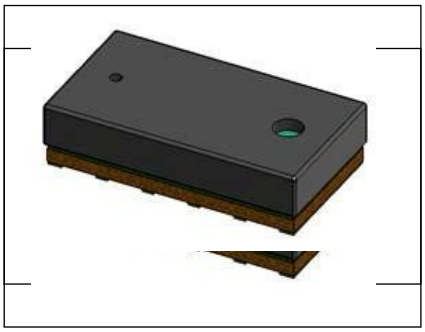
VL53L0X

World smallest Time-of-Flight ranging and gesture detection sensor
世界上最小的飞行时间测距和姿态检测传感器

Datasheet - production data



Applications
应用程序

Features
特征

- Fully integrated miniature module
- 完全集成的微型模块
  - 940nm Laser VCSEL
  - 940 纳米激光垂直腔面发射激光器
  - VCSEL driver
  - VCSEL 驱动器
  - Ranging sensor with advanced embedded micro controller
  - 具有先进嵌入式微控制器的测距传感器
  - 4.4 x 2.4 x 1.0mm
  - 4.4 x 2.4 x 1.0 毫米
- Fast, accurate distance ranging
- 快速、精确的测距
  - Measures absolute range up to 2m
  - 测量最高 2 米的绝对范围
  - Reported range is independent of the target reflectance
  - 报告的范围与目标反射率无关
  - Operates in high infrared ambient light levels
  - 在高红外环境光水平下工作
  - Advanced embedded optical cross-talk compensation to simplify cover glass selection
  - 先进的嵌入式光学串扰补偿，简化盖板玻璃选择
- Eye safe
- 眼睛安全
  - Class 1 laser device compliant with latest standard IEC 60825-1:2014 - 3rd edition
  - 符合最新标准 IEC 60825-1:2014 第三版的 1 级激光设备
- Easy integration
- 易于集成
  - Single reflowable component
  - 单个可回流元件
  - No additional optics
  - 没有附加光学器件
  - Single power supply
  - 单电源
  - I2C interface for device control and data transfer
  - 用于设备控制和数据传输的 I2C 接口
  - Xshutdown (Reset) and interrupt GPIO
  - Xshutdown(复位)并中断 GPIO
  - Programmable I2C address
  - 可编程 I2C 地址

- User detection for Personal Computers/ Laptops/Tablets and IoT (Energy saving).
- 个人电脑/笔记本电脑/平板电脑和物联网(节能)的用户检测。
- Robotics (obstacle detection).
- 机器人技术(障碍物检测)。
- White goods (hand detection in automatic faucets, soap dispensers etc...)
- 白色家电(自动水龙头、皂液器等的手部检测...)
- 1D gesture recognition.
- 1D 手势识别。
- Laser assisted Auto-Focus. Enhances and speeds-up camera AF system performance, especially in difficult scenes (low light levels, low contrast) or fast moving video mode.
- 激光辅助自动对焦。增强和加快相机自动对焦系统的性能，尤其是在困难的场景(低亮度、低对比度)或快速移动视频模式下。

Description
描述

The VL53L0X is a new generation Time-of-Flight (ToF) laser-ranging module housed in the smallest package on the market today, providing accurate distance measurement whatever the target reflectances unlike conventional technologies. It can measure absolute distances up to 2m, setting a new benchmark in ranging performance levels, opening the door to various new applications.

VL53L0X 是新一代飞行时间(ToF)激光测距模块，采用当今市场上最小的封装，与传统技术不同，无论目标反射率如何，都能提供精确的距离测量。它可以测量高达 2 米的绝对距离，在测距性能水平方面树立了新的基准，为各种新应用打开了大门。

The VL53L0X integrates a leading-edge SPAD array (Single Photon Avalanche Diodes) and embeds ST's second generation FlightSense™ patented technology.

VL53L0X 集成了前沿的 SPAD 阵列(单光子雪崩二极管)，并嵌入了 ST 的第二代 FlightSenseTM 专利技术。

The VL53L0X's 940nm VCSEL emitter (Vertical Cavity Surface-Emitting Laser), is totally invisible to the human eye, coupled with internal physical infrared filters, it enables longer ranging distance, higher immunity to ambient light and better

robustness to cover-glass optical cross-talk.

VL53L0X 的 940 纳米垂直腔面发射激光器发射器(垂直腔面发射激光器)，人眼完全看不见，加上内部的物理红外滤波器，它能够实现更长的测距距离、更高的环境光抗扰度以及对盖玻片光学串扰的更好鲁棒性。

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1.1 Technical specification
1.2 技术规范

Table 1. Technical specification

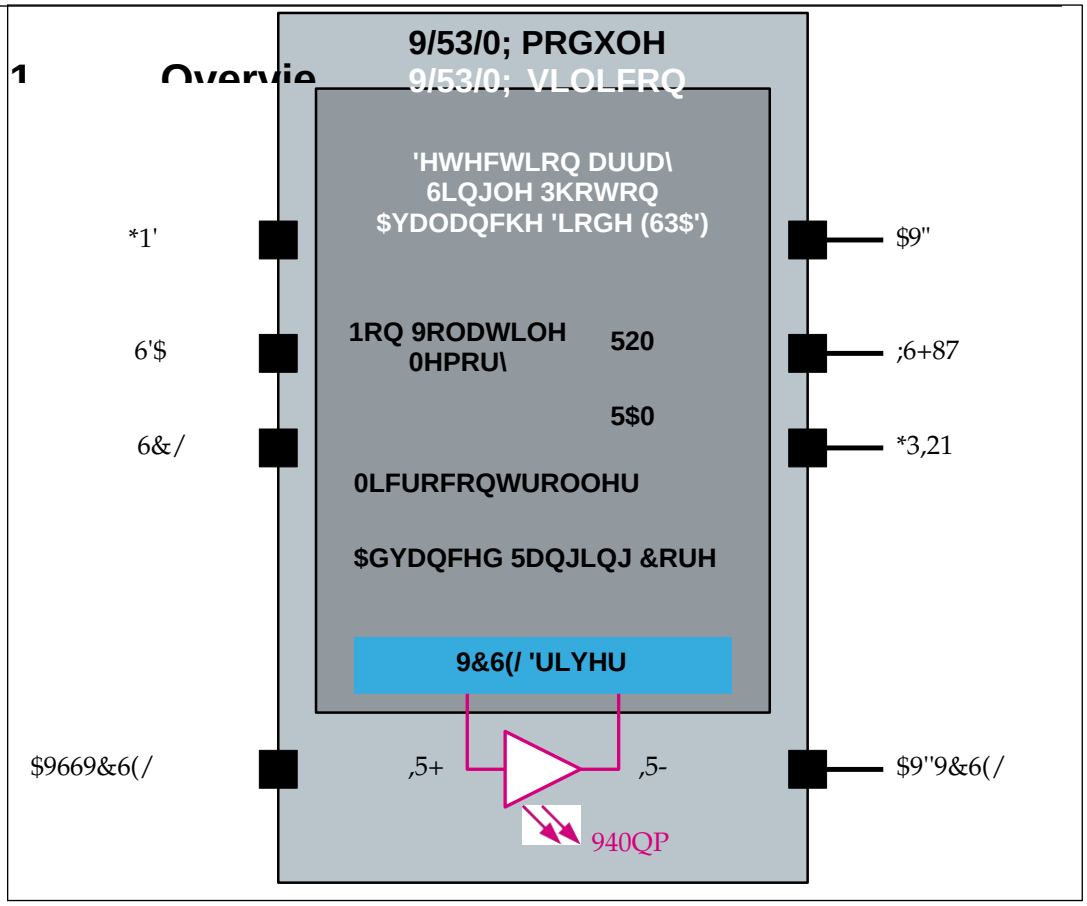
表 1。技术规范

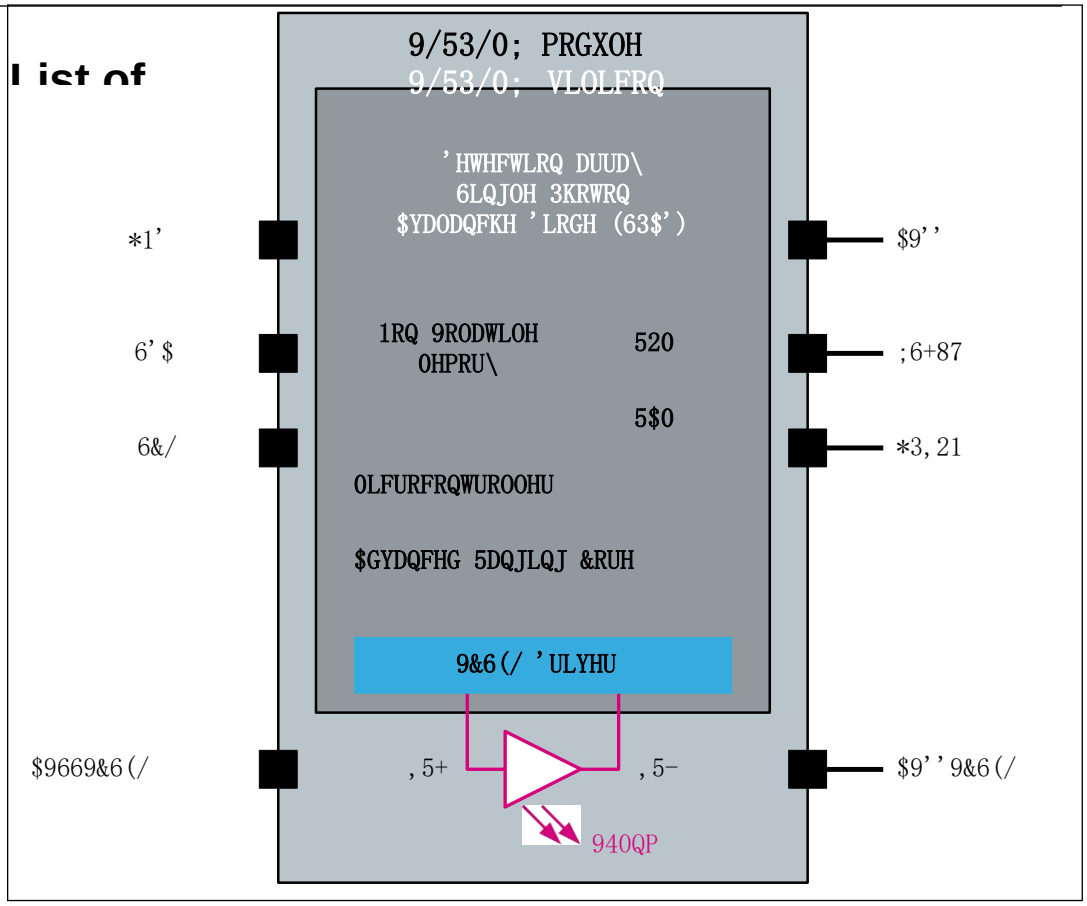
Feature	Detail
Package	Optical LGA12
Size	4.40 x 2.40 x 1.00 mm
Operating voltage	2.6 to 3.5 V
Operating temperature:	-20 to 70°C
Infrared emitter	940 nm
I^2C	Up to 400 kHz (FAST mode) serial bus Address: 0x52
特征	**详述**
包裹	光学 LGA12
大小	4.40 x 2.40 x 1.00 毫米
工作电压	2.6 至 3.5 伏
工作温度:	-20 至 70℃
红外发射器	940 牛米
I2C	最高 400 千赫(快速模式)串行总线地址:0x52

1.3 System block diagram
1.4 系统框图

Figure 1. VL53L0X block diagram

图 1。VL53L0X 框图


9/53/0; PRGXOH
9/53/0; VLOLFRQ
'HWHFWLRQ DUUD\
6LQJOH 3KRWRQ
$YDODQFKH 'LRGH (63$')
*1'
$9"
1RQ 9RODWLOH
0HPRU\
520
6'$
;6+87
5$0
6&/
*3,21
0LFURFRQWURROHU
$GYDQFHG 5DQJLQJ &RUH
9&6(/ 'ULYHU
$9669&6(/
,5+
,5-
$9''9&6(/
940QP


9/53/0; PRGXOH
9/53/0; VLOLFRQ
’HWHFWLRQ DUUD\
6LQJOH 3KRWRQ
$YDODQFKH ’LRGH (63$’)
1RQ 9RODWLOH
0HPRU\
520
5$0
OLFURFRQWURROHU
$GYDQFHG 5DQJLQJ &RUH
9&6(/ ’ULYHU
*1’
6’$
6&/
$9669&6(/
,5+
,5-
940QP
$9’’
;6+87
*3,21
$9’’9&6(/

1 Application

Figure 2 shows the pinout of the VL53L0X (see also *Figure 22*).

Figure 2 显示了 VL53L0X 的引脚排列(另请参见 *Figure 22*

Figure 2. VL53L0X pinout (bottom view)

图 2。VL53L0X 引脚排列(仰视图)

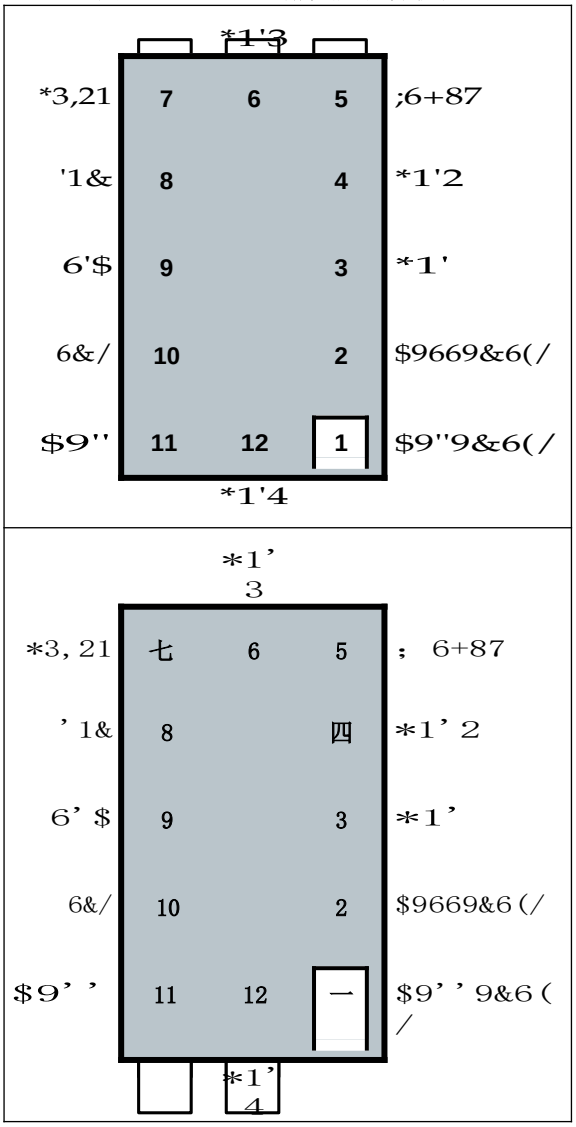


Table 2. VL53L0X pin description

表 2。VL53L0X 引脚描述

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	Ground	To be connected to main ground
4	GND2	Ground	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	I^2C serial data
10	SCL	Digital input	I^2C serial clock input
11	AVDD	Supply	Supply, to be connected to main supply
12	GND4	Ground	To be connected to main ground
插脚数	**信号名称**	**信号类型**	**信号描述**
一	AVDDVCSEL	供应	连接到主电源的垂直腔面发射激光器电源
2	AVSSVCSEL	地面	垂直腔面发射激光器地，连接到主地
3	GND	地面	连接到主接地
四	GND2	地面	连接到主接地
5	XSHUT	数字输入	Xshutdown 引脚，低电平有效
6	GND3	地面	连接到主接地
七	GPIO1	数字输出	中断输出。开漏输出。
8	昼夜能力 (Day-Night Capability)	数字输入	不连接，必须保持浮动。
9	国家药品监督管理局	数字输入/输出	I2C 串行数据
10	SCL	数字输入	I2C 串行时钟输入
11	AVDD	供应	电源，连接到主电源
12	GND4	地面	连接到主接地

