


# STMicroelectronics UM3239 Motion Mems and Environmental Sensor Expansion Board User Manual

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**UM3239**

**User manual**

**Getting started with the X-NUCLEO-IKS4A1 motion  
MEMS and environmental  
sensor expansion board for STM32 Nucleo**

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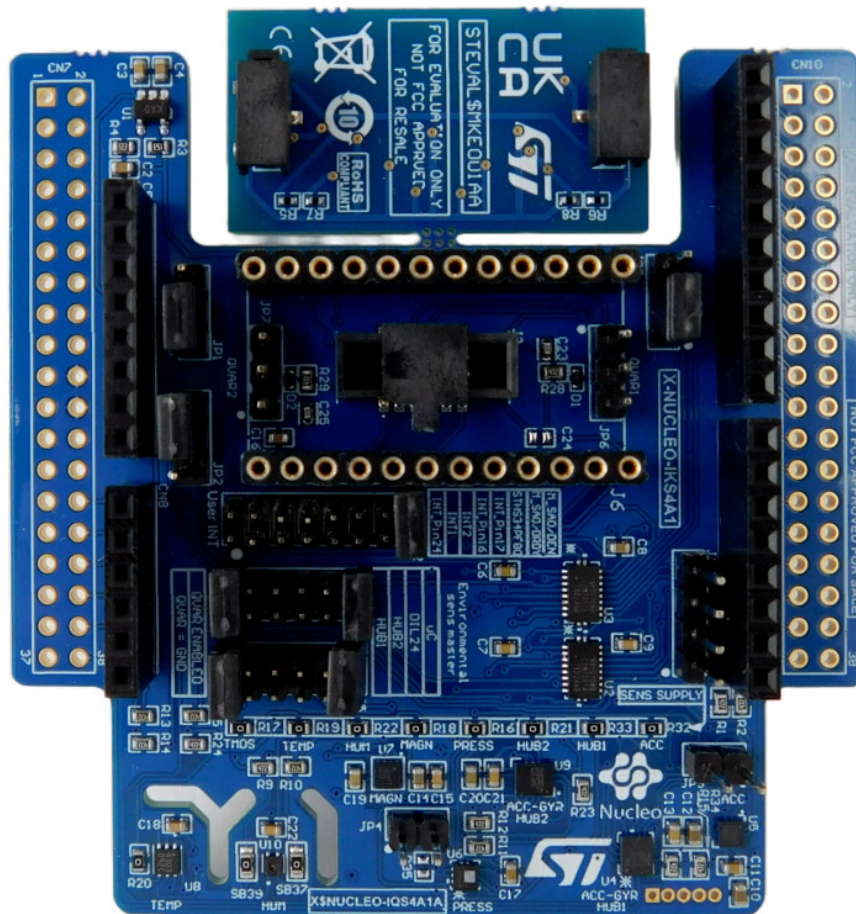
## Introduction

The X-NUCLEO-IKS4A1 is a motion MEMS and environmental sensor evaluation board kit consisting of the main board XNUCLEO-IQS4A1, which hosts the motion MEMS and environmental sensors, and the detachable add-on board STEVALMKE001A, which hosts the Qvar swipe electrodes.

It is compatible with the Arduino UNO R3 connector layout and features the LSM6DSO16IS and LSM6DSV16X MEMS 3D accelerometers, the LIS2MDL 3-axis magnetometer, the LIS2DUXS12 3-axis accelerometer, the LPS22DF MEMS pressure sensor, the SHT40AD1B humidity and temperature sensor, and the STTS22H temperature sensor.

The X-NUCLEO-IKS4A1 interfaces with the STM32 microcontroller via the I<sup>2</sup>C pin or, for external sensors mounted on DIL24 adaptor, SPI Pins.

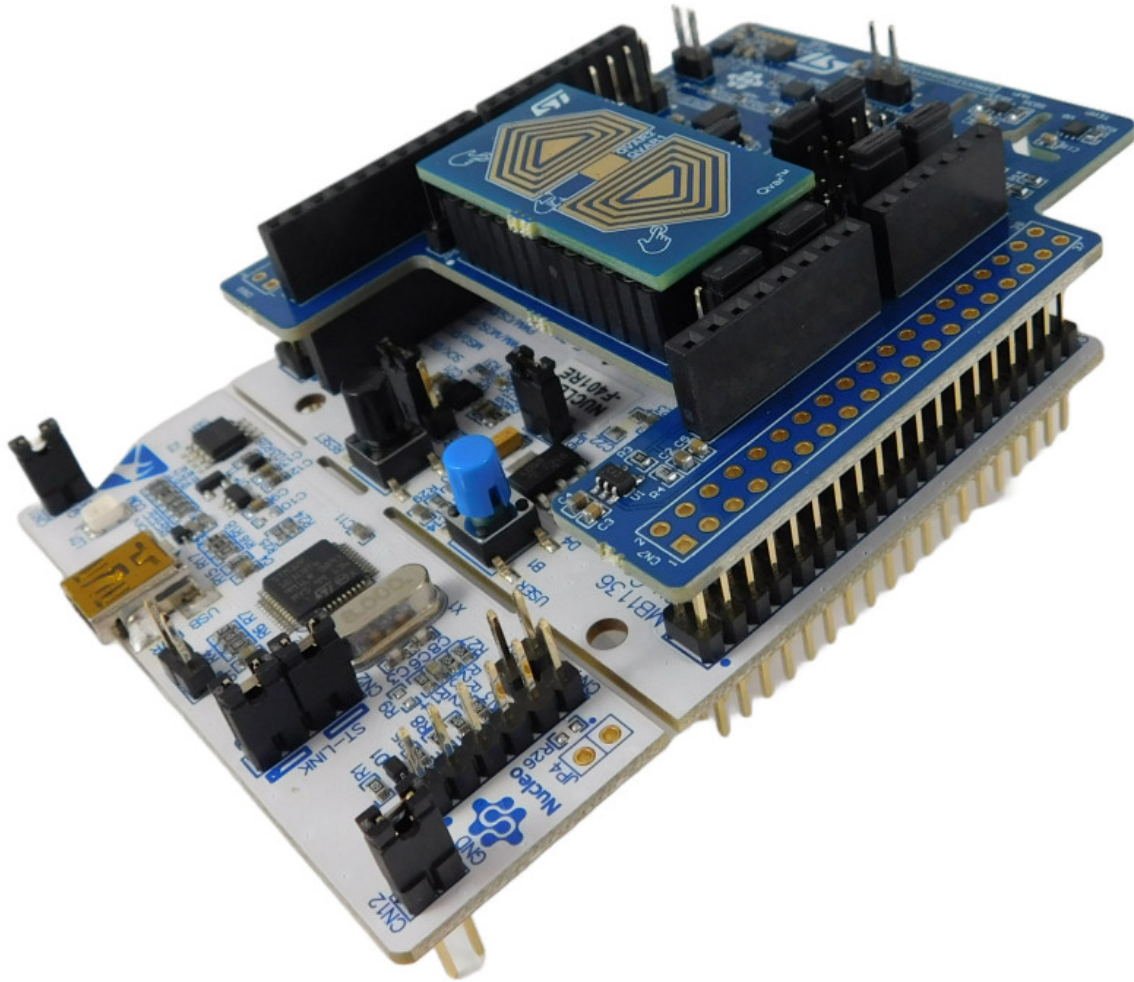
**Figure 1. X-NUCLEO-IKS4A1 expansion board**



