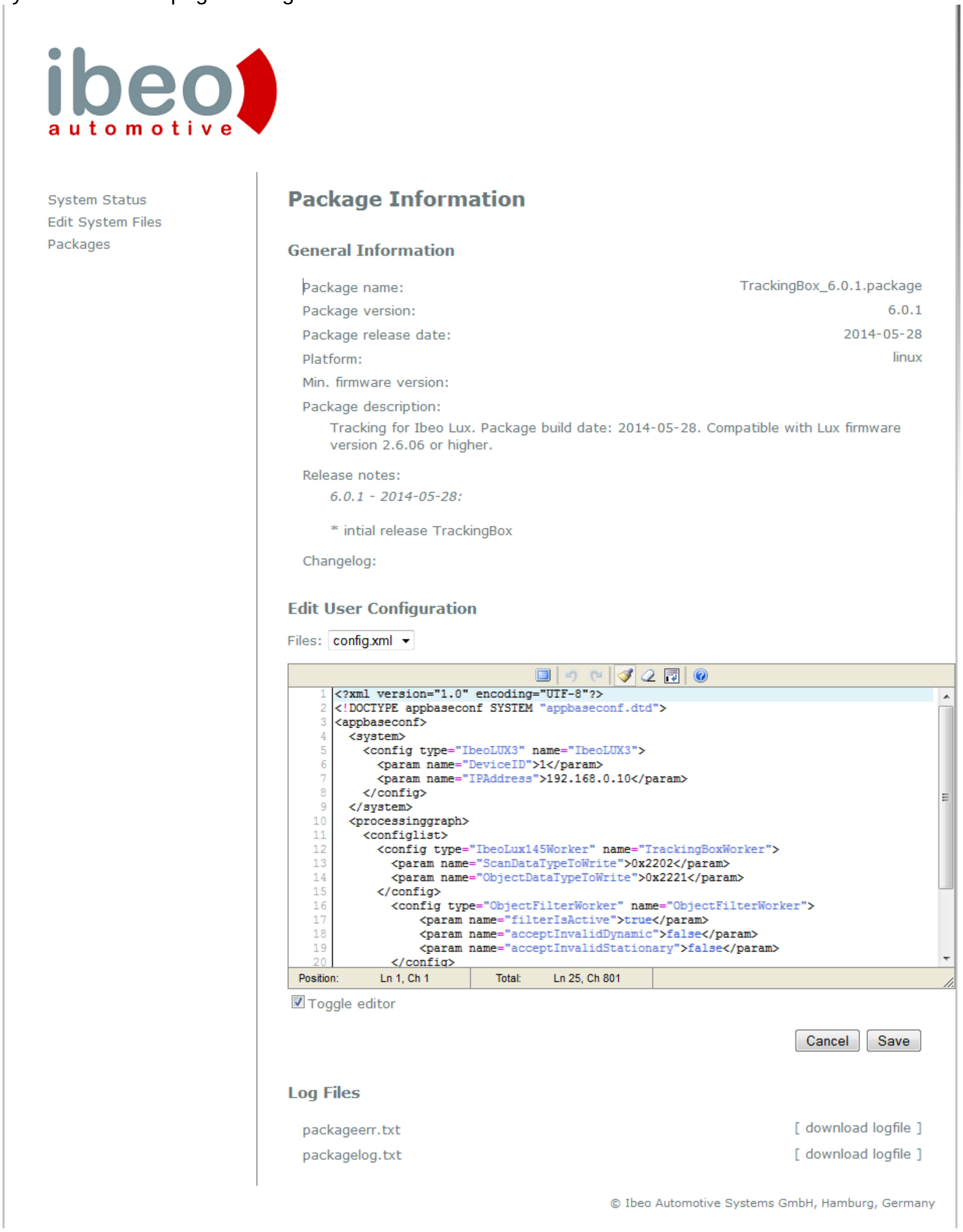
Packages

On the Packages Page there is an overview of the installed software packages.
This is also the entry point for potential future updates.



Package Configuration

By clicking on the name of a package in the list, the corresponding Package Information page is opened. Here is some general Information on this package available.
In addition the configurations of this particular package can be changed.
On the very bottom of this page the logfiles can be found.



