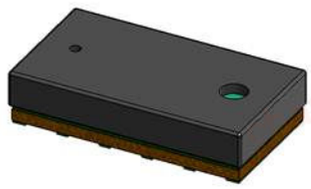
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VL53L3CX

Datasheet

Time-of-Flight ranging sensor with multitarget detection



Features

- Fully integrated miniature module
  - Emitter: 940 nm invisible laser (VCSEL) and its analog driver
  - Low-power microcontroller running advanced digital firmware
  - Size: 4.4 x 2.4 x 1 mm
- Fast, accurate distance ranging
  - Histogram based technology
  - Up to 300 cm+ detection with full field of view (FoV)
  - Immune to cover glass crosstalk and fingerprint smudge at long distance with patented algorithms (direct ToF)
  - Dynamic fingerprint smudge compensation
  - Short distance, high accuracy linearity
  - Multitarget detection and distance measurement
- Typical full FoV: 25°
- Easy integration
  - Reflowable component
  - Part-to-part or generic shape crosstalk calibration is available
  - Single power supply
  - Works with many types of cover glass materials
  - I²C interface (up to 1 MHz)
  - Xshutdown (reset) and interrupt GPIO to optimize ranging operation
  - C and Linux® full set of software drivers for turnkey ranging

Application

- Service robots and vacuum cleaners (wall following and fast obstacle detection)
- Sanitary (robust user detection whatever the target reflectance)
- Smart buildings and smart lighting (user detection to wake up devices)
- IoT (user and object detection)
- Laser assisted autofocus (AF): Enhances the camera AF system speed and robustness, especially in difficult scenes (low light and low contrast). An ideal companion for phase-detection autofocus (PDAF) sensors.
- Video focus tracking assistance

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Description

The VL53L3CX is the latest Time-of-Flight (ToF) product from STMicroelectronics and embeds ST's third generation FlightSense patented technology. It combines a high performance proximity and ranging sensor, with multitarget distance measurements and automatic smudge correction. The miniature reflowable package integrates a single photon avalanche diode (SPAD) array and physical infrared filters to achieve the best ranging performance in various ambient lighting conditions, with a wide range of cover glass windows.

The VL53L3CX combines the benefits of a high-performance proximity sensor, with excellent short distance linearity, together with ranging capability up to 3 m.

With patented algorithms and ingenious module construction, the VL53L3CX is also able to detect different objects within the FoV with depth understanding. The ST histogram algorithms allow cover glass crosstalk immunity beyond 80 cm, and dynamic smudge compensation.

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1 Acronyms and abbreviations

Acronym/abbreviation	Definition
AF	autofocus
API	application programming interface
ESD	electrostatic discharge
FoV	field of view
FW	firmware
I²C	inter-integrated circuit (serial bus)
MSB	most significant bit
NVM	nonvolatile memory
PDAF	phase-detection autofocus
SCL	serial clock line
SDA	serial data line
SPAD	single photon avalanche diode
ToF	Time-of-Flight
VCSEL	Vertical-cavity surface-emitting laser

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2 Product overview

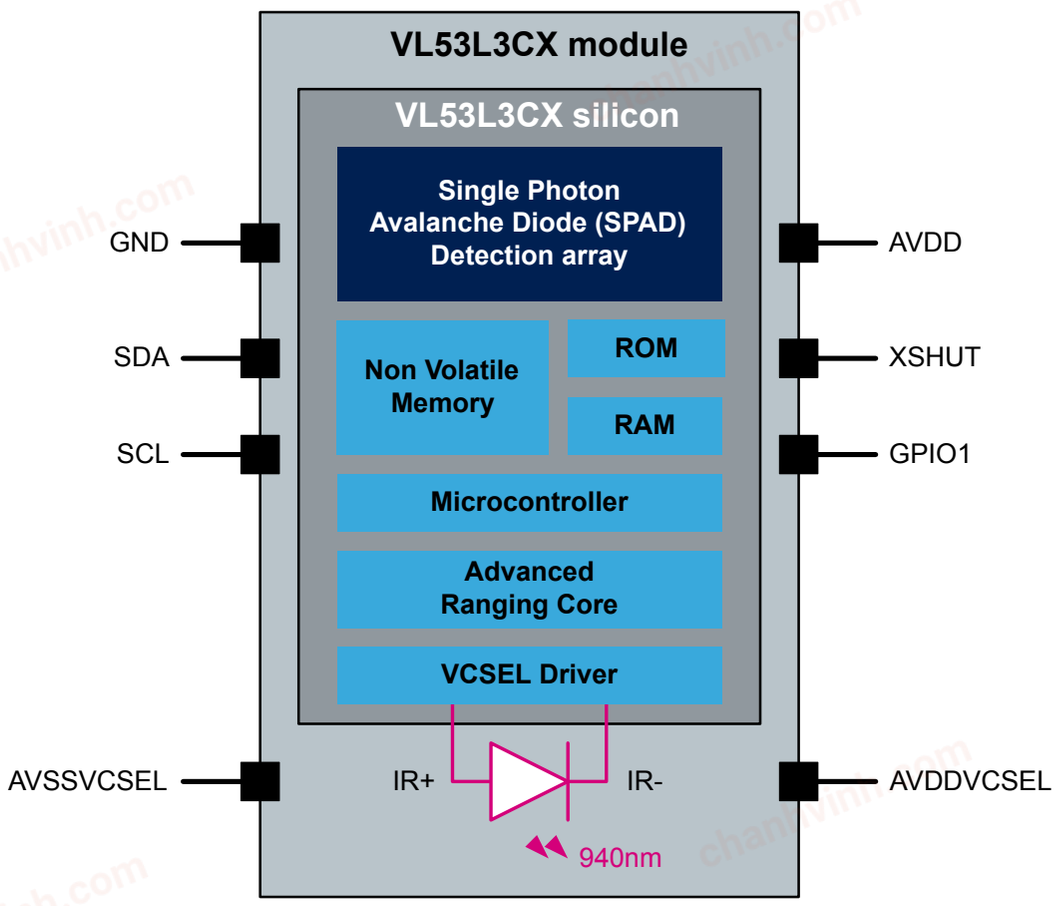
2.1 Technical specification

Table 1. **Technical specification**

Feature	Detail
Package	Optical LGA12
Size	4.4 x 2.4 x 1 mm
Operating voltage	2.6 to 3.5 V
Operating temperature	-20 to 85°C
Infrared emitter	940 nm
I2C	Up to 1 MHz (Fast mode plus) serial bus Address: 0x52

2.2 System block diagram

Figure 1. **VL53L3CX block diagram**



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2.3 Device pinout

The figure below shows the pinout of the device.

Figure 2. Device pinout (bottom view)

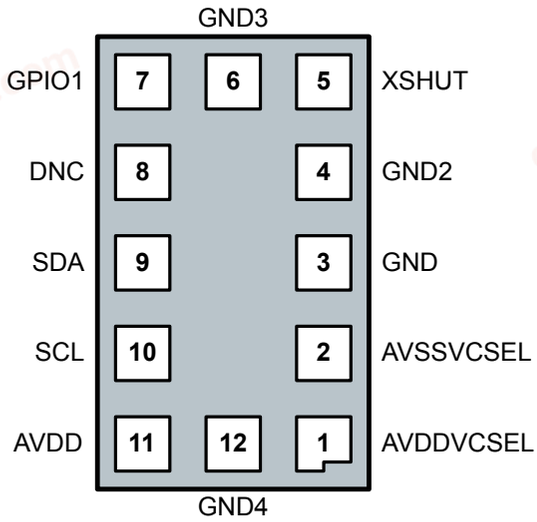


Table 2. Device pin description

Pin number	Signal name	Signal type	Signal description
1	AVDDVCSEL	Supply	VCSEL supply, to be connected to main supply
2	AVSSVCSEL	Ground	VCSEL ground, to be connected to main ground
3	GND		To be connected to main ground
4	GND2		To be connected to main ground
5	XSHUT	Digital input	Xshutdown pin, active low
6	GND3	Ground	To be connected to main ground
7	GPIO1	Digital output	Interrupt output. Open drain output
8	DNC	Digital input	Do not connect, must be left floating
9	SDA	Digital input/output	I2C serial data
10	SCL	Digital input	I2C serial clock input
11	AVDD	Supply	Supply, to be connected to main supply
12	GND4	Ground	To be connected to main ground

Note: AVSSVCSEL and GND are ground pins and can be connected together in the application schematics.

