Manual

LDS10A

Version 1.0

CE

Dear User,

You are advised to carefully read this User Manual before powering on the LDS10A LED distance sensor for the first time.

This is necessary to ensure that you will be able to utilize all the capabilities and features which your new acquisition provides.

This technology is subject to continuously ongoing development.

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Note:

Proper care has been used in compiling this document. No liability will be accepted in the event of damage resulting from failure to comply with the information contained herein.

Revisions history

Manual Version	Date	Changes
1.0	01.02.2018	First release
1.1	01.05.2018	First update

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I. Content

II. List of Figures

III. List of Tables

1 General

The LDS10A is an industrial grade distance sensor using advanced measurement and detection capabilities based on patented signal processing algorithms. It provides different interfaces to transmit the detection results to post processing unit like PLCs in industrial applications.

The implemented sensing technology is based on infrared LED illumination and the time-of-flight of light principle. The LED emitters illuminate the area of interest (pulsed at high frequency) and the single channel sensor receiver collects the backscatter of the emitted light and measures the time taken for the emitted light to return back to the sensor. A single photodetector is used and provides a full-beam sensing module. Oversampling and accumulation techniques are used to provide extended resolution and range.

2 Safety Instructions

2.1 General Safety Instructions

These safety and operating instructions should be carefully read and followed during practical work with the LDS10A.

There is danger of electrical shock. For necessary repair work, the LDS10A may not be opened by anyone other than authorized personnel. Unauthorized intervention into the inner product space will void any warranty claims.

Compliance with all specified operating conditions is necessary.

Failure to observe advisory notes or nonconforming product usage may cause physical injury to the user or material damage to the LDA10A.

Cable connectors must not be plugged or unplugged under voltage. Remember to turn voltage supply off before you begin working on cable connections.

2.2 Intended & Conforming Use

- Measurement of distances
- Special measuring functions

- Compliance with prescribed temperatures for operation/storage
- Operation at correct voltage level
- Application of specified signal levels to the appropriate data lines

2.3 Nonconforming use

- Do not operate the LDS10A in any other way than described under "Intended & Conforming Use" above and only in a proper working condition
- Safety devices must not be defeated or otherwise rendered ineffective
- Information and warning signs must not be removed
- Repair work on the LDS10A must not be carried out by anyone other than authorized personnel.
- Avoid using the LDS10A without certified protection in an explosive environment
- Measurement with the LDS10A pointed at the sun or other strong light sources may produce faulty results
- Measurement of targets with poor surface reflectance in a strongly reflecting environment may also result faulty measurements.
- Measurement of strongly reflecting surfaces may deliver faulty results.
- Measurement performed through transparent optical media, for example glass, optical filters, Plexiglas, etc. may equally produce incorrect results.
- Measurement on translucent objects (materials allow light to pass through, but are not transparency, e.g. polystyrene, wax, different plastics etc.) can give a too large measured value, since also light is reflected by deeper layers
- Rapidly changing measuring conditions are likely to falsify the result of measurement

2.4 LED Classification

The LDS10A meets the requirements of the “Exempt lamp class” of IEC 62471:2006.

The sensor can be used without any additional safety protection.

2.5 Electric Supply

Use only 10 V to 30 V (direct voltage) for LDS10A operation. Use only the specially designated connector terminal for voltage supply.

Specified signal levels must not be exceeded, in order to guarantee correct data communication.

2.6 Important Operating Advice

To make full use of the systems inherent performance capabilities and achieve a long service life, you should always follow these operating rules:

- Do not touch any of the module's parts with bare hands.
- Proceed with care when removing dust or contamination from optical surfaces!
- Prevent shock impacts during transport and use of the LDS10A
- Prevent the LDS10A from overheating.
- Prevent the LDS10A from major temperature variances during operation
- In accordance with IP67 internal protection standards, the LDS10A is designed to be splash proof and dustproof.
- Read these safety and operating instructions with care and follow them in practical use.

