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Sensor Solutions for Condition Monitoring and Predictive Maintenance - Introduction

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EMEA AMS Marketing and Application

EBV webinar

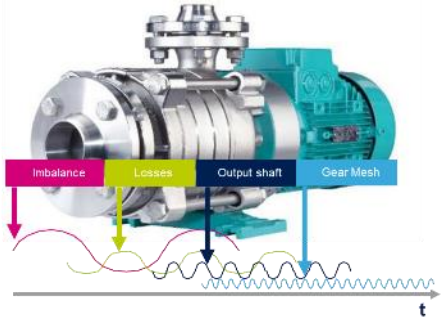
Agenda

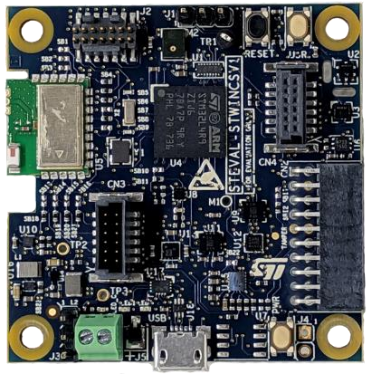
#1 Condition Monitoring and Predictive Maintenance Overview

#2 Typical Application Block Diagram

#3 Focus on IIS3DWB MEMS vibration sensor

#4 Tools Overview including STWIN details





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Predictive maintenance

Predictive Maintenance (PdM) enables **cost savings** over time-based preventive maintenance.

The maintenance tasks are performed while machine is running using:

- condition based monitoring with sensors
- local processing
- cloud analytics

ST provides solutions that will help you create Predictive Maintenance applications.

For more information, visit our pages on Condition Monitoring and Predictive Maintenance

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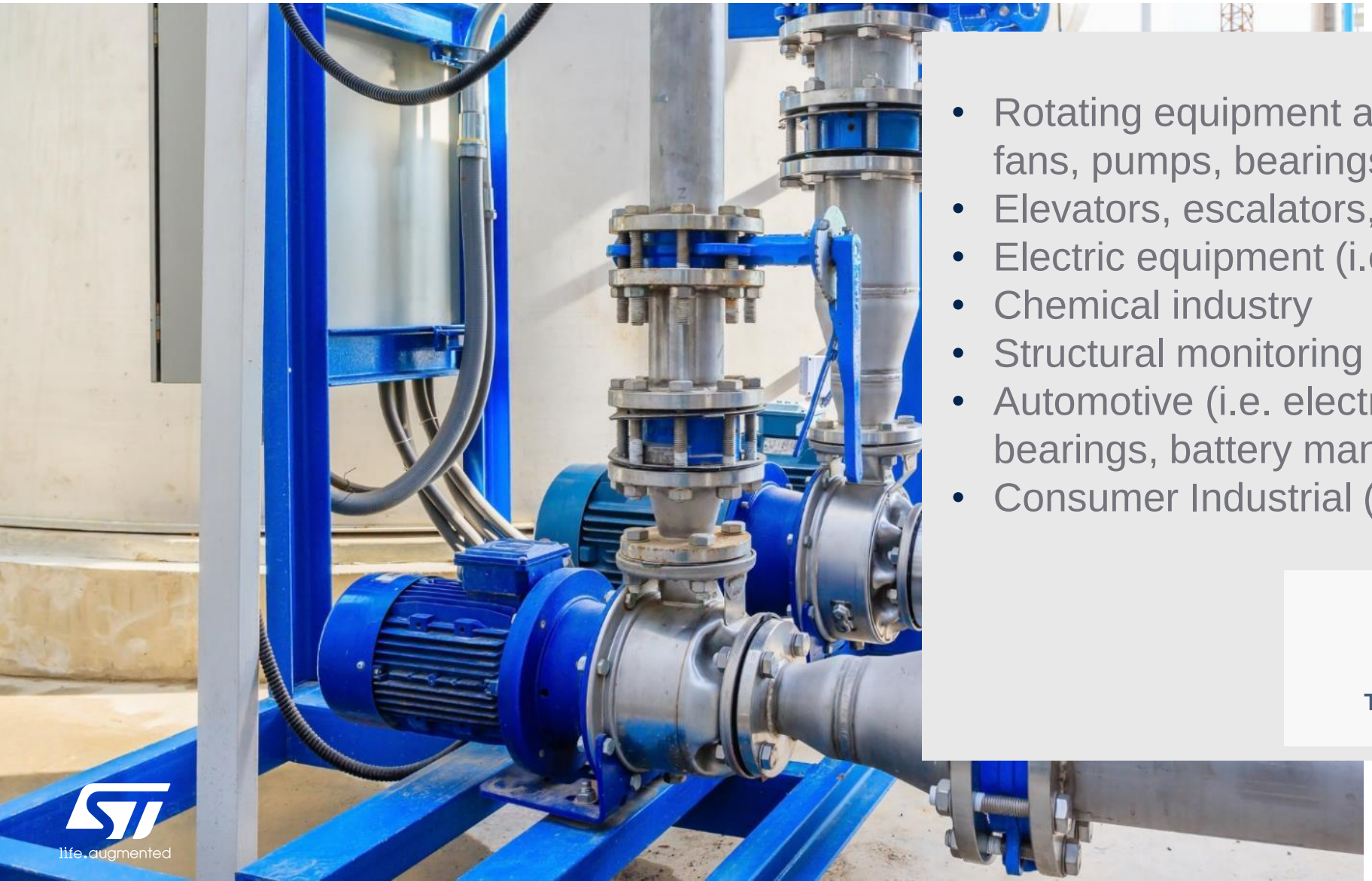
Market and applications split main market segmentation



- Rotating equipment and related parts (i.e. motors, fans, pumps, bearings, spindles)
- Elevators, escalators, ...
- Electric equipment (i.e. circuit breakers)
- Chemical industry
- Structural monitoring (i.e. bridges, railways)
- Automotive (i.e. electrical motors and parts - bearings, battery management)
- Consumer Industrial (i.e. HVAC)

