Getting started with the X-NUCLEO-OUT11A1 industrial digital output expansion board for STM32 Nucleo

Introduction

The X-NUCLEO-OUT11A1 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 ISO808 octal high-side smart power solid state relay, with embedded galvanic isolation, in a digital output module connected to 0.7 A industrial loads.

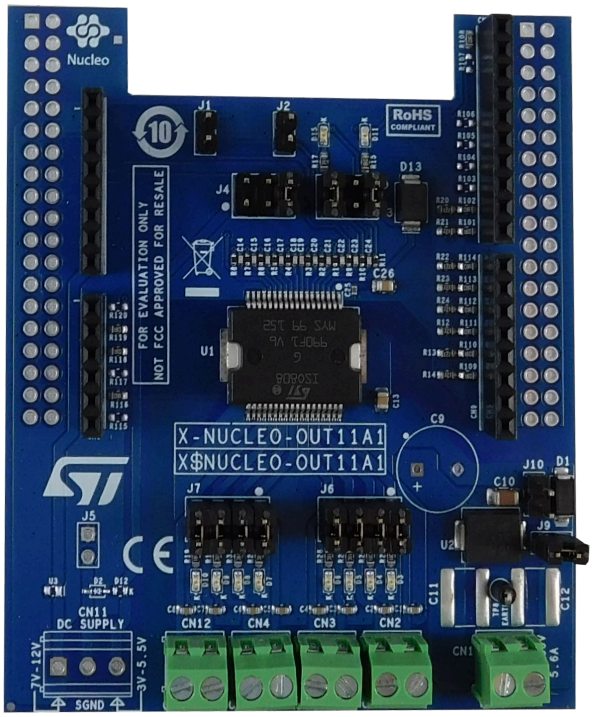
The X-NUCLEO-OUT11A1 directly interfaces with the microcontroller on the STM32 Nucleo driven by GPIO pins and Arduino® R3 connectors.

The galvanic isolation between the microcontroller and the process stage is guaranteed by the ISO808.

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-OUT11A1 stacked on other expansion boards.

Figure 1. X-NUCLEO-OUT11A1 expansion board



1 Getting started

1.1 Overview

The X-NUCLEO-OUT11A1 embeds the ISO808 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 ISO808 satisfies this requirement, avoiding the necessity of external optocouplers, with a consequent cost saving and a reduced application size.

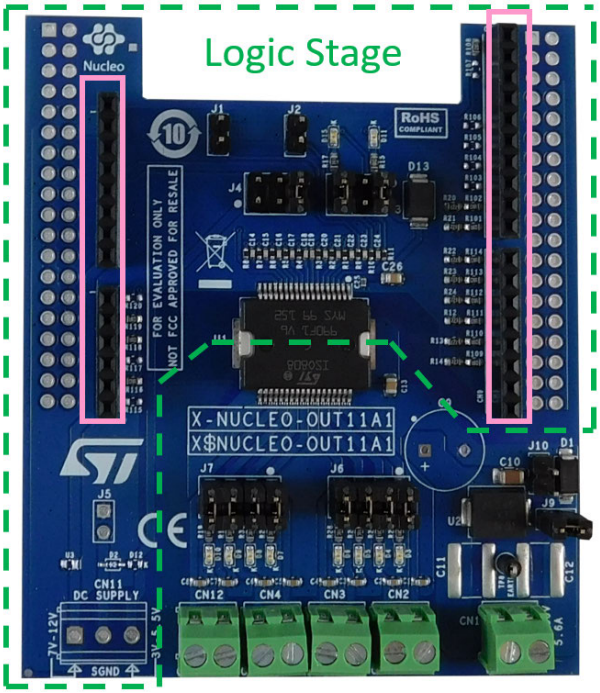
The expansion board features:

- Based on the ISO808 octal high-side switch, which features:
  - Operating range 9.2 to 36 V
  - Low power dissipation ($R_{ON(MAX)}$ = 260 mΩ)
  - Process side operating current: up to 0.7 A per channel
  - Embedded 2k 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
  - PowerSO36 package
- Application board process side operating range: 10 (J10 open) to 33 V (J9 closed)
- Extended operating range of process side from 9.2 (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, J2 closed)
- Synchronous control mode (J1, J2 open)
- 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 Digital section

The digital section is associated with the STM32 interface and the digital supply voltage to and from the X-NUCLEO-OUT11A1 expansion board.

Figure 2. X-NUCLEO-OUT11A1 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-OUT11A1 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 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 J5 (without reverse polarity). In this scenario, the logic side of the ISO808 can be supplied by the 3.3 V supply rail generated by the expansion board: in this case, on the X-NUCLEO-OUT11A1, 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.

