Sensing at the Speed of Light: Introduction to ST's Time of Flight Technology

Imaging Division

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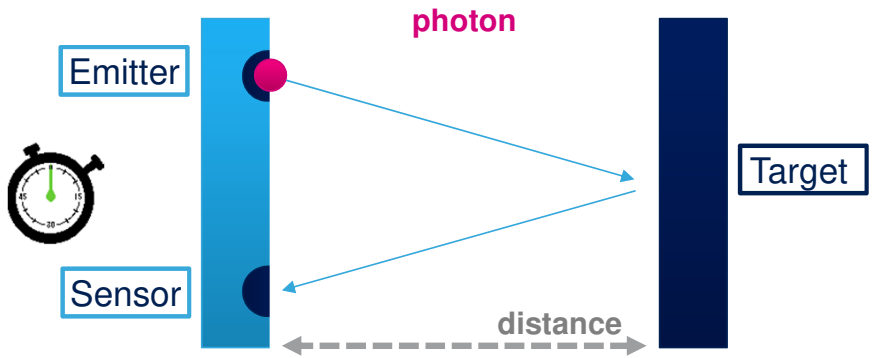
Technology Tour 2019

Anaheim, CA | March 26

Flightsense™ Breakthrough Technology

Measurement at the speed of light!

FlightSense™ Principle



Measured distance = Photon travel time / 2 x Speed of light

Key benefits:

Direct distance measurement
Independent of target size, color & reflectance

Fully Integrated Time of Flight Module
ST #1 World Wide Supplier

Very fast (few ms)

Low power

Light is 1 million times faster than sound!

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Flightsense™

Optical Time-of-Flight Product Family

ST is Worldwide
#1 ToF supplier

Proven track record in manufacturing

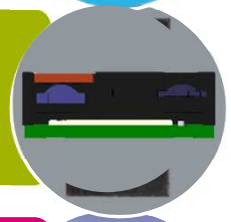
>700Mu products shipped

300% AAGR

Single Photon Avalanche Diode
Ultra fast time resolution enabling Direct ToF processed in ST CMOS SPAD process

ST Proprietary Time-of-Flight IP
Best compromise of cost, complexity & power vs performance

Compact integrated system
Sensor, filters, optics, VCSEL and driver integrated
Fully calibrated system



Optimized and reliable supply chain
High volume & low cost

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Introducing Flightsense™ Technology

- Ranging Sensor
- Laser IR Light Source
- Ambient Light Sensor (VL6180X)

Accurate

Patented Technology
based on Time-of-Flight

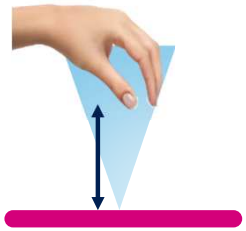
all in one solution

Flexible integration

Invisible Industrial Design
- Easy to integrate
- Can be hidden behind cover glass

Added value

Ranging & Gesture Control



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FlightSense™ vs.
Other Proximity Sensing Technologies

	Capacitive	Ultra-Sonic	Conventional IR	ST FlightSense™
Size/Weight	Small/light	2xToF/Heavy	Small/Light	**Small/Light**
Mechanical integration	Complex (antenna)	Complex (large module)	Easy (if all-in-one)	**Easy (all in one, reflowable)**
Signal Amplitude	No	Yes	Yes	**Yes**
Real distance output	No Very un-precise	No (computed)	No (computed)	**Real distance in mm** (readable thru i²C)
Minimum distance	0cm	10cm	0cm	**0cm**
Maximum distance	Few cms	Up to 1.5m	20cm	up to **4 meters** (1)
Reliable (Vs objects color and reflectance)	No. May detect target in all directions around antenna	No, impacted	No, impacted	**Yes** even black (3%), gloves, …
Reliable (Vs material finish/roughness)	No. Sensitive to body or object charge	No. Isotropic, impacted by wide Sound	No. Angular dependency	**Yes**, with angular dependency
Gesture control Tap vs Swipe		Yes	No	**Yes**

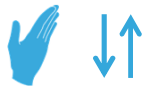
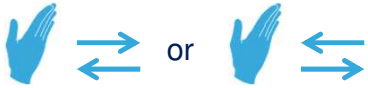
(1) depending on conditions

FlightSense™ Gesture Recognition

Basic Movement Detection

- 4 Gestures from a **single** ToF sensor
- Directional swipe detection when using 2x ToF sensors

