Getting started with the X-NUCLEO-OUT16A1 industrial digital output expansion board for STM32 Nucleo

Introduction

The X-NUCLEO-OUT16A1 industrial digital output expansion board, for STM32Nucleo, provides a powerful and flexible environment for the evaluation of the driving and diagnostic capabilities of the IPS8200HQ octal high-side smart power solid state relay, in a digital output module connected to 0.7 A industrial loads.

The X-NUCLEO-OUT16A1 interfaces with the microcontroller on the STM32 Nucleo via STISO620 and STISO621 and Arduino® R3 connectors. The user can select which driving mode controls the IPS8200HQ: Parallel (SEL2 = L by JP21 = open) or SPI (SEL2 = H by JP21 = closed). In the case of SPI selection, the user can select the communication protocol between 8 bits (SEL1 = L by JP22 = open) or 16 bits (SEL1 = H by JP22 = closed).

The V_{CC} supply pin of the IPS8200HQ is provided by the connector CN1, while the loads (driven by the eight output channels of the IPS8200HQ) can be connected between the connectors CN2, CN3, CN4, CN12, and the pin 2 of the connector CN1.

The on-board digital isolators (STISO620 and STISO621) feature the 2.8k V_{RMS} (4k V_{PK}) galvanic isolation between the two application sides: Logic and process sides.

The logic side is the application side of the MCU and it is supplied by the VISO_L rail (3.3 V or 5.0 V). VISO_L can be supplied by an external power supply connected to CN13 or, alternatively by the pin 4 (SW1 = close 1-2) or pin 5 (SW1 = close 2-3) of CN6.

The process side is the application side of the industrial loads and it is supplied by the VCC and VISO_P rails. The VISO_P (3.3 or 5.0 V) is usually supplied by the VREG rail (JP31 = closed) that can be generated by the step-down embedded in the IPS8200HQ (SW17 = close 1-2, JP20 = closed, JP15 = closed and JP28 = close 2-4 (VREG = 3.3 V) or JP28 = 1-3 (VREG = 5.0 V)). Alternatively, VREG can be provided by an external power supply connected to CN14 (SW17 = close 2-3, JP20 = open, JP15 = open).

In parallel driving mode (active with the default jumper and switch settings) the application board can work even without any Nucleo board: in this case, the user must provide the process side voltage (usually 24 V) by the CN1 and the VISO_L (usually 3.3 V) by the CN13. The IN_X signals, available on CN5[1, 2, 3], CN8[4] and CN9[3, 5, 7, 8], drive on/off the correspondent OUT_X connected to the loads on the process side. The IN_X pins can be driven low/high swinging between 0V and VISO_L. The activation of each OUTX (OUT1… OUT8) can be monitored by the green LEDs DOX (DO1… DO8).

The activation of the three diagnostic pins (TWARN, PGOOD, FAULT) can be visualized on the correspondent red LEDs (D11, D12, D13, respectively) or monitored by an oscilloscope on TP6, TP7, and TP5.

Note: Although the pins CN8[5], CN5[9], CN5[10] are connected to the nets FAULT_L, PGOOD_L and TWARN_L, these pins cannot correctly report the status of the corresponding signals on the process side (FAULT, PGOOD, and TWARN) due to routing mistake on the same side.

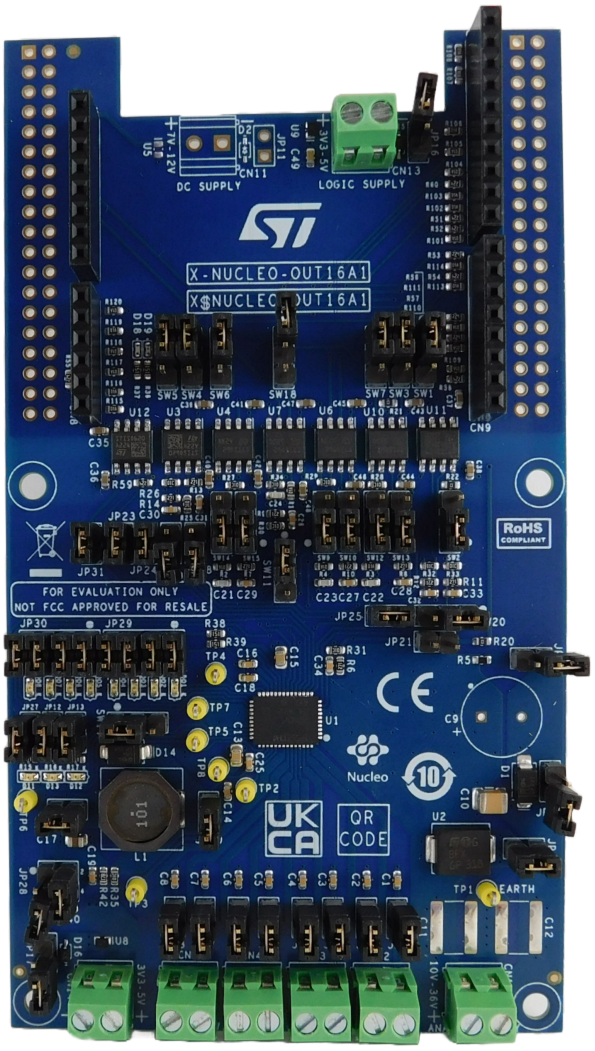
The SPI driving mode can be set by changing the default configuration (JP21 = close; SW4, SW5, SW6, SW7, SW9, SW10, SW11, SW12, SW13, SW14, SW15, and SW20 = close 2-3, SW18 = close 1-2). The SPI-8bits is the default mode (JP22 = open), while the SPI-16bits mode can be activated by JP22 = close.

In SPI driving mode it is also possible to activate the MCU freeze detection feature by setting SW3 = close 2-3.

