Getting started Guide

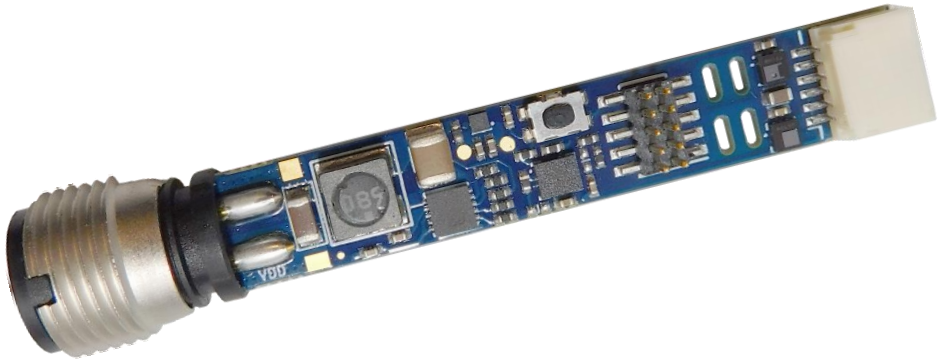
STEVAL-BFA001V1B

Predictive maintenance kit with sensors and IO-Link capability

System Research and Applications

March 2019

V1.1



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Contents

STEVAL-BFA001V1B Kit Overview

STEVAL-BFA001V1B Kit

What's inside

The **STEVAL-BFA001V1B** is based on 3D digital accelerometer, environmental and acoustic MEMS sensors

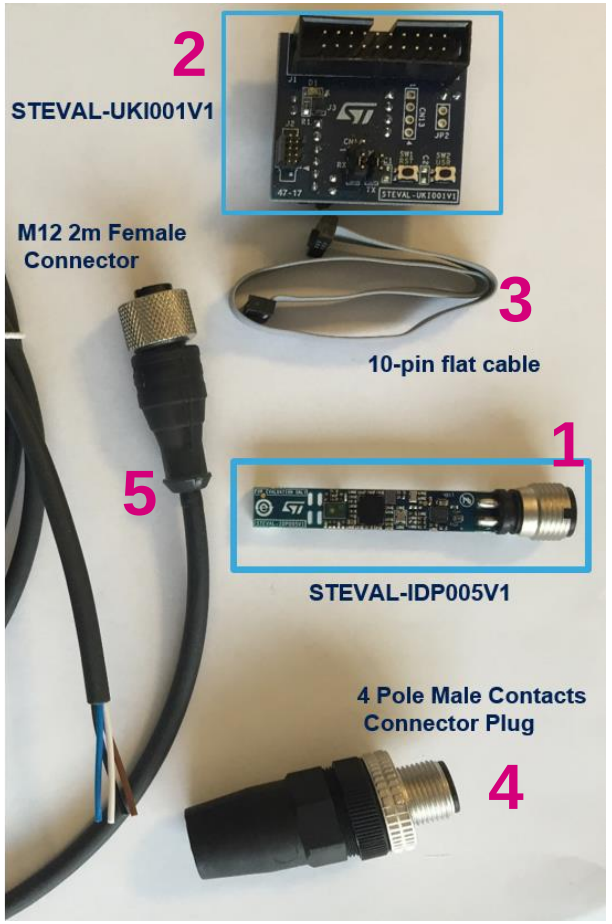
Designed for:

- Condition Monitoring (CM)
- Predictive Maintenance (PdM)

What's inside?

The STEVAL-BFA001V1B includes:

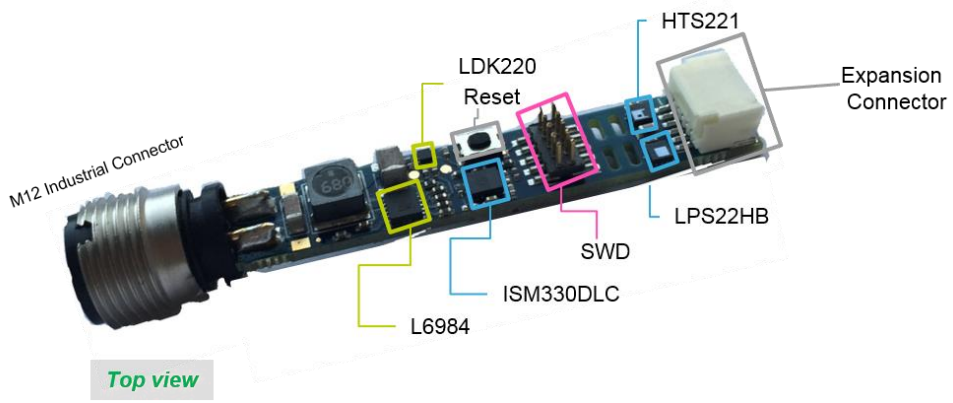
1. STEVAL-IDP005V1- industrial sensor board
2. STEVAL-UKI001V1 - Adapter board for ST-LINK/V2-1
3. 0.050" 10-pin flat cable
4. 4-pole cable mount connector plug, with male contacts
5. M12 female connector with 2m cable



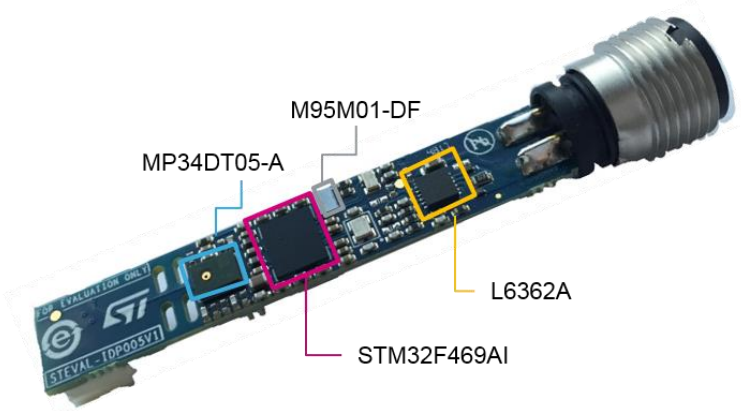
STEVAL-IDP005V1

Hardware Overview

The **STEVAL-BFA001V1B** kit is designed around the **STEVAL-IDP005V1**



Top view



Bottom view

Main supply voltage: 18..32V

Main components:

- 32-bit ARM® Cortex®-M4 core for signal processing and analysis (STM32F469AI)
- Sensors:
  - iNEMO 6DoF (ISM330DLC- accelerometer and gyroscope)
  - Absolute Digital Pressure (LPS22HB)
  - Relative Humidity and temperature sensors (HTS221)
  - Digital Microphone sensor (MP34DT05-A)
- IO-Link PHY Device (L6362A)
- EEPROM (M95M01-DF) for data Storage
- Step-down switching regulator and LDO regulator (L6984 and LDK220)

- M12 industrial connector
- SWD connector for debugging and programming capability
- Reset button
- Expansion connector with GPIO, ADC, I^2C bus

