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

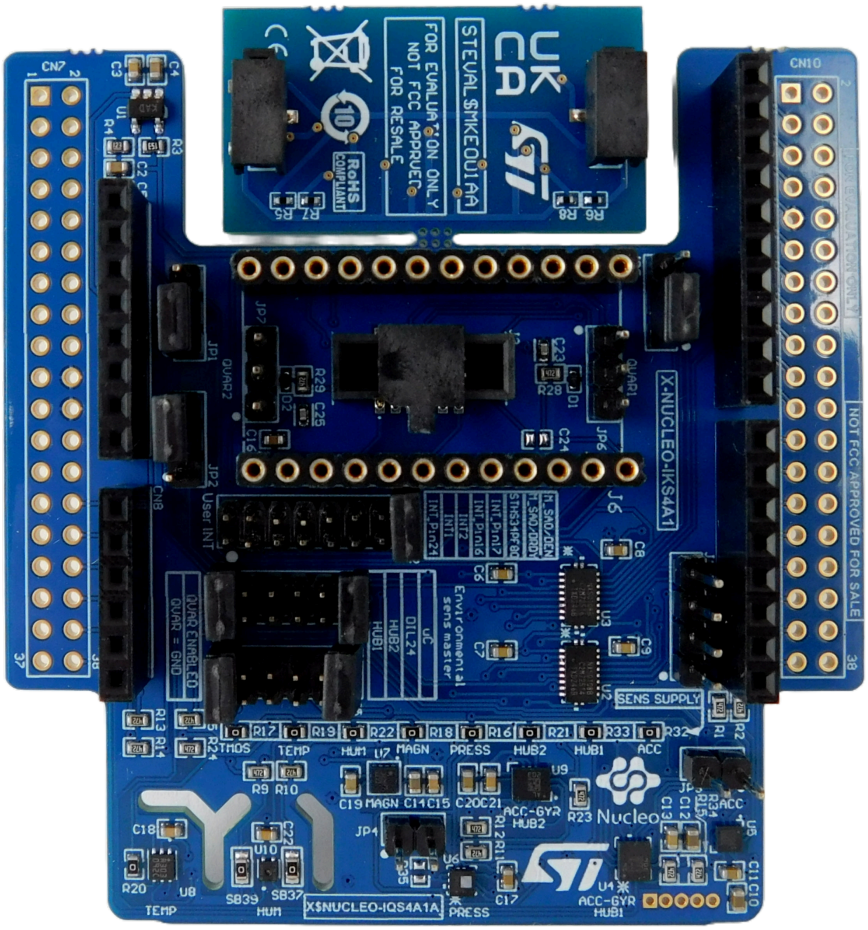
Introduction

The X-NUCLEO-IKS4A1 is a motion MEMS and environmental sensor evaluation board kit consisting of the main board X-NUCLEO-IQS4A1, which hosts the motion MEMS and environmental sensors, and the detachable add-on board STEVAL-MKE001A, 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 I²C pin or, for external sensors mounted on DIL24 adaptor, SPI Pins.