Focus on

Vibration monitoring
Temperature and Environmental
Ultrasound detection

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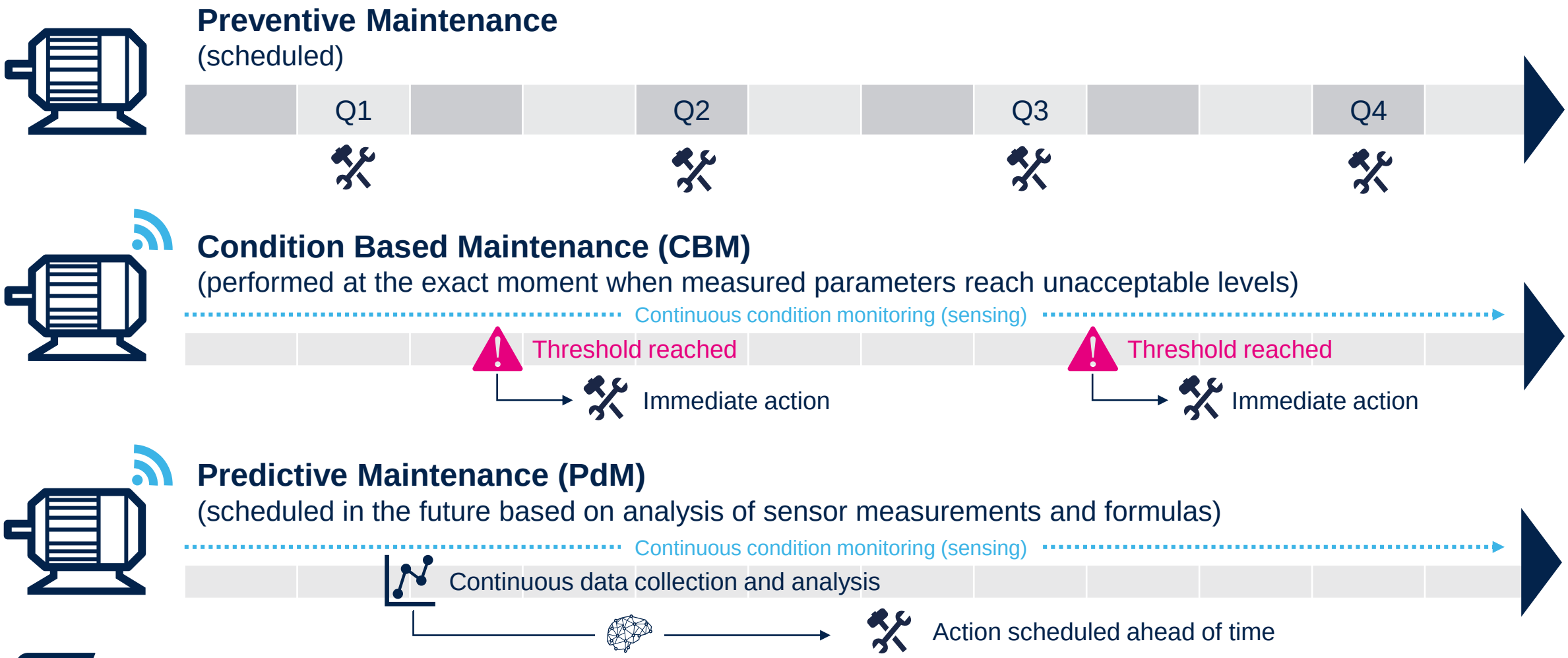
Preventive, condition monitoring and predictive what's different



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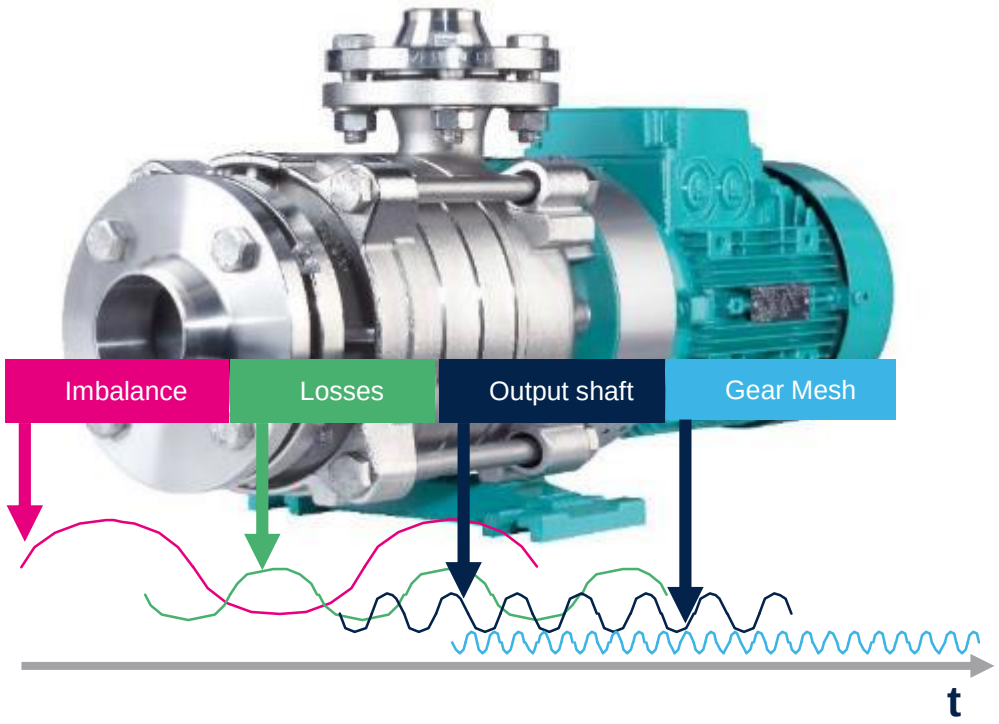
Typical use case industrial motor monitoring

Any parameter deviation is an indicator of potential failure

Mechanical vibration

- Displacement
- Speed
- Acceleration
- Acoustic noise
- Angular speed
- Torque



Functions to enable monitoring

Vibration Capture

Connectivity

Wireless Connectivity

Processing

A
f

Secure Connections

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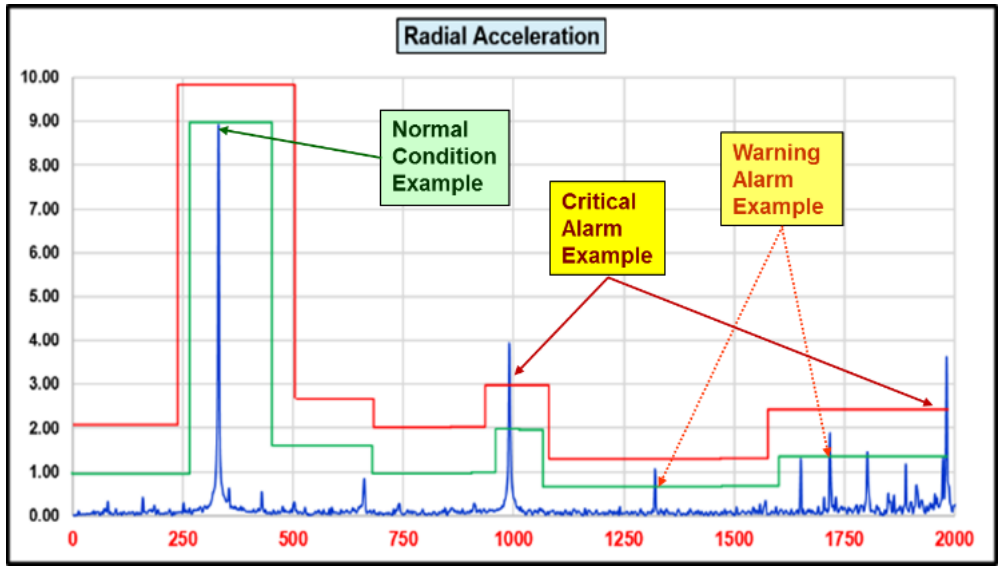
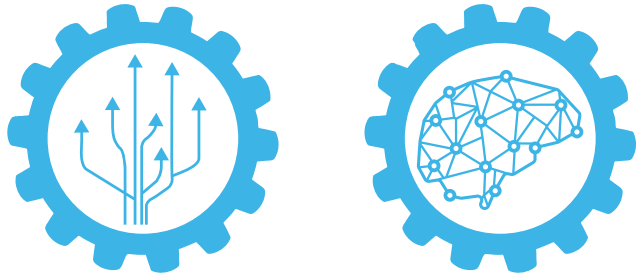
Processing at the edge from FFT to machine learning

While FFT thresholds are widely used,
Machine Learning and AI can enable new scenarios

- **Embedded FFT** analysis at the sensor can **isolate vibration**
- **Thresholds** are based on human based features extraction
- **Alarm** can be set according to specific threshold to detect potential defects.