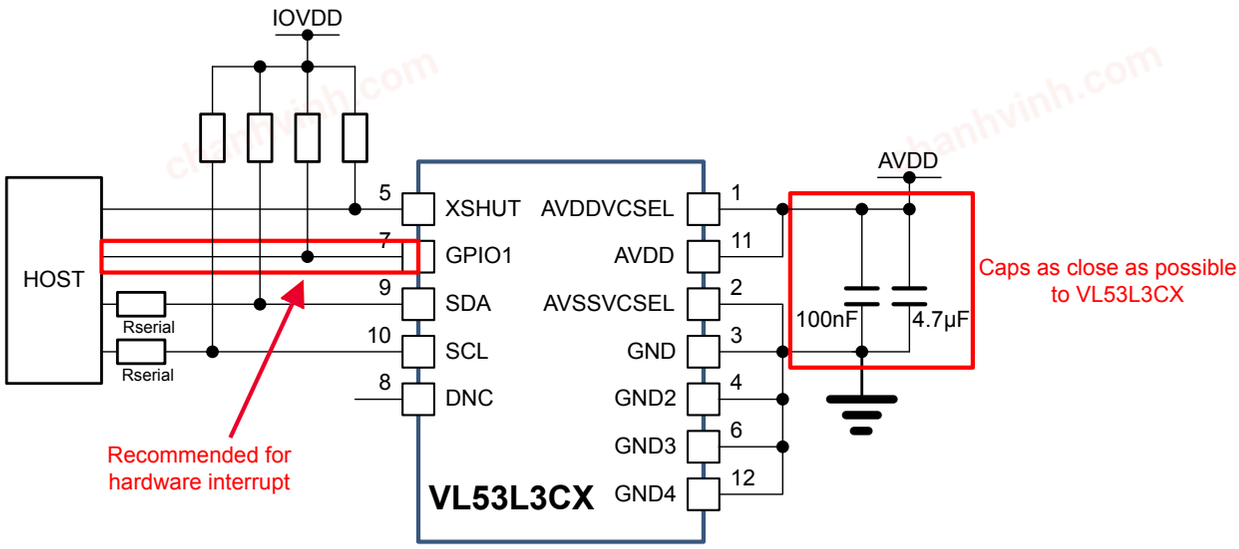
Note: GND2, GND3, and GND4 are standard pins that are forced to the ground domain in the application schematics to avoid possible instabilities if set to other states.

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2.4 Application schematic

The figure below shows the application schematic of the device.

Figure 3. VL53L3CX schematic



Note: Capacitors on the external supply AVDD should be placed as close as possible to the AVDDVCSEL and AVSSVCSEL module pins.

Note: External pull-up resistor values can be found in I2C-bus specification. Pull-ups are typically fitted only once per bus, near the host. For suggested values see tables below.

Note: XSHUT pin must always be driven to avoid leakage current. A pull-up is needed if the host state is not known. XSHUT is needed to use hardware standby mode (no I²C communication).

Note: XSHUT and GPIO1 pull-up recommended values are 10 kOhms. GPIO1 should be left unconnected if not used.

The tables below show recommended values for pull-up and series resistors for an AVDD of 1.8 V to 2.8 V in I²C fast mode (up to 400 kHz) and fast mode plus (up to 1 MHz).

Table 3. Suggested pull-up and series resistors for I²C fast mode

I²C load capacitance (C_L)	Pull-up resistor (Ohms)	Series resistor (Ohms)
$C_L \leq 90$ pF	3.6 k	0
90 pF < $C_L \leq 140$ pF	2.4 k	0
140 pF < $C_L \leq 270$ pF	1.2 k	0
270 pF < $C_L \leq 400$ pF	0.8 k	0

Table 4. Suggested pull-up and series resistors for I²C fast mode plus

I²C load capacitance (C_L)	Pull up resistor (Ohms)	Series resistor (Ohms)
$C_L \leq 90$ pF	1.5 k	100
90 pF < $C_L \leq 140$ pF	1 k	50
140 pF < $C_L \leq 270$ pF	0.5 k	50
270 pF < $C_L \leq 400$ pF	0.3 k	50

Note: For each bus line, C_L is measured in the application PCB by the customer.

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3 Functional description

3.1 System functional description

The figure below shows the system level functional description. The host customer application controls the device using an application programming interface (API). The API implementation is delivered to the customer as a driver (bare C code, or Linux driver).

The driver shares with the customer application a set of high-level functions that allow control of the device firmware like initialization, ranging start/stop, setting the system accuracy.

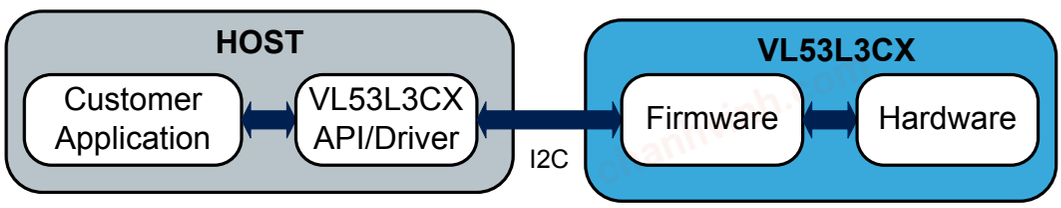
The driver is a turnkey solution consisting of a set of “C” functions. This enables fast development of end-user applications without the complication of direct multiple register access. The driver is structured so that it can be compiled on any kind of platform, through a well abstracted platform layer. The driver package allows the user to take full advantage of the device capabilities.

A detailed description of the driver is available in the device driver user manual.

The device firmware fully manages the hardware register accesses.

Section 3.2: State machine description details the firmware state machine.

Figure 4. VL53L3CX system functional description

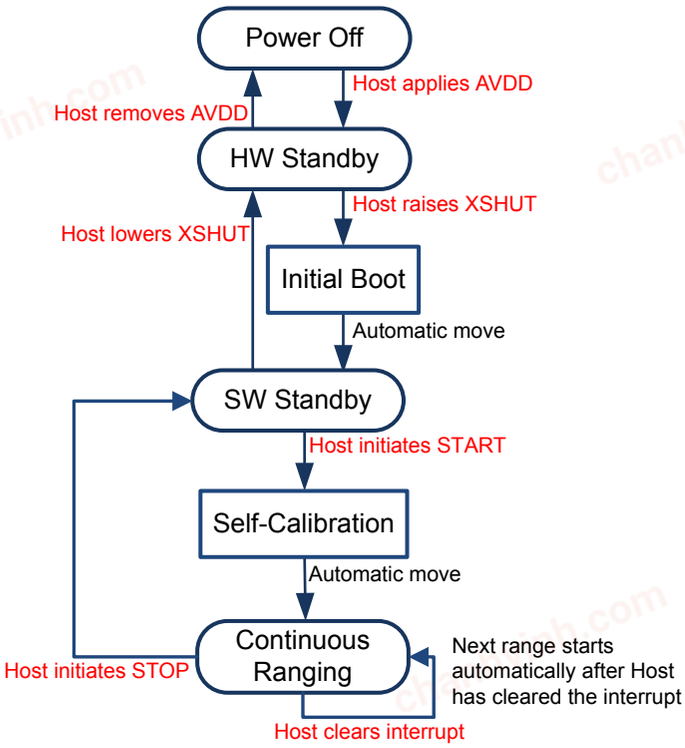


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3.2 State machine description

The figure below shows the device state machine.

Figure 5. Device state machine



3.3 Customer manufacturing calibration flow

Up to three calibrations are needed to ensure the best sensor performances. Offset and RefSpad calibration are needed in all applications. If a cover glass is used, the crosstalk calibration is needed also.

“Generic shape” crosstalk calibration is also available. In this case, part-to-part calibration is not needed and a standard set of calibration values is loaded.

The detailed procedure is provided in the device driver user manual.