Figure 1. X-NUCLEO-IKS4A1 expansion board



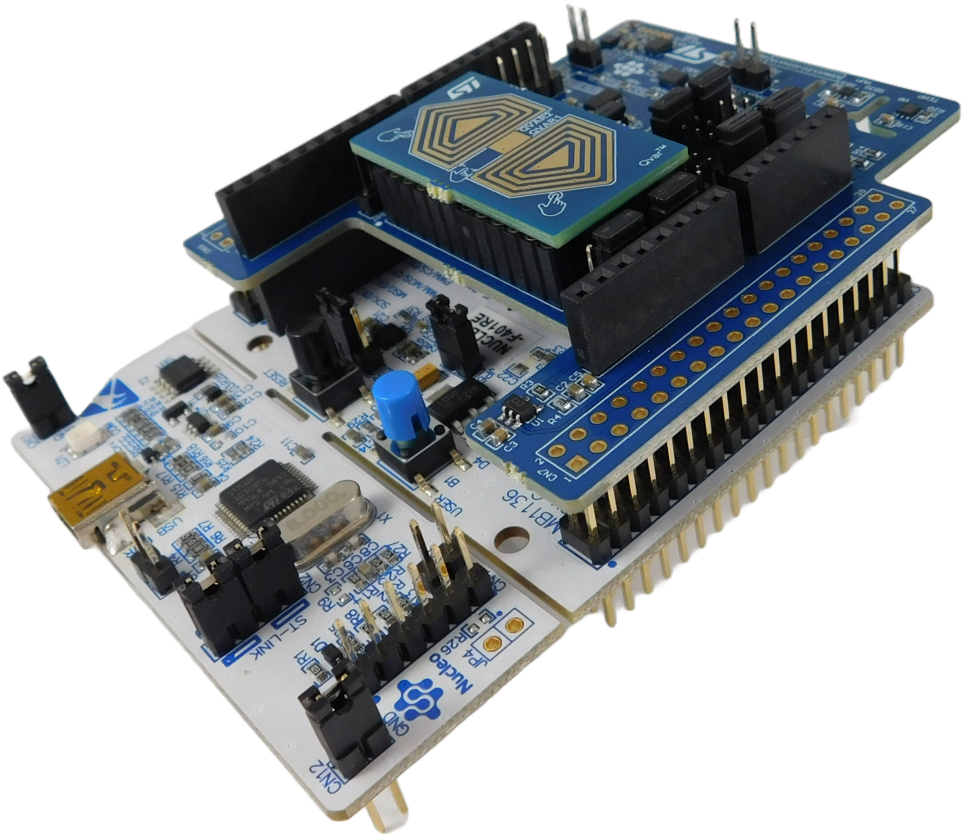
Notice: *For dedicated assistance, submit a request through our online support portal at **www.st.com/support**.*

1 Getting started

1.1 Hardware requirements

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

Figure 2. X-NUCLEO-IKS4A1 plugged on an STM32 Nucleo board



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

Note: 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.

Related links

See the X-CUBE-MEMS1 product page for firmware and related documentation

2 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

3 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 I²C 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 3-axis accelerometer (±2/±4/±8/±16 g) + 3-axis gyroscope (±125/±250/±500/±1000/±2000 dps) with ISPU (Intelligent processing unit)
- LIS2MDL: MEMS 3-axis magnetometer (±50 gausses)
- LIS2DUXS12: ultralow power MEMS 3-axis accelerometer (±2/±4/±8/±16 g) with Qvar, AI, & antialiasing
- LPS22DF: low-power and high-precision MEMS pressure sensor, 260-1260 hPa absolute digital output barometer
- SHT40AD1B: high-accuracy, ultra-low-power relative humidity and temperature sensor (by Sensirion)
- STTS22H: Low-voltage, ultralow power, 0.5°C accuracy temperature sensor (-40°C to +125°C)
- LSM6DSV16X: MEMS 3-axis accelerometer (±2/±4/±8/±16 g) + 3-axis gyroscope (±125/±250/±500/±1000/±2000/±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
- I²C sensor hub features on LSM6DSO16IS 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 a DIL24 adapter
- Available interface for external camera module applications coupled with LSM6DSV16X 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.

3.1 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.

3.2 Block diagram

The LSM6DSO16IS and the LSM6DSV16X have an I²C sensor hub that allows them to behave as the I²C master for other slave devices connected via an I^2C_{aux} bus. Various bus configurations are possible to select the I²C master of the environmental/DIL24 sensors.

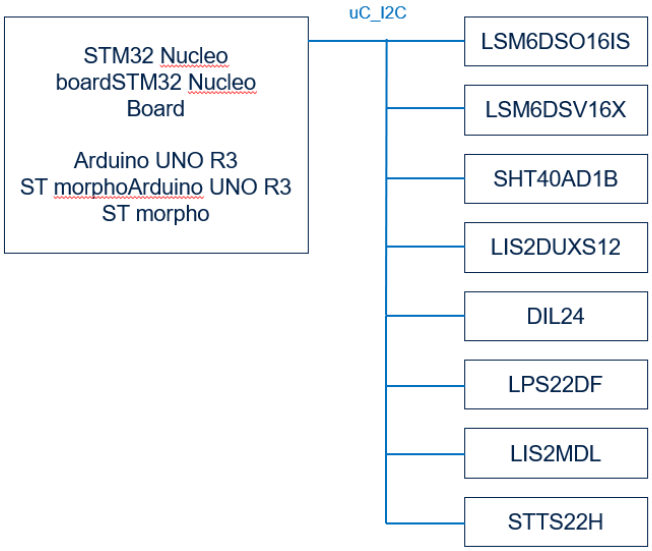
Mode 1: standard I²C bus connection (all sensors)

