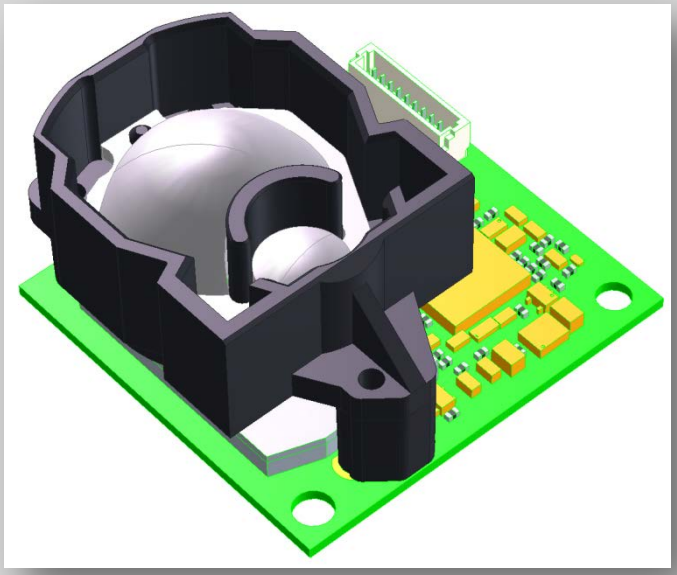
TECHNICAL INFORMATION

STORM Module

Optical Distance Measurement Module

SICK
Sensor Intelligence.



Described product

STORM Module

Manufacturer

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Legal information

Original document

This document is an original document of SICK AG.

Contents

1. System Specification

STORM is an optical distance measure module based on statistical time-of-flight measurement. The primary objective of the module is a cost, size and performance optimized distance measuring device. With HDDM, the used technology is a SICK state-of-the-art time of flight method.
The laser diode sends a light pulse, which is reflected by the object to be detected. The time in which the light pulse signal travels from the sensor to the object and back is measured and evaluated. Using the measured time and the speed of light the distance is calculated.