3.4 Device programming and control

The VL53L3CX physical control interface is I²C, described in Section 4: Control interface.

A software layer (driver) is provided to control the device. This avoids complex I²C register operations with turnkey functions to start, stop, and read the ranging values.

The driver structure and functions are described in the device driver user manual.

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3.5 Ranging mode description

The VL53L3CX dedicated operating mode (called “preset”) is “ranging mode”. In this mode, the software driver proposes a turnkey to allow fast and easy ranging in all customer applications:

Ranging mode is the configuration to get the best of the VL53L3CX functionalities.

- Ranging mode is natively immune to cover glass crosstalk and smudge beyond 80 cm. With patented algorithms (direct ToF), a temporal filtering is possible to distinguish crosstalk from the object signal over long distances > 80 cm. A best-in-class ranging performance of 300 cm with the cover glass in place is now possible, and can be reached with any computation unlike other sensors on the market.
- Ranging mode can detect several objects concurrently within the FoV. Up to four ranges can be output simultaneously by the software driver, to indicate an object's range. Check the latest software driver manual for further details.
- Ranging operation is performed by default at 30 Hz once the driver function is called (typical ranging operation lasts 33 ms). It includes internal housekeeping, ranging, and postprocessing.

Note: Ranging mode requires a handshake between the host and the VL53L3CX, at each ranging operation. This handshake is mandatory to ensure that the right result is read by the host to continue the ranging operation.

Refer to Section 3.10: Handshake management.

3.6 Digital processing

Digital processing is the final operation of the ranging sequence that computes, validates or rejects a ranging measurement. Part of this processing is performed by the VL53L3CX internal firmware and completed on the host processor running the software driver.

At the end of digital processing, the ranging distance is computed by the VL53L3CX itself. If the distance cannot be measured (no target or weak signal), a corresponding status error code is generated and can be read by the host.

A full description of the status errors is provided inside the device driver user manual.

3.7 Reading the results

The VL53L3CX software driver provides turnkey functions to read output results after the measurement:

- Signal rate per object detected
- Ranging distance per object detected
- Min. and max. distances where the object is located

A full description is provided inside the device driver user manual.

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3.8 Power sequence

3.8.1 Power up and boot sequence

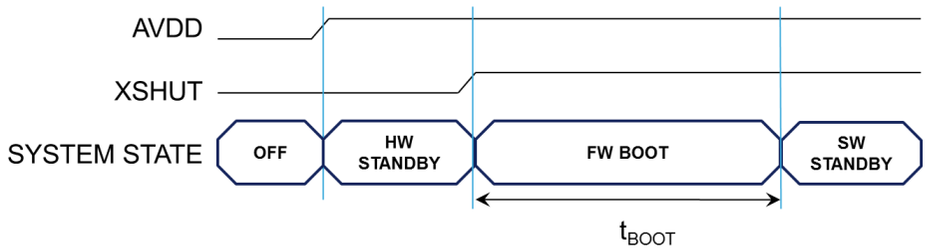
There are two options available for device power up/boot.

Option 1: The XSHUT pin is connected and controlled from the host.

This option optimizes power consumption as the device can be completely powered off when not used, and then woken up through the host GPIO (using the XSHUT pin).

Hardware standby mode is defined as the period when AVDD is present and XSHUT is low.

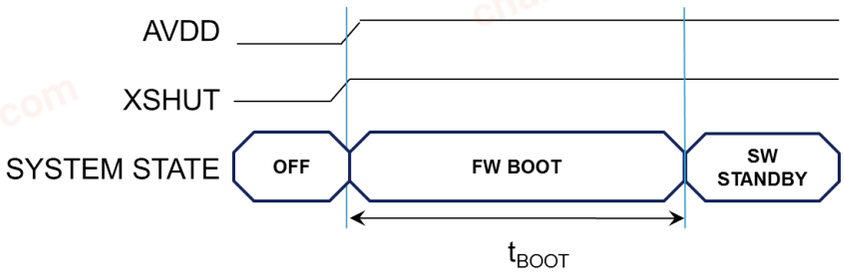
Figure 6. Power up and boot sequence



Option 2: The host does not control the XSHUT pin. It is tied to AVDD through the pull-up resistor.

When the XSHUT pin is not controlled, the power-up sequence is presented in the figure below. In this case, the device goes automatically to SW STANDBY after FW BOOT, without entering HW STANDBY.

Figure 7. Power up and boot sequence with XSHUT not controlled



Note: In both cases, t_{BOOT} is 1.2 ms max.

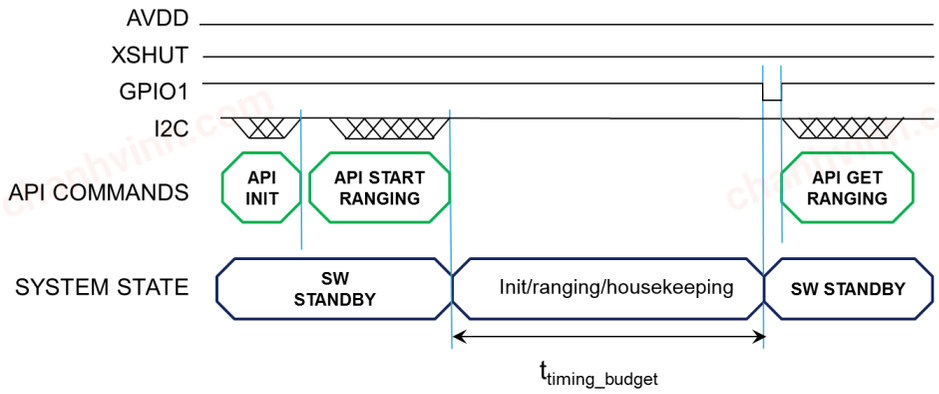
Note: In both cases, XSHUT has to be raised only when AVDD is tied on.

Note: The VL53L3CX must only exit reset when there is no existing I²C transaction taking place on the bus. That is, do not raise the XSHUT when there is an existing I²C command in progress, wait until the current I²C command has completed.

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3.9 Ranging sequence

Figure 8. Ranging sequence



3.10 Handshake management

Once a ranging measurement is available, an interrupt is generated. This is communicated to the host as a physical signal on the GPIO1 pin, which is driven low, and the output of a driver function. The former operating method is called “hardware interrupt”, and the latter is referred as “polling mode”.

Once the host reads the result, the interrupt is cleared by the driver and the ranging sequence can repeat. If the interrupt is not cleared, the ranging operation inside the VL53L3CX is on hold. The interrupt behavior allows a good synchronization between the VL53L3CX and the host, avoids losing results if the host is not available to acquire or process the data.

It is strongly recommended to use the hardware interrupt pin to manage this handshake.

For more details, refer to the device driver user manual.

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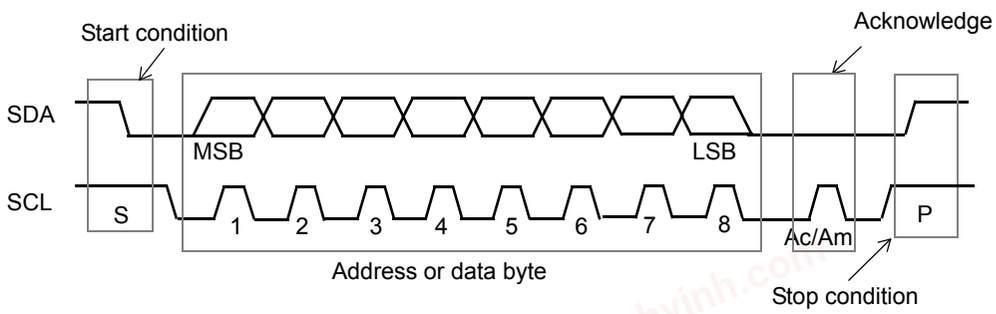
4 Control interface

This section describes the control interface. The I²C interface uses two signals: serial data line (SDA) and serial clock line (SCL). Each device connected to the bus uses a unique address and a simple controller/target relationship exists.

Both SDA and SCL lines are connected to a positive supply voltage using pull-up resistors located on the host. Lines are only actively driven low. A high condition occurs when lines are floating and the pull-up resistors pull lines up. When no data is transmitted, both lines are high.