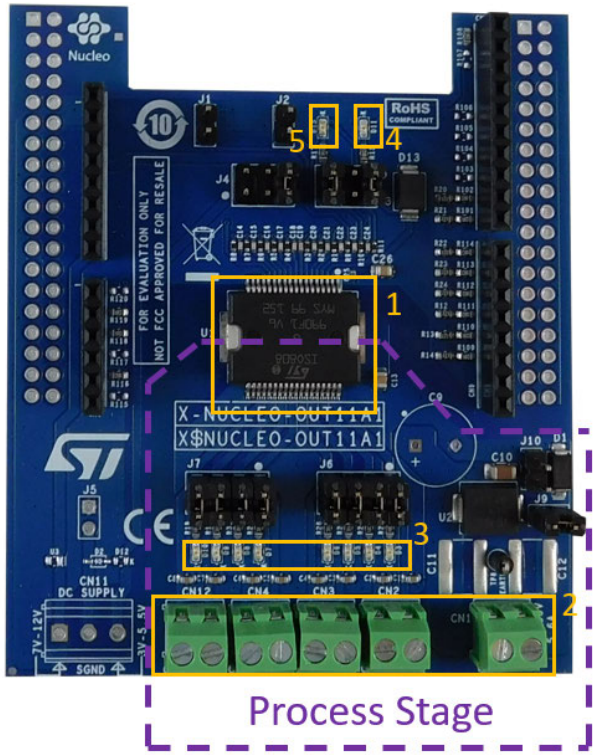
The pin 3 of the connector CN11 can be used to supply the logic side of the ISO808 independently by the expansion board. In this case, on the X-NUCLEO-OUT11A1, the pins 1 and 2 of J4 must be closed (pins 5-6 open).

1.3 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-OUT11A1 expansion board: power section components

1. ISO808
2. Output and power supply connector
3. Output channels - green LEDs
4. Status (overtemperature) red LED
5. Output Enable yellow LED



For EMC:

- the SM15T39CA transient voltage suppressor (U2), enabled by closing J9, is placed between V_{CC} and GND tracks to protect the ISO808 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 ISO808 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-OUT11A1 is detailed below:

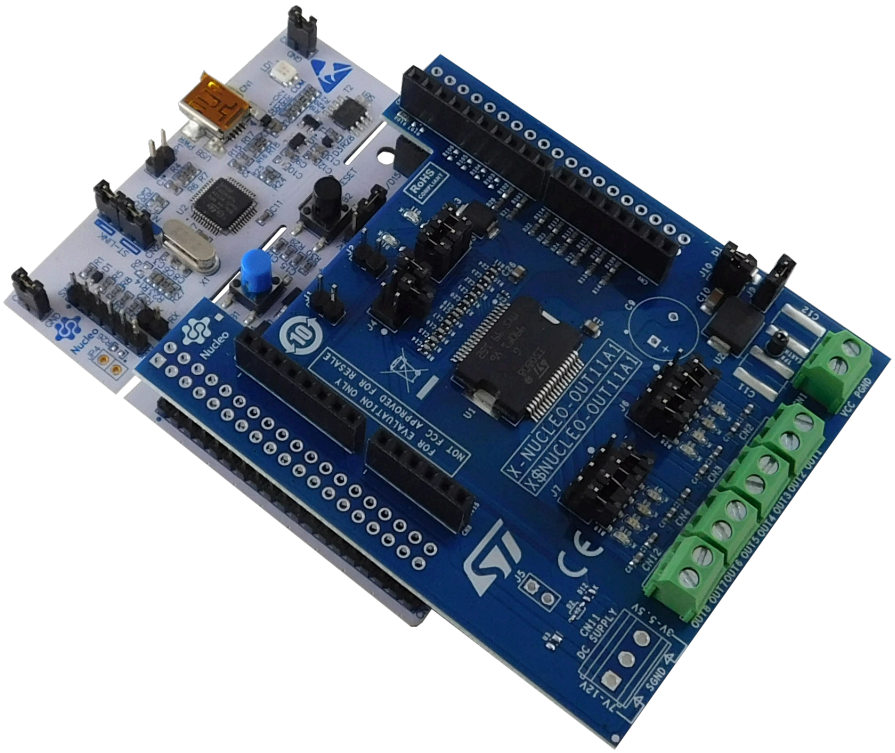
- for emission (when the DC input port of the board is powered by an AC-DC, DC-DC or battery with a cable that does not exceed a three-meter length), compliance with standards:
  - EN IEC 61000-6-3:2021
  - EN 55032:2015 +A1:2020
- for immunity, compliance with standards:
  - EN IEC 61000-6-1:2019
 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

1.4 Hardware requirements

The X-NUCLEO-OUT11A1 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT11A1 must be plugged onto the matching Arduino® UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-OUT11A1 and STM32 Nucleo stack



1.5 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT11A1 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-OUT11A1 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.