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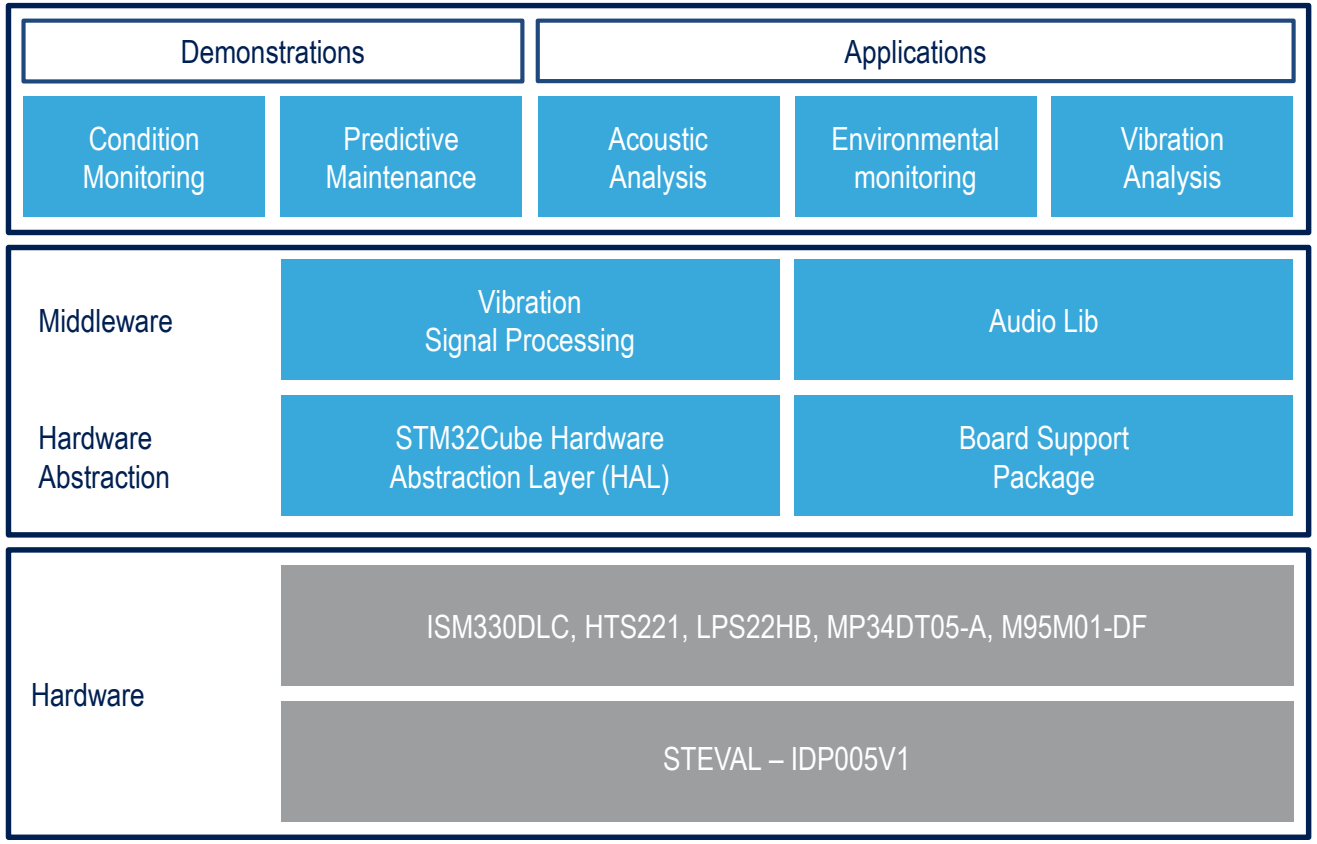
STEVAL-IDP005V1

Software Overview

STSW-BFA001V1 is the software package for the **STEVAL-IDP005V1**



STSW-BFA001V1 architecture

Software Description

Set of firmware examples for CM and PdM based on 3D digital accelerometer (only accelerometer is supported in fw package), environmental and acoustic MEMS sensors.

Key features

- Developed for STM32F469AI with easy portability across different MCU families
- Middleware including algorithms for advanced time and frequency domain signal processing for vibration analysis:
  - Programmable FFT size (256, 512, 1024, 2048 points)
  - Programmable FFT overlapping
  - Programmable acquisition time window
  - FFT averaging during acquisition time
  - Programmable windowing (Flat Top, Hanning, Hamming)
  - Speed RMS moving average, acceleration max peak.
- Middleware integrating microphone algorithms for:
  - PDM to PCM
  - Sound pressure
  - Audio FFT
- Environmental, acoustic and vibration data monitoring through freely available terminal emulator.
- Example firmware to communicate with STEVAL-IDP004V1 (IO-Link master capable, multi-port evaluation board) and dedicated PC GUI.

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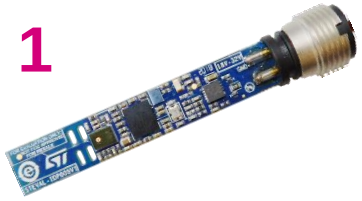
Setup and Programming

Setup

Hardware prerequisities

Unpack the STEVAL-BFA001V1B ...

1



STEVAL-IDP005V1

2

STEVAL-UKI001V1

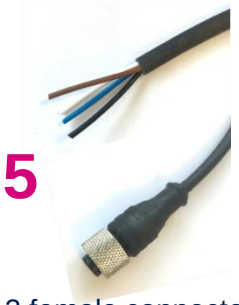
3

10-pin flat cable

4

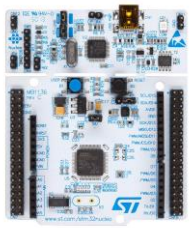
4-pole male connector

5



M12 female connector
with 2m cable

What else do you need? *– not included in the kit –*



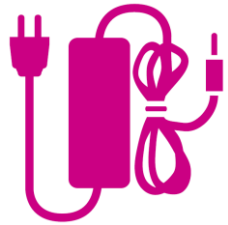
Any **STM32 nucleo-64** to program debug and interface with PC

USB cable Type-A to Mini B

STEVAL-IDP004V1 Master board and generic RS-485/422 USB adapter

(required only to use the GUI)

Laptop



Generic power supply
(range 18..32V)

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STEVAL-IDP005V1 Demo Setup

Software prerequisities

- **STSW-LINK009**
  ST-LINK/V2-1 USB driver
- **STSW-LINK007**
  ST-LINK/V2-1 firmware upgrade
- Common freely **Serial line terminal** (i.e. TeraTerm)
- **ST IDP005V1-GUI** (setup included in *.\STSW-BFA001V1\Utilities* folder)
- **Microsoft.net** version 4.5 or higher (this is only to run the GUI)
- **RS-485/USB adapter driver** (this only to use STEVAL-IDP005V1 connected to IO-Link master capable multi port board)

STEVAL-IDP005V1

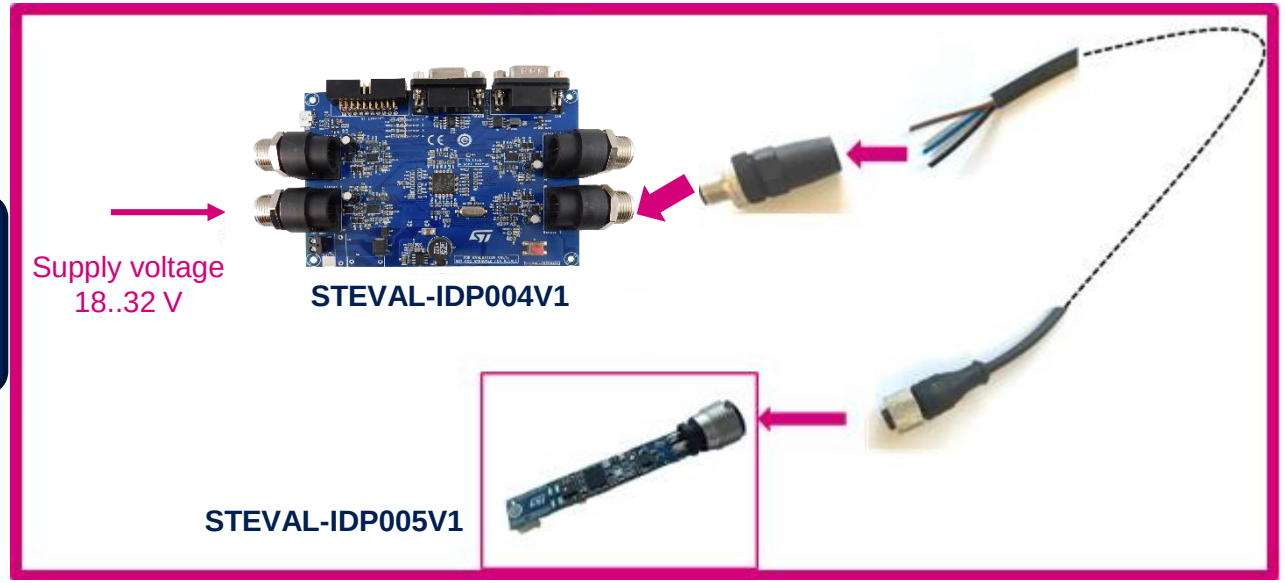
Power-on

The STEVAL-IDP005V1 can be powered in two ways

Plug the M12 cable onto the STEVAL-IDP005V1 and connect the other end to a power supply 18..32V

or

If available, use the STEVAL-IDP004V1 to supply the STEVAL-IDP005V1 through the M12 cable