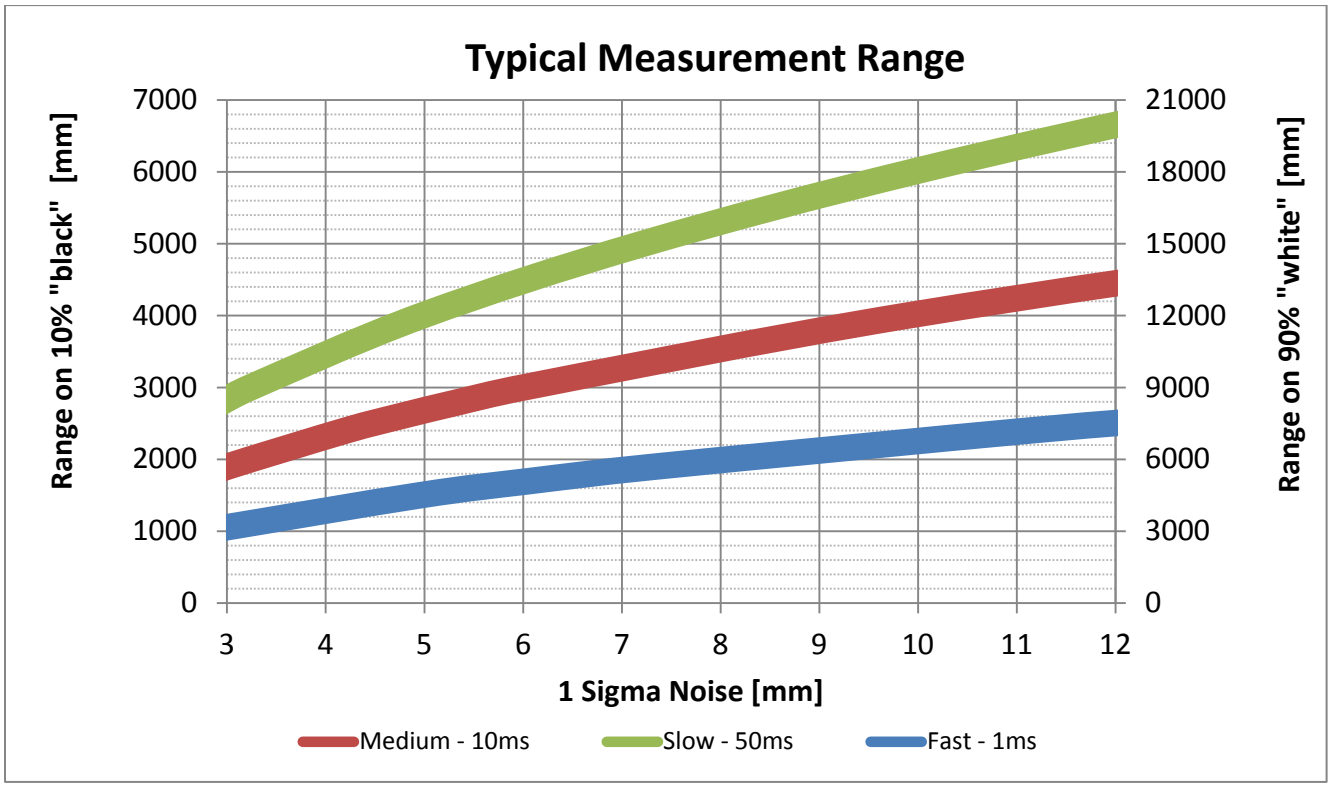
Absolute Maximum Ratings	
Power supply (operating) Vcc	Vcc = +3.3V +/- 5%
Power supply (single failure safety)*	Vcc = 0V…+5V
Power consumption **	< 1.5 W
Module board temperature during operation*	+10 °C … +70 °C During operation the application has to apply a heat sink to discharge the thermal energy from the modules body. SICK recommends an electrical isolating heat sink from the back side of the module.
Storage temperature	-40 °C … +75 °C
Ambient light	≤ 40,000 lux

* beyond this values „single failure (eye) safety“ cannot be guaranteed
** typical power consumption at reference board temperature 30°C: 800 mW

General Specifications		
Distance range limits*	typ. max.	50 mm … 20 m 0 mm … 80 m
Distance repeatability range**	1σ	1 mm … 30 mm
Distance error*** 10%... 90%	max.	± 30 mm
Distance error reflections****	max.	± 100 mm
Temperature drift	typ.	± 0.5 mm/°K

