ST Sensors and Connectivity

Predictive Maintenance and Asset Tracking

Antonio Cirone - Product Marketing

Filippo Colaianni – System Solutions

Innovation boosted by Sensor Processing Capabilities

Motion, Environmental, Sound, Presence, Distance - Evolution

High-g shock accelerometers

Inclinometers

Vibration sensors

Time of Flight & Global Shutter

Flight Sense

6-axis IMU + Machine Learning

STRed-ISPU Processor for AI

High-bandwidth microphones

TMOS

Pressure sensors

Humidity sensors

Temperature sensors

QVAR

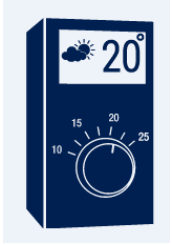
Qvar

Focus applications and macro trends in Industry 4.0

Predictive Maintenance

Inclination monitoring and active antenna systems

Asset Tracking



Sensors Nodes for Environmental monitoring

Audio (noise and voice)

Artificial Intelligence

and Cloud integration

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ST Leading Industrial Sensors and Predictive Maintenance

Markets and applications segmentation

New equipment (greenfield)

Integration possible with power supply and existing sensors

In-field maintenance (retrofit)

Battery-powered simplifies installation

Industrial

- Manufacturing and Process Automation
- Power and energy
- Smart Building Automation

Automotive and Transportation

- Vehicles
- Railways
- Infrastructures

Home

- Washing Machine
- Vacuum cleaner, Air conditioning

Focus on

Vibration monitoring
Temperature and Environmental
Ultrasound detection


Industrial motor vibration monitoring


Bearing's ultrasound monitoring


Motor current monitoring

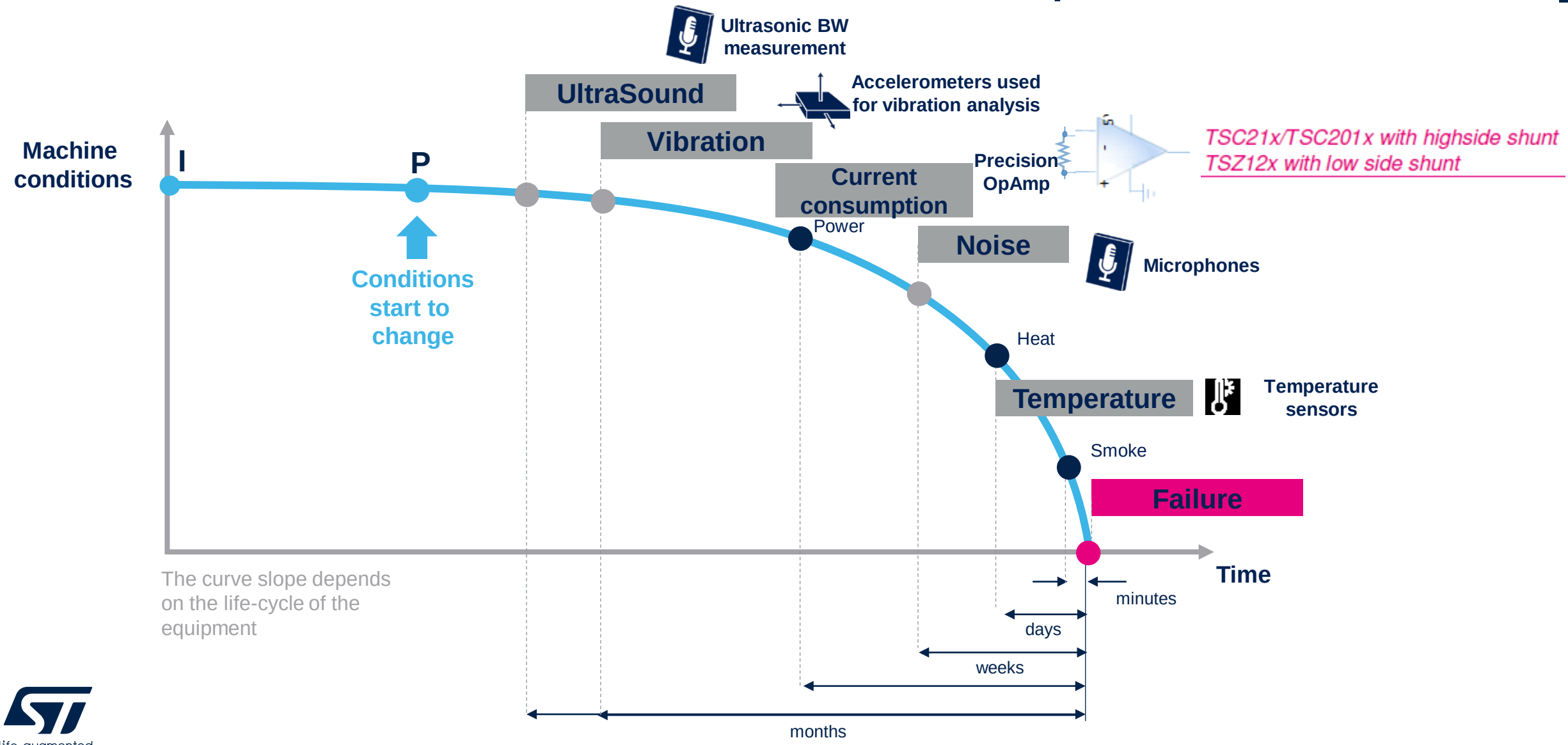

Crankshaft rotation monitoring


Pipe flow monitoring


Temperature, humidity, gas monitoring


acoustic monitoring

ST Sensors inside condition monitoring and point failure curve



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ST sensors for industry 4.0

10 years longevity commitment
ST focuses on markets requiring long lifecycles

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State-of-the-art sensors for industry 4.0

Deep expertise in Automotive

Leadership in consumer MEMS

10-year longevity
from product introduction date

Design and manufacturing for higher robustness

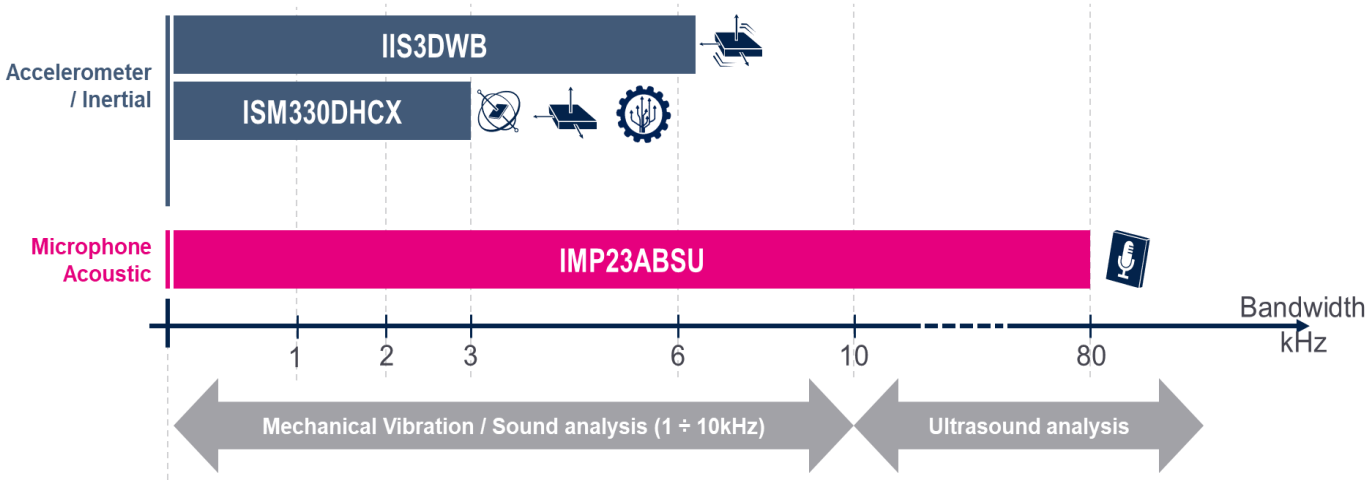
Calibration & testing for higher accuracy & quality

Higher endurance to shock and vibration

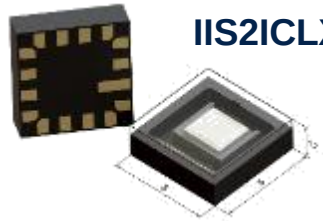
Extended temperature range

New Sensors x Condition Monitoring

Vibration analysis



Precise Inclinometer



IIS2ICLX

Tilt error <0.5°
over Temp. and Time

New Industrial Pressure sensors

Full Scale up to 4Bar
Molded and Water Proof robust packages
Extended Operating Temperature: -40°C +105°C

Temperature sensor

Accuracy: <0.5°C
exposed pad down for better temperature matching with external environment

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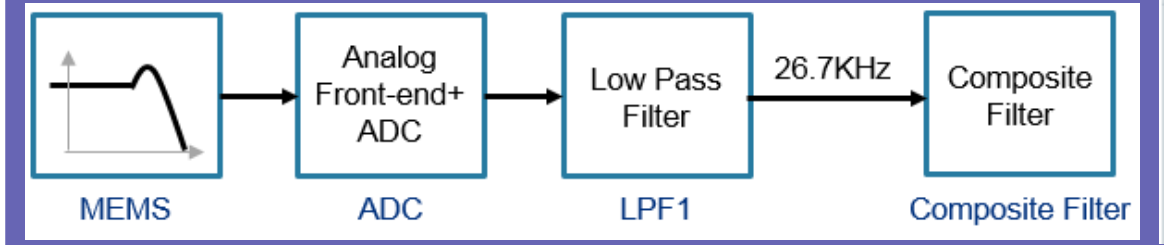
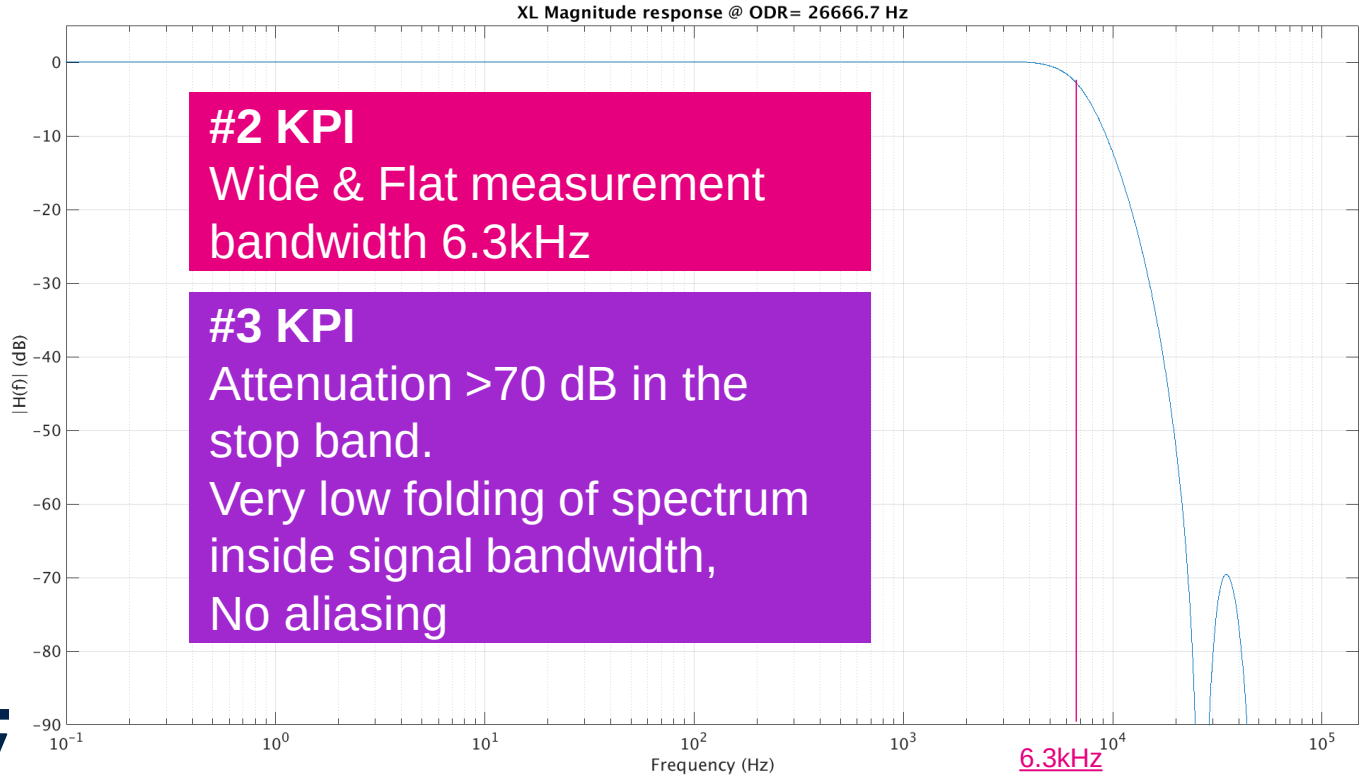
IIS3DWB Key Performance Indicators for condition monitoring

#1 KPI Filtering chain and Low noise levels

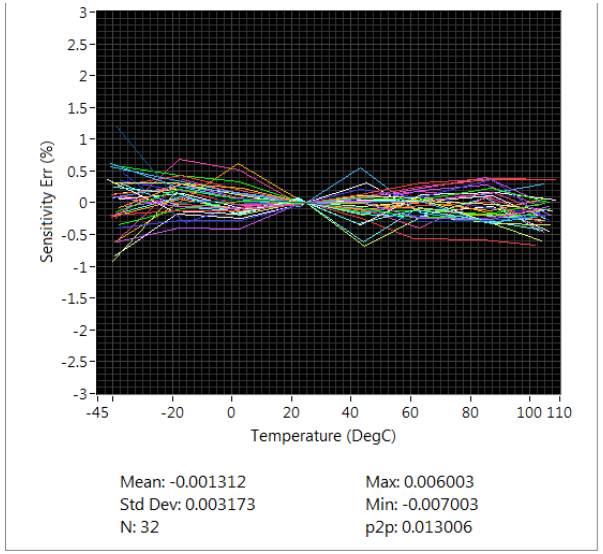


			Typ.	Max.	
An	Acceleration noise density 3 axes enabled[6]	X-axis	75	110	µg/√Hz
		Y-axis	75	110	
		Z-axis	110	190	
	Acceleration noise density only 1 axis enabled[6]	X-axis	60	90	
		Y-axis	60	90	
		Z-axis	80	130	



#2 KPI
Wide & Flat measurement bandwidth 6.3kHz

#3 KPI
Attenuation >70 dB in the stop band.
Very low folding of spectrum inside signal bandwidth,
No aliasing



#4 KPI
Stable thermal behavior over extended temperature range

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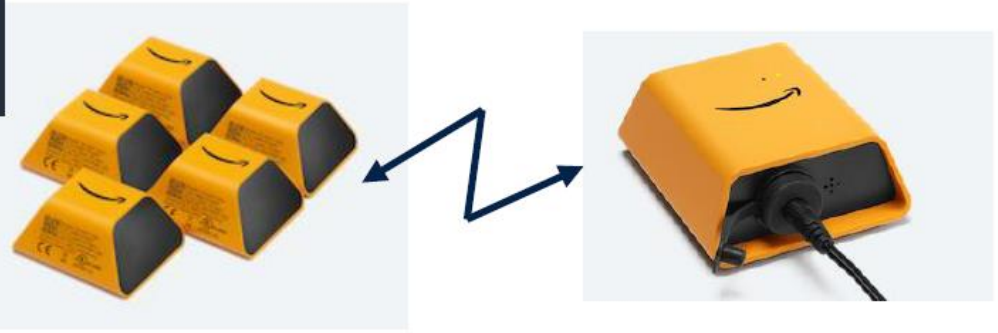
Frequency response determined by CAD simulation – at the output of LPF1

ST success stories and positioning
Vibration Sensor IIS3DWB

IIS3DWB across customer base in EMEA (Amazon GER, SPM, Schaefflerc, Symphony Industrial)



ISM330DHCX Always-on and Stability

6-axis Inertial Module for Industry 4.0 and high-end applications

Axel Performance

Typ. Noise Density: 60 µg/√Hz

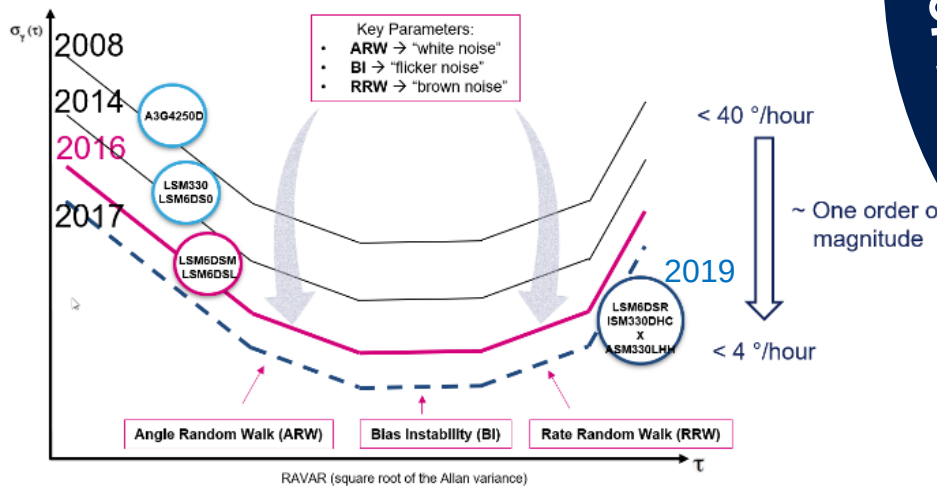
ODR: up to 6.6KHz / BW up to ODR/2

Gyro Stability Features

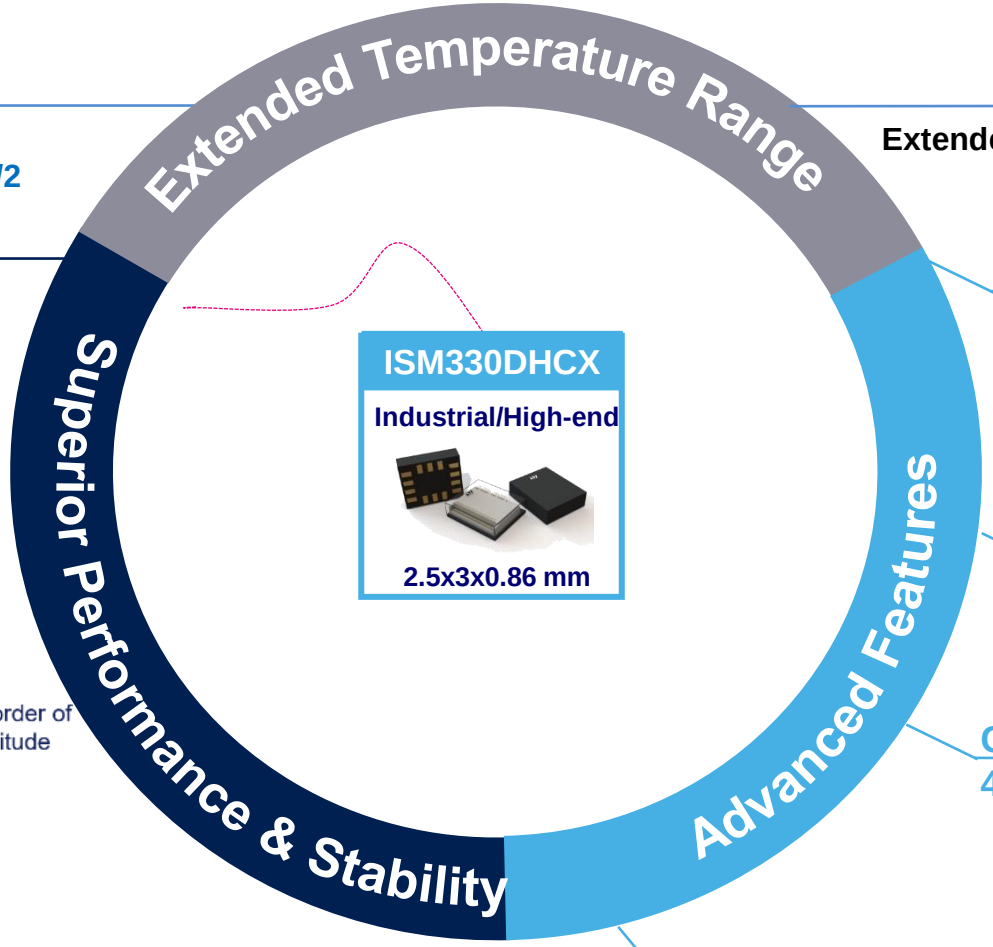
Typ. ARW: 0.21 deg/√h

Typ. BI: 3°/hr (High accuracy)