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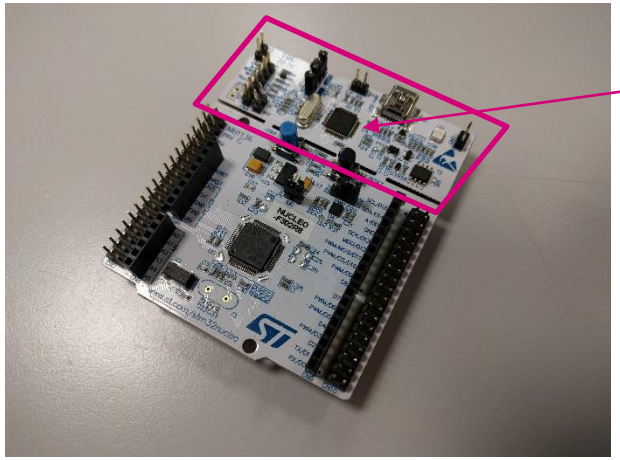
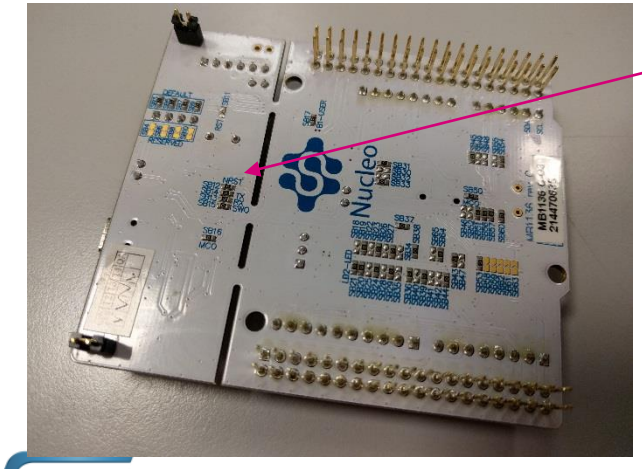
Programming the STEVAL-IDP005V1 1/2

STEVAL-UKI001V1 and ST-LINK/V2-1 overview



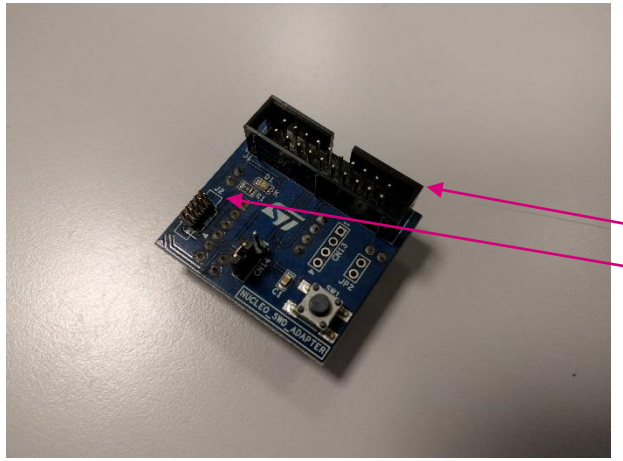
STM32 NUCLEO-64 comes with ST-LINK/V2-1

1



Make sure that SB12 is open

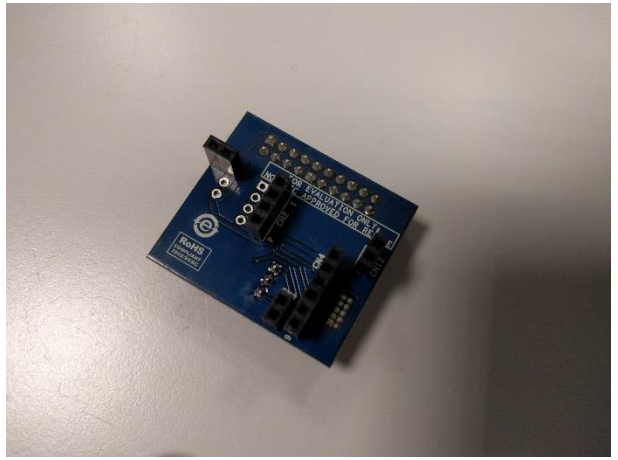
2



STEVAL-UKI001V1 (top view) has two SWD sockets:

- 20-pin (100 mils)
- 10-pin (50mils)

3

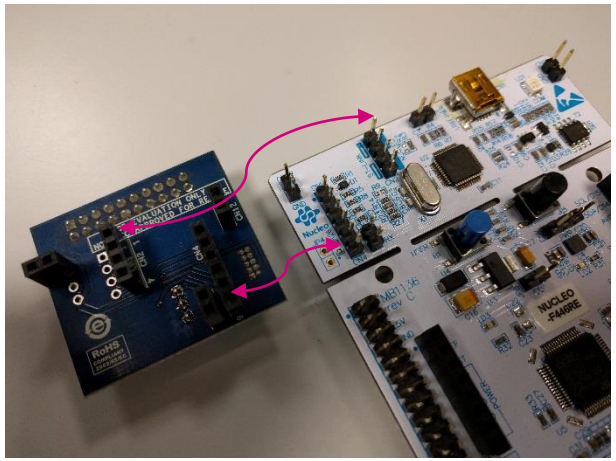


STEVAL-UKI001V1 (bottom view)

4

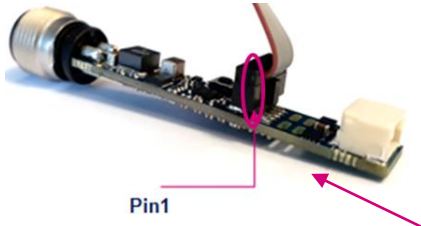
Programming the STEVAL-IDP005V1 2/2

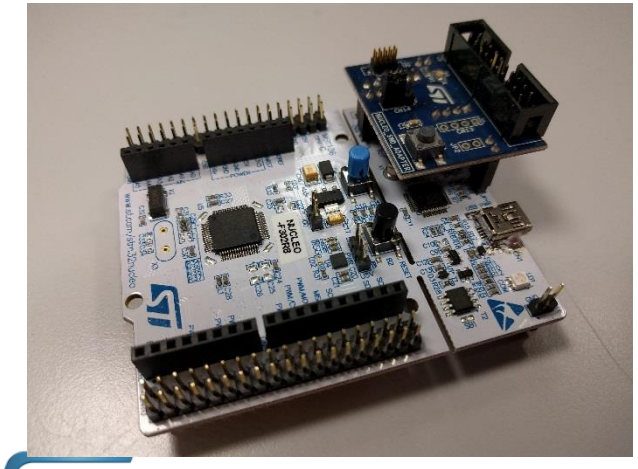
Setup



1

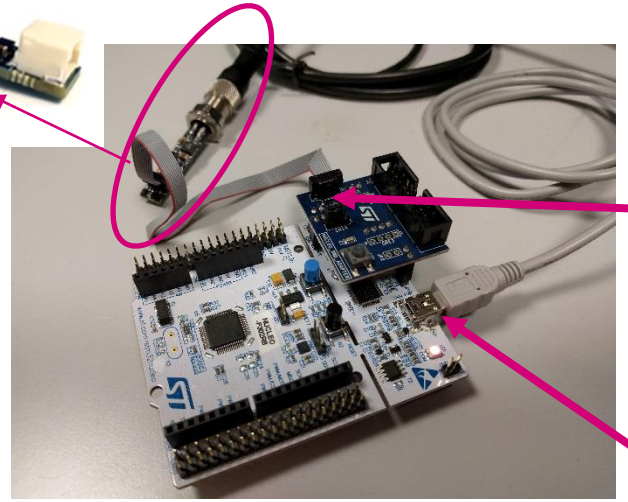
Remove all short cap jumpers from the STM32-NUCLEO





2

Plug the STEVAL-UKI001V1 on the STM32-NUCLEO respecting the CNx ref.

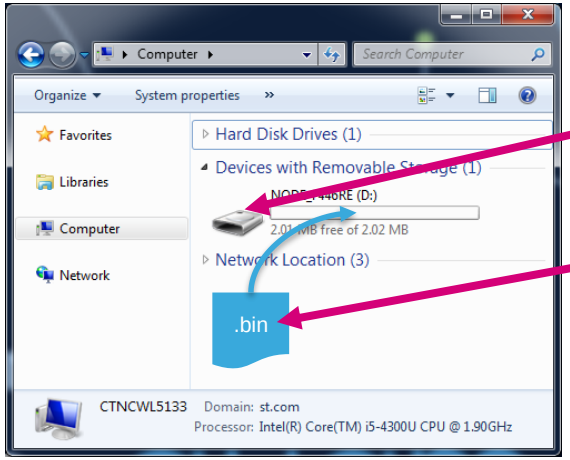


3

Programming steps:

a. Connect the application board to the ST-LINK/V2-1 via the 10-pin flat cable plugged on J2 (on the STEVAL-UKI001V1), then power-on.

b. Connect the ST-LINK/V2-1 with a PC via an USB cable plugged on CN1.



