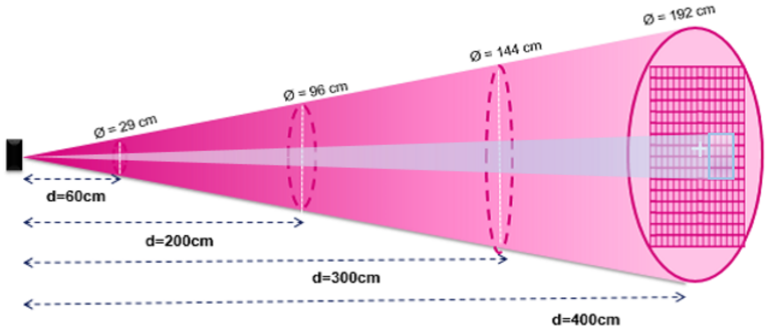
User manual

VL53L1X ultra lite driver multiple zone implementation

Introduction

The VL53L1X ultra lite driver (ULD) allows a region of interest (ROI) to be selected. This region is defined by default in the center of the single photon avalanche diode (SPAD) array, but the center of the ROI can be programmed in other locations of the SPAD array, as explained in this user manual (see figure below).

Figure 1. 27 ° field of view (FoV) down to 15 °



This user manual explains how to configure the ROI of the VL53L1X with a view to moving the FoV so that each range produces a distance in a different zone. This can be achieved using the software (SW) driver application programming interface in conjunction with the instructions given in this document.

1 Document scope

In this user manual:

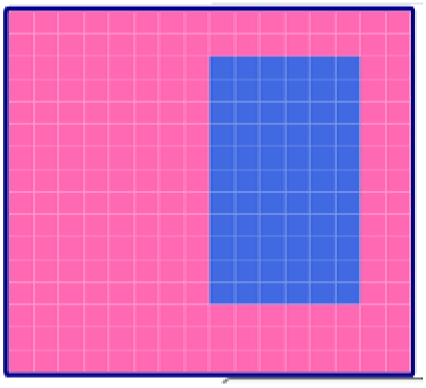
- The VL53L1X contains a 16x16 array of SPADs to collect the light.
- "ROI selection" means positioning the reduced sensing area at a selected place on the SPAD array to detect and measure the distance of the specified area of interest of the external scene.
- "Reduced FoV" means using a reduced number of SPADs for the ROI sensing area to limit the viewingangle of the sensor device.
- A "multiple zone" provides the ability to change the ROI position after each range.

The selected ROI is defined by a combination of the X and Y axis lengths and the selection of a center of the rectangle. The ROI must be at least a 4 x 4 region, and the center must be specified so the entire region is within the SPAD array. The X and Y lengths are specified by the function VL53L1X_SetROI(X, Y) and the center is specified by the function VL53L1X_SetROICenter(C).

In the figure below, the X length is 6 and the Y is 11. Selection and use of the center SPAD VL53L1X_SetROICenter(C) is the main focus of this user manual.

ST delivers a software ultra lite driver referred to as the “driver” in this document.

Figure 2. VL53L1X ROI selection with reduced sensing area (blue represents the active sensing area)



2 Acronyms and abbreviations

Table 1. **Acronyms and abbreviations**

Acronym/abbreviation	Definition
FoV	field of view
ROI	region of interest
SPAD	single photon avalanche diode
SW	software
ULD	ultra lite driver

3 VL53L1X_SetROICenter()

The function that sets the center of the ROI is VL53L1X_SetROICenter(). This function is included starting with revision 1.0.3 of the API. For earlier versions, it can be added. It is a very short function. The code is:

```
VL53L1X_ERROR VL53L1X_SetROICenter(VL53L1_Dev_t dev, uint8_t ROICenter)
{
    VL53L1X_ERROR status = 0;

    status = VL53L1_WrByte(&dev, ROI_CONFIG__USER_ROI_CENTRE_SPAD, ROICenter);
    return status;
}
```

Where "dev" is the device structure and "ROICenter" is the SPAD to be used at the center.

The prototype is:

```
/**
 * @brief This function programs the center of the ROI (Region of Interest)
 * It MUST be called after having called VL53L1X_SetROI
 * It allows to change the ROI position
* @param ROICenter: Region of Interest center
 */
VL53L1X_ERROR VL53L1X_SetROICenter(VL53L1_Dev_t dev, uint8_t ROICenter);
```