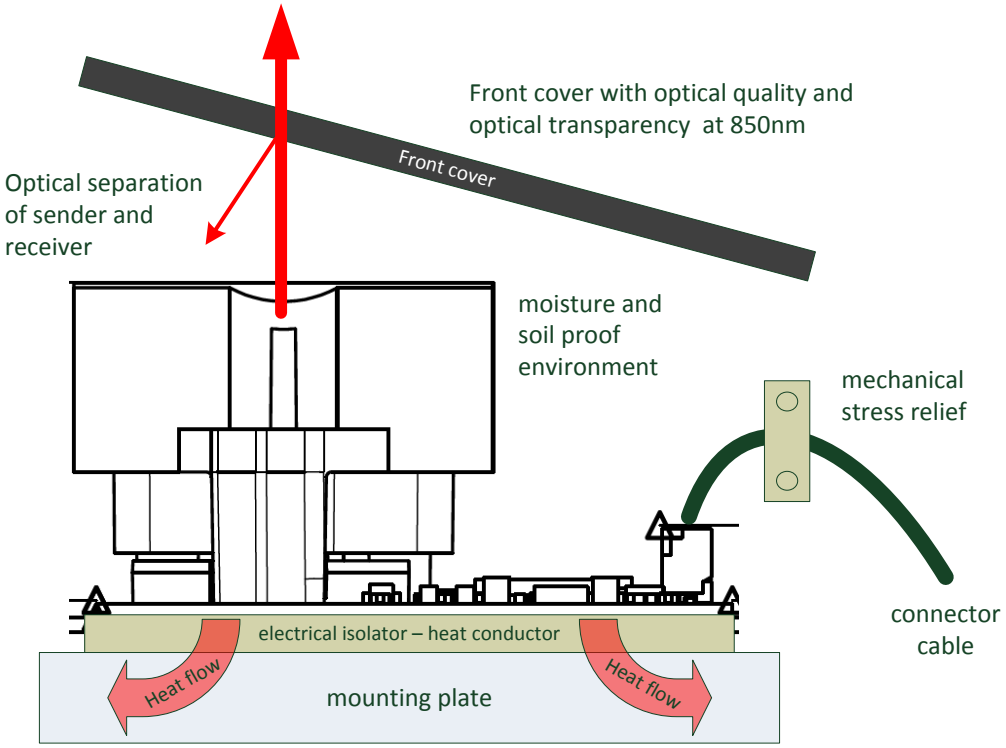
* depending on target remission (10%....90%) and measurement profile
** short term repeatability: temperature, pressure, Vcc are constant
*** maximum distance deviation, reference board temp 30°C
**** at distances <1500mm there can be additional multipath artifacts

1.1. Typical performance chart



The diagram shows the typical reachable distances over measurement noise. The different colors represent the available measurement profiles.

1.2. Reference System



Please be aware that this is a sensor module. The application has to take care about some major environmental aspects:

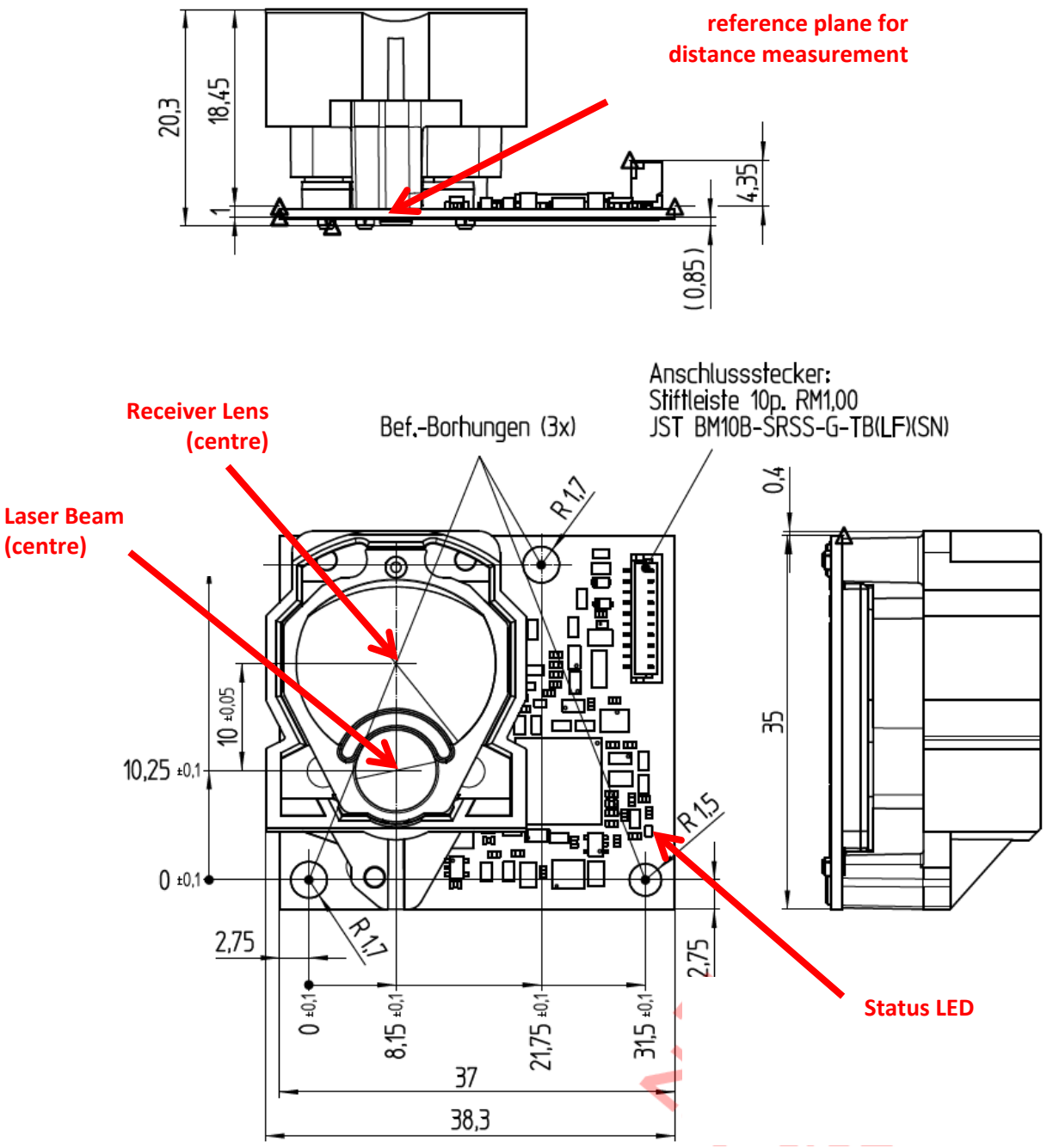
- CHANNEL SEPARATION: As this is a highly sensitive optical sensor any kind of scattered light from the laser source can lead into faulty measurement results. It is strongly recommended to incline the front cover or even better having a mechanical part for channel separation to prevent optical cross coupling between sender and receiver. Examples for disruptive influences are any kind of internal reflections and dirt or scratches on the front cover.