Clock signal (SCL) generation is performed by the controller device. The controller device initiates data transfer. The I²C bus on the product device has a maximum speed of 1 Mbits/s and uses a default device address of 0x52.

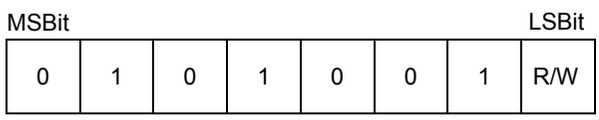
Figure 9. Data transfer protocol



Information is packed in 8-bit packets (bytes) always followed by an acknowledge bit, Ac for VL53L3CX acknowledge and Am for controller acknowledge (host bus controller). The internal data is produced by sampling SDA at a rising edge of SCL. The external data must be stable during the high period of SCL. The exceptions to this are start (S) or stop (P) conditions when SDA falls or rises respectively, while SCL is high.

A message contains a series of bytes preceded by a start condition and followed by either a stop or repeated start (another start condition but without a preceding stop condition) followed by another message. The first byte contains the device address (0x52) and also specifies the data direction. If the least significant bit is low (that is, 0x52) the message is a controller-write-to-the-target. If the LSB is set (that is, 0x53) then the message is a controller-read-from-the-target.

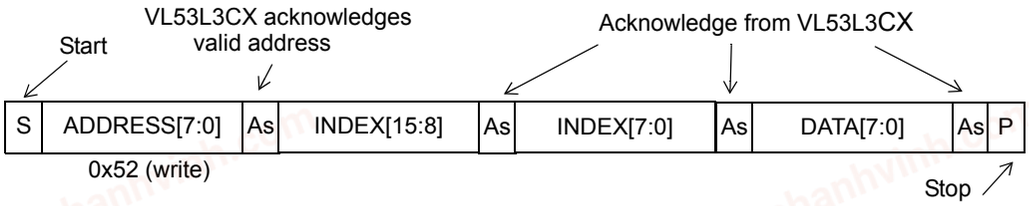
Figure 10. VL53L3CX I²C device address: 0x52



All serial interface communications with the Time-of-Flight sensor must begin with a start condition. The VL53L3CX module acknowledges the receipt of a valid address by driving the SDA wire low. The state of the read/write bit (LSB of the address byte) is stored and the next byte of data, sampled from SDA, can be interpreted. During a write sequence, the second byte received provides a 16-bit index, which points to one of the internal 8-bit registers.

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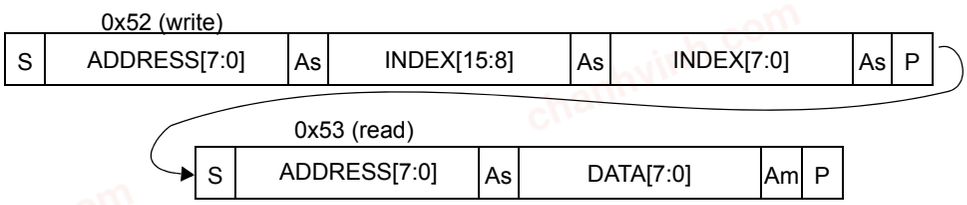
Figure 11. **VL53L3CX data format (write)**



As data are received by the target, they are written bit by bit to a serial/parallel register. After each data byte is received by the target, an acknowledge is generated. The data are then stored in the internal register addressed by the current index.

During a read message, the contents of the register addressed by the current index is read out in the byte following the device address byte. The contents of this register are parallel loaded into the serial/parallel register, and clocked out of the device by the falling edge of SCL.

Figure 12. **VL53L3CX data format (read)**

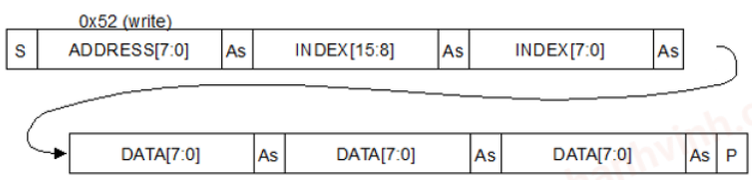


At the end of each byte, in both read and write message sequences, an acknowledge is issued by the receiving device (that is, the VL53L3CX device for a write and the host for a read).

A message can only be terminated by the bus controller, either by issuing a stop condition or by a negative acknowledge (that is, not pulling the SDA line low) after reading a complete byte during a read operation.

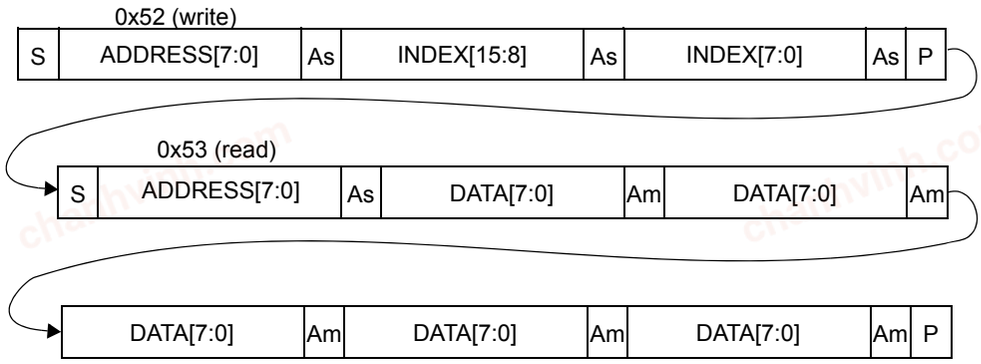
The interface also supports auto-increment indexing. After the first data byte is transferred, the index is automatically incremented by 1. The controller can therefore send data bytes continuously to the target until the target fails to provide an acknowledge, or the controller terminates the write communication with a stop condition. If the auto-increment feature is used the controller does not have to send address indexes to accompany the data bytes.

Figure 13. **VL53L3CX data format (sequential write)**



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Figure 14. **VL53L3CX data format (sequential read)**



4.1 I²C interface - timing characteristics

Timing characteristics are shown in the tables below. Refer to the figure below for an explanation of the parameters used.

Timings are given for all PVT conditions.

Table 5. **I²C interface - timing characteristics for fast mode plus (1 MHz)**

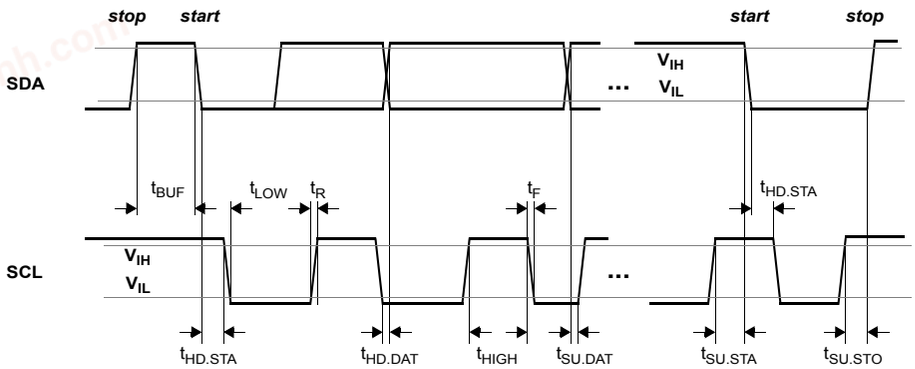
Symbol	Parameter	Minimum	Typical	Maximum	Unit
F_{I2C}	Operating frequency	0		1000	kHz
t_{LOW}	Clock pulse width low	0.5		—	µs
t_{HIGH}	Clock pulse width high	0.26		—	
t_{SP}	Pulse width of spikes that are suppressed by the input filter	—		50	ns
t_{BUF}	Bus free time between transmissions	0.5		—	µs
$t_{HD.STA}$	Start hold time	0.26		—	
$t_{SU.STA}$	Start setup time	0.26		—	
$t_{HD.DAT}$	Data in hold time	0	—	0.9	
$t_{SU.DAT}$	Data in setup time	50		—	ns
t_R	SCL/SDA rise time	—		120	
t_F	SCL/SDA fall time	—		120	
$t_{SU.STO}$	Stop setup time	0.26		—	µs
Ci/o	Input/output capacitance (SDA)	—		10	pF
Cin	Input capacitance (SCL)	—		4	
C_L	Load capacitance	—	140	550	