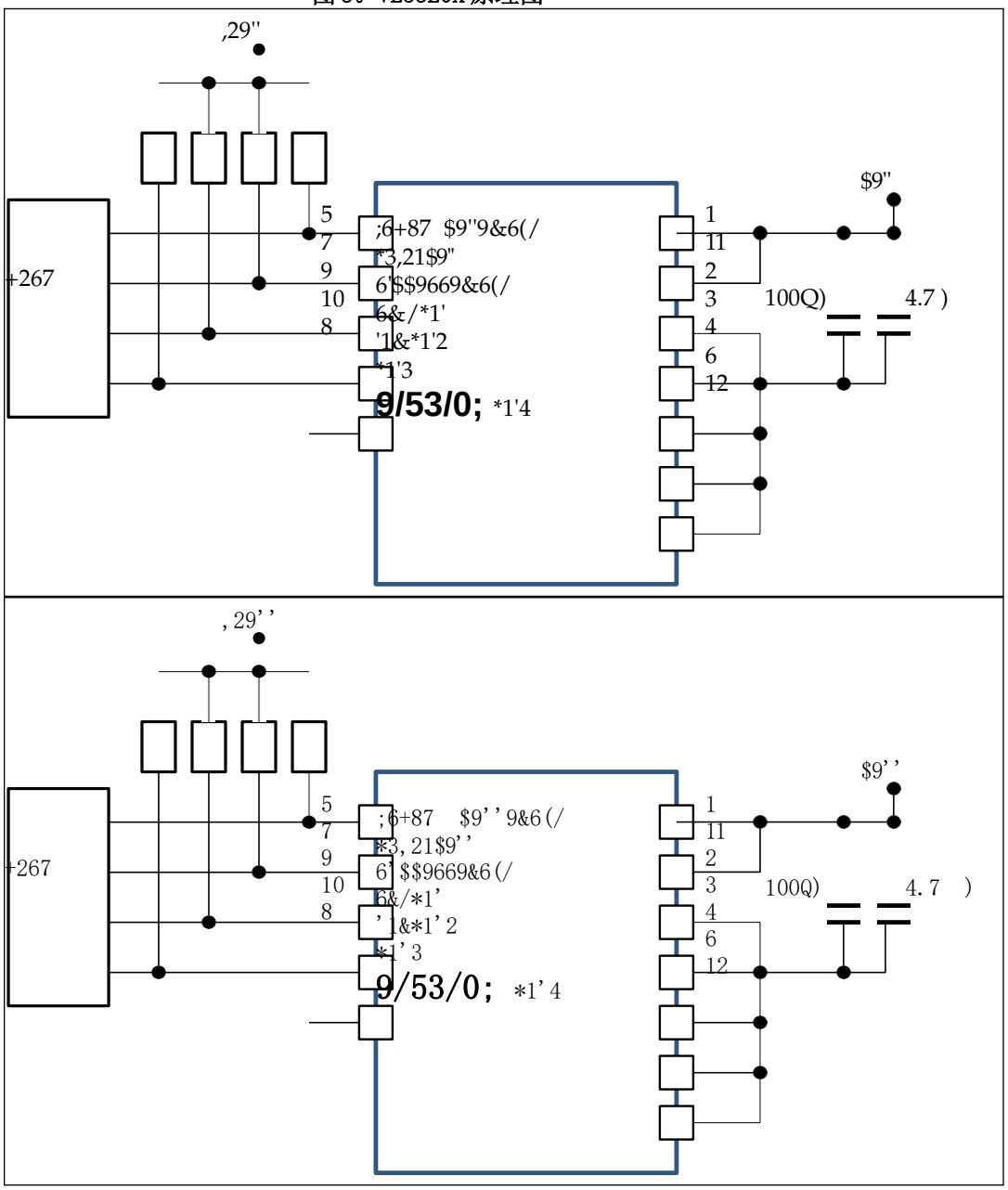
1 Application

Figure 3 shows the application schematic of the VL53L0X.

Figure 3 显示了 VL53L0X 的应用示意图。

Figure 3. VL53L0X schematic

图 3。VL53L0X 原理图



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

注:外部电源 AVDD 上的电容应尽可能靠近 AVDDVCSEL 和 AVSSVCSEL 模块引脚。

Note: External pull-up resistors values can be found in I2C-bus specification. Pull-up are typically fitted only once per bus, near the host.

注:外部上拉电阻值可以在 I2C 总线规范中找到。主机附近的每条总线通常只安装一次上拉。

Recommended values for pull-up resistors for an AVDD of 2.8V and 400KHz I^2C clock would be 1.5k to 2k Ohms.

2.8V 和 400 千赫 I2C 时钟的 AVDD 上拉电阻推荐值将是 1.5k 到 2k 欧姆。

Note: XSHUT pin must always be driven to avoid leakage current. Pull-up is needed if the host state is not known.

注意:XSHUT 引脚必须始终被驱动，以避免漏电流。如果主机状态未知，则需要上拉。

XSHUT is needed to use HW standby mode (no I^2C comm).

需要 XSHUT 来使用硬件待机模式(无 I2C 通信)。

Note: XSHUT and GPIO1 pull up recommended values are 10k Ohms

Note: GPIO1 to be left unconnected if not used

注:XSHUT 和 GPIO1 上拉推荐值为 10k 欧姆注:如果不使用，GPIO1 保持不连接

2.1 System functional description

2.2 系统功能描述

Figure 4 shows the system level functional description. The host customer application is controlling the VL53L0X device using an API (Application Programming Interface).

Figure 4 显示了系统级功能描述。主机客户应用程序正在使用应用编程接口控制 VL53L0X 设备。

The API is exposing to the customer application a set of high level functions that allows control of the VL53L0X Firmware (FW) like initialization/calibration, ranging Start/Stop, choice of accuracy, choice of ranging mode.

该应用编程接口向客户应用程序公开了一组高级功能，允许控制 VL53L0X 固件(FW)，如初始化/校准、测距启动/停止、精度选择、测距模式选择。

The API is a turnkey solution, it consists of a set of C functions which enables fast development of end user applications, without the complication of direct multiple register access. The API is structured in a way that it can be compiled on any kind of platform through a well isolated platform layer.

该应用编程接口是一个交钥匙解决方案，它由一组 C 函数组成，能够快速开发最终用户应用程序，而无需复杂的直接多寄存器访问。该应用编程接口的结构使得它可以通过隔离良好的平台层在任何类型的平台上编译。

The API package allows the user to take full benefit of VL53L0X capabilities.

应用编程接口包允许用户充分利用 VL53L0X 的功能。

A detailed description of the API is available in the VL53L0X API User Manual (separate document, DocID029105).

在 VL53L0X 应用编程接口用户手册(单独的文档，文档 029105)中提供了该应用编程接口的详细描述。

VL53L0X FW fully manages the hardware (HW) register accesses.

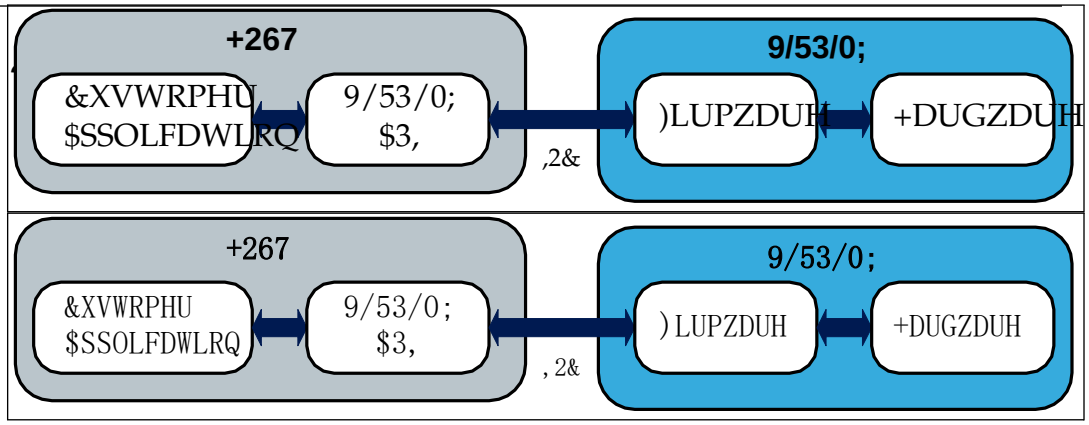
VL53L0X FW 完全管理硬件(HW)寄存器访问。

Section 2.2: Firmware state machine description details the Firmware state machine.

Section 2.2: Firmware state machine description 详细说明固件状态机。

Figure 4. VL53L0X system functional description

图 4。VL53L0X 系统功能描述


+267
&XVWRPHU
$SSOLFDWLRQ
9/53/0;
$3,
,2&
9/53/0;
)LUPZDUH
+DUGZDUH
+267
&XVWRPHU
$SSOLFDWLRQ
9/53/0;
$3,
,2&
9/53/0;
)LUPZDUH
+DUGZDUH

2.3 Firmware state machine description

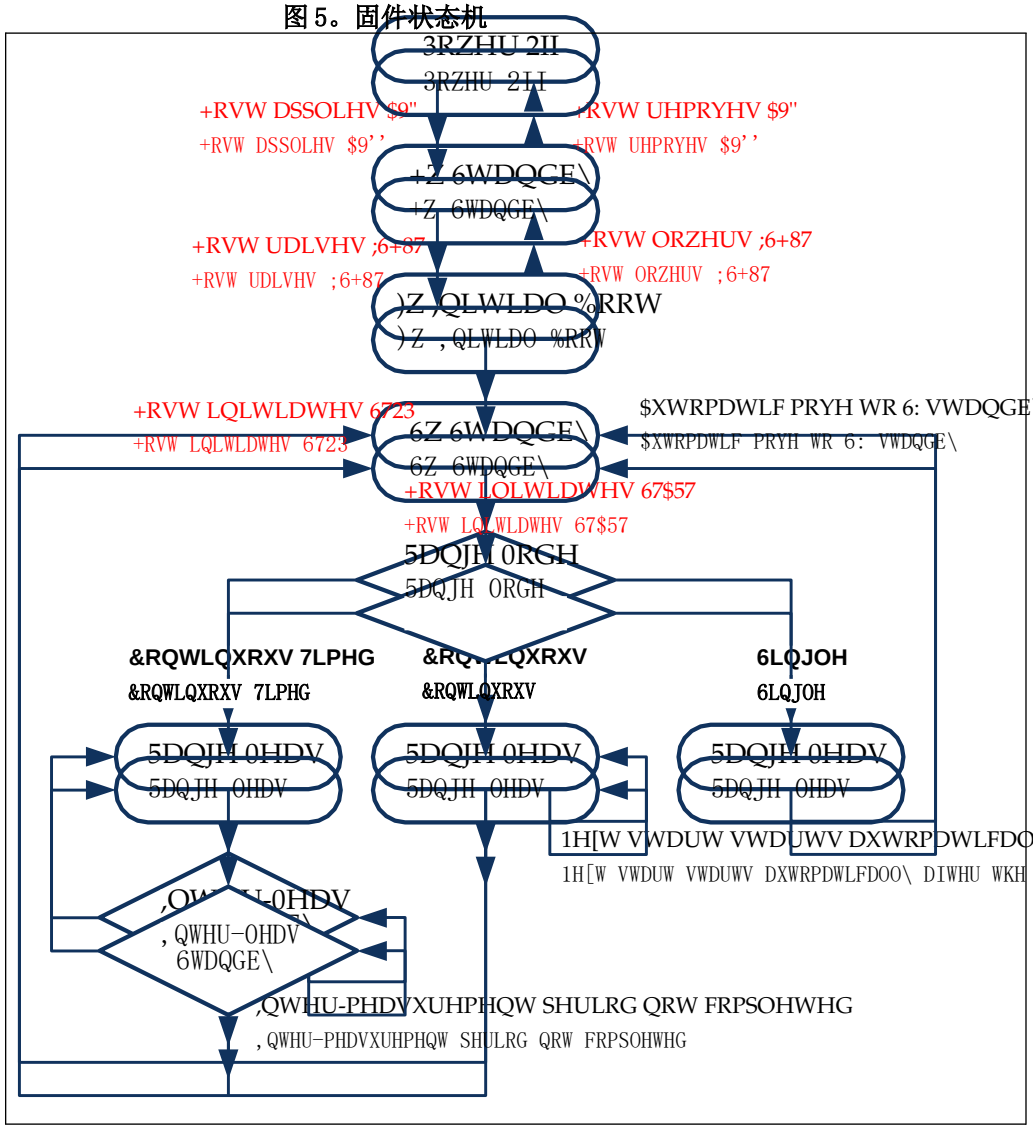
2.4 固件状态机描述

Figure 5 shows the Firmware state machine.

Figure 5 显示了固件状态机。

Figure 5. Firmware state machine

图 5。固件状态机



2 Functional

2.5 Customer manufacturing calibration flow

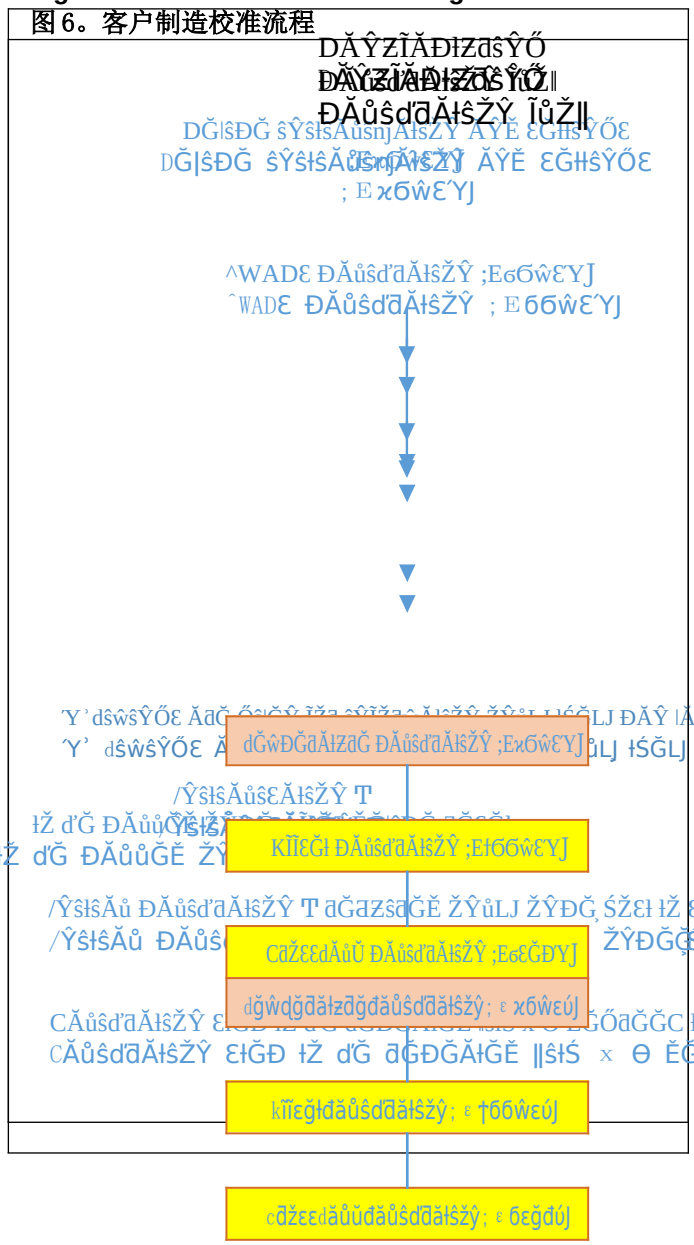
2.6 客户制造校准流程

Figure 6 shows the recommended calibration flow that should be applied at customer level, at factory, once only. This flow takes into account all parameters (cover glass, temperature & voltage) from the application.

Figure 6 显示了建议的校准流程，该流程应仅在客户层面、工厂应用一次。该流程考虑了应用中的所有参数(盖板玻璃、温度和电压)。

Figure 6. Customer manufacturing calibration flow

图 6。客户制造校准流程



2.6.1 SPAD and temperature calibration
2.6.2 SPAD 和温度校准

In order to optimize the dynamic of the system, the reference SPADs have to be calibrated. Reference SPAD calibration needs to be done only once during the initial manufacturing calibration, the calibration data should then be stored on the Host.

为了优化系统的动态特性，必须校准参考 SPADs。在初始制造校准过程中，参考 SPAD 校准只需进行一次，校准数据应存储在主机上。

Temperature calibration is the calibration of two parameters (VHV and phase cal) which are temperature dependent. These two parameters are used to set the device sensitivity.

温度校准是对与温度相关的两个参数(VHV 和相位校准)的校准。这两个参数用于设置设备灵敏度。

Calibration should be performed during initial manufacturing calibration, it must be performed again when temperature varies more than 8degC compared to the initial
校准应在初始制造校准期间进行，当温度与初始温度相比变化超过 8℃时，必须再次进行校准

calibration temperature.

校准温度。

For more details on SPAD and temperature calibration please refer to the VL53L0X API User Manual.