3 Technical Data

Table 1 : Technical Data

Sensing range[1)]	
Onto natural target (20 %)	0.1 m … 10 m
Onto target board (90%)	0.1 m … 40 m
Accuracy[2)]	± 50 mm
Repeatability	± 5 mm
Resolution	1 mm
Measuring frequency	2.2 Hz … 140 Hz
Lighting	Infrared-LED, 850 nm
Lighting classification	Exempt class IEC 62471:2006
Lighting beam divergence	3°
Receiver beam divergence	6°
Operating temperature	-25 °C up to +75 °C
Supply voltage	10 V … 30 V DC (protected against polarity reversal)
Power consumption	< 3 W
Serial data interface	RS485, MODBUS RTU, 19.400 Baud
Digital output	2x PNP, NO/NC selectable
Analogue output	0/4 mA ... 20 mA current output, Adjustable range limits, 10 bit
Load impedance of analogue Output	< 500 Ω at V_{CC} = 24V, < 150 Ω at V_{CC} = 12 V
Status indicator	2x RGB-LED on top cover
Connector	8 pin, M12-standard, male
Housing material	Aluminum, powder coated
Dimensions (L x W x H)	131 mm x 64 mm x 50 mm, incl. connector
Weight	280 g
Mounting	2 holes for M4 screws, 105 mm x 56 mm
Protection class	IP 67 (waterproof and dust protected)
EMC	IEC 61326-1

1) Dependent on target reflectance, surface structure, ambient light and atmospheric conditions
2) Single measurement, statistical spread 95 %

4 Mechanical Mounting Conditions

The casing consists of rugged, corrosion-resistant, casted aluminum with powder coating. It provides 2 through holes for base plate mounting.

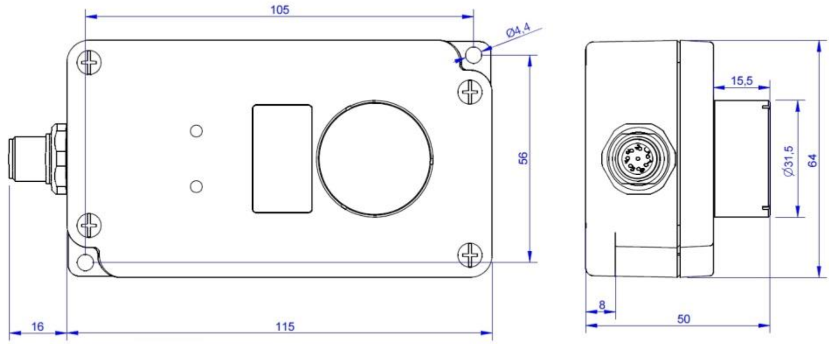

Figure 1 : Dimensional drawing

The zero-point has been introduced for constructional design reasons. It is located appr. 8 mm above the bottom of the housing and can be compensated with the help of parameter “Offset“.

5 Electrical Connection

5.1 Connector Terminal

The male connector flange is made in compliance with industry M12-standard with 8 pins. This connector type guarantees optimized screening and a high IP degree. The connection provides IP67 protection in connected state.

Compatible cable jacks and interface cables with different length are available (standard 5 m).

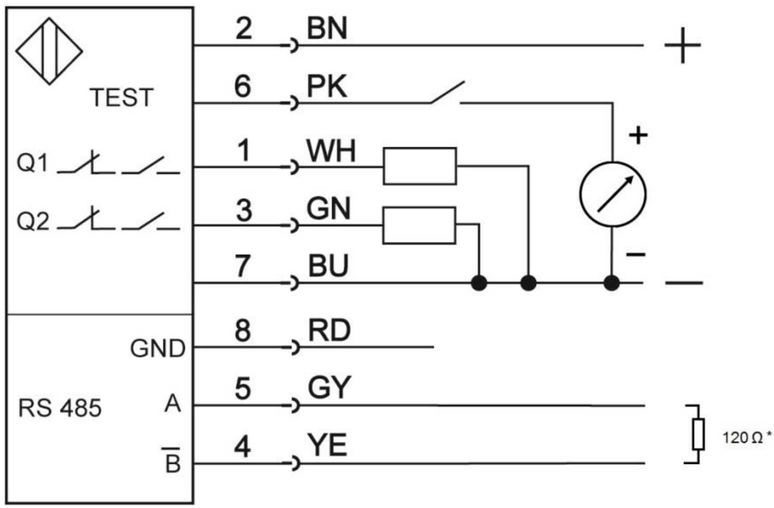

Figure 2 : LDS10A connector pin assignments

Table 2 : Pin assignment connector and interface cable

Pin	Color	Assignment	Function
1	White	Q1	Digital output 1
2	Brown	VCC	Power supply
3	Green	Q2	Digital output 2
4	Yellow	RS485-B	RS485 line B, inverted
5	Grey	RS485-A	RS485 line A, not inverted
6	Pink	QA	Analogue output 4-20 mA
7	Blue	GND	Ground (power supply)
8	Red	GND-RS485	Ground (RS485, internally connected to GND)