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Table 6. I²C interface - timing characteristics for fast mode (400 kHz)

Symbol	Parameter	Minimum	Typical	Maximum	Unit
F_{I2C}	Operating frequency	0		400	kHz
t_{LOW}	Clock pulse width low	1.3		—	µs
t_{HIGH}	Clock pulse width high	0.6		—	
t_{SP}	Pulse width of spikes that are suppressed by the input filter	—		50	ns
t_{BUF}	Bus free time between transmissions	1.3		—	µs
$t_{HD.STA}$	Start hold time	0.26		—	
$t_{SU.STA}$	Start setup time	0.26		—	
$t_{HD.DAT}$	Data in hold time	0	—	0.9	
$t_{SU.DAT}$	Data in setup time	50		—	ns
t_R	SCL/SDA rise time	—		300	
t_F	SCL/SDA fall time	—		300	
$t_{SU.STO}$	Stop setup time	0.6		—	µs
Ci/o	Input/output capacitance (SDA)	—		10	pF
Cin	Input capacitance (SCL)	—		4	
C_L	Load capacitance	—	125	400	

Figure 15. I²C timing characteristics



IL or V_{IH}.

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4.2 I²C interface - reference registers

The registers shown in the table below can be used to validate the user I²C interface.

Table 7. Reference registers

Register name	Index	Value
Model_ID	0x010F	0xEA
Module_Type	0x0110	0xAA

Note: The I²C read/write can be 8, 16, or 32 bits. Multibyte reads/writes are always addressed in ascending order with MSB first as shown in the table below. The customer must use the device software driver for easy and efficient ranging operations to match performance and accuracy criteria. Hence, full register details are not exposed. The customer should refer to the device user manual.

Table 8. 32-bit register example

Register address	Byte
Address	MSB
Address + 1	...
Address + 2	...
Address + 3	LSB

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5 Thermal characteristics

5.1 Absolute maximum rating (T_{STG})

Warning: *Stresses above those listed in the following table may cause permanent damage to the device. These are stress ratings only. Functional operation of the device is not implied at these or any other conditions above those indicated in the operational sections of the specification. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

The storage temperature (T_{STG}) is the ambient temperature at which the device can be stored with no voltage applied.

Table 9. Absolute maximum rating conditions

Parameter	Min.	Max.	Unit
Storage temperature (T_{STG})	-40	125	°C

5.2 Ambient operating temperature

The ambient operating temperature is the temperature at which the device may be powered and can operate without any damage.

Table 10. Recommended operating temperature

Parameter	Min.	Max.	Unit
Ambient operating temperature	-20	85	°C

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6 Electrical characteristics

6.1 Absolute maximum ratings

Table 11. Absolute maximum ratings

Parameter	Min.	Typ.	Max.	Unit
AVDD	-0.5	—	3.6	V
SCL, SDA, XSHUT, and GPIO1	-0.5	—	3.6	

Caution: Stresses above those listed as "Absolute maximum ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of the specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

6.2 Recommended operating conditions

Table 12. Recommended operating conditions

There are no power supply sequencing requirements. The I/Os may be high, low or floating when AVDD is applied. The I/Os are internally failsafe with no diode connecting them to AVDD

Parameter		Min.	Typ.	Max.	Unit
Voltage (AVDD)		2.6	2.8	3.5	V
IO (IOVDD) (1)	Standard mode	1.6	1.8	1.9	
	2V8 mode (2)	2.6	2.8	3.5	

1. *XSHUT should be high level only when AVDD is on.*
2. *SDA, SCL, XSHUT and GPIO1 high levels have to be equal to AVDD in 2V8 mode.*

6.3 Electrostatic discharge

The device is compliant with the electrostatic discharge (ESD) values presented in the table below.

Table 13. ESD performances

Parameter	Specification	Condition
Human body model	JS-001-2012	± 2 kV, 1500 ohms, 100 pF
Charged device model	JESD22-C101	± 500 V

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6.4 Current consumption

Table 14. Power consumption at ambient temperature

All current consumption values include silicon process variations. Temperature and voltage are nominal conditions (23°C and 2v8). All values include AVDD and AVDDVCSEL.

Parameter	Min.	Typ.	Max.	Unit
HW STANDBY	3	5	7	µA
SW STANDBY (2V8 mode) (1)	4	6	9	
Active ranging average consumption (including VCSEL) (2) (3)		16	18	mA

1. *In standard mode (1v8), pullups have to be modified, then SW STANDBY consumption is increased by 0.6 µA.*
2. *Active ranging is an average value, measured using default driver settings. Ranging mode is with default settings.*
3. *Peak current (including VCSEL) can reach 40 mA.*

6.5 Digital input and output

Symbol	Parameter	Min.	Typ.	Max.	Unit
Interrupt pin (GPIO1)					
V_{IL}	Low level input voltage	—	—	0.3 IOVDD	V
V_{IH}	High level input voltage	0.7 IOVDD		—	
V_{OL}	Low level output voltage (I_{OUT} = 4 mA)	—		0.4	
V_{OH}	High level output voltage (I_{OUT} = 4 mA)	IOVDD-0.4		—	
F_{GPIO}	Operating frequency (C_{LOAD} = 20 pF)	0		108	MHz
I2C interface (SDA/SCL)					
V_{IL}	Low level input voltage	-0.5	—	0.6	V
V_{IH}	High level input voltage	1.12		3.5	
V_{OL}	Low level output voltage (I_{OUT} = 4 mA)	—		0.4	
$I_{IL/IH}$	Leakage current (1)	—		10	µA
	Leakage current (2)	—		0.15	

1. *AVDD = 0 V*
2. *AVDD = 2.85 V; I/O voltage = 1.8 V*

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7 Ranging performances

7.1 Measurement conditions

In all measurement tables of the document, it is considered that:

1. The full FoV is covered (typically 25° is covered).
2. Charts used as targets are: gray (17% reflectance, N4.74 Munsell) and white (88% reflectance N9.5 Munsell).
3. Nominal voltage (2.8 V) and temperature (23°C)
4. The device is controlled through the driver using the default settings (refer to the user manual for driver settings description).
5. Indoor (no IR) means that there is no contribution of light in the band 940 nm ± 30 nm. Outdoor overcast conditions mean an illumination level of 0.7 W/m² back on the sensor, in the band 940 nm ± 30 nm.
6. No cover glass is present.
7. Typical samples used.

7.2 Minimum ranging distance

A target can be detected down to 10 mm.

7.3 Maximum ranging distance

The table below shows the ranging specification for the typical device bare module, without cover glass, at room temperature (23°C), with nominal voltage (2.8 V), and full FoV covered.

Table 15. Maximum ranging capabilities with 30 ms timing budget

Target reflectance level, full FoV (reflectance %)	Indoor (detection rate %)	Outdoor overcast (detection rate %)
White target (88%)	Typical: 310 cm @ 94% min. Minimum: 310 cm @ 50% min.	Typical: 100 cm @ 94% min. Minimum: 110 cm @ 50% min.
Light gray target (54%)	Typical: 290 cm @ 94% min. Minimum: 290 cm @ 50% min.	Typical: 70 cm @ 94% min. Minimum: 90 cm @ 50% min.
Gray target (17%)	Typical: 170 cm @ 94% min. Minimum: 200 cm@ 50% min.	Typical: 70 cm @ 94% min. Minimum: 90 cm @ 50% min.

Note: In the table above:

- "Indoor" corresponds to no infrared
- "Outdoor overcast" corresponds to a parasitic noise of 10 kcps/SPAD for the device module. For reference, this corresponds to a 1.2 W/m^2 at 940 nm and is equivalent to 5 kLux daylight while ranging on a grey 17% chart at 40 cm.
- Detection rate is the worst case percentage of measurements that return a valid measurement.
- The ranging distances reported are the ones reported by the driver by the parameter called RangeMilliMeter.