4 SPAD details

4.1 SPAD locations

The photon detector is made up of a 16 x 16 array of SPADs. Each SPAD is identified by a number as shown in the table below.

```
/* Table of SPAD locations. Each SPAD has a number which is not obvious.
*
* 128,136,144,152,160,168,176,184,  192,200,208,216,224,232,240,248
* 129,137,145,153,161,169,177,185,  193,201,209,217,225,233,241,249
* 130,138,146,154,162,170,178,186,  194,202,210,218,226,234,242,250
* 131,139,147,155,163,171,179,187,  195,203,211,219,227,235,243,251
* 132,140,148,156,164,172,180,188,  196,204,212,220,228,236,244,252
* 133,141,149,157,165,173,181,189,  197,205,213,221,229,237,245,253
* 134,142,150,158,166,174,182,190,  198,206,214,222,230,238,246,254
* 135,143,151,159,167,175,183,191,  199,207,215,223,231,239,247,255

* 127,119,111,103, 95, 87, 79, 71,   63, 55, 47, 39, 31, 23, 15,  7
* 126,118,110,102, 94, 86, 78, 70,   62, 54, 46, 38, 30, 22, 14,  6
* 125,117,109,101, 93, 85, 77, 69,   61, 53, 45, 37, 29, 21, 13,  5
* 124,116,108,100, 92, 84, 76, 68,   60, 52, 44, 36, 28, 20, 12,  4
* 123,115,107, 99, 91, 83, 75, 67,   59, 51, 43, 35, 27, 19, 11,  3
* 122,114,106, 98, 90, 82, 74, 66,   58, 50, 42, 34, 26, 18, 10,  2
* 121,113,105, 97, 89, 81, 73, 65,   57, 49, 41, 33, 25, 17,  9,  1
* 120,112,104, 96, 88, 80, 72, 64,   56, 48, 40, 32, 24, 16,  8,  0 /*Pin 1*/
```

4.2 SPAD selection

The numbering system is easy for the hardware, but not intuitive to people. Select the SPAD number that is closest to the center of your ROI.

If the center of your region falls between two SPAD numbers, choose the one to the right, or above the center location.

An ROI center definition example is explained in Section 5.1 Example ROI.

5 ROI details

5.1 Example ROI

The yellow color in the figure below shows the ROI. The center of this region is 223 (see pink text below). This is the exact center of the region in the Y direction and it is a half-SPAD right of the exact center in the X direction (as the X direction contains an even number of SPADs).

Figure 3. SPAD locations

```
/* Table of SPAD locations. Each SPAD has a number which is not obvious.
*
* 128,136,144,152,160,168,176,184,  192,200,208,216,224,232,240,248
* 129,137,145,153,161,169,177,185,  193,201,209,217,225,233,241,249
* 130,138,146,154,162,170,178,186,  194,202,210,218,226,234,242,250
* 131,139,147,155,163,171,179,187,  195,203,211,219,227,235,243,251
* 132,140,148,156,164,172,180,188,  196,204,212,220,228,236,244,252
* 133,141,149,157,165,173,181,189,  197,205,213,221,229,237,245,253
* 134,142,150,158,166,174,182,190,  198,206,214,222,230,238,246,254
* 135,143,151,159,167,175,183,191,  199,207,215,223,231,239,247,255

* 127,119,111,103, 95, 87, 79, 71,   63, 55, 47, 39, 31, 23, 15,  7
* 126,118,110,102, 94, 86, 78, 70,   62, 54, 46, 38, 30, 22, 14,  6
* 125,117,109,101, 93, 85, 77, 69,   61, 53, 45, 37, 29, 21, 13,  5
* 124,116,108,100, 92, 84, 76, 68,   60, 52, 44, 36, 28, 20, 12,  4
* 123,115,107, 99, 91, 83, 75, 67,   59, 51, 43, 35, 27, 19, 11,  3
* 122,114,106, 98, 90, 82, 74, 66,   58, 50, 42, 34, 26, 18, 10,  2
* 121,113,105, 97, 89, 81, 73, 65,   57, 49, 41, 33, 25, 17,  9,  1
* 120,112,104, 96, 88, 80, 72, 64,   56, 48, 40, 32, 24, 16,  8,  0 - Pin 1*/
```

5.2 Error 13

As the input parameter is an unsigned 8-bit value, and the valid range is 0-256, there is no error when the ROI is set at center. However, when ranging, if the configuration is not correct, the range status returns a 13 error.

The 13 simply means the hardware was not able to select that particular ROI with that specific center location.

This situation happens a lot when moving the ROI as close to the edge as possible. To avoid it, reduce the X or Y dimensions or move the ROI_Center one SPAD toward the middle.

5.3 Multiple zones

The easy way to implement zones is to choose an X and Y size region and then move the ROI center for each range. In this way, there is one range for each zone. This user manual assumes a common region size unless otherwise stated.

6 Timing considerations

There are two basic timing consideration principles:

- Each range completes with the parameters it started with, even if that parameter is changed part way through the ranging operation.
- Each ranging operation restarts using the timing budget and intermeasurement period currently available without host intervention.

The multiple zone application uses these two basic principles to ensure the hardware operates correctly.

The application must start ranging and then ensure the new region is programmed PRIOR to the start of the next range.

7 Example code

In the example below, the code ranges using one of two regions: the right region centered about ROI 231 and the left region centered about ROI 167. Both regions are 8 SPADs wide by 16 SPADs high.