Single Tap | Double Tap | Single Swipe | Double Swipe

	Name	Description
	**Single Tap**	Press a virtual ‘button’ on top of the sensor, once
	**Double Tap**	Press a virtual ‘button’ on top of the sensor, twice
	**Single Swipe**	Slide hand left to right or from right to left over the sensor
	**Double Swipe**	Slide hand from left to right and back to left or from right to left and back to right over the sensor

- Discriminate right to left, from left to right gesture when using 2x sensors

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FlightSense™ Product Longevity

7-years Commitment

FlightSense™ benefits from ST Longevity Program

- **7-years** longevity from Product Introduction Date

- VL6180X since January 2015
- VL53L0X since Sept.2016
- VL53L1X since January 2018

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FlightSense™ Product Descriptions

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FlightSense™ Mass-Market Products

VL6180X

- 1st Generation ST ToF Sensor
- Proximity/ALS sensor up to **60cm**

VL53L0X

- 2nd Generation ST ToF Sensor
- Ranging sensor up to **2m**

VL53L1X

NEW

- 3rd Generation ST ToF Sensor, with lens
- Ranging sensor up to **4m**, with programmable **FoV**

Main use-cases: proximity, distance measurement, user / object detection, robotics, lighting control, basic gesture…

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Endless New Applications

Drones

PC & Tablet

Vacuum cleaners

Sanitary

Smart home

Printers

Medical

Service Robots

White Goods

AR/VR

Industrial

Wearable & IoT

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VL53L1X Focus

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VL53L1X: Product Highlights

New Generation ToF Sensor with Lens, for Long-distance Ranging and ROI Selection

Enhanced performance:

- **Full FoV ranging: 400cm+** (white target, no IR)
- SPAD array zone selection (2x2; 4x4; full screen) for FoV reduction

Cutting-edge module and silicon:

- **Longest ranging distance miniature ToF product in the market**
- **Integrated lens** for longer range and better immunity to ambient light
- **Programmable settings** to best fit customer's application:
  - Low power with interrupts for user / object detection
  - Long distance ranging
  - High accuracy for small movement detection

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VL53L1X: Examples of Applications

Presence user detection

- Autonomous mode with interrupts
- Low-power
- Long distance 400cm+
- PC, tablets, IoT, portable handsets, security…

Obstacle detection

- Robots: Obstacle avoidance
- Vacuum cleaners: Wall following, cliff detection
- Drones: Take-off and landing, Ceiling detection

Accurate objects distance scanning

- Vending machines: control of objects in racks
- Coins dispensers: coins counting
- Smart shelves: Consumer scanning

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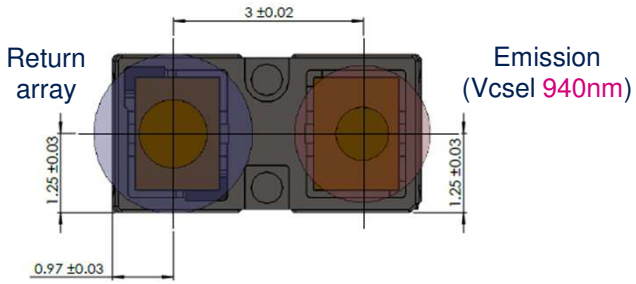
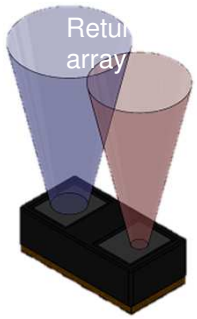
VL53L1X System FoV (Field of View)

Compatible Footprint with VL53L0X: Easy Migration





Typical System
Field of View: **27°**

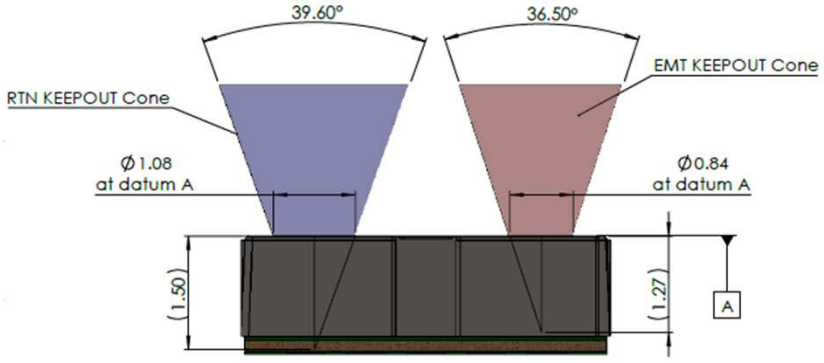
Emission
(Vcsel 940nm)

