

Getting started with the X-NUCLEO-OUT01A2 industrial digital output expansion board for STM32 Nucleo

Introduction

The **X-NUCLEO-OUT01A2** is an industrial digital output expansion board for **STM32 Nucleo**. It provides a powerful and flexible environment for the evaluation of the driving and diagnostic capabilities of the **ISO8200BQ** octal high-side smart power solid state relay, with embedded galvanic isolation, in a digital output module connected to 0.7 A industrial loads.

The **X-NUCLEO-OUT01A2** directly interfaces with the microcontroller on the STM32 Nucleo driven by GPIO pins and Arduino® R3 connectors.

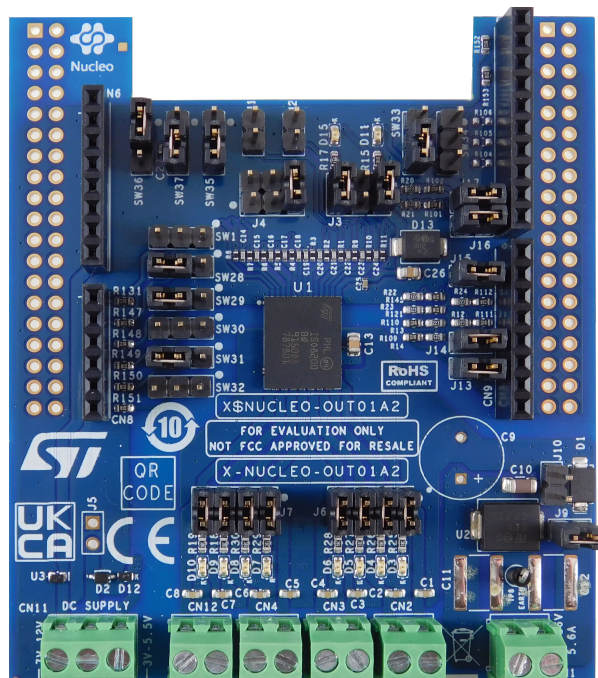
The galvanic isolation between the microcontroller and the process stage is guaranteed by the **ISO8200BQ**.

The expansion board can be connected to either a **NUCLEO-F401RE** or a **NUCLEO-G431RB** development board.

It is also possible to evaluate a system composed of a **X-NUCLEO-OUT01A2** stacked on other expansion boards.

The board can be configured as the former **X-NUCLEO-OUT01A1** by a set of jumpers (open: J13, J14, J15, J16, J17) and switches (close 1-2: SW1, SW28, SW29, SW30, SW31, SW32, SW33, SW35, SW37). In this case, the driving firmware can be only the **X-CUBE-OUT1** and the board can be connected to the **X-NUCLEO-PLC01A1** to form a powerful industrial PLC with 8 inputs and 16 outputs. Also, wireless communication capabilities can be added with the **X-NUCLEO-IDW01M1**, which establishes communication on a smart device to manage the PLC remotely. A dedicated ST-PLC app is available for Android™ and iOS™ systems for this purpose.

Figure 1. X-NUCLEO-OUT01A2 expansion board



1 Getting started

1.1 Overview

The X-NUCLEO-OUT01A2 embeds the ISO8200BQ intelligent power switch (IPS), which features galvanic isolation, 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.

The galvanic isolation embedded by the ISO8200BQ satisfies this requirement, avoiding the necessity of external optocouplers, with a consequent cost saving and a reduced application size.

The expansion board features:

- Based on the ISO8200BQ octal high-side switch, which features:
 - Operating range 10.5 to 36 V
 - Low power dissipation ($R_{ON(MAX)} = 240\text{ m}\Omega$)
 - Process side operating current: up to 0.7 A per channel
 - Embedded 2.5k V_{RMS} galvanic isolation
 - Direct (jitter < 20us) and synchronous (jitter < 6us) control modes
 - Fast decay for inductive loads
 - Undervoltage lock-out
 - Overload and overtemperature protections
 - Loss of ground protection
 - TFQFPN32 package
- Application board process side operating range: 11 (J10 open) to 33 V (J9 closed)
- Extended operating range of process side from 10.5 (J10 closed) up to 36 V (J9 open)
- Application board logic side operating voltage 3.3 to 5 V
- Green LEDs for outputs on/off status (J6 and J7 close 1-2, 3-4, 5-6, 7-8)
- Red LED for common overheating and communication error diagnostic (J3 close 1-2)
- Yellow LED for output enable status signalization (J3 close 5-6)
- Direct control mode (J1 and J2 closed, SW37 close 2-3, SW36 close 1-2)
- Synchronous control mode (J1 and J2 open, SW37 close 2-3, SW36 close 2-3)
- Process and logic supply rails reverse polarity protections
- Compatible with STM32 Nucleo development boards
- Equipped with Arduino® UNO R3 connectors
- RoHS and China RoHS compliant
- CE certified
- Radiated emission: class B according to the standard EN 55032

1.2 Board configuration

A set of jumpers and switches is available to configure the board. The Table 1 shows the standard configuration, whereas the Table 2 shows how to configure the board to maintain the hardware compatibility with the previous version. At last, in Table 3 is reported a list of switch and jumpers which configuration is common for both version

Table 1. X-NUCLEO-OUT01A2

Jumpers / Switches	Default configuration
SW1, SW30, SW32, SW34	all open
SW28, SW29, SW31, SW33, SW35, SW37	close 2-3
J13, J14, J15, J16, J17	close

Table 2. X-NUCLEO-OUT01A1

Jumpers / Switches	Default configuration
SW1, SW28, SW29, SW30, SW31, SW32, SW33, SW34, SW35, SW37	close 1-2
J13, J14, J15, J16, J17	open

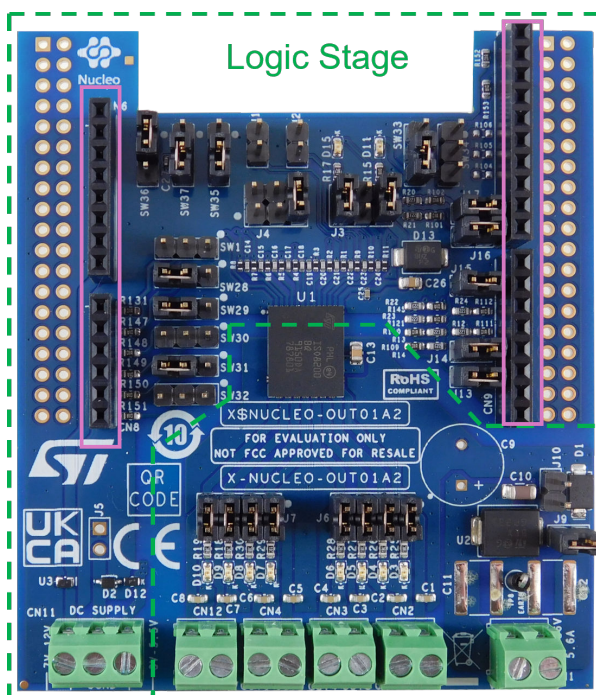
Table 3. A1 and A2 version

Jumpers / Switches	Default configuration
SW36	close 1-2
J1, J2, J10	open
J3	close 1-2, 5-6
J4	close 5-6
J6, J7	close 1-2, 3-4, 5-6, 7-8
J9	close

1.3 Digital section

The digital section is associated with the STM32 interface and the digital supply voltage to and from the X-NUCLEO-OUT01A2 expansion board.

Figure 2. X-NUCLEO-OUT01A2 expansion board: digital interface section



The dotted green line indicates the whole digital interface section. The pink rectangles identify the Arduino® UNO R3 connectors.

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-OUT01A2** expansion board, in either direction.

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 J5 (without reverse polarity). In this scenario, the logic side of the **ISO8200BQ** can be supplied by the 3.3 V supply rail generated by the expansion board: in this case, on the **X-NUCLEO-OUT01A2**, J4 must be closed between pins 5 and 6.

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**.