4

c. The ST-LINK/V2-1 will be recognized as a removable storage.

d. To download the firmware, simply drag the .bin file onto it.

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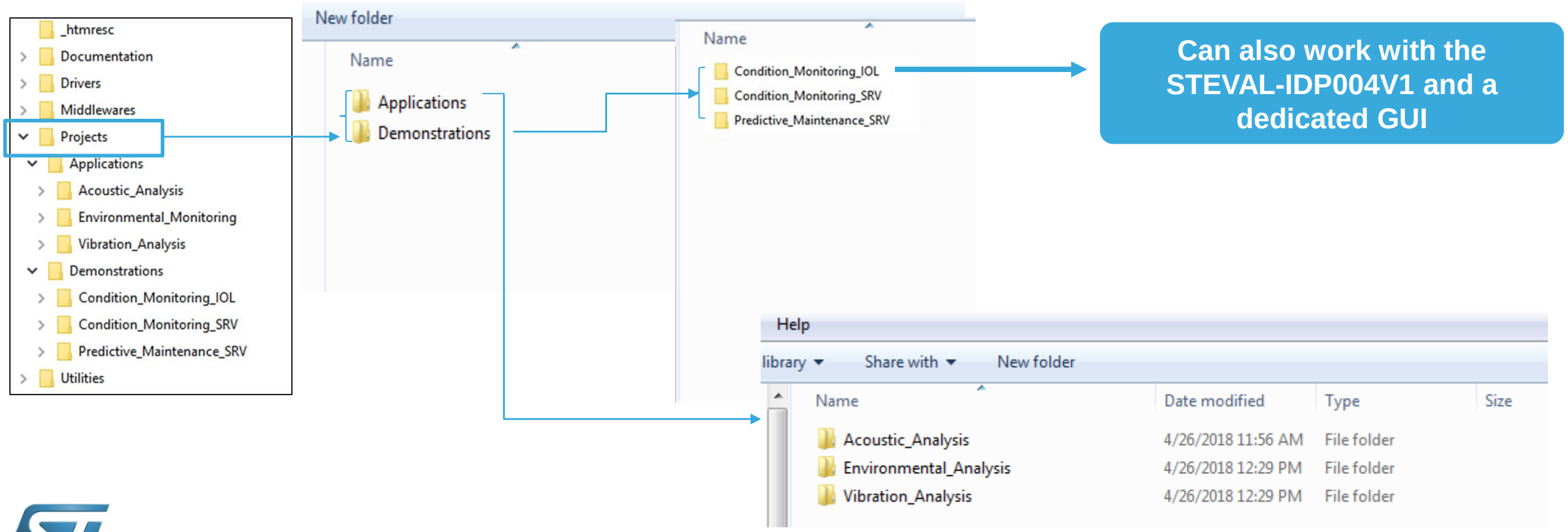
Data Monitoring / Logging

STSW-BFA001V1

Firmware architecture

The STEVAL-IDP005V1 offers applications and examples as detailed below. All projects allow data monitoring through serial terminal with board connected to PC.



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STEVAL-IDP005V1 Data Monitoring

STEVAL-IDP005V1 sensor and analysis data can be displayed on a PC in two ways

Terminal emulator
(TeraTerm or others freely available)

```
UART Initialized

STMicroelectronics
        STEVAL-BFA001V1
        Demostration - Condition Monitoring by SRV UART
        Version: 1.1.0

STM32F4xx Libraries & IDE informations:
        (HAL 1.7.4_0)
        Compiled Feb 22 2019 12:49:08 (IAR)

        Board                   STEVAL-IDP005V1

        STM32 MCU ID            0x393832383035511700280030
        STM32 MCU SYSCLK        180.00 MHz
        STM32 MCU HCLK          180.00 MHz
        STM32 MCU PCLK1         45.00 MHz
        STM32 MCU PCLK2         90.00 MHz


STEVAL-IDP005V1 device infos:
        ISM330DLC used
        OK Accelero Sensor
        OK Gyroscope Sensor
        OK Temperature and Humidity Sensor
        OK Temperature and Pressure Sensor
        Enabled Accelero Sensor
        Enabled Gyroscope Sensor
        Enabled Temperature     (Sensor1)
        Enabled Humidity        (Sensor1)
        Enabled Temperature     (Sensor2)
        Enabled Pressure        (Sensor2)


Starting project
        Set Accelerometer & Vibration Parameters
```

or

GUI to be used through the STEVAL-IDP004V1 (multiport Master board)

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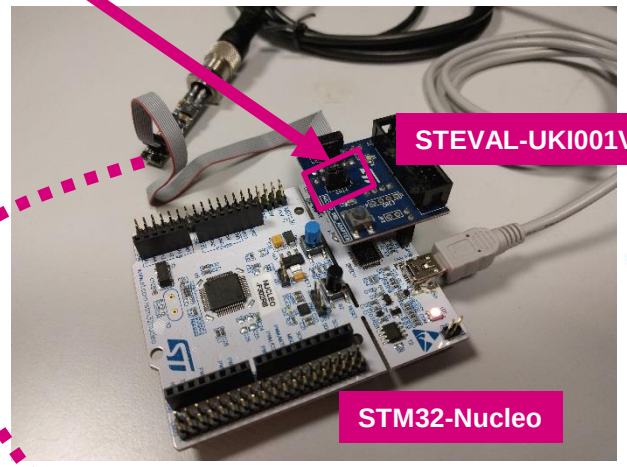
STEVAL-IDP005V1 Data Monitoring

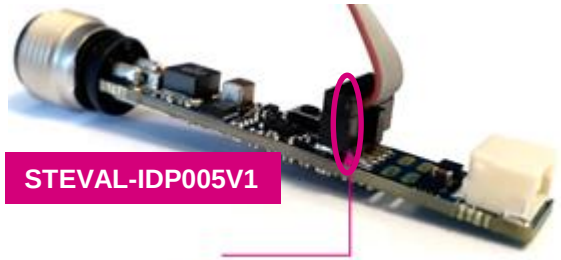
Setup the terminal emulator

1

Plug the STEVAL-UKI001V1 on the STM32-NUCLEO, then connect to the STEVAL-IDP005V1

CN15: closed
CN14: 2-3 position





2

Open the terminal emulator

Terminal emulator settings

- **Name: COM Port name**
- **Baud Rate: 230400**
- **Data:8**
- **Parity: None**
- **Stop Bit: One**
- **Flow Control: None**

3

Push the Reset button on the STEVAL-UKI001V1 (or STEVAL-IDP005V1)

```
**********************************************************
*   Accelerometer & Vibration DEFAULT parameters         *
**********************************************************

Accelerometer parameters are:
HpfCut =3       Acc_Odr=6660    FifoOdr=6660    Acc_Fs =2

MotionSP parameters are:
size=2048       tau=50  wind=1  tdtype=0        tacq=5000

Change the parameters? [y/n]
y
```

Insert the new parameters or press ENTER

4

5

Press Y to start monitoring

```
y
ISM330DLC (Accelerometer): Initialized Ena
ISM330DLC (Accelerometer): real ODR 6645.0


Time Domain Data ***
     Speed [mm/s]       |    RMS(tau1) [mm/s]    |    RMS(tau2) [mm/s]    |
|   X   |   Y   |   Z   |   X   |   Y   |   Z   |   X   |   Y   |   Z   |
| -0.015| -0.053| -0.002|  0.028|  0.101|  0.126|  0.027|  0.099|  0.126|
| -0.033|  0.214|  0.211|  0.026|  0.111|  0.131|  0.025|  0.108|  0.130|
| -0.013|  0.174|  0.224|  0.027|  0.149|  0.156|  0.027|  0.143|  0.152|
|  0.013|  0.142|  0.224|  0.025|  0.149|  0.170|  0.025|  0.144|  0.165|
|  0.002|  0.080|  0.057|  0.024|  0.145|  0.170|  0.024|  0.142|  0.166|
```

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STEVAL-IDP005V1 Data Monitoring