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7.4 Ranging accuracy

Ranging accuracy is defined as follows:

$$RangingAccuracy = \frac{RangeMilliMeter - TargetDistance}{TargetDistance} \times 100$$

The ranging accuracy is a direct evaluation of the measurement, including offset errors and output noise.

At least 94% of the ranging values are within the declared ranges. This quality indicator includes measure-to-measure and part-to-part dispersion.

Table 16. Ranging accuracy with 30 ms timing budget

Target reflectance level, full FoV	Distance (mm)	Indoor (no infrared)	Outdoor overcast
White target (88%)	25-90	±10 mm	±10 mm
	90-110	±5%	±9%
	>110	±2.5%	±7%
Light gray target (54.5%)	25-90	±9 mm	±9 mm
	90-110	±5%	±7%
	>110	±3%	±8%
Gray target (17%)	25-90	±7 mm	±7 mm
	90-110	±5%	±8%
	>110	±5%	±10%

Measurement conditions:

- Offset correction made at 10 cm from sensor
- Indoor: no infrared
- Outdoor: eq. 5 kLux equivalent sunlight (10 kcps/SPAD)
- Nominal voltage (2v8) and temperature (23°C)
- All distances are for a complete FoV covered
- Measurement is made on typical device bare modules

7.5 Ranging drift with temperature

When the temperature increases, the ranging value is affected by an offset of 1.3 mm per degree Celsius change.

This value is an offset and not a gain, and it does not depend on the target distance.

The VL53L3CX device embeds a feature that allows the temperature variation effect to be compensated while ranging.

When the ranging is started, the self-calibration is performed once and this allows the ranging drift to be removed.

To get the best accuracy performances, it is recommended to perform a self-calibration when temperature varies. This operation is realized calling in sequence the functions “stop” and “start”.

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8 Outline drawings

ST delivers any of the two alternative dual source cap assemblies as detailed in the drawings below. Both versions are transparent for the customer, since the pad and substrate design are identical for both versions and have no impact on customer PCB design. Ranging performances, reflow, and technical parameters are identical for both module designs presented in the second figure below.

Note: The module drawings below are based on the DM00392521 revision 8.0.

Figure 16. Outline drawing 1/5

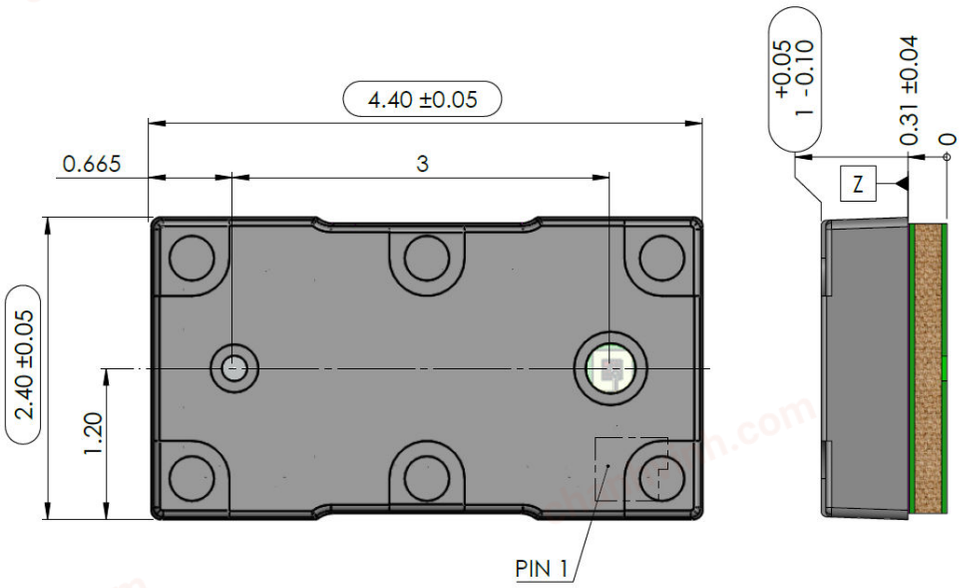
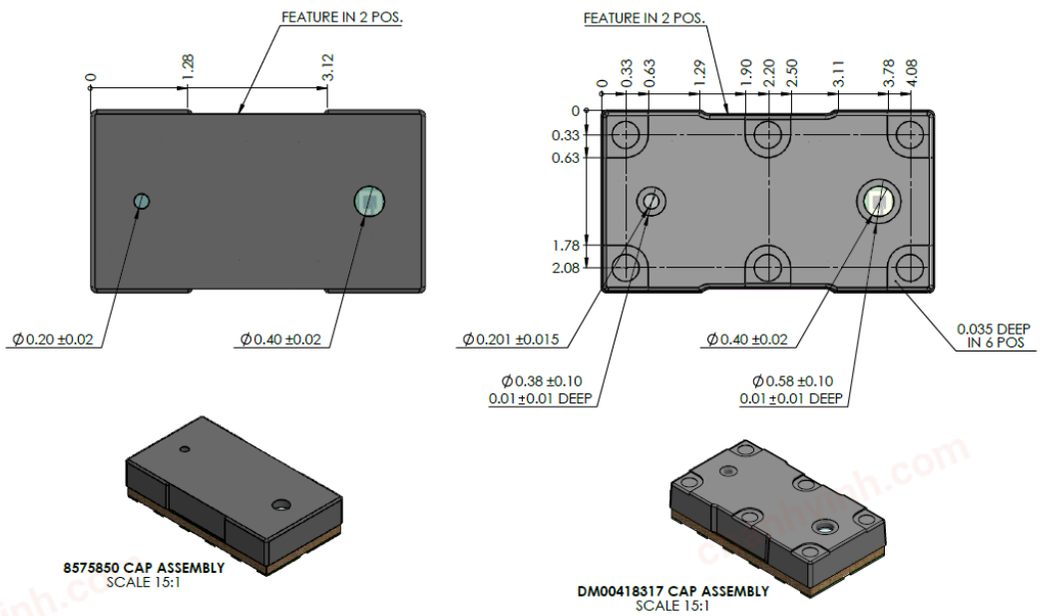
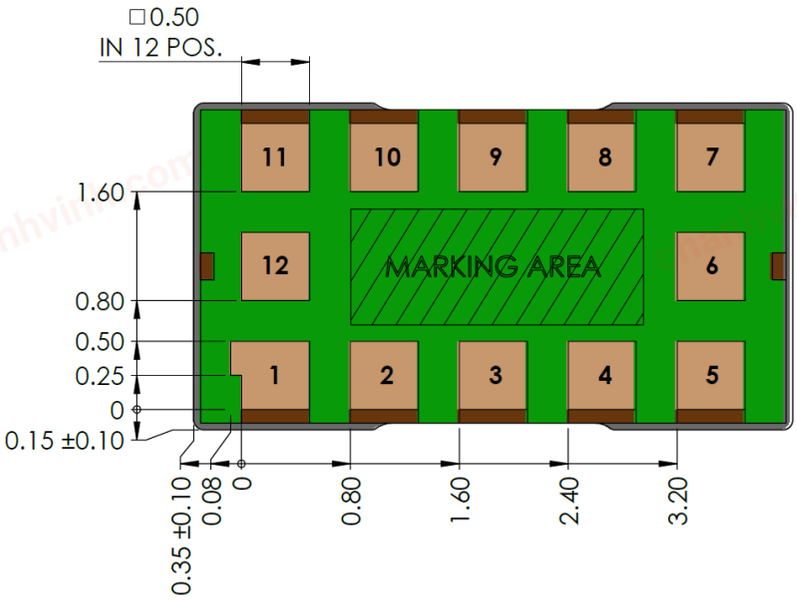