- HEAT FLOW: There must be a low resistive thermal coupling to the modules' thermal environment. Otherwise there is a risk to operate the module beyond the maximum temperature specification. The backside of the module must be protected from electrical short cuts

- CABLE STRESS RELIEF: To guarantee proper communication but also to ensure the strictly defined 3.3V power supply a low resistive interface connection is required

- ISOLATION, MOISTURE AND SOIL: The application has to ensure a clean, dry and electrically isolated environment to guarantee the specified optical and electrical function as well as to guarantee the "single failure (eye) safety"

2. Mechanical Specification



Mechanical specification	
Module weight	30 g ±1 g module only
Connector load and stress	During operation any stress on the connector as well as on the module's PCB shall be avoided. The use of separate cable fixtures (zip ties) is recommended for safe operation.

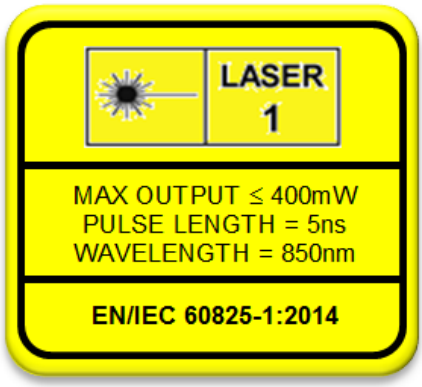
3. Optical Specification

General optical data	
Angle of emitted beam with reference to PCB normal	typ. ± 20 mrad max. ± 30 mrad
Focal length of emitter	11.7 mm, at a wavelength of 850 nm
Focal length of receiver	14.1 mm, at a wavelength of 850 nm
Viewing angle of receiver	± 21 mrad, square FWHM centered around emitted beam
Aperture of receiver lens	175 mm²
Light source	VCSEL – Infrared Laser, wavelength 850 nm
Spot diameter	typ. 6 mm (0.1 m distance) typ. 25 mm (3.0 m distance) max. 30 mm (3.0 m distance)
Pulse duration / Repetition	5 ns / 2900 ns

*FWHM = Full Width Half Maximum (50% of peak)

3.1. Laser Safety Classification

CLASS 1 LASER PRODUCT, IEC60825-1:2014-05 Ed. 3.0



WARNING: THE LASER RADIATION IS NOT VISIBLE!