GND wires are connected to an internal collective ground point. They provide the reference potential for all voltage values quoted below.

Caution: If input signals are applied to an output port, this may damage the LDS10A!
Do not connect the current output QA to the power supply. This will destroy the interface board!

All outputs are protected against steady short-circuit currents.

Caution: The cable end is exposed! The user is responsible to take precautions that will prevent any kind of shorts! The cable shield has to be connecting to earth with low resistance.

5.2 RS485 connection

The serial data interface of the LDS10A works according to the RS485-standard (EIA-485) with two data lines with inverse polarity. It provides fieldbus capabilities with multiple access and device identification by address.

The used protocol is Modbus RTU with binary data transmission. The communication setup is as follows:

Baudrate: 19.200 baud

Parity: even

Start/Stop bits: 1 Stop Bit

The signal lines of the RS485 interface should not be left open. If not in use it is recommended to connect a termination resistor of 120 Ω between the signal lines A and B.

5.3 Analog current output

The purpose of the analog output QA is to allow transmission of measured values as analogue current value. QA can be configured to a range of 4 mA … 20 mA (factory setting) or 0 mA … 20 mA. In second case the output current can be transformed to 0-10V by a 500 Ω precision resistor. The parameter QA_KBYTE controls the current range of QA.

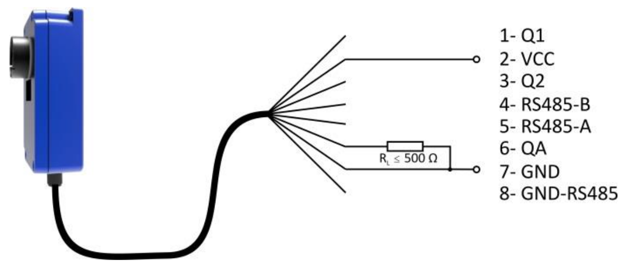

Figure 3 : Wiring diagram of analog output

The current is proportional to the measured target distance. This applies within a distance interval that is marked by the two limiting parameters QA_LOW and QA_HIGH, where QA_HIGH may be greater or smaller than QA_LOW. The output current value for 4 mA … 20 mA output is calculated according to this equation:

$$\text{QA\_LOW} < \text{QA\_HIGH}:\ \text{IOUT[mA]} = \ 4\ \text{mA} + 16 \cdot \left(\frac{\text{Distance} - \text{QA\_LOW}}{\text{QA\_HIGH} - \text{QA\_LOW}}\right) \cdot \text{mA}$$

$$\text{QA\_LOW} < \text{QA\_HIGH}:\ \text{IOUT[mA]} = 20\ \text{mA} - 16 \cdot \left(\frac{\text{Distance} - \text{QA\_HIGH}}{\text{QA\_LOW} - \text{QA\_HIGH}}\right) \cdot \text{mA}$$

Example:

QA_LOW	QA_HIGH	0 m	2 m	4 m	6 m	8 m	10 m	11 m
2 m	10 m	4 mA	4 mA	8 mA	12 mA	16 mA	20 mA	20 mA

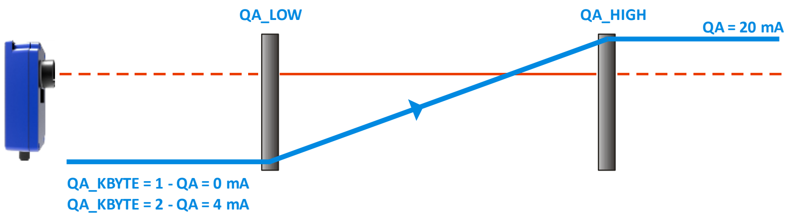

Figure 4 : Output current and parameter of QA

5.4 Digital switching outputs Q1 and Q2

With the help of a user-selectable distance threshold, the switching outputs Q1 and Q2 can be set to monitor objects or conditions for positive or negative overstep.