- **Machine and Deep Learning can be used to automatically extract features** with several benefits
- Machine and Deep Learning techniques and acquisition strategies can be differentiated according to the use case
- Both can now run in a MCU



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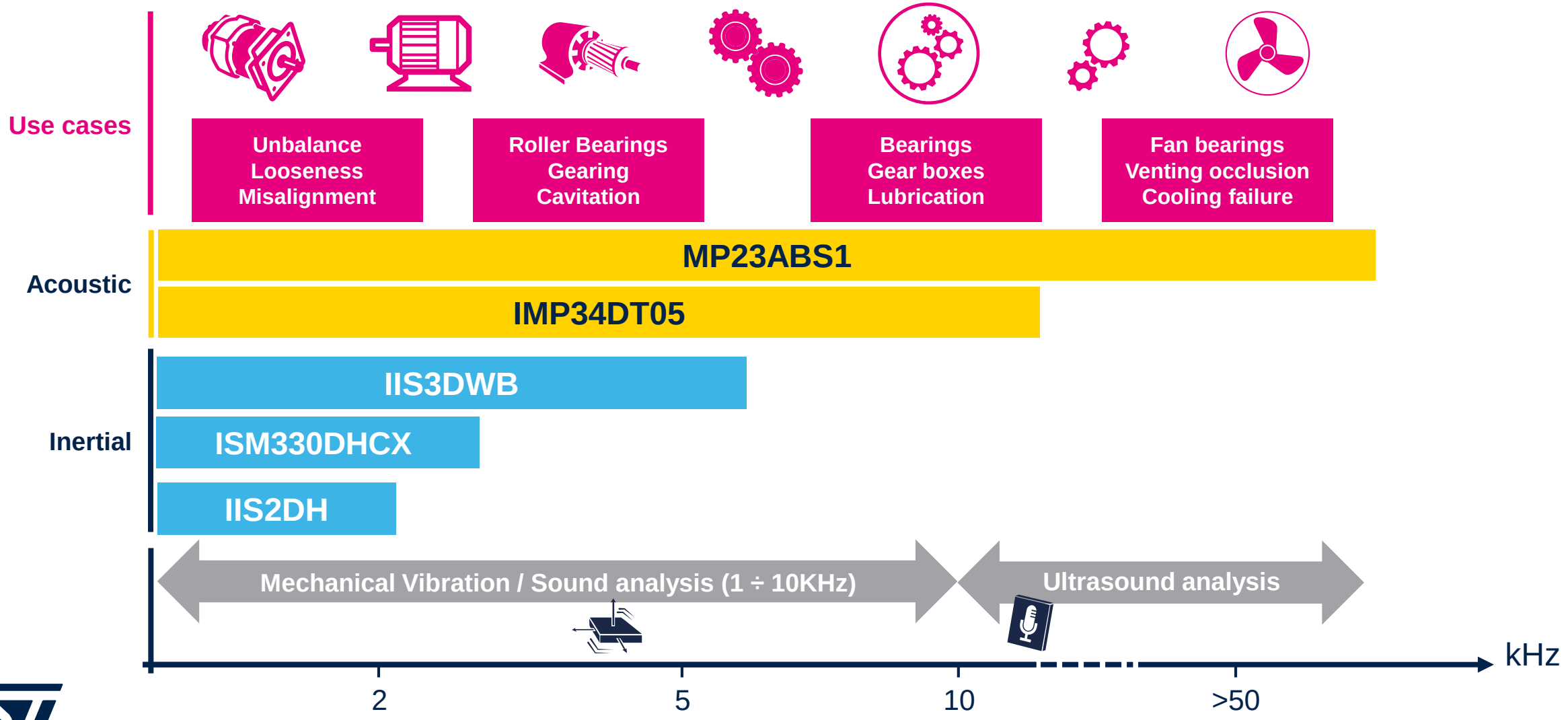
Industrial sensors for vibration analysis sensors and defects over bandwidth



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IIS3DWB 3-axis digital vibration sensor ultra-wide bandwidth and low-noise

KPI for vibration monitoring

- Wide & flat measurement bandwidth
- Flat freq. response, sharp out of band roll-off, no aliasing
- Freq. response and low noise levels
- Stable thermal behavior over extended temperature range
- Power consumption suitable for wireless sensor node
- Operating temperature range

Pin2pin compatible with ISM330x/LSM6DSx devices

Parameter	Value
N. of axis	**3-axis**
Full Scale [g]	±2/±4/±8/±16
Output i/f	Digital: SPI, I2C (single axis or debug mode)
Bandwidth (-3dB) [kHz]	**6.3**
ODR [kHz]	26.7
Noise Density [µg/√Hz]	**90 (65 in single axis)**
Current Consumption [mA]	1.1
Features	FIFO (3kbyte) Programmable HP Filter Interrupts Temp. Sensor Embedded Self Test
Operating Temp [°C]	**-40 to +105**
Operating Voltage [V]	2.1 ÷ 3.6
Package [mm3]	LGA 2.5x3x0.83 14Lead

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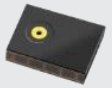
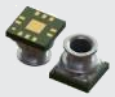
Industrial sensors for CBM and PdM

Function	IC	Description	Package	Features	
Vibration	IIS3DWB	**Ultra-wide bandwidth (up to 6kHz), low-noise 3-axis digital vibration sensor**	LGA-14, 2.5x3 mm 	• 3D Accelerometer – 16g Full Scale • Ultra low noise + up to 105°C operating T°	• Digital Output • Ultra Wide Bandwidth (up to 6.3kHz)
	ISM330DLC ISM330DHCX	**Wide bandwidth accelerometer + gyroscope**		• 3D Accelerometer + 3D Gyro - Digital Output • 3 kHz bandwidth accelerometer	• Ultra Low Power + Smart Features
	IIS2DH	**Wide bandwidth, ultra-low-power accelerometer**	LGA-12, 2x2 mm 	• 3D Accelerometer – Digital Output • Up to 2.3 kHz bandwidth	• Ultra Low Power – Ultra Compact
	IIS2MDC	**Low-noise, low power magnetometer**		• 3D Magnetometer – Digital Output • AMR Technology - Up to 50 Gauss Full Scale	• Ultra Low Noise, Low Power
Acoustic	MP23ABS1TR	**Analog differential microphone**	RHLGA metal cap 5-L, 3.5x2.65x0.98 mm	• Bottom port Microphone • Wide Acoustic Bandwidth (up to 80 kHz)	• Wide Dynamic Range (AOP up to 130 dBSPL)
	IMP34DT05-A	**Digital top port microphone**	3x4x1 mm 	• Top port Microphone with Digital Output • Wide dynamic range (AOP up to 122 dBSPL)	• ESD up to ±15kVolt
Environmental	LPS22HH	**High accuracy – Compact size absolute pressure sensor**	HLGA-10-L, 2x2x0.76 mm Ultra Compact full molded	• 260 to 1260 hPa Range - Digital Output • High Accuracy (±1 hPa)	• Low noise (0.75 Pa RMS)
	LPS27HHW LPS33HW	**Water-resistant absolute pressure sensor**	2.7x2.7x1.7 mm 3.3x3.3x2.9 mm 	• 260 to 1260 hPa Range - Digital Output • High Accuracy (±2.5 hPa)	• Low noise (0.8 Pa RMS) • Water resistant up to 10 atm
	STTS22H	**Digital temperature sensor**	2 x 2 x 0.50 mm 6-lead UDFN	• Operating temperature -40 °C to +125 °C • Accuracy: ±0.5 ºC max (-10 °C to +60 °C)	• Programmable threshold, One-shot mode
	STLM20	**Analog temperature sensor**	SOT323-5L, UDFN-4L	• Accuracy ±0.5 °C (typ.)	• Operating Temp –55 °C to +130 °C

