

Getting started with the X-NUCLEO-OUT09A1 industrial digital output expansion board for STM32 Nucleo

Introduction

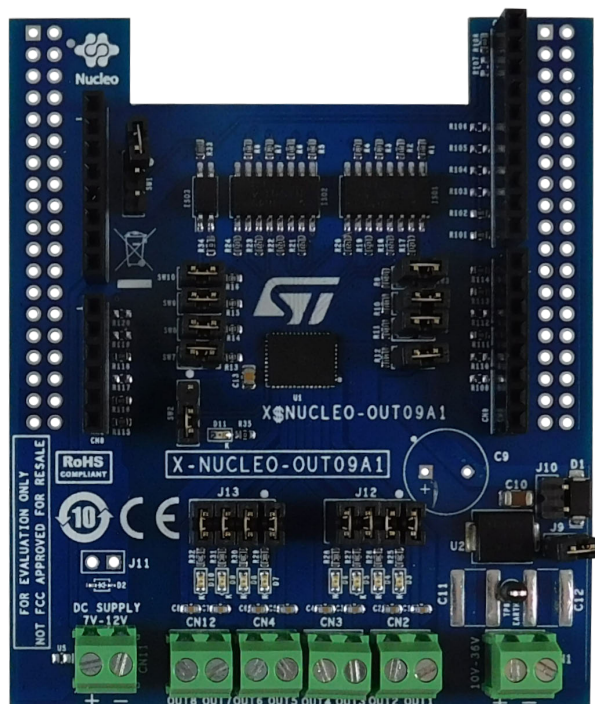
The **X-NUCLEO-OUT09A1** industrial digital output expansion board for **STM32 Nucleo** provides a powerful and flexible environment for the evaluation of the driving and diagnostic capabilities of the **IPS8160HQ** octal high-side smart power solid state relay, in a digital output module connected to 0.7 A industrial loads.

The **X-NUCLEO-OUT09A1** interfaces with the microcontroller on the STM32 Nucleo via 3 kV and 3.7 kV optocouplers driven by GPIO pins and Arduino® R3 connectors.

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-OUT09A1** stacked on other expansion boards.

Figure 1. X-NUCLEO-OUT09A1 expansion board



1 Getting started

1.1 Overview

The [X-NUCLEO-OUT09A1](#) embeds the [IPS8160HQ](#) intelligent power switch (IPS), which features 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 optocouplers (ISO1, ISO2, ISO3) for the input signals forward to the device and the status cumulative diagnostic feedback signal of the device.

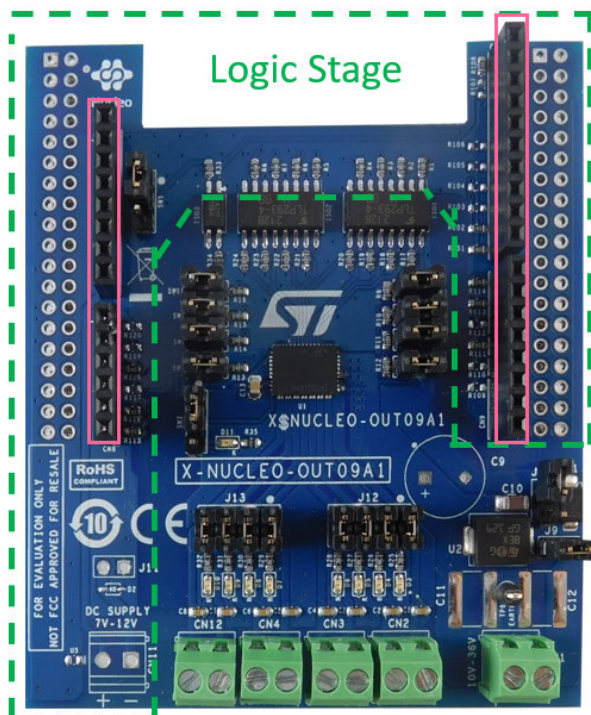
The expansion board features:

- Based on the [IPS8160HQ](#) octal high-side switch, which features:
 - Operating range 10.5 to 36 V
 - Low power dissipation ($R_{ON(MAX)} = 280\text{ m}\Omega$)
 - Fast decay for inductive loads
 - Undervoltage lock-out
 - Overload and overtemperature protections
 - Loss of ground protection
 - QFN48L 8x6 mm package
- Application board voltage operating range: 15 to 33 V
- Extended voltage operating range (J9 open) up to 36 V
- Operating current: up to 0.7 A per channel
- Green LEDs for outputs on/off status (J12 and J13 close 1-2, 3-4, 5-6, 7-8)
- Red LED for common overheating diagnostic (SW2 close 2-3)
- 3 kV galvanic isolation
- 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 Digital section

The digital section is associated with the STM32 interface and the digital supply voltage to and from the X-NUCLEO-OUT09A1 expansion board.