In standard I²C mode, all devices are connected to an external main board via the same I²C 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 I²C



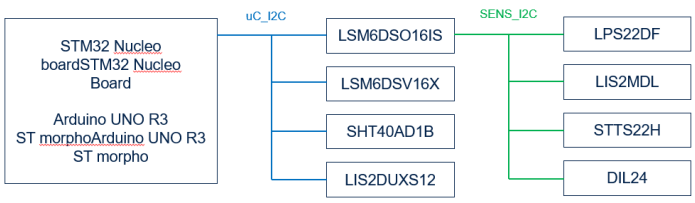
Mode 2: LSM6DSO16IS I²C sensor hub (all sensors)

In this sensor hub I²C 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 I²Cz 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: 7-8 (HUB2_SDx = SENS_SDA)
- J5: 7-8 (HUB2_SCx = SENS_SCL)

Figure 4. X-NUCLEO-IKS4A1 LSM6DSO16IS I²C sensor hub



Mode 3: LSM6DSV16X I²C 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 I2C bus "SENS_I2C". LSM6DSO16IS, LIS2DUXS12 and SHT40AD1B remains connected to the main bus "uC_I2C" coming from the external board.

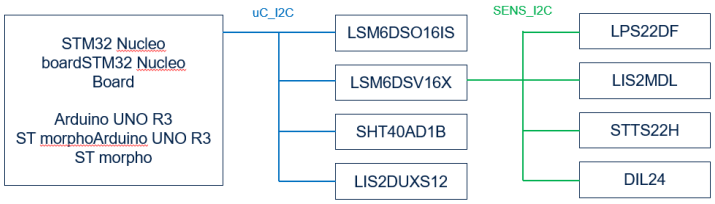
The board configuration is:

- J4: 5-6 (HUB1_SDx = SENS_SDA)
- J5: 5-6 (HUB1_SDx = SENS_SDA)

DIL24 adapter (to I²C2): SB16, SB21

Not mounted: SB6, SB10, SB12, SB14, SB18, SB19, SB20, SB22

Figure 5. LSM6DSV16X I²C sensor hub



Mode 4: DIL24 I²C sensor hub (all sensors)

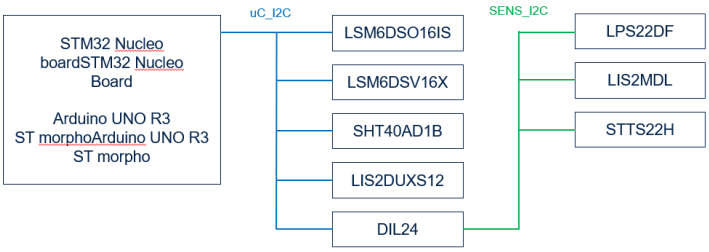
In case a sensor with sensor hub embedded functionality is mounted to the board through DIL24 adapter, it is possible to exploit this functionality as for LSM6DSO16IS and the LSM6DSV16X.

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 I2C 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, I²C 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 I²C address selection

Most sensors allow I²C 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 I²C address

Address in bold are the default I2C 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.

Note: 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 I²C 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 I²C solder bridges

Sensor	SDA	SCL
LIS2MDL (U7)	SB30	SB26
LSM6DSO16IS (U9)	SB38	SB36
SHT40AD1B (U10)	SB39	SB37
LIS2DUXS12 (U5)	SB22	SB16

Sensor	SDA	SCL
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 the J6 DIL24 socket.

If the additional sensor on the DIL24 adapter is an IMU with the same I2C address of LSM6DSV16X/ LSM6DSO16IS, it is mandatory to disconnect the device with I2C address conflict removing the proper I2C solder bridges. To avoid firmware modification, it is suggested to disconnect LSM6DSO16IS by opening the solder bridges SB36 and SB38.