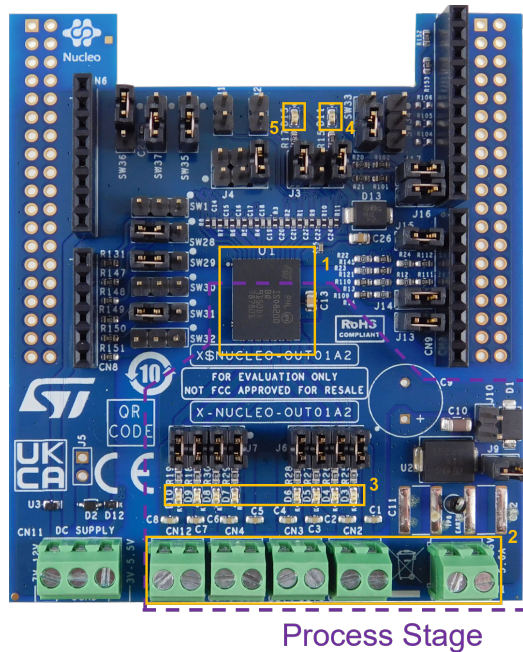
The pin 3 of the connector CN11 can be used to supply the logic side of the **ISO8200BQ** independently by the expansion board. In this case, on the **X-NUCLEO-OUT01A2**, the pins 1 and 2 of J4 must be closed (pins 5-6 open).

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-OUT01A2 expansion board: power section

1. ISO8200BQ
2. Output and power supply connector
3. Output channels - green LEDs
4. Status (overtemperature) red LED
5. Output Enable yellow LED



Process Stage

For EMC:

- the **SM15T39CA** transient voltage suppressor (U2), enabled by closing J9, is placed between V_{CC} and GND tracks to protect the **ISO8200BQ** against surge discharge on the supply rail path up to $\pm 1 \text{ kV}/2 \Omega$ coupling;
- in the common mode surge testing, two single-layer capacitors (C11 and C12 - not included) must be soldered at the predisposed locations;
- the **ISO8200BQ** 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-OUT01A2** is detailed below:

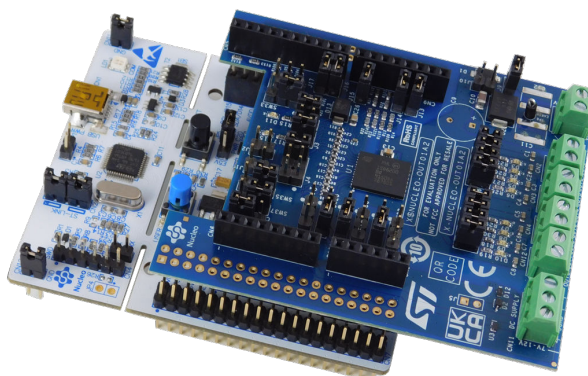
- for emission (when the DC input port of the board is powered by an AC-DC, DC-DC or battery with a cable that does not exceed a three-meter length), compliance with standards:
 - EN IEC 61000-6-3:2021
 - EN 55032:2015 +A1:2020
- for immunity, compliance with standards:
 - EN IEC 61000-6-1:2019
 - EN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

1.5 Hardware requirements

The X-NUCLEO-OUT01A2 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT01A2 must be plugged onto the matching Arduino® UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-OUT01A2 and STM32 Nucleo stack



1.6 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT01A2 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

If the board is configured as [X-NUCLEO-OUT01A1](#), refer to [UM2209](#) and [X-CUBE-OUT1](#) as the control firmware. When the board is configured as [X-NUCLEO-OUT01A2](#), refer to the following steps:

- Step 1.** Connect the mini-USB or micro-USB cable to your PC to use the [X-NUCLEO-OUT01A2](#) with [NUCLEO-F401RE](#) or [NUCLEO-G431RB](#) development board
- Step 2.** Download the firmware (.bin) provided with the [X-CUBE-IPS](#) software package as detailed in [Table 4](#). The [X-NUCLEO-OUT01A2](#) must be configured coherently to the selected control mode for [ISO8200BQ](#) through SW37 and SW36. These switches define the level of ISO_DRV signal: according to the level of this signal (high or low), the firmware will properly manage respectively the synchronous or the direct control mode.