The expansion board can be connected to either a NUCLEO-F401RE or a NUCLEO-G431RB development board. In this case the companion firmware X-CUBE-IPS detects the selected configuration (GPIO, SPI-8bits, SPI-16bits) by reading the signals SEL2_L and SEL1 from CN8[1] and CN8[6]. The activation of the MCU freeze feature is detected by WDEN(in) on CN9[4].

It is also possible to evaluate a system composed of a X-NUCLEO-OUT16A1 stacked on other expansion boards. In fact, SPI driving mode allows the daisy-chaining communication with another X-NUCLEO-OUT16A1 stacked through the Arduino connectors: the two stacked boards must be configured with SW6, SW18 = close 2-3 on one board, and SW6, SW18 = close 1-2 on the other board.

Figure 1. **X-NUCLEO-OUT16A1 expansion board**



1 Getting started

1.1 Overview

The X-NUCLEO-OUT16A1 embeds the IPS8200HQ intelligent power switch (IPS), which features serial/parallel selectable interface on-chip, 8-bit and 16-bit SPI interface for IC command and control diagnostic, Power Good diagnostic, IC warning temperature detection, overcurrent and overtemperature protection for safe output loads control.

The board is designed to meet the application requirements for the galvanic isolation between the user and power interfaces.

An optical isolation satisfies this requirement. The isolation is implemented through three dual channel digital isolators with 2 – 0 channel directionality (U3, U11, U12) for the input signals forward to the device, and four dual channel digital isolators with 1 – 1 channel directionality (U4, U6, U7, U10) for the diagnostic feedback signals of the device and the daisy chaining service lines.

The expansion board features:

- Based on the IPS8200HQ octal high-side switch, which features:
  - Operating range 10.5 to 36 V
  - Operating output current ≤ 0.7 A
  - Low power dissipation (RON(MAX) = 200 mΩ)
  - Undervoltage lock-out
  - Selectable driving modes parallel or 5 MHz SPI (8 or 16 bits)
  - Embedded step-down converter
  - 4x2 LED matrix for efficient status indication
  - MCU freeze detection
  - Fast decay for inductive loads
  - Overload and overtemperature protections
  - Loss of ground protection
  - Junction Overtemperature and parity check diagnostic pin (FAULT)
  - Case overtemperature diagnostic pin (TWARN)
  - Supply voltage Level diagnostic pin (PGOOD)
  - QFN48L 8x6 mm package
- Application board voltage operating range: 12 to 33 V
- Extended voltage operating range (J9 open) up to 36 V
- Operating current: up to 0.7 A per channel
- Blue LED showing SPI mode selection
- Yellow LED showing SPI mode 16-bits selection
- Red LED for FAULT diagnostic pin (JP12 closed)
- Red LED for PGOOD diagnostic pin (JP13 closed)
- Red LED for TWARN diagnostic pin (JP27 closed)
- 4 kV_{PK} galvanic isolation guaranteed by STISO620 and STISO621
- Supply rail reverse polarity protection
- Compatible with STM32 Nucleo development boards
- Equipped with Arduino® UNO R3 connectors
- RoHS and China RoHS compliant
- CE certified

1.2 Board configuration

A set of jumpers and switches is available to configure the board. Table 1 shows the configurations to be used respectively for Parallel 8 Channels Mode, SPI 8 Channels Mode and Daisy Chain Mode.