- OLGA12 Package
- **LxW = 4.9 x 2.5 mm**
- **Height: 1.56mm**
- Reflowable (IPC/JEDEC JSTD-020-C)

- **A 30° lens is added on return aperture** (SPAD array) to increase the signal strength back from the target (8x more signal than VL53L0X)
  It **increases ranging performance** and accuracy

- The VCSEL is not equipped with an emitter lens
  Emitted optical power is identical to VL53L0X
  Retain full laser class1 registration

Exclusion cones for
mechanical integration



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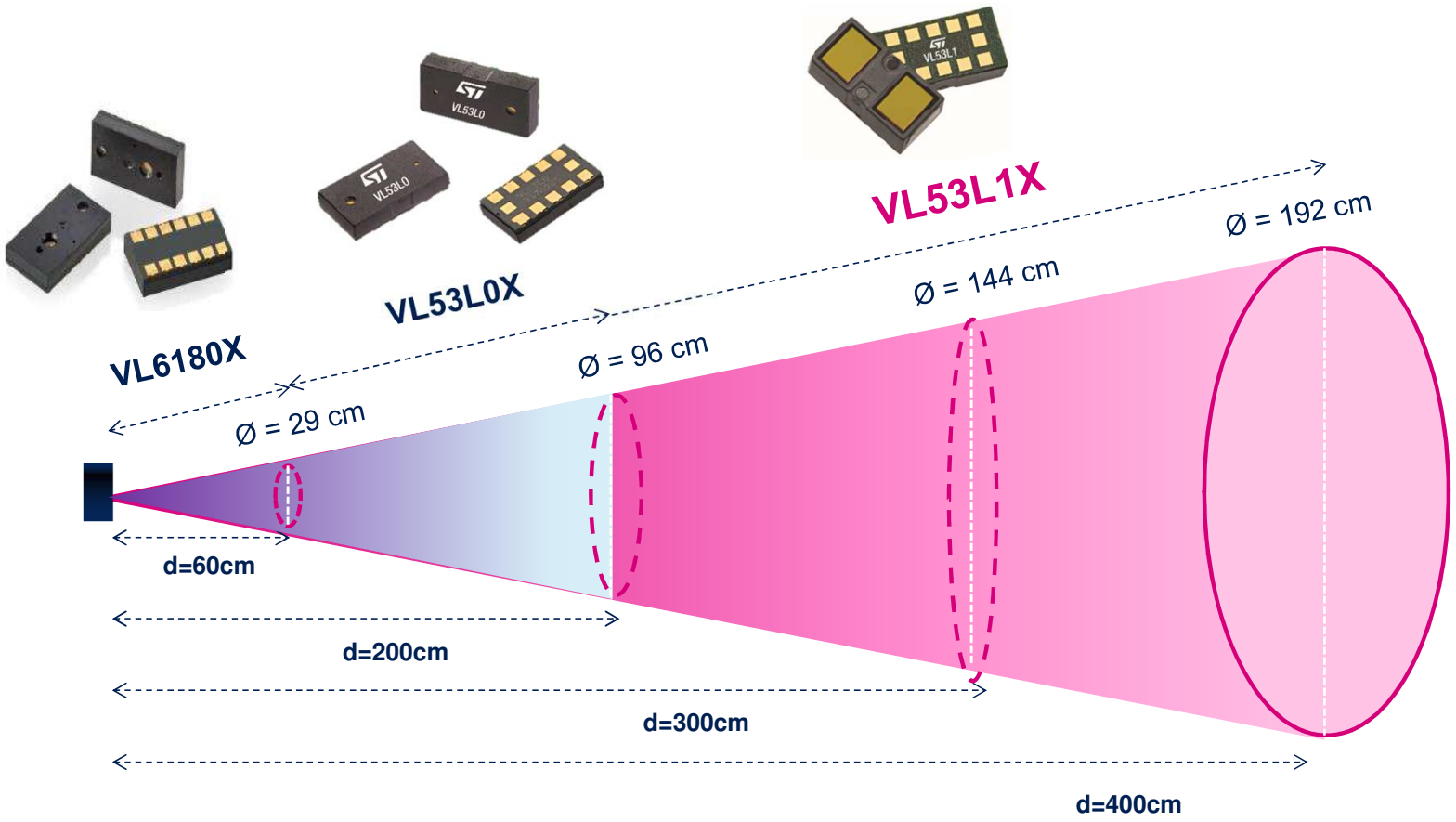
Detection Cone