## Getting started

### 1.1 Hardware requirements

The X-NUCLEO-IKS4A1 is designed to be used with STM32 Nucleo boards (visit [www.st.com](http://www.st.com) for further information).



The X-NUCLEO-IKS4A1 must be connected on the matching pins of any STM32 Nucleo board with the Arduino UNO R3 connector.

X-NUCLEO-IKS4A1 components are ESD sensitive and, as the board has male/female pass-through connectors, it is important to handle it with care to avoid bending or damaging the pins.

## System requirements

To complete the system setup, you need:

- a Windows® (7, 8, 10) PC
- a USB type A to mini-B USB cable to connect the STM32 Nucleo to the PC
- board firmware and software package (X-CUBE-MEMS1) installed on the user PC

## Hardware description

The board lets you test the functionality of the motion MEMS accelerometer, gyroscope and magnetometer, and environmental humidity, temperature and pressure sensors, via the I<sup>2</sup>C communication bus.

It also allows complete testing of all LSM6DSO16IS and LSM6DSV16X functionalities and Qvar touch and swipe gestures. There is also the possibility to attach the STHS34PF80 IR sensor to enable presence and motion detection applications.

The board features:

- LSM6DSO16IS: MEMS 3D accelerometer ( $\pm 2/\pm 4/\pm 8/\pm 16$  g) + 3D gyroscope ( $\pm 125/\pm 250/\pm 500/\pm 1000/\pm 2000$  dps) with ISPU (Intelligent Processing Unit)
- LIS2MDL: MEMS 3D magnetometer ( $\pm 50$  gauss)

- LIS2DUXS12: ultralow power MEMS 3D accelerometer ( $\pm 2/\pm 4/\pm 8/\pm 16$  g) with Qvar, AI, & anti-aliasing
- LPS22DF: Low-power and high-precision MEMS pressure sensor, 260-1260 hPa absolute digital output barometer
- SHT40AD1B
- STTS22H: Low-voltage, ultralow power, 0.5 °C accuracy temperature sensor (-40°C to +125°C)
- LSM6DSV16X: MEMS 3D accelerometer ( $\pm 2/\pm 4/\pm 8/\pm 16$  g) + 3D gyroscope ( $\pm 125/\pm 250/\pm 500/\pm 1000/\pm 2000/\pm 4000$  dps) with embedded sensor fusion, AI, Qvar
- DIL 24-pin socket available for additional MEMS adapters and other sensors
- Free comprehensive development firmware library and example for all sensors compatible with STM32Cube firmware
- Equipped with Qvar touch/swipe electrode
- I<sup>2</sup>C sensor hub features on LSM6DSO and LSM6DSV16X available
- MIPI I3C® compatibility for communication with LIS2DUXS12, LSM6DSV16X and LPS22DF
- Compatible with STM32 Nucleo boards
- Equipped with Arduino UNO R3 connector
- Equipped with industrial connector for IR sensor (STHS34PF80) application development. It can be connected at the same time of external MEMS through DIL24 adapter
- Available interface for external camera module applications coupled with LIS2DUXS12 through aux SPI (3/4 w)
- RoHS compliant
- WEEE compliant
- UKCA compliant

Each device has a separate power supply to allow power consumption measurement of every sensor.

The expansion board is power supply compatible with STM32 Nucleo boards: it mounts an LDO to generate 1.8 V for all the MEMS sensors except for the external sensor mounted on DIL24 adapter, which can be supplied both from 1.8 V and 3.3 V (main supply from Nucleo board).

All signals between the sensors and the main board are translated by a level shifter.

#### **Default solder bridge configuration**

The user can configure several aspects of the X-NUCLEO-IKS4A1 through several solder bridges which can be left open (not mounted) or closed (mounted) to configure different hardware settings.

#### **Block diagram**

The LSM6DSO16IS and the LSM6DSV16X have an I<sup>2</sup>C sensor hub that allows them to behave as the I<sup>2</sup>C master for other slave devices connected via an I<sup>2</sup>Caux bus. Various bus configurations are possible to select the I<sup>2</sup>C master of the environmental/DIL24 sensors.