Figure 2. X-NUCLEO-OUT09A1 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 board microcontroller accessing the STM32 peripheral and GPIO resources;
- provide the digital supply voltage between the **STM32 Nucleo** development board and the **X-NUCLEO-OUT09A1** expansion board, in either direction.

Usually, the **STM32 Nucleo** development board supplies the expansion board by a 3v3 or 5v0 generated by the USB. You can select the preferred voltage on the expansion board via SW3 (3v3 closing pins 1-2; 5v0 closing pins 2-3).

Alternatively, it is possible to supply the **STM32 Nucleo** development board by 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 J11 (without reverse polarity).

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

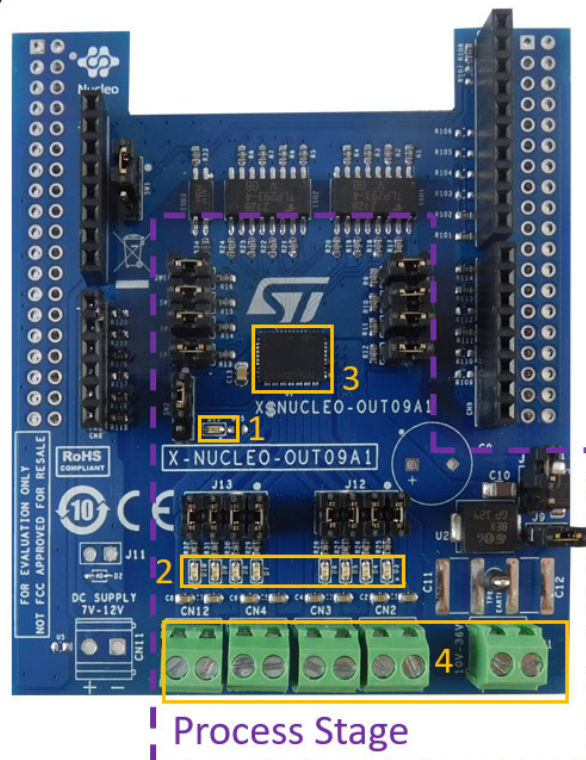
- close the JP5 jumper between pins 2 and 3 and open the JP1 jumper on the **NUCLEO-F401RE**;
- open the JP5 jumper between pins 1 and 2 and close the JP5 jumper between pins 3 and 4 on the **NUCLEO-G431RB**.

1.3 Power section

The power section involves the power supply voltage (CN1, pin 1 for VCC, 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-OUT09A1 expansion board: power section components

1. Status (overtemperature) red LED
2. Output channels - green LEDs
3. [IPS8160HQ](#)
4. Output and power supply connector



For EMC:

- the [SM15T39CA](#) transient voltage suppressor (U2), enabled by closing J9, is placed between VCC and GND tracks to protect the [IPS8160HQ](#) 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 [IPS8160HQ](#) 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-OUT09A1](#) is detailed below:

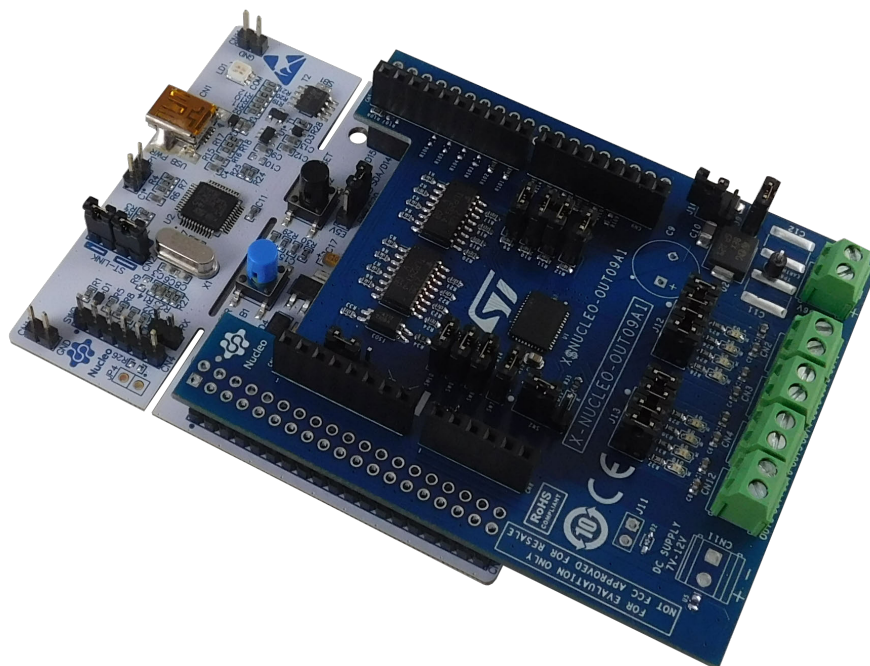
- for emission, compliance with standards:
 - EN IEC 61000-6-3:2021
 - EN 55032:2015 +A1:2020
- for immunity, compliance with standards:
 - EN IEC 61000-6-1:2019
 - EN 55035:2017 +A11:2020

1.4 Hardware requirements

The X-NUCLEO-OUT09A1 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT09A1 must be plugged onto the matching Arduino® UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-OUT09A1 and STM32 Nucleo stack



1.5 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT09A1 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

1.6

Board setup

- Step 1.** Connect the mini-USB or micro-USB cable to your PC to use the [X-NUCLEO-OUT09A1](#) with [NUCLEO-F401RE](#) or [NUCLEO-G431RB](#) development board
- Step 2.** Download the firmware (.bin) onto the [STM32 Nucleo](#) development board microcontroller through [STM32 ST-LINK utility](#), [STM32CubeProgrammer](#), and according to your IDE environment as detailed in the table below.

Table 1. NUCLEO-F401RE development board supported IDEs - bin files

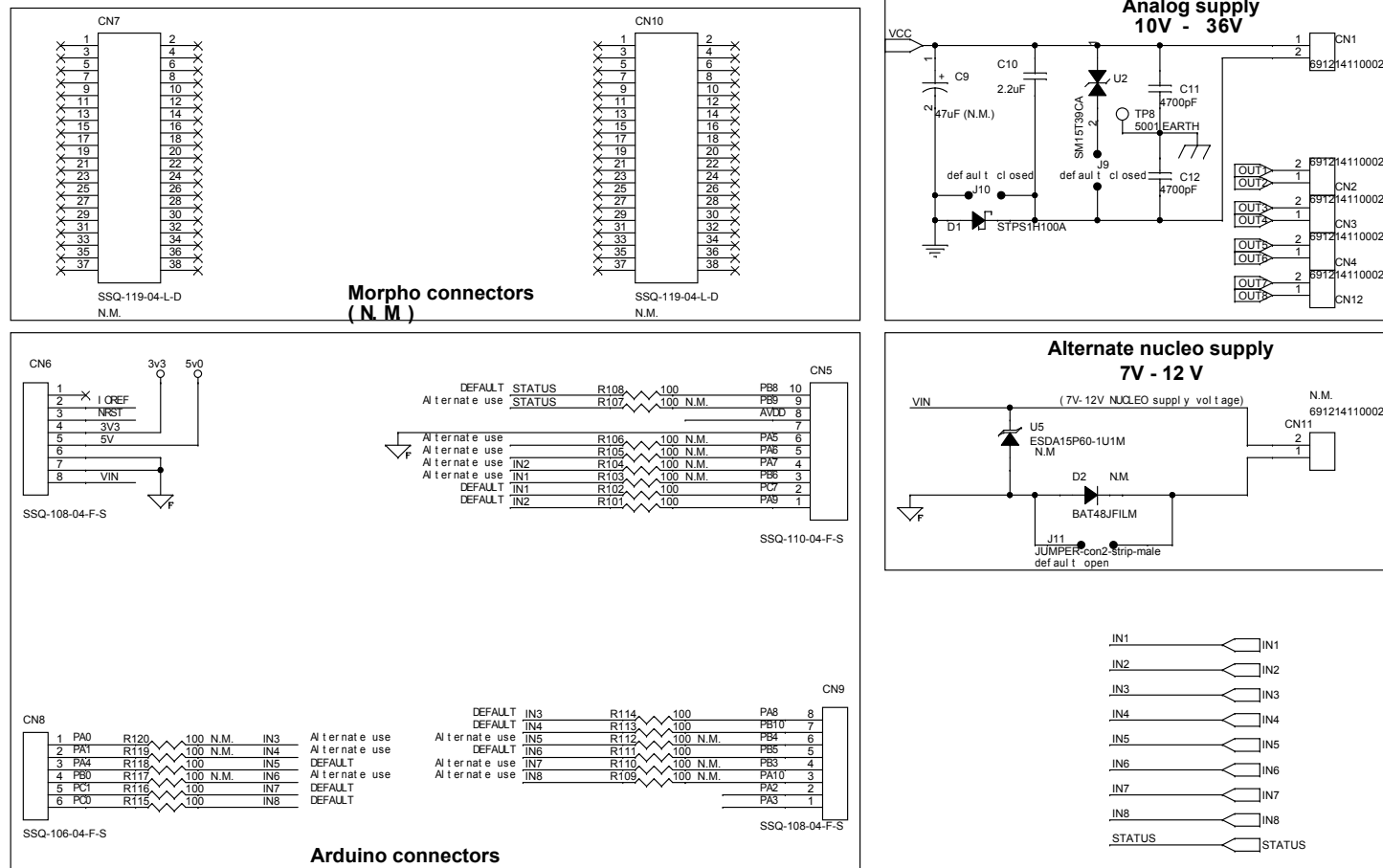
NUCLEO-F401RE		
IAR	Keil	STM32CubeIDE
EWARM-OUT09_19-STM32F4xx_Nucleo.bin	MDK-ARM-OUT09_19-STM32F4xx_Nucleo.bin	STM32CubeIDE-OUT09_19-STM32F4xx_Nucleo.bin