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	Pin(1)	Signal
CN5	7	GND
	9	I²C SDA
	10	I²C 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	LSM6DSO16IS INT1
CN9	3	USER INT
	4	SPI CLK
	5	LSM6DSV16X INT2
	6	LSM6DSV16X INT1
	7	LPS22DF INT1
	8	LSM6DSO16IS INT2

1. *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	I²C SCL
	5	I²C SDA
	23	LSM6DSO16IS INT2
	25	LPS22DF INT1
	27	LSM6DSV16X INT1
	29	LSM6DSV16X INT2
	31	SPI CLK
	33	USER INT

1. *The unlisted pins are not connected.*

4 Schematic diagrams

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

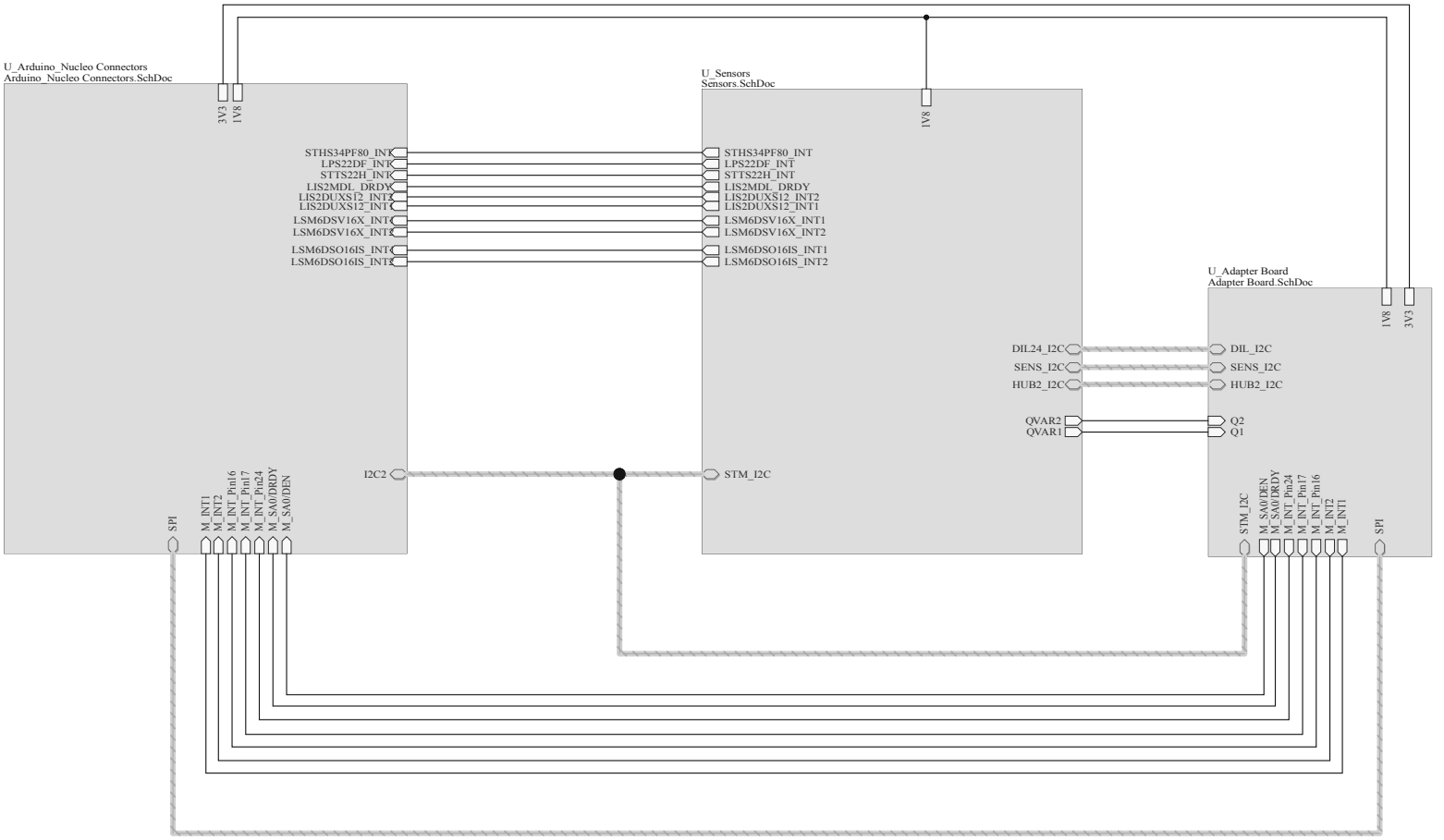


Figure 8. X-NUCLEO-IKS4A1 circuit schematic (2 of 4)

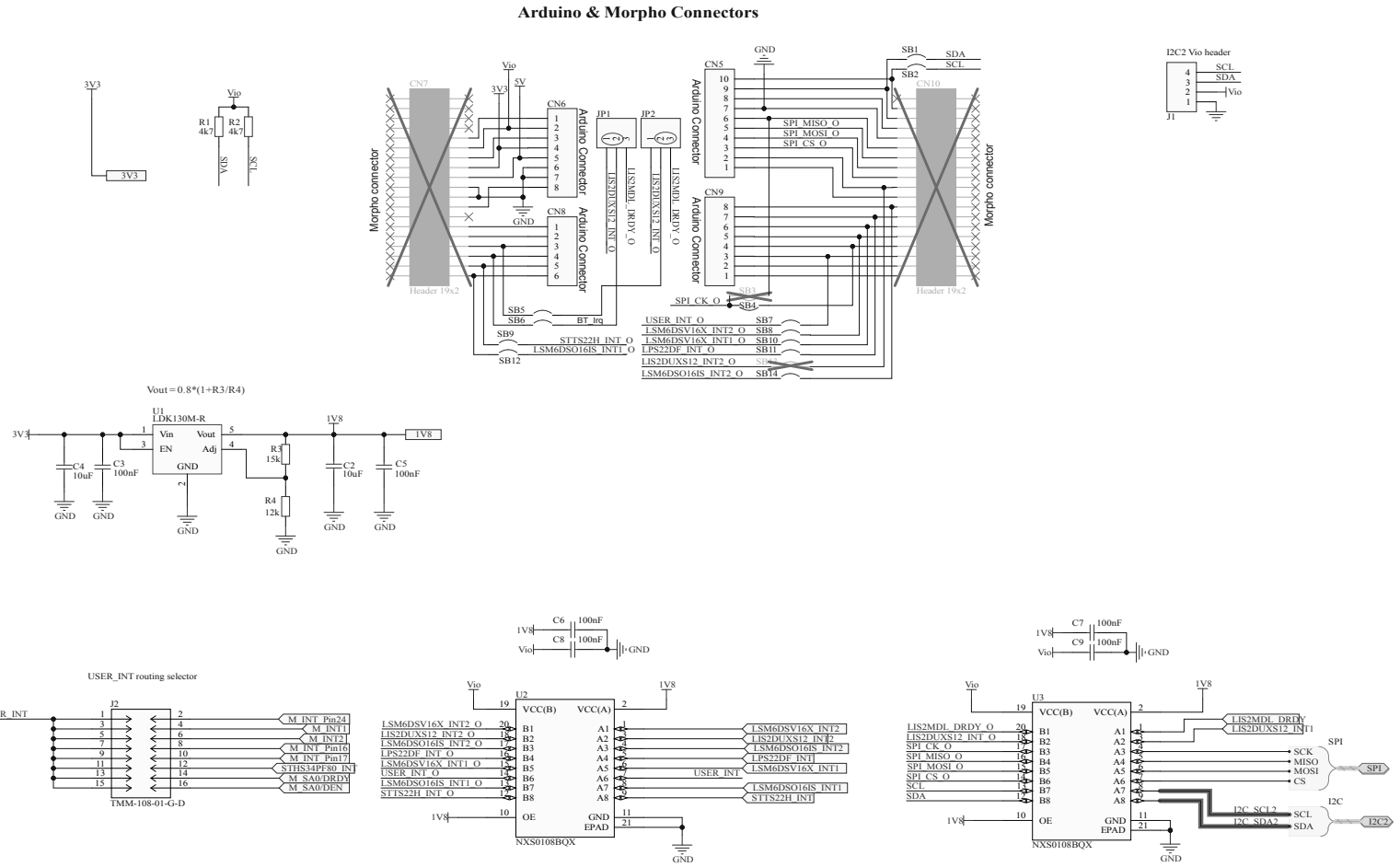


Figure 9. X-NUCLEO-IKS4A1 circuit schematic (3 of 4)