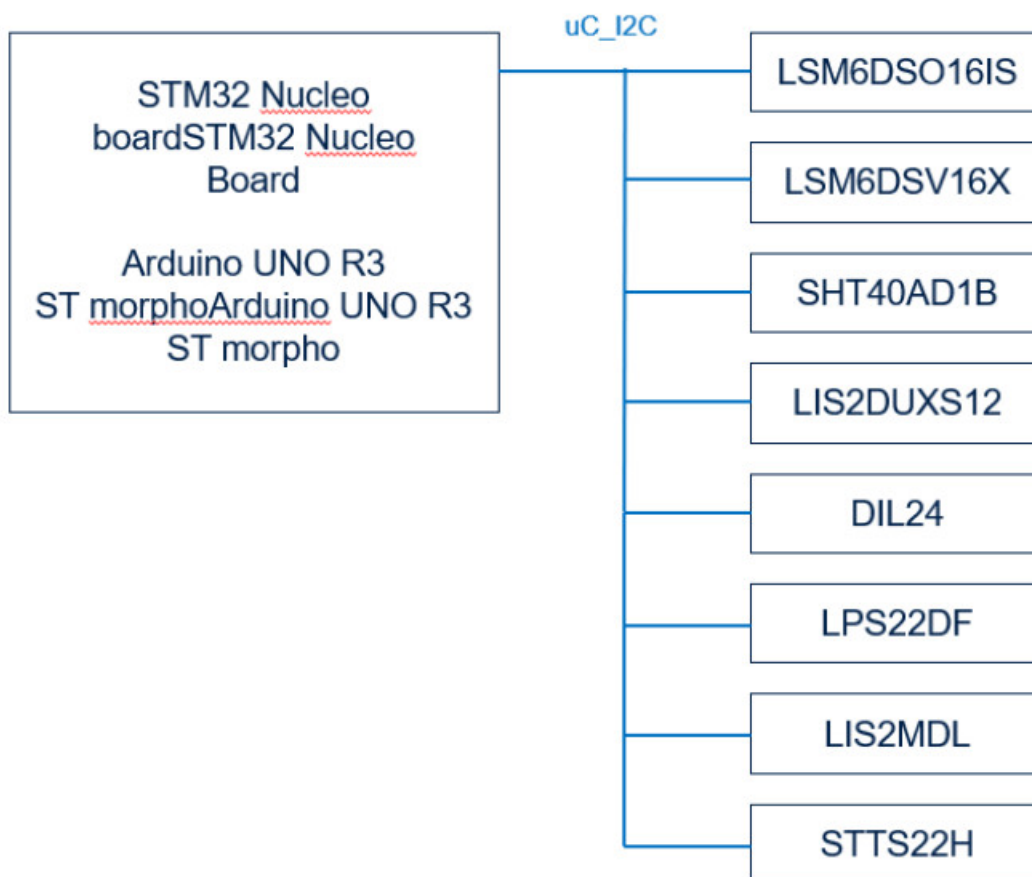
Mode 1: standard I<sup>2</sup>C bus connection (all sensors)

In standard I<sup>2</sup>C mode, all devices are connected to an external main board via the same I<sup>2</sup>C bus.

The board configuration is:

- J4: 1-2, 11-12 (STM\_SDA = SENS\_SDA, HUB\_SDx = GND)
- J5: 1-2, 11-12 (STM\_SCL = SENS\_SCL, HUB\_SCx = GND)

**Figure 3. X-NUCLEO-IKS4A1 standard I<sup>2</sup>C**

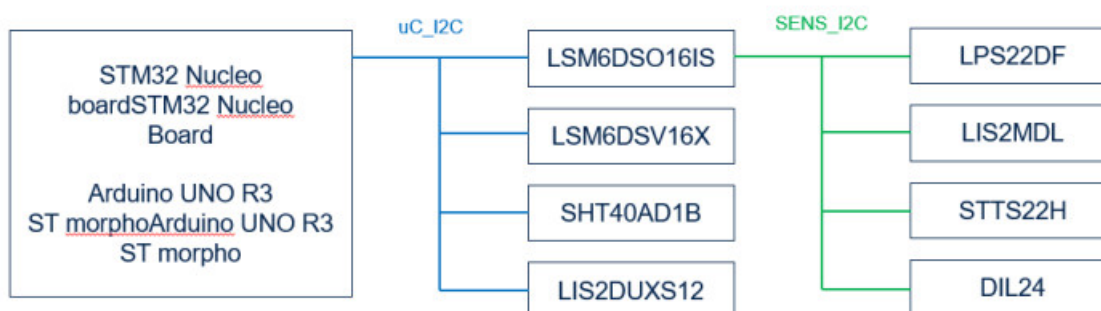


**Mode 2: LSM6DSO16IS I<sup>2</sup>C sensor hub (all sensors)**

In this sensor hub I<sup>2</sup>C mode, it is possible to power-up the 6-axes IMU (Inertial Measurement Unit) functionalities by collecting external data through a direct control of the on-board environmental sensors (temperature, pressure and magnetometer) and external sensor (DIL24) through the auxiliary I<sup>2</sup>Cz bus “SENS\_I2C”. LSM6DSV16X, LIS2DUXS12 and SHT40AD1B remains connected to the main bus “uC\_I2C” coming from the external board. The board configuration is:

- J4: 5-6 (HUB2\_SDx = SENS\_SDA)
- J5: 5-6 (HUB2\_SCx = SENS\_SCL)

**Figure 4. X-NUCLEO-IKS4A1 LSM6DSO16IS I<sup>2</sup>C sensor hub**



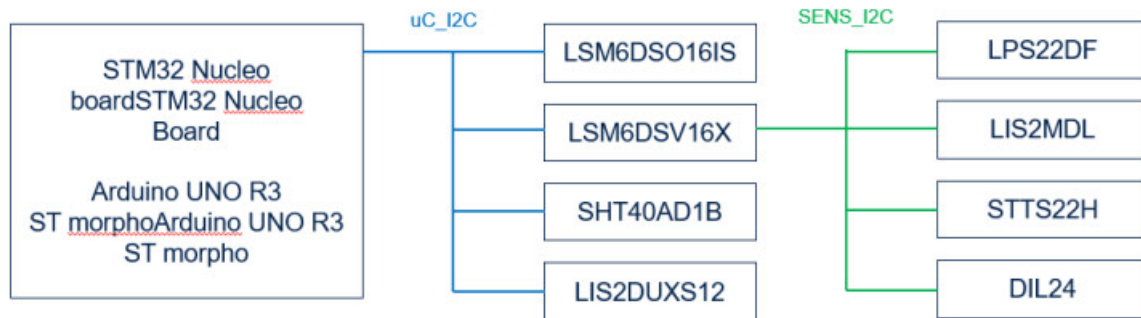
**Mode 3: LSM6DSV16X I<sup>2</sup>C sensor hub**

In this sensor hub, it is possible to power-up the 6-axes IMU (Inertial Measurement Unit) functionalities by collecting external data through a direct control of the on-board environmental sensors (temperature, pressure and magnetometer) and external sensor (DIL24) through the auxiliary I<sup>2</sup>C bus “SENS\_I2C”. LSM6DSO16IS, LIS2DUXS12 and SHT40AD1B remains connected to the main bus “uC\_I2C” coming from the external board. The board configuration is:



- J4: 7-8 (HUB1\_SDx = SENS\_SDA)
  - J5: 7-8 (HUB1\_SDx = SENS\_SDA)
- DIL24 adapter (to I<sup>2</sup>C2): SB16, SB21
- Not mounted: SB6, SB10, SB12, SB14, SB18, SB19, SB20, SB22

**Figure 5. LSM6DSV16X I<sup>2</sup>C sensor hub**



#### Mode 4: DIL24 I<sup>2</sup>C sensor hub (all sensors)

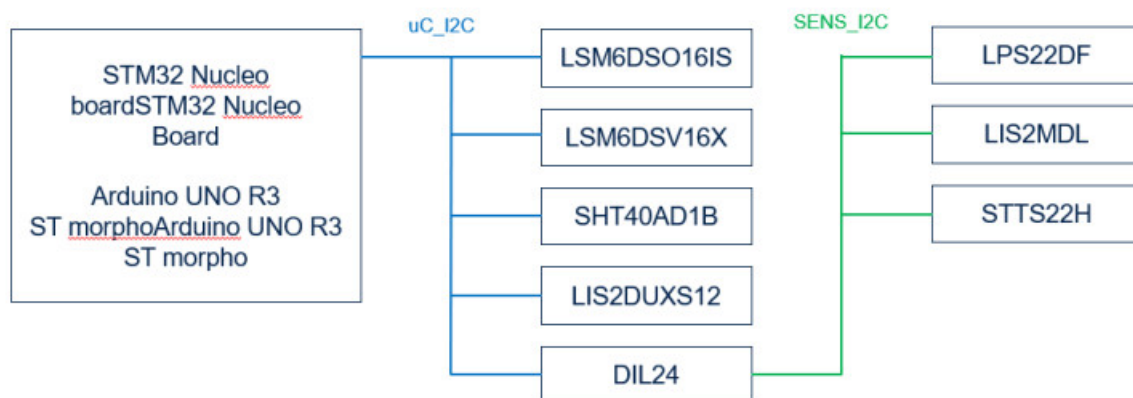
In case a sensor with sensor hub embedded functionality is mounted to the board through DIL24 adapter, it is possible to exploit this functionality as for LSM6DSO16IS and the LSM6DSV16X.

In this configuration, may be necessary to connect the DIL24 to the external board through SPI lines in order to avoid an address conflict on I<sup>2</sup>C bus with the LSM6DSO16IS and the LSM6DSV16X. This is done by changing the SBx configuration.

The board configuration is:

- J4: 9-10 (DIL\_SDx = SENS\_SDA)
- J5: 9-10 (DIL\_SDx = SENS\_SDA)

**Figure 6. X-NUCLEO-IKS4A1 DIL24, I<sup>2</sup>C sensor hub (all sensors)**



#### Mode 5: LSM6DSO16IS as Qvar controller

In this configuration, it is possible to use the equipped Qvar swipe electrode (by plugging it on JP6 and JP7 connectors) through the LSM6DSO16IS.

The board configuration is:

- J4: 3-4 (HUB1\_SDx = QVAR1)
- J5: 3-4 (HUB1\_Scx = QVAR2)

### 3.3 Sensor I<sup>2</sup>C address selection

Most sensors allow I<sup>2</sup>C address LSB selection by pulling the SD0 pin low or high. The board has solder bridges to

control SD0 level.

Table 1. Solder bridges for I<sup>2</sup>C address

Address in bold are the default I<sup>2</sup>C addresses

Sensor	SD0 low	SD0 high
STTS22H (U8)	ADD= 71h	
LIS2DUXS12 (U5)	SB19 ADD=31h	SB20 ADD=33h
LSM6DSO16IS (U9)	SB35 ADD=D5h	SB34 ADD=D7h
LPS22DF (U6)	SB31 ADD=B9h	SB29 ADD=BBh
LIS2MDL (U7)	ADD =3Ch	ADD =3Ch
SHT40AD1B (U10)	ADD= 89h	ADD= 89h
DIL24 Adapter (J1)	SB43/SB44	SB41/SB42
LSM6DSV16X (U4)	SB17 ADD=D5h	SB15 ADD=D7h

### 3.4 Sensor current consumption measurement

The X-NUCLEO-IKS4A1 expansion board is equipped with OR resistors that allow separate current consumption measurement for each sensor.

To measure current consumption, connect an ammeter to the appropriate pads.

As the sensors have very low current consumption, you should set a suitable range and use an ammeter with low burden voltage.

Table 2. Resistors/jumpers for current consumption measurement

Sensor	Resistor/jumper
LIS2MDL (U7)	R18
LSM6DSO16IS (U9)	R21
SHT40AD1B (U10)	R22
LIS2DUXS12 (U5)	R16
STTS22H (U8)	R19
LPS22DF (U6)	R32
DIL24 Adapter (J1)	JP5
LSM6DSV16X	R33

### 3.5 Sensor disconnection

To disconnect a sensor, you should disconnect the I<sup>2</sup>C bus as well as the power supply. See the table below for the relevant jumpers and solder bridges.

Table 3. Link between sensors, jumpers and I<sup>2</sup>C solder bridges

Sensor	SDA	SCL
LIS2MDL (U7)	SB30	SB26
LSM6DSO16IS (U9)	SB38	SB36
SHT40AD1B (U10)	SB39	SB37
LIS2DUXS12 (U5)	SB22	SB16
STTS22H (U8)	SB33	SB32
LPS22DF (U6)	SB28	SB25
DIL24 Adapter (J1)	SB47, SB49, SB48	SB51, SB53, SB52
LSM6DSV16X	SB21	SB18

### 3.6 Adapter board for DIL24 socket

An additional sensor can be connected as an adapter board to J6 DIL24 socket.

As there are a few different interrupt signal assignments for DIL24 pins, the appropriate pin can be selected using the J2 header.