The X-NUCLEO-OUT11A1 must be configured coherently to the selected control mode for ISO808-1: J1 and J2 open (synchronous) or J1 and J2 closed (direct).
The binary files provided with the X-CUBE-IPS software package are generated by enabling the synchronous control mode. The user can anyway set the preferred control mode by using the preprocessor directive USE_SCM (for synchronous) or USE_DCM (for direct). The modification to control mode becomes effective on the binary files after rebuilding.

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

NUCLEO-F401RE		
IAR	**Keil**	**STM32CubeIDE**
EWARM-OUT11_13-STM32F4xx_Nucleo.bin	MDK-ARM-OUT11_13-STM32F4xx_Nucleo.bin	STM32CubeIDE-OUT11_13-STM32F4xx_Nucleo.bin

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

NUCLEO-G431RB		
IAR	**Keil**	**STM32CubeIDE**
EWARM-OUT11_13-STM32G4xx_Nucleo.bin	MDK-ARM-OUT11_13-STM32G4xx_Nucleo.bin	STM32CubeIDE-OUT11_13-STM32G4xx_Nucleo.bin

Step 3. Connect the ISO808 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.

2 Schematic diagrams

Figure 5. **X-NUCLEO-OUT11A1 circuit schematic (1 of 2)**

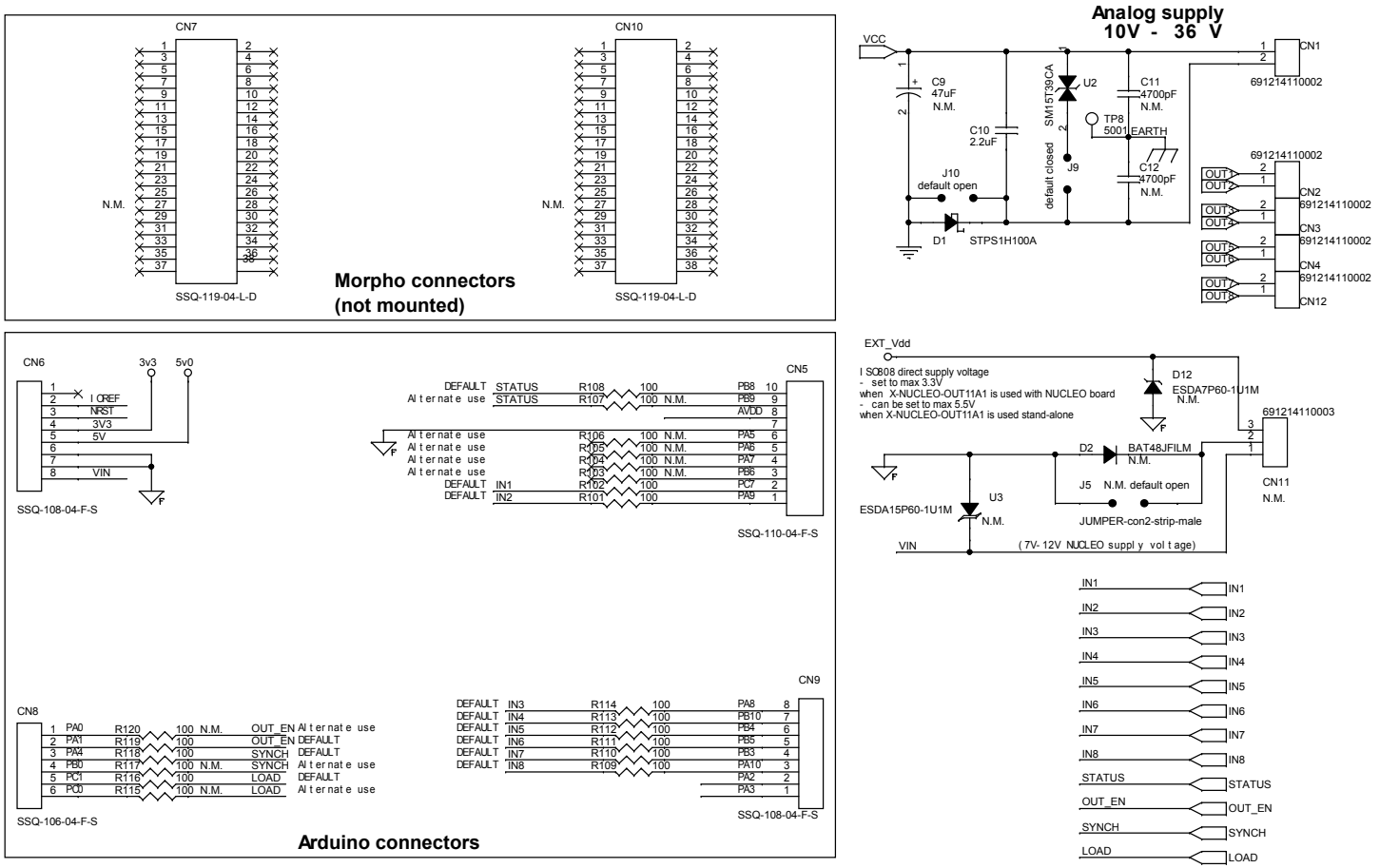
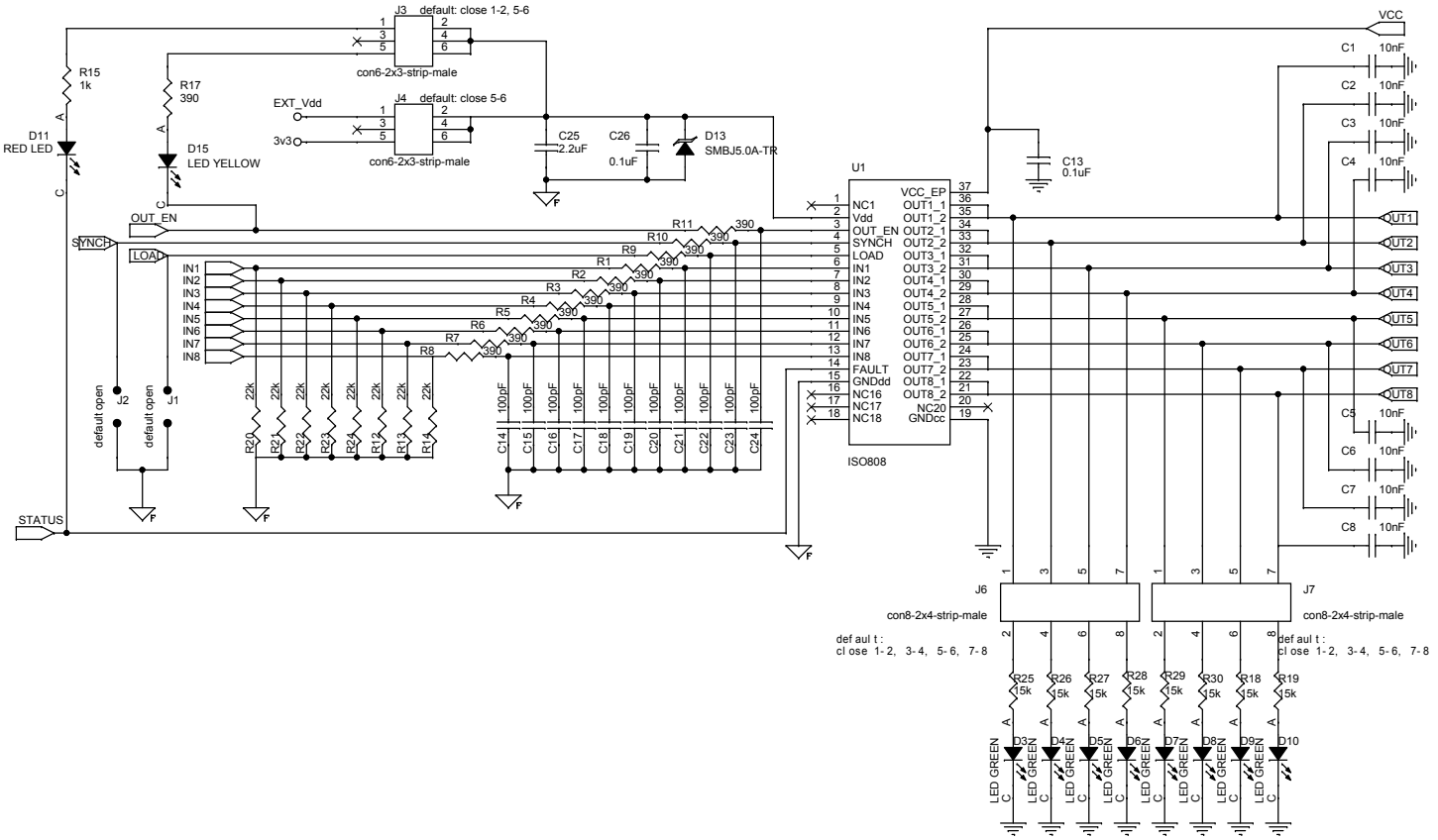