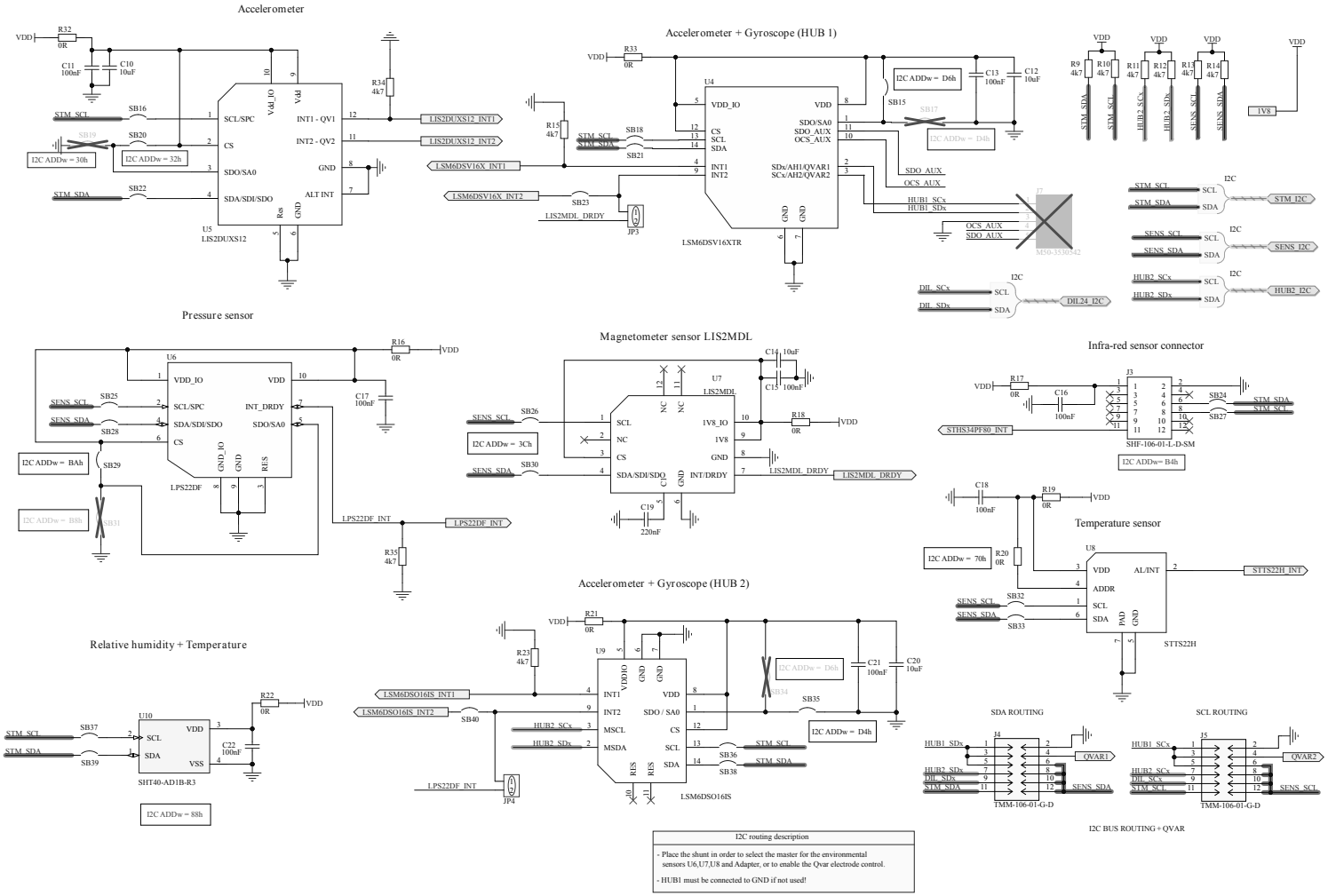