Stability: Over time & Temperature



Allan Variance (AVAR) analysis of stability in time and noise contribution



Operative Temperature

Extended Temp. Range: up to +105°C

10 years Longevity

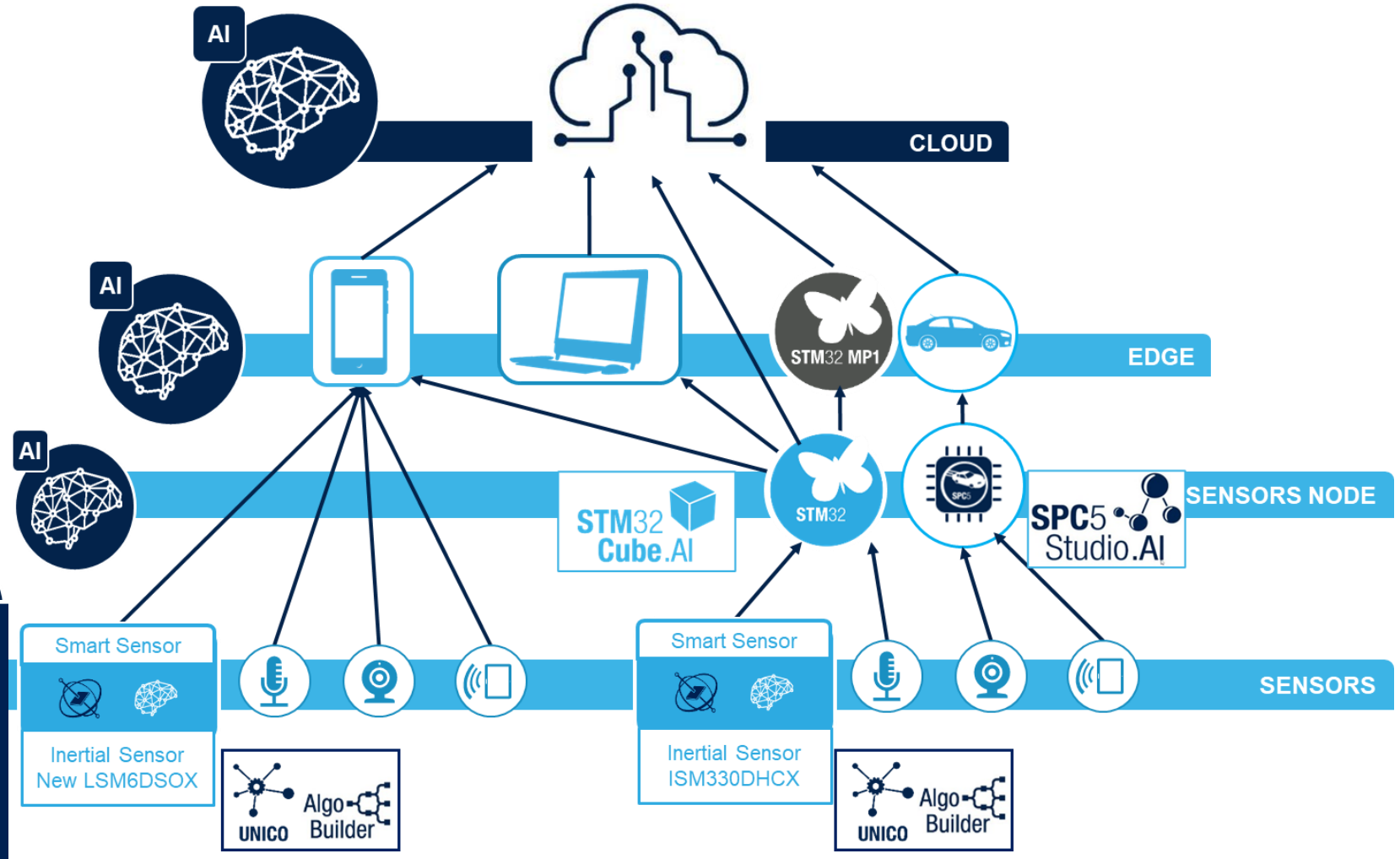
Ultra Low Power

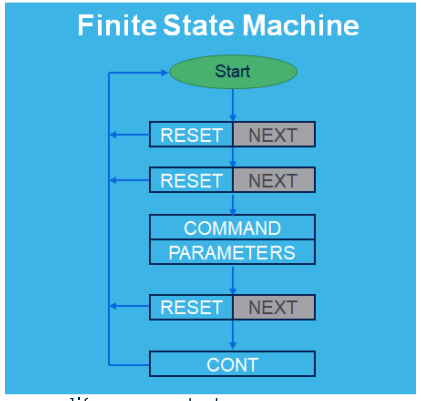
Gyro FS up to 4000dps

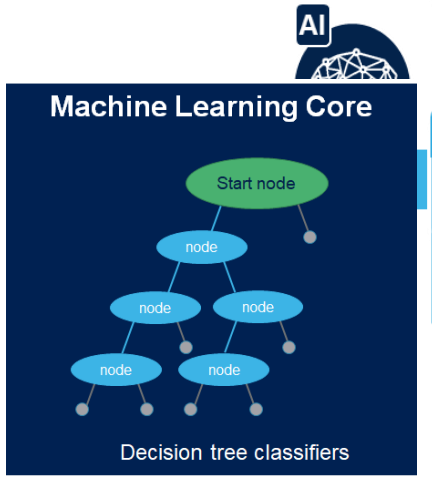
Programmable embedded FSM and MLC

ST Sensors enable Distributed Artificial Intelligence @ the deep edge

- **Responsiveness**
- **Bandwidth**
- **Privacy**
- **Security**
- **Energy Saving**







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Example of Machine learning configuration flow in ISM330DHCX

Definition of the classes to be recognized: running, walking, car, ... Capture data …

1

User defines Classes to be recognized

2

Collect data Logs for each class and label data

3

Select Features that best characterize the identified classes

4

Machine Learning tools generate program for ST IMU ISM330DHCX based on Logs and Features

5

Configure the ST IMU ISM330DHCX and run the application

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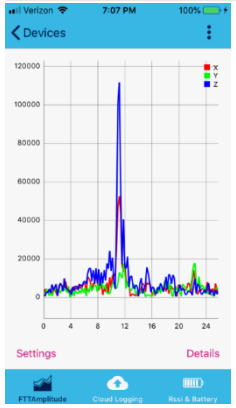
Sophisticated movement detection
More intelligence examples
with embedded Machine Learning Core

Get inspired by MLC examples!

Personal Electronics

- Activity recognition
- Gym activity recognition
- Head gestures
- Sleep monitoring
- Yoga pose recognition
- Man Down

Industrial & IoT



- Motion intensity
- Orientation detection
- Vibration monitoring
- Tilt angle
- Drilling machine (under preparation)

Automotive and Asset tracking

- Vehicle stationary motion detection
- Boats tracker
- Airplane mode detection

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MLC examples are available online at dedicated GitHub project for Machine Learning Core

by STWIN development Kit including 6-axis IMU with MLC

Machine Learning Core in power tools, drilling machine as intelligence example

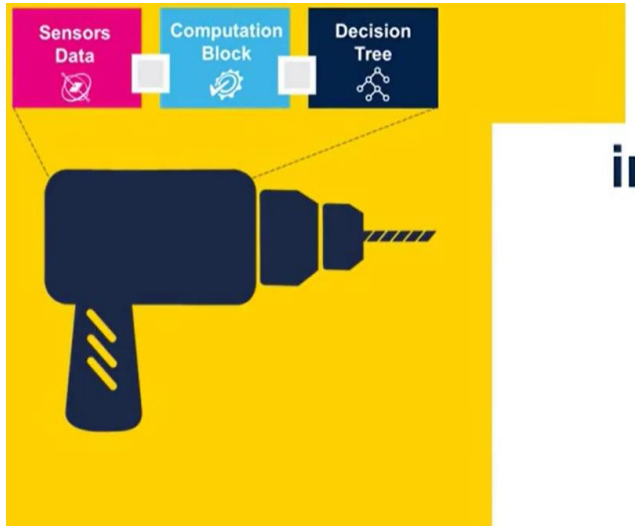
Classes/Classification:

Idle

Tightening screw

Drilling

Loosening screw



Three classes are defined in the Machine Learning Core

- **Implementation details**
  - STWIN board attached to a drilling equipment sensing movements / vibration (AXL, IMU)
  - Programmable embedded decision tree detects different drill operations / screwing
- **Benefits in real application**
  - Auto adjust of drill setup based on current utilization of the tool
  - Better user experience (no need to readjust drill manually)
  - Power consumption optimization - longer battery life

Put your own Decision Tree

Other equipment: electric saws, cutters, screwdrivers, wrenches, grinders, …

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Process new data

Another example by MLC

Real time classification of the FAN status in ST BLE Sensor App
To recognize three different classes of a fan rack operation

STEVAL-STWINKT1

I.e. Fan_fault: can be obtained in a disruptive way by breaking one of the fan fins or, in a non disruptive way, by applying a small weight (e.g. a metal spring clip)

ST BLE Sensor App classification

https://github.com/STMicroelectronics/STMems_Machine_Learning_Core/tree/master/configuration_examples/example_4_stwin_stble_unico

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Cooperation promotes AI-Enabled Systems Solutions

Smart Sensor
with Machine Learning Core

FSM up to 16

MLC up to 8

Inertial Sensor
New LSM6DSOX

Raw Data

Event Decision

FSM and MLC
Re-configuration

Smart STM32
Second level of AI processing

Deep Learning
Neural Networks
Machine Learning

SRA/MSD/MCD Context Awareness Function Pack NOW AVAILABLE!
Presented at TINY ML EMEA Event

Sensor Expansion Board
for Automotive

MLC up to 8

Raw Data

Event Decision

MLC re-configuration

ADG Ecosystem

SPC5

SPC5 MCU

AutoDevKit

MSD/ADG Co-Development of SPC58-SENSOR expansion board
PoC on-going

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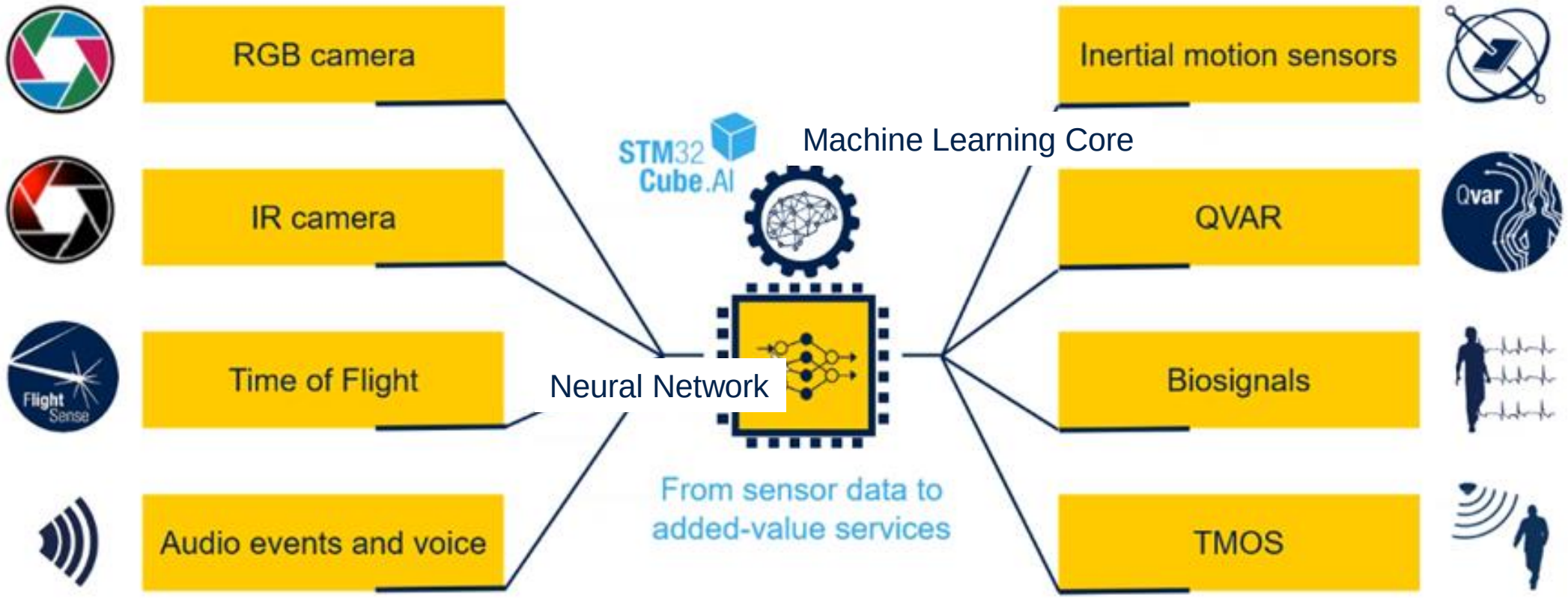
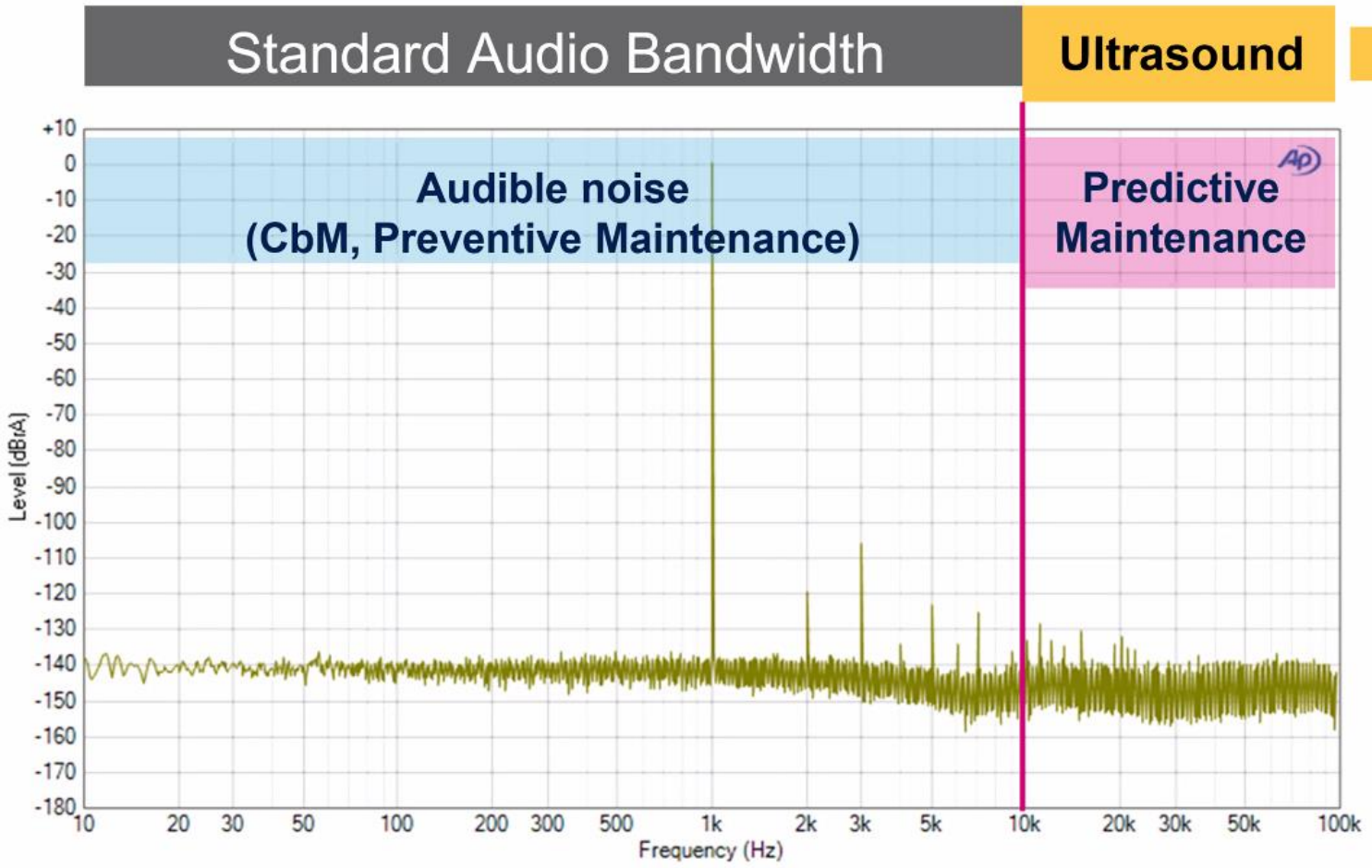
Get the best out of the sensors with AI technology



Standard Audio vs Ultrasound



Post processing analysis Ultrasound frequencies to **detect** and **classify** leaks

Most common maintenance applications

- Air Leak Detection of compressed air equipment
- Vibration monitor
- Compressor Valve Inspections
- Acoustic Lubrication
- Heat Exchanger and Condenser Leaks
- Hydraulic Systems
- Pump Cavitation

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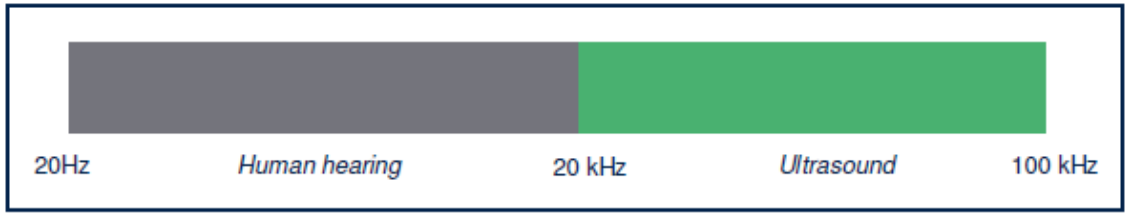
IMP23ABSU
High performance microphone up to 80 kHz

Key Features

- **Ultrasound Bandwidth (up to 80 kHz) for predictive maintenance**
- **Bottom Port Analog Single Ended Microphone**
- **Low power and with flat and ultra wide frequency response:**
  - Roll off @ 15Hz
  - Sensitivity : 38dB ±1dB
  - AOP: 130 dBSPL
  - SNR: 64dB(A) (min)
- Operating temperature range from -40 to +85 °C
- Package RHLGA 5L - 3.5 x 2.65 x 0.98 mm
- Supply 1.52 - 3.6V

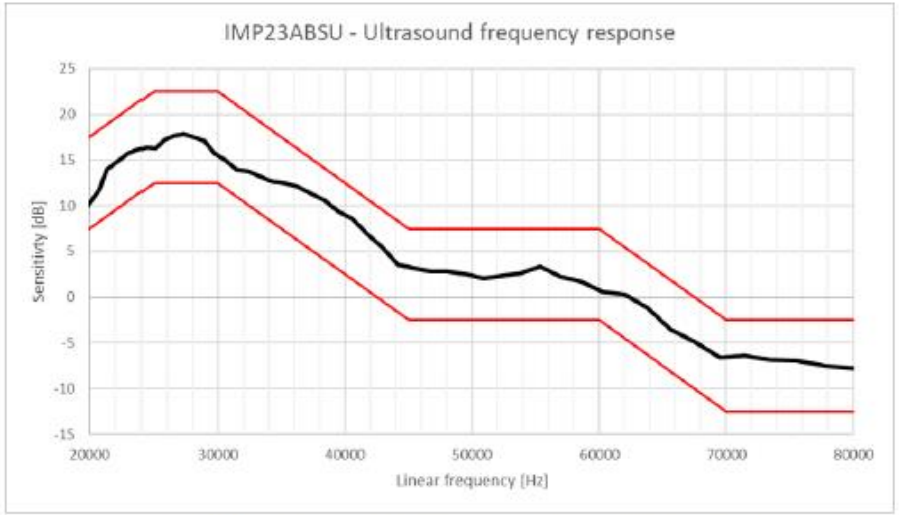


"Acoustic sound within the human hearing range. ***Most background noise*** *in plants and other industrial facilities, including turbines, motors, and compressors, falls within this frequency range " **