Sensor configuration

Each device connected to the system is assigned to a unique name and a device ID.
Make sure that all names and device IDs are unique. The range for device IDs can be selected from 1 to 254.
The sensor's IP address must be selected according to the IP address of the sensor that should be placed into the application.

Parameter	Data type	Default	Description
DeviceID	UNIT8	0	Unique Device ID in the whole Ibeo System.
IPAddress	UINT8.UINT8.UINT8.UINT8	-	IP address of the sensor.

ObjectFilterworker configuration

This worker enables you to only let validated objects be put on the Ethernet interface.

Parameter	Data type	Default	Description
filterIsActive	Boolean	True	Should this worker be used
acceptInvalidDynamic	Boolean	False	Refer to definition of object flags
acceptInvalidStationary	Boolean	False	Refer to definition of object flags

Definition of object flags

Valid	Mobile detected	Static. Model/ Dynamic model	Description	Customer IF relevant	Put out for evaluation
0	0	0	Unvalidated object hypotheses	no	yes
0	0	1		no	yes
0	1	0	n.a.	No	No
0	1	1		No	No
1	0	0		no	no
1	**0**	**1**	**Validated stationary object („a priori stationary")**	**Yes**	**Yes**
1	**1**	**0**	**validated dynamic object with validated track („moving")**	**Yes**	**Yes**
1	**1**	**1**	**validated object, dynamic before, which is now stationary („stopped")**	**Yes**	**Yes**

DataType Configuration in IbeoLux145Worker

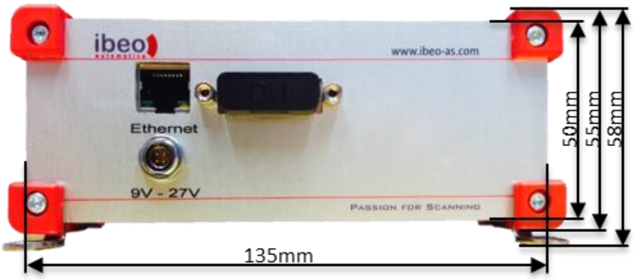
This worker enables you to choose the data types sent over Ethernet.

Parameter	Data type	Default	Description

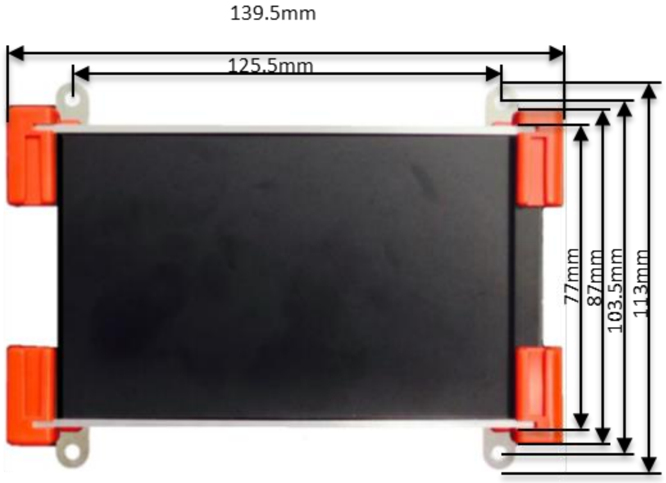
ScanDataTypeToWrite	Hex16	0x2202	Choose here from a list of Scan Data Types described in the Customer Documentation Ethernet: 0x2202, 0x2208)
ObjectDataTypeToWrite	Hex16	0x2221	Choose here from a list of Object Data Types described in the Customer Documentation Ethernet: 0x2221, 0x2225, 0x2280, 0x2281)

Dimensions

Front view:



Top view:

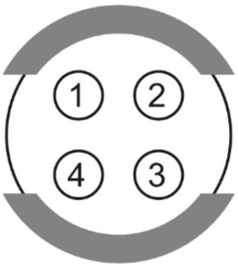


Specifications

Voltage	9…27V
Current	190…420mA
Power	<5W (320mA@13,8)
Connectors	Ethernet, Power
Operating Temperature	0…50°C ambient
Max Size (HxWxD)	58mm x 139,5mm x 113mm

Power connector pin Assignment

Pin	Description
1	Voltage supply ground
2	Voltage supply DC 12 V
3	Voltage supply DC 12 V



4	Voltage supply ground

Package Content

1. Ibeo Lux Tracking Box
2. Power Cable 2m
3. Ethernet Cable 2m

Cleaning and maintenance

	DANGER
	Opening the ibeo LUX 2010® is strictly forbidden. Some parts inside the ibeo LUX 2010® are under high voltage.
	DANGER
	Opening the ibeo LUX 2010® is strictly forbidden. If the housing is open, the safety of your eyes cannot be ensured because direct eye contact with the laser is possible.
☞	**NOTE**
	Send the ibeo LUX 2010® immediately to Ibeo for repair if you notice damages to the plastic panel of the ibeo LUX 2010®.