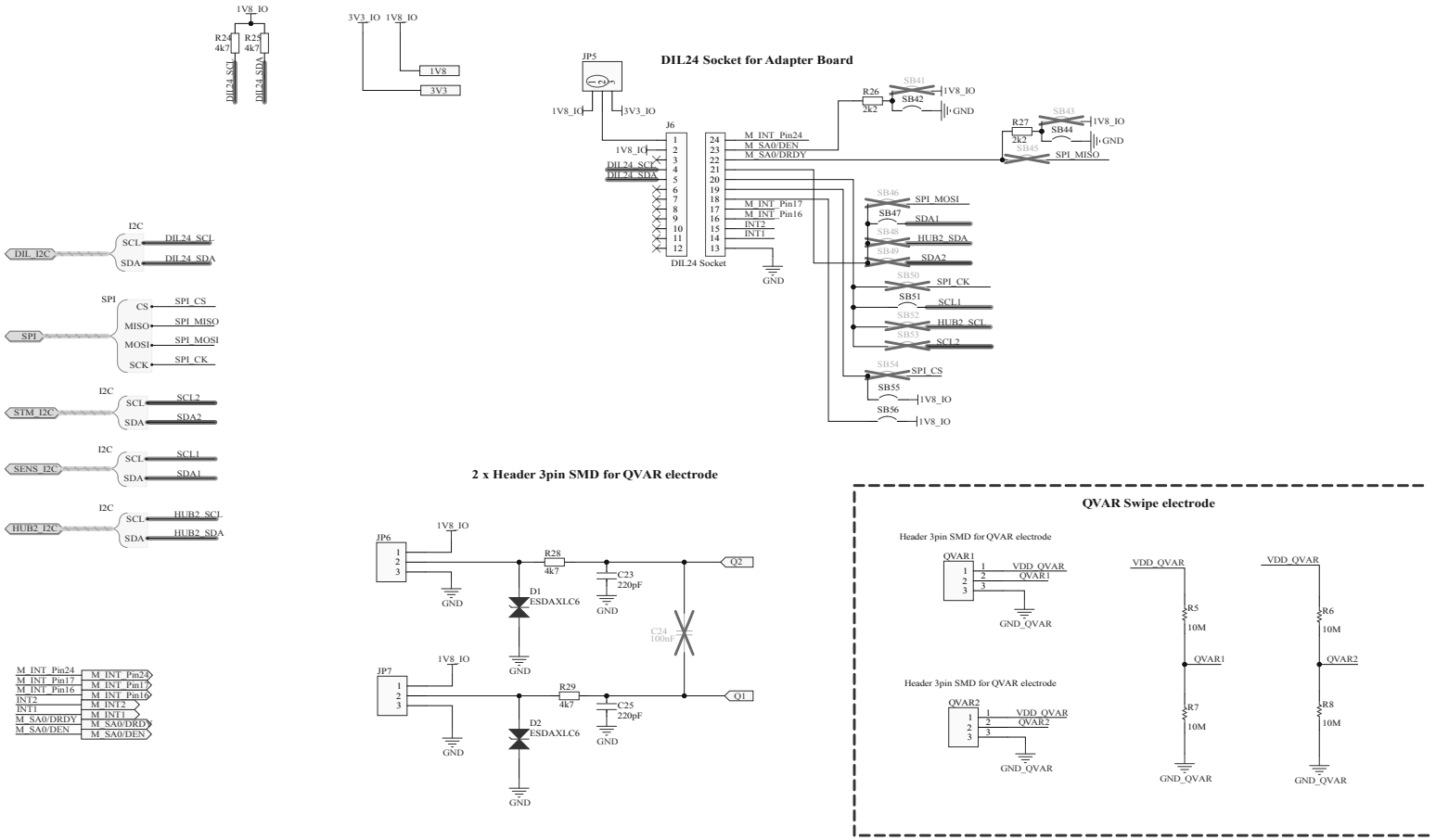