Using the digital switching outputs, objects can be monitored for excision of a threshold value. To do this, parameter settings for a measurement window are required. Settings for this window can be made with four parameters: Qx_ON, Qx_OFF, Qx_HYST, Qx_NONC (x=1 means Q1, x=2 means Q2)

The range which will be subject to monitoring begins at Qx_ON and ends at Qx_OFF. Switching transitions can be set via parameter Qx_HYST.

All distance parameters are given in millimeters.

The logic state of the switching output is determined by the parameter QX_NONC. See chapter 7 for more information about parameterization of Q1 and Q2.

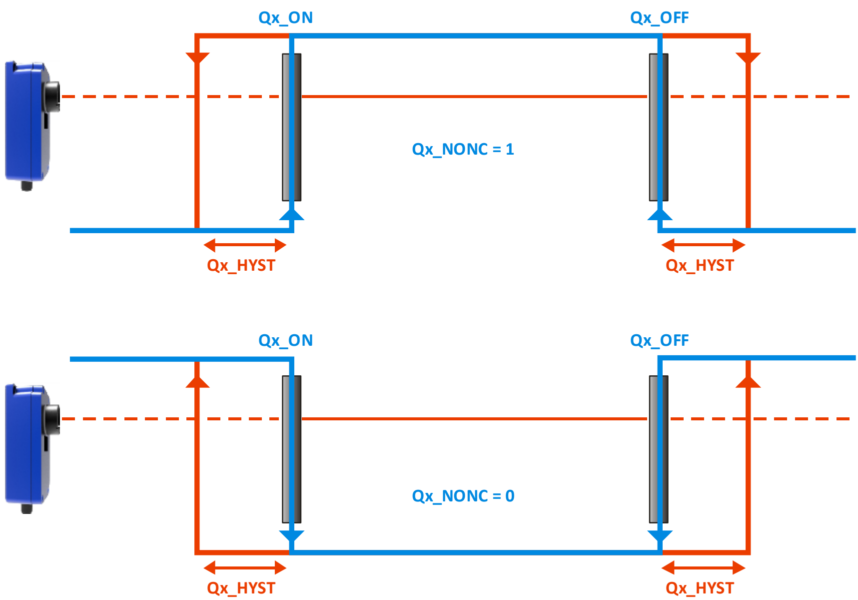

Figure 5 : Digital switching output

Example:

A moving object is assumed to be monitored with output Q1 in normally open mode within a window of 8 m to 9 m with a hysteresis of 0.2 m.

Q1_ON = 8000
Q1_OFF = 9000
Q1_HYST = 200
Q1_NONC = 0

5.5 Device LEDs

There are two multi-color LEDs on the front side of the LDS10A. They are supposed to signalize the current status without any connected data interface.

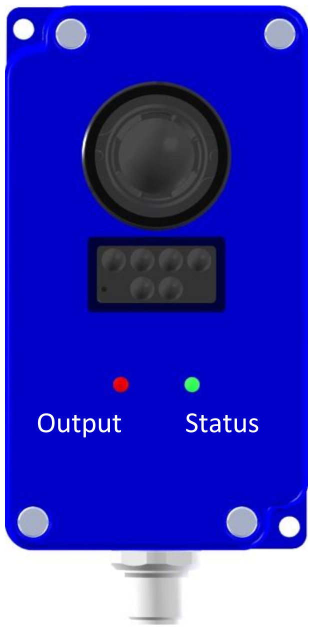

Figure 6 : Device LEDs

Meanings of the LED-colors are shown in Table 3 and Table 4.

Table 3 : Meaning of Status-LED signals

Signal	Meaning
Green, blinking	Target reflectivity barely sufficient
Green	Target reflectivity ok
Red, blinking	Temperature warning, temperature 4 Kelvin before end of range
Red	Temperature range exceeded
Blue, blinking	Target reflectivity not sufficient
Blue	Internal communication error Reset necessary
Off	Output-LED is blinking red

Table 4 : Meaning of Output-LED signals

Signal	Meaning
Green	No output active
Red	Q1 and/or Q2 active
Red blinking	Max. current of Q1 and/or Q2 exceeded
Off	Status-LED is blinking blue

6 Start-up and measurement principle

6.1 Start up

Make sure that all cable ends are protected against short circuit effects before you turn on power supply!