Parameter Configuration Details

```
UART Initialized

STMicroelectronics
        STEVAL-BFA001V1:
        Application - Vibration Analysis
        Version 1.1.0


STM32F4xx Libraries & IDE informations
        (HAL 1.7.4_0)
        Compiled Feb 26 2019 11:33:13 (IAR)

        Board                   STEVAL-IDP005V1

        STM32 MCU ID            0x393832383035511700 4A002E
        STM32 MCU SYSCLK        180.00 MHz
        STM32 MCU HCLK          180.00 MHz
        STM32 MCU PCLK1         45.00 MHz
        STM32 MCU PCLK2         90.00 MHz

SPI initialized
MEMS initializations
        ISM330DLC used
        OK Accelero Sensor
        OK Gyroscope Sensor
        Enabled Accelero Sensor
        Enabled Gyroscope Sensor

Starting project

        Set Accelerometer & Vibration Parameters


        ****************************************************
        *   Accelerometer & Vibration DEFAULT parameters   *
        ****************************************************

        Accelerometer parameters are:
        HpfCut =3       Acc_Odr=6660    FifoOdr=6660    Acc_Fs =2

        MotionSP parameters are:
        size=2048       tau=50  wind=1  tdtype=0        tacq=5000
Change the parameters? [y/n]
```

STEVAL-IDP005V1 allows data monitoring using the service UART

The CM application allows data plot and vibration parameters setting (only selected parameters can be changed)

Odr -> Accelerometer ODR in Hz
fs-> accelerometer full scale in g
Hpf -> accelerometer high pass filter
- 0 - HPF_ODR_DIV_4:
- 1 - HPF_ODR_DIV_100:
- 2 - HPF_ODR_DIV_9:
- 3 - HPF_ODR_DIV_400:

Size -> FFT size (256, 512, 1024, 2048)
ovl -> fft overlapping in % (5 ÷ 95)
Tacq -> acquisition time in ms (0.5 ÷ 60000)
Tau -> time constant for RMS in ms
(25,50,100,150,250,500,1000,1500,2000)
Subrng-> 8, 16, 32, 64 number of spectral subrange
Wind-> 0 (Hanning)
1 (Hamming)
2 (Flat Top)
Tdtype -> 0 Speed RMS
1 Acc RMS
2 Acc RMS and Speed RMS

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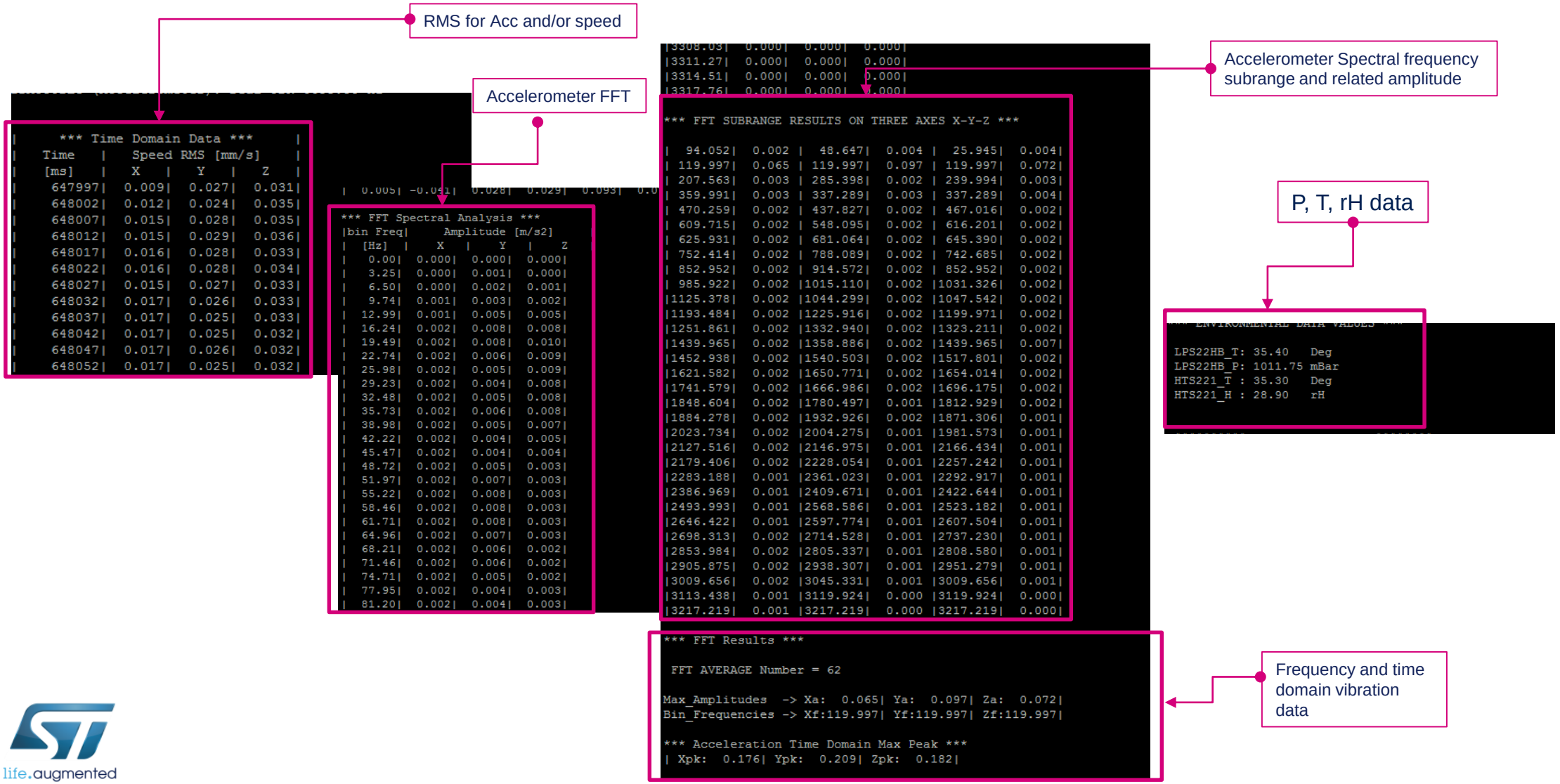
STEVAL-IDP005V1 Data Monitoring

Data Details (1/3)



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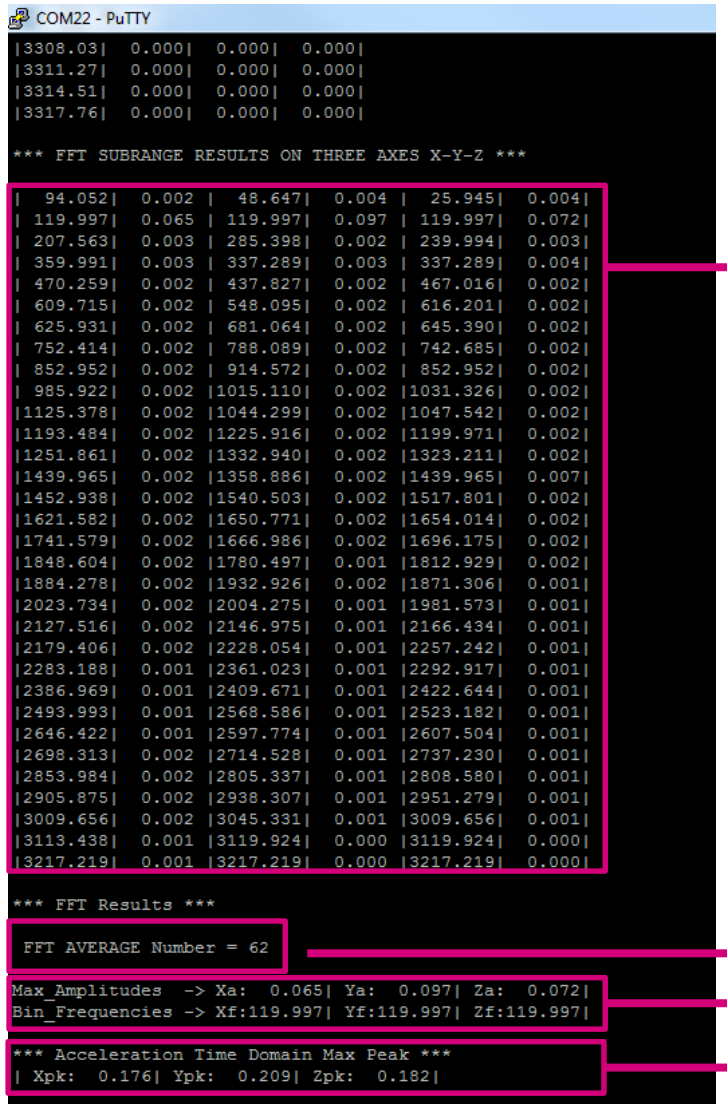
STEVAL-IDP005V1 Data Monitoring

Data Details 2/3



Frequency and max amplitude in subrange on 3 Accelerometer axis

FFT Averaging number. It is a fuction of overlapping and acquisition time

Max amplitude at related frequency

Acc peak on 3 axis

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STEVAL-IDP005V1 Data Monitoring

Data Details 3/3

The displayed data can be saved and plotted on an external program (i.e. Excel)
For example, the FFT spectral analysis.