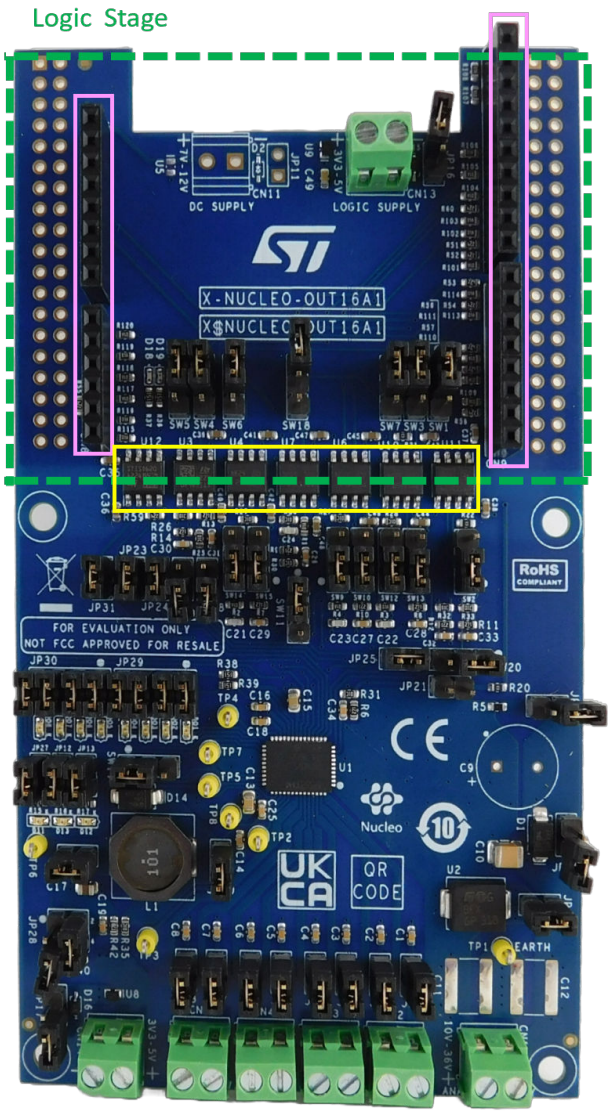
Table 1. X-NUCLEO-OUT16A1

Jumpers/Switches	Parallel 8 Ch	SPI 8 Ch	Daisy Chain
SW1, SW3, SW17	Closed 1-2	Closed 1-2	Closed 1-2
JP1, JP2, JP3, JP4, JP5, JP6, JP7, JP8, JP9, JP12, JP13, JP15, JP20, JP23, JP24, JP25, JP27, JP31	Closed	Closed	Closed
JP10, JP14, JP16, JP17, JP18, JP19	Open	Open	Open
JP11	Not mounted	Not mounted	Not mounted
JP28	Closed 2-4	Closed 2-4	Closed 2-4
JP29, JP30	Closed 1-2, 3-4, 5-6, 7-8	Closed 1-2, 3-4, 5-6, 7-8	Closed 1-2, 3-4, 5-6, 7-8
SW4, SW5, SW7, SW9, SW10, SW11, SW12, SW13, SW14, SW15	Closed 1-2	Closed 2-3	Closed 2-3
SW6	Closed 1-2	Closed 2-3	Board 0: Closed 2-3 Board 1: Closed 1-2
SW18	Open	Closed 1-2	Board 0: Closed 2-3 Board 1: Closed 1-2
SW20	Closed 1-2	Closed 2-3	Closed 2-3
JP21	Open	Closed	Closed
JP22	Open	Open (SEL1 L, SPI 8bits) Closed (SEL1 H, SPI 16 bits)	Open (SEL1 L, SPI 8bits) Closed (SEL1 H, SPI 16 bits)

1.3 Digital section

The digital section is associated with the STM32 interface and the digital supply voltage to and from the X-NUCLEO-OUT16A1 expansion board.

Figure 2. X-NUCLEO-OUT16A1 expansion board: digital interface section



The dotted green line indicates the whole digital interface section. The pink rectangles identify the Arduino® UNO R3 connectors and the yellow ones identify STISO620 and STISO621 digital isolators.

The four Arduino® UNO R3 connectors:

- allow the expansion board to communicate with the STM32 Nucleo development microcontroller board accessing the STM32 peripheral and GPIO resources;
- provide the digital supply voltage between the STM32 Nucleo development board and the X-NUCLEO-OUT16A1 expansion board, in either direction.

The five digital isolators (STISO620 and STISO621) provide 4 kV_{PK} galvanic isolation between logic and process sides of the expansion board.

Usually, the STM32 Nucleo development board supplies the expansion board by a 3.3 V or 5.0 V generated by the USB.

Alternatively, it is possible to supply the STM32 Nucleo development board from the expansion board. In this case, an external supply voltage (7-12 V) should be connected to the CN11 connector (not mounted by default) on the expansion board and the ground loop should be closed by mounting D2 (enabling the reverse polarity protection) or by closing JP11 (without reverse polarity).

To supply the VIN voltage rail, it is necessary to:

- close the JP5 jumper between pins 2 and 3 and open the JP1 jumper on the NUCLEO-F401RE;
- open the JP5 jumper between pins 1 and 2 and close the JP5 jumper between pins 3 and 4 on the NUCLEO-G431RB.

Logic side is then supplied by the VISO_L rail (3.3 V or 5.0 V). VISO_L can be supplied by an external power supply connected to CN13 (SW1 open) or, alternatively by the pin 4 (SW1 = close 1-2) or pin 5 (SW1 = close 2-3) of CN6.

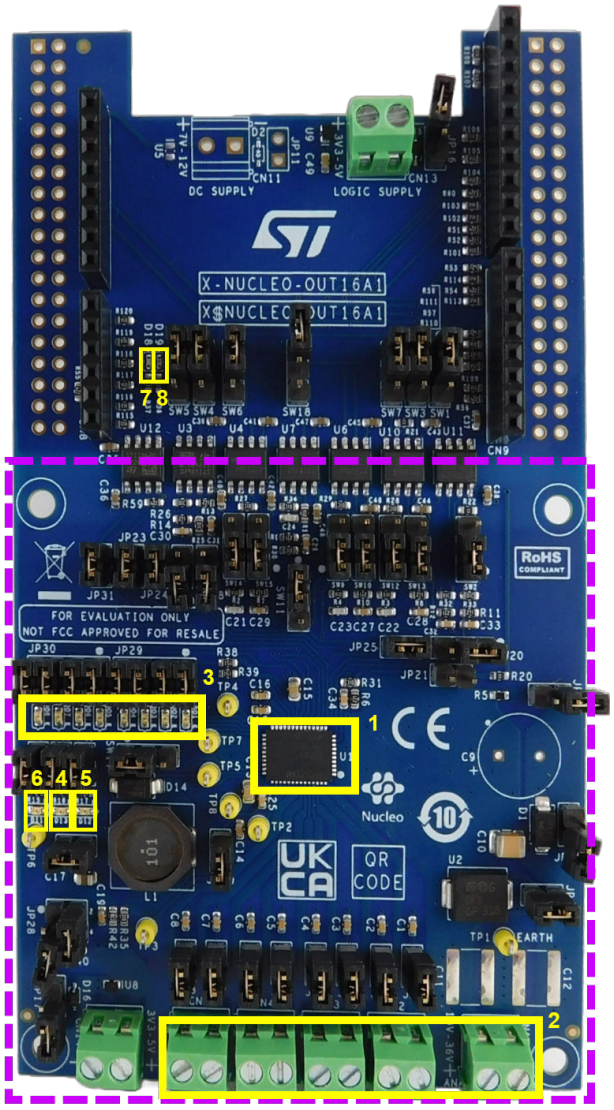
The user can select which driving mode controls the IPS8200HQ: parallel (SEL2 = L by JP21 = open) or SPI (SEL2 = H by JP21 = closed). In the case of SPI selection, the user can select the communication protocol between 8 bits (SEL1 = L by JP22 = open) or 16 bits (SEL1 = H by JP22 = closed).

1.4 Power section

The power section involves the power supply voltage (CN1, pin 1 for V_{CC}, pin 2 for GND), the load connection (eight loads can be connected between each pin of CN2, CN3, CN4, and CN12 and pin 2 of CN1), EMC protections (U2), and supply reverse polarity protection (D1).