有关 SPAD 和温度校准的更多详细信息，请参考 VL53L0X 应用编程接口用户手册。

2.6.3 Ranging offset calibration
2.6.4 测距偏移校准

Ranging offset can be characterized by the mean offset, which is the centering of the measurement versus the real distance.

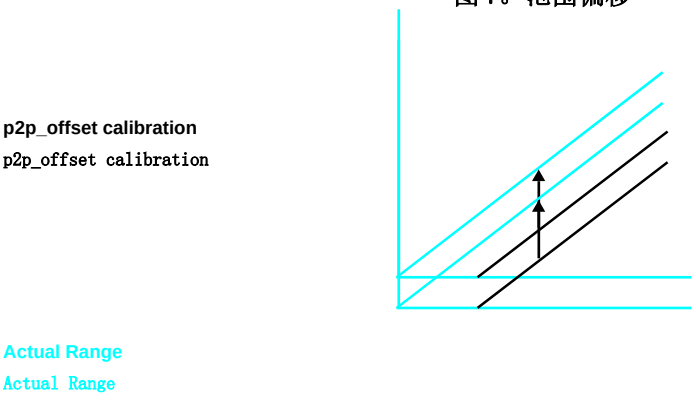
测距偏移可以通过平均偏移来表征，平均偏移是测量相对于实际距离的中心。

Offset calibration should be performed at factory for optimal performances (recommended at 10cm). The offset calibration should take into account:

偏移校准应在工厂进行，以获得最佳性能(建议在 10 厘米处)。失调校准应考虑:

- Supply voltage and temperature
- 电源电压和温度
- Protective cover glass above VL53L0X module
- VL53L0X 模块上方的保护盖玻璃

Figure 7. Range offset
图 7。范围偏移



2.6.5 Cross-talk calibration

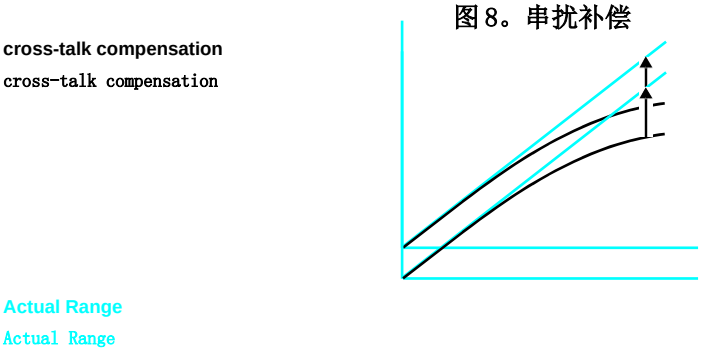
2.6.6 串扰校准

Cross-talk is defined as the signal return from the cover glass. The magnitude of the cross-talk depends on the type of glass and air gap. Cross-talk results in a range error which is proportional to the ratio of the cross-talk to the signal return from the target.

串扰被定义为从盖板玻璃返回的信号。串扰的大小取决于玻璃的类型和气隙。串扰会导致距离误差，该误差与串扰与从目标返回的信号之比成正比。

Figure 8. Cross-talk compensation

图 8。串扰补偿



Full offset and cross-talk calibration procedure is described in the VL53L0X API User Manual.

VL53L0X 应用编程接口用户手册中描述了全偏移和串扰校准程序。

2.7 Ranging operating modes
2.8 测距工作模式

There are 3 ranging modes available in the API:

API 中有 3 种测距模式:

1. Single ranging
2. 单一测距

   Ranging is performed only once after the API function is called.
   System returns to SW standby automatically.

   调用 API 函数后，测距只执行一次。系统自动返回软件待机状态。
3. Continuous ranging
4. 连续测距

   Ranging is performed in a continuous way after the API function is called. As soon as the measurement is finished, another one is started without delay.

   调用 API 函数后，以连续方式执行测距。测量一结束，立即开始另一次测量。
   User has to stop the ranging to return to SW standby. The last measurement is completed before stopping.
   用户必须停止测距才能返回软件待机状态。停止前完成最后一次测量。
5. Timed ranging
6. 定时测距

   Ranging is performed in a continuous way after the API function is called. When a measurement is finished, another one is started after a user defined delay.

   调用 API 函数后，以连续方式执行测距。测量完成后，在用户定义的延迟后，将开始另一次测量。
   This delay (inter-measurement period) can be defined through the API.

User has to stop the ranging to return to SW standby.

这个延迟(测量间隔期)可以通过应用编程接口来定义。用户必须停止测距才能返回软件待机状态。

If the stop request comes during a range measurement, the measurement is completed before stopping. If it happens during an inter-measurement period, the range measurement stops immediately.
如果在距离测量过程中出现停止请求，测量将在停止前完成。如果在测量间隔期间发生，距离测量会立即停止。

2.9 Ranging profiles
2.10 测距剖面

There are 4 different ranging profiles available via API example code. Customers can create their own ranging profile dependent on their use case performance requirements.

通过应用编程接口示例代码，有 4 种不同的测距配置文件可供使用。客户可以根据他们的用例性能需求创建自己的范围配置文件。
For more details please refer to the VL53L0X API User Manual.
更多详情请参考 VL53L0X 应用编程接口用户手册。

1. Default mode
2. 默认模式
3. High speed
4. 高速的
5. High accuracy
6. 高准确度
7. Long range
8. 远程

2.11 Ranging profile phases
2.12 测距剖面相位

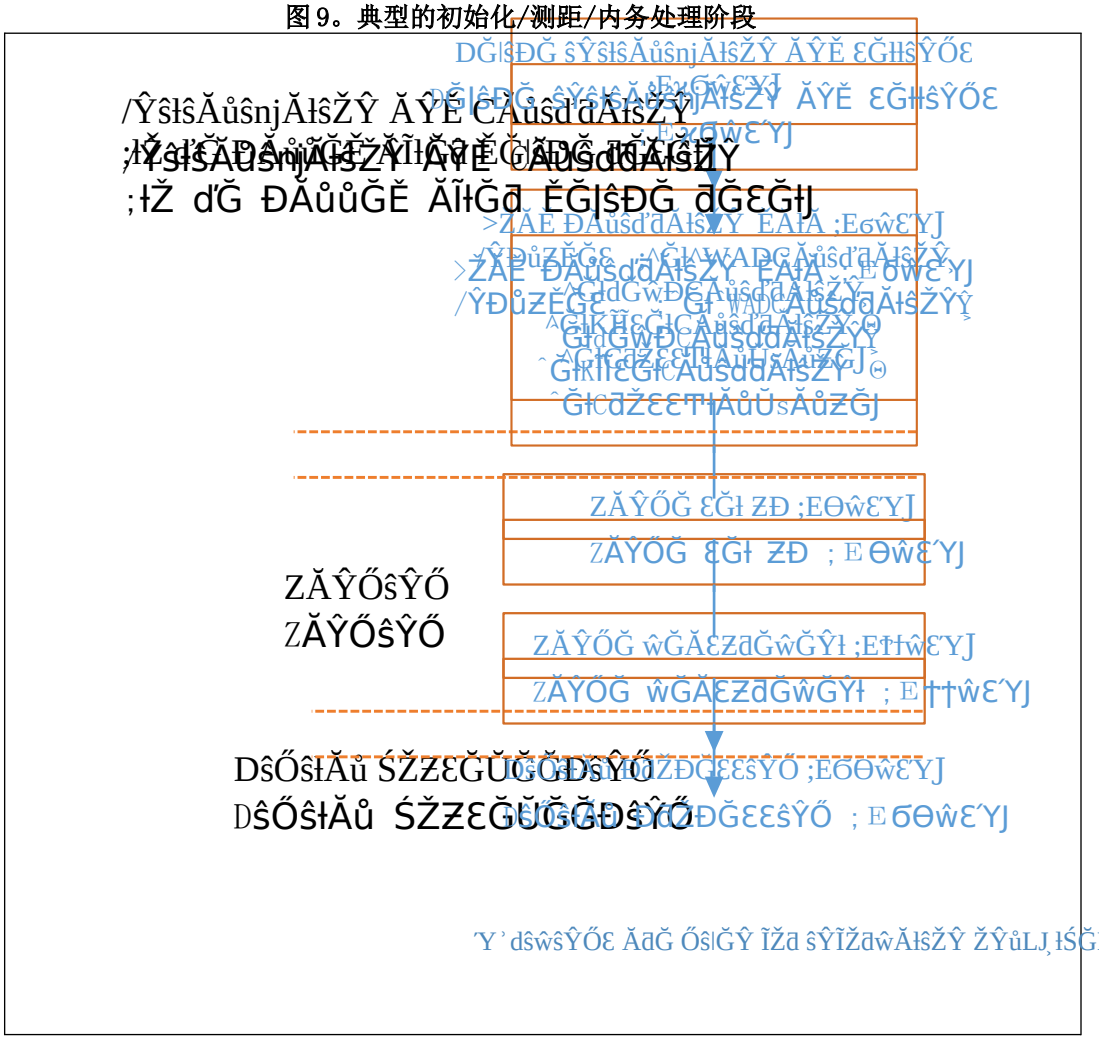
Each range profile consists of 3 consecutive phases:

每个距离剖面由 3 个连续的阶段组成：

- Initialization and load calibration data
- 初始化和加载校准数据
- Ranging
- 排列
- Digital housekeeping
- 数字管家

Figure 9. Typical initialization / ranging / housekeeping phases

图 9。典型的初始化/测距/内务处理阶段



2.12.1 Initialization and load calibration data phase
2.12.2 初始化和加载校准数据阶段

Initialization and calibration phase is performed before the first ranging or after a device reset, see *Figure 9*.

初始化和校准阶段在第一次测距之前或设备复位之后执行，请参见 *Figure 9*
The user may then have to repeat the temperature calibration phase in a periodic way, depending on the use case.
根据使用情况，用户可能需要定期重复温度校准阶段。

For more details on the calibration functions please refer to the VL53L0X API User Manual.

有关校准功能的更多详细信息，请参考 VL53L0X 应用编程接口用户手册。

2.12.3 Ranging phase
2.12.4 测距阶段

The ranging phase consists of a range setup then range measurement.

测距阶段包括测距设置和测距测量。

During the ranging operation, several VCSEL infrared pulses are emitted, then reflected

back by the target object, and detected by the receiving array. The photo detector used inside VL53L0X is using advanced ultra-fast SPAD technology (Single Photon Avalanche Diodes), protected by several patents.

在测距操作期间，发射几个垂直腔面发射激光器红外脉冲，然后由目标物体反射回来，并由接收阵列检测。VL53L0X 内部使用的光电探测器采用先进的超快 SPAD 技术(单光子雪崩二极管)，受多项专利保护。

The typical timing budget for a range is 33ms (init/ranging/housekeeping), see *Figure 12*, with the actual range measurement taking 23ms, see *Figure 9*. The minimum range measurement period is 8ms.

一个范围的典型时序预算为 33 毫秒(初始化/测距/内务处理)，参见 *Figure 12Figure 9*

Note: The minimum range timing budget is 20ms. Maximum is 5 seconds. The longer the timing budget, the higher the accuracy and the ranging distance capability.

注:最小距离计时预算为20毫秒。最长为5秒。定时预算越长，精度和测距能力越高。

2.12.5 Digital housekeeping
2.12.6 数字管家

Digital processing (housekeeping) is the last operation inside the ranging sequence that computes, validates or rejects a ranging measurement. Part of this processing is performed internally while the other part is executed on the Host by the API.

数字处理(内务处理)是测距序列中计算、验证或拒绝测距测量的最后一个操作。该处理的一部分在内部执行，而另一部分由应用编程接口在主机上执行。

At the end of the digital processing, the ranging distance is computed by VL53L0X itself. If the distance could not be measured (weak signal, no target…), a corresponding error code is provided.

在数字处理结束时，测距距离由VL53L0X自己计算。如果无法测量距离(信号弱，无目标…)，则提供相应的错误代码。

The following functions are performed on the device itself:

以下功能在设备本身上执行:

- Signal value check (weak signal)
- 信号值检查(弱信号)
- Offset correction
- 偏移校正
- Cross-talk correction (in case of cover glass)
- 串扰校正(在盖玻片的情况下)
- Final ranging value computation

While the API performs the following:

- 最终测距值计算当应用编程接口执

行以下操作时:

- Return Ignore Threshold RIT check (Signal check versus cross talk)
- 返回忽略阈值RIT检查(信号检查与串扰)
- Sigma check (accuracy condition)
- 适马检查(准确度条件)
- Final ranging state computation
- 最终测距状态计算

If the user wants to enhance the ranging accuracy, some extra processing (not part of the API) can be carried out by the host, for example, rolling average, hysteresis or any kind of filtering.

如果用户想要提高测距精度，主机可以执行一些额外的处理(不是应用编程接口的一部分)，例如滚动平均、滞后或任何类型的滤波。

2.13 Getting the data: interrupt or polling
2.14 获取数据:中断或轮询

User can get the final data using a polling or an interrupt mechanism.

用户可以使用轮询或中断机制获取最终数据。

Polling mode: user has to check the status of the ongoing measurement by polling an API function.

轮询模式:用户必须通过轮询 API 函数来检查正在进行的测量的状态。

Interrupt mode: An interrupt pin (GPIO1) sends an interrupt to the host when a new measurement is available.

中断模式:当新的测量可用时，中断引脚(GPIO1)向主机发送中断。

The description of these 2 modes is available in the VL53L0X API User Manual.

这两种模式的描述可在 VL53L0X API 用户手册中找到。

2.15 Device programming and control
2.16 设备编程和控制

Device physical control interface is I^2C, described in *Section 3: Control interface*.

设备物理控制接口是 I2C，如中所述 *Section 3: Control interface*

A software layer (API) is provided to control the device. The API is described in the VL53L0X API User Manual.

提供软件层(API)来控制设备。该应用编程接口在 VL53L0X 应用编程接口用户手册中有所描述。

2.17 Power sequence

2.18 电源序列

2.18.1 Power up and boot sequence
2.18.2 通电和引导顺序

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

设备加电/启动有两种选择。

Option 1: XSHUT pin connected and controlled from host.

选项 1:通过主机连接和控制 XSHUT 引脚。

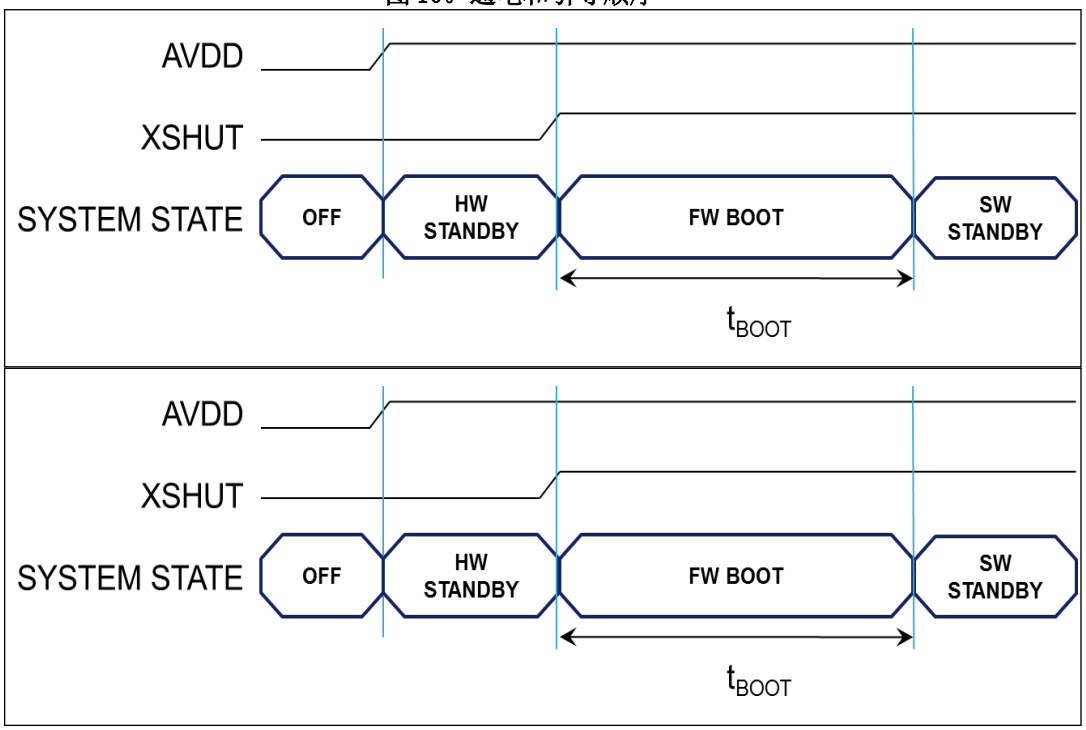
This option helps to optimize power consumption as the VL53L0X can be completely powered off when not used, and then woken up through host GPIO (using XSHUT pin).