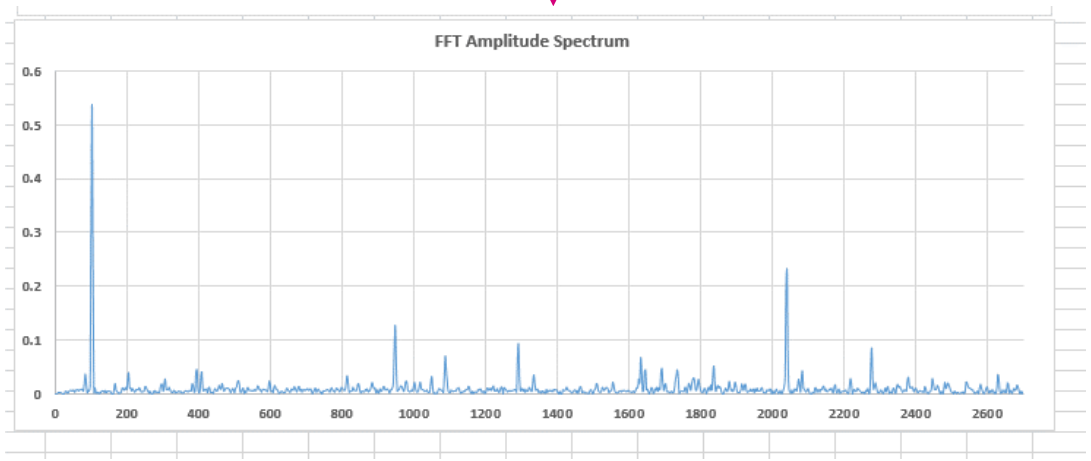
COM22 - PuTTY

```
|   0.027|   0.025| -0.029|   0.031|   0.113|   0.094|   0.045|   0.206|   0.209|
|  -0.038|   0.019| -0.026|   0.031|   0.108|   0.091|   0.045|   0.205|   0.209|
|   0.037|   0.100| -0.107|   0.030|   0.106|   0.090|   0.045|   0.205|   0.208|
|   0.001|   0.096| -0.061|   0.030|   0.106|   0.091|   0.045|   0.205|   0.208|
|   0.047|   0.034| -0.067|   0.030|   0.103|   0.088|   0.045|   0.204|   0.207|
|  -0.016|  -0.069| -0.003|   0.029|   0.100|   0.085|   0.045|   0.204|   0.207|
|   0.032|   0.048| -0.029|   0.029|   0.097|   0.082|   0.045|   0.203|   0.207|
|  -0.034|   0.079|  0.007|   0.028|   0.096|   0.079|   0.045|   0.203|   0.206|
|   0.005|  -0.041|  0.028|   0.029|   0.093|   0.076|   0.045|   0.203|   0.206|

*** FFT Spectral Analysis ***
|bin Freq|     Amplitude [m/s2]      |
|  [Hz]  |    X    |    Y    |    Z   |
|    0.00|   0.000|   0.000|   0.000|
|    3.25|   0.000|   0.001|   0.000|
|    6.50|   0.000|   0.002|   0.001|
|    9.74|   0.001|   0.003|   0.002|
|   12.99|   0.001|   0.005|   0.005|
|   16.24|   0.002|   0.008|   0.008|
|   19.49|   0.002|   0.008|   0.010|
|   22.74|   0.002|   0.006|   0.009|
|   25.98|   0.002|   0.005|   0.009|
|   29.23|   0.002|   0.004|   0.008|
|   32.48|   0.002|   0.005|   0.008|
|   35.73|   0.002|   0.006|   0.008|
|   38.98|   0.002|   0.005|   0.007|
|   42.22|   0.002|   0.004|   0.005|
|   45.47|   0.002|   0.004|   0.004|
|   48.72|   0.002|   0.005|   0.003|
|   51.97|   0.002|   0.007|   0.003|
|   55.22|   0.002|   0.008|   0.003|
|   58.46|   0.002|   0.008|   0.003|
|   61.71|   0.002|   0.008|   0.003|
|   64.96|   0.002|   0.007|   0.003|
|   68.21|   0.002|   0.006|   0.002|
|   71.46|   0.002|   0.006|   0.002|
|   74.71|   0.002|   0.005|   0.002|
|   77.95|   0.002|   0.004|   0.003|
```

Save log and

plot on .xls format



One axis accelerometer FFT

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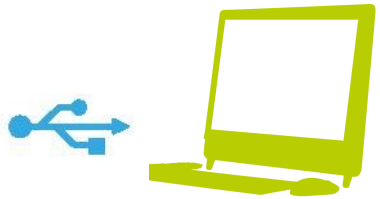
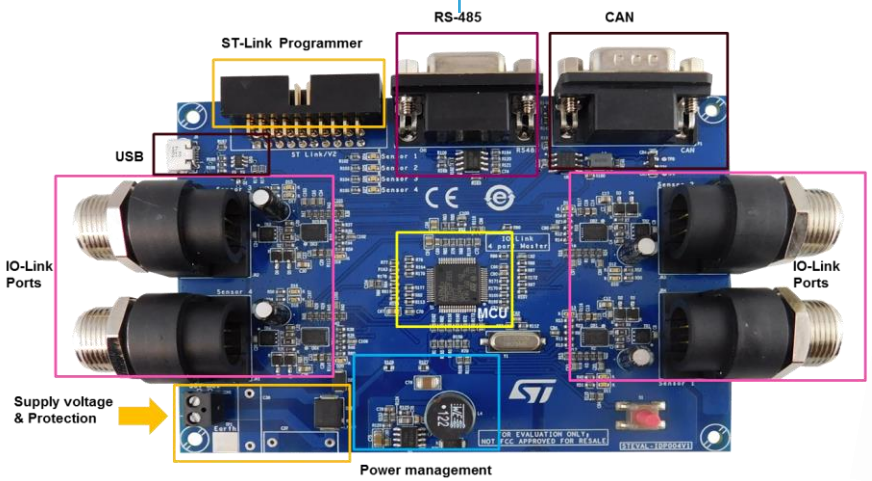
Dedicated GUI through STEVAL-IDP004V1

STEVAL-IDP005V1 communication based on Master Board

Adapter RS-485 / USB
Optional USB





STEVAL-IDP004V1
STSW-IO-LINK Firmware package

Axel spectrum

Axel Peak

Speed RMS

P, T, H parameters

STEVAL-IDP005V1

Download the *condition monitoring_iol* firmware from the STSW-BFA001V1 Demonstration folder