Table 4. Nucleo development boards binary files

Nucleo board	Binary path
<i>NUCLEO-F401RE</i>	Projects\STM32F401RE-Nucleo\Examples\OUT01A2\EightChannels\Binary\EightChannels.bin
<i>NUCLEO-G431RB</i>	Projects\STM32G431RB-Nucleo\Examples\OUT01A2\EightChannels\Binary\EightChannels.bin

- Step 3.** Connect the [ISO8200BQ](#) 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-OUT01A2 circuit schematic (1 of 2)

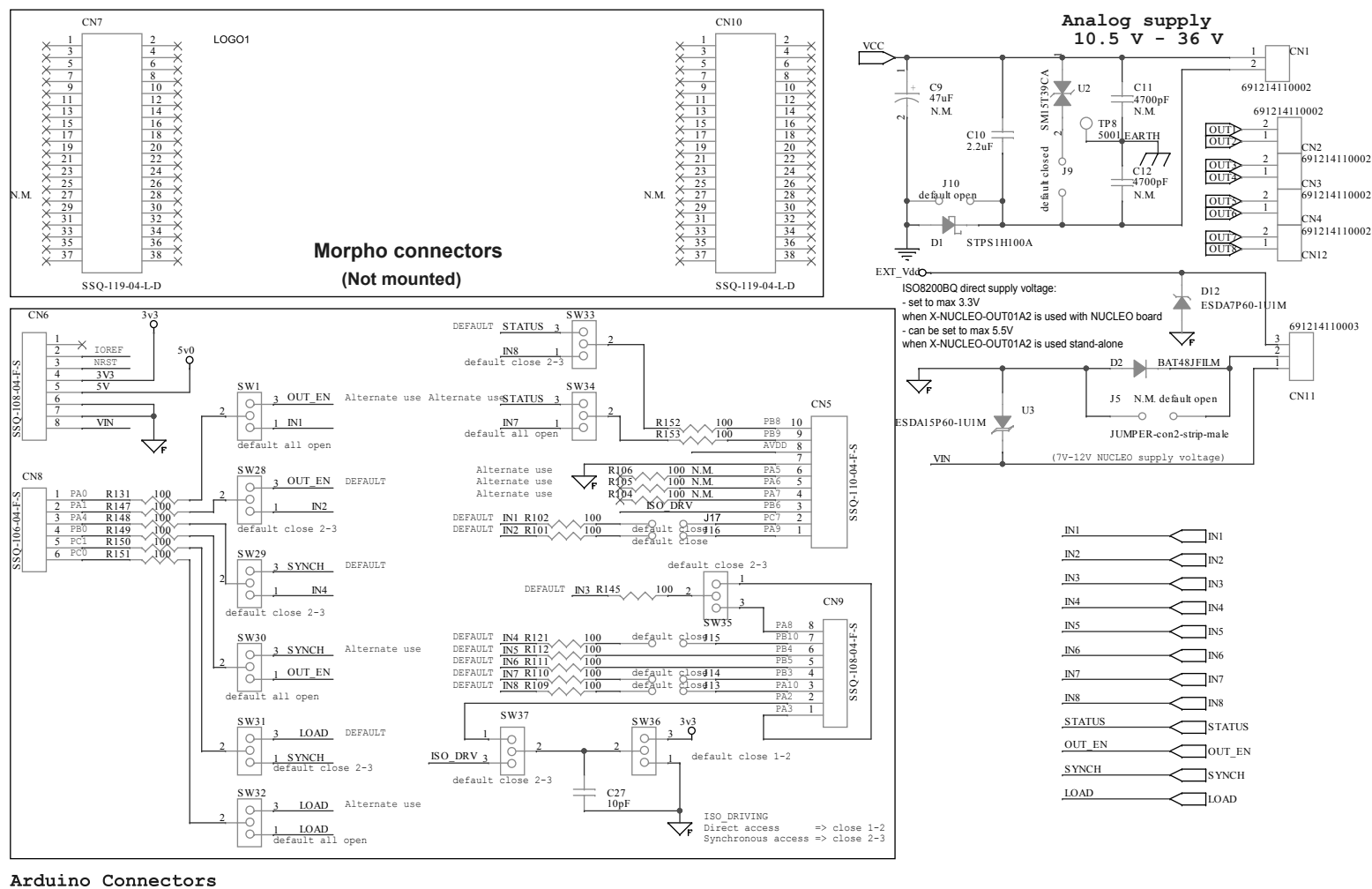
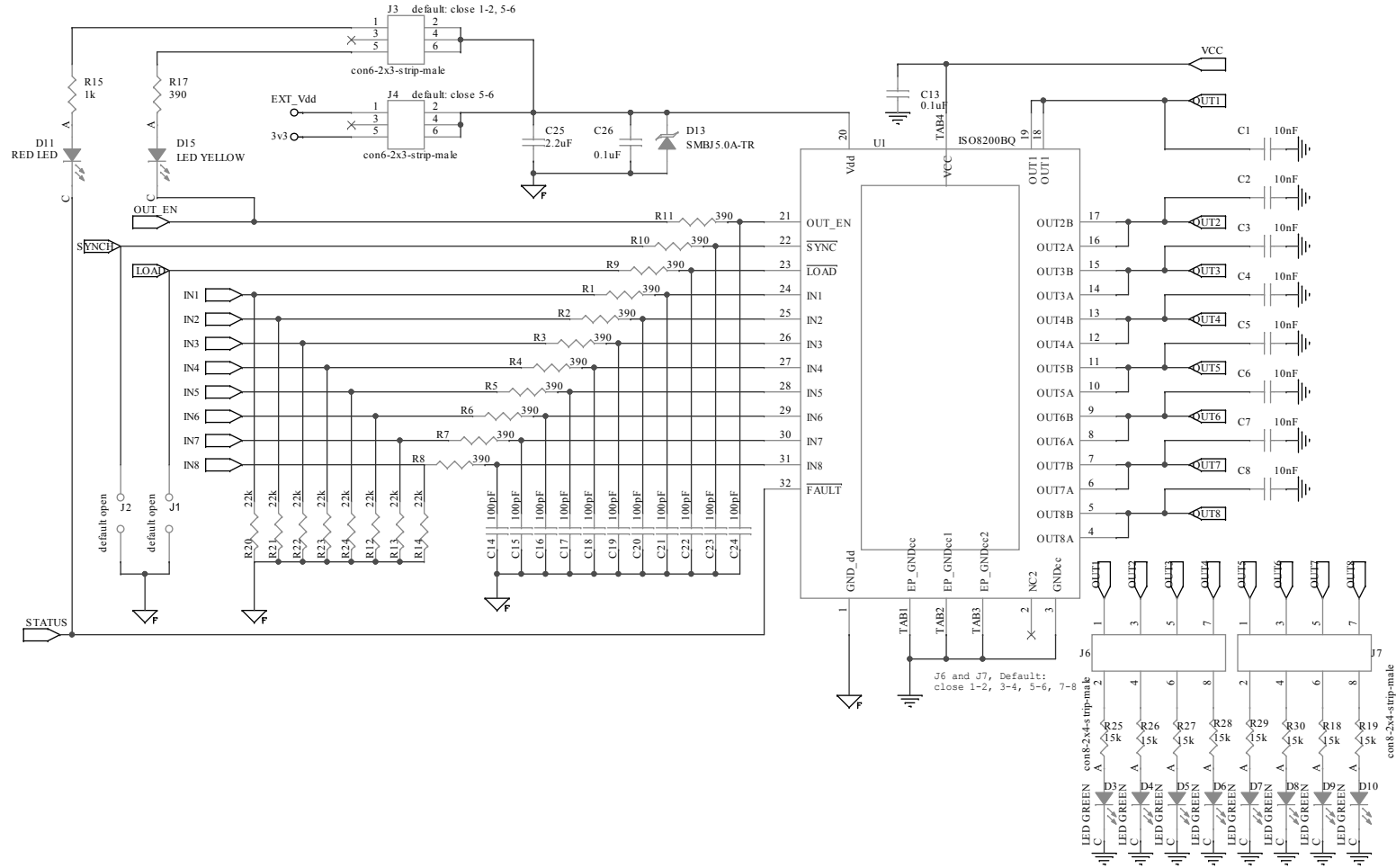