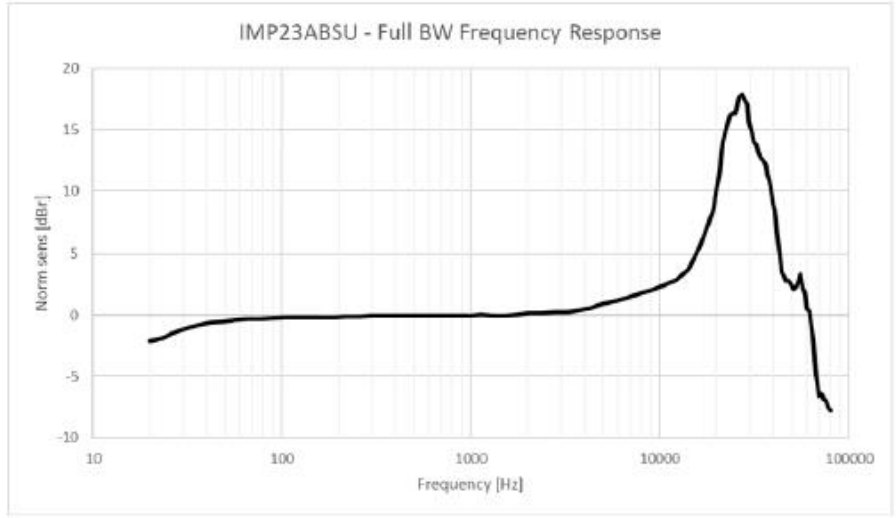
"Acoustic sound beyond the human hearing range. Very few background noise will occur on this area. ***Leaking gas produces acoustical sound within this range" ****

**) Reference AZOsensors.com*

See AN5522 for more details



Ultrasound frequency response



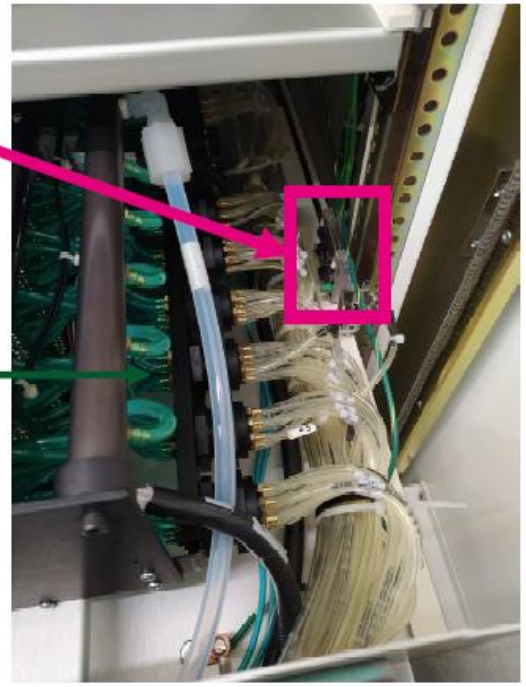
Full frequency response in logarithmic scale

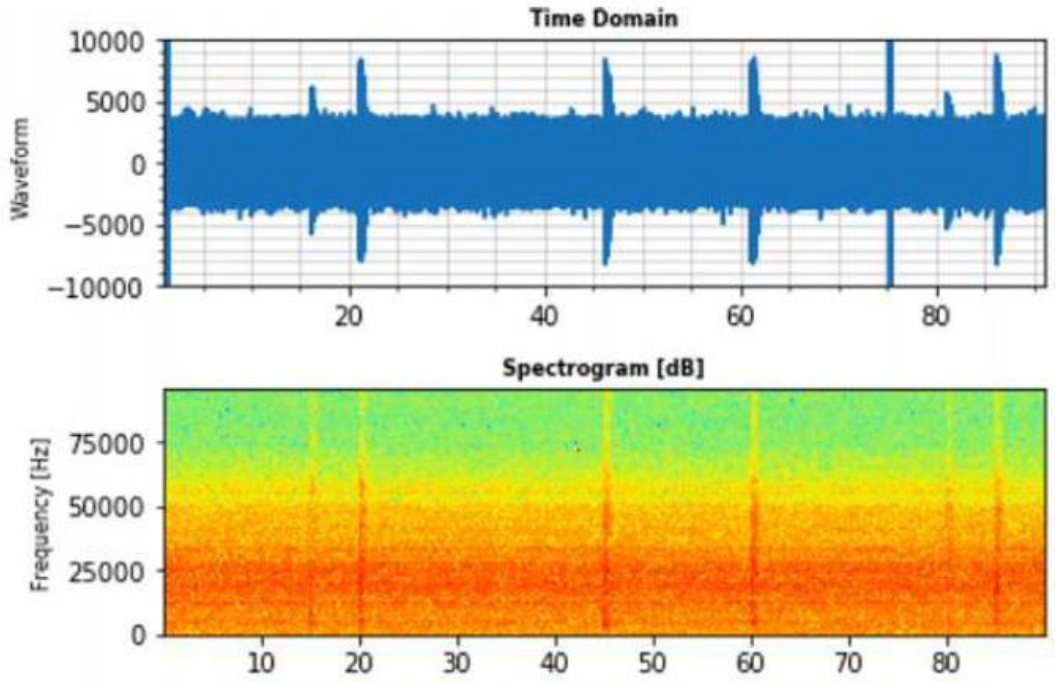
Ultrasound microphone for air and gas leakages

- N2 or air leaks are common on tools with large number of pneumatic valves
- Widely used in chemical process industry where the presence of chemical vapor harms valves functionality, keeping under control every valve is very challenging
- Gas leak detector with ultra-sound microphone is an “non-intrusive” monitoring method

STWIN

Pneumatic valves rack





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Sensor Tile Wireless Industrial Node
STEVAL-STWINKT1B

Motors

Equipment

Environment

Processing

Local Processing & Security

- Ultra-low-power ARM® Cortex®-M4 STM32L4R9
- **Secure Element STSAFE-A110**

Connectivity

Embedded Wireless and Extension

- BLE 5.0 (**BlueNRG-M2**) , WiFi (Inventek)
- Modular expansion: LTE, LoRa, Industrial Ethernet

Sensing

Industrial-grade sensors for

- Vibration analysis (IIS3DWB, ISM330DHCX)
- Sound Emission up to 80 kHz (**IMP23ABSU**)
- Environment monitoring (HTS221, STTS751, LPS22HH)

Power

Power Management

- Li-Ion linear battery charger with load switches
- Miniaturized synchronous step-down converter with high-efficiency conversion

STEVAL-STWINWFV1 (Optional)

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http://www.st.com/stwin

Datalogging and labeling have never been so easy

SWIN connected to a smartphone app allowing to:

- Configure sensors
- Implement datalogging and labeling
- Interfacing MLC configuration

Out-of-the-box STWIN1B connects to a smartphone allowing to configure sensors, interfacing MLC configuration, implement datalogging and labeling and offer host integrated environment

BLE

SD Card

USB

Wi-Fi

Control

Data High throughput

Data Low throughput

Host / Gateway

GUI

SDK

ST-Unico

STM32 Cube.AI

python

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Wide application examples

Several STM32Cube function pack by step

Data Logging

USB and WiFi High Speed Data Streaming (6Mb/s)
SD Card High Speed Data Recording
Host integrated environment Python, C++ and Matlab

- **FP-SNS-DATALOG1**

Cloud Connection

Cloud Connectivity SDK and Application for fast implementations (*AWS, Azure*)
Offer examples of Security Features

- **FP-CLD-AZURE1**
- **FP-CLD-AWS1**

involving Partners

Authorized Partner

Condition Monitoring

Vibration / Ultrasound monitoring with Time Domain / Frequency Domain and Environmental Analysis

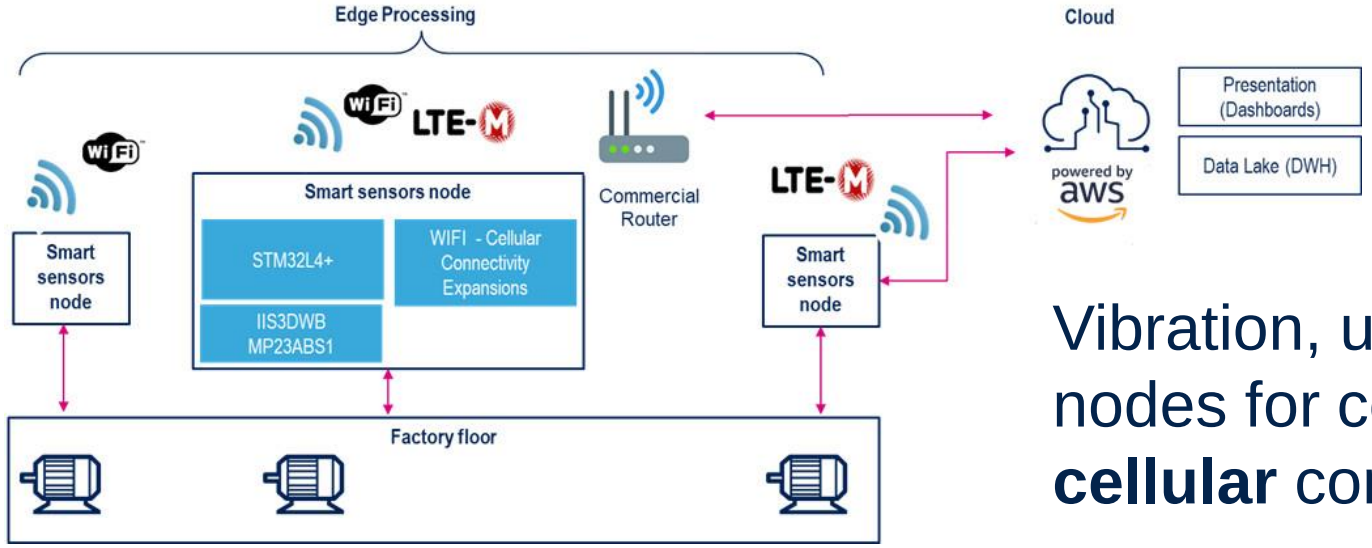
- **FP-IND-PREDMNT1**: BLE / Wi-Fi
- **STSW-STWINCELL**: CatM / NbIoT (to be updated)
- **SL-PREDMNT-S2C**

Anomaly Detection and Classification

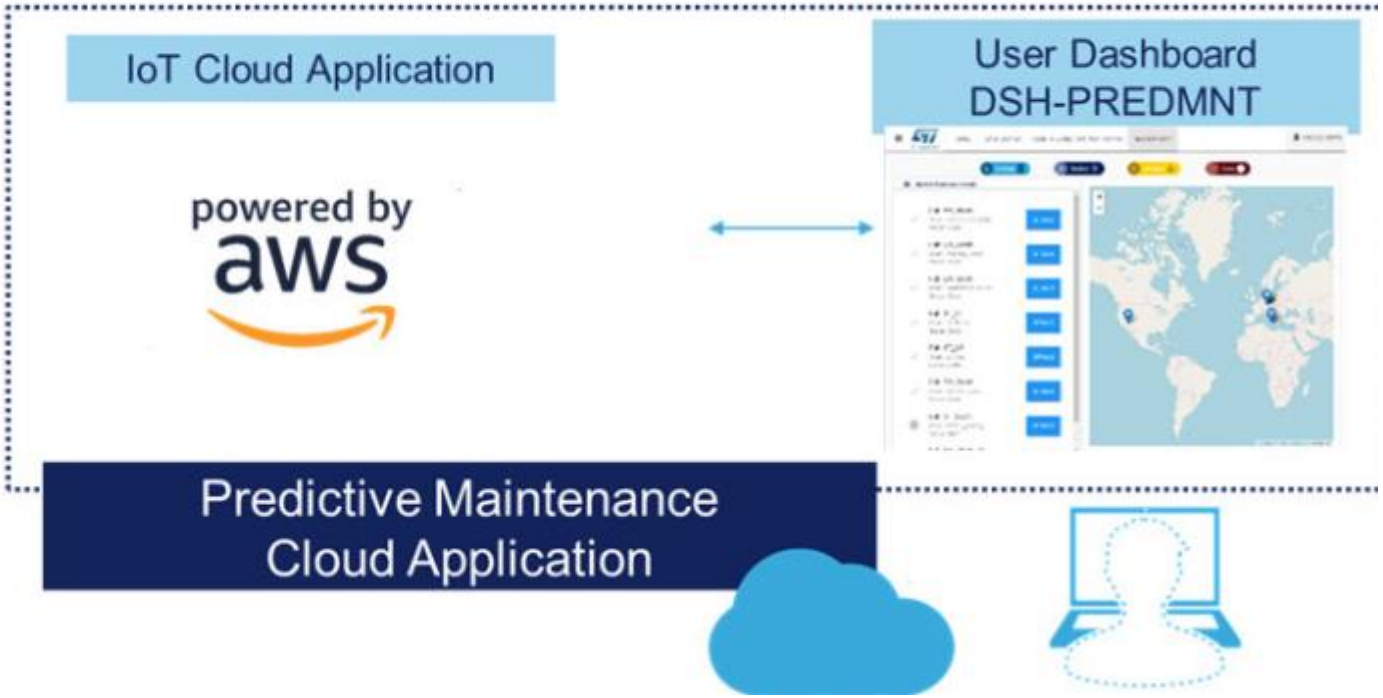
Anomaly Detection with Machine Learning Libraries generated with NanoEdgeTM AI STUDIO

- **FP-AI-NANOEDG1**: Command line and/or standalone mode
- **FP-AI-MONITOR1**
- **FP-AI-PREDMNT2**

SL-PREDMNT-S2C



Vibration, ultrasound and environmental sensor nodes for condition monitoring with **Wi-Fi** and **cellular** connectivity to cloud applications



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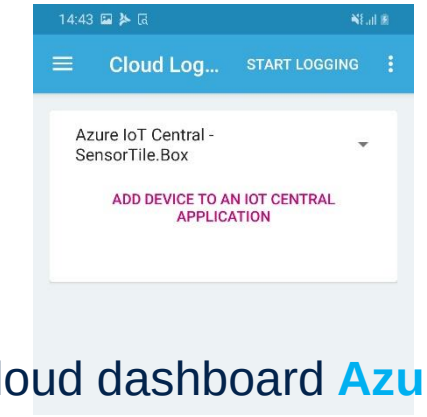
Cloud Services

Predictive maintenance dashboard

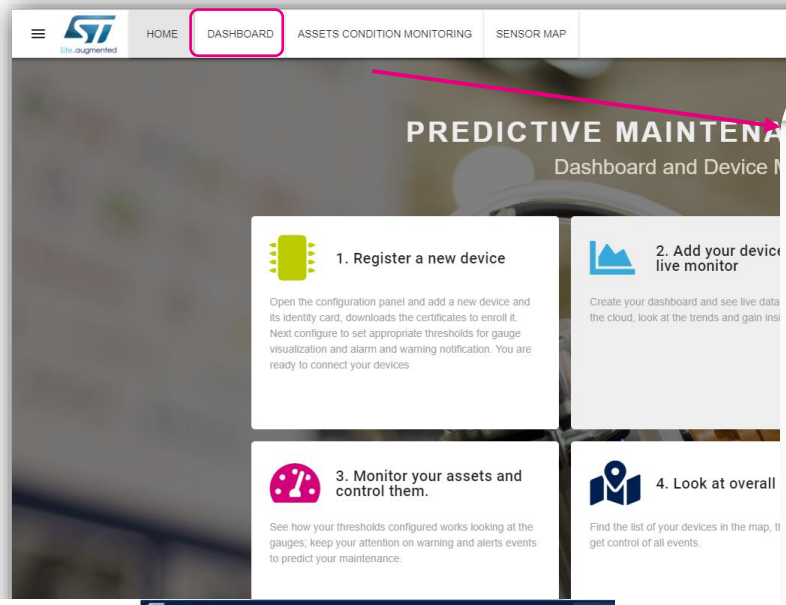
Cloud logging on Azure and AWS

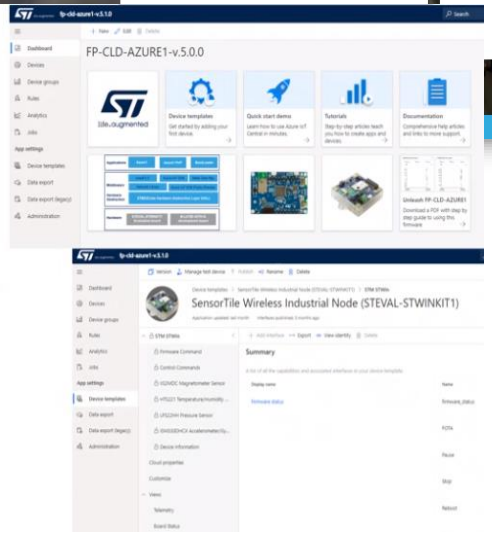


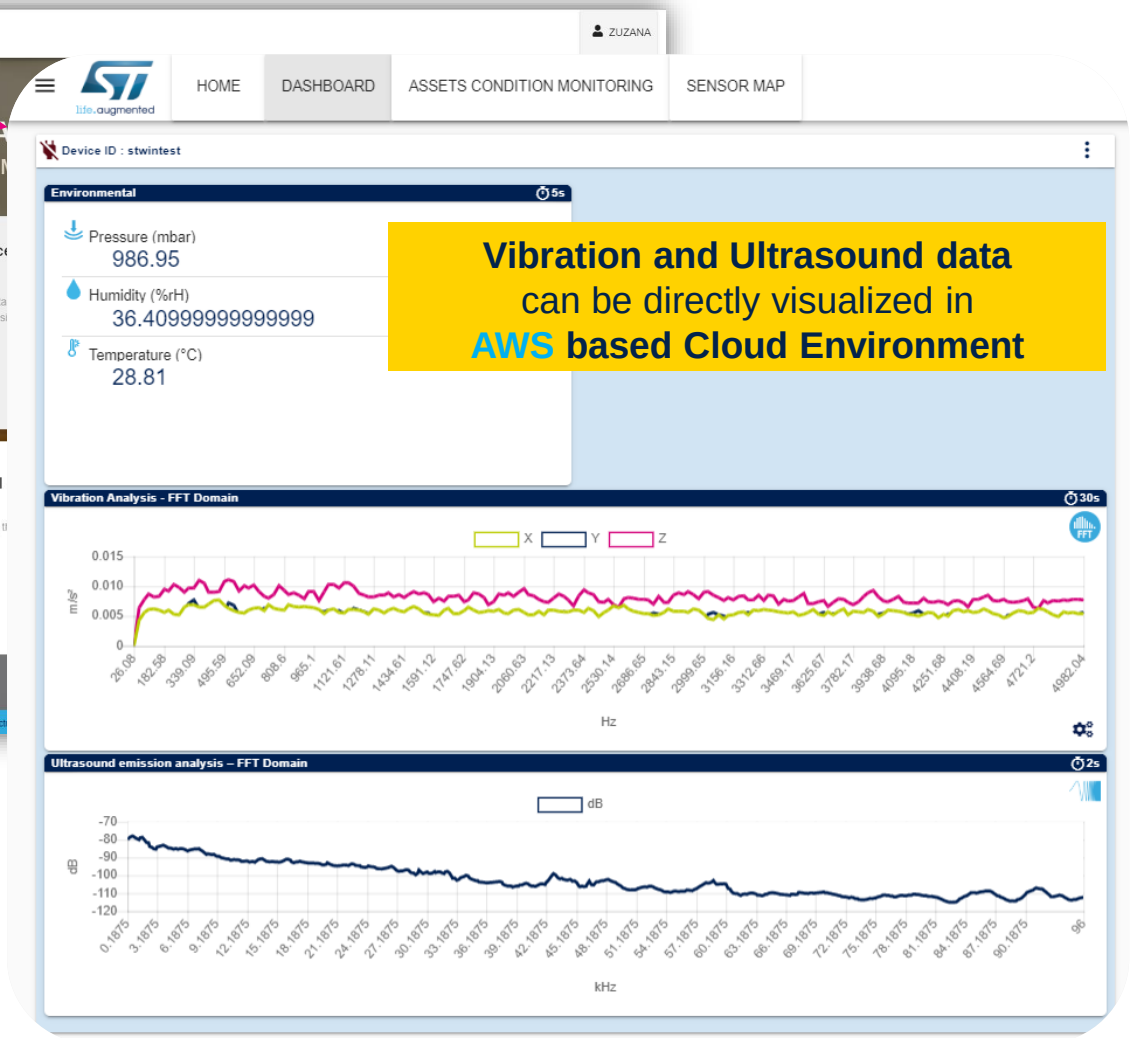
Cloud dashboard **Azure**

- IoT Central now supports device templates according to DTDLv2
  - DTDLv1 is now deprecated
- New DTDLv2 model for STWIN available as draft (neither published nor certified yet)
- Azure PnP certification will have to be aligned with U5 discovery kit launch