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Wireless connectivity changes the game
STEVAL-STWINKT1 is the answer

SensorTile Wireless Industrial node

STEVAL-STWINKT1 kit includes:

- Hardware Board
- Battery + plastic case for field testing
- STLink-V3MINI + cable for programming

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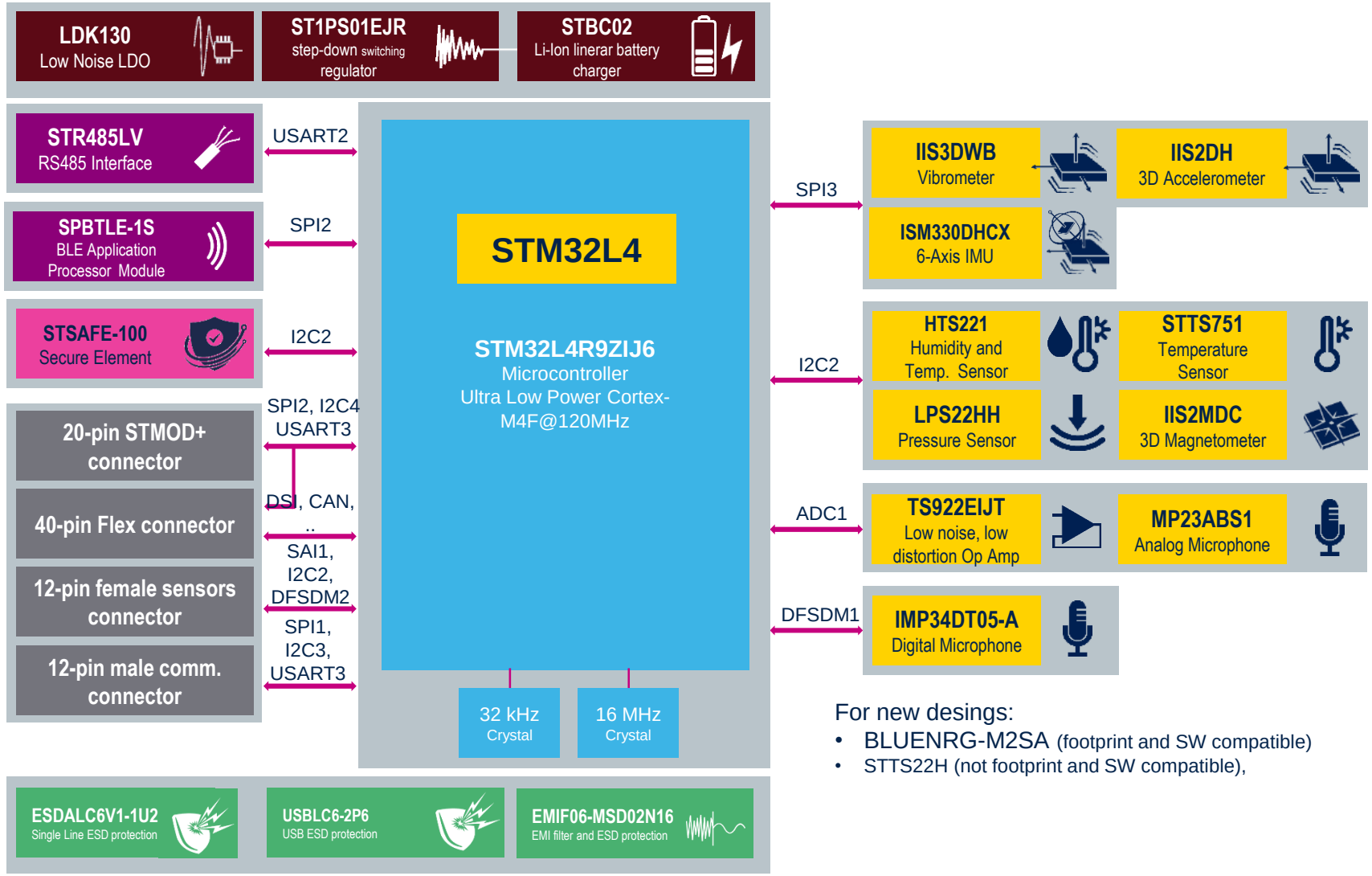
STEVAL-STWINKT1 block diagram, ICs and features in one slide

- Power supply: Li-Po battery or ext. 5 V
- Best-in-class industrial-grade sensors (i.e. ultrasound detection, to vibration analysis)
- Smart power to increase battery life
- Multiple algorithms running on the STM32L4+
- Secure connection and authentication with **STSAFE-100** (footprint)
- BLE connectivity
- Connectivity and sensor expansions support
- USB and SD-card holder



For new desings:

- BLUENRG-M2SA (footprint and SW compatible)
- STTS22H (not footprint and SW compatible),

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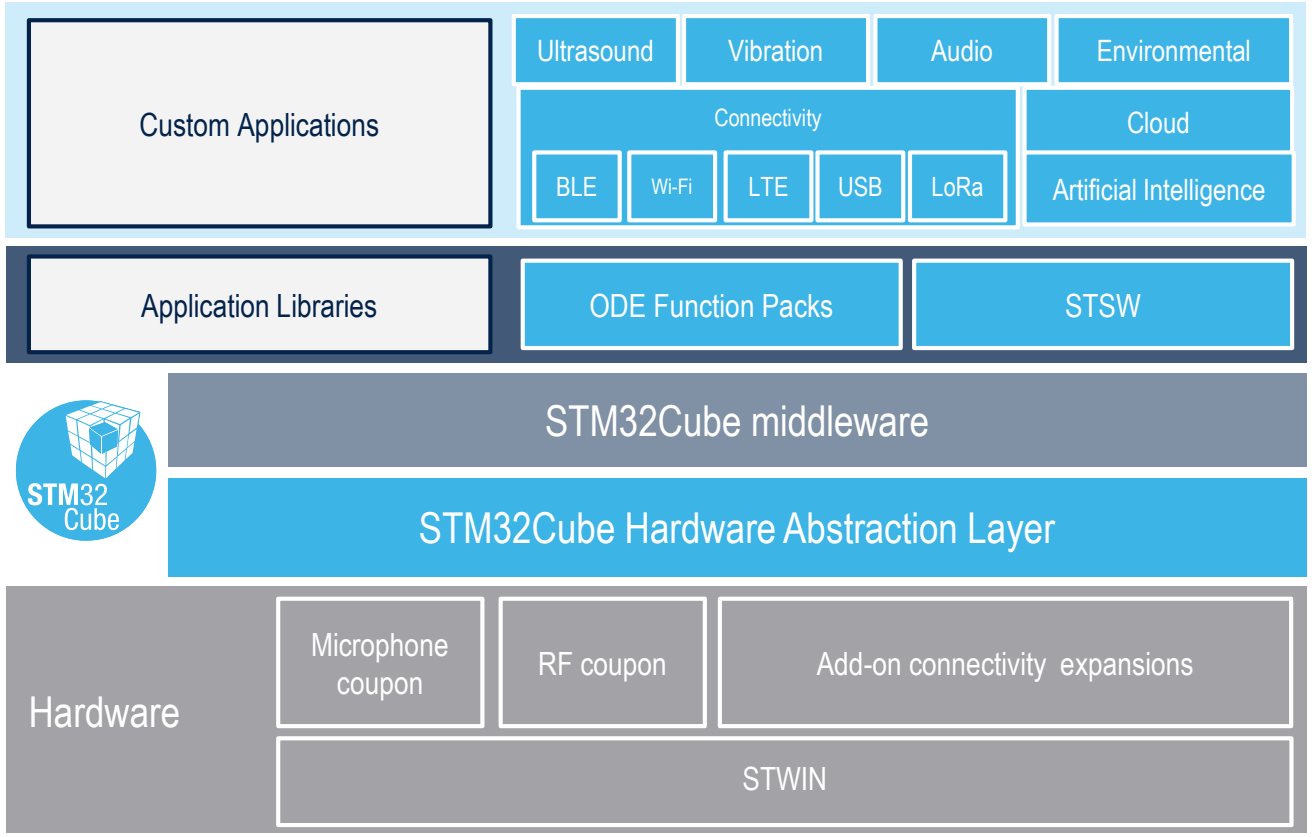
STEVAL-STWINKT1 software support