Connect cable terminals as required for the particular operating mode. To prevent short circuits, you should seal unused cable ends!

For starting up, a PC with RS485 data interface or suitable USB-to-RS485 converter is required. We recommend the Windows program ProsoftP1 Version 2.17 or higher.

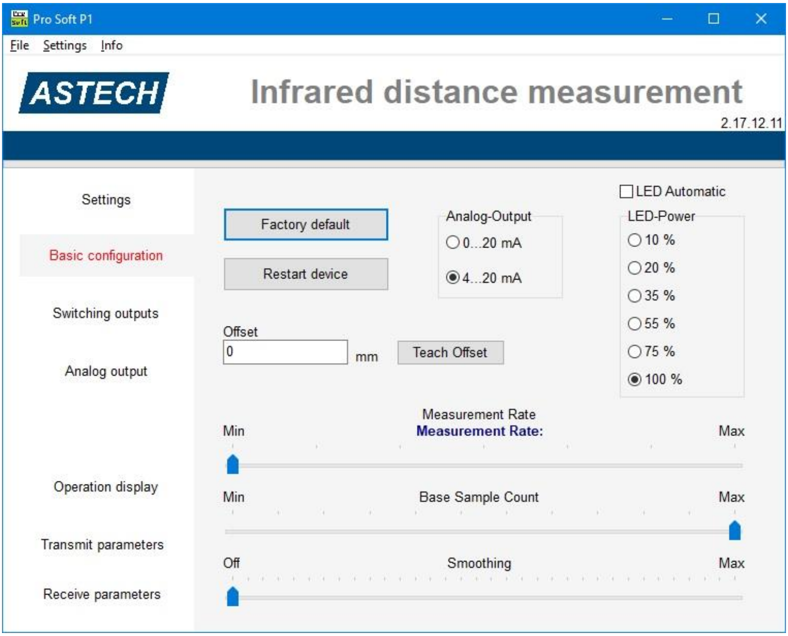

Figure 7 : Program ProsoftP1

As part of preparative actions, the LDS10A must be properly installed in the designated working site, oriented onto the target and kept in a stable position. The target to be measured should preferentially have a homogeneous, bright surface.

6.2 Measurement principle

The measurement principle of the LDS10A consists of a number of separate data acquisition and processing algorithms.

Signal Acquisition

The signal acquisition module samples the signal of the photodiode element using a patented oversampling and accumulation strategy to maximize the signal resolution and the signal to noise ratio. It provides the light intensity received by the sensor as a function of the time (corresponding to distance knowing the speed of light) also called full-waveform signal. This full-waveform signal allows the use of advanced signal processing techniques to extract the distances of the objects and other useful information about the scene.

Static Noise Removal

The static noise removal algorithm removes, as its name indicates, the static noise in the full-waveform signal induced by undesirable light reflections due to sensor enclosure or electromagnetic interferences. This algorithm increases drastically the distance measurement accuracy and linearity. The static noise shape is learned during a calibration procedure during which the waveform of the signal is captured while the reception lens of the sensor is shielded from the backscattered light. The sensor comes with a static noise factory calibration.

Pulse Detection

The objects in the sensor field of detection create a particular signature in the full-waveform signal called pulses. The pulse detector analyses the full-waveform signal in order to recognize these pulses and compute their distance. By nature, time-of-flight sensor using full-waveform analysis is able to detect several distinct objects with a single photodiode element.

The detected pulses have specific amplitudes based on their distance from the sensor and on the reflectivity of the objects. It is well known that pulses of small amplitudes do not lead to accurate and precise distance measurements. Consequently, the algorithm removes all pulses with amplitudes under a given threshold.