- Azure PnP certification is now based on Github
  - Official Microsoft repository must be 1) forked, 2) modified with our device models and 3) sent as pull request to Microsoft, who will respond within 3 days
  - Before we can start this process, we must have firmware available







Vibration and Ultrasound data can be directly visualized in **AWS based Cloud Environment**

NanoEdge™ AI Studio: Your way to Machine Learning at the edge

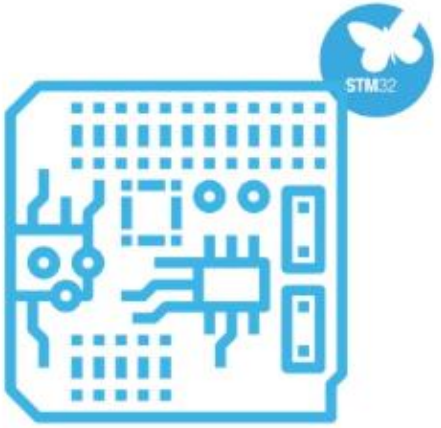
1 CREATE the library ONCE

Standalone PC (Win/Linux) application

- For embedded developers
- Create the best ML library for each project
- No data science skills required
- Search across millions of possible algorithms
- Output is not a static model but a self learning engine

2 USE the library MANY TIMES

Create and embed a self learning engine



Model is self trained at the Edge

- Dynamic learning on device
- 100% accuracy
- Any embedded developer can do it
- Any STM32 Cortex M0 - M7
- Super small RAM footprint

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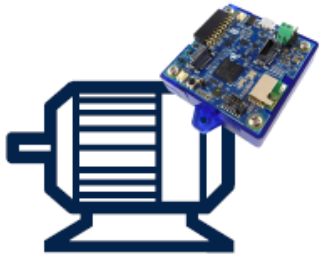
Fine tune the ML model with on-device learning

1

Set the STWINKT1B next to your motor

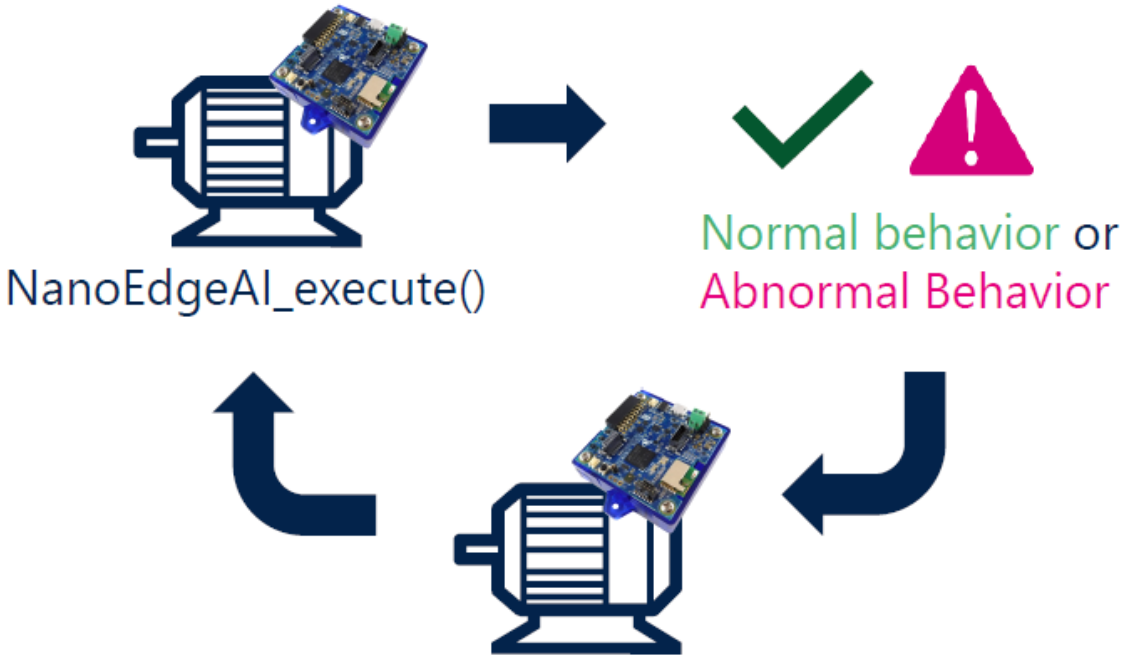
And learn normal behavior through board user button or CLI application on your PC



2

Monitor your motor health

Switch between learning and monitoring phase whenever you want to fine tune your model



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Inclinometer and Structural health monitoring

IIS2ICLX

Inclinometers in Industrial applications

Pointing, levelling and stabilization

Antenna pointing, platform leveling and stabilization

Robotics and IIoT

Robotics and Industrial automation

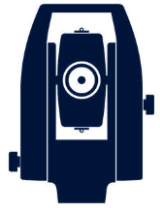
Inclinometers for industrial vehicles

High accuracy inclinometers for industrial vehicles, forklift, construction machines

Equipment Installation and monitoring

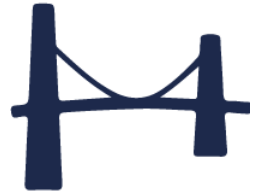
Installation and monitoring of equipment, tracker for solar panels

Leveling Instruments



Precise leveling instruments

Structural Health Monitoring



Building and infrastructure condition monitoring (inclination and low frequency vibration)

Inclinometers accurately measure a tilt angle under static or quasi-static conditions.
To measure angles of objects in highly dynamic conditions, see also
Dynamic Inclinometer using 6-axis IMU in st.com

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IIS2ICLX

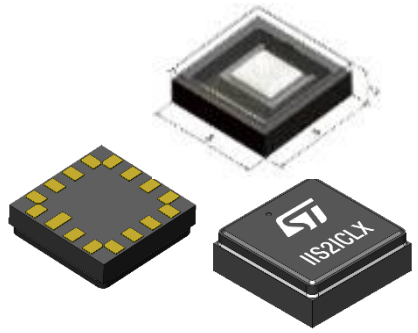
High-accuracy 2-axis digital inclinometer

Ultra-high-accuracy, high-resolution, low-power, 2-axis digital inclinometer with embedded Machine Learning Core

Key Features

- 2-axis, digital plug & play inclinometer
- Top notch performance: resolution, accuracy, stability over temperature and time
- Accuracy better than 0.5° over full temperature range and over time
- Ultra-low noise (15 µg/√Hz)
- Low power
- Programmable Machine Learning Core & Finite State Machines to integrate AI algorithms and reduce power consumption at system level
- Extended operating temperature range: from -40 to +105 °C

Parameter	Value
N. of axes	**2-axis**
Full Scale [g]	± 0.5/1.0/2.0/3.0
Output i/f	Digital I2C/SPI
Bandwidth (-3dB) [Hz]	Programmable, up to 260
ODR [Hz]	2.5 to 833
Noise Density [µg/√Hz]	**15**
Offset change vs Temp [mg/°C]	**<0.075**
Current consumption [mA]	0.42
Features	**MLC (Machine Learning Core)** FSM (Finite State Machine) Sensor HUB FIFO (3kbyte), Interrupts Embedded Temp. Sensor
Operating Temp [°C]	**-40 ; +105**
Operating Voltage [V]	1.71 ÷ 3.6



Ceramic Cavity LGA 5x5x1.7 16L

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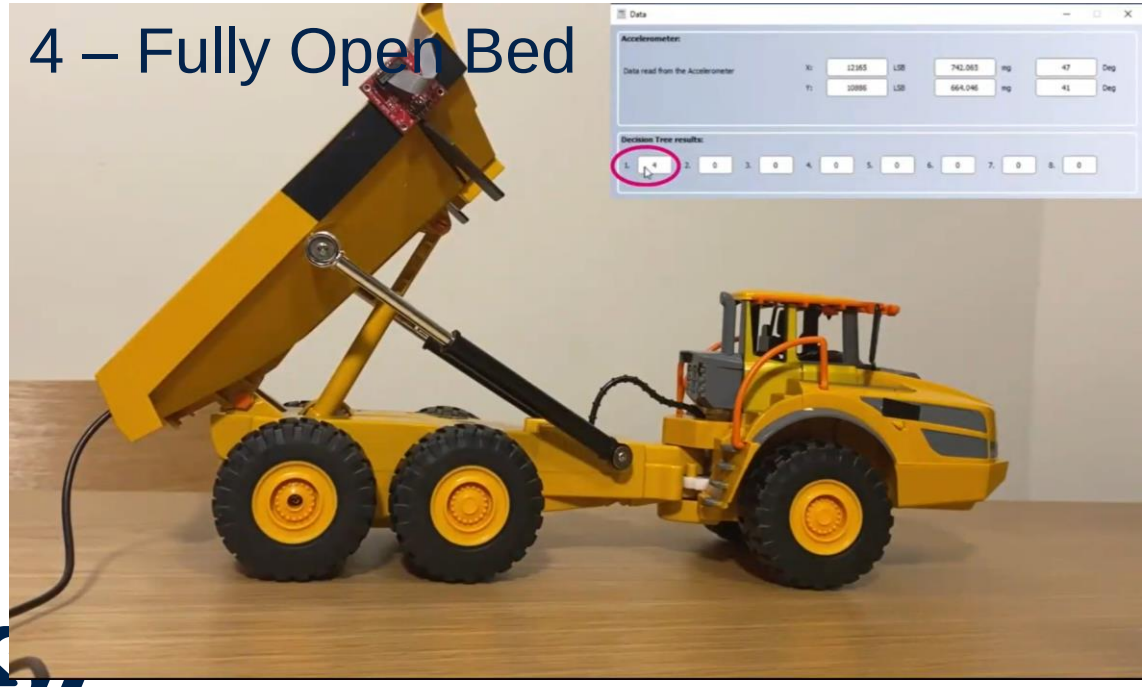
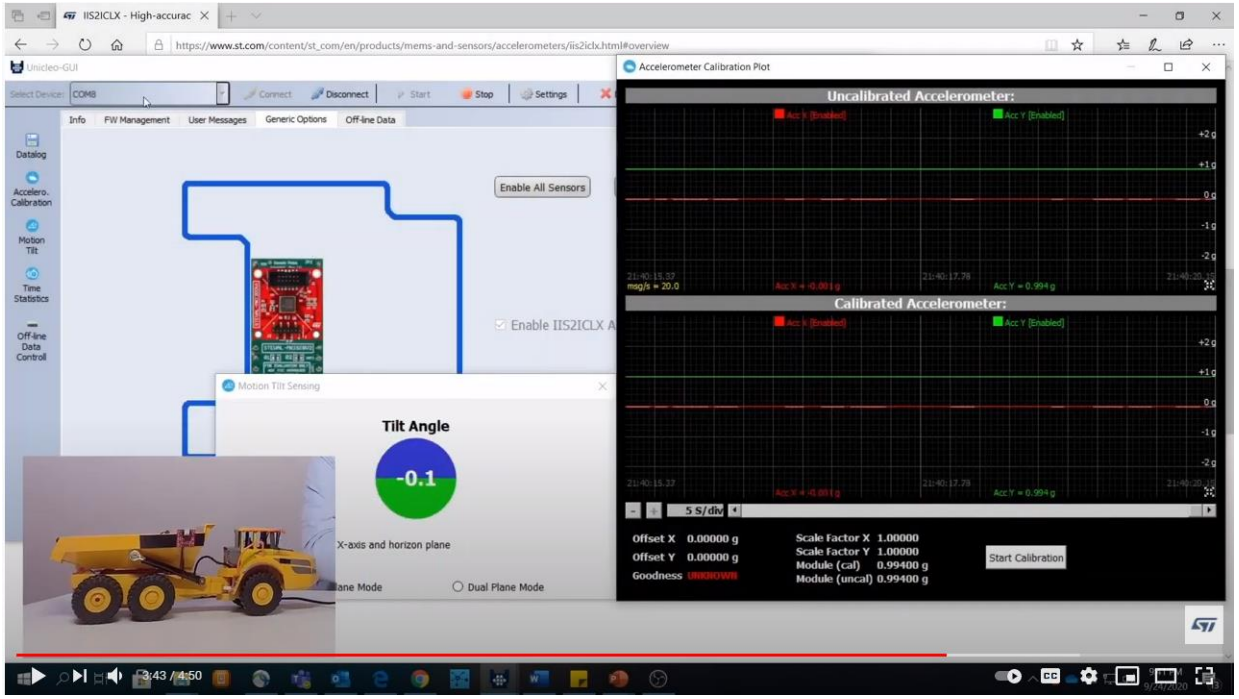
Machine Learning Core example in Tilt sensing

Accuracy and embedded digital capabilities to detect positions and movements (i.e. moving up and down).
DEMO: IIS2ICLX with STM32 Nucleo board and Unicleo GUI (CES 2021)





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The **IIS2ICLX** high accuracy, 2-axis digital inclinometer has won the **2021 Best of Sensors Award for the Industrial Sensors** Category.
2021 winners were announced onsite at Sensors Converge on the 23rd Sept.
It is the second recognition this year, following a CES 2021 Innovation Award!

BEST OF Sensors AWARDS 2021

Congratulations to the 2021 Winners!

Read more

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Structural Health Monitoring

Not only accurate tilt for SHM Applications

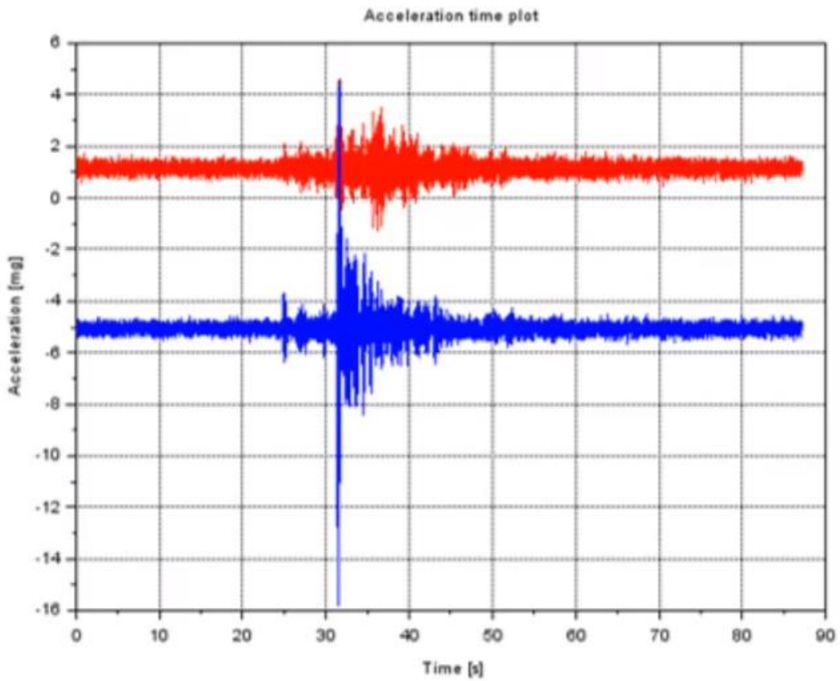
IIS2ICLX measures with **very high resolution** the **vibrations in the low frequency range (up to 260 Hz)**, which are essential for **vibration-based monitoring (VBM) of structures**, an important method of assessing the condition and the safety of vulnerable structures

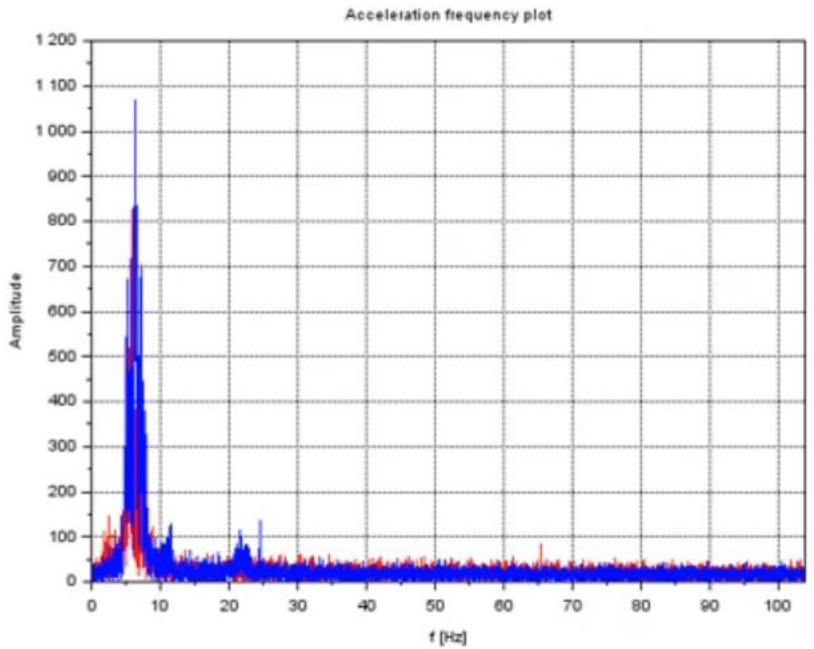
Milan earthquake
December, 17th at 16:59 CET

Magnitude **MI 3.9**

Epicenter 4 km from Milan
Hypocenter 56 km depth

Recorded with IIS2ICLX at ST@Corenaredo (6km from the epicenter)





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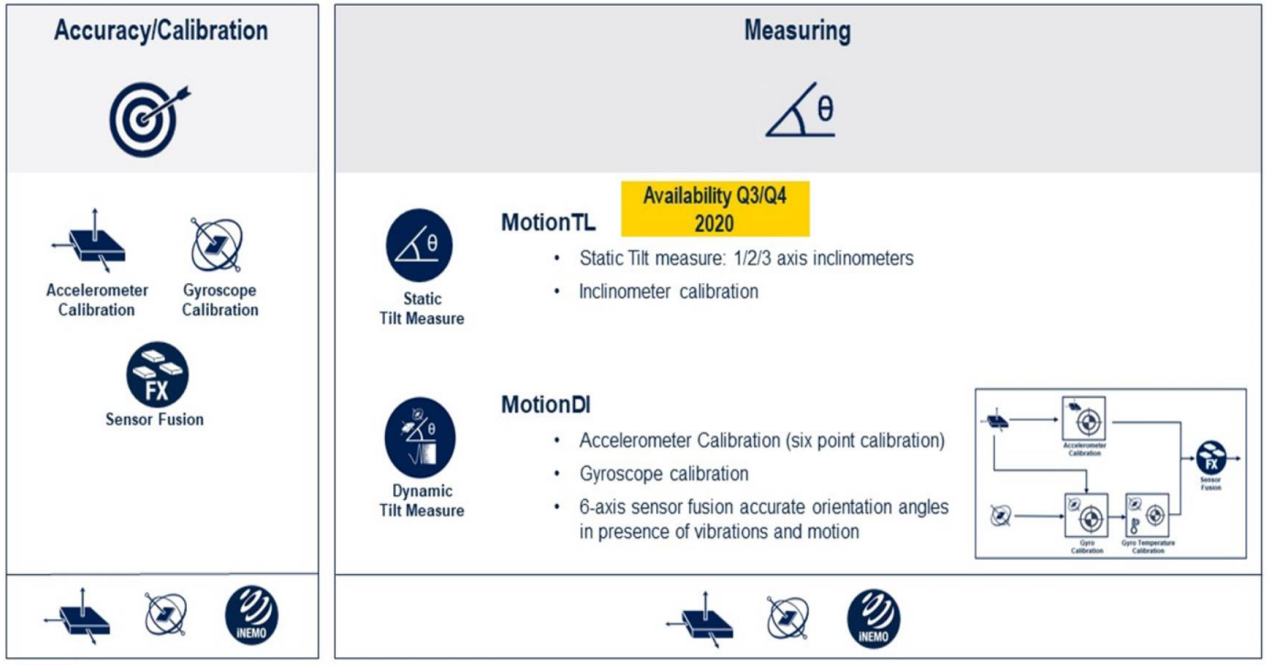
CES Honoree Award has been recognized