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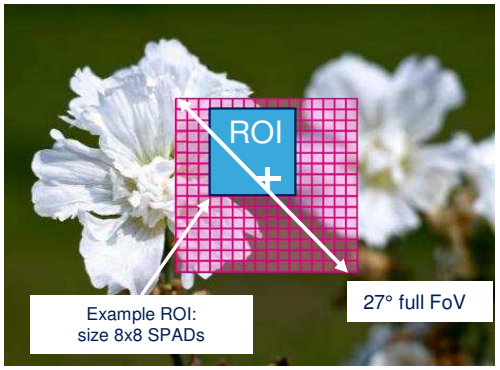
VL53L1X Allows Custom FoV Selection

Region of Interest (ROI) Selection by the User

- No fixed pre-defined size for the sensing array (Region of Interest)
  Unlike other sensors on the market or VL53L0X
- Sensing array is composed by 16x16 SPADs (Single Photon Avalanche Diodes) that **can be selected by customer**
- VL53L1X returns the distance to object covered by the ROI FoV
- **User defines the 2 corners of the array**, through SW driver (API) or the Eval Kit GUI.
  It could even be rectangular. Only condition is to have a minimum of 4x4 SPADs array.
- The change of ROI can be done “on the fly” by the host



Changing the ROI by software allows to virtually reduce the FoV

ROI zone size	Diagonal FOV covered by the zone *
4x4 spads	6.9° (smallest)
5x5 spads	8.6°
6x6 spads	10.3°
7x7 spads	12.0°
8x8 spads	13.7°
16x16 spads	27.0 (largest, full FoV)

* (Exact FOV per ROI size being characterized)

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Adapt VL53L1X Performance
to Your Application

Target performance to best fit application	Autonomous Low Power (ALP)	Fast Ranging
	 	  
Description	• Low power mode • VL53L1X works as master (autonomous state machine) • Sends Interrupt to host if target detected • ROI size selection	• Fast ranging (up to 10ms) • ROI size selection
Max Ranging (Typical, in the Dark, full FoV, white target 88%)	Ultra low power: 1.3m (20ms) Long range: 3.6m (100ms), up to 4.1m	Up to 4.1m
Accuracy	White: 1.5% Grey: 2.5% (offset +/-25mm)	
Power consumption	Ultra Low power: 0.9 mW (no target, 20ms ranging@1Hz)	Typical: 20mW (33ms ranging @ 10Hz)
Ranging under ambient light	■■■□	■■□□

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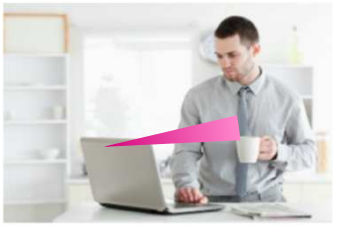
Autonomous Low-Power User Detection

Save Power When No User Detected, and Easily Wake-up Your Device for <1mW

- The ToF sensor must consume as little as possible, just to detect if someone is approaching the device in sleep mode
- VL53L1X includes an Autonomous low-power mode, specially defined for this application



Embedded low-power MCU

- **Programmable** thresholds and repetition rate
- **Autonomous** state machine in VL53L1X
- Once target detected, an interrupt is sent on GPIO1 pin to wake-up the host (no need of i2C)

Example of Energy Saving:

- **VL53L1X in low-power autonomous mode: 0.9mW** (1Hz, 20ms ranging operation)
- Tablet (iPAD3): Active: 40W, Sleep Mode: 0.4W
- Laptop (iMAC 27”inch): Active: 80W, Display off: 20W, Sleep mode: 1W