Figure 3. X-NUCLEO-OUT16A1 expansion board: power section

1. IPS8200HQ
2. Output and power supply connector
3. Output channels - green LEDs
4. FAULT (diagnostic pin) red LED
5. PGOOD (diagnostic pin) red LED
6. TWARN (diagnostic pin) red LED
7. SEL2 H (SPI) blue LED
8. SEL1 H (16 bits SPI data width) yellow LED



The process side is supplied by the VCC and VISO_P rails. The VISO_P (3.3 or 5.0 V) is usually supplied by the VREG rail (JP31 = closed) that can be generated by the step-down embedded in the IPS8200HQ (SW17 = close 1-2, JP20 = closed, JP15 = closed and JP28 = close 2-4 (VREG = 3.3 V) or JP28 = 1-3 (VREG = 5.0 V)). Alternatively, VREG can be provided by an external power supply connected to CN14 (SW17 = close 2-3, JP20 = open, JP15 = open).

For EMC:

- the SMC30J30CA transient voltage suppressor (U2), enabled by closing J9, is placed between V_{CC} and GND tracks to protect the IPS8200HQ against surge discharge on the supply rail path up to ±1 kV/2 Ω coupling;
- in the common mode surge testing, two single-layer capacitors (C11 and C12 - not included) must be soldered at the predisposed locations;
- the IPS8200HQ output stages do not require additional EMC protections with respect to the IEC61000-4-2, IEC61000-4-3, IEC61000-4-4, IEC61000-4-5, IEC61000-4-8 standards.

The EMC performance of the X-NUCLEO-OUT16A1 is detailed below:

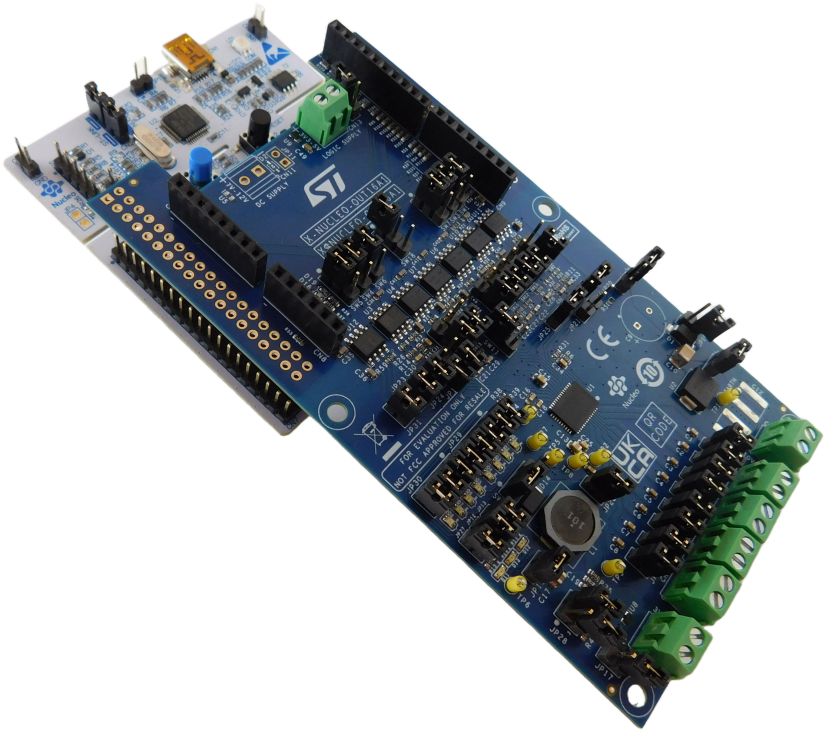
- for emission (when the DC input port of the board is powered by an AC-DC, DC-DC or battery with a cable that does not exceed a three-meter length), compliance with standards:
  - EN IEC 61000-6-3:2021
  - EN 55032:2015 +A1:2020
- for immunity, compliance with standards:
  - EN IEC 61000-6-1:2019
  - EN 55035:2017 +A11:2020

1.5 Hardware requirements

The X-NUCLEO-OUT16A1 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT16A1 must be plugged onto the matching Arduino® UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-OUT16A1 and STM32 Nucleo stack



1.6 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT16A1 expansion board, you need:

- a Windows PC/laptop (Windows 7 or above)
- a type A to mini-B USB cable to connect the STM32 Nucleo board to the PC when using a NUCLEO-F401RE development board
- a type A to micro-B USB cable to connect the STM32 Nucleo board to the PC when using a NUCLEO-G431RB development board
- the X-CUBE-IPS firmware and software package installed on your PC/laptop

1.7 Board setup

Step 1. Connect the mini-USB or micro-USB cable to your PC to use the X-NUCLEO-OUT16A1 with NUCLEO-F401RE or NUCLEO-G431RB development board

Step 2. Download the proper firmware (.bin) onto the STM32 Nucleo development board microcontroller through STM32 ST-LINK utility, STM32CubeProgrammer, and according with the information detailed in the table below. The X-NUCLEO-OUT16A1 can be used to control the IPS8200HQ device in three different operating modes available for the user in three different example projects: *Parallel_8_Channels* (one board configured in parallel 8 channels mode, direct pin input interface), *SPI_8_Channels* (one board configured in SPI 8 channels mode, SPI input interface) and *DaisyChain* (two stacked boards properly configured in Daisy chain mode, SPI input interface with daisy chaining). The binary files provided with the X-CUBE-IPS software package enable the user to choose the preferred control mode by selecting the binary file contained in the proper example project *Binary* folder, as reported in the following table