Saturation Compensation

The algorithm classifies the detected pulses based on their shape. The LDS10A determines which pulses are saturated and which have a normal shape. Saturated pulse occurs when the signal backscattered by the object is so strong that the full-waveform signal is clipped. If not treated, this phenomenon creates an important degradation of the distance measurement accuracy. It is why a saturation compensation algorithm is executed when saturated pulses are detected. This innovative algorithm uses a sophisticated approach to provide distance measurement accuracy better than 10 cm even with a strongly clipped signal.

Temperature Compensation

The signal processing algorithm also embeds an advanced temperature compensation scheme which attenuates the distance measurement drift over large and sudden sensor temperature changes. With this algorithm, the distance measurements stabilize inside 1 cm in less than 10 seconds on cold sensor startup. The temperature compensation also ensures optimal accuracy over the full operating temperature range.

Smoothing

The smoothing algorithm reduces the distance measurement jitter. It can be seen as a recursive average filter which continuously adapts its cutoff frequency (or averaging history length) as a function of the current measurement noise. This innovative algorithm increases the precision of the device (decreases the standard deviation of the measurements). The level of smoothing of the algorithm can be adjusted to fit the requirements of the user applications, please see section7 for more details.

Automatic LED intensity control

The automatic LED intensity control adjusts the intensity of the LEDs in real time in order to maintain optimal pulse magnitudes at all times. For instance, if pulses become suddenly saturated, the sensor will decrease automatically the intensity of the LEDs to a level that ensures optimal distance measurement accuracy.

6.3 Measurement rate

The sensor acquires a base input waveform at a rate of 72131 Hz (44MHz/610). Multiple acquisitions are used to perform accumulations and oversampling and generate a final waveform, which is processed afterwards to detect the presence of objects and measure their position.
The final measurement rate is therefore:

$$\text{Measurement rate} = \frac{base\ rate}{accumulations\ \cdot oversamplinng}$$

For example, with 256 accumulations and an oversampling value of 8:

$$\text{Measurement rate} = \frac{72131\ Hz}{256\ \cdot 8} = 35.22\ Hz$$

The configuration software ProsoftP1 automatically calculates the most suitable combination of accumulations and oversampling according to the selected measurement rate.

Table 5 : Examples for resulting measurement rate

Accumulation	Oversampling	Measurement rate (Hz)
4096	8	2.20
2048	8	4.40
1024	8	8.81
512	8	17.61
256	8	35.22
128	8	70.44
4096	4	4.40
2048	4	8.81
1024	4	17.61
512	4	35.22
256	4	70.44
128	4	140.88

Measurement rates above 140 Hz will cause unpredicted behavior of the measurement algorithm.

7 MODBUS-Parameter

7.1 General

The LDS10A data communication interface uses the Modbus RTU protocol according to standard Modbus specifications. It includes several parameters which represent all the information from the sensor, measured values and parameters for the device setup.

Read-only parameters are not allowed to be changed by the user. R/W parameters are used to change the device setup. Write-only parameters trigger just internal actions inside the LDS10A. There are not transmitted data.

See chapter 7.5 for the Modbus address references.

7.2 Read-only parameters

- **Device type number**
- **Device serial number**
- **Device firmware version**
- **Internal temperature**
- **Configuration Byte:**

  Bit number 2 of the configuration byte indicates the current setup of the analogue output QA.

  Bit 2 = 0: 0-20 mA or 0-10 V

  Bit 2 = 1: 4-20 mA

- **Signal quality**
- **Distance value:**

  The measured distance value is given by 4 bytes divided into the MSW (higher 16 bits) and the LSW (lower 16 bits)

- **Status Byte:**

The current state of the digital outputs and some additional device information are given in one byte.

Table 6 : Status byte information

Bit 0	Q1
Bit 1	Q2
Bit 2	Not used
Bit 3	No target
Bit 4	Short circuit
Bit 5	Temperature range exceeded
Bit 6	Not used
Bit 7	Not used

7.3 Write-only parameters

- **Restore factory settings:**

If this parameter is triggered the LDS10A is set back to factory settings. The setup is stored immediately.

Table 7 : Factory settings of the LDS10A

ACCUMULATIONEXPO	4096
OVERSAMPLING	8
BASESAMPLECOUNT	15
SMOOTHING	-17
LEDCHANGEDELAY	1
LEDPOWERMODE	0
LEDPOWER	100
Q1_ON	250
Q1_OFF	5000

Q1_HYST	100
Q1_NONC	1
Q2_ON	250
Q2_OFF	5000
Q2_HYST	100
Q2_NONC	1
OFFSET	0

- **Teach:**

  This parameter triggers the automatic teach of the threshold values for Q1 and Q2.