该选项有助于优化功耗，因为 VL53L0X 在不使用时可以完全断电，然后通过主机 GPIO 唤醒(使用 XSHUT 引脚)。

HW Standby mode is defined as the period when AVDD is present and XSHUT is low.

硬件待机模式定义为 AVDD 存在且 XSHUT 为低电平的时间段。

Figure 10. Power up and boot sequence
图 10。通电和引导顺序



t_{BOOT} is 1.2ms max.

tBOOT 最大 1.2 毫秒。

Option 2: XSHUT pin not controlled by host, and tied to AVDD through pull-up resistor.

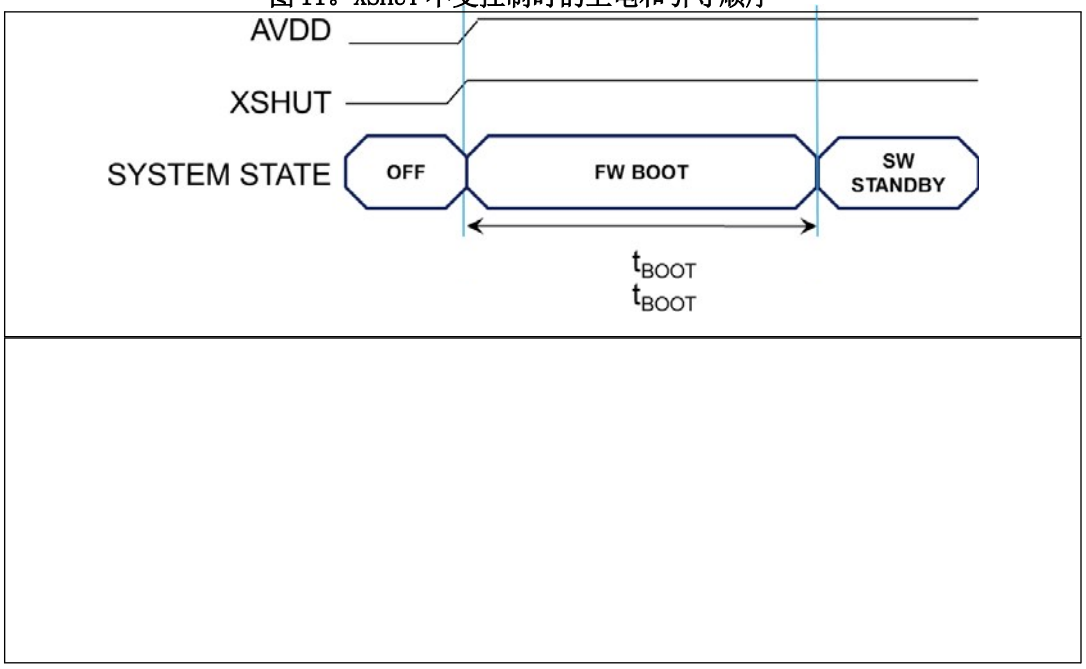
选项 2：XSHUT 引脚不受主机控制，通过上拉电阻与 AVDD 相连。

In case XSHUT pin is not controlled, the power up sequence is presented in *Figure 11*. In this case, the device is going automatically in SW STANDBY after FW BOOT, without entering HW STANDBY.

如果 XSHUT 引脚不受控制，上电顺序如所示 *Figure 11*

Figure 11. Power up and boot sequence with XSHUT not controlled

图 11。XSHUT 不受控制时的上电和引导顺序



t_{BOOT} is 1.2ms max.

tBOOT 最大 1.2 毫秒。

2.19 Ranging sequence

2.20 测距序列

Figure 12. Ranging sequence

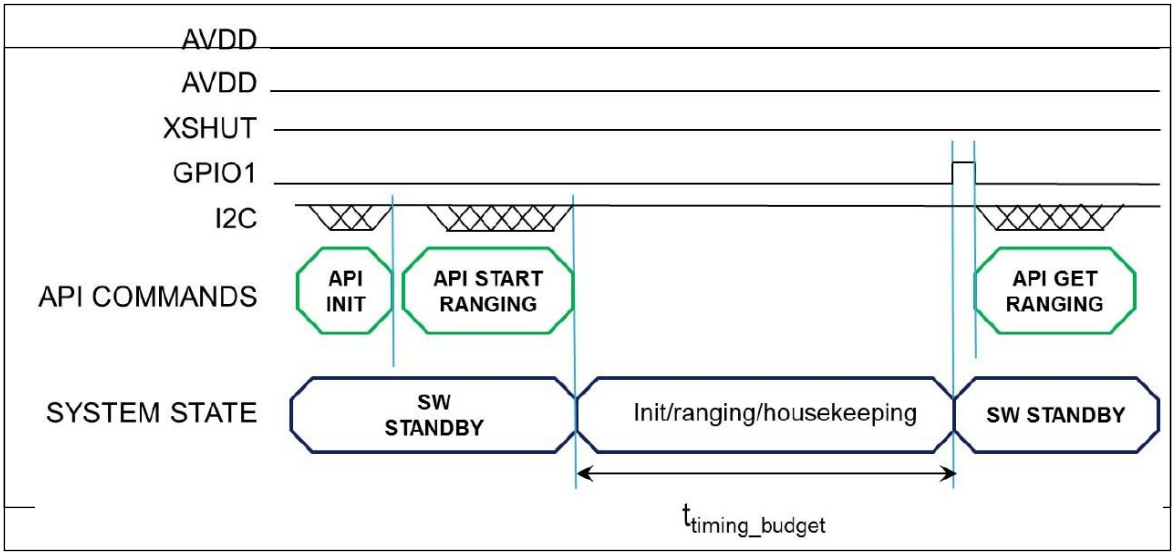


图 12。测距序列

t_{timing_budget} is a parameter set by the user, using a dedicated API function.

Default value is 33ms.

ttiming_budget 是用户使用专用的 API 函数设置的参数。默认值为 33 毫秒。

3 Control interface

4 控制接口

This section specifies the control interface. The I^2C interface uses two signals: serial data line (SDA) and serial clock line (SCL). Each device connected to the bus is using a unique address and a simple master / slave relationships exists.
本节指定控制接口。I2C 接口使用两个信号:串行数据线(SDA)和串行时钟线(SCL)。连接到总线的每个设备都使用唯一的地址，并且存在简单的主/从关系。

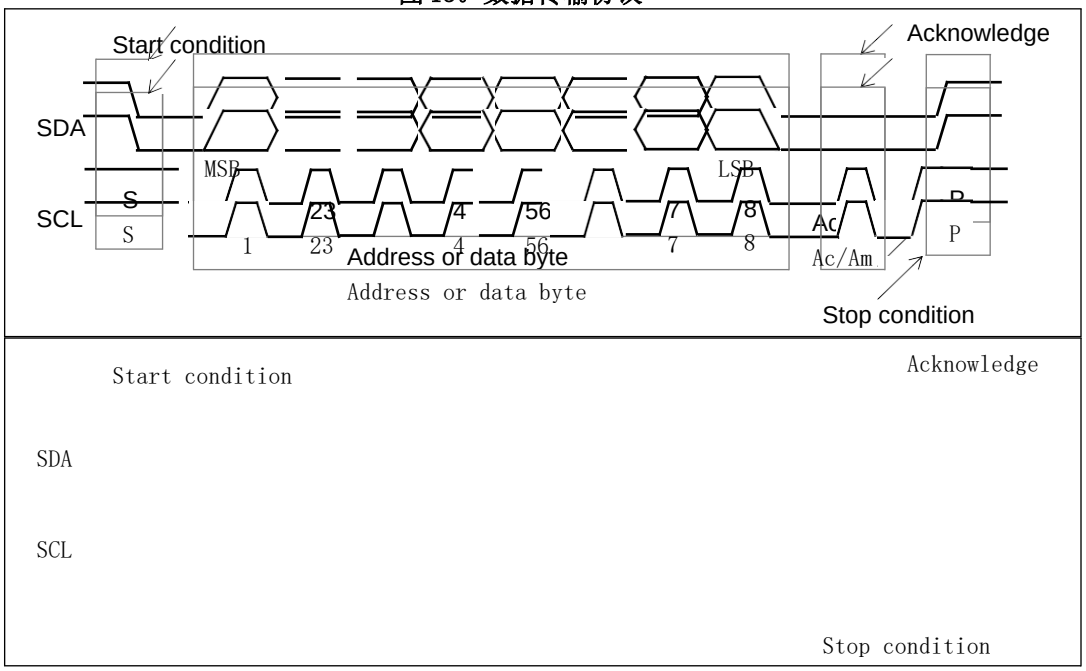
Both SDA and SCL lines are connected to a positive supply voltage using pull-up resistors located on the host. Lines are only actively driven low. A high condition occurs when lines are floating and the pull-up resistors pull lines up. When no data is transmitted both lines are high.

SDA 和 SCL 线都通过主机上的上拉电阻连接到正电源电压。线路仅被主动拉低。当线路浮动且上拉电阻将线路上拉时，出现高电平状态。当没有数据传输时，两条线路都为高电平。

Clock signal (SCL) generation is performed by the master device. The master device initiates data transfer. The I^2C bus on the VL53L0X has a maximum speed of 400 kbits/s and uses a device address of 0x52.

时钟信号(SCL)生成由主设备执行。主设备启动数据传输。VL53L0X 上的 I2C 总线的最大速度为 400 千位/秒，使用的设备地址为 0x52。

Figure 13. Data transfer protocol
图 13。数据传输协议



Information is packed in 8-bit packets (bytes) always followed by an acknowledge bit, Ac for VL53L0X acknowledge and Am for master acknowledge (host bus master). 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.

信息封装在 8 位数据包(字节)中，后面总是跟着一个确认位，Ac 表示 VL53L0X 确认，Am 表示主机确认(主机总线主机)。内部数据是通过在 SCL 上升沿对 SDA 进行采样产生的。外部数据必须在 SCL 的高发期保持稳定。这种情况的例外是，当 SDA 分别下降或上升，而 SCL 高时，开始(S)或停止(P)条件。

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 master write to the slave. If the lsb is set (that is, 0x53) then the message is a master read from the slave.

一条消息包含一系列字节，前面是开始条件，后面是停止或重复开始(另一个开始条件，但没有前面的停止条件)，后面是另一条消息。第一个字节包含设备地址(0x52)，还指定了数据方向。如果最低有效位为低(即 0x52)，则该消息是主机对从机的写操作。如果 lsb 被置位(即 0x53)，则该消息是从从机读取的主机信息。

Figure 14. VL53L0X I2C device address: 0x52

图 14。VL53L0X I2C 设备地址:0x52

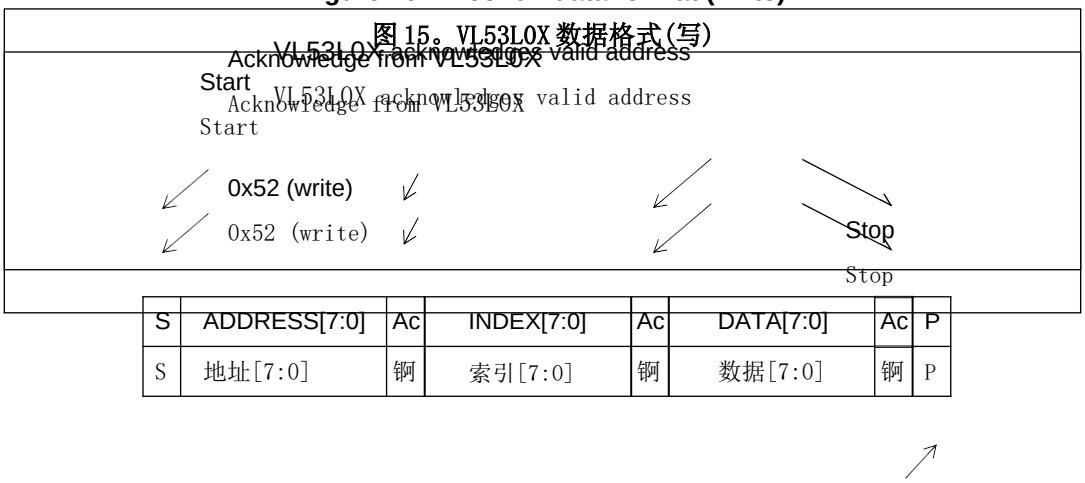
MSBit MSBit　　LSBit LSBit

~~0~~	~~1~~	~~0~~	~~1~~	~~0~~	~~0~~	~~1~~	~~R/W~~
0	一	0	一	0	0	一	拆装

All serial interface communications with the camera module must begin with a start condition. The VL53L0X 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 provide a 8-bit index which points to one of the internal 8-bit registers.
与摄像机模块的所有串行接口通信必须从启动条件开始。VL53L0X 模块通过将 SDA 线拉低来确认收到有效地址。存储读/写位(地址字节的 lsb)的状态，并可以解释从 SDA 采样的下一个数据字节。在写序列期间，接收到的第二个字节提供一个指向内部 8 位寄存器之一的 8 位索引。

Figure 15. VL53L0X data format (write)

图 15。VL53L0X 数据格式(写)



S	ADDRESS[7:0]	Ac	INDEX[7:0]	Ac	DATA[7:0]	Ac	P
S	地址[7:0]	钢	索引[7:0]	钢	数据[7:0]	钢	P

As data is received by the slave it is written bit by bit to a serial/parallel register. After each data byte has been received by the slave, an acknowledge is generated, the data is then stored in the internal register addressed by the current index.

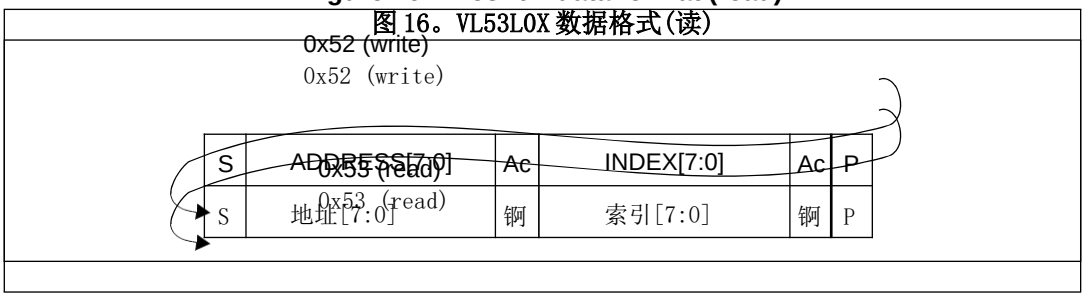
从机接收到数据后，会一位一位地写入串行/并行寄存器。从机接收到每个数据字节后，会产生一个应答，然后将数据存储在由当前索引寻址的内部寄存器中。

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.

在读取消息期间，由当前索引寻址的寄存器内容在器件地址字节之后的字节中读出。该寄存器的内容并行载入串行/并行寄存器，并在 SCL 下降沿从器件输出。

Figure 16. VL53L0X data format (read)

图 16。VL53L0X 数据格式(读)



S	ADDRESS[7:0]	Ac	DATA[7:0]	Am	P
S	地址[7:0]	钢	数据[7:0]	是	P

At the end of each byte, in both read and write message sequences, an acknowledge is issued by the receiving device (that is, the VL53L0X for a write and the host for a read).

在每个字节的末尾，在读和写消息序列中，接收设备都会发出一个确认(即，VL53L0X 用于写，主机用于读)。

A message can only be terminated by the bus master, 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.