STEVAL-STWINKT1 software platform for industrial IoT solution development



STM32 Open Development Environment

- STSW-STWINKT01:
  - set of source code example implementations of functionalities of the STWIN platform
- Predictive Maintenance + AWS Dashboard:
  - FP-IND-PREDMNT1
  - STSW-STWINCELL
- Cloud Function Pack for IoT telemetry and device control
  - FP-CLD-AZURE1: Microsoft Azure Cloud

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Condition-based & predictive maintenance edge processing enabling end-to-end

Ultrasound, vibration, environmental monitoring and anomaly detection

Smart Sensor Nodes

STM32 MCU

STEVAL-IDP004V1

STEVAL-BFA001V1B

STEVAL-STWINKT1

Serial Connectivity

Wi-Fi Connectivity

Edge Processing

STM32 MPU

STM32MP157C-DK2
rev. C01

AWS Lambda **AWS IoT Greengrass**

Cloud Dashboard

AWS IoT Core

AWS Shield

AWS Lambda

AWS WAF

Amazon DynamoDB

Amazon Cognito

Amazon Simple Storage Service (S3)

Amazon API Gateway

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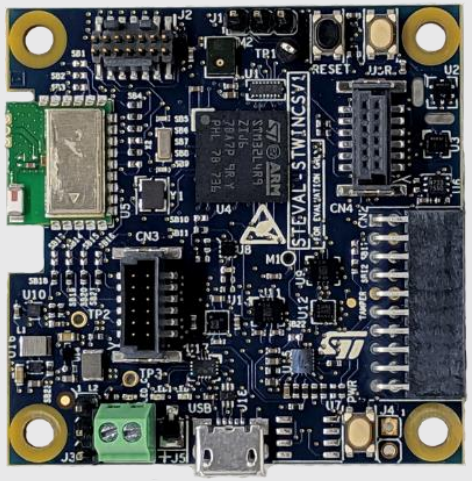
High-speed datalog STSW-STWINKT01

EVALUATION TOOL SOFTWARE

Picture	Part number	Manufacturer	Description
	STSW-STWINKT01	ST	Firmware for STEVAL-STWINKT1 evaluation kit for predictive maintenance, smart industry, IoT and remote monitoring applications



STWIN

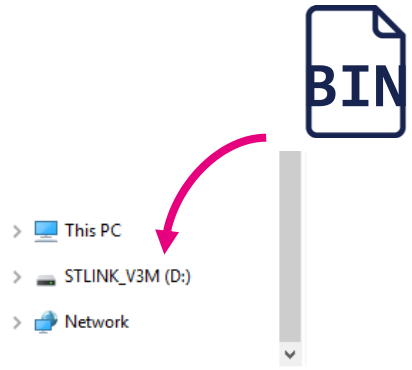
- BLE_SampleApp
- HS_DataLog
- MicArrayCoupon
- OnboardMics
- Serial_DataLog
- UltrasoundFFT
- WiFi_Connectivity

MicroSD card or USB

High-speed MicroSD logging run the demo

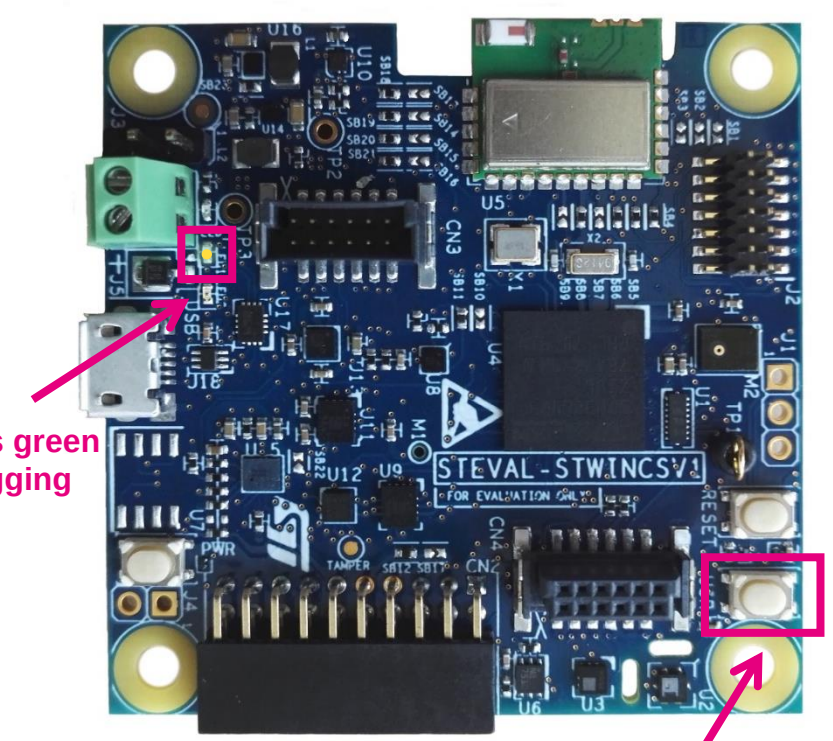
1. Program STWIN

with HS_DataLog.bin
from STSW-STWINKT01
be sure you have **SD card inserted**
Same BINARY file used for USB logging