Cleaning

The ibeo LUX 2010® is waterproof.
Use a soft cloth with water and a non-aggressive, nonabrasive cleaning agent for cleaning.
If mounted, the ibeo LUX 2010® can also be cleaned with a high pressure cleaner as long as the maximum values regarding pressure, duration and distance of the high pressure cleaner to the ibeo LUX 2010® comply with DIN 40050.
Else water can permeate the seals or damage parts of the ibeo LUX 2010® housing.

Maintenance

The ibeo LUX 2010® is maintenance-free, you do not need to service any inner parts.

Customer service

In case of malfunctions / failure please contact your local customer service representative, your vendor or the Ibeo customer service.
Ibeo Automotive Systems GmbH
Merkurring 60-62
D - 22143 Hamburg
Phone: +49 - (0) 40 298 676 - 0
Fax: +49 - (0) 40 298 676 - 10
E-mail: support@ibeo-as.com

Warnings and fault messages

If a fault occurs at the ibeo LUX 2010®, warnings and fault messages are issued via CAN and Ethernet.
The user can extract the warnings and fault messages from the data stream of the CAN or the Ethernet.

	NOTE
☞	*If you use ibeoLaserView (ILV) for the visualization of the scan / object data, the faults are displayed in that system, see chapter* ***Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.****, page* ***Fehler! Textmarke nicht definiert.****.*

The warnings and fault messages contain Bit fields, each Bit represents one warning or one fault. Available are a maximum of twice 16 Bit each for warnings and faults.

	NOTE
☞	*The fault messages are contained in the file Ethernet-Protocol description. You find the files on the provided CD-ROM.*

Technical data

ibeo LUX 2010®

Identification

Type	Laserscanner
Designation	ibeo LUX 2010®
Laser class	1
Protection type (mounted)	IP69K (DIN EN 40050 (1993-05) / EN 60529 (1991-10) + A1 (2002-02);
Plugs (connected)	IP68
Operating temperature	-40 °C ... +85 °C
Dimensions (H x W x D)	max. 88 x 164,5 x 93,2 mm
Weight	< 1,000 g

Electric data

Supply voltage	12 V, 24 V nominal
Operating voltage	9 V ... 27 V
Overvoltage protection	2 h at 30 V, 2 min at 36 V
Polarity proof	up to 36 V permanently
Starting current	2 A for < 0.1 s at 12 V
Operating current	< 0.6 A at 12 V, medium output load (< 0.8 A at 12 V, max. output load)
Power consumption	< 7 W, medium output load (< 10 W, max. output load)

Miscellaneous

Working range	horizontal 85° (extended 110°)
Opening angle	vertical 3.2°
Detection range	from 0 m on
Measurement range	0.3 m … 200.0 m in 0° direction
Range to target with 10% remission	50 m
Distance resolution	0.04 m
Repeat accuracy (1 σ)	0.1 m
Scan levels	4 parallel
Echoes per shot and measurement level	3
Scan frequency	12.5 Hz/25 Hz/50 Hz
Sender	pulsed laser diode
Wavelength	895 nm ... 915 nm
Horizontal divergence of the collimated beam	0.08°
Pulse duration	approx. 4.5 ns
Startup time	< 20 s (at room temperature)
Data interfaces	CAN, Ethernet 100 MBit/s
Material of Housing	Aluminum (EN AlCu4PbMgMn AW-2007) and plastic pane