Table 2. Nucleo development boards binary files

Nucleo board	Binary path
NUCLEO-F401RE	Projects\STM32F401RE-Nucleo\Examples\OUT16A1\DaisyChain\Binary\DaisyChain.bin
	Projects\STM32F401RE-Nucleo\Examples\OUT16A1\Parallel_8_Channels\Binary\Parallel_8_Channels.bin
	Projects\STM32F401RE-Nucleo\Examples\OUT16A1\SPI_8_Channels\Binary\SPI_8_Channels.bin
NUCLEO-G431RB	Projects\STM32G431RB-Nucleo\Examples\OUT16A1\DaisyChain\Binary\DaisyChain.bin
	Projects\STM32G431RB-Nucleo\Examples\OUT16A1\Parallel_8_Channels\Binary\Parallel_8_Channels.bin
	Projects\STM32G431RB-Nucleo\Examples\OUT16A1\SPI_8_Channels\Binary\SPI_8_Channels.bin

Note: Additional details on each operating mode configuration are available inside the X-CUBE-IPS software package as reported in the below table:

Table 3. Additional information on board configuration

Board configuration	*Readme file*
DaisyChain	*Examples\OUT16A1\DaisyChain\readme.html*
Parallel_8_Channels	*Examples\OUT16A1\Parallel_8_Channels\readme.html*
SPI_8_Channels	*Examples\OUT16A1\SPI_8_Channels\readme.html*

Step 3. Connect the IPS8200HQ device supply voltage via CN1 (see Section 1.4: Power section).

Step 4. Provide the digital supply voltage (see Section 1.3: Digital section).

Step 5. Connect the load on the output connector (see Section 1.4: Power section).

Step 6. Reset the example sequence by pushing the black button on the STM32 Nucleo board.

Step 7. Push the blue button on the STM32 Nucleo board to choose among the examples provided in the default firmware package.

2 Schematic diagrams

Figure 5. **X-NUCLEO-OUT16A1 circuit schematic (1 of 3)**

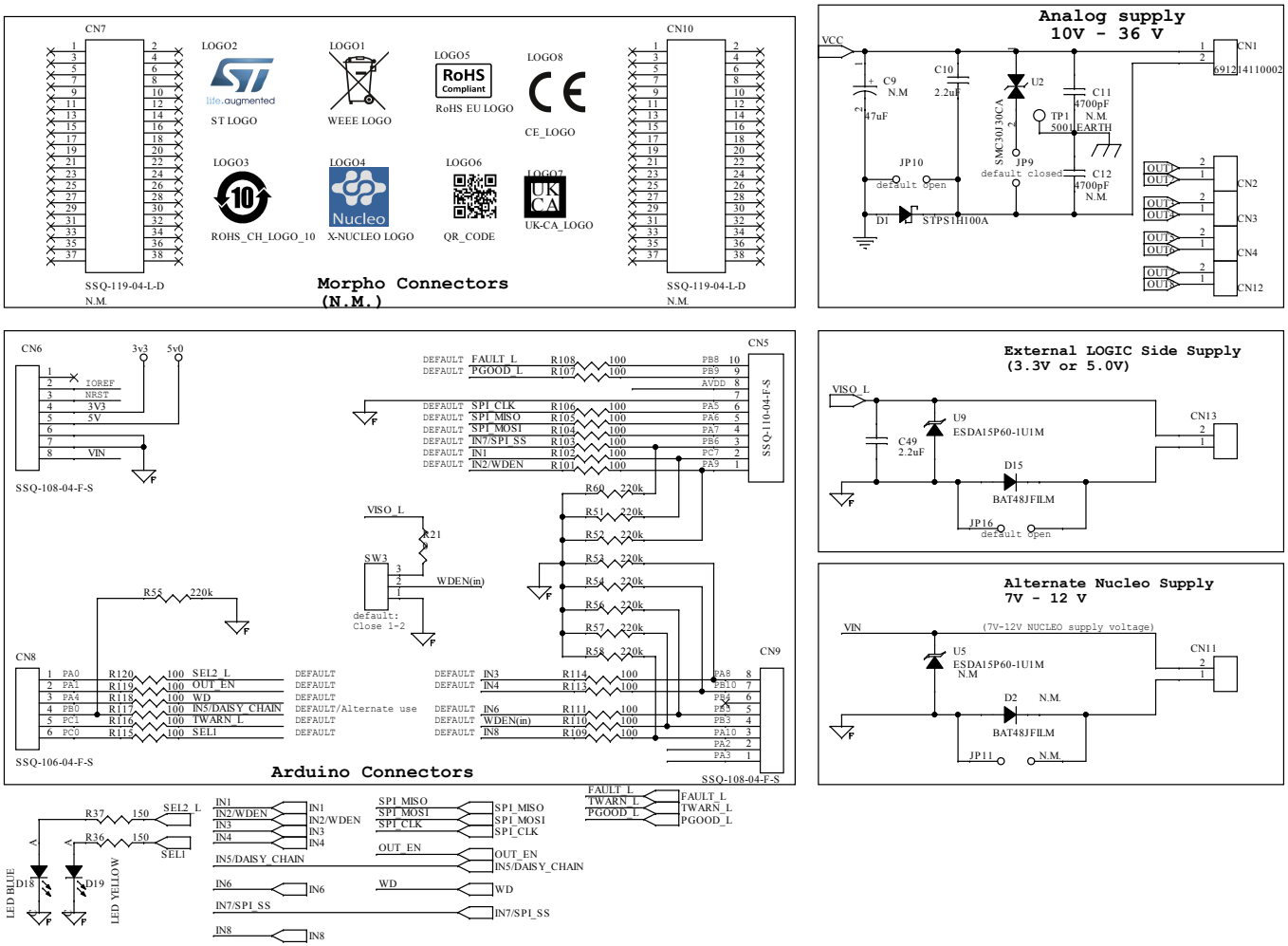


Figure 6. X-NUCLEO-OUT16A1 circuit schematic (2 of 3)