Table 2. NUCLEO-G431RB development board supported IDEs - bin files

NUCLEO-G431RB		
IAR	Keil	STM32CubeIDE
EWARM-OUT09_19-STM32G4xx_Nucleo.bin	MDK-ARM-OUT09_19-STM32G4xx_Nucleo.bin	STM32CubeIDE-OUT09_19-STM32G4xx_Nucleo.bin

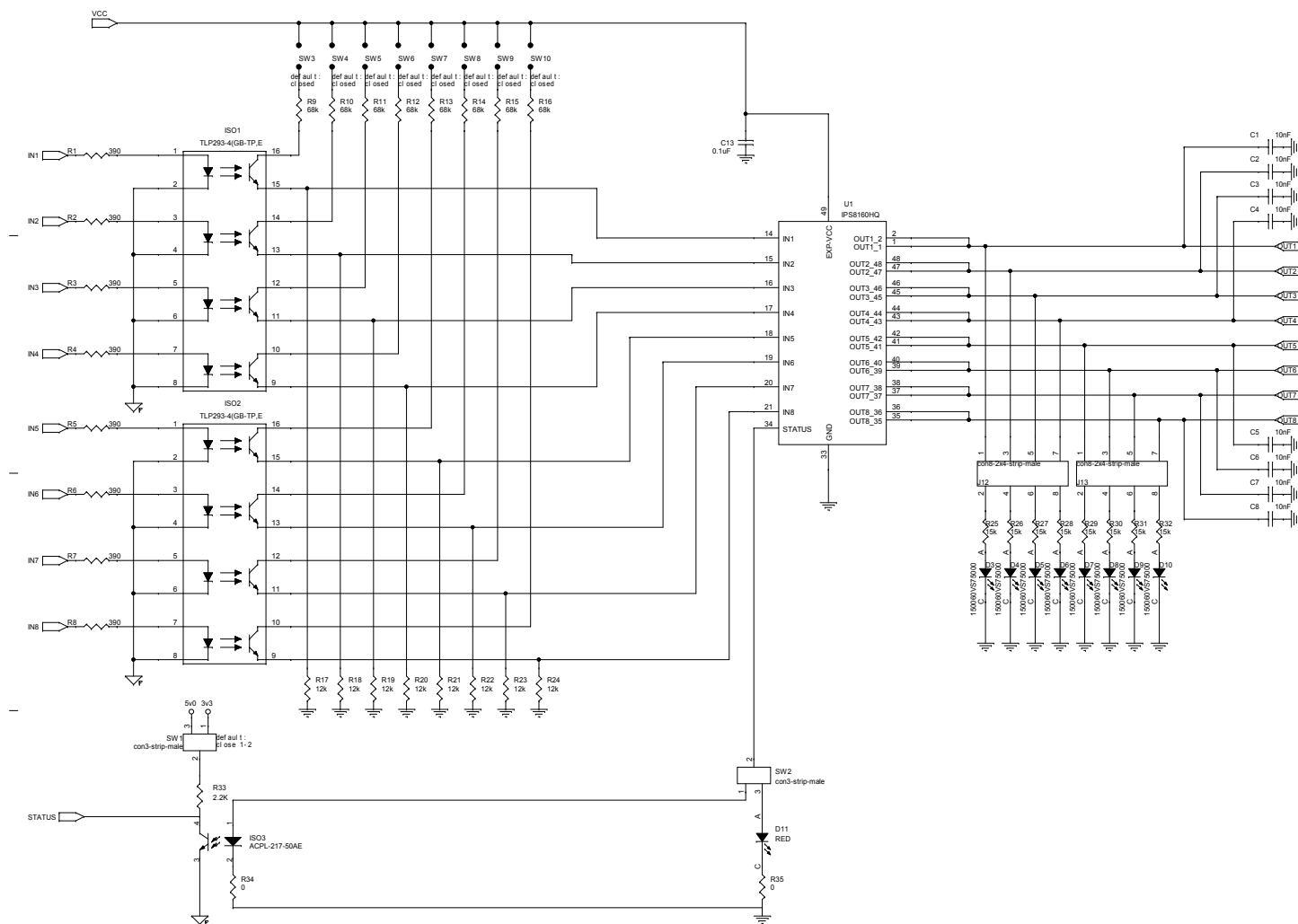
- Step 3.** Connect the [IPS8160HQ](#) device supply voltage via CN1 (see [Section 1.3 Power section](#)).
- Step 4.** Provide the digital supply voltage (see [Section 1.2 Digital section](#)).
- Step 5.** Connect the load on the output connector (see [Section 1.3 Power section](#)).
- Step 6.** Reset 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.