Figure 10. X-NUCLEO-IKS4A1 circuit schematic (4 of 4)



5 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 C0G 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	MC0603B104K250CT
4	1	C19	220nF	CAP CER 0603 220nF 25V X7R 10%	KEMET	C0603X224K4RACTU
5	1	CN5		1x10 Pin elevated socket	Samtec	ESQ-110-24-T-S
6	2	CN9, CN6		1x8 Pin elevated socket	Samtec	ESQ-108-24-T-S
7	1	CN8		1x6 Pin elevated socket	Samtec	ESQ-106-24-T-S
8	2	D1, D2	SOD-882	Trans Voltage Suppressor Diode, 40W, Bidirectional, 1 Element, Silicon	STMicroelectronics	ESDAXLC6-1BT2
9	1	J1		Header 4	MULTICOMP	2211S-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 1x2 pins, 2.54mm, stright	MULTICOMP	2211S-02G
16	2	QVAR1, QVAR2		Header_3pin_SMD	GCT	BG125-03-A-1-1-0440-N-D

Item	Quantity	Reference	Part / value	Description	Manufacturer	Part number
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 15k 1% 1/16W, RESISTOR	YAGEO	RC0603FR-1315KL
19	1	R4	12k	RES 0603 12k 1% 1/16W, RESISTOR	YAGEO	RC0603FR-1312KL
20	9	R32, R33, R16, R17, R18, R19, R20, R21, R22	0R	RES 0603 0R0 1% 1/16W	YAGEO	RC0603FR-070RL
21	2	R26, R27	2k2	RES 0603 2k2 1% 1/16W	YAGEO	RC0603FR-132K2L
22	4	R5, R6, R7, R8	10M	RES Thick Film, 10MΩ, 1%, 0.1W, 100ppm/°C, 0603	YAGEO	RC0603FR-0710ML
23	40	SB1, SB2, SB4, SB5, SB6, SB7, SB8, SB9, SB10, SB11, SB12, SB14, SB15, SB16, SB18, SB20, SB21, SB22, SB23, SB24, SB25, SB26, SB27, SB28, SB29, SB30, SB32, SB33, SB35, SB36, SB37, SB38, SB39, SB40, SB42, SB44, SB47, SB51, SB55, SB56	0R	RES 0603 0R0 1% 1/16W	YAGEO	RC0603FR-070RL
24	1	U1	SOT23-5L	LDO Voltage Regulators 300mA Low Quiescent Crnt low noise LDO	STMicroelectronics	LDK130M-R

Item	Quantity	Reference	Part / value	Description	Manufacturer	Part number
25	2	U2, U3		IC TRANSLATOR BIDIRECTIONAL 20VQFN	Nexperia	NXS0108BQX
26	1	U4	VFLGA2.5X3X.86 14L P.5 L.475X.25	6-axis IMU with embedded sensor fusion, AI, Qvar for high-end applications	STMicroelectronics	LSM6DSV16XTR
27	1	U5	LGA 2X2X0.74MAX 12 LEADS	Ultra-low-power 3-axis smart accelerometer with embedded machine learning core and anti-aliasing filter	STMicroelectronics	LIS2DUXS12TR
28	1	U6	HLGA 2X2X.8 10L 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.5 L.475X.25	3-axis accelerometer and 3-axis gyroscope with ISPU	STMicroelectronics	LSM6DSO16ISTR
32	1	U10		Digital Relative Humidity Temperature Sensor, Â±1.8 / max 3.5 %RH, Â±0.2 Â°C, Ultra-Low-Power	Sensirion	SHT40-AD1B-R3

6 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-NUCLEO-IQS4A1 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.*

7 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.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

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-2023	1	Initial release.
29-Nov-2023	2	Updated Introduction and *Section 3: Hardware description*.
14-Feb-2024	3	Updated *Mode 2: LSM6DSO16IS I²C sensor hub (all sensors)* and *Mode 3: LSM6DSV16X I²C sensor hub.*
19-Mar-2024	4	Updated *Figure 9. X-NUCLEO-IKS4A1 circuit schematic (3 of 4)*. Minor text changes.
18-Feb-2025	5	Updated Section 3.6: Adapter board for DIL24 socket .

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