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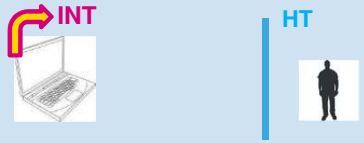
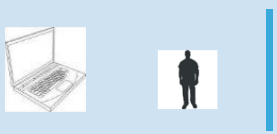
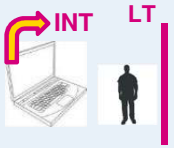
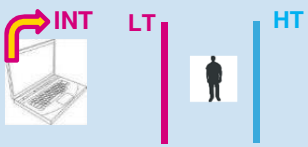
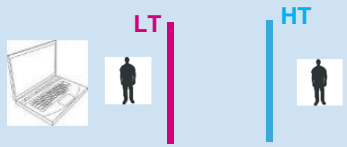
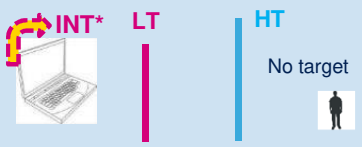
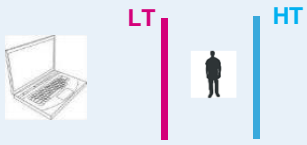
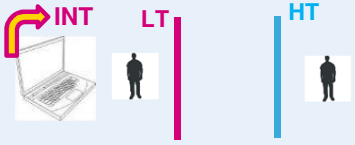
Customizable Thresholding

Threshold condition set in VL53L1X	Human & device situation and Interrupt raised by VL53L1X		
“Above HIGH” (> High)			
“Below LOW” (< Low)			
“In Window” (>= Low AND <= High)			
“Out of Window” (> High OR < Low)			

INT* (optional interrupt), customer choice

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Cover-Glasses and Special Module

for FlightSense™ Sensors

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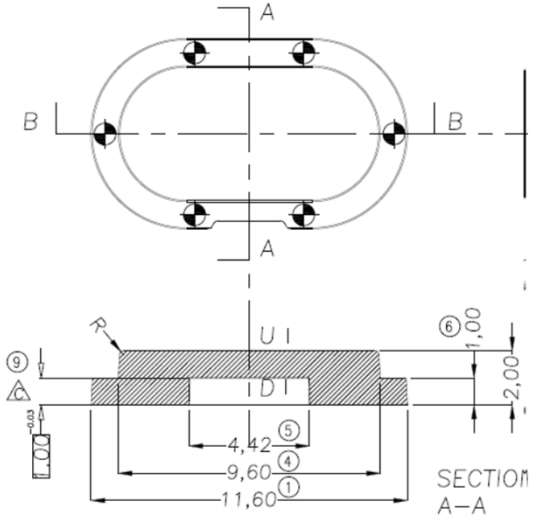
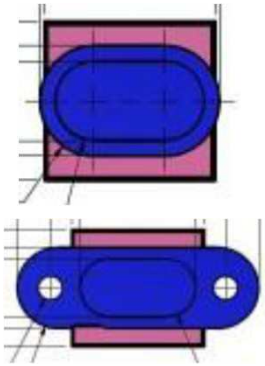
Cover Glass by Hornix

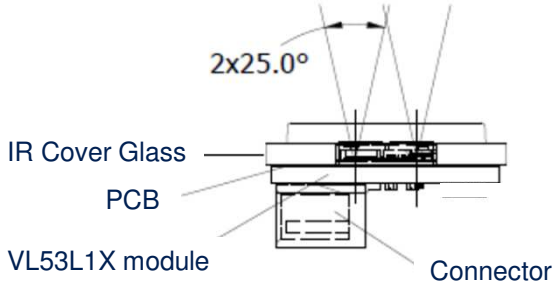
Low Xtalk CG Ready to be Clipped above ToF Sensors, and Fixed on a PCB

- Detail of Cover Glass, with a cavity underneath clipped on the ToF sensor, and a shape around the glass for insertion into a frame
- One version to be glued on PCB
- One version with holes to screw the CG on PCB





- Detail of complete module, with ToF sensor soldered on PCB, CG clipped on sensor and glued on PCB, and connector below the PCB



HORNIX OPTICAL TECHNOLOLOGY INC.