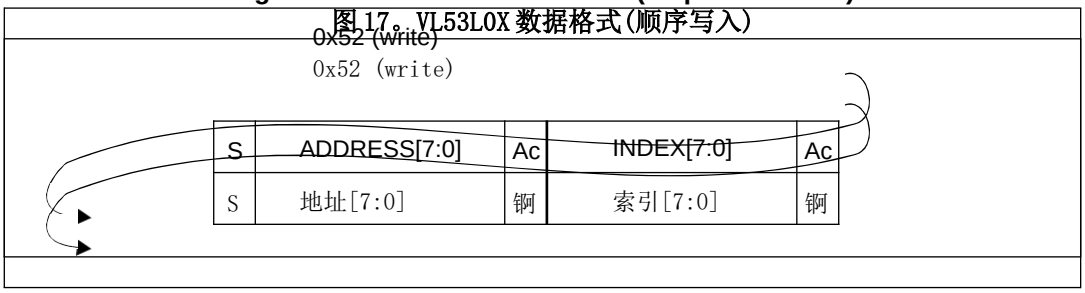
一条消息只能由总线主控器终止，要么通过发出停止条件，要么通过在读操作期间读完一个完整字节后发出否定应答(即不将 SDA 线拉低)。

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

该接口还支持自动增量索引。传输完第一个数据字节后，索引自动递增 1。因此，主机可以连续向从机发送数据字节，直到从机无法提供应答或主机以停止条件终止写通信。如果使用自动递增功能，主机不必发送地址索引来伴随数据字节。

Figure 17. VL53L0X data format (sequential write)

图 17。VL53L0X 数据格式(顺序写入)



DATA[7:0]	Ac	DATA[7:0]	Ac	DATA[7:0]	Ac	P
数据[7:0]	钢	数据[7:0]	钢	数据[7:0]	钢	P

Figure 18. VL53L0X data format (sequential read)

图 18。VL53L0X 数据格式(顺序读取)

S	ADDRESS[7:0]	Ac	INDEX[7:0]	Ac	P
S	地址[7:0]	锕	索引[7:0]	锕	P

S	ADDRESS[7:0]	Ac	DATA[7:0]	Am	DATA[7:0]	Am
S	地址[7:0]	锕	数据[7:0]	是	数据[7:0]	是

DATA[7:0]	Am	DATA[7:0]	Am	DATA[7:0]	Am	P
数据[7:0]	是	数据[7:0]	是	数据[7:0]	是	P

4.1 I²C interface - timing characteristics

4.2 I2C 界面定时特性

Timing characteristics are shown in *Table 3*. Please refer to *Figure 19* for an explanation of the parameters used.

时序特性如所示 *Table 3Figure 19*

Timings are given for all PVT conditions.

给出了所有 PVT 条件下的计时。

Table 3. I²C interface - timing characteristics

表 3。I2C 界面定时特性

Symbol	Parameter	Minimum	Typical	Maximum	Unit
F_{I2C}	Operating frequency (Standard and Fast mode)	0	-	400(1)	kHz

t_{LOW}	Clock pulse width low	1.3	-	-	µs
t_{HIGH}	Clock pulse width high	0.6	-	-	µs
t_{SP}	Pulse width of spikes which are suppressed by the input filter	-	-	50	ns
t_{BUF}	Bus free time between transmissions	1.3	-	-	ms
$t_{HD.STA}$	Start hold time	0.26	-	-	µs
$t_{SU.STA}$	Start set-up time	0.26	-	-	µs
$t_{HD.DAT}$	Data in hold time	0	-	0.9	µs
$t_{SU.DAT}$	Data in set-up time	50	-	-	ns
t_R	SCL/SDA rise time	-	-	120	ns
t_F	SCL/SDA fall time	-	-	120	ns
$t_{SU.STO}$	Stop set-up time	0.6	-	-	µs
Ci/o	Input/output capacitance (SDA)	-	-	10	pF
Cin	Input capacitance (SCL)	-	-	4	pF
C_L	Load capacitance	-	125	400	pF
标志	**参数**	**最低限度**	**典型的**	**最高的**	**单位**
FI2C	工作频率(标准和快速模式)	0	–	400(1)	千赫
tLOW	时钟脉冲宽度低	1.3	–	–	s
大腿	时钟脉冲宽度高	0.6	–	–	s
一茶匙的量	输入滤波器抑制的尖峰脉冲宽度	–	–	50	纳秒
tBUF	传输之间的总线空闲时间	1.3	–	–	女士
tHD。无线电台临时使用许可证	开始保持时间	0.26	–	–	s
tSU。无线电台临时使用许可证	开始设置时间	0.26	–	–	s
tHD。数据；数字录音带	保持时间内的数据	0	–	0.9	s
tSU。数据；数字录音带	设置时间内的数据	50	–	–	纳秒
tR	SCL/民主行动党上升时间	–	–	120	纳秒
法国南部（French Southern Territories 的缩写）	SCL/民主行动党秋季会议	–	–	120	纳秒
tSU。长期定货(standing order)	停止设置时间	0.6	–	–	s
Ci/o	输入/输出电容	–	–	10	性能因素(Performance Factor)

Cin	输入电容(SCL)	-	-	四	性能因素(Performance Factor)
化学发光	负载电容	-	125	400	性能因素(Performance Factor)

1. The maximum bus speed is also limited by the combination of 400pF load capacitance and pull-up resistor. Please refer to the I^2C specification for further information.
2. 最大总线速度也受到 400pF 负载电容和上拉电阻组合的限制。更多信息请参考 I2C 规范。

Figure 19. I²C timing characteristics

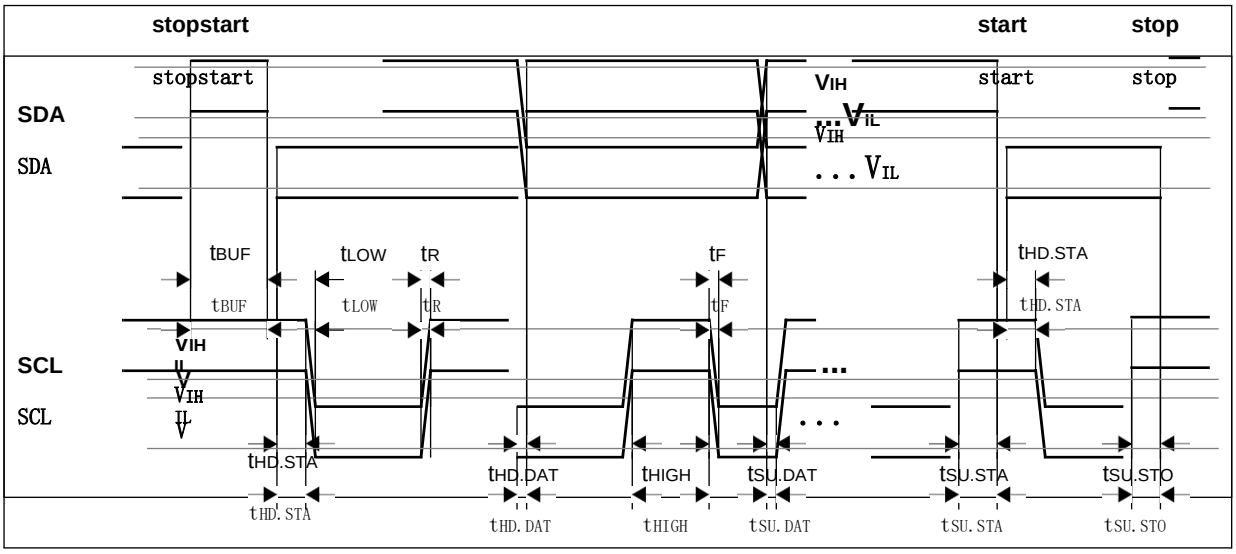


图 19。I2C 计时特性

All timings are measured from either V_{IL} or V_{IH}.

所有计时都是从 VIL 或 VIH 开始测量的。

4.3 I²C interface - reference registers

4.4 I2C 接口参考寄存器

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

下表所示的寄存器可用于验证用户 I2C 接口。

Table 4. Reference registers

表 4。参考寄存器

Address	(after fresh reset, without API loaded)
0xC0	0xEE
0xC1	0xAA
0xC2	0x10
0x51	0x0099
0x61	0x0000
地址	（重新设置后，未加载应用编程接口）
0xC0	0xEE
0xC1	0xAA

0xC2	0x10
0x51	0x0099
0x61	0x0000

Note: I2C read/writes can be 8,16 or 32-bit. Multi-byte reads/writes are always addressed in ascending order with MSB first as shown in Table 5.

注意:I2C 读/写可以是 8 位、16 位或 32 位。多字节读/写总是以升序进行寻址，MSB 优先，如所示 Table 5.

Table 5. 32-bit register example

表 5。32 位寄存器示例

Register address	Byte
Address	MSB
Address + 1	..
Address + 2	..
Address + 3	LSB
寄存器地址	**字节**
地址	最高有效位
地址+ 1	..
地址+ 2	..
地址+ 3	最低有效位

4 Current

4.1 Absolute maximum ratings

4.2 绝对最大额定值

Table 6. Absolute maximum ratings

表 6。绝对最大额定值

Parameter	Min.	Typ.	Max.	Unit
AVDD	-0.5	-	3.6	V
SCL, SDA, XSHUT and GPIO1	-0.5	-	3.6	V
参数	量滴	典型。	最大值	单位
AVDD	-0.5	-	3.6	V
SCL、民主行动党、XSHUT 和 GPIO1	-0.5	-	3.6	V

Note: Stresses above those listed in Table 6. 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.

注:应力高于中列出的应力 Table 6.

Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

长时间暴露在绝对最大额定值条件下可能会影响设备的可靠性。

4.3 Recommended operating conditions

4.4 推荐的操作条件

Table 7. Recommended operating conditions(1)

表 7。推荐的操作条件(1)

Parameter		Min.	Typ.	Max.	Unit
Voltage (AVDD)		2.6	2.8	3.5	V
IO (IOVDD)(2)	Standard mode	1.6	1.8	1.9	V
	2V8 mode(3)(4)	2.6	2.8	3.5	V
Temperature (normal operating)		-20		+70	°C
参数		量滴	典型。	最大	单位

				值	
电压(AVDD)		2.6	2.8	3.5	V
输入输出(IOVDD)(2)	标准模式	1.6	1.8	1.9	V
	2V8 模式(3)(4)	2.6	2.8	3.5	V
温度(正常运行)		-20		+70	C

1. 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
2. 没有电源时序要求。当应用 AVDD 时，输入/输出可以是高电平、低电平或浮动电平。输入/输出是内部故障安全的，没有二极管将它们连接到 AVDD
3. XSHUT should be high level only when AVDD is on.
4. 只有当 AVDD 开启时，XSHUT 才应该是高电平。
5. SDA, SCL, XSHUT and GPIO1 high levels have to be equal to AVDD in 2V8 mode.
6. 在 2V8 模式下，SDA、SCL、XSHUT 和 GPIO1 高电平必须等于 AVDD。
7. The default API mode is 1V8.
8. 默认的 API 模式是 1V8。
   2V8 mode is programmable using device settings loaded by the API. For more details please refer to the VL53L0X API User Manual.
   2V8 模式可使用 API 加载的设备设置进行编程。更多详情请参考 VL53L0X 应用编程接口用户手册。

4.5 ESD

4.6 （同 Esdras）[圣经]以斯拉记

VL53L0X is compliant with ESD values presented in *Table 8*

VL53L0X 符合中所示的静电放电值 *Table 8*

Table 8. ESD performances

表 8。静电放电性能

Parameter	Specification	Conditions
Human Body Model	JS-001-2012	+/- 2kV, 1500 Ohms, 100pF
Charged Device Model	JZSD22-C101	+/- 500V
参数	**规格**	**情况**
人体模型	JS-001-2012	+/- 2kV，1500 欧姆，100pF
带电设备模型	JZSD22-C101	+/-500 伏

4 Current

Table 9. Consumption at ambient temperature(1)

表 9。环境温度下的消耗量(1)

Parameter	Min.	Typ.	Max.	Unit
HW STANDBY	3	5	7	uA
SW STANDBY (2V8 mode)(2)	4	6	9	uA
Timed ranging Inter measurement		16		uA
Active Ranging average consumption (including VCSEL) (3)(4)		19		mA
Average power consumption at 10Hz with 33ms ranging sequence			20	mW
参数	**量滴**	**典型。**	**最大值**	**单位**
硬件待机	3	5	七	美国联合航空公司
软件待机(2V8 模式)(2)	四	6	9	美国联合航空公司
定时测距间测量		16		美国联合航空公司
主动测距平均功耗(包括垂直腔面发射激光器)(3)(4)		19		妈
10Hz 时的平均功耗，33 毫秒测距序列			20	毫瓦

1. All current consumption values include silicon process variations. Temperature and Voltage are at nominal conditions (23degC and 2.8V).
2. 所有电流消耗值都包括硅工艺变化。温度和电压处于标称状态(23 摄氏度和 2.8 伏)。

   All values include AVDD and AVDDVCSEL.

   所有值包括 AVDD 和 AVDDVCSEL。
3. In standard mode (1V8), pull-ups have to be modified, then SW STANDBY consumption is increased by
4. 在标准模式(1V8)下，必须修改上拉，然后软件待机功耗增加
   +0.6uA.
   +0.6uA。
5. Active ranging is an average value, measured using default API settings (33ms timing budget).
6. 主动测距是一个平均值，使用默认的应用编程接口设置(33 毫秒定时预算)进行测量。
7. Peak current (including VCSEL) can reach 40mA.
8. 峰值电流(包括 VCSEL)可达 40mA。

4 Electrical

Table 10. Digital I/O electrical characteristics

表 10。数字输入输出电气特性

Symbol	Parameter	Minimum	Typical	Maximum	Unit
Interrupt pin (GPIO1)					
V_{IL}	Low level input voltage	-	-	0.3 IOVDD	V
V_{IH}	High level input voltage	0.7 IOVDD	-	-	V
V_{OL}	Low level output voltage (I_{OUT} = 4 mA)	-	-	0.4	V
V_{OH}	High level output voltage at (I_{OUT} = 4 mA)	IOVDD-0.4	-	-	V
F_{GPIO}	Operating frequency (C_{LOAD} = 20 pF)	0	-	108	MHz
I^2C interface (SDA/SCL)					
V_{IL}	Low level input voltage	-0.5	-	0.6	V
V_{IH}	High level input voltage	1.12	-	IOVDD+0.5	V
V_{OL}	Low level output voltage (I_{OUT} = 4 mA in Standard and Fast modes)	-	-	0.4	V
I_{IL}/I_{IH}	Leakage current(1)	-	-	10	µA
	Leakage current(2)	-	-	0.15	µA
标志	**参数**	**最低限度**	**典型的**	**最高的**	**单位**
中断引脚(GPIO1)					
垂直注入逻辑	低电平输入电压	–	–	0.3 IOVDD	V
VIH	高电平输入电压	0.7 IOVDD	–	–	V
卷（volume 的缩写）	低电平输出电压(IOUT = 4 毫安)	–	–	0.4	V
VOH	高电平输出电压(IOUT = 4 毫安)	IOVDD-0.4	–	–	V
FGPIO	工作频率(CLOAD = 20 pF)	0	–	108	兆赫
I2C 接口(民主行动党/SCL)					
垂直注入逻辑	低电平输入电压	-0.5	–	0.6	V
VIH	高电平输入电压	1.12	–	IOVDD+0.5	V
卷（volume 的缩写）	低电平输出电压(标准和快速模式下 IOUT = 4 毫安)	–	–	0.4	V
IIL/IH	泄漏电流(1)	–	–	10	A
	漏电流(2)	–	–	0.15	A

1. AVDD = 0 V
2. AVDD = 0 V
3. AVDD = 2.85 V, I/O voltage = 1.8 V
4. AVDD = 2.85V；输入/输出电压= 1.8 伏

5 Performanc

5.1 Measurement conditions

5.2 测量条件

In all measurement tables in the document, it is considered that the full Field Of View (FOV) is covered.

在文件中的所有测量表中，都认为涵盖了整个视野(FOV)。
VL53L0X system FOV is 25degrees.
VL53L0X 系统 FOV 是 25 度。
Reflectance targets are standard ones (Grey 17% N4.74 and White 88% N9.5 Munsell charts).
反射率目标是标准目标(灰色 17% N4.74 和白色 88% N9.5 芒塞尔图)。

Unless mentioned, device is controlled through the API using the default settings (refer to VL53L0X API User Manual for API settings description).