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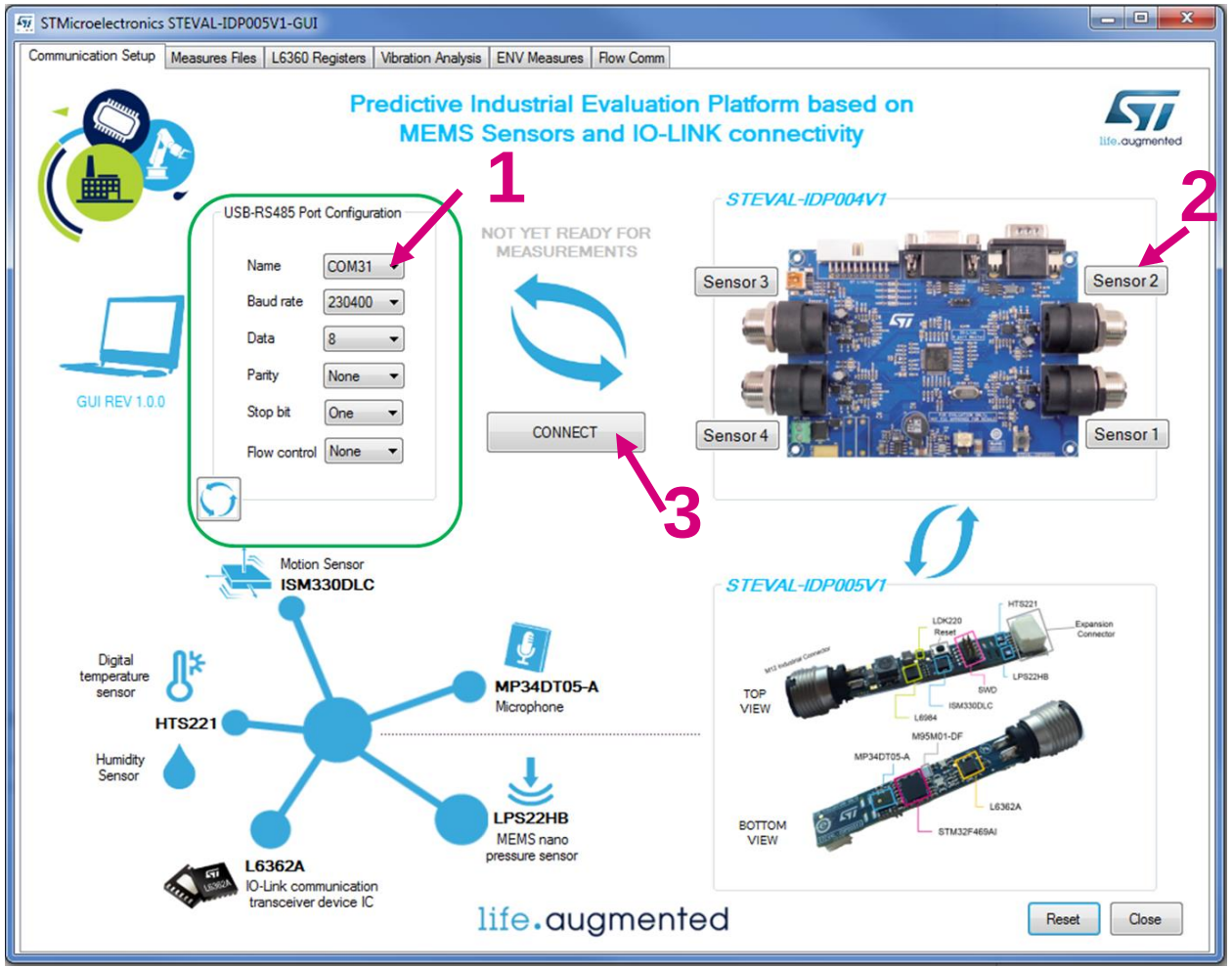
STEVAL-IDP005V1 GUI

How to connect one or more nodes

Install the GUI from setup included in .\STSW-BFA001V1\Utilities folder



The GUI is included in the STSW-BFA001V1 utilities folder.

Once installed please follow:

1. Select the right COM
2. Select the port (more nodes can be connected)
3. Click on connect and wait for connection

STEVAL-IDP005V1 GUI

Vibration Analysis

Frequency domain parameters

Time domain parameters

Plot related to nodes 2 and 3 in this example

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STEVAL-IDP005V1 GUI

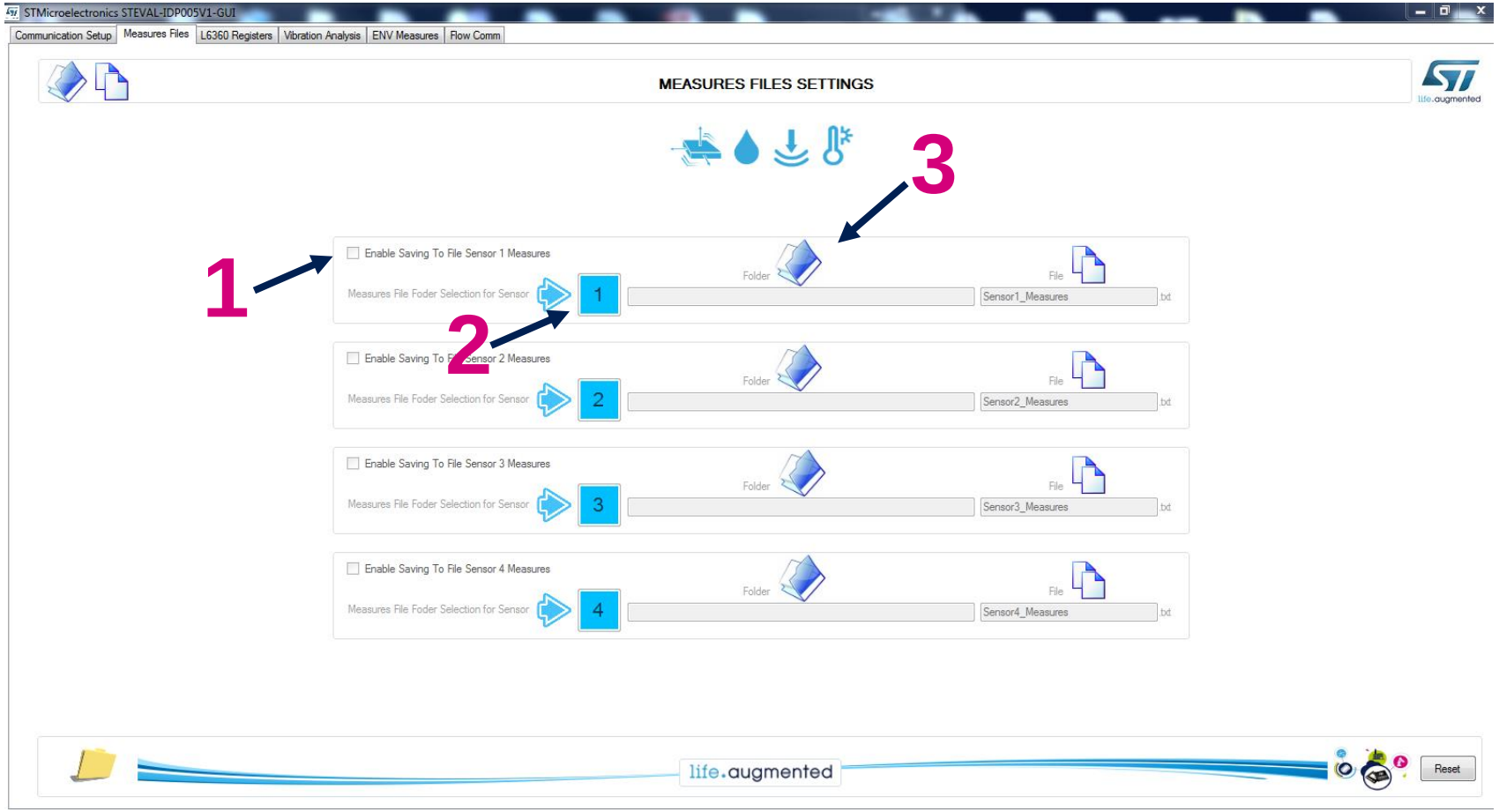
Environmental Monitoring

- Pressure
- Relative Humidity
- Temperature

Nodes 2 and 3 in this example

STEVAL-IDP005V1 GUI

Save data log



1. Check the box “ Enable Saving To File Sensor X Measures”

2. Click the related square blue button

3. Select the folder path where to store the file, and choose the file name

How to enable Predictive Maintenance

Predictive Maintenance Demonstration FW

The Predictive Maintenance demonstration project (PredMaint_SVR), inside STSW-BFA001V1\Projects\Demonstrations\Predictive_Maintenance folder, allows programmable vibration thresholds and outputs motor status details coming from **time** and **frequency vibration analysis**.

The motor status are:

- ***Good***
- ***Warning***
- ***Alarm***

PC connection through service UART

Time domain

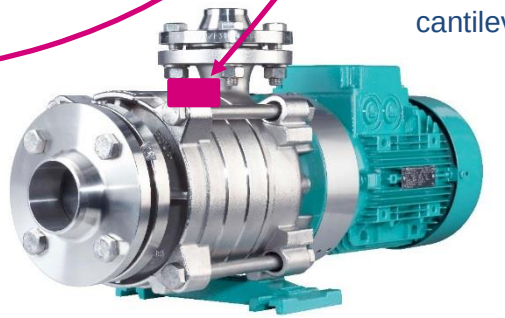
```
*** TIME DOMAIN SPEED RMS THRESHOLDS STATUS X-Y-Z

|   GOOD   |   GOOD   |   GOOD   |
|  0.325   |  2.649   |  0.597   |

*** TIME DOMAIN ACC PEAK THRESHOLDS STATUS X-Y-Z

|   GOOD   |  ALARM   |  ALARM   |
|  3.144   | 17.187   |  7.279   |
```