Table 8 : Teach byte description

Bit 0	Set Q1_ON
Bit 1	Set Q1_OFF
Bit 2	Set Q2_ON
Bit 3	Set Q2_OFF
Bit 4	Set QA_LOW
Bit 5	Set QA_HIGH
Bit 6	Set Offset

7.4 Read/Write parameters

- **Slave Address**

  Reads / Writes the slave address of the LDS10A for RS485 mode with multiple bus access

- **Accumulation Exponent**

  The Accumulation Exponent is an important parameter for the measurement quality. It controls the number of measurements taken to generate on distance value. Higher values will lead to an enhanced detection range and reduced noise, but also to a reduced measurement rate.

  Data Format: 12 bit, each bit stands for the corresponding exponent

  Range: 0; 1; 2…; 12

  Example: Bit 6 = 1; Accumulation = $2^6 = 64$

- **Oversampling**

  There are four steps of oversampling available. Small oversampling will increase measurement rate and noise.

  Data Format: 4 bit

  Range: 1; 2; 4; 8

  Example: Bit 2=1; Oversampling = 4

- **Base sample count**

  The number of base sample counts controls the maximum detection processing range.

  Data format: Decimal number

  Range: 2 … 15

- **Smoothing**

  The behavior of the smoothing algorithm can be adjusted in 32 steps. Higher values enhance the sensor precision, but reduce the sensor reactivity. The smoothing algorithm can be deactivated.

  Data Format: Decimal number

  Range: -16 … +16; -17 = off

  The PC parameterization software ProsoftP1 shifts the data range of the smoothing function to 1 … 33; 0 = smoothing off.

- **LED power mode**

  This parameter selects between automatic or manual LED power control.

  Data Format: 1 Bit (Bit 0)

  Range: 0 = manual mode; 1 = automatic mode

- **LED power**

  The power of the used infrared illumination LED can be adjusted manually in 6 steps

  Data Format: Percentage as decimal number

  Range: 10; 20; 35; 55; 75; 100

- **LED change delay**

  The change delay defines the number of frames required before allowing the sensor to increase or decrease by one the LED power level. For example, with the same change delay, the maximum rate of change (per second) of the LED power will be two times higher at 17.6 Hz than at 8.8 Hz.

  Data Format: Decimal number

  Range: 0 … 65535

- **Offset**

The offset enables the user to set the zero point for the distance measurement to a specific point outside the LDS10A. This is helpful for direct measurements of lengths or deviations starting in front or behind the LDS10A.

⚠ The offset has direct influence on all other parameters which use the measured distance value.

Data Format: Distance in mm as decimal number

Range: -65535 … 65536

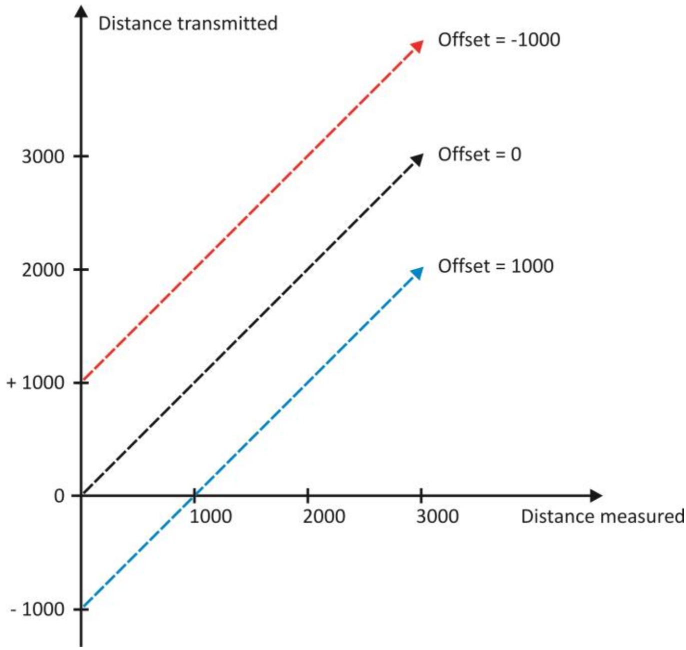

Figure 8 : Example for parameter OFFSET

- **Qx_ON**

  Qx_ON sets the distance value where the switching outputs change their logical state from 0 to 1.