FlightSense™ Development Tools and Technical Support

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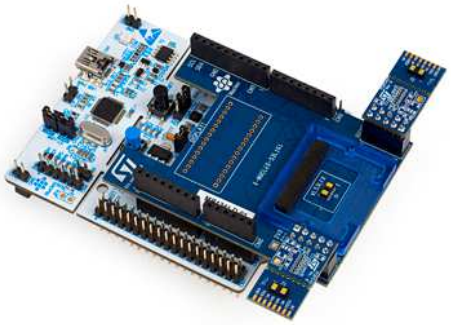
FlightSense™ Development Tools

- **Quick and easy evaluation and application development** thanks to X-NUCLEO expansion boards and STM32 NUCLEO boards
- Small form factor satellites for **easy integration** into customers' devices
- Basic evaluation in stand-alone USB, or advanced through GUI on PC



- Complete suite of SW tools and documentation (API, X-CUBE…)
- Code examples for plug and play application (Ranging, ALS, gesture…)

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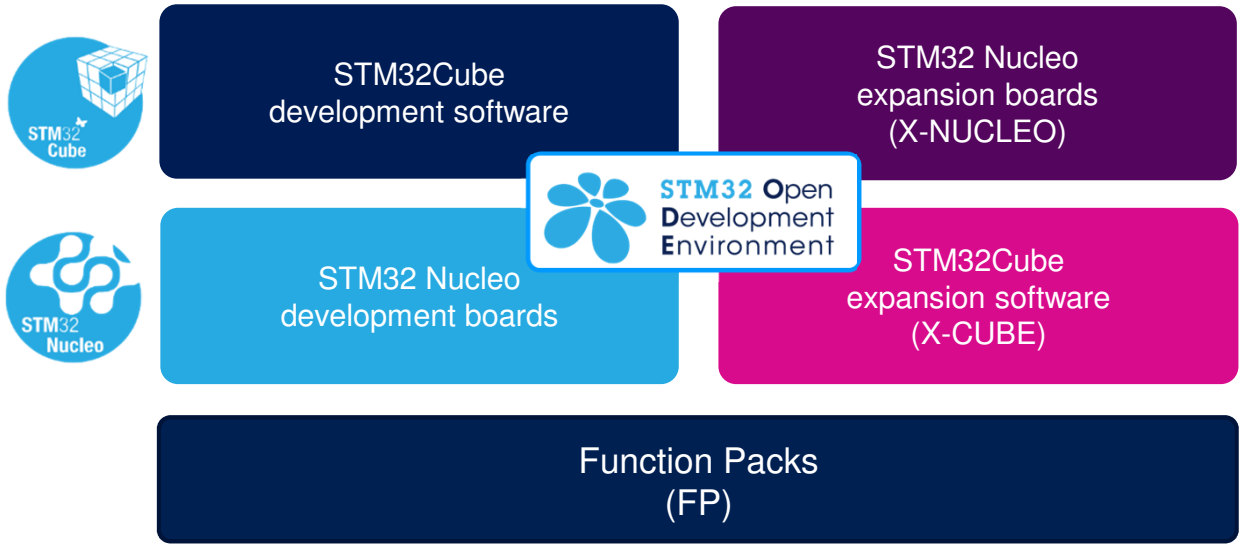
STM32 Open Development Environment

Fast, Affordable Prototyping and Development

- The STM32 Open Development Environment (ODE) consists of a set of stackable boards and a modular open SW environment designed around the STM32 microcontroller family.