除非另有说明，设备是通过使用默认设置的应用编程接口来控制的(关于应用编程接口设置的描述，请参考 VL53L0X 应用编程接口用户手册)。

Figure 20. Typical ranging (default mode)

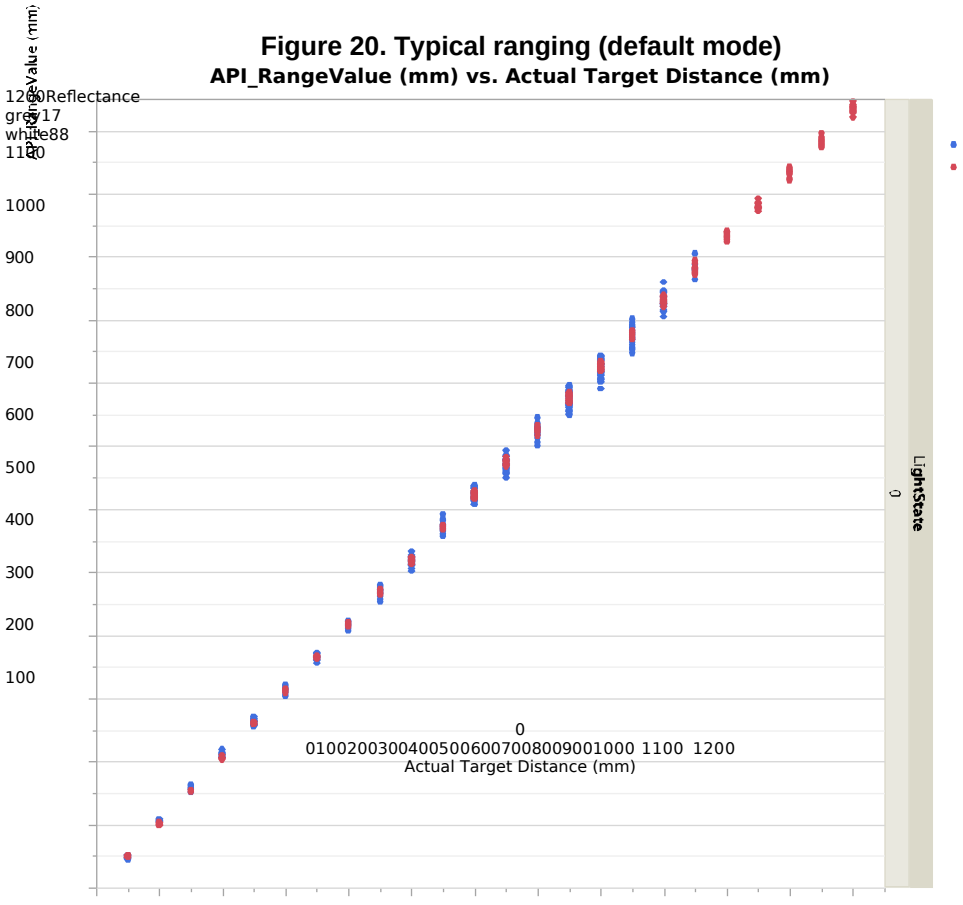


图 20。典型测距(默认模式)

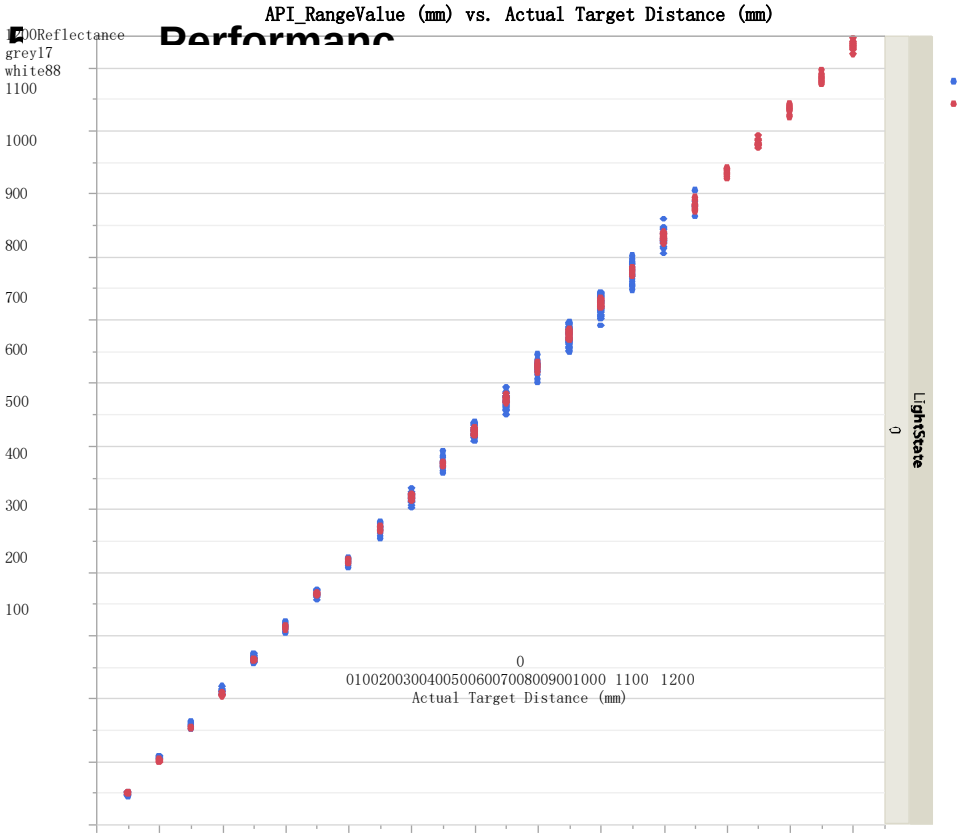


Figure 21. Typical ranging - Long range mode

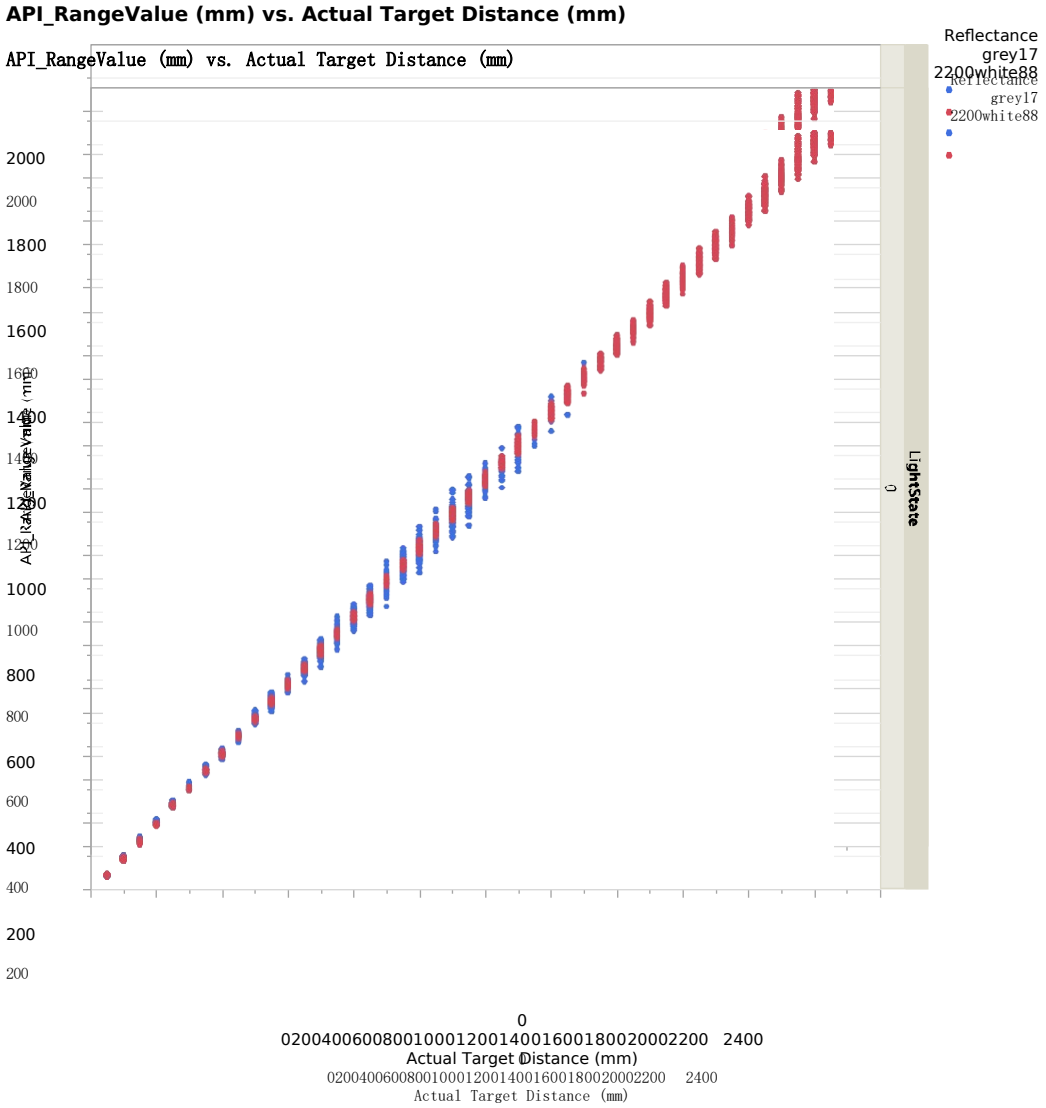


图 21。典型测距-远程模式

5.3 Max ranging distance

5.4 最大测距距离

Table 11 presents the ranging specification for VL53L0X bare module, without cover glass, at room temperature (23degreesC) and with nominal voltage (2.8Volts).

Table 11 介绍了在室温(23 摄氏度)和标称电压(2.8 伏)下，不带盖板玻璃的 VL53L0X 裸模块的测距规格。

Table 11. Max ranging capabilities with 33ms timing budget

表 11。33 毫秒定时预算的最大测距能力

Target reflectance level (Full FOV)	Conditions	Indoor (2)	Outdoor overcast (2)
White Target (88%)	Typical	200cm+ (1)	80cm
	Minimum	120cm	60cm
Grey Target (17%)	Typical	80cm	50cm
	Minimum	70cm	40cm
目标反射水平(全 FOV)	情况	室内 (2)	室外阴天(2)
白色目标(88%)	典型的	200 厘米+ (1)	80 厘米
	最低限度	120 厘米	60 厘米
灰色目标(17%)	典型的	80 厘米	50 厘米
	最低限度	70 厘米	40 厘米

Note (1): using long range API profile
注(1):使用远程应用编程接口配置文件

- Indoor: no infrared
- 室内:无红外线
- Outdoor overcast corresponds to a parasitic noise of 10kcps/SPAD for VL53L0X module. For reference, this corresponds to a 1.2W/m² at 940nm, and is equivalent to 5kLux daylight, while ranging on a grey 17% chart at 40cm
- 室外阴天对应于 VL53L0X 模块 10k PS/SPAD 的寄生噪声。作为参考，这相当于 940 纳米处的 1.2W/m，相当于 5 勒克司日光，而在 40 厘米处的灰色 17%图表上的范围

Measurement conditions:

测量条件:

- Targets reflectance used : Grey (17%), White (88%)
- 使用的目标反射率:灰色(17%)，白色(88%)
- Nominal Voltage (2.8V) and Temperature (23degreesC)
- 标称电压(2.8V)和温度(23 摄氏度)
- All distances are for a complete Field of View covered (FOV = 25degrees)
- 所有距离均为完整的覆盖视野(FOV = 25 度)
- 33ms timing budget
- 33ms 时序预算

All distances mentioned in this table are guaranteed for a minimum detection rate of 94% (up to 100%). Detection rate is the worst case percentage of measurements that will return a valid measurement when target is detected.

此表中提到的所有距离都保证最低检测率为 94%(最高为 100%)。检测率是检测到目标时返回有效测量值的测量值的最坏情况百分比。

5.5 Ranging accuracy
5.6 测距精度

5.6.1 Standard deviation
5.6.2 标准偏差

Ranging accuracy can be characterized by standard deviation. It includes Measure-to-Measure and Part-to-Part (silicon) dispersion.

测距精度可以用标准偏差来表征。它包括测量到测量和部分到部分(硅)分散。

Table 12. Ranging accuracy

表 12。测距精度

	Indoor (no infrared)	Outdoor

Target reflectance level (Full FOV)	Distance	33ms	66ms	Distance	33ms	66ms
White Target (88%)	at 120cm	4%	3%	at 60cm	7%	6%
Grey Target (17%)	at 70cm	7%	6%	at 40cm	12%	9%
	室内(无红外线)			户外的		
目标反射水平(全 FOV)	距离	33 毫秒	66 毫秒	距离	33 毫秒	66 毫秒
白色目标(88%)	在 120 厘米处	4%	3%	在 60 厘米处	7%	6%
灰色目标(17%)	在 70 厘米处	7%	6%	40 厘米	12%	9%

Measurement conditions:
测量条件:

- Targets reflectance used: Grey (17%), White (88%)
- 使用的目标反射率:灰色(17%)，白色(88%)
- Offset correction done at 10cm from sensor.
- 在距离传感器 10 厘米处进行偏移校正。
- Indoor: no Infrared / Outdoor: eq. 5kLux equivalent sunlight (10kcps/SPAD)
- 室内:无红外线/室外:情商。5 千瓦当量阳光(10kcps/SPAD)
- Nominal Voltage (2v8) and Temperature (23degreesC)
- 标称电压(2v8)和温度(23 摄氏度)
- All distances are for a complete Field of View covered (FOV = 25degrees)
- 所有距离均为完整的覆盖视野(FOV = 25 度)
- Detection rate is considered at 94% minimum
- 检测率最低为 94%

5.6.3 Range profile examples
5.6.4 范围概况示例

Table 13 details typical performance for the four example ranging profiles, as per measurement conditions in *Section 5.3: Ranging accuracy*.

Table 13 根据中的测量条件，详细说明了四种示例测距曲线的典型性能 *Section 5.3: Ranging accuracy*

Table 13. Range profiles

表 13。范围配置文件

Range Profile	Range timing budget	Typical performance	Typical application
Default mode	30ms	1.2m, accuracy as per *Table 12*	standard
High accuracy	200ms	1.2m, accuracy < +/- 3%	precise measurement
Long range	33ms	2m, accuracy as per *Table 12*	long ranging, only for dark conditions (no IR)
High speed	20ms	1.2m, accuracy +/- 5%	high speed where accuracy is not priority
范围概况	**距离计时预算**	**典型性能**	**典型应用**
默认模式	30 毫秒	1.2m，精度符合 *Table 12*	标准
高准确度	200 毫秒	1.2m，精度<+/- 3%	精确测量
远程	33 毫秒	2m，精度符合 *Table 12*	长距离，仅适用于黑暗条件(无红外线)
高速的	20 毫秒	1.2m，精度+/- 5%	精度不是重点的高速

5.6.5 Ranging offset error
5.6.6 测距偏移误差

The table below shows how range offset may drift over distance, voltage and temperature.

下表显示了范围偏移如何随距离、电压和温度漂移。

Assumes offset calibrated at 10cm. See VL53L0X API User Manual for details on offset calibration.