Related links

Please visit the ST website to find other available sensors

### 3.7 Connectors

Table 4. Arduino R3 UNO connectors



Connector	Pie(1)	Signal
CN5	7	GND
	9	PC SDA
	10	PC SCL
CN6	2	3.3 V
	4	3.3 V
	6	GND
	7	GND
	8	N.C.[FT1]
CN8	3	LIS2MDL DRDY
	4	LIS2DUXS12 INT
	5	STTS22H INT
	6	LSM6DS0161S INT1
CN9	3	USER INT
	4	SPI CLK
	5	LSM6DSV16X INT2
	6	LSM6DSV16X INT1
	7	LPS22DF INT1
	8	LSM6DS0161S INT2

1. The unlisted pins are not connected.

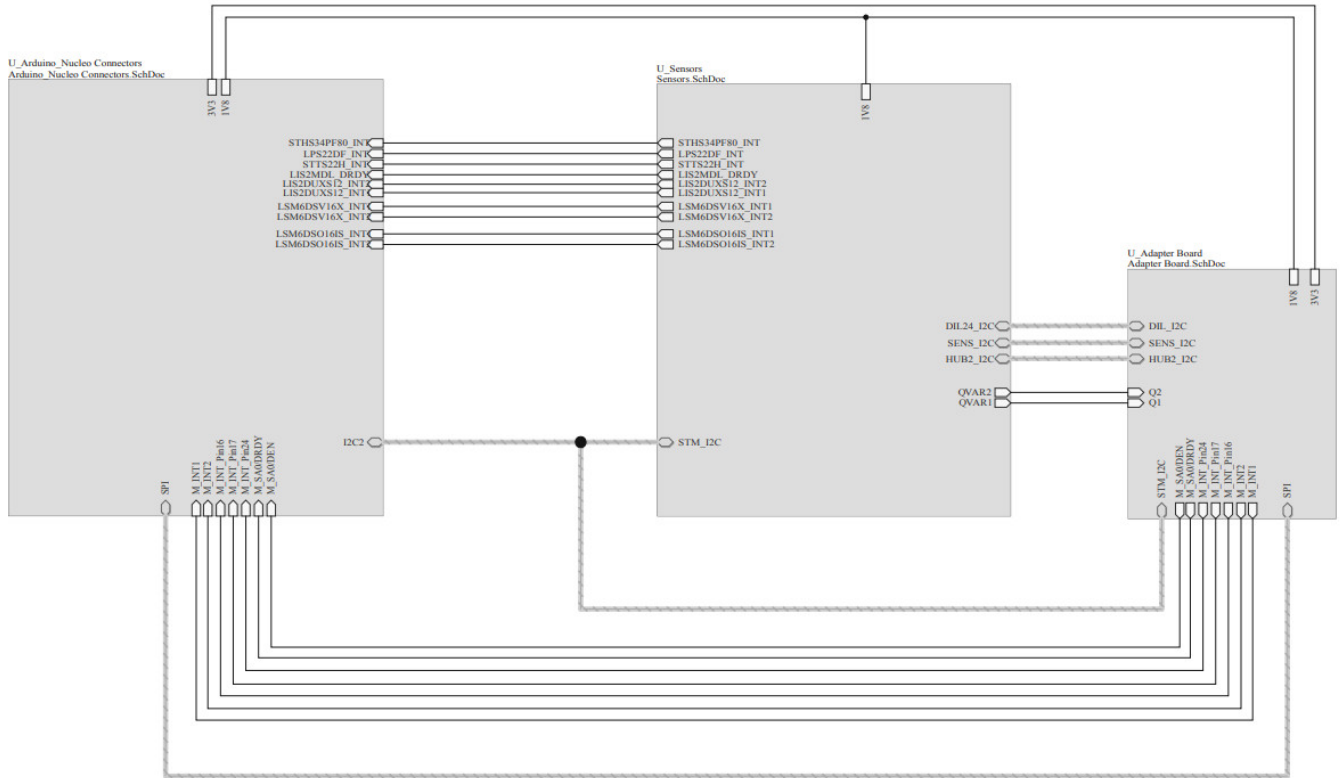
Table 5. ST morpho connectors

Connector	Pin(1)	Signal
CN7	12	3.3 V
	16	3.3 V
	20	GND
	22	GND
	32	LIS2MDL DRDY
	34	LIS2DUXS12 INT
	36	STTS22H INT
	38	LSM6DSO16IS INT1
CN10	3	I <sup>2</sup> C SCL
	5	I <sup>2</sup> C SDA
	23	LSM6DSO16IS INT2
	25	LPS22DF INT1
	27	LSM6DSV16X INT1
	29	LSM6DSV16X INT2
	31	SPI CLK
	33	USER INT

1. unlisted pins are not connected.