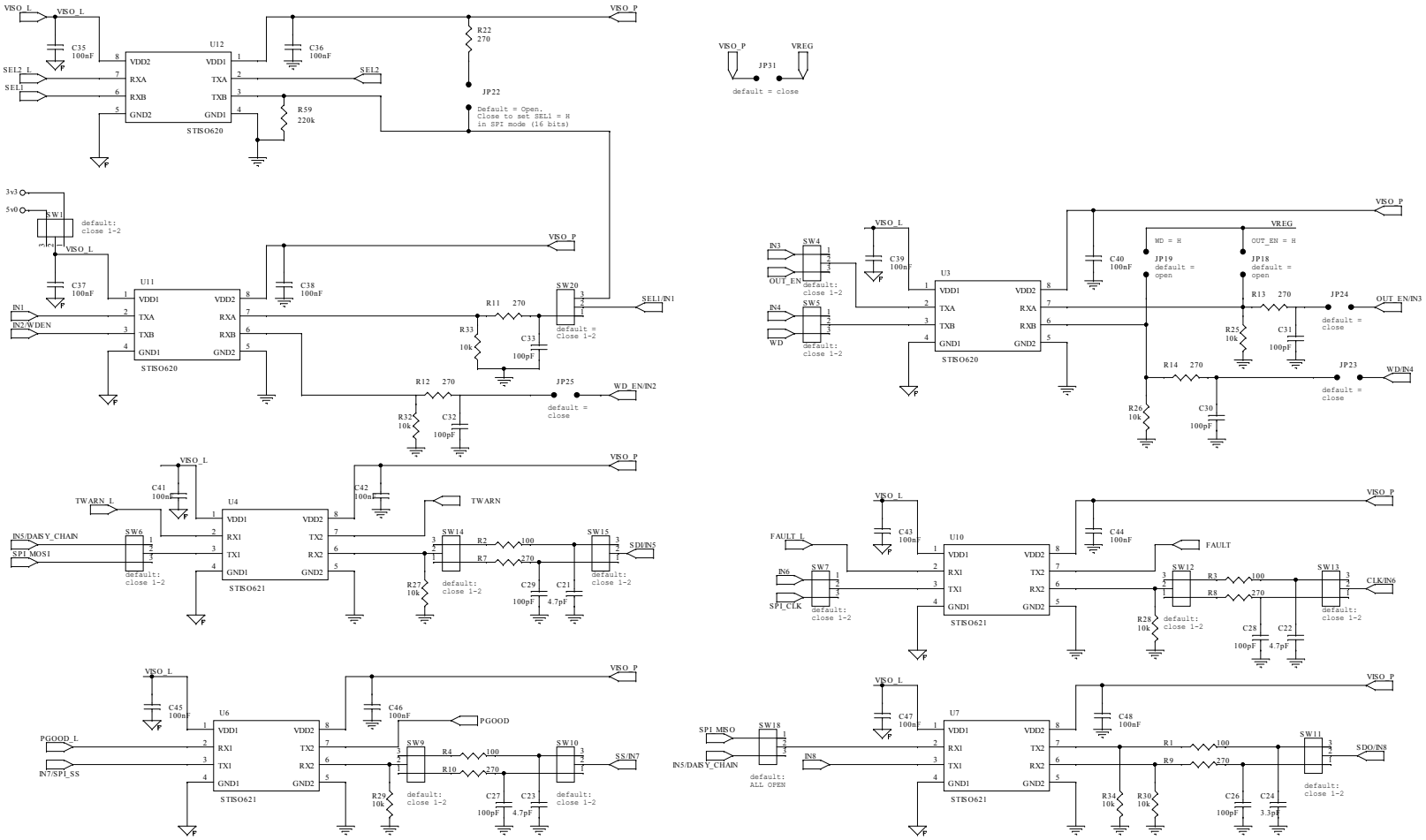
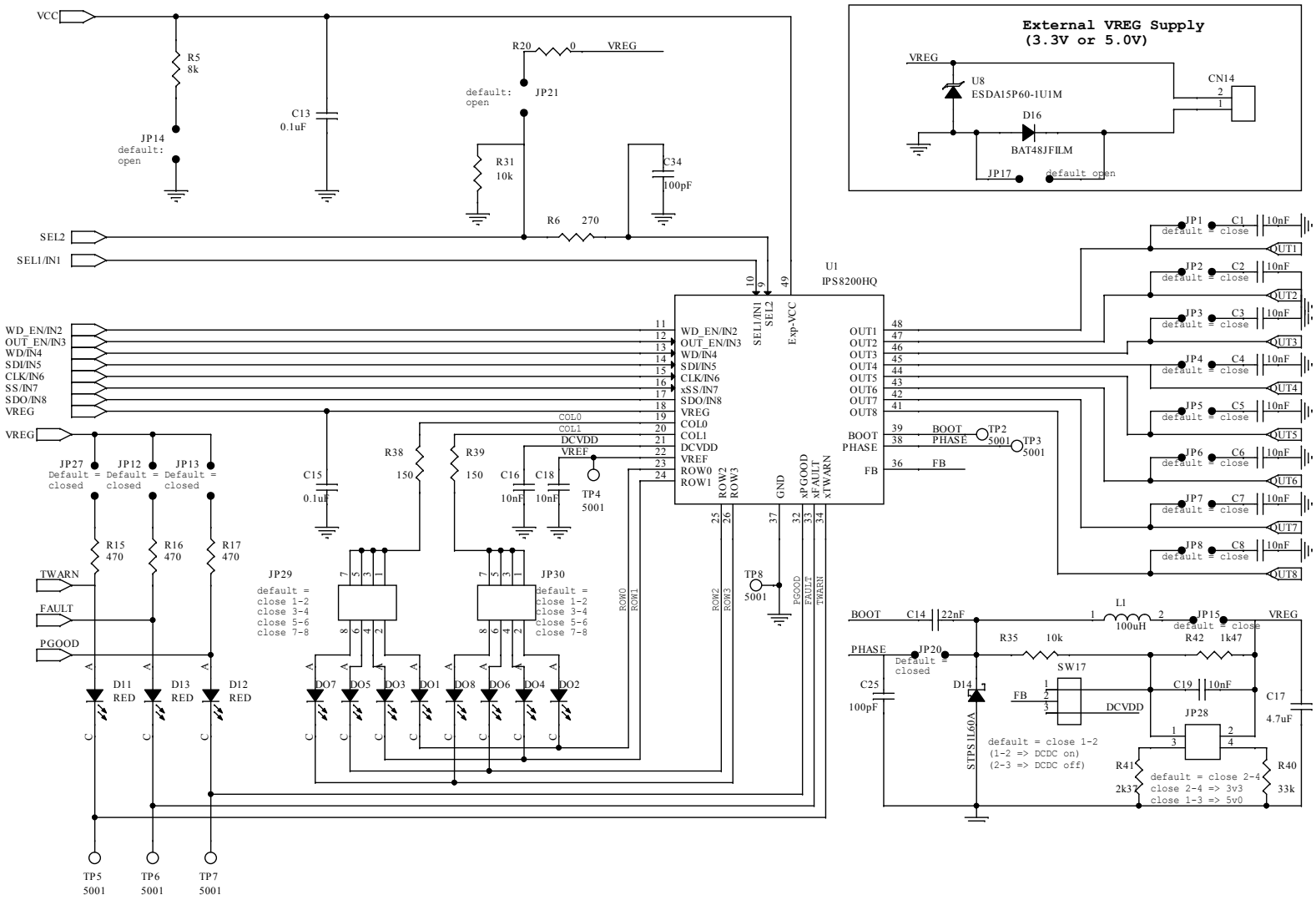