Tilt sensing with Industrial Sensors

Technical Material, libraries and documentation support



- **Tilt Sensing with ST's Industrial sensors**
  - Technical presentation about tilt sensing to show the theory behind and introduce our industrial sensor portfolio and HW and SW tools
- **Tilt sensing using MLC (IIS2ICLX)**
  - Describes new MLC example for tilt sensing with IIS2ICLX, presents available tools and shows how to use these tools

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Smart Industry | Smart Home & City Smart Things | Smart Driving

Environmental Sensors

PRESSURE SENSOR

LPS22HH / LPS33(H)W LPS27HHW

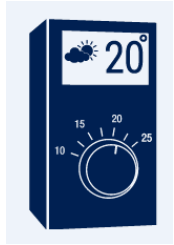
Compact, low power, water resistant

- LPS22HH: high accuracy, ODR
- LPS33(H)W/LPS27HHW: resistant to harsh environment (automotive gel, metal lid, ceramic substrate)

TEMPERATURE

STTS22H / STTS751 / STLM20 Analog

High accuracy, low power, digital or analog



- High accuracy
- Power consumption
- Small size

TEMP + HUMIDITY

HTS221

Relative Humidity and Temperature

- Power consumption
- Small size

ST Advantage

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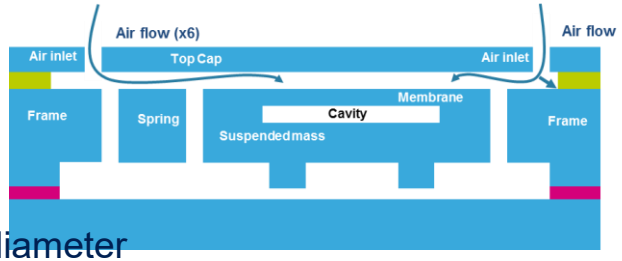
Unique ST Pressure Sensors portfolio
Dust and Water resistant packages

Full molded package



- 6 Holes @ 20µm diameter

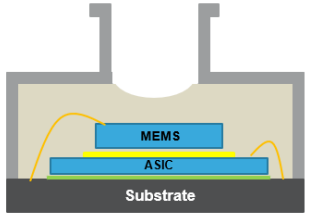
ST unique technology and advantages

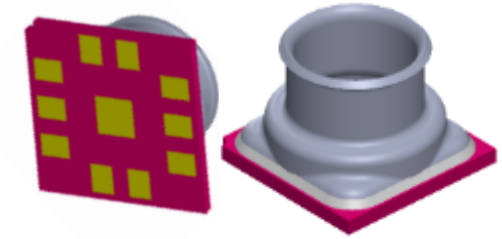
- Full molded package
- Silicon cap
- Suspended membrane

✓ Improved shock and vibration suppression
✓ Improved reliability, dust and moisture resistance
✓ Ultra-thin package

Water proof pressure sensor

A look inside



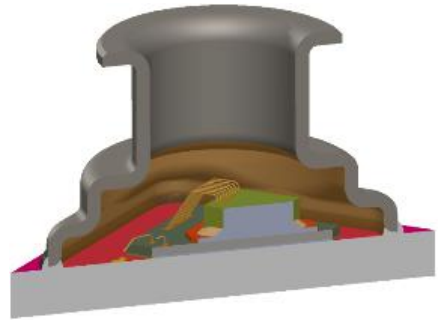


Small & thin form factor
2.7 x 2.7 x 1.7mm

Features and tests

- Metal LID
- Potting GEL from automotive
- Ceramic Substrate

✓ n-Pentane Chemical liquid (corrosion test)
✓ Chlorine, Bromine mixed, Salt water test
✓ Over Pressure Test (up to 10Bar / up to 24hr) (swimming pool, sea use case)



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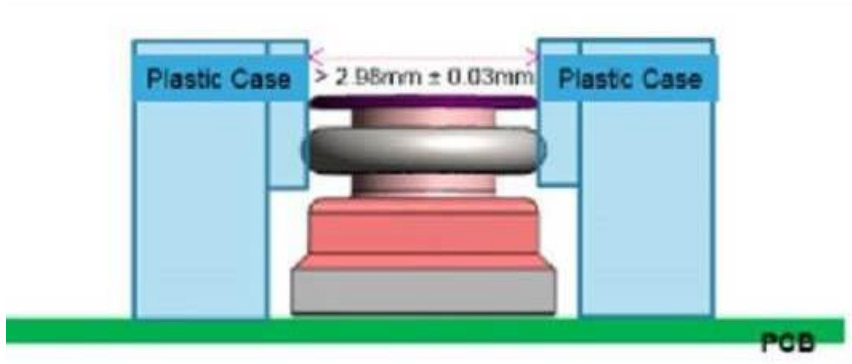
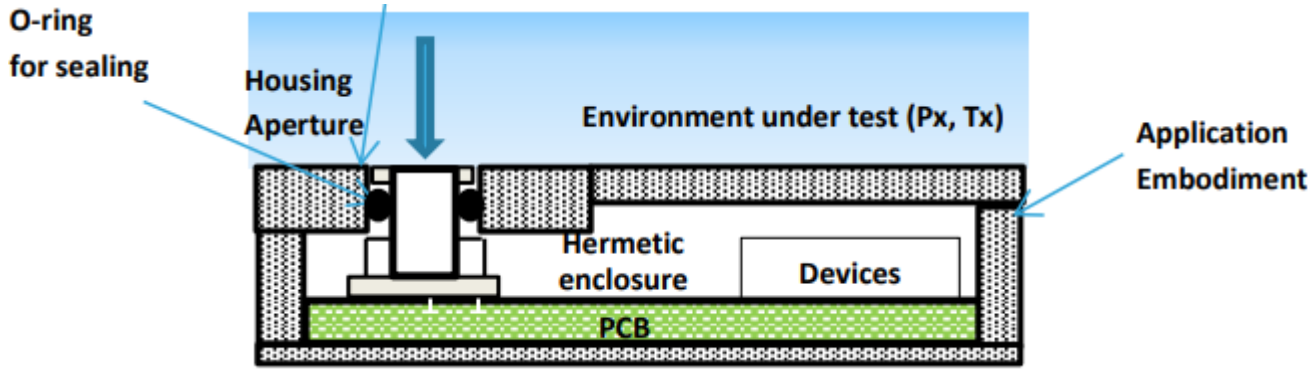
Waterproof pressure sensor integration and housing

Specific Application Note:

https://www.st.com/resource/en/application_note/an5606-lps27hhw-digital-pressure-sensor-guidelines-for-system-integration--stmicroelectronics.pdf





Pressure Sensors - How to go further in Industrial

Applications and Key customers identification

Enabled by new generation of ST Pressure Sensors

LONGEVITY 10 YEARS COMMITMENT

Industrial use cases

Gas Meters and Boilers

Gas monitoring in Maters and Domestic Boilers / new electric injection generation

Gas metering
Boilers
Gas tank

Industrial measurements

Differential measurements, Pick and place machines, Tools

Industrial measurements

Water Meters and Faucets

Flow rate and Leakage detection

Water meter
Faucets & irrigation

Pumps, Pools and Lifts

Altitude and Depth

Pumps
Pool Robot
Lifts manufacturers

Airplane mode detection

Recognize take-off and landing to set the radio/GPS signal

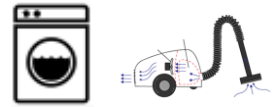
Asset Tracking

Air Flow and Monitoring

Air flow detection

SMART Filter
HVAC
Condition Monitoring

Home Appliances



Water level and Air flow detection

Washing Machine
Dish Washer
Vacuum Cleaner
Cooking chamber
Laundry dryer filter

Motors/Liquids and Batteries

Sensor comes in direct contact with liquids, water, gasoline, diesel, oil .. checking the height

Motors as chainsaw and lawnmower
Liquids level

Medical

Monitoring of atmospheric pressure and in the patient's airways during insufflation of air and oxygen

Ventilators

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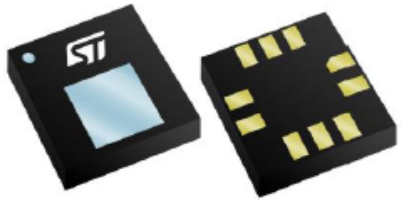
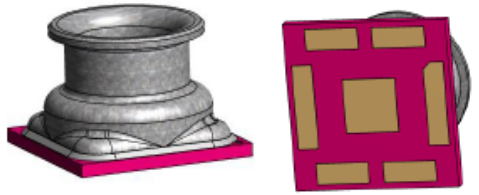
New ST Pressure Sensors ILPS22QS and ILPS28QSW

1st Dual Full scale (up to 4Bar) Pressure sensor enable to cover a wide spectrum of industrial applications

Sample Available
MP : Q1-22



QVAR Enabled



ILPS22QS

Dual Full Scale Barometer

- ✓ **Dual FS : ~ 1.26Bar / ~ 4Bar**
- ✓ High performance with low power
- ✓ Absolute Accuracy = ± 0.5hPa (-20~80'C)
- ✓ Power consumption : 3.6uA [LP] / 9.2uA[HP]
- ✓ Noise RMS [UHP] = 0.3Pa
- ✓ 1.2V I3C Digital Interface
- ✓ **LGA 2 x 2 x 0.73 mm3**
- ✓ Extended Operating Temperature: **-40°C +105°C**

ILPS28QSW

Dual Full Scale WP Pressure Sensor

- ✓ **Dual FS : ~ 1.26Bar / ~ 4Bar**
- ✓ Power consumption : 3.6uA [LP] / 9.2uA[HP]
- ✓ Noise RMS [UHP] = 0.3Pa
- ✓ Superior robustness to ESD
- ✓ Robustness PKG to mechanical stress.
- ✓ Small Soldering Drift
- ✓ **CLGA 2.85 x 2.85 x 1.95 mm3**
- ✓ Extended Operating Temperature: **-40°C +105°C**

Water Proofing Package up to 10Bar

Wider Full Scale up to 4Bar

Ultra low power consumption

Robustness PKG to mechanical stress of 10Bar Water proofing

Embedded Temperature sensor with accuracy ±1.5°

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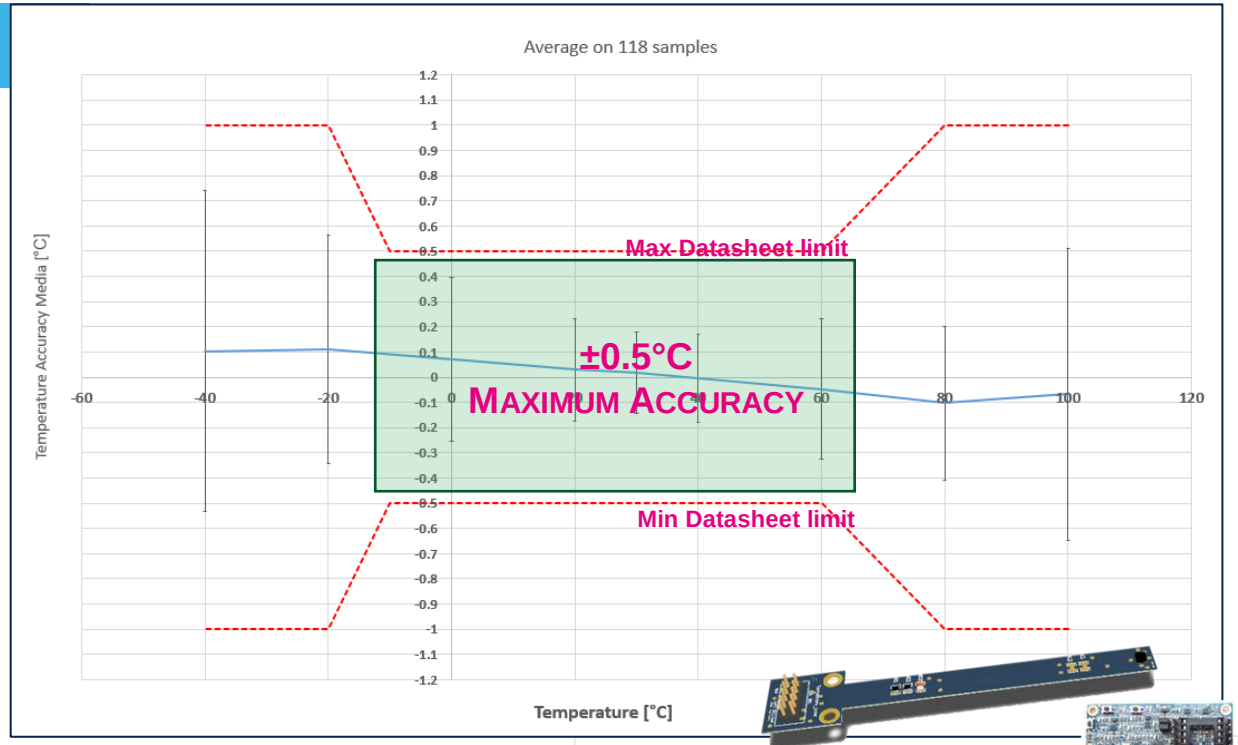
New Temperature sensor STTS22H in brief
Technology evolution

TARGET SPECIFICATIONS

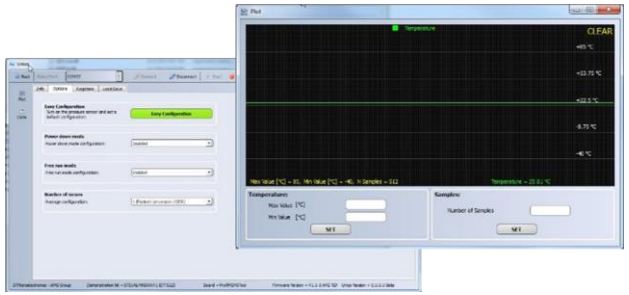
- Supply voltage: **1.5V – 3.6V**
- Current consumption: **1.7uA** in one shot mode
- Output interface: I2C / **SMBus 3.0**
- Programmable **interrupt / threshold**
- SMBus **ALERT support**
- Programmable I2C address (up to 4)
- Operating temperature range -40 °C to +125 °C
- Accuracy: **±0.5°C (max) [-10°C – 60°C]**
- **Selectable ODR** (down to 1Hz)
- **One shot reading mode**
- Package: UDFN-6L 2.0 x 2.0 x 0.5mm with **exposed pad down** for better temperature matching with external environment.

Shortest time/latency

Exposed pad to measure temperature



Temperature Sensors Demo KIT



NIST certification available

10-years longevity commitment

±1°C Max (-25-105°C) – STTS22M – MP Q4 2021

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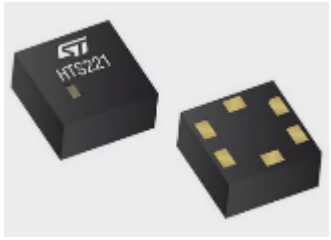
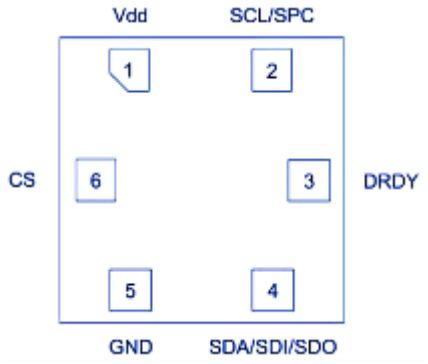
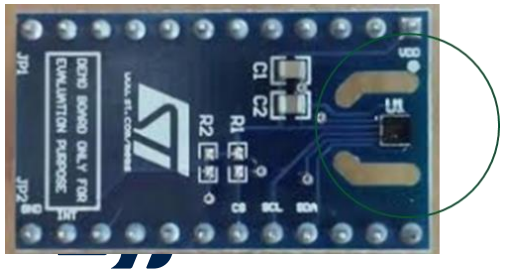
HTS221
Humidity and temperature sensor

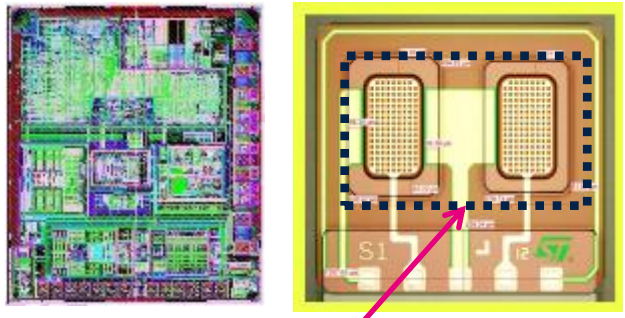
HLGA 6LD
2.0x2.0x0.9mm







Double die approach



Humidity is absorbed by the polyimide and changes the capacitor value

Humidity specifications

Main parameters:
• **Range: 0% to 100%**
• **Accuracy:**
  • **±3.5% [20% : +80%]**
  • **±5.0% [0% : 100%]**

Temperature specifications

Main parameters:
• **Range: -40°C to +125°C**
• **Accuracy:**
  • **±0.5°C [15°C : 40°C]**
  • **±1.0°C [0°C : 60°C]**

Features / Benefits

- Temperature and humidity sensor integration for BOM optimization
- Direct H and T data readout
- Low current consumption for battery operated sensor nodes 2uA (1Hz)
- Industrial temperature operating range
- SPI and I^2C output interfaces, ODR from 1 to 12.5Hz

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STDES-BFTAG01
Battery-free wireless sensor node

Solution Spec.

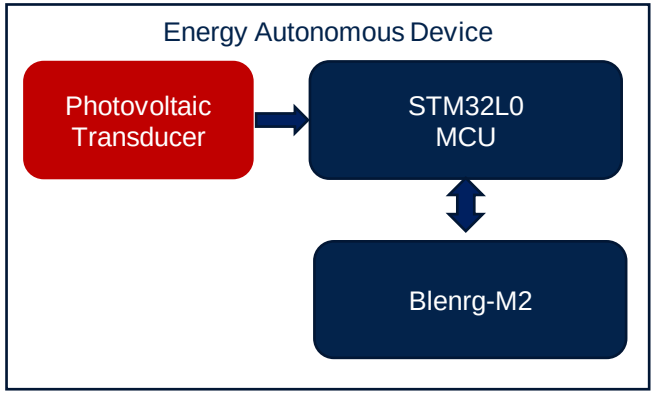
- ✓ Energy Autonomous and Battery-Free device
- ✓ Sensor-Free light monitor
- ✓ Sensor-Free vibrations monitor

Key Prodcuts

- STM32L0 – Cortex M0+
- BlueNRG-M2SA – Bluetooth Low Energy Module
- *HTS221 Temperature Humidity Sensor*

What is doing:

- *It sends a number of beacons, in a given time interval, in proportion to the intensity of ambient light.*
- *Self-powered by energy harvesting, e.g. a small solar panel.*



Key Features

- ✓ Small form factor
- ✓ Bluetooth Low Energy (BLE) connectivity
- ✓ Low cost solution
- ✓ Digital Read Out

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STDES is a reference board, not available in stock

ST Asset Tracking Introduction

VIDEO **Discover ST's range of asset tracking solutions**

Asset tracking categories Emerging applications

Logistics:

- Supply Chain Quality Control, from manufacturing to end user.
- Transportation and Storage Handling monitor (object dropping, vibration etc…)

Things tracking

Find your things/location tracking

Animal tracking

Activity, Temperature, location data monitoring

People tracking

Smart band for concerts/entrance/payment/ amusement parks/cruise ships

Retails

Storage/Shelf life, Temperature & Humidity, beacons

Perishable Goods:

Exp. date alert, Shelf/Storage Life Calculation/Condition of goods

Smart Packaging:

Temperature, Vibration Use, ID

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Asset Tracking

Asset Tracking

ST Main Components

Accelerometer — Vibration, Orientation, Free Fall detection, Shocks (high-g)

Temperature sensor — Shipping Environment, Goods Status

Pressure sensor — Take off and landing detection, Seal detection

Analog — Including Signal Conditioning, Protections, …

STM32 — Computation by STM32 Family

BLE — Bluetooth Low Energy Connectivity to gateway/tablet

Sub-1GHz — Long Range Connectivity to base stations/Sigfox

NFC — Short Range Connectivity To handheld devices

Battery — DCDC, LDO, Battery Charger, Fuel Gauge…

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LIS2DW12 or LIS2DTW12?