## Schematic diagrams

**Figure 7. X-NUCLEO-IKS4A1 circuit schematic (1 of 4)**



**Figure 8. X-NUCLEO-IKS4A1 circuit schematic (2 of 4)**

## Arduino & Morpho Connectors

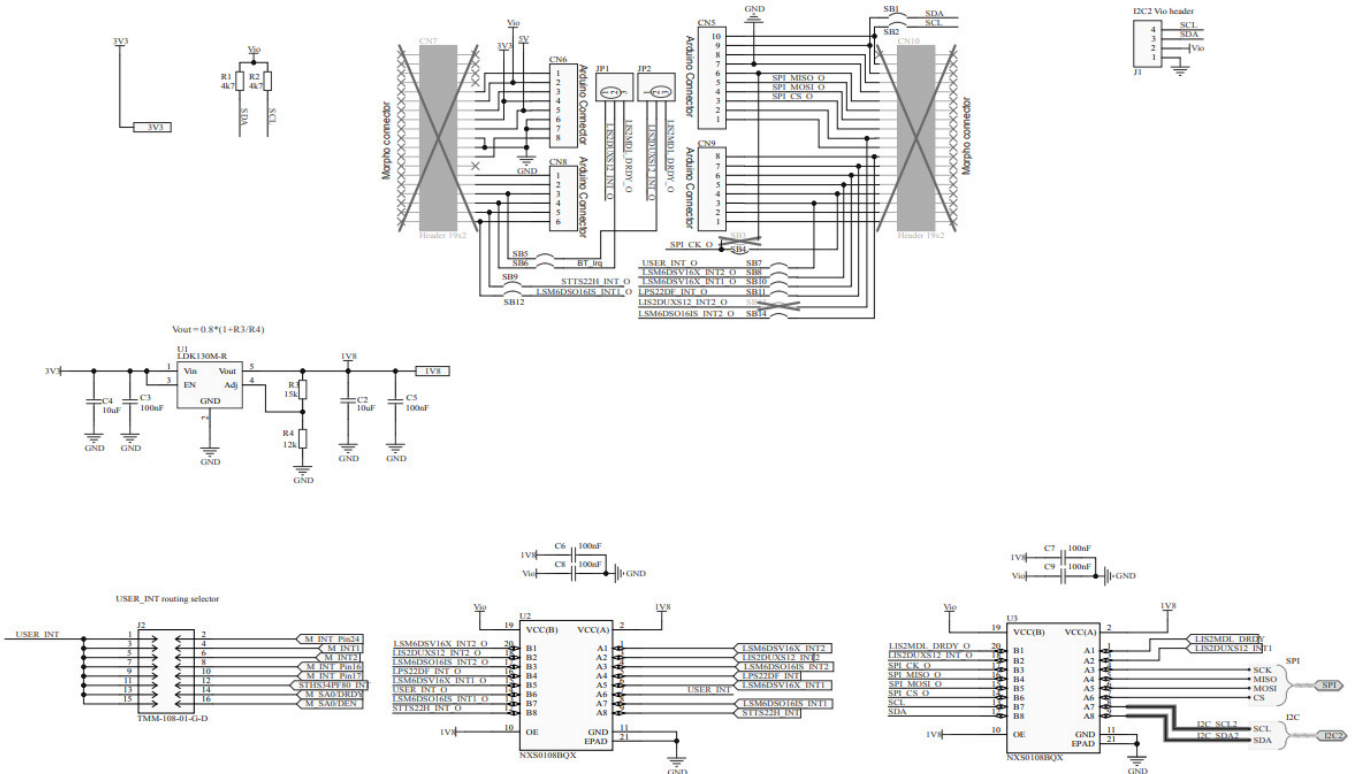


Figure 9. X-NUCLEO-IKS4A1 circuit schematic (3 of 4)

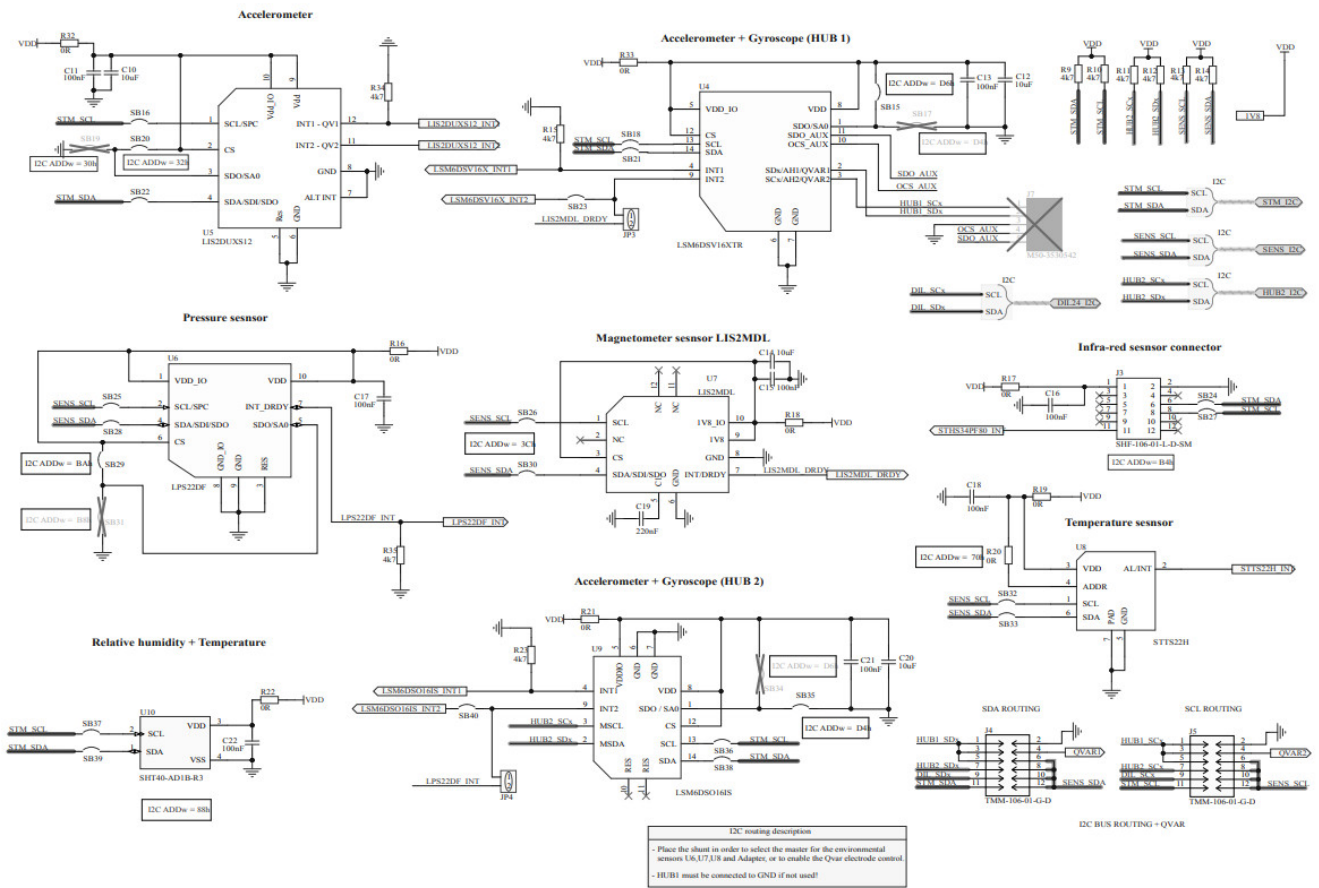
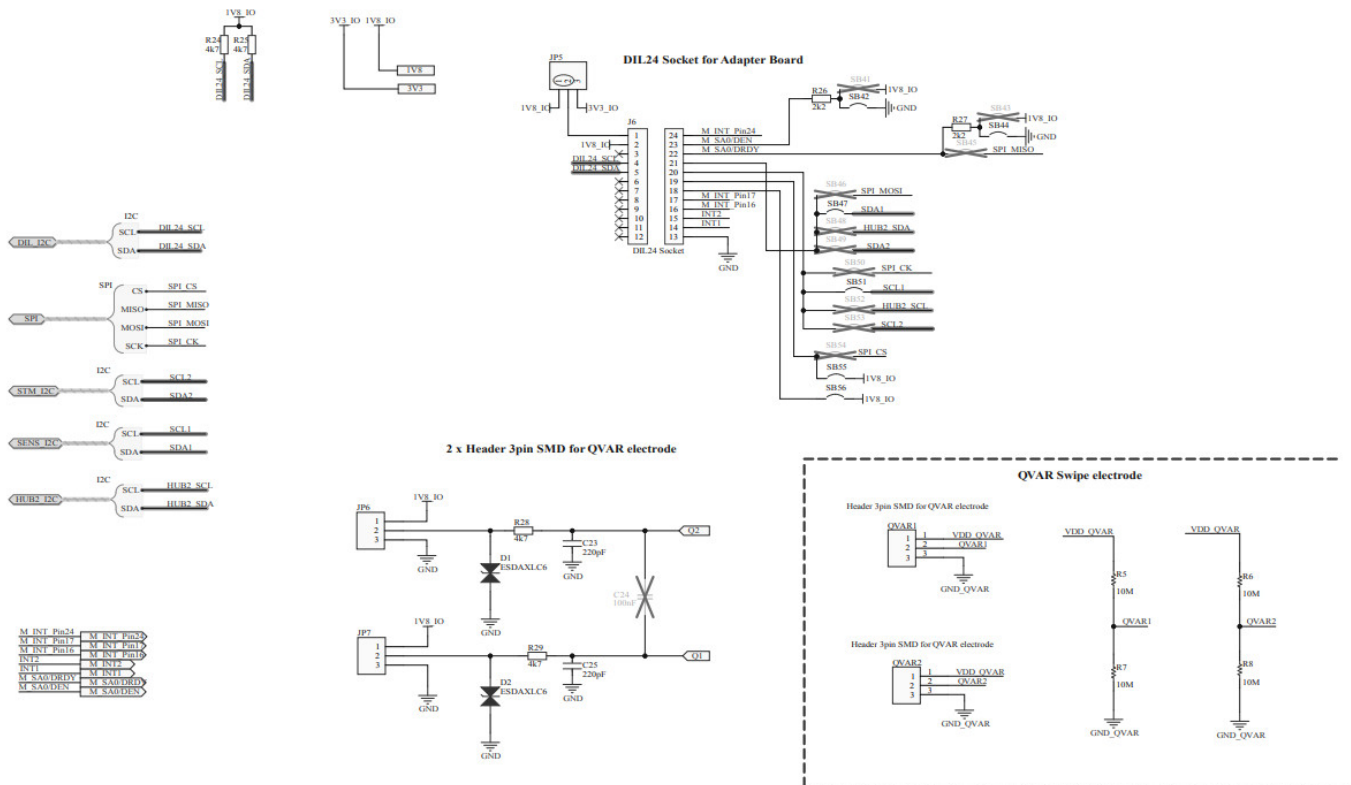