Figure 7. **X-NUCLEO-OUT16A1 circuit schematic (3 of 3)**



3 Bill of materials

Table 4. **X-NUCLEO-OUT16A1 bill of materials**

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	11	C1 C2 C3 C4 C5 C6 C7 C8 C16 C18 C19	10nF, 0603 (1608 Metric), 50V, +/-10%	CAP CER 10000PF 50V X7R 0603	Wurth Electronics Inc.	885382206002
2	2	C13 C15	0.1uF, 0805 (2012 Metric), 100V, +/-10%	CAP CER 0.1UF 100V X7R 0805	Wurth Electronics Inc.	885012207128
3	1	C14	22nF 0603 50V 10%		Wurth Electronics Inc.	885382206003
4	0	C11 C12	4700pF, 1825 (4564 Metric), 3000V (3kV), +/-10%	CAP CER 4700PF 3KV X7R 1825 (not assembled)	Vishay Vitramon	HV1825Y472KXHATHV
5	1	C17	4.7uF, 0805, 10V, +/-10%	CAP CER 4.7UF 10V X7R 0805	Wurth Electronics Inc.	885012207025
6	1	C10	2.2uF, 1210 (3225 Metric), 100V, +/-10%	CAP CER 2.2UF 100V X7R 1210	Wurth Electronics Inc.	885382209002
7	0	C9	47uF, Radial Can, 100V, +/-20%	CAP 47 UF 20% 100 V (not assembled)	Wurth Electronics Inc.	860040875002
8	3	C21 C22 C23	4.7pF, 0603, 10V, +/-10%	CAP CER 4.7PF 10V COG 0603	Wurth Electronics Inc.	885012006001
9	1	C24	3.3pF, 0603, 50V, +/-10%	CAP CER 3.3PF 50V COG 0603	Wurth Electronics Inc.	885012006048
10	10	C25 C26 C27 C28 C29 C30 C31 C32 C33 C34	100pF, 0603, 25V, +/-10%	CAP CER 100PF 25V X7R 0603	Wurth Electronics Inc.	885012206028
11	14	C35 C36 C37 C38 C39 C40 C41 C42 C43 C44 C45 C46 C47 C48	100nF, 0603, 10V, +/-10%	CAP CER 0.1UF 10V X7R 0603	Wurth Electronics Inc.	885012206020
12	1	C49	2.2uF, 0603, 10V, +/-10%	CAP CER 2.2UF 10V X7R 0603	Wurth Electronics Inc.	885012206027
13	7	CN1 CN2 CN3 CN4 CN11 CN12 CN13 CN14	691214110002, 7.4X7, pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB	Wurth Electronics Inc.	691214110002
14	0	CN11	691214110002, 7.4X7, pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB	Wurth Electronics Inc.	691214110002
15	1	CN5	10 ways, 1 row	CONN RCPT 10POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-110-14-T-S 17896
16	2	CN6 CN9	8 ways, 1row	CONN RCPT 8POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-108-14-T-S 15782

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
17	0	CN7 CN10		CONN RCPT 38POS 0.1 GOLD PCB (not assembled)	Samtec Inc.	SSQ-119-04-L-D
18	1	CN8	6 ways, 1 row	CONN RCPT 6POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-106-04-T-S 15781
19	8	DO1 DO2 DO3 DO4 DO5 DO6 DO7 DO8	150060VS75000, 0603 (1608 Metric), 20mA	LED GREEN CLEAR 0603 SMD	Wurth Electronics Inc.	150060VS75000
20	1	D1	STPS1H100A or STPS1H100AFN, DO-214AC, SMA Flat Notch, 1A	DIODE SCHOTTKY 100V 1A SMA	ST	STPS1H100A STPS1H100AFN
21	3	D11 D12 D13	RED, 0603 (1608 Metric), 20mA	LED RED CLEAR 0603 SMD	Wurth Electronics Inc.	150060RS75000
22	1	D14	STPS1L60A DO-214AC, SMA, 1A	STMicroelectronics	ST	STPS1L60A
23	2	D15 D16	BAT48JFILM SC-76, SOD-323, 750mV @ 200mA 350mA (DC)	DIODE SCHOTTKY 40V 350MA SOD323	ST	BAT48JFILM
24	0	D2	BAT48JFILM SC-76, SOD-323, 750mV @ 200mA 350mA (DC)	DIODE SCHOTTKY 40V 350MA SOD323 (not assembled)	ST	BAT48JFILM
25	1	D18	BLUE, 0402, 20mA	LED LIGHT BLUE 0402 SMD	Wurth Electronics Inc.	150040BS73220
26	1	D19	YELLOW, 0402, 20mA	LED LIGHT YELLOW 0402 SMD	Wurth Electronics Inc.	150040YS73220
27	26	JP1 JP2 JP3 JP4 JP5 JP6 JP7 JP8 JP9 JP10 JP12 JP13 JP14 JP15 JP16 JP17 JP18 JP19 JP20 JP21 JP22 JP23 JP24 JP25 JP27 JP31	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS	Wurth Electronics Inc.	61300211121
28	0	JP11	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS (not assembled)	Wurth Electronics Inc.	61300211121