4. Digital Interface

4.1. Interface Connector

All digital IO ports are single-ended 3.3V (LVCMOS33), partly with internal pull behavior.

Pin	Name	Direction		Function
1	Vcc	Input	3.3V	Power Supply
2	GND	Input	0V	Ground
3	CLK	Input		SPI CLOCK
4	CSN	Input	Pull Up	SPI SLAVE SELECT
5	MISO	Output		SPI SLAVE OUT
6	MOSI	Input		SPI SLAVE IN
7	RDY	Output	Pull Down	READY
8	TRG	Input	Pull Down	TRIGGER
9	PRG *	Input	Pull Up	-
10	LSR **	Input	Pull Up	LASER ON = 'High', LASER OFF = 'Low'

* for SICK internal use only. If this port is connected, drive constant "high".

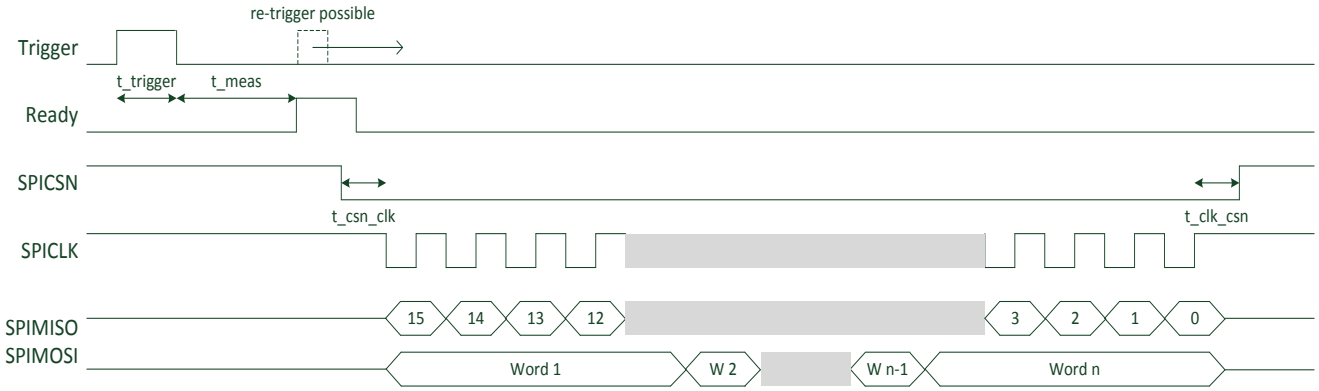
** If port LSR is connected, drive this pin "high" during operation or "low" to turn the laser off due to an internally weak pull up behavior

4.2. SPI Interface

The module acts as a SPI slave. The input / output is Word-oriented (16 bits), beginning with the MSB of the first data word. A transmission ends with the release of the CSN signal. There is read and write access to separate register pages with parameters and measurement data.
Register pages can only be read or written sequentially. If you want to write only a single register, you have to follow a read/modify/write procedure. It is possible to stop a SPI transfer early by pulling CSN up at any time, however.
The first word on MOSI selects the register page and access mode (CMD). The first response of the module on MISO is always the User ID and a word with status flags regardless of the CMD. This is necessary to give the module time to decode the command and prepare a response.
The Module appends a checksum to read data to give you the possibility to check for transmission errors.