Frequency domain

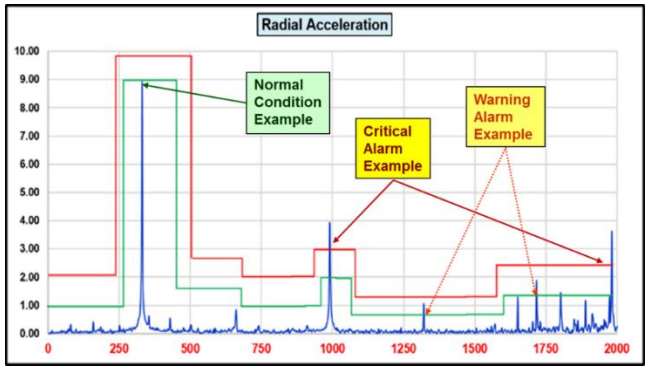
```
*** FREQUENCY DOMAIN THRESHOLDS STATUS ON SUBRANGE vs X-Y-Z ***

|      GOOD      |      GOOD      |      GOOD      |
|  64.81  |  0.053  |  29.17  |  0.373  |  45.37  |  0.076  |

|      GOOD      |      GOOD      |      GOOD      |
| 777.77  |  0.010  | 567.13  |  0.031  | 576.85  |  0.016  |

|      GOOD      |      GOOD      |      GOOD      |
| 891.20  |  0.010  | 884.72  |  0.028  | 936.57  |  0.015  |

|      GOOD      |      GOOD      |      GOOD      |
|1529.62  |  0.005  |1335.18  |  0.011  |1442.12  |  0.018  |

|      GOOD      |      GOOD      |      GOOD      |
|1769.43  |  0.004  |1892.58  |  0.005  |1659.25  |  0.008  |

|      GOOD      |      GOOD      |      GOOD      |
|2446.75  |  0.003  |2449.99  |  0.002  |2099.99  |  0.002  |

|      GOOD      |      GOOD      |      GOOD      |
|2748.13  |  0.003  |2874.52  |  0.002  |2495.36  |  0.002  |

|      GOOD      |      GOOD      |      GOOD      |
|2903.69  |  0.003  |3030.08  |  0.002  |2910.17  |  0.001  |

|################## TIME DOMAIN STATUS ##################

|     ----------->  ALARM <-----------      |

|################## FREQUENCY DOMAIN STATUS ##############

|     ----------->  GOOD  <-----------      |

|################### Next Measurement ###################
```

General motor status

Supply voltage
18..32 V



Fix STEVAL-IDP005V1 very close to equipment. It is recommended not use cantilever board fixing.



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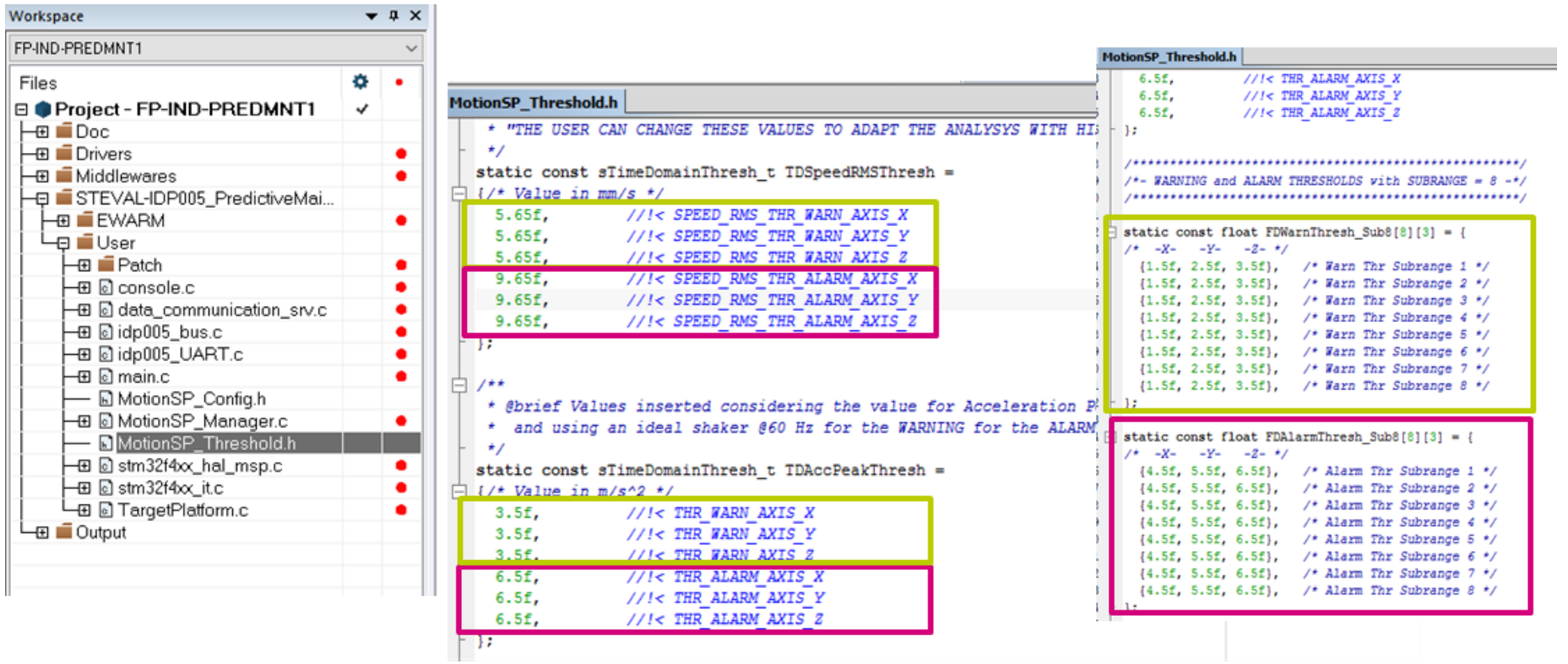
Predictive Maintenance Demonstration FW

Threshold settings

User can modify the alarm and warning thresholds for Speed RMS, Acc peak and spectral band. It is done in precompiling phase on ***MotionSP_Threshold.h*** file. Spectral band can be subdivided in 8, 16, 32 or 64 subrange.

*Open the PredMaint_SVR project from **STSW-BFA001V1\Projects\Demonstrations\Predictive_Maintenance_SRV folder****



(*) to change thresholds and recompile firmware it is necessary install one of the supported IDEs

Predictive Maintenance Demonstration FW

Terminal Emulator Data Output

PC Data output displayed are detailed below:

Time domain Motor Status details for each axis

```
*** TIME DOMAIN SPEED RMS THRESHOLDS STATUS X-Y-Z ***
|   GOOD    |   GOOD    |   GOOD    |
|   0.325   |   2.649   |   0.597   |
*** TIME DOMAIN ACC PEAK THRESHOLDS STATUS X-Y-Z ***
|   GOOD    |   ALARM   |   ALARM   |
|   3.144   |  17.187   |   7.279   |
```

Status on spectral band for each axis in 8 subranges

```
*** FREQUENCY DOMAIN THRESHOLDS STATUS ON SUBRANGE vs X-Y-Z ***
|       GOOD        |       GOOD        |       GOOD        |
|  64.81   |   0.053 |  29.17  |   0.373 |  45.37  |   0.076 |
|       GOOD        |       GOOD        |       GOOD        |
| 777.77   |   0.010 | 567.13  |   0.031 | 576.85  |   0.016 |
|       GOOD        |       GOOD        |       GOOD        |
| 891.20   |   0.010 | 884.72  |   0.028 | 936.57  |   0.015 |
|       GOOD        |       GOOD        |       GOOD        |
|1529.62   |   0.005 |1335.18  |   0.011 |1442.12  |   0.018 |
|       GOOD        |       GOOD        |       GOOD        |
|1769.43   |   0.004 |1892.58  |   0.005 |1659.25  |   0.008 |
|       GOOD        |       GOOD        |       GOOD        |
|2446.75   |   0.003 |2449.99  |   0.002 |2099.99  |   0.002 |
|       GOOD        |       GOOD        |       GOOD        |
|2748.13   |   0.003 |2874.52  |   0.002 |2495.36  |   0.002 |
|       GOOD        |       GOOD        |       GOOD        |
|2903.69   |   0.003 |3030.08  |   0.002 |2910.17  |   0.001 |
|################## TIME DOMAIN STATUS ###################
|     ----------->  ALARM <-----------      |
|################## FREQUENCY DOMAIN STATUS ##############
|     ----------->  GOOD  <-----------      |
|#################### Next Measurement ####################
```

General Motor Status in Time and in Frequency domain

Thank you

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