Figure 10. X-NUCLEO-IKS4A1 circuit schematic (4 of 4)



## Bill of materials

Table 6. X-NUCLEO-IKS4A1 bill of materials

Item	Quantity	Reference	Part / value	Description	Manufacturer	Part number
1	2	C23, C25	220pF	Multilayer Ceramic Capacitors 220pF ±5% 100V COG SMD 0402	TDK	C1005C0G2A221J050BA
2	6	C2, C4, C10, C12, C14, C20	10uF	CAP CER 0603 10uF 6.3V X5R 20%	Walsin	0603X106M6R3CT
3	12	C3, C5, C6, C7, C8, C9, C11, C13, C15, C16, C17, C18, C21, C22	100nF	CAP CER 0603 100nF 25V X7R 10%	MULTICOMP	MC06038104K250 CT
4	1	C19	220nF	CAP CER 0603 220nF 25V X7R 10%	KEMET	C0603X224K4RACTU
5	1	CN5		1×10 Pin elevated	socket Samtec	ESQ-110-24-T-S —
6	2	CN9, CN6		1×8 Pin elevated socket	Samtec	ESQ-108-24-T-S
7	1	CN8		1×6 Pin elevated socket	Samtec	ESQ-106-24-T-S
8	2	D1, D2	SOD-882	Trans Voltage Suppressor Diode, 40 W, Bidirectional, 1 Element, Silicon	STMicroelectronics	ESDAXLC6-1BT2
9	1	J1		Header 4	MULTICOMP	2211 S-04G
10	1	J2		16 Position, Dual – Row, Shrouded Terminal Strip, 2mm pitch	Adam Tech	2PH2-16-UA
11	1	J3		12 Position, Dual – Row, Shrouded Terminal Strip, 2mm pitch	Samtec	SHF-106-01-L-D-SM
12	2	J4, J5		12 Position, Dual – Row, Shrouded Terminal Strip, 2mm pitch	Adam Tech	2PH2-12-UA
13	1	J6		Adapter DIL24	E-TEC	2BL1-036-G-700-01

14	5	JP1, JP2, JP5, JP6, JP7		Header 3	MULTICOMP	2211S-03G
15	2	JP3, JP4		Header 1×2 pins, 2.54mm, stright	MULTICOMP	2211S-02G
16	2	QVAR1, QVAR2		Header_3pin_SMD	GCT	BG125-03-A-1-1-0440- ND
17	15	R1, R2, R9, R10, R11, R12 , R13, R14 , R15, R23 , R24, R25 , R28, R29 , R34	4k7	RES 0603 4k7 1% 1/16W, RESISTOR	YAGEO	RC0603FR-074K7L
18	1	R3	15k	RES 0603 12k 1% 1/16W, RESISTOR	YAGEO	RC0603FR-1315KL
19	1	R4	12k	RES 0603 0R0 1% 1/16W	YAGEO	RC0603FR-1312KL
20	9	R32, R33 , R16, R17 , R18, R19 , R20, R21 , R22	0R	RES 0603 2k2 1% 1/16W	YAGEO	RC0603FR-070RL
21	2	R26, R27	2k2	RES Thick Film, 10MΩ, 1%, 0.1W, 100ppm/°C, 0603	YAGEO	RC0603FR-132K2L
22	4	R5, R6, R7, R8	10M	RES 0603 0R0 1% 1/16W	YAGEO	RC0603FR-0710ML