Figure 6. X-NUCLEO-OUT01A2 circuit schematic (2 of 2)



3 Bill of materials

Table 5. X-NUCLEO-OUT01A2 bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	8	C1 C2 C3 C4 C5 C6 C7 C8	10nF	CAP CER 10000PF 50V X7R 0603	Würth Electronics Inc.	885382206002
2	0	C9	47uF	CAP 47 UF 20% 100 V	Würth Electronics Inc.	860040875002
3	1	C10	2.2uF	CAP CER 2.2UF 100V X7R 1206	AVX Corporation	12061C225KAT 2A
4	0	C11 C12	4700pF	CAP CER 4700PF 3KV X7R 1825	Vishay Vitramon	HV1825Y472KX HATHV
5	2	C13 C26	0.1uF	CAP CER 0.1UF 100V X7R 0805	Würth Elektronik	885012207128
6	11	C14 C15 C16 C17 C18 C19 C20 C21 C22 C23 C24	100pF	CAP CER 100PF 10V C0G/NP0 0402	Würth Electronics Inc.	885012005013
7	1	C25	2.2uF	CAP CER 2.2UF 10V X5R 0402	Würth Electronics Inc.	885012105013
8	1	C27	10pF	CAP CER 10PF 10V C0G/NP0 0402	Würth Electronics Inc.	885012005007
9	5	CN1 CN2 CN3 CN4 CN12	691214110002	TERM BLK 2POS SIDE ENT 3.5MM PCB	Würth Electronics Inc.	691214110002
10	1	CN5	10 ways, 1 row	CONN RCPT 10POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-110-14-T- S 17896
11	2	CN6 CN9	8 ways, 1 row	CONN RCPT 8POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-108-14-T- S 15782
12	0	CN7 CN10	SSQ-119-04-L- D	CONN RCPT 38POS 0.1 GOLD PCB	Samtec Inc.	SSQ-119-04-L- D
13	1	CN8	6 ways, 1 row	CONN RCPT 6POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-106-04-T- S 15781
14	1	CN11	691214110003	TERM BLK 3POS SIDE ENT 3.5MM PCB	Würth Electronics Inc.	691214110003
15	1	D1	STPS1H100A, SMA	DIODE SCHOTTKY 100V 1A SMA	STMicroelectron ics	STPS1H100A
16	1	D2	BAT48JFILM, SOD323	DIODE SCHOTTKY 40V 350MA SOD323	STMicroelectron ics	BAT48JFILM

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
17	8	D3 D4 D5 D6 D7 D8 D9 D10	LED GREEN	LED GREEN CLEAR 0603 SMD	Würth Electronics Inc.	150060VS7500 0
18	1	D11	RED LED	LED RED CLEAR 0603 SMD	Würth Electronics Inc.	150060RS7500 0
19	1	D12	ESDA7P60-1U1 M, QFN-2L	TVS DIODE 5VWM 11.6VCL 1610	STMicroelectron ics	ESDA7P60-1U1 M
20	1	D13	SMBJ5.0A-TR, QFN-2L	TVS DIODE 5V 13.4V SMB	STMicroelectron ics	SMBJ5.0A-TR
21	1	D15	LED YELLOW	LED YELLOW CLEAR 0603 SMD	Würth Electronics Inc.	150060YS7500 0
22	9	J1 J2 J9 J10 J13 J14 J15 J16 J17	JUMPER-con2- strip-male	JUMPER- CONN HEADER .100 STR 2POS	Würth Electronics Inc	61300211121
23	0	J5	JUMPER-con2- strip-male	JUMPER- CONN HEADER .100 STR 2POS	Würth Electronics Inc	61300211121
24	2	J3 J4	con6-2x3-strip- male	CONN HEADER .100 DUAL STR 6POS	Würth Electronics Inc.	61300621121
25	2	J6 J7	con8-2x4-strip- male	CONN HEADER VERT 8POS 2.54MM	Würth Electronics Inc.	61300821121
26	11	R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11	390	CHIP RESISTOR SMD 5% 1/10W 0402	Panasonic	ERJH2GJ391X
27	8	R12 R13 R14 R20 R21 R22 R23 R24	22k	RES SMD 22K OHM 1% 1/10W 0603	Yageo	RC0603FR-072 2KL
28	1	R15	1k	RES SMD 1K OHM 1% 1/10W 0603	Yageo	RC0603FR-071 KL
29	1	R17	390	RES SMD 390 OHM 1% 1/10W 0603	Yageo	RC0603FR-073 90RL
30	8	R18 R19 R25 R26 R27 R28 R29 R30	15k	RES SMD 15K OHM 1% 1/10W 0603	Yageo	RC0603FR-071 5KL
31	16	R101 R102 R109 R110 R111 R112 R121 R131 R145 R147 R148 R149 R150 R151 R152 R153	100	RES SMD 100 OHM 1% 1/10W 0603	Yageo	RC0603FR-071 00RP
32	0	R104 R105 R106	100	RES SMD 100 OHM 1% 1/10W 0603	Yageo	RC0603FR-071 00RP