Annex

Abbreviations

ACC	Adaptive Cruise Control
CAN	Controller Area Network
DSP	Digital Signal Processor
ECU	Electronic Control Unit = processing unit for segmentation, classification and tracking
FPGA	Field Programmable Gate Array = programmable integrated circuit (IC) used in digital technology
GND	ground = uncharged conducting body
GPS	Global Positioning System
ILV	Software program IbeoLaserView
LASER	Light Amplification by Stimulated Emission of Radiation
LIDAR	Light Detection And Ranging = method to measure distances basing on Laser technology
TOF	Time of Flight = method to measure the distance of objects to the sensor's origin

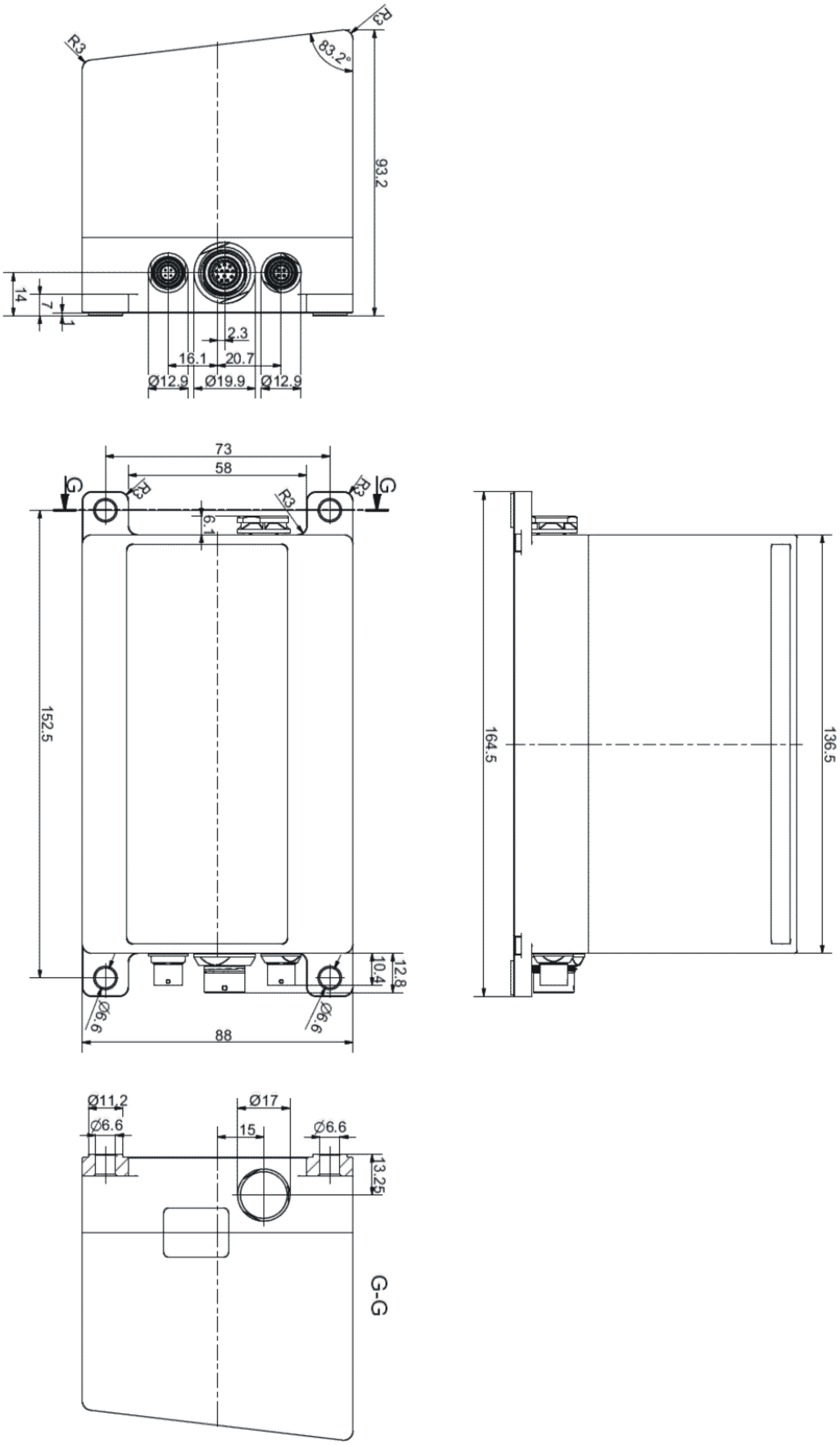
Glossary

Auto-MDI(X)	Current network interfaces are usually capable to recognize the transmission and reception lines of the connected device independently and to adjust correspondingly.This is called Auto-MDI(X). In this regard the use of the cable type (crossed (crossover cable) or not crossed (patch cable)) is irrelevant. All devices of the media type 1000Base-T (Gigabit-Ethernet) or higher must have Auto-MDI(X) as standard.
User interface	Windows oriented input interface in the PC software "CLV-Setup" for operation and configuration.
Big / Little Endian	In a computer, the memory is divided into small units called byte. If a number value higher than the memory capacity must be stored in memory, the value must be distributed onto several bytes. There are some options to arrange the individual bytes of such a number value in the memory. The two most important ones are called Big Endian (big end first) and Little Endian (little end first).
CAN bus	asynchronous, serial bus system; often used in vehicles
Crossover cable	Crossed wires are called crossover cables, they are used to connect two participants directly.
Divergence	Drifting of two objects or processes, starting with one origin, hence the opposite of convergence. For a laser this means that the beam opens out.
DSP	A digital signal processor is a special microprocessor for digital signal processing in real-time systems.
D-Sub	Type of plug system for data connections.
Echo (pulse)	A pulse reflecting from an object or a person in the surroundings of a vehicle, which is detected and thus allows for conclusions regarding distance and reflectivity of the object.