23	40	SB1, SB2 , SB4, SB5 , SB6, SB7 , SB8, SB9 , SB10, SB 11, SB12, SB 14, SB15, SB 16, SB18, SB 20, SB21, SB 22, SB23, SB 24, SB25, SB 26, SB27, SB 28, SB29, SB 30, SB32, SB 33, SB35, SB 36, SB37, SB 38, SB39, SB 40, SB42, SB 44, SB47, SB 51, SB55, SB 56	0R		YAGEO	RC0603FR-070RL
24	1	U1	SOT23-5L	LDO Voltage Regulators 300mA Low Quiescent Crnt low noise LDO	STMicroelectr onics	LDK130M-R
25	2	U2, U3		IC TRANSLATOR BIDIRECTIONAL 20VQFN	Nexperia	NXS0108BQX
26	1	U4	VFLGA2.5X3 X.86 14L P.5 L.475X.25	6-axis IMU with embed ded sensor fusion, AI, Qvar for high-end applications	STMicroelectr onics	LSM6DSV16XTR

27	1	U5	LGA 2X2X0.74MAX 12 LEADS	Ultra-low-power 3axis smart accelerometer with embedded machine learning core and antialiasing filter	STMicroelectronics	LIS2DUXS12TR
28	1	U6	HLGA 2X2X.810L EXP. SILIC .91SQ	Low-power and high-precision MEMS nano pressure sensor: 260-1260 hPa	STMicroelectronics	LPS22DFTR
29	1	U7	LGA 2x2 12L	Ultra-low-power, high-performance 3-axis magnetometer	STMicroelectronics	LIS2MDLTR
30	1	U8	UDFN-6L_2X2X0P5_STM	Low-voltage, ultralow-power, 0.5 °C accuracy temperature sensor	STMicroelectronics	STTS22HTR
31	1	U9	VFLGA2.5X3X.86 14L P.5L.475X.25	3-axis accelerometer and 3-axis gyroscope with I SPU	STMicroelectronics	LSM6DSO16ISTR
32	1	U10		Digital Relative Humidity Temperature Sensor, $\hat{A} \pm 1.8$ / max 3.5 %RH, $\hat{A} \pm 0.2$ $\hat{A}$ °C, UltraLow-Power	Sensirion	SHT40-AD1B-R3

## Kit versions

Table 7. X-NUCLEO-IKS4A1 versions

Finished good	Schematic diagrams	Bill of materials
X\$NUCLEO-IKS4A1A(1)	X\$NUCLEO-IKS4A1A schematic diagrams	X\$NUCLEOIKS4A1A bill of materials

1. This code identifies the X-NUCLEO-IKS4A1 evaluation kit first version. The kit consists of the main board X-NUCLEOIQS4A1 whose version is identified by the code X\$NUCLEO-IQS4A1A and the detachable board STEVAL-MKE001A whose version is identified by the code STEVAL\$MKE001AA.

## Regulatory compliance information

### Notice for US Federal Communication Commission (FCC)

For evaluation only; not FCC approved for resale

FCC NOTICE – This kit is designed to allow:

1. Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and
2. Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

#### **Notice for Innovation, Science and Economic Development Canada (ISED)**

For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

#### **Notice for the European Union**

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

#### **Notice for the United Kingdom**

This device is in compliance with the UK Electromagnetic Compatibility Regulations 2016 (UK S.I. 2016 No. 1091) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK S.I. 2012 No. 3032).

#### **Revision history**

Table 8. Document revision history

Date	Version	Changes
11-Oct-23	1	Initial release.

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	<p><a href="#">STMicroelectronics UM3239 Motion Mems and Environmental Sensor Expansion Board [pdf] User Manual</a></p> <p>X-NUCLEO-IQS4A1, LSM6DSO16IS, LSM6DSV16X, UM3239, UM3239 Motion Mems and Environmental Sensor Expansion Board, Motion Mems and Environmental Sensor Expansion Board, Mems and Environmental Sensor Expansion Board, Environmental Sensor Expansion Board, Sensor Expansion Board, Expansion Board, Board</p>
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## References

-  [STMicroelectronics: Our technology starts with you](#)
-  [STMicroelectronics Trademark List - STMicroelectronics](#)
-  [MEMS and Sensors - STMicroelectronics](#)
-  [LIS2DUXS12 - Ultralow-power 3-axis smart accelerometer with Qvar, AI, antialiasing filter, and advanced digital features - STMicroelectronics](#)
-  [LIS2MDL - Magnetic sensor, digital output, 50 gauss magnetic field dynamic range, ultra-low power high performance 3-axis magnetometer - STMicroelectronics](#)
-  [LPS22DF - Low-power and high-precision MEMS nano pressure sensor: 260-1260 hPa absolute digital output barometer - STMicroelectronics](#)
-  [LSM6DSO16IS - iNEMO inertial module: always-on 3D accelerometer and 3D gyroscope with ISPU - Intelligent Sensor Processing Unit - STMicroelectronics](#)
-  [LSM6DSV16X - 6-axis IMU with embedded sensor fusion, AI, Qvar for high-end applications - STMicroelectronics](#)
-  [STTS22H - Low-voltage, ultra-low-power, 0.5 °C accuracy I2C/SMBus 3.0 temperature sensor - STMicroelectronics](#)
-  [LDK130 - 300 mA low quiescent current very low noise LDO \(automotive for SOT23-5L package\) - STMicroelectronics](#)
-  [X-CUBE-MEMS1 - Sensor and motion algorithm software expansion for STM32Cube - STMicroelectronics](#)
-  [X-NUCLEO-IKS4A1 - Motion MEMS and environmental sensor expansion board for STM32 Nucleo - STMicroelectronics](#)
-  [ESDAXLC6-1BT2 - Single-line bidirectional ESD protection for high speed interface - STMicroelectronics](#)
- [User Manual](#)