This example can be used as the basis for a system to detect motion to the right or left.

Figure 4. Example code

```
/* Table of SPAD locations. Center SPADs are Bold and underlined.
 *
 * 128,136,144,152,160,168,176,184, 192,200,208,216,224,232,240,248
 * 129,137,145,153,161,169,177,185, 193,201,209,217,225,233,241,249
 * 130,138,146,154,162,170,178,186, 194,202,210,218,226,234,242,250
 * 131,139,147,155,163,171,179,187, 195,203,211,219,227,235,243,251
 * 132,140,148,156,164,172,180,188, 196,204,212,220,228,236,244,252
 * 133,141,149,157,165,173,181,189, 197,205,213,221,229,237,245,253
 * 134,142,150,158,166,174,182,190, 198,206,214,222,230,238,246,254
 * 135,143,151,159,167,175,183,191, 199,207,215,223,231,239,247,255
 * 127,119,111,103, 95, 87, 79, 71, 63, 55, 47, 39, 31, 23, 15, 7
 * 126,118,110,102, 94, 86, 78, 70, 62, 54, 46, 38, 30, 22, 14, 6
 * 125,117,109,101, 93, 85, 77, 69, 61, 53, 45, 37, 29, 21, 13, 5
 * 124,116,108,100, 92, 84, 76, 68, 60, 52, 44, 36, 28, 20, 12, 4
 * 123,115,107, 99, 91, 83, 75, 67, 59, 51, 43, 35, 27, 19, 11, 3
 * 122,114,106, 98, 90, 82, 74, 66, 58, 50, 42, 34, 26, 18, 10, 2
 * 121,113,105, 97, 89, 81, 73, 65, 57, 49, 41, 33, 25, 17, 9, 1
 * 120,112,104, 96, 88, 80, 72, 64, 56, 48, 40, 32, 24, 16, 8, 0 - Pin 1*/
/*
 These are the SPAD centers of the 2 8*16 zones. Note they are a half-SPAD up and to the right
 of the exact center of the region
*/
        int center[2] = {167,231};
        int Zone = 0;
        int jk=0, i=0;

/* This function must to be called */
        status += VL53L1X_SensorInit(Dev);


/* Initialize and configure the device according to people counting need */
        status = VL53L1X_SensorInit(dev);
        status += VL53L1X_SetDistanceMode(dev, 2); /* 1=short, 2=long */
        status += VL53L1X_SetTimingBudgetInMs(dev, 20); /* 20ms ranges */
        status += VL53L1X_SetInterMeasurementInMs(dev, 21); /* no gap between ranges */
        status += VL53L1X_SetROI(dev, 8, 16); /* minimum ROI 4,4 */
        status += VL53L1X_SetROICenter(dev, center[Zone]); /* start on the Pink Zone */
        status += VL53L1X_StartRanging(dev); /* Begin */
        while(1) { /* read and display data */
                while (dataReady == 0) {
                        status = VL53L1X_CheckForDataReady(dev, &dataReady);
                        usleep(1); //HAL_Delay(2);
                }
                dataReady = 0;
                status += VL53L1X_GetRangeStatus(dev, &RangeStatus);
                status += VL53L1X_GetDistance(dev, &Distance);
                status += VL53L1X_ClearInterrupt(dev); /* for next time */
                printf("Ctr = %1d, s - %2d, d = %5d    ", center[Zone], RangeStatus, Distance);

/* wait a couple of ms to ensure the setting of the new ROI center for the next ranging */
                Zone ++;
                Zone = Zone% 2;
                status += VL53L1X_SetROICenter(dev, center[Zone]);
                status += VL53L1X_SetOffset(dev, OffsetValue[Zone]);
                status += VL53L1X_SetXtalk(dev, XtalkValue[Zone]);
        }
```

In this simplified example, there is no error checking. The center [zone] written at the bottom of the loop is the center of the NEXT range.

8 Calibration details

8.1 Offset

For the best accuracy, each zone must be calibrated separately. The procedure is as follows:

- Set the ROI and the ROI center
- Call the calibration function **VL53L1X_CalibrateOffset()** with a target at a known distance

After each calibration call the function **VL53L1X_GetOffset()** and retain the value in an array.

When calibration is in progress, and immediately after setting the ROI center, call the function **VL53L1X_SetOffset (),** and set the offset calibration for that zone.

8.2 Crosstalk

It is assumed that crosstalk calibration is the same for each zone, but you will need to do some testing to confirm this in your design.

After testing, if the range result is too short it might be due to crosstalk from the cover glass. The cross talk calibration can be run for each ROI. Set the ROI, do the crosstalk calibration, read the crosstalk with the VL53L1X_GetXtalk() and store it.

Every time the ROI is set, set the crosstalk with the function VL53L1X_SetXtalk().

Revision history

Table 2. **Document revision history**

Date	Version	Changes
16-Apr-2019	1	Initial release

Contents