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
33	11	SW1 SW28 SW29 SW30 SW31 SW32 SW33 SW34 SW35 SW36 SW37	con3-strip-male	CONN HEADER .100 STR 3POS	Würth Elektronik	61300311121
34	1	TP8	5001	TEST POINT PC MINI .040"D BLACK	Keystone Electronics	5001
35	1	U1	ISO8200BQ, TFQFPN 11.0X9.0X1.05 32L	Galvanic isolated octal high side smart power solid state relay with parallel interface	STMicroelectron ics	ISO8200BQTR
36	34	N/A		Close jumper	Würth Electronics Inc.	60900213421
37	1	U2	SM15T39CA, SMC	TVS DIODE 33.3V 69.7V SMC	STMicroelectron ics	SM15T39CA
38	1	U3	ESDA15P60-1U 1M, QFN-2L	TVS DIODE 13.2V 22.7V 1610	STMicroelectron ics	ESDA15P60-1U 1M

4 Board versions

Table 6. X-NUCLEO-OUT01A2 versions

PCB version	Schematic diagrams	Bill of materials
X\$NUCLEO-OUT01A2 ⁽¹⁾	X\$NUCLEO-OUT01A2 schematic diagrams	X\$NUCLEO-OUT01A2 bill of materials

1. This code identifies the X-NUCLEO-OUT01A2 evaluation board first version. It is printed on the board PCB.

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.

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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:

- [ISO8200BQ datasheet](#)
- [UM3035: "Getting started with X-CUBE-IPS industrial digital output software for STM32 Nucleo"](#)
- [NUCLEO-F401RE documentation](#)
- [NUCLEO-G431RB documentation](#)

Revision history

Table 7. Document revision history

Date	Revision	Changes
04-Jul-2023	1	Initial release.

Contents

1	Getting started	2
1.1	Overview	2
1.2	Board configuration	3
1.3	Digital section	4
1.4	Power section	5
1.5	Hardware requirements	6
1.6	System requirements	6
1.7	Board setup	7
2	Schematic diagrams	8
3	Bill of materials	10
4	Board versions	13
5	Regulatory compliance information	14
6	References	15
	Revision history	16
	List of tables	18
	List of figures	19

List of tables

Table 1.	X-NUCLEO-OUT01A2	3
Table 2.	X-NUCLEO-OUT01A1	3
Table 3.	A1 and A2 version	3
Table 4.	Nucleo development boards binary files	7
Table 5.	X-NUCLEO-OUT01A2 bill of materials	10
Table 6.	X-NUCLEO-OUT01A2 versions	13
Table 7.	Document revision history	16

List of figures

Figure 1.	X-NUCLEO-OUT01A2 expansion board.	1
Figure 2.	X-NUCLEO-OUT01A2 expansion board: digital interface section	4
Figure 3.	X-NUCLEO-OUT01A2 expansion board: power section	5
Figure 4.	X-NUCLEO-OUT01A2 and STM32 Nucleo stack.	6
Figure 5.	X-NUCLEO-OUT01A2 circuit schematic (1 of 2)	8
Figure 6.	X-NUCLEO-OUT01A2 circuit schematic (2 of 2)	9

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