- The LIS2DTW12 delivers the same high performances as the LIS2DW12. Differently from the LIS2DW12 the LIS2DTW12 is factory calibrated to ensure a narrower accuracy relieving the customer from the need of a costly calibration along the manufacturing line.

Fan Condition Monitoring

THE CASE

Servers run multiple fans to ensure the proper temperature operating conditions. When a fan wears out the server has to be stopped with the consequent machine down cost.

THE NEED

Anticipating the failure by monitoring both the fan vibrations and the air flow temperature is key to reduce the machine down time.

THE PERFECT FIT
LIS2DTW12

Asset Trackers

THE CASE

Delivery services monitor the parcel to ensure no high-g shock or thermal shock occurred to the goods in package.

THE NEED

An integrated low power solution (axl + temperature sensor) is the ideal solution to contain the application BOM and size

THE PERFECT FIT
LIS2DTW12

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Inside SensorTile.box
Sensing, processing and connectivity

The Board

Micro USB connector

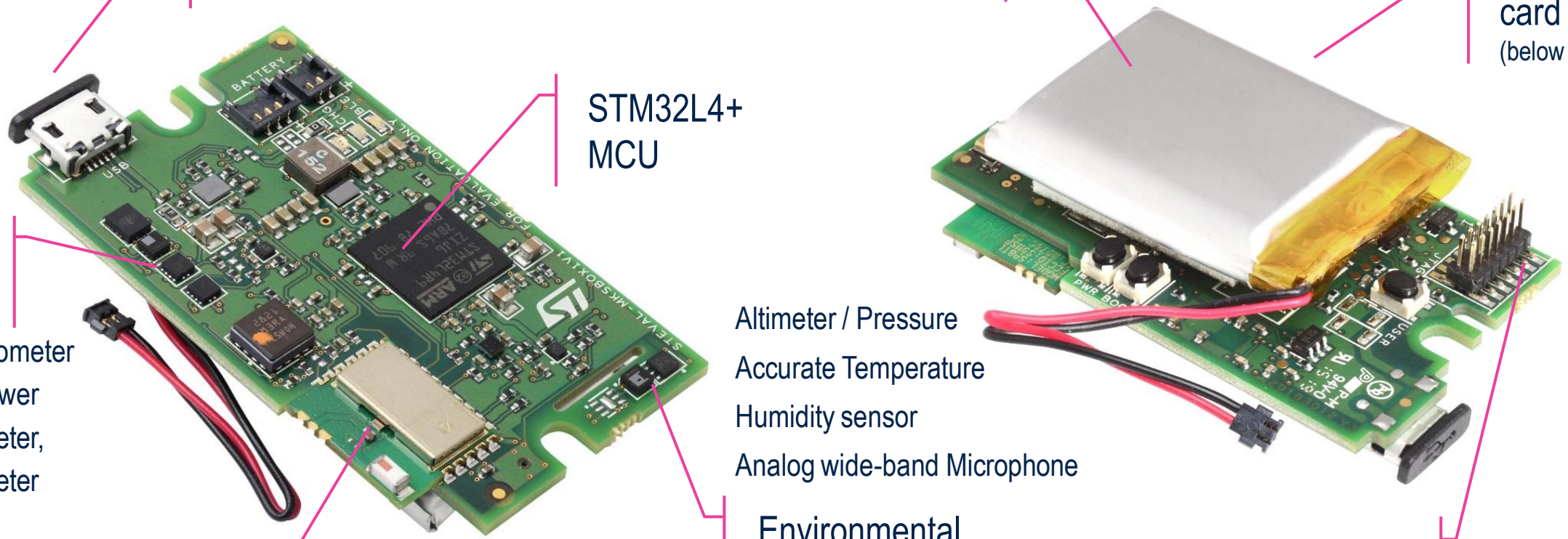
500 mA-h Li-Po battery

microSD card socket (below battery)

STM32L4+ MCU

Motion sensors

IMU, Inclinometer and low power Accelerometer, Magnetometer



Altimeter / Pressure

Accurate Temperature

Humidity sensor

Analog wide-band Microphone

Environmental sensors

BLE module

STLink V3 connector

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End-to-end Proof of Concepts
Asset Tracking

STEVAL-SMARTAG1
FP-SNS-SMARTAG1

NFC

ST Asset Trakking

ST Asset Tracking

Telecom operator

SensorTile.box
FP-ATR-BLE

Bluetooth®

ST Asset Tracking

ST Asset Tracking

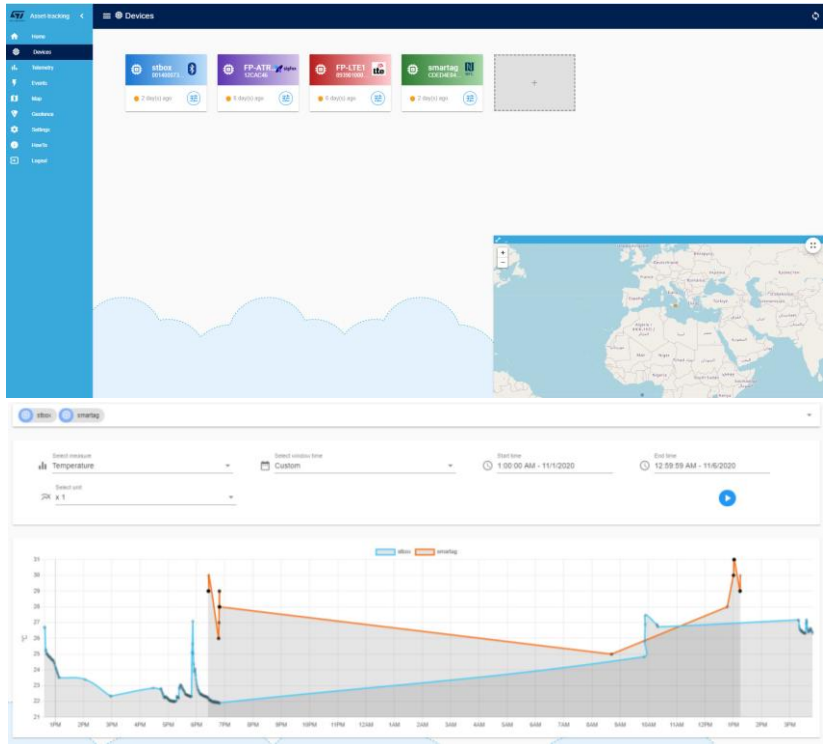
Telecom operator

STEVAL-STWINKT1B
FP-CLD-AWS

Wi Fi

Wi-Fi access

DSH-ASSETRACKING Cloud Dashboard



sigfox

X-NUCLEO-S2868A2
FP-ATR-SIGOFX1

Sigfox backend

LoRa

STEVAL-STRKT01
FP-ATR-LoRa1

LoRa Network Server

NRND

LTE-M

P-L496G-CELL02
FP-ATR-LTE1

Telecom operator

NRND

Evaluation boards for Asset Tracking

New Mobile apps and Cloud dashboards (AWS)

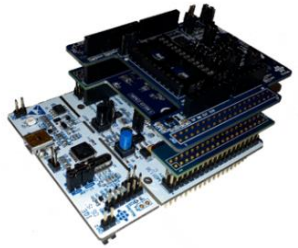
STEVAL-SMARTAG1
FP-SNS-SMARTAG1

NFC

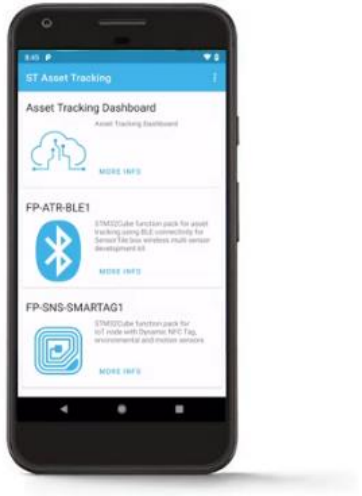
STEVAL-MKSBOX1V1
FP-ATR-BLE1

STEVAL-STWINKT1B
FP-CLD-AWS1

x-NUCLEO-S2868
FP-ATR-SIGFOX1



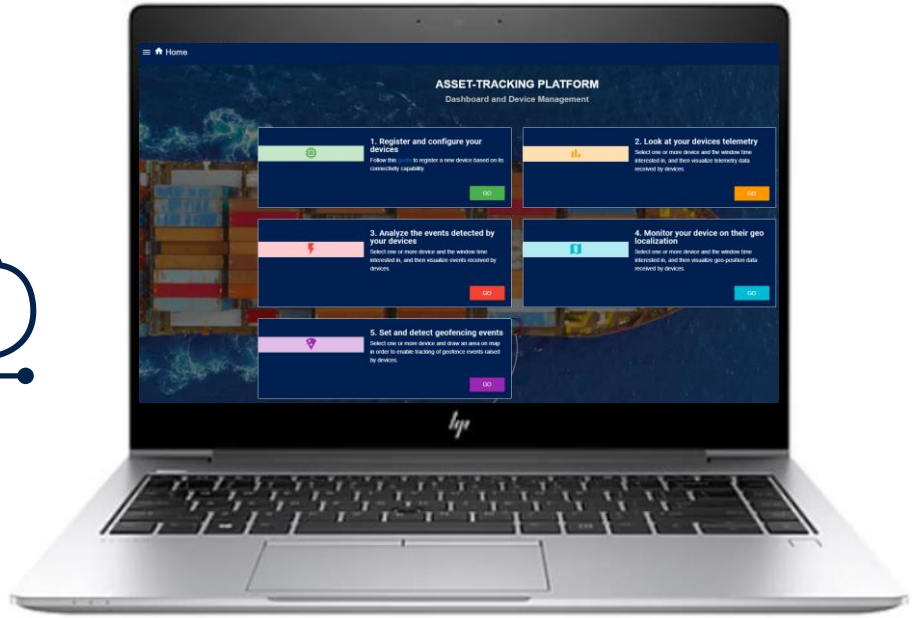
ST Asset Tracking app



Wi Fi

sigfox

Laptop with DSH-ASSETRACKING dashboard on Chrome browser



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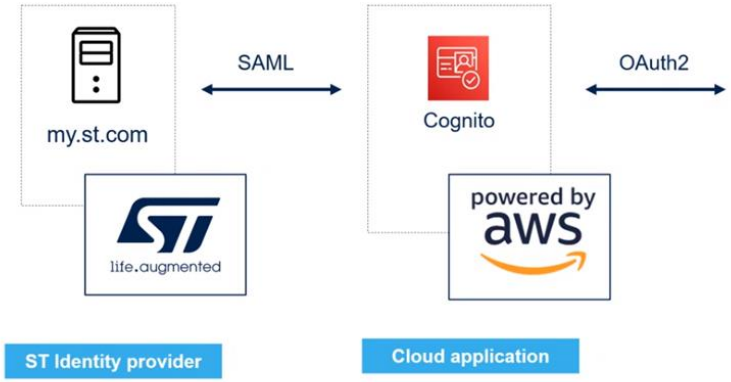
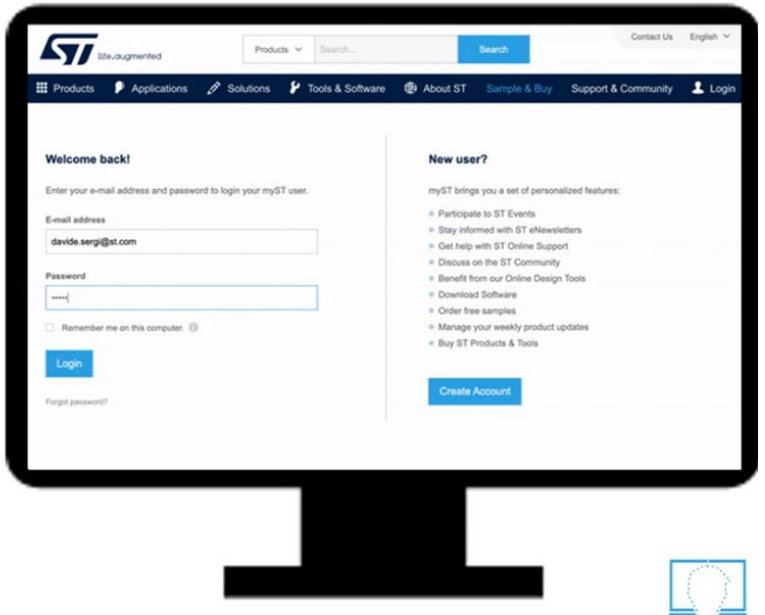
my.st.com login and services

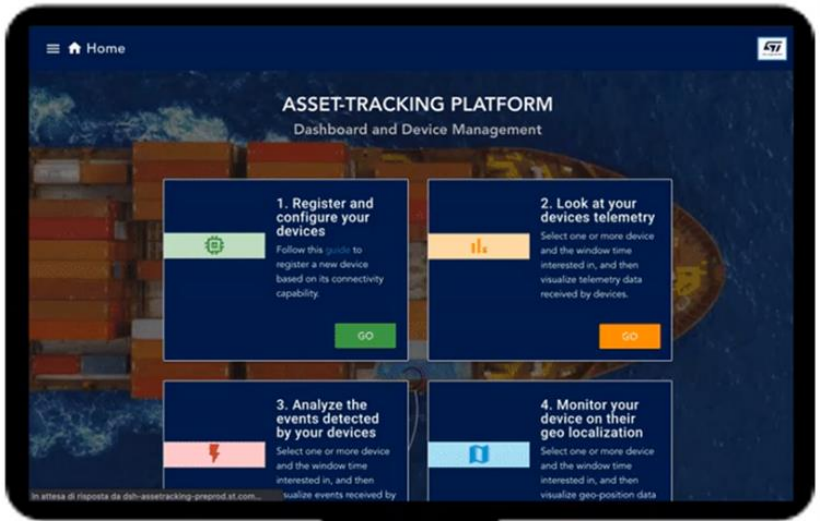
Integration with my.st.com IdP

User authentication OAuth2.0

Marketing analytics enabled

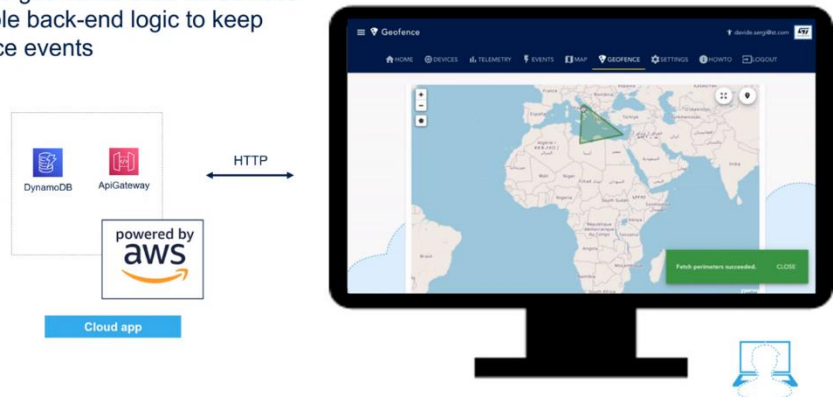






Geofencing

Create and store geo-fence area for devices in order to enable back-end logic to keep track of geofence events

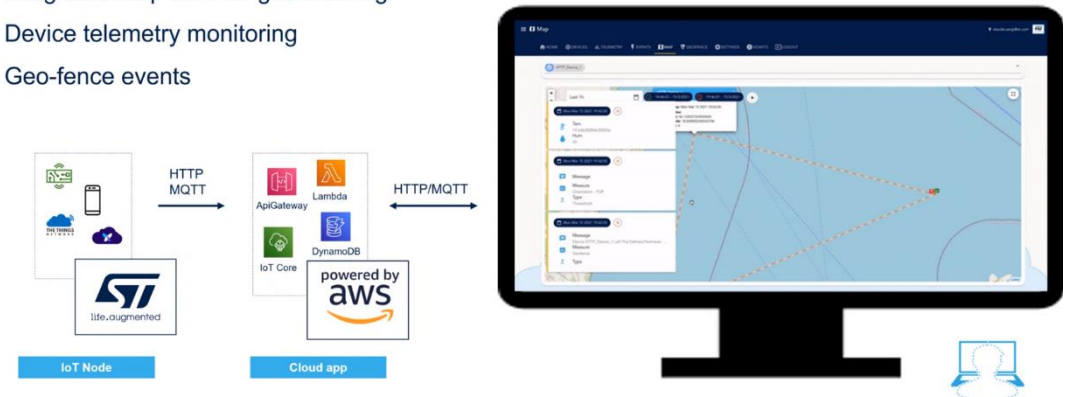


Device geo-tracking

Integrated map view for geo-tracking

Device telemetry monitoring

Geo-fence events



ST Partner Solution
Qeexo AutoML

Qeexo AutoML for embedded AI

Qeexo - fully-automated AutoML software platform helps you leverage sensor data to rapidly build machine learning solutions

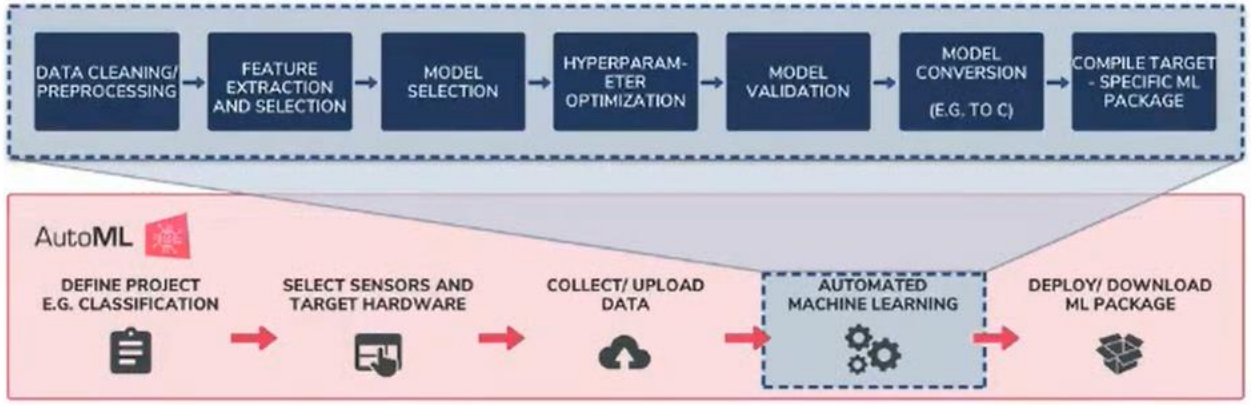
KEY FEATURES

- **Automates** complex and labor-intensive ML processes – no coding or ML expertise required!
- **Wide range** of ML methods – 17 different ML algorithms: GBM, XGBoost, Random Forest, Logistic Regression, Gaussian Naive Bayes, Decision Tree, Polynomial SVM, RBF SVM, SVM, ,CNN, RNN, CRNN, ANN, Local Outlier Factor, One Class SVM, One Class Random Forest, Isolation Forest
- **Easy-to-use** interface for labeling, recording, validating, visualizing time-series sensor data
- **Optimized** for low latency, low power consumption, and a small memory footprint
- **On-device inference** – Supports Arm® **Cortex™-M0** to Cortex™-M4 class MCUs & **ST MLC sensors**

ST HARDWARE SUPPORT:

- STM32 Arm® Cortex™- M0 to M4 class MCUs (STM32L0, STM32L4)
- MLC Sensors (LSM6DSOX, ISM330DHCX)

QEEXO AUTOML: END-TO-END MACHINE LEARNING PLATFORM



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Qeexo - Intelligent asset tracking using Qeexo AutoML