Figure 17. Outline drawing 2/5



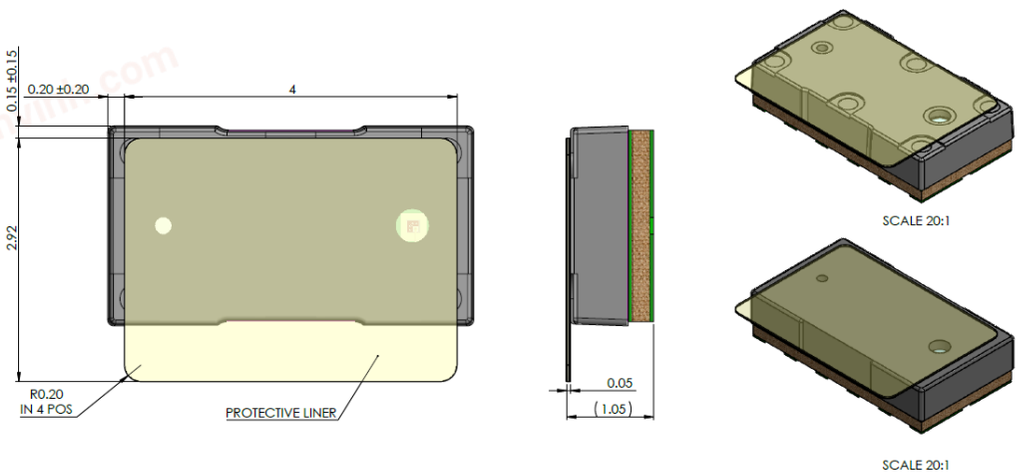
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Figure 18. **Outline drawing 3/5**



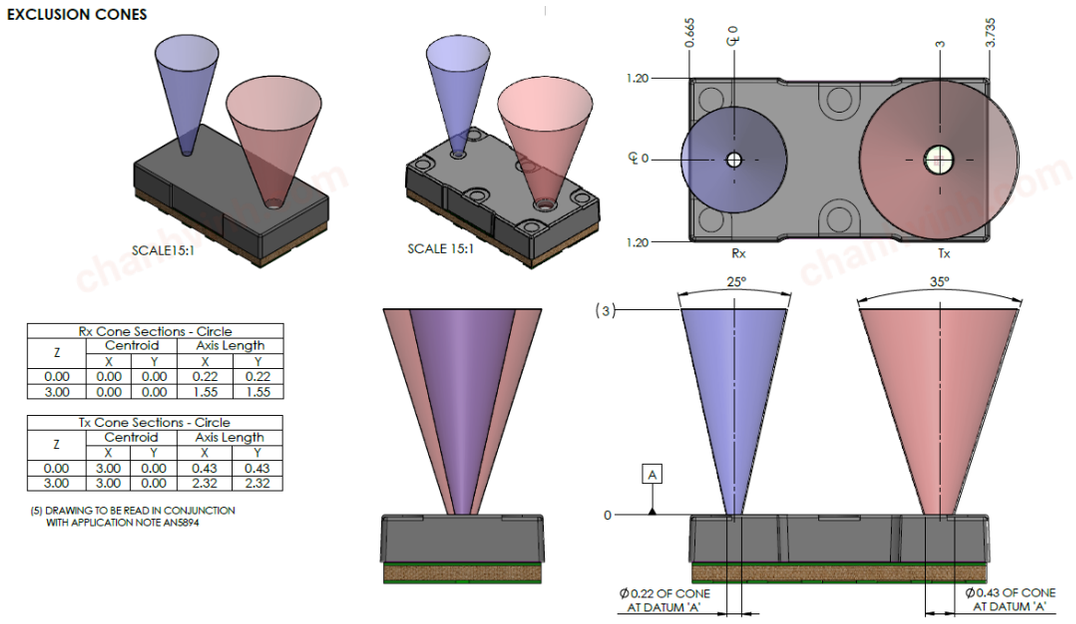
Note: For more information on the above figure, refer to Table 2. Device pin description.

Figure 19. **Outline drawing - option with liner (4/5)**



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Figure 20. **Outline drawing 5/5**



Rx Cone Sections - Circle				
Z	Centroid		Axis Length	
	X	Y	X	Y
0.00	0.00	0.00	0.22	0.22
3.00	0.00	0.00	1.55	1.55

Tx Cone Sections - Circle				
Z	Centroid		Axis Length	
	X	Y	X	Y
0.00	3.00	0.00	0.43	0.43
3.00	3.00	0.00	2.32	2.32

(5) DRAWING TO BE READ IN CONJUNCTION WITH APPLICATION NOTE AN5894

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9 Laser safety

This product contains a laser emitter and corresponding drive circuitry. The laser output is designed to meet Class 1 laser safety limits under all reasonably foreseeable conditions including single faults in compliance with IEC 60825-1:2014.

Do not increase the laser output power by any means. Do not use any optics to focus the laser beam.

Caution: Use of controls or adjustments, or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Figure 21. Class 1 laser label



This product complies with:

- IEC 60825-1:2014
- 21 CFR 1040.10 and 1040.11, except for conformance with IEC 60825-1:2014 as described in the laser notice number 56, dated May 8, 2019.
- EN 60825-1:2014 including EN 60825-1:2014/A11:2021
- EN 50689:2021, however STMicroelectronics does not guarantee compliance with the requirement of clause 5 from EN50689 regarding child appealing products. If designing a child appealing product, contact STMicroelectronics' technical application support.

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10 Packing and labeling

10.1 Product marking

A two-line product marking is applied on the backside of the module (i.e. on the substrate). The first line is the silicon product code, and the second line is the internal tracking code.

10.2 Inner box labeling

The labeling follows the ST standard packing acceptance specification.

The following information is written on the inner box label:

- Assembly site
- Sales type
- Quantity
- Trace code
- Marking
- Bulk ID number

10.3 Packing

At customer/subcontractor level, it is recommended to mount the device in a clean environment to avoid foreign material deposition.

To help avoid any foreign material contamination at product assembly level, the modules are shipped in a tape and reel format, starting from production version (cut1.1). The tape is described in the Section 10.4: Tape outline drawing.

The packing is vacuum-sealed and includes a desiccant.

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10.4 Tape outline drawing

The pictures below show the tape outline drawings for modules without and with liner. The pin1 of the module is referenced by a red star in the figures.

Figure 22. Tape outline drawing - option modules without liner

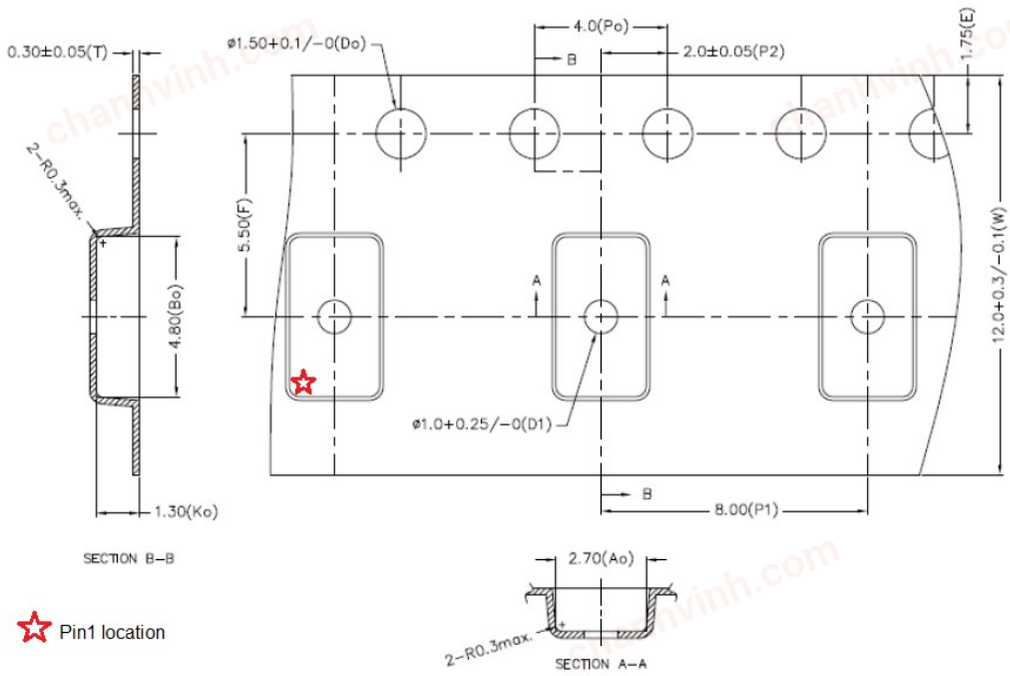
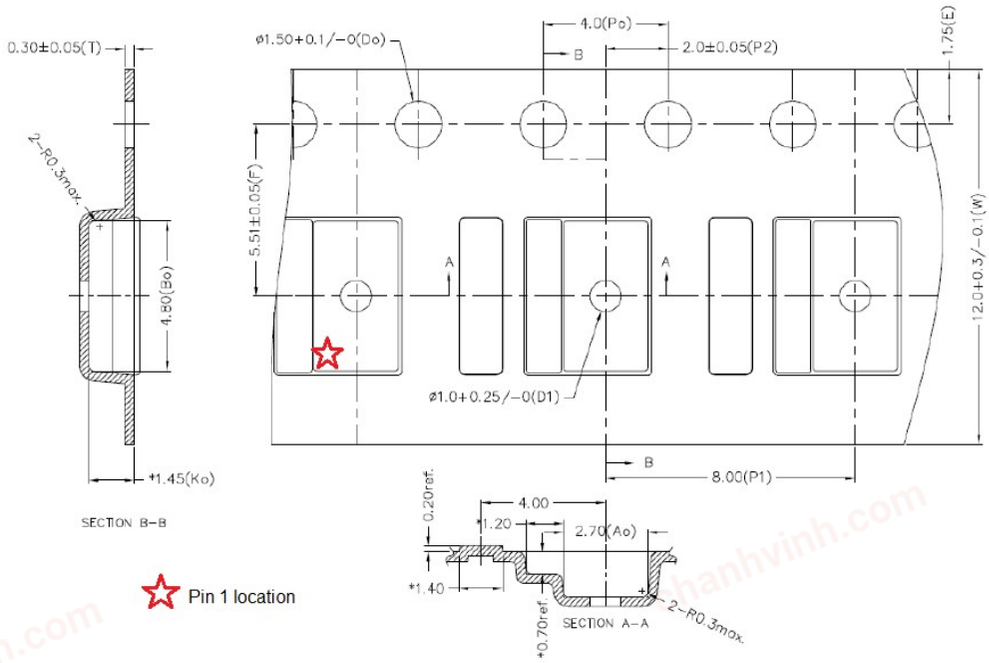