www.st.com/stm32ode

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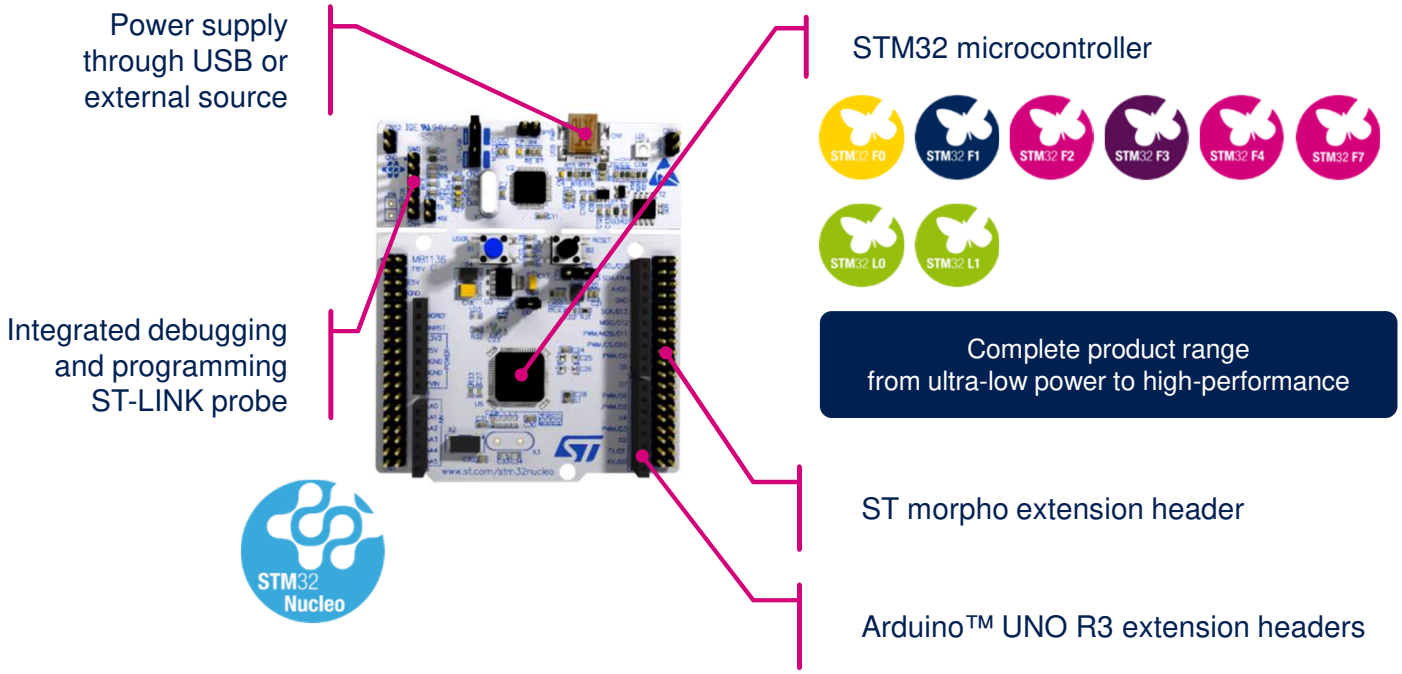
STM32 Nucleo
Development Boards (NUCLEO)

- A comprehensive range of affordable development boards for all the STM32 microcontroller series, with unlimited unified expansion capabilities and integrated debugger/programmer functionality.