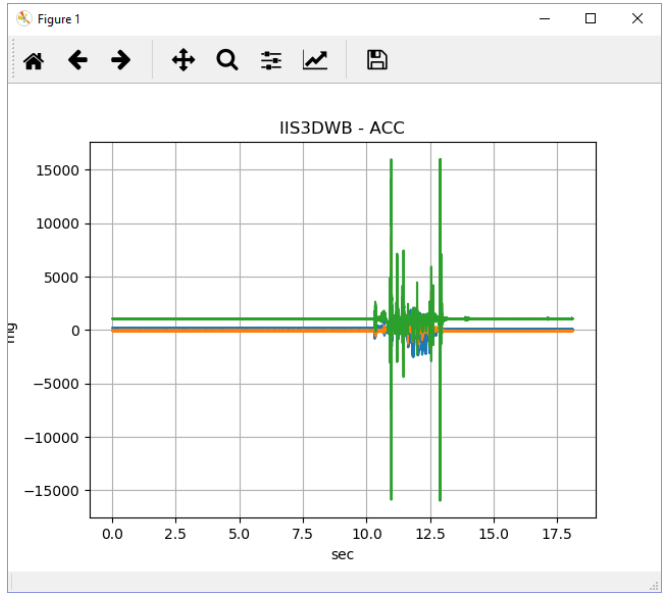
2. Log data

Press USR button to start and stop logging,
green LED blinks while logging



3. Enjoy demo

After finish of logging, data can be read/converted on PC from the microSD card by MATLAB script found in Utilities\HS_DataLog\ subdirectory or a Python script
Install first Anaconda Python environment:
https://www.anaconda.com/distribution/



Python script available in STSW-STWINKT01 v1.3.1

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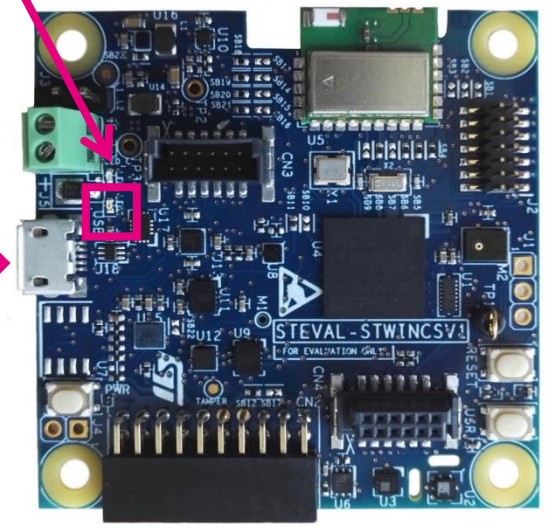
High-speed USB logging
Run the demo

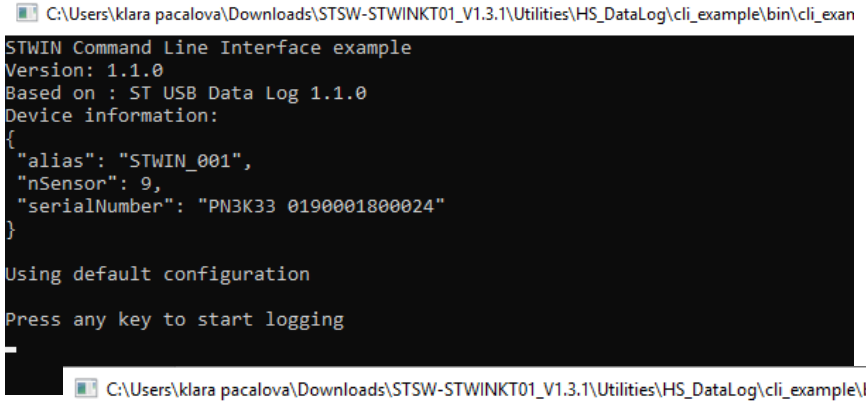
Orange LED blinks
during USB logging

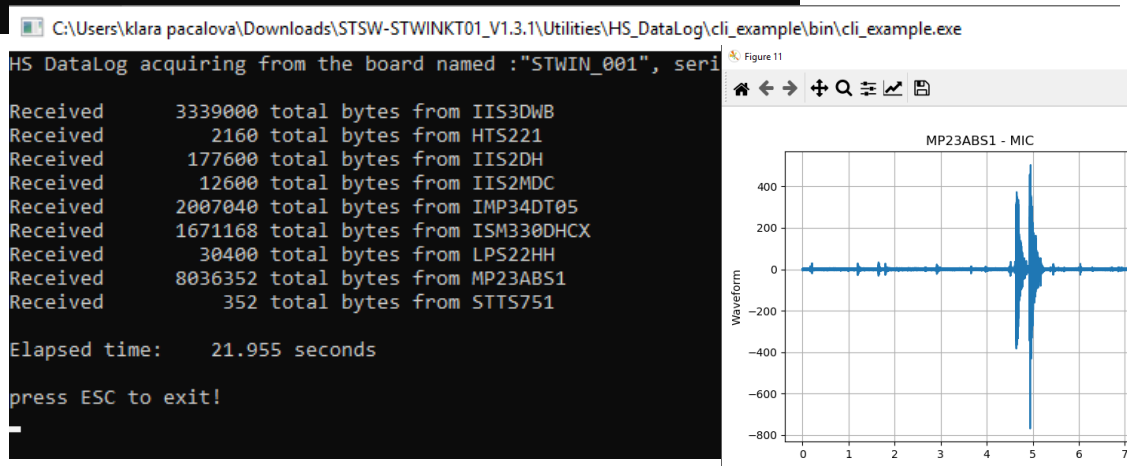
USB



2. Log data

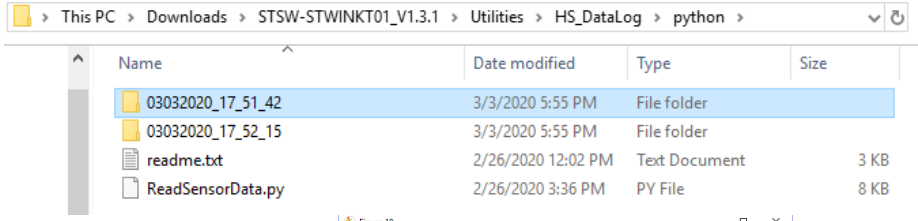
From STSW-STWINKT01_VX.X.X\
Utilities\HS_DataLog\cli_example\bin
run cli_example.exe and follow instructions

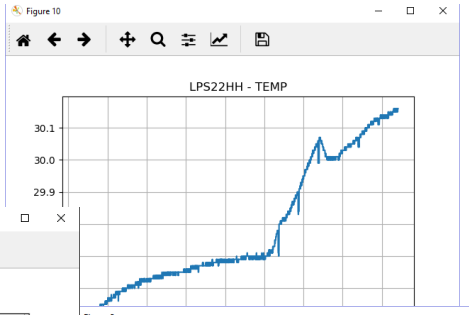


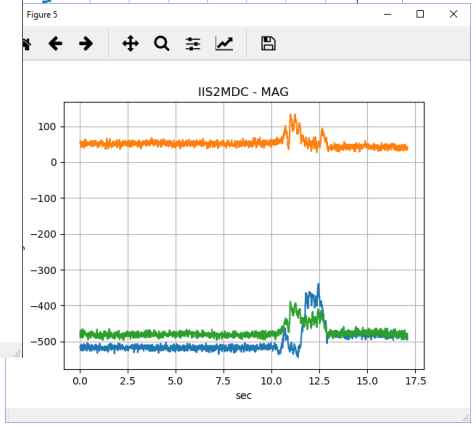


3. Enjoy demo

After finish of logging, copy folder with data to
Utilities\HS_DataLog\python and run
ReadSensorData.py to plot the data