  Data Format: Decimal number

  Range: -65535 … +65536

- **Qx_OFF**

  Qx_OFF sets the distance value where the switching outputs change their logical state from 1 to 0.

  Data Format: Decimal number

  Range: -65535 … +65536

- **Qx_HYST**

  Ox_HYST selects the hysteresis range for the respective digital switching output. See section 5.4 for more information.

  Data Format: Decimal number

  Range: -65535 … +65536

- **Qx_NONC**

  Qx_NONC selects the logical switching behavior of the respective digital output.

  Data Format: 1 Bit

  Range: 0 = normally open; 1 = normally closed

- **QA_LOW**

  QA_LOW selects the starting distance for the analogue output range.

  Data Format: Decimal number

  Range: -65535 … +65335

- **QA_HIGH**

  QA_HIGH selects the end distance for the analogue output range.

  Data Format: Decimal number

  Range: -65535 … +65335

- **QA_KBYTE**

  QA_KBYTE selects the operating mode of the analog current output

  Data Format: Decimal number

  Range: 1 = 0…20 mA / 0…10 V; 2 = 4…20 mA

7.5 MODBUS RTU – Register addressing

Table 9 : List of Modbus register addresses

Register-Address	R/W	Description
0	R	Version
1	R	Sub-Version
2	R	Device serial number
3	R/W	Slave address
4	R	Internal temperature
5	R	Maximum temperature
6	R	Minimum temperature
7	W	Factory settings
8	R	Device type ID
9	R	Level of target reflectivity
10	R	Distance value (MSW)
11	R	Distance value (LSW)
21	W	Start bootloader
22	R	Configuration byte (QA)
122	R	Signal Quality
128	R	Status byte
140	R/W	Accumulation Exponent
141	R/W	Oversampling
142	R/W	Base sample count
143	R/W	LED power in %
144	W	Teach-Byte
145	R/W	LED power mode
146	R/W	LED change delay
147	R/W	Smoothing
148	W	Store parameters of sensor module
250	R/W	Q1_ON MSW
251	R/W	Q1_ON LSW
252	R/W	Q1_OFF MSW
253	R/W	Q1_OFF LSW
254	R/W	Q1_HYST
255	R/W	Q1_NONC

256	R/W	Q2_ON MSW
257	R/W	Q2_ON LSW
258	R/W	Q2_OFF MSW
259	R/W	Q2_OFF LSW
260	R/W	Q2_HYST
261	R/W	Q2_NONC
262	R/W	QA_LOW MSW
263	R/W	QA_LOW LSW
264	R/W	QA_HIGH MSW
265	R/W	QA_HIGH LSW
266	R/W	Offset MSW
267	R/W	Offset LSW

8 Part Numbers

Table 10 : Part Numbers

Part-No.	Name
10-2055-00	LDS10A Sensor
15-0044-05	Connection cable M12F8A-open, 5 m
15-0044-10	Connection cable M12F8A-open, 10 m
15-0044-20	Connection cable M12F8A-open, 20 m
15-0048-05	Connection cable M12F8A-open, 5 m, 90°
15-0048-10	Connection cable M12F8A-open, 10 m, 90°
15-0048-20	Connection cable M12F8A-open, 20 m, 90°
11-0001-02	USB-RS485 interface converter for LDS10A

9 EG Declaration of Conformity

In accordance with the

Directive of Electromagnetic Compatibility 2004/108/EG

The company ASTECH Angewandte Sensortechnik GmbH in Schonenfahrerstr. 5, 18057 Rostock / Germany herewith declare, represented by the signatory, that the following designated product

LED Distance Sensor

LDS10A

agrees with the following harmonized standard:

IEC 61326-1

Electromagnetic interference and electromagnetic compatibility (EMC) *including radio interference

Rostock, March 15th 2018

ASTECH Angewandte Sensortechnik GmbH

Jens Mirow

General Manager