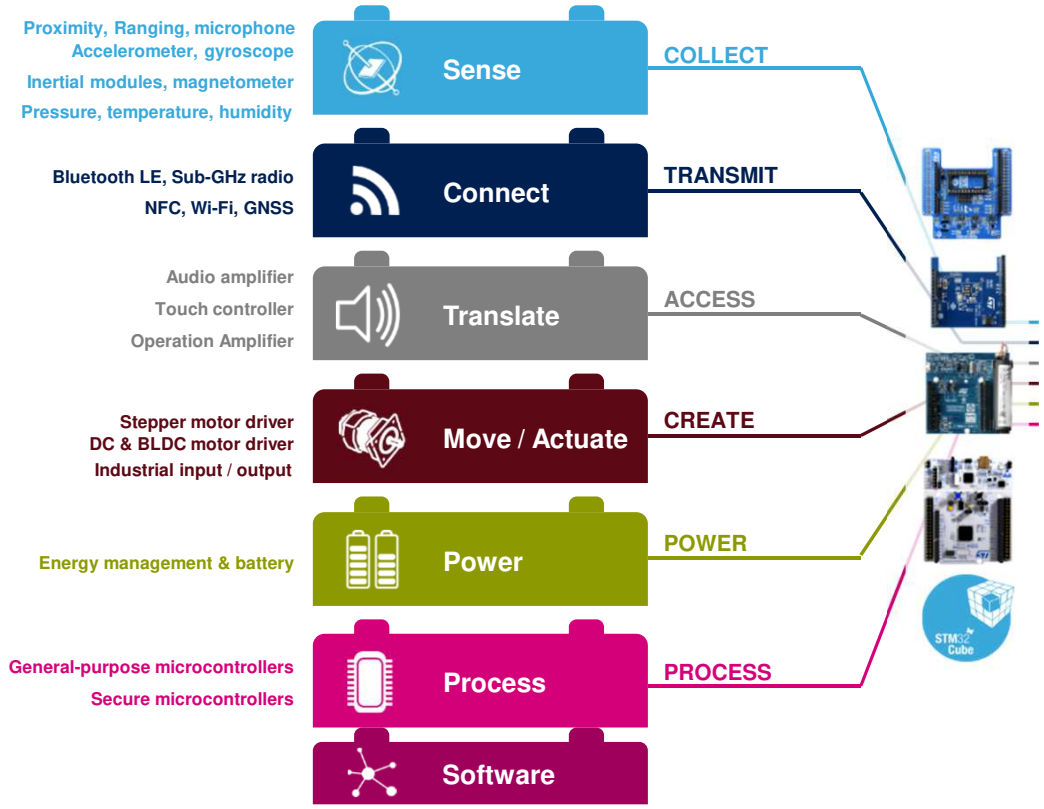


www.st.com/stm32nucleo

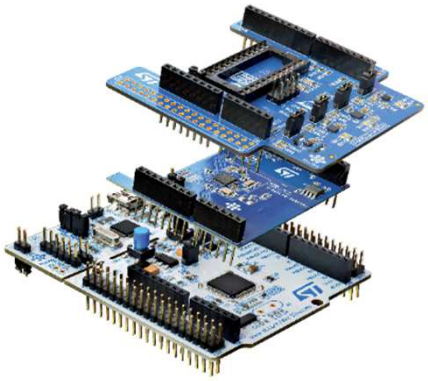
STM32 Open Development Environment

Expansion Boards Can be Plugged Together

The building blocks	Your need	Our answer



STM32 Open Development Environment



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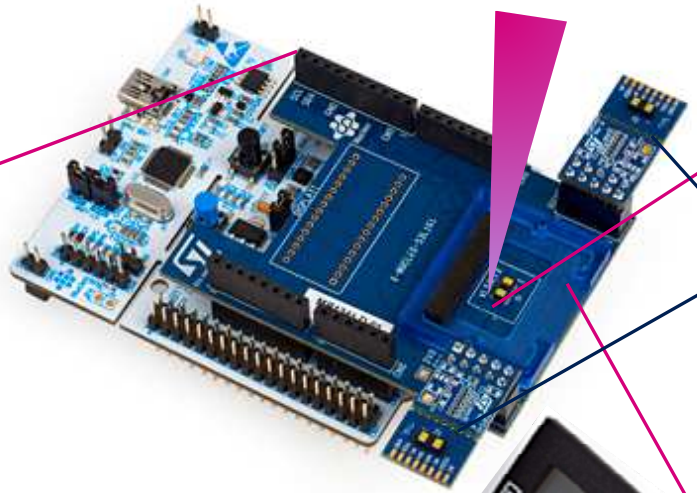
VL53L1X Nucleo Expansion Board

X-NUCLEO-53L1XA1 Works with STM32F401RE

https://www.st.com/content/st_com/en/extended-query.html?querycriteria=productId=SC1971$$associatedTo=SC1934



Arduino
Connectors

VL53L1X
Ranging sensor

2x VL53L1X breakout boards
(plugged or hardwired)

Cover Glass holder
(Can hold Cover Glass and spacers)

Spacers and Cover Glass
3 spacers 0.25/0.5/1mm to create various air gaps below CG

PC GUI interface

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X-CUBE SW Package
for FlightSense™ Sensors

Nucleo-centric SW package following STM32Cube SW architecture
Code is structured in a way ToF sensors-based applications can be built very quickly on Nucleo platforms

Based on FlightSense™ sensor API
Sensor API appears as a BSP component

Validated on Nucleo pack
Example codes available for various NUCLEO STM32 boards (F401RE, L476RG, L053R8) plugged with ToF sensors X-NUCLEO expansion boards and satellites

Ranging, Ranging with satellites, ALS examples + Gesture detection demos
Examples: RangingAndALS (VL6180X) or RangingWithSatellites (VL6180X or VL53L0X)
1 application: GestureDetect (TAP & SWIPE)
Source code with pre-compiled binaries and Keil, IAR and STM32Workbench projects

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FlightSense™ Sensors Adopted by

Multiple System Development Tools

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“Getting Started” Video for VL53L1X

Nucleo Expansion Board

Videos available on:

- st.com
- Imaging YouTube

https://www.st.com/en/imaging-and-photonics-solutions/vl53l1x.html

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How to Order

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Ordering Codes

Go to St.com or Contact Your Usual Distributor

- VL53L1X: https://www.st.com/content/st_com/en/products/imaging-and-photonics-solutions/proximity-sensors/vl53l1x.html#samplebuy-scroll
- VL53L0X: https://www.st.com/content/st_com/en/products/imaging-and-photonics-solutions/proximity-sensors/vl53l0x.html#samplebuy-scroll
- VL6180X: https://www.st.com/content/st_com/en/products/imaging-and-photonics-solutions/proximity-sensors/vl6180x.html#samplebuy-scroll