MCU & MPU EMBEDDED SOFTWARE

Picture	Part number	Manufacturer	Description
	FP-IND-PREDMNT1	ST	STM32Cube function pack for multi sensors node with signal processing to enable predictive maintenance

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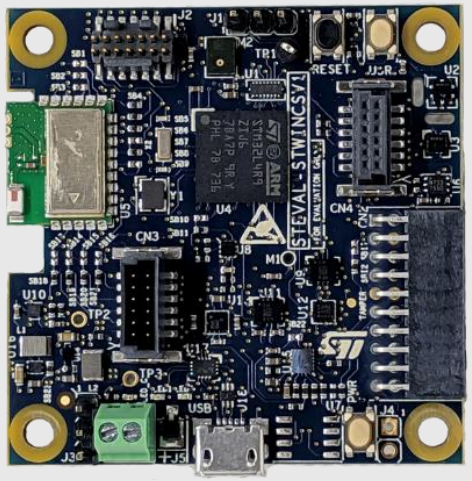
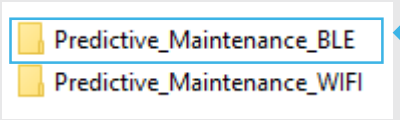
STWIN / ST BLE Sensor App FP-IND-PREDMNT1



STWIN

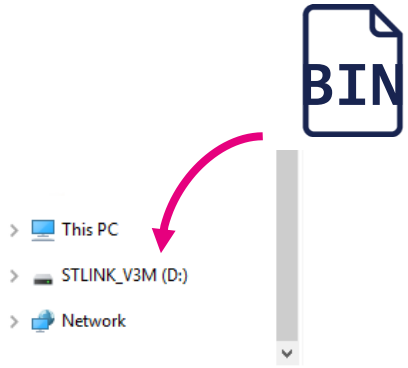


DEFAULT STWIN SW

Run the demo (1/3)

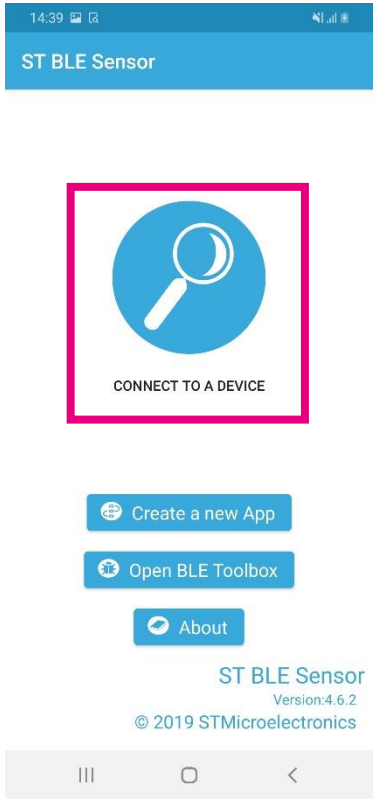
1. Program the STWIN

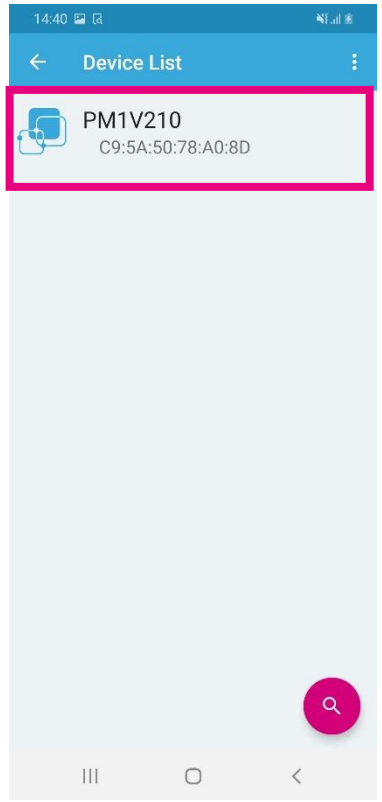
with STM32L4R9ZI-STWIN_PredictiveMaintenance_BL_v2.1.0.bin
from FP-IND-PREDMNT1



2. Open the ST BLE Sensor

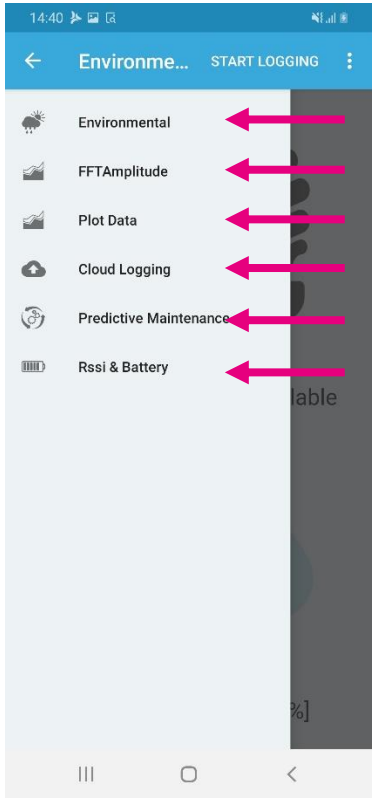
And connect to device





3. Enjoy the demo

Go through multiple functions

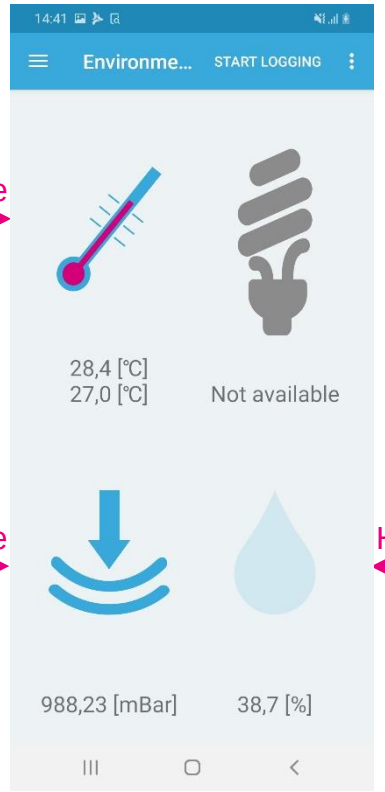


Note: Use above binary with Bootloader to copy-paste the image.
See Quick Start for details.