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
29	1	JP28	con4-2x2-strip-male	CONN HEADER .100 DUAL STR 4POS	Wurth Electronics Inc.	61300421121
30	2	JP29 JP30	con8-2x4-strip-male	CONN HEADER .100 DUAL STR 8POS	Wurth Electronics Inc.	61300821121
31	1	L1	100uH indm1030x1030 x300l180x460	INDUCTOR 100UH 1A 470MΩ	Wurth Electronics Inc.	744065101
32	24	R1 to R4 R101 to R111, R113 to R120	100Ω, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 100 Ω 1% 1/10W 0603	Yageo	RC0603FR-07100RP
33	1	R5	8kΩ, 0603, 0.1W, 1/10W	RES SMD 8k Ω 1% 1/10W 0603	Vishay	PLTU0603U8001LST5
34	10	R6 to R14, R22	270 Ω, 0603, 0.1W, 1/10W	RES SMD 270 Ω 1% 1/10W 0603	Vishay	CRCW0603270RJNECC
35	3	R15 R16 R17	470 Ω, 0603, 0.1W, 1/10W	RES SMD 470 Ω 1% 1/10W 0603	Vishay	CRCW0603470RJNEBC
36	2	R20 R21	0 Ω, 0603, 0.1W, 1/10W	RES SMD 0 Ω 1% 1/10W 0603	Yageo	RC0603JR-070RL
37	11	R25 to R35	10kΩ, 0603, 0.1W, 1/10W	RES SMD 10k Ω 1% 1/10W 0603	Bourns	CR0603-JW-103ELF
38	4	R36 R37 R38 R39	150 Ω, 0603, 0.1W, 1/10W	RES SMD 150 OHM 1% 1/10W 0603	Bourns	CR0603-FX-1500ELF
39	1	R40	33kΩ 0603 0.1W, 1/10W	RES SMD 33k Ω 1% 1/10W 0603	Bourns	CR0603-JW-333ELF
40	1	R41	2.37kΩ, 0603, 0.1W, 1/10W	RES SMD 2.37k Ω 1% 1/10W 0603	Bourns	CR0603-FX-2371ELF
41	1	R42	1.47kΩ, 0603, 0.1W, 1/10W	RES SMD 1.47k Ω 1% 1/10W 0603	Bourns	CR0603-FX-1471ELF
42	16	SW1 SW3 SW4 SW5 SW6 SW7 SW9 SW10 SW11 SW12 SW13 SW14 SW15 SW17 SW18 SW20	con3-strip-male	CONN HEADER .100 STR 3POS	Wurth Electronics Inc.	61300311121
43	8	TP1 TP2 TP3 TP4 TP5 TP6 TP7 TP8	5001, 0.100" Dia x 0.180" L (2.54mm x 4.57mm)	TEST POINT PC MINI .040"D BLACK	Keystone Electronics	5001
44	1	U1	IPS8200HQ QFN48L 8x6 mm (opt A)	8 channel/0.5A high side driver	ST	IPS8200HQ

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
45	3	U3 U11 U12	STISO620 SOIC8P127_490X600X175L83X42N	Digital Isolator 2ch unidirectional	ST	STISO620
46	4	U4 U6 U7 U10	STISO621 SOIC8P127_490X600X175L83X42N	Digital Isolator 2ch bidirectional	ST	STISO621
47	2	U8 U9	ESDA15P60-1U1M 2-UDFN	TVS DIODE 13.2V 22.7V 1610	ST	ESDA15P60-1U1M
48	0	U5	ESDA15P60-1U1M 2-UDFN	TVS DIODE 13.2V 22.7V 1610 (not assembled)	ST	ESDA15P60-1U1M
49	1	U2	SMC30J30CA	TVS DIODE 33.3V 48.7V SMC	ST	SMC30J30CA
50	55	No Reference	jumper close 2.54mm jumper close 2.54mm	jumper close 2.54mm	Wurth Electronics Inc.	60900213421
51	10	R51 R52 R53 R54 R55 R56 R57 R58 R59 R60	220kΩ, 0603, 0.1W, 1/10W	RES SMD 220kΩ 1% 1/10W 0603	ANY	ANY

4 Board versions

Table 5. **X-NUCLEO-OUT16A1 versions**

Finished good	Schematic diagrams	Bill of materials
X$NUCLEO-OUT16A1 (1)	X$NUCLEO-OUT16A1 schematic diagrams	X$NUCLEO-OUT16A1 bill of materials

1. *This code identifies the X-NUCLEO-OUT16A1 evaluation board first version.*

5 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).

6 References

Freely available on www.st.com:

- IPS8200HQ datasheet
- UM3035: "Getting started with X-CUBE-IPS industrial digital output software for STM32 Nucleo"
- NUCLEO-F401RE documentation
- NUCLEO-G431RB documentation

Revision history

Table 6. **Document revision history**

Date	Revision	Changes
09-Nov-2023	1	Initial release.
24-Apr-2024	2	Updated Introduction, Section 1.2: Board configuration and Section 1.7: Board setup.

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