Time-of-Flight Distance Sensor (VL53L0X)

PHYS 398 FA18
By Simon Hu, Charlie Xiao, Qier An
Overview

- Used to detect gestures or objects in small distances.
How It Works

- A tiny laser emits photons at 940 nm.
- Detects the photons that bounce back with a single-photon avalanche diode
- Calculates distance based on time interval.
Single-Photon Avalanche Diode

Sensitive enough to detect a single photon.

But how?

Single-Photon Avalanche Diode

- Photon hits a semiconductor with a p-n junction.
- Photoelectric effect!
- The emitted electron triggers an avalanche current!

With more detail...

- The p-n junction connected to a reversed-biased voltage above the breakdown voltage that produces a large electric field.
- The emitted electron is accelerated by the electric field and gains enough kinetic energy to trigger an avalanche current through impact ionization.
- The reverse-biased voltage decreases until current ceases to prevent overheating.
- The reverse-biased voltage raise above breakdown voltage of the p-n junction and reverse the diode to its original state.
Specification

- Operating voltage: 2.6-3.5 V
- Operating temperature: -20 to 70 °C
- Laser: 940 nm
- Communicates with I2C.
Sensing Profile

- Default (30ms). 1.2 m range, accuracy discussed later.
- Long range (33ms), up to 2 m, accuracy discussed later. Use in dark conditions with less IR noise.
- High speed (20 ms), 5% accuracy below 1.2 m. Use when accuracy not priority.
- High accuracy (200 ms), 3% accuracy below 1.2m.
Sensing Range

Default mode: 30 mm - 1200mm

Notice white objects have a longer detecting range than grey objects.
Sensing Range

Figure 21. Typical ranging - Long range mode

Long range mode: 30 mm - 1200mm
### Table 11. Max ranging capabilities with 33ms timing budget

<table>
<thead>
<tr>
<th>Target reflectance level (Full FOV)</th>
<th>Conditions</th>
<th>Indoor (2)</th>
<th>Outdoor overcast (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Target (88%)</td>
<td>Typical</td>
<td>200cm+ (1)</td>
<td>80cm</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>120cm</td>
<td>60cm</td>
</tr>
<tr>
<td>Grey Target (17%)</td>
<td>Typical</td>
<td>80cm</td>
<td>50cm</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>70cm</td>
<td>40cm</td>
</tr>
</tbody>
</table>

Note (1): using long range API profile

https://www.adafruit.com/product/3317
### Table 12. Ranging accuracy

| Target reflectance level (Full FOV) | Indoor (no infrared) | Outdoor | |
|------------------------------------|----------------------|---------|
|                                    | 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%   |

https://www.adafruit.com/product/3317
Wiring

- Vin to power
- GND to ground
- SCL to digital 21
- SDA to digital 20

https://learn.adafruit.com/adafruit-vl53l0x-micro-lidar-distance-sensor-breakout/arduino-code
Code support

https://github.com/adafruit/Adafruit_VL53L0X
Sources

https://www.adafruit.com/product/3317


https://en.wikipedia.org/wiki/Avalanche_breakdown

https://en.wikipedia.org/wiki/P%E2%80%93n_junction#Reverse_bias

https://en.wikipedia.org/wiki/Impact_ionization

https://learn.adafruit.com/adafruit-vl53l0x-micro-lidar-distance-sensor-breakout