Partner Program

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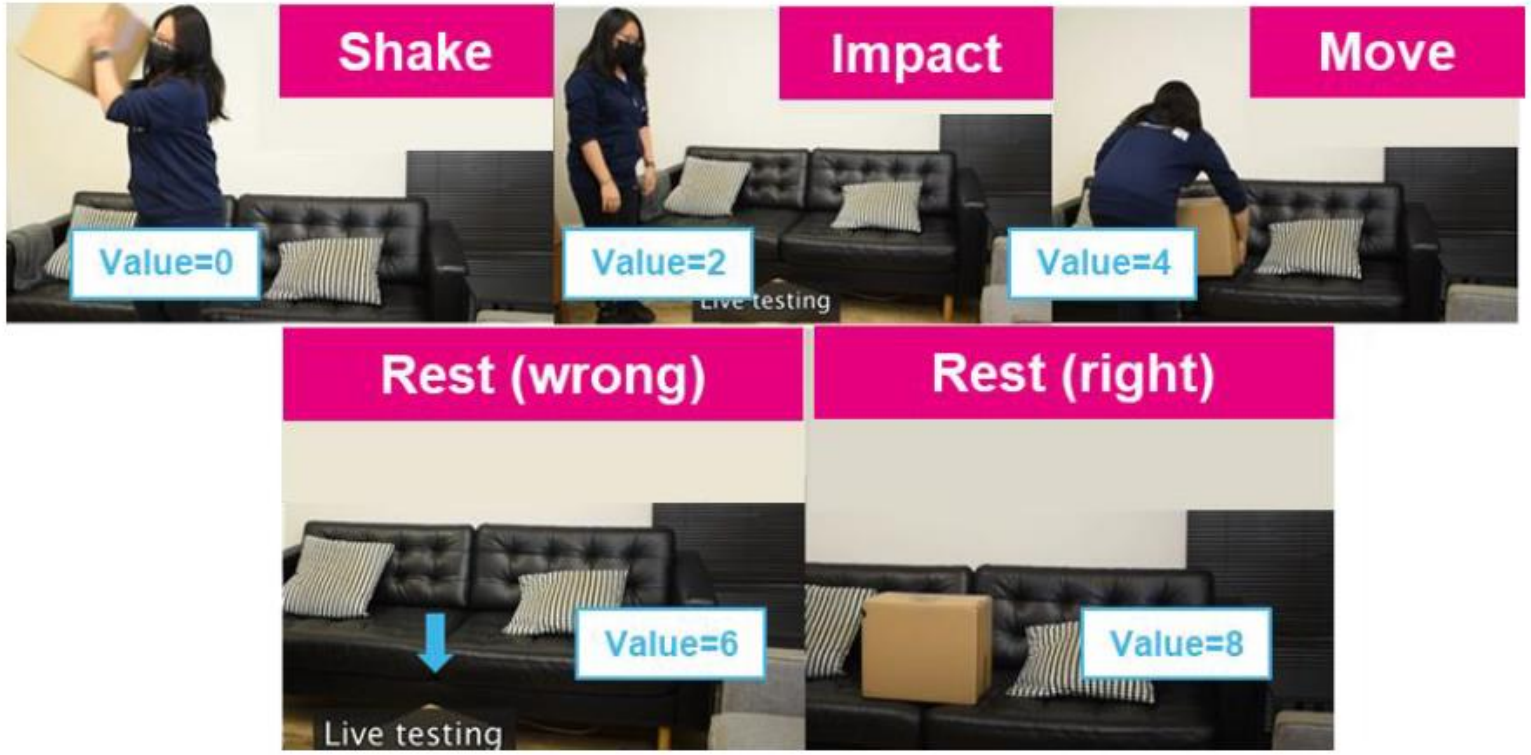
Qeexo AutoML



Watch: https://www.youtube.com/watch?v=qMA0QNfxh-I

Sensors evaluation and development platforms

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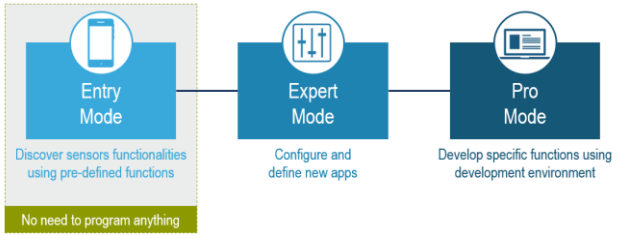
Most Useful tools to have in mind

Hardware devices

Software



SensorTile.box

STWIN

for the graphical design of algorithms

AlgoBuilder Suite

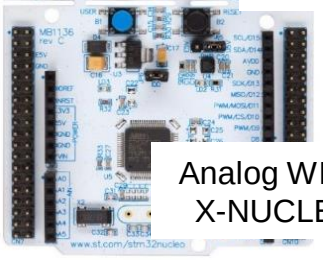
for Android and iOS

Display, program and sensor data push to Clouds

ST BLE Sensor App

Consumer sensors
X-NUCLEO-IKS01A3

Industrial sensors
X-NUCLEO-IKS02A1



Analog WB Microphones
X-NUCLEO-AMICAM1

Digital MEMS Microphones
X-NUCLEO-CCA02M2

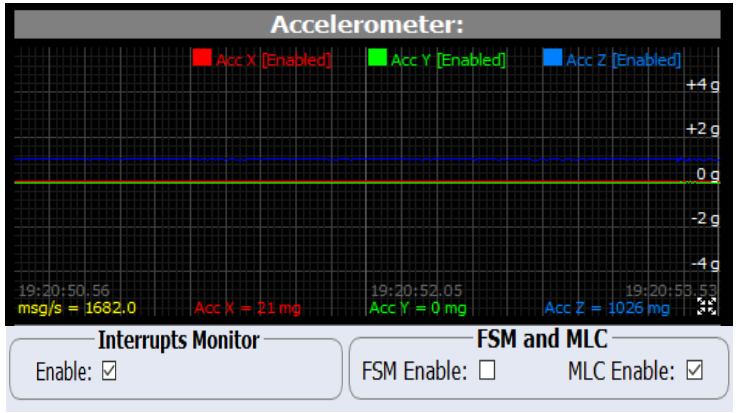
Nucleo and expansions

Evaluate All ST sensors through DIL24 adapter

STEVAL-MKI109V3

Profi MEMS tool

for Linux, Mac OSX and Windows

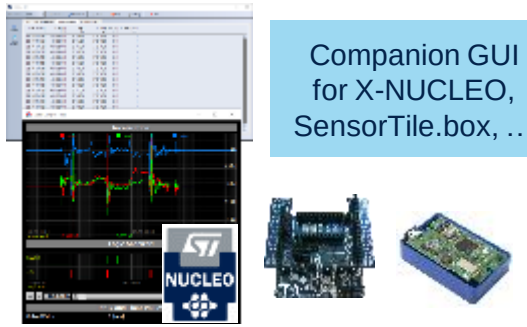


Unico & Unicleo - GUI

Nucleo mother board, i.e. NUCLEO-L476RG or NUCLO-F401RE

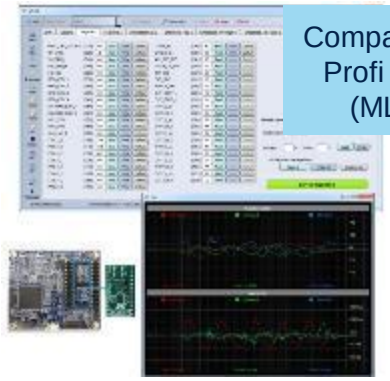
Sensors software

PC software
Unicleo-GUI



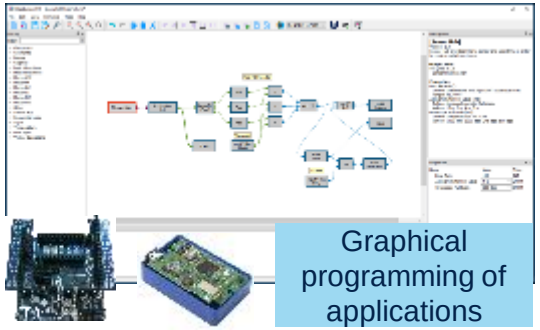
Companion GUI for X-NUCLEO, SensorTile.box, …

PC software
UNICO GUI



Companion GUI for Profi MEMS tool (MLC, FSM)

PC software
Algobuilder



Graphical programming of applications

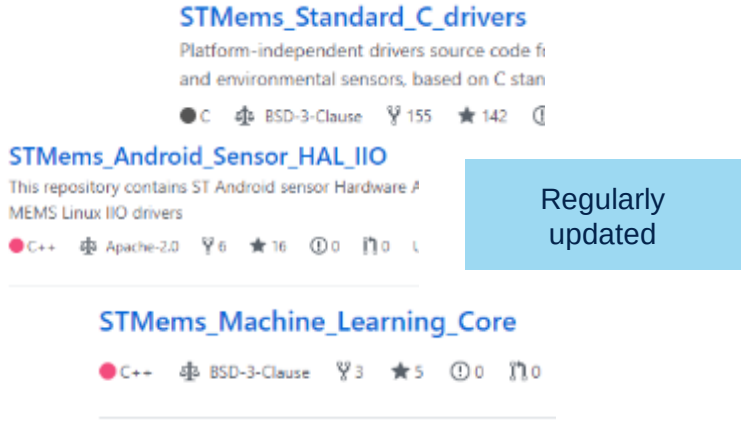
Phone App
ST BLE Sensor

Display, program and sensor data push to Clouds

Embedded software
X-CUBE-MEMS1, Libraries, Function packs

Function packs support combination of stacked X-NUCLEOs or IoT nodes

Low level drivers & Examples (incl. MLC/FSM)
github.com/STMicroelectronics/



Regularly updated

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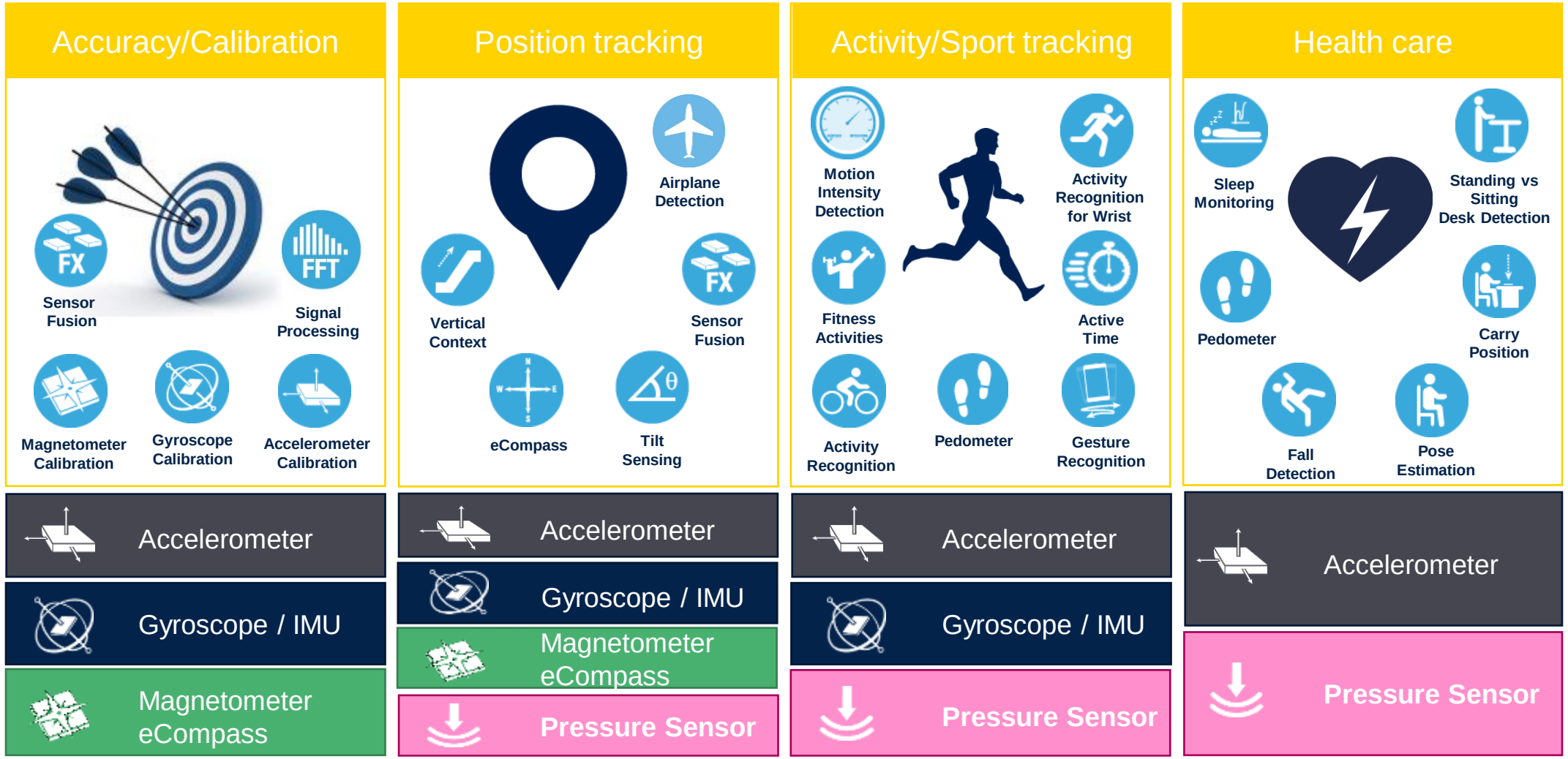
X-cube MEMS1

The right SW for your Sensor



These libraries are available free of charge in X-CUBE-MEMS1 and X-CUBE-MEMS-XT1 packages.

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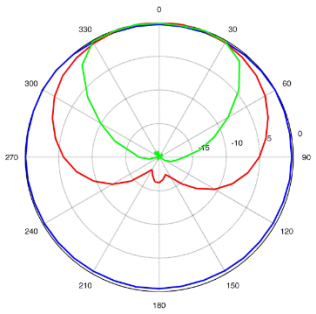
Some Acoustic libraries

Beamforming (AcousticBF)

Using a MEMS (omnidirectional) microphone array, it creates a virtual directional microphone:

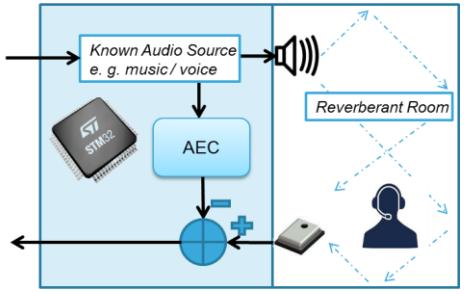
- ✓ Fine-tuned for ST Digital MEMS Microphones
- ✓ PDM to PCM conversion can be integrated for high efficiency
- ✓ 4 synchronous output channels :
  - Omnidirectional microphone
  - Cardioid basic
  - ASR ready
  - Strong



Acoustic Echo Cancelation (AcousticEC)

Removes echo of playback audio in speech capture application:

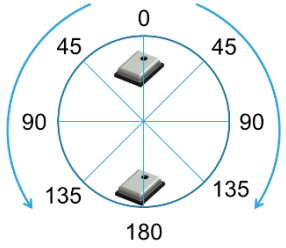
- ✓ Typical use when a microphone and a loudspeaker coexist in the same environment and are driven by the same microcontroller
- ✓ The ST AEC library is based on the Open Source Speex suite

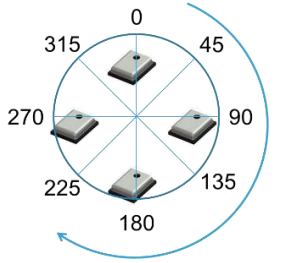


Sound Source Localization (AcousticSL)

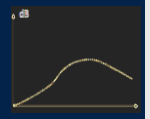
Signals are acquired by one or two *couples* of microphones in order to estimate the sound direction of arrival:

- ✓ 360 degrees range with at least 3 mics.,180 degrees range with 2 mics
- ✓ Selectable resolution, up to 1 degree
- ✓ Simple Voice activity detector included, based on energy threshold



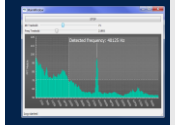


dBNoise : Noise level



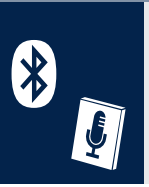
Environmental noise level estimation.

UltraSound FFT



Real time FFT up to 96KHz

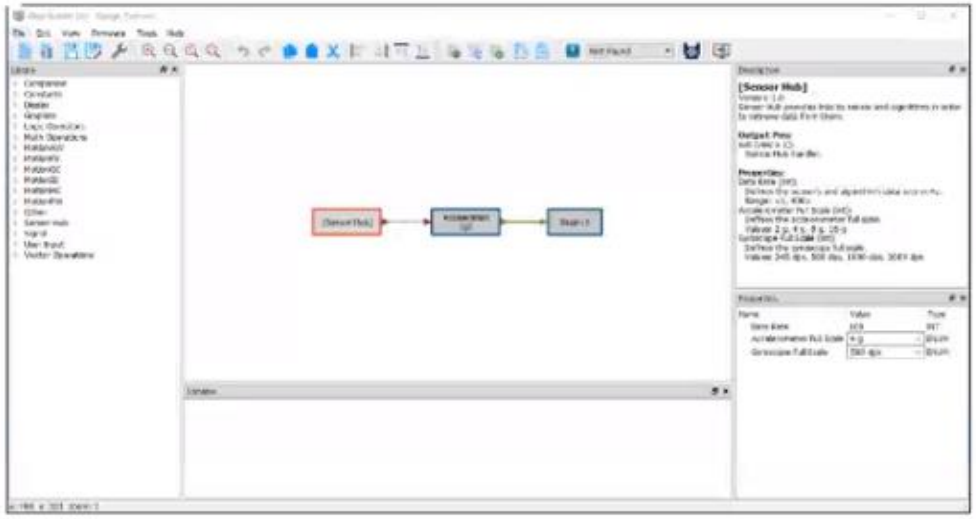
Voice over BLE

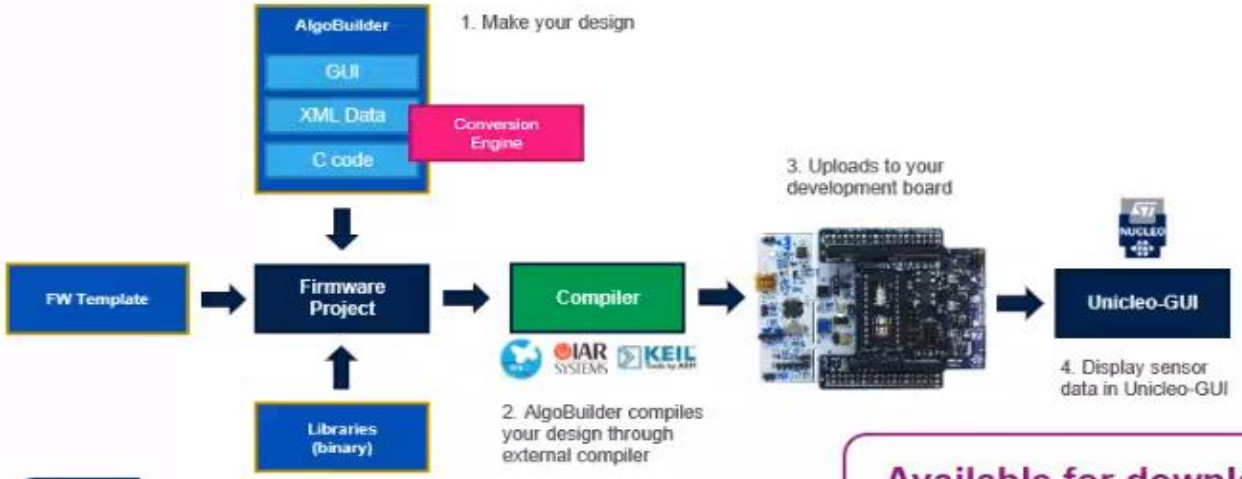


Full duplex voice over BLE solution.