Figure 23. Tape outline drawing - option modules with liner



Caution: For sensors with the liner option, the liner must be removed during assembly of the customer device, just before mounting the cover glass. The liner is compliant with a reflow at 260°C (as per JEDEC-JSTD-020-C).

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11 Handling, moisture, and reflow precautions

11.1 Shock precaution

Sensor modules house numerous internal components that are susceptible to shock damage. If a unit is subject to excessive shock, is dropped on the floor, or a tray/reel of units is dropped on the floor, it must be rejected, even if no apparent damage is visible.

11.2 Part handling

Handling must be done with nonmarring ESD safe carbon, plastic, or teflon tweezers. Ranging modules are susceptible to damage or contamination. The customer is advised to use a clean assembly process after removing the tape from the parts, and until a protective cover glass is mounted.

11.3 Compression force

A maximum compressive load of 25 N should be applied on the module.

11.4 Moisture sensitivity level

Moisture sensitivity is level 3 (MSL) as described in JEDEC JSTD-020-C.

For devices that are classified to the levels defined in JEDEC JSTD-020-C, JEDEC JSTD-033-C provides:

- Manufacturers and users with standardized methods for handling, packing, and shipping.
- Standardized methods for using moisture/reflow and process sensitive devices.

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11.5 Pb-free solder reflow process

The figure and table below show the recommended and maximum values for the solder profile.

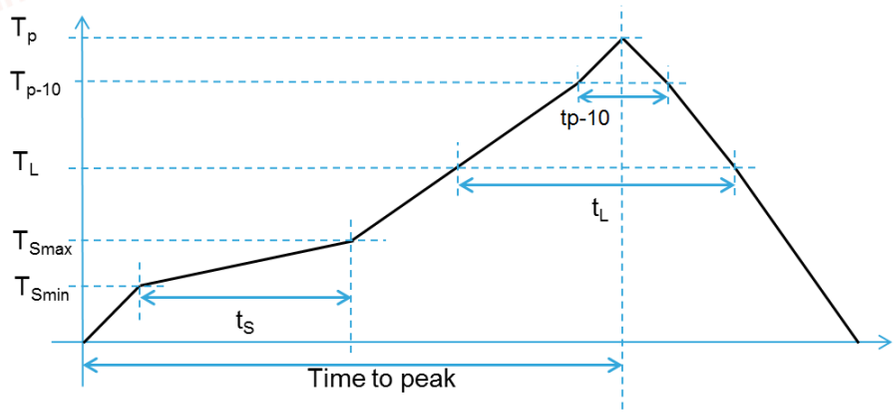
Customers have to tune the reflow profile depending on the PCB, solder paste, and material used. Customers must follow the “recommended” reflow profile, which is specifically tuned for this specific device package.

If a customer must perform a reflow profile which is different from the “recommended” one (especially peak >240°C), this new profile is qualified by the customer at their own risk. In any case, the profile must be within the “maximum” profile limit described in JEDEC JSTD-020-C and in the table below.

Table 17. Recommended solder profile

Parameters	Recommended	Maximum	Units
Minimum temperature (T_S min)	130	150	°C
Maximum temperature (T_S max)	200	200	°C
Time t_S (T_S min to T_S max)	90-110	60 - 120	s
Temperature (T_L)	217	217	°C
Time (t_L)	55-65	55 - 65	s
Ramp up	2	3	°C/s
Temperature (T_{p-10})	—	250	°C
Time (t_{p-10})	—	10	s
Ramp up	—	3	°C/s
Peak temperature (T_p)	240	260 max	°C
Time to peak	300	300	s
Ramp down (peak to T_L)	-4	-6	°C/s

Figure 24. Solder profile



Note: The temperature mentioned in the above table is measured at the top of the device package.

Note: The component is limited to a maximum of three passes through this solder profile.

Note: As the device package is not sealed, only a dry re-flow process should be used (such as convection re-flow). Vapor phase re-flow is not suitable for this type of optical component.

Note: The device is an optical component and as such, it should be treated carefully. This would typically include using a ‘no-wash’ assembly process.

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12 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

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13 Ordering information

Table 18. **Order codes**

Order codes	Package	Packing	Minimum order quantity
VL53L3CXV0DH/1	Optical LGA12 with liner	Tape and reel	4500 pcs
VL53L3CXV9DH/1	Optical LGA12 without liner	Tape and reel	4500 pcs

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Revision history

Table 19. **Document revision history**

Date	Version	Changes
20-Dec-2019	1	Initial release
07-Feb-2020	2	Updated "Application" and "Description" on the first page, and updated the following sections: Section 7.2: Minimum ranging distance, Section 7.3: Maximum ranging distance, and Section 7.4: Ranging accuracy.
11-Mar-2021	3	Updated Figure Example of prototype marking.
13-Oct-2021	4	Section 4: Control interface: replaced “camera module” with “Time-of-Flight” sensor.
18-Mar-2022	5	Updated Section 10.4: Tape outline drawing.
29-Jun-2022	6	Updated: Figure 13. VL53L3CX data format (sequential write).
12-Mar-2024	7	Updated V_{IH} max in Section 6.5: Digital input and output. Section 8: Outline drawings: updated existing figures, added Figure 19. Outline drawing - option with liner (4/5), and added two notes. Updated Section 9: Laser safety. Section 11.2: Part handling: updated text to include information about option with liner. Table 18. Order codes: added order code VL53L3CXV9DH/1.
25-Apr-2024	8	Modified Section 10.1: Product marking. Modified Section 10.4: Tape outline drawing.
12-Aug-2024	9	Updated master/slave to controller/target. Added Section 5: Thermal characteristics, including AMR with maximum at 125°C. Section 6.2: Recommended operating conditions: Removed ambient temperature data. Updated Section 10: Packing and labeling. Removed "Storage temperature and conditions". Renamed Section 11: Handling, moisture, and reflow precautions. Updated Section 11.2: Part handling. Updated Section 11.4: Moisture sensitivity level. Added reference to JEDEC JSTD-020-C in Section 11.5: Pb-free solder reflow process.

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