Ethernet	Cable-bound data network technology for local data networks. It allows for data exchange in form of a data frame between all connected devices.
FPGA	A FPGA is a programmable integrated circuit (IC) used in digital technology. In FPGAs internal structures can be configured such that these can reproduce different circuits up to microprocessors.
Gateway	A Gateway allows the communication of networks which base on entirely different protocols.
Yaw angle	If the ibeo LUX 2010® is rotated around the z-axis of the coordinate system, this angle is called yaw angle.
Hub	A hub is a network component to connect several computers or devices with network access in a local area network (LAN), see also switch.
Classification	Assignment of an object to an object class (pedestrian, car,..)
Collimated beam	Parallel direction of the laser beam
Laser pulse	Pulsed laser beam
Laser detector	The laser detector has a diode which is sensitive to the wave range of the laser and issues optical and/or acoustic signals if a laser beam is detected.
Pitch angle	If the ibeo LUX 2010® rotates around the y-axis of the coordinate system, this angle is calked pitch angle.
Object	Element in the surroundings of a vehicle to which certain properties can be assigned, e.g. size, position, speed, type
Patch cable	Connector cable in networks are called patch cables. These 1:1-cables connect network participants via switches or hubs.
Remission	Reemission of incoming visible light and other electromagnetic waves as lights (passive light source) or wave radiation
Roll angle	If the ibeo LUX 2010® rotates around the x-axis, the angle is called roll angle. The roll angle is also called bank angle as the ibeo LUX 2010® banks to the side.
Scan	Generated distance profile of all measurement levels for one pass of the entire defined working range of the sensor.
Scan data	Information about reflected echoes, consisting of compensated radial distance data, pulse widths and angular information.
Interfaces	The interfaces are the part of a systems that serve for communication. Information is exchanged as physical values (e. g. voltage, current) or logical values (data).
Segmentation	Generation of groups of scan data belonging together
Switch	A switch is a network component to connect several computers or devices with network access in a local area network (LAN), see also hub.