AlgoBuilder

Algobuilder can be used together with Unicleo-GUI to show the data from Algobuilder firmware also with ST-WIN



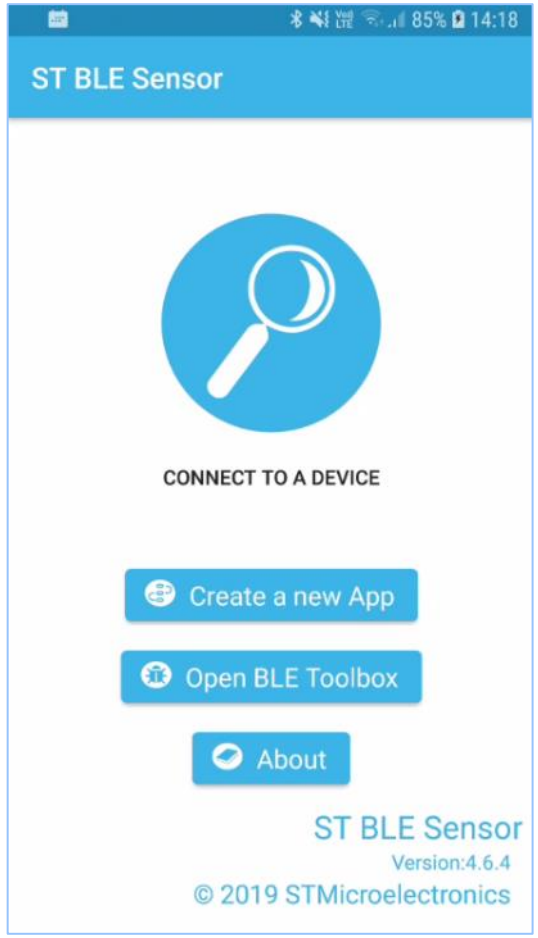


Available for download at AlgoBuilder

- PC application for **graphical design of algorithms using ST MEMS sensors**
- Simple graphical design (drag and drop, connect, set properties)
- Wide range of function blocks including motion sense algorithms (e.g. Sensor fusion, gyroscope and magnetometer calibration or pedometer)
- **C code is generated** from the graphical design
- Outputs from generated firmware can be **displayed in Unicleo-GUI** application
- Compatible with:
  - boards from ST: SensorTile.box, STWIN, STM32Nucleo MEMS expansions
  - custom boards: using STM32CubeMX and X-CUBE-ALGOBUILD pack

X-CUBE-ALGOBUILD

ST BLE Sensor
app for Android and iOS

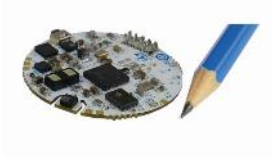


SensorTile.Box

STWIN

SensorTile

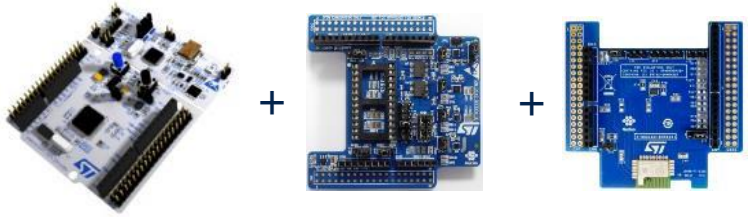
BlueTile



WESU1

BlueCoin

STM32Nucleo + MEMS + BLE expansion



Sensor data reception over BLE
Data plot and log, publish to cloud

Application for SensorTile.box creation & upload

Support multiple platforms and STM32Cube Function Packs through **BlueST-SDK** protocol

ANDROID iOS

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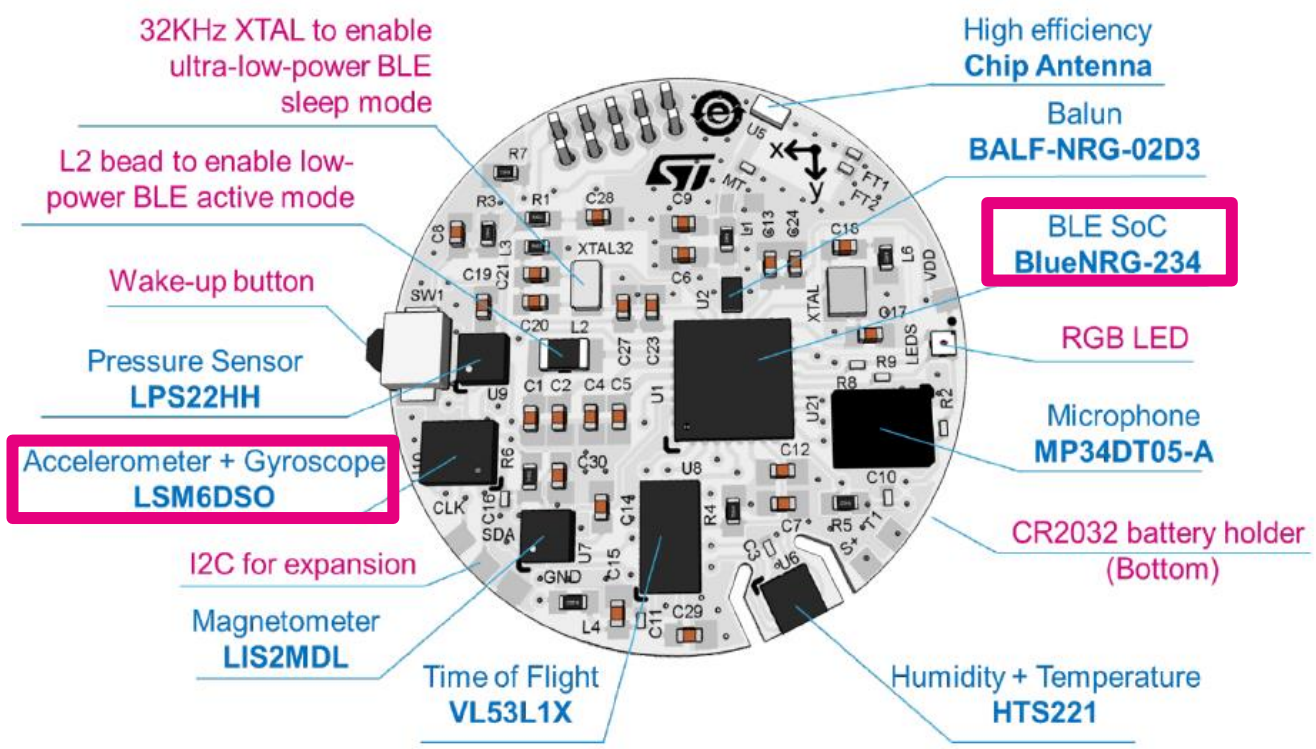
Social distance proximity detection Solution over BlueNRG-Tile



STEVAL-BCN002V1

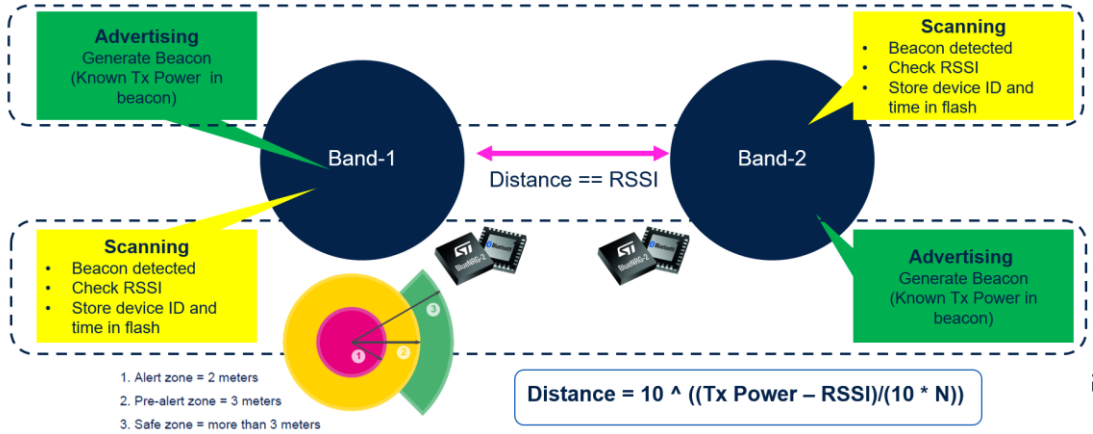
AN5508 implemented over STEVAL-BCN002V1

BlueNRG-2 SoC

- simultaneously advertising (beacon data, Tx Power, Tilt Angle) and scanning
- implementing RSSI filtering and generating Alert Threshold

LSM6DSO Accelerometer

- used to measure the tilt of the board (part of the beacon data)
- Wakeup device (movement detection)



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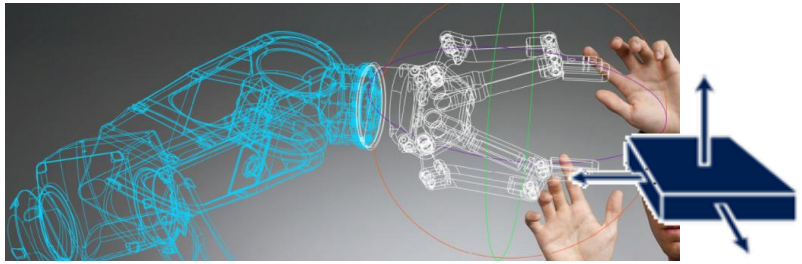
From Industry 4.0 to 5.0 - Collaborative Robots
New categories of sensors

Gesture/Movements recognition

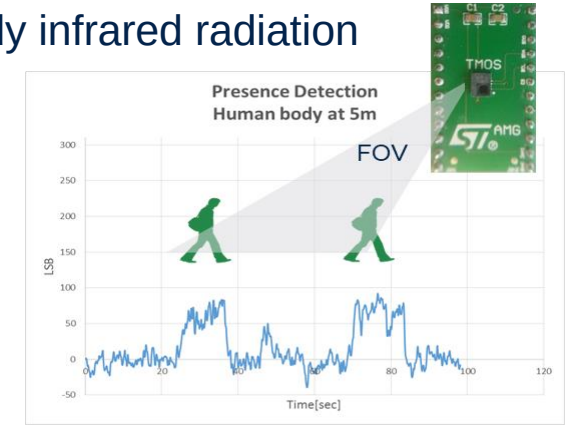


Qvar - Electric Charge (**Q**) Variation (**var**), detecting the differential electric potential variations around human body

AR/VR with
ST Micro-Mirros

Voice interaction / controlled robots

TMOS measures the amount of human body infrared radiation



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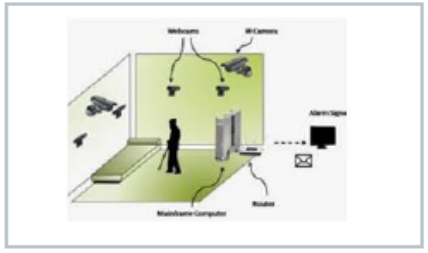
Presence Detection - Examples of Use Cases

Smart Home: Indoor comfort, Outdoor lighting, Life safety, Medical monitoring and emergency, intrusions, …

Office buildings: comfort, safety, security/access control and location tracking, space optimization and energy savings,…

Factory automation: Operator safety and productivity (geofencing, worker/machine collision avoidance, worker/robot collaboration, worker/worker distance,…)



Healthcare buildings: patient location tracking, activity and fall detection

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Introducing new category of sensors: Qvar™ and TMOS

QVAR: Sensing Electrostatic charge variation (1-2 meters)

Qvar stands for Electric Charge (**Q**) Variation (**var**):

Enabled sensors detect the differential electric potential variation induced on the **electrodes** connected on

Electrodes on body
(In contact/Not in contact with human skin)

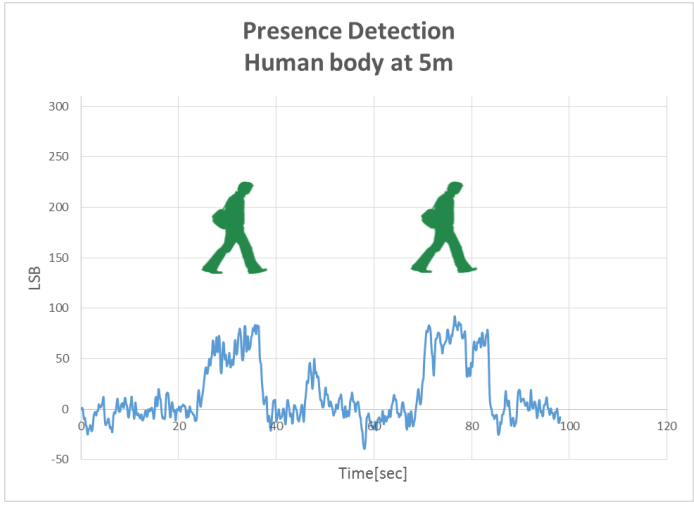
Improved Activity Detection

Electrodes in proximity
(Radar function)

Presence Sensing

TMOS: Infrared Radiation Sensing (5-10 meters)

STHS34PF80 is the first of a family Presence/Motion detection by absolute temperature from embedded IR technology



QVar only available at ST

Also to detect static presence (no movement)
Compete with PIR sensor

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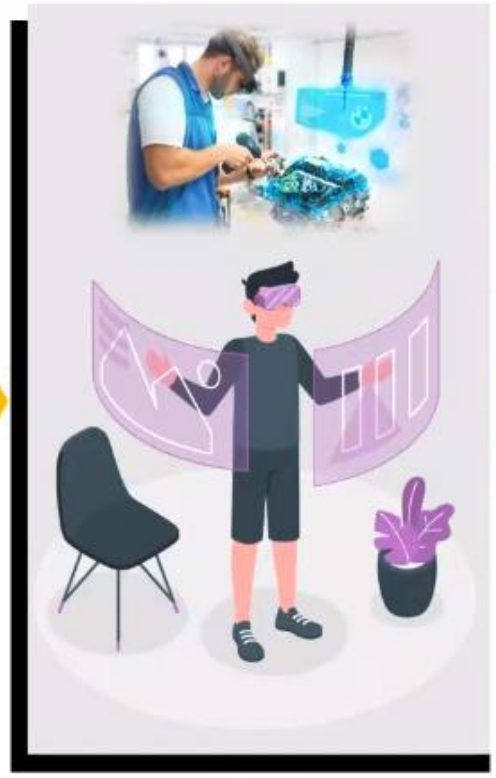
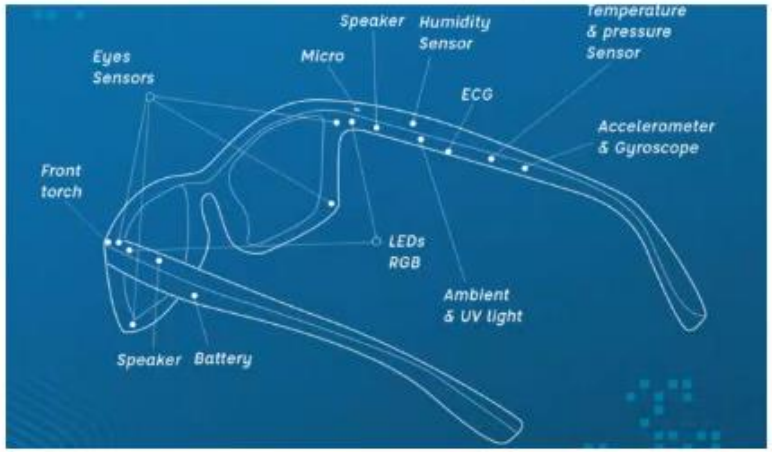
ST ready to enhance Augmented Reality / Virtual Reality

With ST Micro-Mirrors



AR/VR

ST BOM : Micro / Sensors/ Analog



Requiring & Vigilance monitoring

Physical activity Stress Level

First prototypes (complete solution opto + electronic) to integrate available from end 2021 – By ODM Quanta (Taiwan)

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Join ST community!

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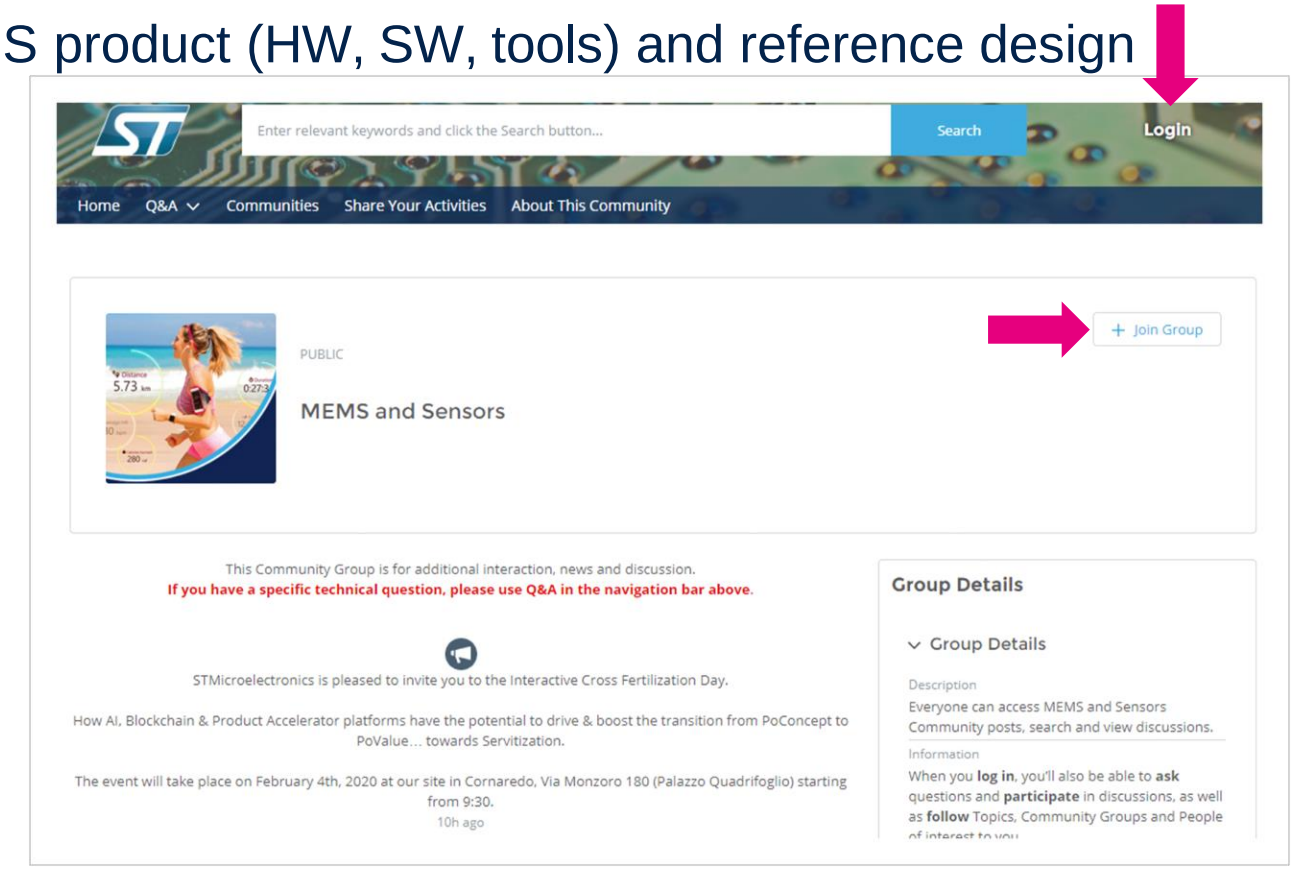
MEMS and sensors
Join ST community and Q&A

- Community:
  - The most updated information on MEMS product (HW, SW, tools) and reference design
  - Join the community to…
  - …share ideas and find sparks!
  - …find potential customers



- **Q&A**:
  - Do you have a technical question? Ask here!
  - 2k posts

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A large ecosystem
to scale-up digital transformation

life.augmented | Ecosystem of Competences

PoC Center

Partner Program

300+ Authorized Partners

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Cloud Provider

Connectivity Provider

Device Management

Consulting/Training

Engineering Services

Analytics/App Development

System Integrator

SW Development/tools

Support

Learn more about ST Sensors

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- For more information on sensors: **www.st.com/sensors**
- Machine Learning Core: **www.st.com/mlc**
- Information on longevity: **10yr Longevity Program**
- Android / Linux / Open Drivers: **Drivers for MEMS**

Thank You!

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