4.2.1. SPI Timing

SPI Mode 3, CPOL = 1, CPHA = 1. Sample on rising edge of CLK, transmit on falling edge. 16 bit word size, MSB first.



	timing	comment
t_trigger	> 5 µs	minimum pulse length TRG
t_ready	25 us	pulse length READY
t_meas	typ. 1 ms / 10 ms / 50 ms	measurement cycle time is depending on selected profile
t_csn_clk	> 200 ns	minimum setup time CSN_falling to CLK_falling
t_clk_csn	> 200 ns	minimum hold time CLK_rising to CSN_rising
t_clk_miso	< 65 ns	maximum Clk-to-out Delay CLK_rising to MISO
t_mosi_clk	> 20 ns	minimum setup time MOSI to CLK_rising
f_clk	typ. 1 MHz	SPI clock frequency depending on driver and cable length

* Maximum spec f_clk is 2 MHz

4.2.2. SPI Read / Write Access

The read, write and command access is steered by a command pattern CMD. This is always the first pattern on MOSI, followed by an additional control word and dummies during read access or parameter data during write access.

To read the register of a page, simply write the CMD pattern followed by “x’0000” and (N+1) Dummies (the dummies can also be zeros). The module responds with User ID, Status, the register values sequentially and a checksum. You can stop reading at any time, but we recommend reading the whole page and check the checksum for transmission errors. If you read past the checksum you will get undefined data.

READ USER PARAMETER							
MOSI	x’E11E	x’0000	<dummy>	<dummy>	<dummy>	<dummy>	<dummy>
MISO	<UserID>	<STATUS>	<REG1>	<REG2>	…	<REG14>	<CHECKSUM>

For write access, the second word after the CMD pattern is “x’4DB2”. Following words are sequentially written to registers within the page. During the register writes, there is no valid data on MISO. You may stop the transfer at any time at word boundaries, if you only want to write the first few registers in the page. If you transfer more words than there are in the register page, additional words are discarded.

WRITE USER PARAMETER						
MOSI	x’1EE1	x’4DB2	<REG1>	<REG2>	…	<REG14>
MISO	<UserID>	<STATUS>	<dummy>	<dummy>	<dummy>	<dummy>

STORE command has to be executed to store all changes permanently from RAM into the flash. Please note that the store command is three words long. Power failure during store can result in permanent memory corruption.

STORE Stores all pages permanently to flash memory			
MOSI	x’00FF	x’4DB2	x’B14E
MISO	<UserID>	<STATUS>	<dummy>

CHECKSUM is calculated by the module as the 16-bit arithmetic unsigned sum of all transmitted words, including User ID and STATUS (with possible intermediate overflows). This sum is bit-inverted before it is appended. You can verify the checksum by calculating the sum over all received words (including the checksum). If this value is different to “0xFFFF”, there were transmission errors.

Algorithm to calculate the checksum:

```
uint16* pData;
uint16 FrameChkSum = *pData++;
for (uint32 i = 1; i < length; i++)
{
    FrameChkSum += *pData++;
}
```

4.2.3. User Page Description

Within the user parameter page the access level is marked as read only and read/write. The factory default setting is given in the last column.