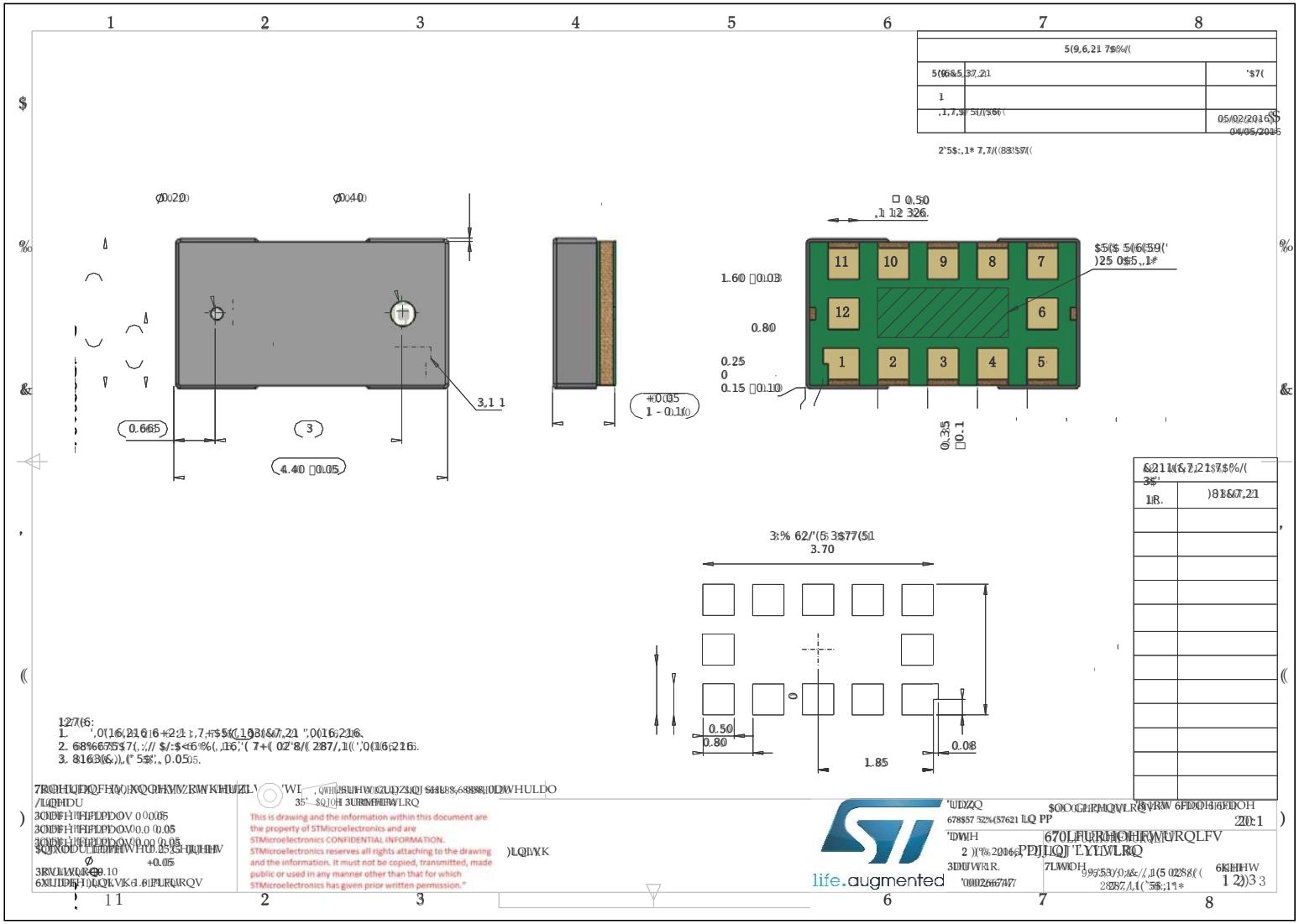
假设偏移量校准为 10 厘米。有关失调校准的详细信息，请参见 VL53L0X 应用编程接口用户手册。

Table 14. Ranging offset

表 14。测距偏移

	Nominal Conditions	Measure point	Typical offset from nominal	Maximum offset from nominal

Ranging distance	Offset calibration at 10cm (“zero”)	White 120cm (indoor) Grey 70cm (indoor) White 60cm (outdoor) Grey 40cm (outdoor)		< 3%
Voltage drift	2.8V	2.6V to 3.5V	+/- 10mm	+/- 15mm
Temperature drift	23°C	-20°C to +70°C	+/- 10mm	+/- 30mm
	标称条件	**测量点**	**标称值的典型偏移**	**标称值的最大偏移**
测距距离	10 厘米(“零”)处的偏移校准	白色 120 厘米(室内) 灰色 70 厘米(室内)白色 60 厘米(室外)灰色 40 厘米(室外)		< 3%
电压漂移	2.8V	2.6V 至 3.5V	+/-10 毫米	±15 毫米
温度漂移	23 摄氏度	-20℃至+70℃	+/-10 毫米	+/-30 毫米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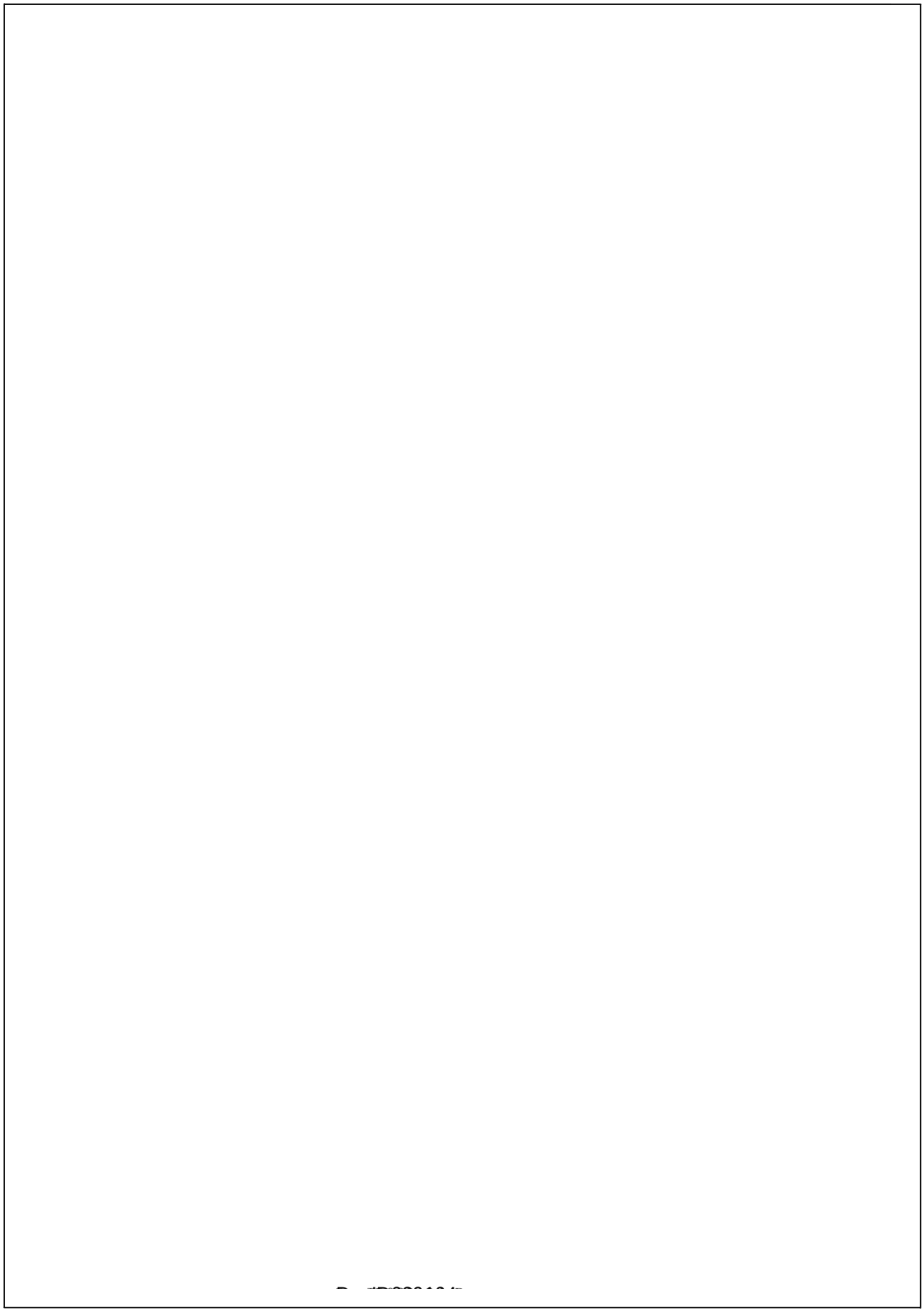
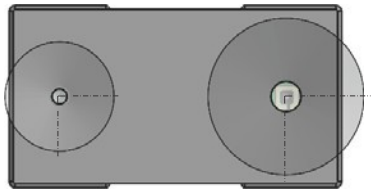
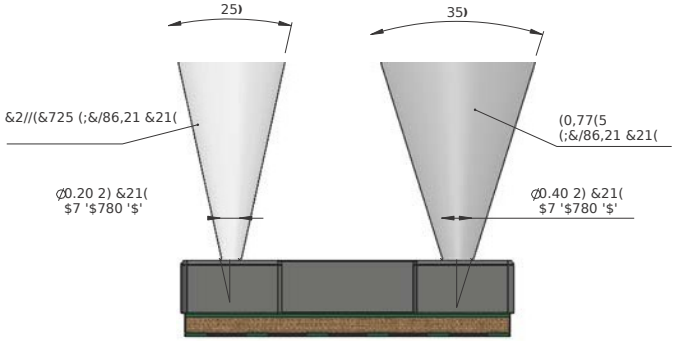
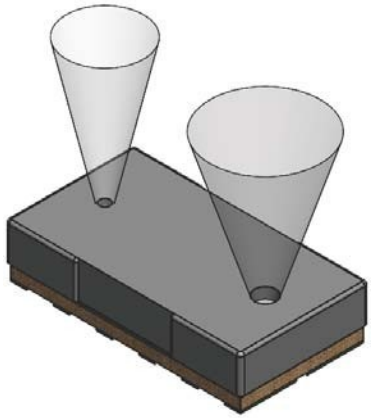
1	$9''9&6(/
2	$9669&6(/
3	*1'
4	*1'2
5	;6+87
6	*1'3
7	*3,21
8	'1&
9	6'$
10	6&/
11	$9''
12	*1'4
—	$9''9&6(/
2	$9669&6(/
3	*1'
四	*1'2
5	;6+87
6	*1'3
七	*3,21
8	'1&
9	6'$
10	6&/
11	$9''
12	*1'4









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7+(7:2 &21(6 6+2:1 21 7+,6 6+((7 5(35(6(17
92/80(6 ,172 :+,&+ 7+(86(56' (48,30(17
+286,1* 6+28/' 127 (17(5.

7ROHUDQFHV, XQOHVV RWKHUZLVH VWDWHG
/LQHDU
3ODFH 'HFLPDOV 0 0.05
3ODFH 'HFLPDOV 0.0 0.05
3ODFH 'HFLPDOV 0.00 0.05
$QJXODU 'LPHQVLRQ 0.25 GHJUHHV
∅ +0.05
3RVLWLRQ 0.10
6XUIDFH)LQLVK 1.6 PLFURQV

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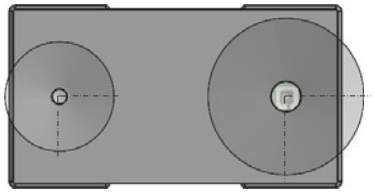
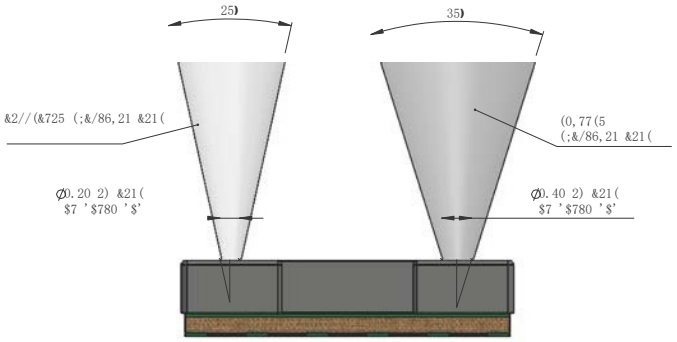
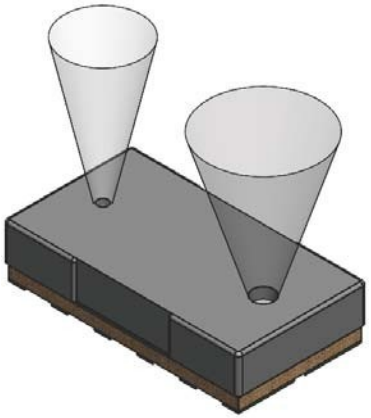
'UDZQ
'DWH
3DUW 1R.
'000266747

7LWOH 9/53/0; & /,1(5 02'8/(6KHHW
287/,1('5$:,1*2 2) 3
20:1







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7+(7:2 &21(6 6+2:1 21 7+,6 6+((7 5(35(6(17
92/80(6 ,172 :+,&+ 7+(86(56' (48,30(17
+286,1* 6+28/' 127 (17(5.

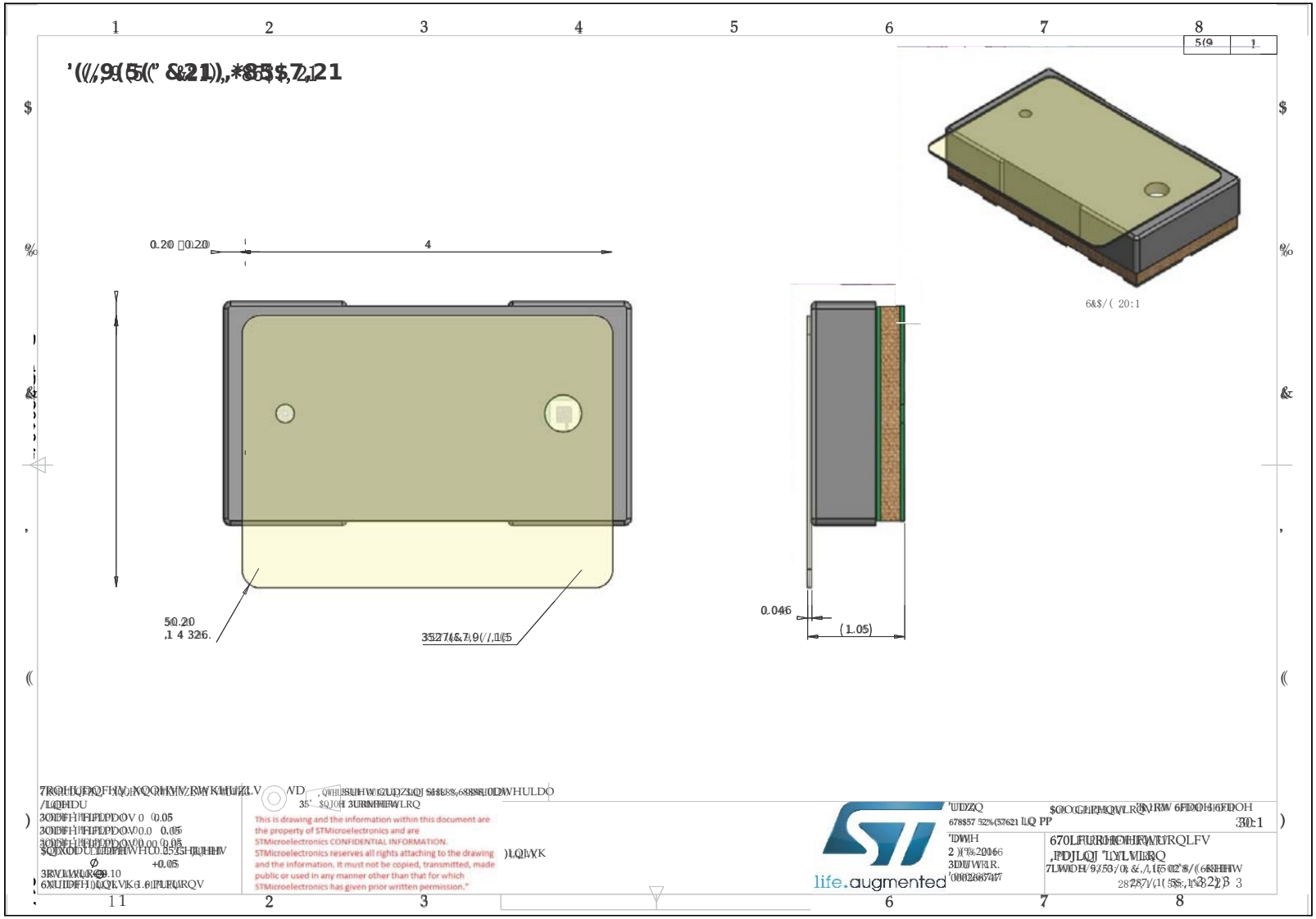
7ROHUDQFHV, XQOHVV RWKHUZLVH VWDWHG
/LQHDU
3DFH 'HFLPDOV 0 0.05
3DFH 'HFLPDOV 0.0 0.05
3DFH 'HFLPDOV 0.00 0.05
$QJXODU 'LPHQVLRQDO 0.25 GHJUHHV
Ø +0.05
3RVLWLRQ0.Ⓜ
6XUIDFH)LQLVK 1.6 PLFURQV

QWHUSUHW GUDZLQJ SHU %68888, 0DWHULDO
35' $QJOH 3URMHFWLRQ

)LQLVK

'UDZQ $OO GLPHQVLRQV 'R 1RW 6FDOH 6FDOH
678$57 52%(57621 LQ PP 20:1
'DWH 2)(% 2016, PDJLQJ 'LYLVLRQ
3DUW 1R. 670LFURHOHFWURQLFV
'000266747 7LWOH 9/53/0; & /,1(5 02'8/(6KHHW
287/,1('5$:,1*2 2) 3

life.augmented


4
0.046
(1.05)
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7 Laser safety

The VL53L0X contains a laser emitter and corresponding drive circuitry. The laser output is designed to remain within Class 1 laser safety limits under all reasonably foreseeable conditions including single faults in compliance with IEC 60825-1:2014 (third edition).

VL53L0X 包含一个激光发射器和相应的驱动电路。激光输出设计为在所有合理可预见的条件下保持在 1 级激光安全限值内，包括符合 IEC 60825-1:2014 标准(第三版)的单一故障。

The laser output will remain within Class 1 limits as long as the STMicroelectronics recommended device settings (API settings) are used and the operating conditions specified are respected.