Figure 5. X-NUCLEO-OUT09A1 circuit schematic (1 of 2)



UM3059

Schematic diagrams



3 Bill of materials

Table 3. X-NUCLEO-OUT09A1 bill of materials

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
1	8	C1 C2 C3 C4 C5 C6 C7 C8	10nF, 0603 (1608 Metric), 50V, +/-10%	CAP CER 10000PF 50V X7R 0603	Würth Electronics Inc.	885382206002
2	0	C9	47uF, Radial, Can, 100V, +/-20%	CAP 47 uF 20% 100 V (not assembled)	Würth Electronics Inc.	860040875002
3	1	C10	2.2uF 1206, (3216 Metric), 100V, +/-10%	CAP CER 2.2uF 100V X7R 1206	AVX Corporation	12061C225KAT2A
4	0	C11 C12	4700pF, 1825, (4564 Metric), 3000V (3kV), +/-10%	CAP CER 4700PF 3KV X7R 1825 (not assembled)	Vishay Vitramon	HV1825Y472KXHATHV
5	1	C13	0.1uF, 0805 (2012 Metric), 100V, +/-10%	CAP CER 0.1uF 100V X7R 0805	Würth Electronics Inc.	885012207128
6	5	CN1 CN2 CN3 CN4 CN12	691214110002, 7.4X7 pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB	Würth Electronics Inc.	691214110002
7	1	CN5	10 ways, 1 row	CONN RCPT 10POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-110-14-T-S 17896
8	2	CN6 CN9	8 ways, 1row	CONN RCPT 8POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-108-14-T-S 15782
9	0	CN7 CN10		CONN RCPT 38POS 0.1 GOLD PCB (not assembled)	Samtec Inc.	SSQ-119-04-L-D
10	1	CN8	6 ways, 1 row	CONN RCPT 6POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-106-04-T-S 15781
11	0	CN11	691214110002, 7.4X7 pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB (not assembled)	Würth Electronics Inc.	691214110002
12	1	D1	STPS1H100, DO-214AC, SMA 1A	DIODE SCHOTTKY 100V 1A SMA	ST	STPS1H100A
13	0	D2	BAT48JFILM, SC-76, SOD-323, 750mV @ 200mA, 350mA (DC)	DIODE SCHOTTKY 40V 350MA SOD323 (not assembled)	ST	BAT48JFILM
14	8	D3 D4 D5 D6 D7 D8 D9 D10	150060VS75000, 0603 (1608 Metric), 20mA	LED GREEN CLEAR 0603 SMD	Würth Electronics Inc.	150060VS75000
15	1	D11	RED 0603, (1608 Metric), 20mA	LED RED CLEAR 0603 SMD	Würth Electronics Inc.	150060RS75000
16	2	ISO1 ISO2	TLP293-4(V4GBT PE, 16-SOIC (0.179", 4.55mm Width)	OPTOISOLATOR 3.75KV TRANS SO16	Toshiba Semiconductor and Storage	TLP293-4(GB-TP,E TLP293-4(V4GBTPE