UserID	User defined ID	x'FFFF
STATUS	(15) SICK internal (not an error) (14) – (13) Laser Error (12) VCC Error (11) High Temperature Shut Down (10) Low Temperature Shut Down (9) Flash Error (8:1) SICK internal Error Codes (0) Laser Off Indicator - mirrors Status LED (inverted)	–
REG 1	Measurement Mode x'FF00 Triggered Mode Standard measurement mode for the 1D module. Every measurement is requested with the TRIGGER Input and valid data and possible re-trigger is indicated by READY Output. Laser pulses are sent continuously even during times without active measurement, to improve measurement quality. x'FE01 Continuous Mode The module measures constantly, the last valid distance is available on SPI at any time. READY is pulsed for 12 µs every time the distance is updated. other values are invalid	x'FF00
REG 2	Measurement Profile x'FF00 fast 1 ms measurement cycle x'FE01 medium 10 ms measurement cycle x'FD02 slow 50 ms measurement cycle x'FC03 <reserved> other values are invalid	x'FE01
REG 3	USER ID This value is presented with the first word transferred on MISO	x'FFFF
REG 4	USER PRESET This signed (two's complement) value is added to every measurement distance output (Unit Millimeter). You can use this to correct the system offset for your application.	x'0000
REG 5	OUTPUT SCALING x'FF00 0.25 mm Step. Range [-8,192 mm, 8,191 mm] x'FE01 0.50 mm Step. Range [-6,384 mm, 16,383 mm] x'FD02 1.00 mm Step. Range [-32,768 mm, 32,767 mm] (Default) x'FC03 4.00 mm Step. Range [-131,072 mm, 131,071 mm] other values are invalid	x'FD02
REG 6 … REG 9	reserved for future use	x'0000
REG 10	FIRMWARE VERSION (15:12) Major (11: 4) Minor (3: 0) Bugfix	actual version
REG 11 REG 12	DEVICE ID (32bit BCD) Order code as printed on label. Default is given as example for order code 1077677	x'0107 x'7677
REG 13 REG 14	Serial Number (32bit BCD) Unique serial number. Default is given as example for 16350279 = year 2016, cw 35, module no 279	x'1635 x'0279

4.2.4. Output Page Description

Access to the output page is given with the following SPI framing:

READ Output Page							
MOSI	x'FF00	x'0000	<dummy>	<dummy>	<dummy>	<dummy>	<dummy>
MISO	<UserID>	<STATUS>	<REG1>	<REG2>	...	<REG10>	<CHECKSUM>

The output page is read only

UserID	User defined ID
STATUS	(15) SICK internal (14) - (13) Laser Error (12) VCC Error (11) High Temperature Shut Down (10) Low Temperature Shut Down (9) Flash Error (8:1) SICK internal Error Codes (0) Laser Off Indicator - mirrors Status LED (inverted)
REG 1	Level x'0000 no target x'FFFF invalid measurement others RSSI of actual measurement
REG 2	Distance Distance to target [resolution*mm]. Resolution is set in user page. This is a signed value that can be negative if the User Preset parameter is used.
REG 3	Distance Raw Uncorrected target distance with sample resolution and 8 fractional digits.
REG 4	15:8 Measurement Mode (User Page) 7:0 Measurement Profile (User Page)
REG 5	SICK internal only
REG 6	SICK internal only
REG 7	SICK internal only
REG 8	Temperature Sensor 1 Monitor value. Informational only *Conversion to °C: Tc = (Value – 500) * 0.1*
REG 9	Temperature Sensor 2 Monitor value. Informational only *Conversion to °C: Tc = (Value – 500) * 0.1*
REG 10	reserved for future use

5. Troubleshooting

Located on the south-eastern side of the PCB is a green status LED. This LED indicates the state of the Laser. The state of this LED is also mirrored in a bit of the STATUS word.

LED State	Status Bit[0]	Description
ON	0	Laser is on, module operational
OFF	1	Laser is off, either external LaserOn Input is Low or Error Condition
BLINKING	1	Laser Error, check additional status word bits for error condition

The module maintains eye safety requirements in the single fault case. When an error condition is detected, the laser is turned off immediately and status word error flags are updated. After a short period of time, the module tries to turn the laser on again. If the error condition was only temporary (e.g. caused by electromagnetic interference or a faulty monitor reading), normal operation continues. If the error condition is persistent, this retry cycle is repeated, causing the LED to blink.
Status Bits are cleared after every SPI exchange. When error flags are set, the measurement result should be considered invalid.
If the LED is blinking, please check first that the recommended operating conditions are matched (Temperature and Supply Voltage)
A module with a permanent error condition should not remain in operation.

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