Run the demo (2/3)

1. Environmental

Environmental dashboard with temperature, humidity and pressure



Temperature

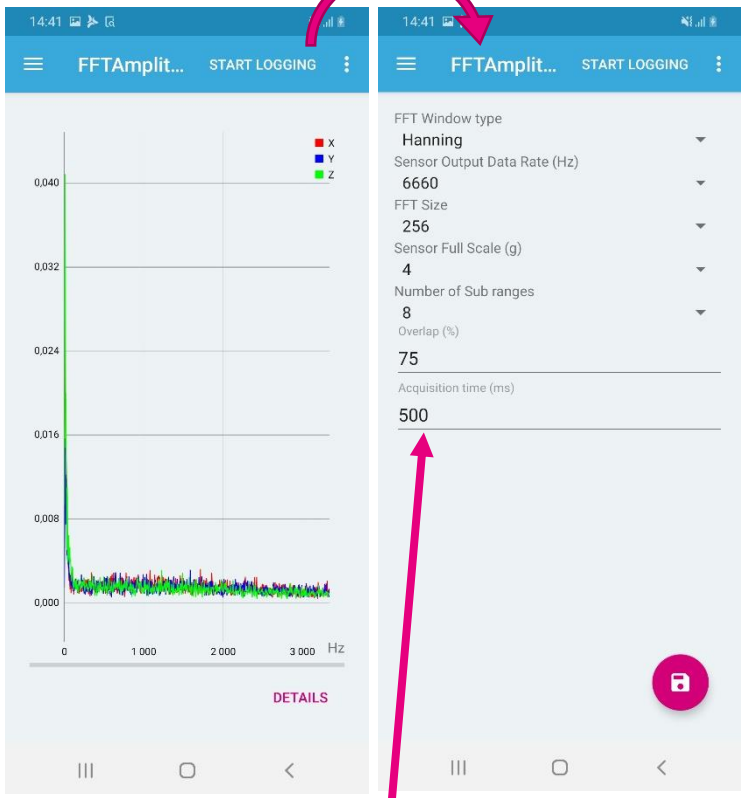
Pressure

Humidity

2. FFTAmplitude

FFT Amplitude visualization

FFT Settings



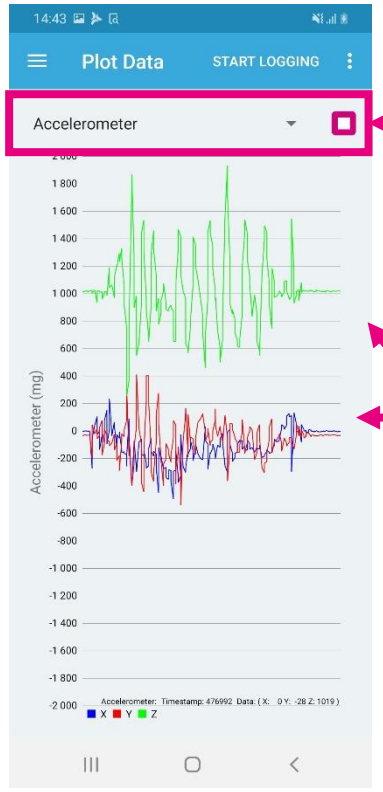
3. Plot data

Data visualization of various sensors

Sensor selection

Start/Stop

Raw data



Note: For faster response, recommendation to use 500ms acquisition time

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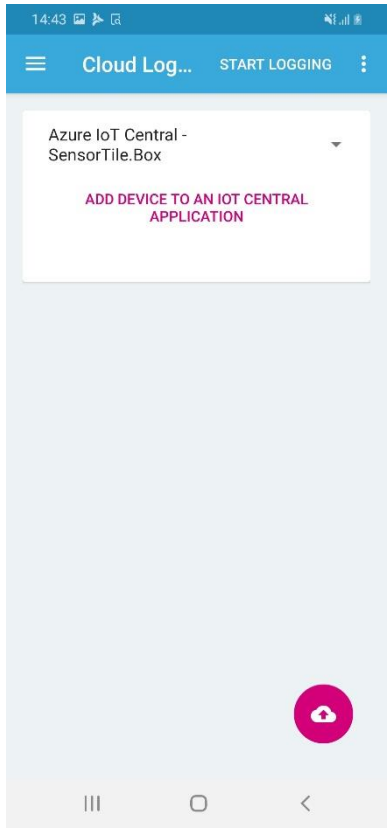
Run the demo (3/3)

4. Cloud logging

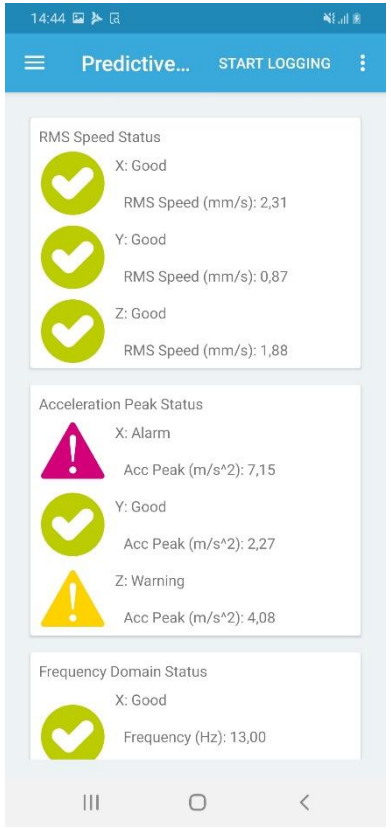
Cloud logging settings



5. Predictive maintenance

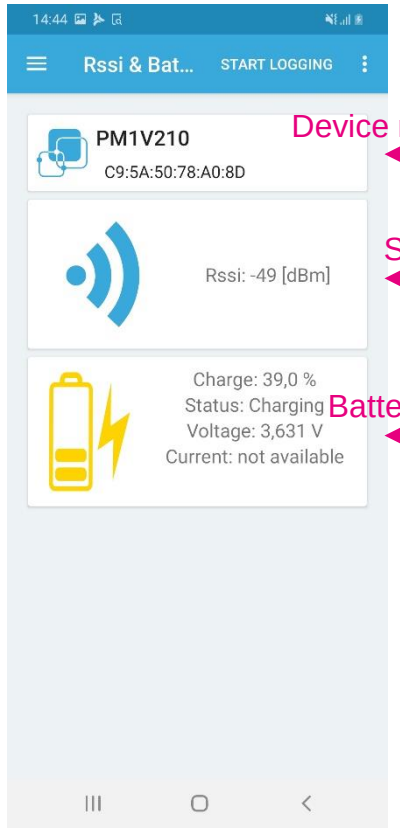
Interactive set of information for predictive maintenance

3 levels of classification – good, warning, alarm (*)



6. RSSI & Battery

Device, signal strength and battery information



Device name & address

Signal strength

Battery information

Device name can be changed in  Settings

(*) 3 levels of classification – thresholds can be changed only by recompiling the project (MotionSP_Threshold.h)

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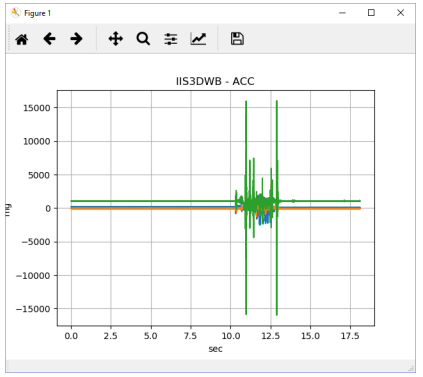
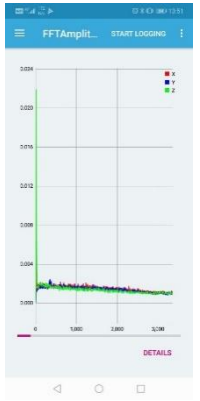
Condition Monitoring summary

- Condition Monitoring applications based on accelerometer vibration analysis with FFT and measuring ultrasound with microphones.
- New IIS3DWB sensor with 6 kHz of bandwidth now available
- New STWIN development kit with latest industrial sensors and SW examples available with BLE and Cloud connectivity
- STWIN includes also best components for power, connectivity and protection.

IIS3DWB

STWIN





Data logging and PREDMNT1 FFT DEMO

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Thank you

Thank You!

For more information, please visit st.com for Predictive Maintenance

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