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
17	1	ISO3	ACPL-217-50AE, 4-SOIC (0.173", 4.40mm Width)	OPTOISOLATOR 3KV TRANSISTOR 4- SO	Broadcom Limited	ACPL-217-50AE
18	10	J9 J10 SW3 SW4 SW5 SW6 SW7 SW8 SW9 SW10	JUMPER-con2- strip-male	JUMPER-CONN HEADER .100 STR 2POS	WURTH	61300211121
19	0	J11	JUMPER-con2- strip-male	JUMPER-CONN HEADER .100 STR 2POS (not assembled)	WURTH	61300211121
20	2	J12 J13	con8-2x4-strip- male	CONN HEADER .100 DUAL STR 8POS	WURTH	61300821121
21	8	R1 R2 R3 R4 R5 R6 R7 R8	390, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 390 OHM 1% 1/10W 0603	Yageo	RC0603FR-07390RL
22	8	R9 R10 R11 R12 R13 R14 R15 R16	68k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 68K OHM 1% 1/10W 0603	Yageo	RC0603FR-0768KL
23	8	R17 R18 R19 R20 R21 R22 R23 R24	12k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 12K OHM 1% 1/10W 0603	Yageo	RC0603FR-0712KL
24	8	R25 R26 R27 R28 R29 R30 R31 R32	15k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 15K OHM 1% 1/10W 0603	Yageo	RC0603FR-0715KL
25	1	R33	2.2K, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 2.2K OHM 1% 1/10W 0603	Yageo	RC0603FR-072K2L
26	2	R34 R35	0603 (1608 Metric), 0.1W, 1/10W, +/-1%	CHIP RESISTOR SMD 1% 1/10W 0603	Yageo	RC0603FR-070RL
27	9	R101 R102 R108 R111 R113 R114 R115 R116 R118	100, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 100 OHM 1% 1/10W 0603	Yageo	RC0603FR-07100RP
28	0	R103 R104 R105 R106 R107 R109 R110 R112 R117 R119 R120	100, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 100 OHM 1% 1/10W 0603 (not assembled)	Yageo	RC0603FR-07100RP
29	2	SW1 SW2	con3-strip-male	CONN HEADER .100 STR 3POS	WURTH	61300311121
30	1	TP8	5001, 0.100" Dia x 0.180", L (2.54mm x 4.57mm)	TEST POINT PC MINI .040"D BLACK	Keystone Electronics	5001
31	1	U2	SM15T39CA, DO-214AB, SMC, 1500W, (1.5kW)	TVS DIODE 33.3V 69.7V SMC	ST	SM15T39CA
32	0	U5	ESDA15P60-1U1 M, 2-UDFN	TVS DIODE 13.2V 22.7V 1610 (not assembled)	ST	ESDA15P60-1U1M

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
33	1	U1	IPS8160HQ, QFN48L 8x6mm	Octal High Side Power Solid State Relay for high inductive loads	ST	IPS8160HQ
34	20			jumper close 2.54mm	WURTH	60900213421

4 Board versions

Table 4. X-NUCLEO-OUT09A1 versions

Finished good	Schematic diagrams	Bill of materials
X\$NUCLEO-OUT09A1 ⁽¹⁾	X\$NUCLEO-OUT09A1 schematic diagrams	X\$NUCLEO-OUT09A1 bill of materials

1. This code identifies the X-NUCLEO-OUT09A1 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:

- [IPS8160HQ datasheet](#)
- [UM3035: "Getting started with X-CUBE-IPS industrial digital output software for STM32 Nucleo"](#)
- [NUCLEO-F401RE documentation](#)
- [NUCLEO-G431RB documentation](#)

Revision history

Table 5. Document revision history

Date	Revision	Changes
14-Oct-2022	1	Initial release.

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