只要使用意法半导体推荐的设备设置(应用编程接口设置)并遵守规定的操作条件，激光输出将保持在 1 级限制内。

The laser output power must not be increased by any means and no optics should be used with the intention of focusing the laser beam.

激光输出功率不得以任何方式增加，不得使用任何光学器件聚焦激光束。

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

警告:使用除此处规定之外的控制或调整或程序执行可能会导致危险的辐射暴露。

Figure 25. Class 1 laser product label
图 25。1 类激光产品标签

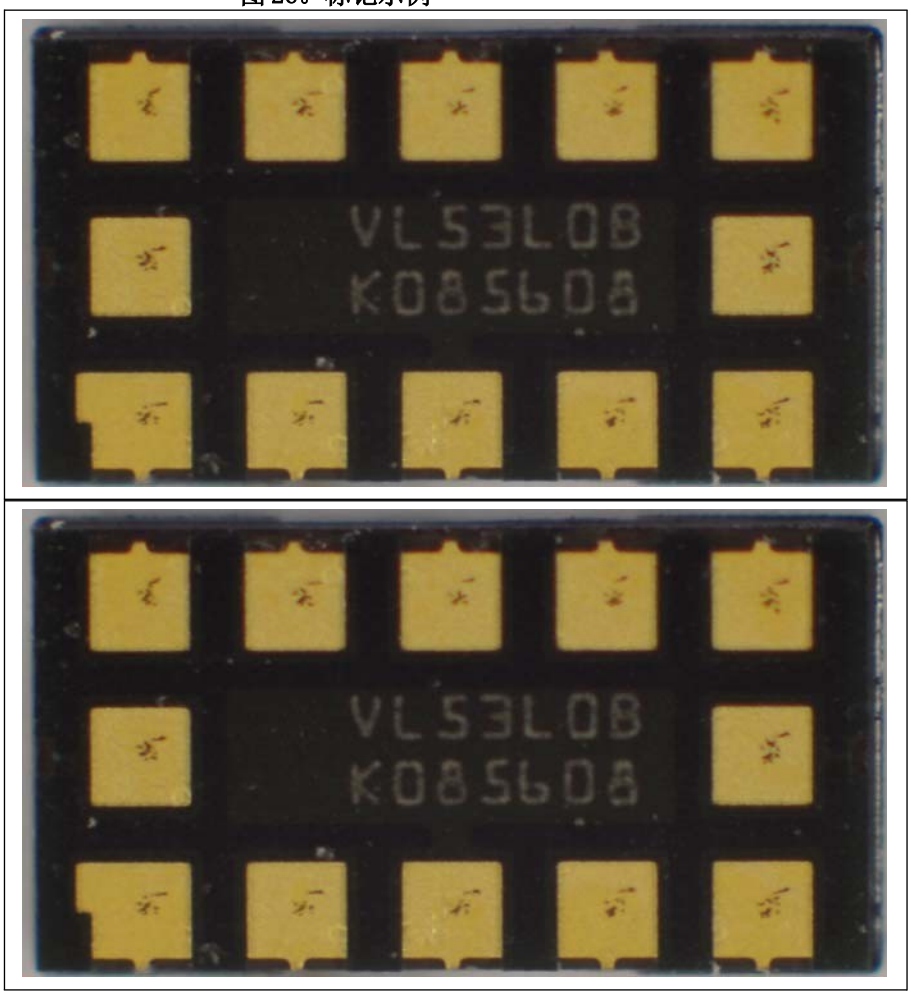
8 Packaging and labeling
9 包装和标签

9.1 Product marking
9.2 产品标记

A 2-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, the internal tracking code.

模块背面(即基板上)贴有双线产品标记。第一行是硅产品代码，第二行是内部跟踪代码。

Figure 26. Example of marking
图 26。标记示例



9.3 Inner box labeling

9.4 内盒标签

The labeling follows the ST standard packing acceptance specification.

The following information will be on the inner box label:

标签遵循 ST 标准包装验收规范。内盒标签上会有以下信息:

- assembly site
- 装配现场
- sales type
- 销售类型
- quantity
- 量
- trace code
- 跟踪代码
- marking
- 标记
- bulk ID number
- 批量身份证号码

9.5 Packing

9.6 包装

At customer / subcontractor level, it is recommended to mount theVL53L0X in a clean environment to avoid foreign material deposition.

在客户/分包商层面，建议在清洁的环境中安装 theVL53L0X，以避免异物沉积。

To help avoid any foreign material contamination at phone assembly level the modules will be shipped in a tape and reel format with a protective liner. The packaging will be vacuum- sealed and include a desiccant.

为了帮助避免电话组件层面的任何异物污染，模块将以带保护衬垫的胶带和卷轴形式运输。包装将被真空密封，并包括干燥剂。

The liner is compliant with reflow at 260°C. It must be removed during assembly of the customer device, just before mounting the cover glass.

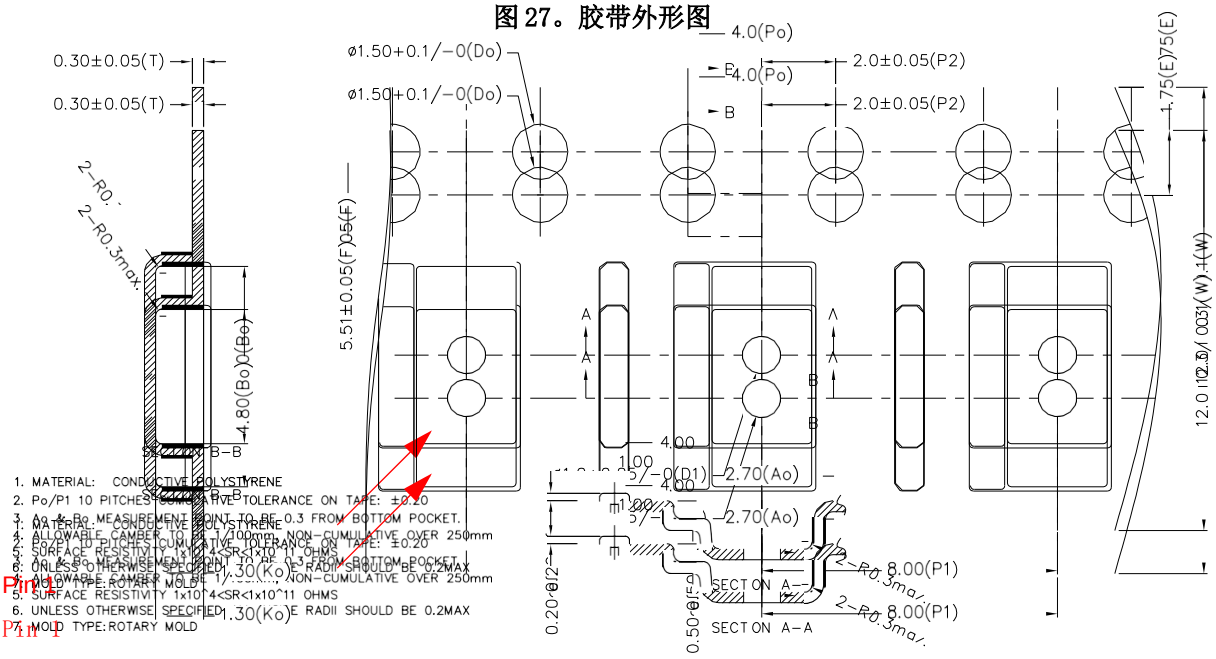
衬垫符合 260℃回流的要求。在客户设备组装期间，就在安装盖板玻璃之前，必须将其移除。

8.3.1 Tape outline drawings

8.3.1 胶带外形图

Figure 27. Tape outline drawing

图 27。胶带外形图



9.7 Pb-free solder reflow process

9.8 无铅回流焊工艺

Figure 28 and *Table 15* shows the recommended and maximum values for the solder profile.

Figure 28 和 *Table 15*

Customers will have to tune the reflow profile depending on the PCB, solder paste and material used.

客户必须根据印刷电路板、焊膏和所用材料调整回流曲线。

We expect customers to follow the “recommended” reflow profile, which is specifically tuned for VL53L0X package.

我们希望客户遵循“推荐的”回流曲线，该曲线专门针对 VL53L0X 封装进行了调整。

For any reason if a customer must perform a reflow profile which is different from “recommended” one (especially peak >240°C), this new profile must be qualified by the customer at its own risk. In any case, the profile have to be within the “maximum” profile limit described in *Table 15*.

出于任何原因，如果客户必须执行不同于“推荐”的回流曲线(尤其是峰值温度> 240° C)，客户必须自行承担风险对新曲线进行鉴定。在任何情况下，配置文件都必须在中描述的“最大”配置文件限制内 *Table 15*

Table 15. Recommended solder profile

表 15。推荐的焊料轮廓

Parameters	Recommended	Maximum	Units
Minimum temperature (T_S min) Maximum temperature (T_S max) Time t_s (T_S min to T_S max)	130 200 90-110	150 200 60 - 120	°C °C seconds
Temperature (T_L) Time (t_L) Ramp up	217 55-65 +2	217 55 - 65 +3	°C seconds °C/second
Temperature (T_{p-10}) Time (t_{p-10}) Ramp up	- - -	250 10 +3	°C seconds °C/second
Peak temperature (Tp)	240	260 max	°C
Time to peak	300	300	seconds
Ramp down (peak to T_L)	-4	-6	°C/second
因素	**被推荐的**	**最高的**	**单位**
最低温度(最低温度) 最高温度(最大温度) 时间 ts （ts 最小值到 TS 最大值）	130 200 90-110	150 200 60 - 120	C C 秒
温度 时间(tL) 扩大生产	217 55-65 +2	217 55 - 65 +3	C 秒 c/秒
温度(Tp-10) 时间(tp-10) 扩大生产	- - -	250 10 +3	C 秒 c/秒
峰值温度(Tp)	240	最大 260	C
高峰时间	300	300	秒
斜坡下降(峰值至 t1)	-4	-6	c/秒

Figure 28. Solder profile

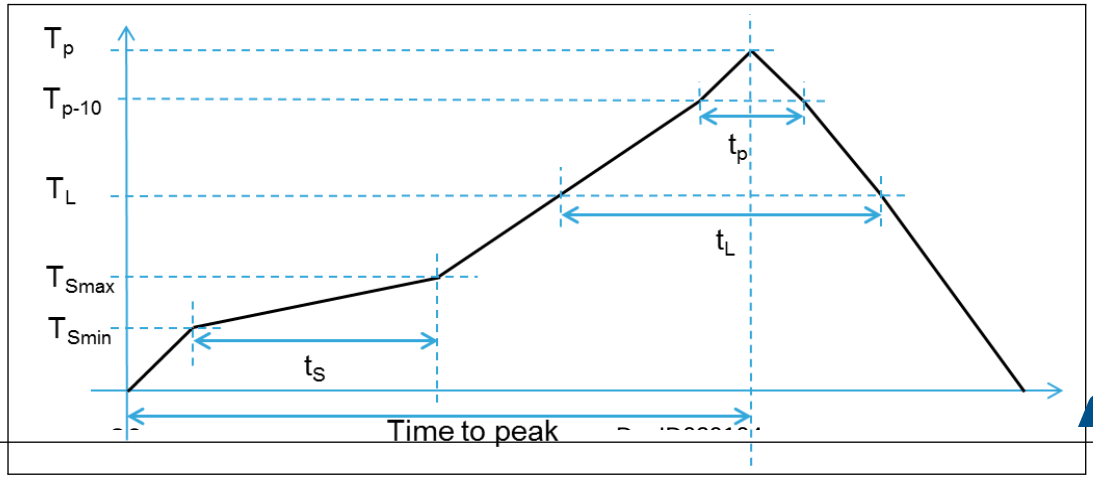
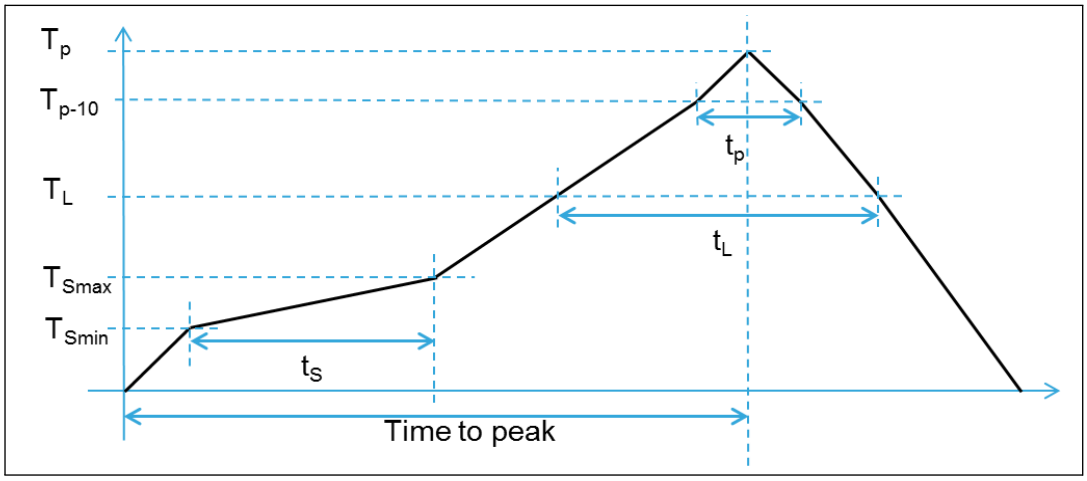


图 28。焊料轮廓



Note: Temperature mentioned in Table 15 is measured at the top of VL53L0X package.

注:中提到的温度 Table 15

Note: The component should be limited to a maximum of 3 passes through this solder profile.

注意:该元件最多只能有 3 次通过该焊料剖面。

9.9 Handling and storage precautions
9.10 搬运和储存注意事项

8.5.1 Shock precaution
8.5.2 防震措施

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

接近传感器模块容纳了许多易受冲击损坏的内部部件。如果设备受到过度冲击，掉落到地板上，或者设备托盘/卷轴掉落到地板上，即使没有明显的损坏，也必须拒收。

8.5.3 Part handling

8.5.4 零件处理

Handling must be done with non-marring ESD safe carbon, plastic, or Teflon tweezers. Ranging module are susceptible to damage or contamination. A clean assembly process is advised at customer after un-taping the parts, and until a protective cover glass is mounted.

必须使用防静电碳、塑料或聚四氟乙烯镊子进行处理。测距模块容易受到损坏或污染。在拆开零件的胶带之后，直到安装了保护盖玻璃之前，建议客户进行清洁的组装过程。

8.5.5 Compression force

8.5.6 压力

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

模块上应施加 25N 的最大压缩载荷。

8.5.7 Moisture sensitivity level

8.5.8 水分敏感水平

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

湿度敏感度为 3 级(MSL)，如 IPC/JEDEC JSTD-020-C 中所述

9.11 Storage temperature conditions

9.12 储存温度条件

Table 16. Recommended storage conditions

表 16。推荐的储存条件

Parameter	Min.	Typ.	Max.	Unit
Temperature (storage)	-40		+85	°C
参数	**量滴**	**典型。**	**最大值**	**单位**
温度(储存)	-40		+85	C

9 Ordering

Table 17. Ordering information
表 17。订购须知

Sales type	Package	Packing
VL53L0CXV0DH/1	Optical LGA12 with liner	Tape and reel
销售类型	**包裹**	**包装**
VL53L0CXV0DH/1	带衬垫的光学 LGA12	磁带和卷轴

10 Acronyms and abbreviations
10 首字母缩略词和缩写

Table 18. Acronyms and abbreviations
表 18。首字母缩略词和缩写

Acronym/ abbreviation	Definition
ESD	Electrostatic discharge
I^2C	Inter-integrated circuit (serial bus)
NVM	Non volatile memory
RIT	Return Ignore Threshold
SPAD	Single photon avalanche diode
VCSEL	Vertical cavity surface emitting laser
缩写词	**定义**
（同 Esdras）[圣经]以斯拉记	静电放电
I2C	集成电路间(串行总线)
非挥发性物质	非易失性存储器
罗切斯特理工学院	返回忽略阈值
危险信号	单光子雪崩二极管
垂直腔面发射激光器	垂直腔面发射激光器

1 ECOPACK

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为了满足环保要求，ST 提供不同等级的 ECOPACK 封装，具体取决于其环保合规性水平。ECOPACK 规格、等级定义和产品状态可从以下网址获得: *www.st.com*

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1 Revision

Table 19. Document revision history
表 19。文档修订历史

Date	Revision	Changes
30-May-2016	1.0	Initial release.
日期	**修订本**	**变化**
2016 年 5 月 30 日	1.0	初次发布。

1 Revision

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