Tracking	Tracking (moving) objects

Dimension sheet

Iibeo LUX 2010®



Boundary conditions for integration

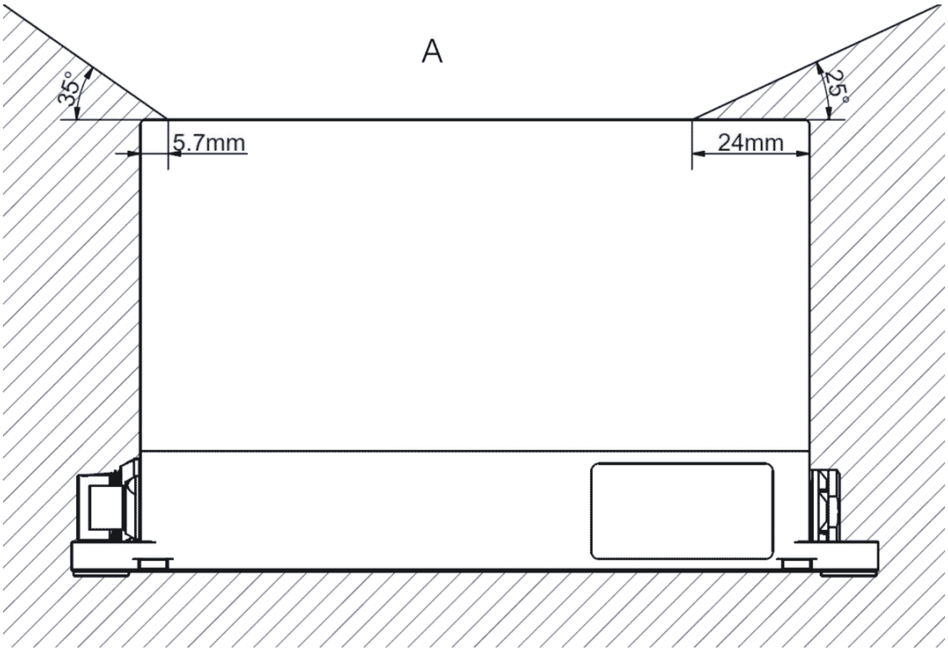
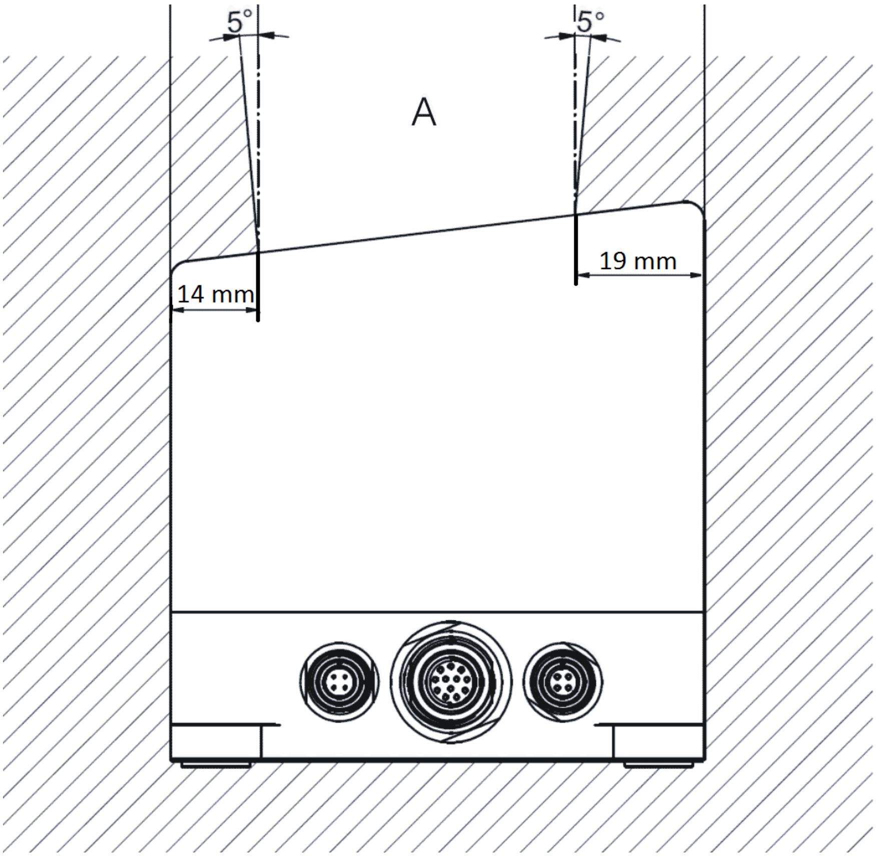


Figure 15-1: Boundary conditions for integration



Ibeo recommends to keep the marked areas (15-1/A) free for the integration of the sensor.
Furthermore, only materials with a low remission should be selected for the materials adjoining the field of view.
Ibeo recommends to avoid edges in the area of the sensor window. For an optimum design integration the transition between surrounding material and ibeo LUX 2010® should be level.
In cooperation with Ibeo also a solution tailored to a respective customer for the sensor lid can be developed such that it adjusts to the conditions of the vehicle and the vehicle contour merges smoothly into the sensor contour.

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