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## Ranging performances of the VL53L1

### Introduction

This application note describes the ranging performances of the VL53L1 device. A bare driver provides the programming interface to control and manage the device and define the performances in Ranging mode, Scanning mode, and Autonomous mode.

Please note in this document that FoV refers to the field of view and SPAD refers to a single-photon avalanche diode.

# 1 Ranging performances

## 1.1 Measurement conditions

When taking ranging measurements, it is considered that:

- The full field of view (FoV) is covered (i.e. 25 °)
- Charts used as targets are grey (17 % reflectance, N4.74 Munsell) and white (88 % reflectance, N9.5 Munsell).
- Nominal voltage is 2.8 V and temperature is 23 °C
- The device is controlled through the driver using the default settings (refer to UM2133 for a description of the driver settings). The ranging distances reported in this document come from the driver parameter: `RangeMeanMilliMeter`.
- The detection rate is considered as 90 % (or 50 % with partial FoV). This is the percentage of good measurements reported by the device.
- "Dark" means there is no light contribution in the bandwidth 940 nm ± 30 nm.
- "Ambient" means a light level of 0.7 W/m<sup>2</sup> on the sensor, in the bandwidth 940 nm ± 30 nm.
- No coverglass is present
- Typical parts are used
- Ranging accuracy is: 
$$Ranging\ accuracy = \frac{RangeMeanMilliMeter - TargetDistance}{TargetDistance} \times 100$$

## 1.2 Minimum ranging distance

A target can be detected down to 10 mm and performance is specified down to 25 mm.

## 2 Ranging mode performances

Performances for Ranging mode, as defined in the bare driver, are provided in the tables below.

**Table 1. Ranging mode performances at 30 Hz: Medium distance mode with full FoV (16x16 SPAD array) and 33 ms/30 Hz**

Reflectance	Performance		Dark	Ambient
88 %	Max. distance (90 %)		8000 mm	1600 mm
	Accuracy	25-100 mm	±14 mm	±14 mm
		100-2500 mm	±2 %	±7 %
		>2500 mm	±4 %	—
17 %	Max. distance (90 %)		3500 mm	1400 mm
	Accuracy	25-100 mm	±7 mm	±9 mm
		100-2500 mm	±1.5 %	±5 %
		>2500 mm	±2.5 %	—

**Table 2. Ranging mode performances at 30 Hz: Long distance mode with full FoV (16x16 SPAD array) and 33 ms/30 Hz**

Reflectance	Performance		Dark	Ambient
88 %	Max. distance (90 %)		6500 mm	1400 mm
	Accuracy	25-100 mm	±14 mm	±14 mm
		100-2500 mm	±2 %	±7 %
		>2500 mm	±4 %	—
17 %	Max. distance (90 %)		3200 mm	1100 mm
	Accuracy	25-100 mm	±7 mm	±9 mm
		100-2500 mm	±1.5 %	±5 %
		>2500 mm	±2.5 %	—

**Note:** Using Ranging mode, "Distance mode" does not correspond to the maximum ranging distance. The VL53L1 can reach 8 m using Medium distance mode, not Long distance mode.

### 3 Scanning mode performances

Performances for Scanning mode, as defined in the bare driver, are provided in the tables below.

**Table 3. Scanning mode performances at 60 Hz with full FoV (16x16 SPAD array) and 16 ms/60 Hz**

Reflectance	Performance		Dark	Ambient
88 %	Max. distance (90 %)		3300 mm	900 mm
	Accuracy	25-100 mm	±14 mm	±14 mm
		>100 mm	±2 %	±7 %
17 %	Max. distance (90 %)		3200 mm	900 mm
	Accuracy	25-100 mm	±7 mm	±9 mm
		>100 mm	±3 %	±9 %

**Table 4. Scanning mode performances at 30 Hz with full FoV (16x16 SPAD array) and 33 ms/30 Hz**

Reflectance	Performance		Dark	Ambient
88 %	Max. distance (90 %)		3300 mm	900 mm
	Accuracy	25-100 mm	±14 mm	±14 mm
		>100 mm	±2 %	±7 %
17 %	Max. distance (90 %)		3300 mm	900 mm
	Accuracy	25-100 mm	±7 mm	±9 mm
		>100 mm	±1.5 %	±5 %

**Table 5. Scanning mode performances with partial FoV and 16 ms in the dark**

Reflectance	Performance		8x8 SPAD array		4x4 SPAD array	
			In corner	Centered	In corner	Centered
88 %	Max. distance	90 %	2800 mm	3300 mm	600 mm	2100 mm
		50 %	3300 mm	3300 mm	1200 mm	2700 mm
	Accuracy	25-90 mm	±22 mm	±18 mm	±40 mm	±22 mm
		90-100 mm	±13.5 %	±7 %	±40 %	±6 %
		>100 mm	±4.5 %	±2.5 %	±23 %	±6 %
17 %	Max. distance	90 %	1000 mm	1800 mm	200 mm	700 mm
		50 %	2000 mm	2600 mm	400 mm	1100 mm
	Accuracy	25-90 mm	±22 mm	±8 mm	±40 mm	±8 mm
		90-100 mm	±10 %	±3.5 %	±40 %	±4.5 %
		>100 mm	±6.5 %	±3.5 %	±30 %	±7.5 %

## 4 Autonomous mode performances

Performances for Autonomous mode, as defined in the bare driver, are provided in the table below.

**Table 6. Autonomous mode performances with full FoV (16x16 SPAD array) and 76 ms**

Reflectance	Performance		Dark	Ambient
88 %	Max. distance (90 %)		3500 mm	200 mm
	Accuracy	25-100 mm	±22 mm	±24 mm
		>110 mm	±3 %	±15 %
17 %	Max. distance (90 %)		1600 mm	200 mm
	Accuracy	25-100 mm	±16 mm	±23 mm
		>110 mm	±5 %	±12 %

## Revision history

**Table 7. Document revision history**

Date	Version	Changes
16-Oct-2020	1	Initial release

## Contents

<b>1</b>	<b>Ranging performances</b>	<b>2</b>
1.1	Measurement conditions	2
1.2	Minimum ranging distance	2
<b>2</b>	<b>Ranging mode performances</b>	<b>3</b>
<b>3</b>	<b>Scanning mode performances</b>	<b>4</b>
<b>4</b>	<b>Autonomous mode performances</b>	<b>5</b>
	<b>Revision history</b>	<b>6</b>
	<b>Contents</b>	<b>7</b>

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