Figure 6. X-NUCLEO-OUT11A1 circuit schematic (2 of 2)



3 Bill of materials

Table 3. **X-NUCLEO-OUT11A1 bill of materials**

Item	Q.ty	Ref.	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	Wurth Electronics Inc.	885382206002
2	0	C9	47uF Radial, Can 100V 20%	CAP 47 UF 20% 100 V (not mounted)	Wurth 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	Vishay Vitramon	HV1825Y472KXHATHV
5	2	C13 C26	0.1uF 0805 (2012 Metric) 100V 10%	CAP CER 0.1UF 100V X7R 0805	Würth Elektronik	885012207128
6	11	C14 C15 C16 C17 C18 C19 C20 C21 C22 C23 C24	100pF 0402 (1005 Metric) 10V 5%	CAP CER 100PF 10V C0G/NP0 0402	Wurth Electronics Inc.	885012005013
7	1	C25	2.2uF 0402 (1005 Metric) 10V 20%	CAP CER 2.2UF 10V X5R 0402	Wurth Electronics Inc.	885012105013
8	5	CN1 CN2 CN3 CN4 CN12	691214110002 7.4X7 pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB	Wurth Electronics Inc.	691214110002
9	1	CN5	10 ways, 1 row	CONN RCPT 10POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-110-14-T-S 17896
10	2	CN6 CN9	8 ways, 1row	CONN RCPT 8POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-108-14-T-S 15782
11	0	CN7 CN10		CONN RCPT 38POS 0.1 GOLD PCB (not mounted)	Samtec Inc.	SSQ-119-04-L-D
12	1	CN8	6 ways, 1 row	CONN RCPT 6POS 0.1 GOLD PCB	SAMTEC 4UCON	ESQ-106-04-T-S 15781
13	0	CN11	691214110003 10.5X7.4 pitch 3.5mm	TERM BLK 3POS SIDE ENT 3.5MM PCB (not mounted)	Wurth Electronics Inc.	691214110003
14	1	D1	STPS1H100A DO-214AC, SMA 1A	DIODE SCHOTTKY 100V 1A SMA	ST	STPS1H100A

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
15	0	D2	BAT48JFILM SC-76, SOD-323 750mV @ 200mA 350mA (DC)	DIODE SCHOTTKY 40V 350MA SOD323 (not mounted)	ST	BAT48JFILM
16	8	D3 D4 D5 D6 D7 D8 D9 D10	LED GREEN 0603 (1608 Metric) 20mA	LED GREEN CLEAR 0603 SMD	Wurth Electronics Inc.	150060VS75000
17	1	D11	RED LED 0603 (1608 Metric) 20mA	LED RED CLEAR 0603 SMD	Wurth Electronics Inc.	150060RS75000
18	0	D12	ESDA7P60-1U1M QFN-2L	TVS DIODE 5VWM 11.6VCL 1610 (not mounted)	ST	ESDA7P60-1U1M
19	1	D13	SMBJ5.0A-TR DO-214AA, SMB 600W	TVS DIODE 5V 13.4V SMB	ST	SMBJ5.0A-TR
20	1	D15	LED YELLOW 0603 (1608 Metric) 20mA	LED YELLOW CLEAR 0603 SMD	Wurth Electronics Inc.	150060YS75000
21	2	J1 J2	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS	Wurth Electronics Inc.	61300211121
22	1	J3	con6-2x3-strip-male	CONN HEADER .100 DUAL STR 6POS	Wurth Electronics Inc.	61300621121
23	1	J4	con6-2x3-strip-male	CONN HEADER .100 DUAL STR 6POS	Wurth Electronics Inc.	61300621121
24	0	J5	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS	Wurth Electronics Inc.	61300211121
25	2	J6 J7	con8-2x4-strip-male	CONN HEADER VERT 8POS 2.54MM	Wurth Electronics Inc.	61300821121
26	2	J9 J10	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS	Wurth Electronics Inc.	61300211121
27	11	R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11	390 0402 (1005 Metric) 0.1W, 1/0W 5%	CHIP RESISTOR SMD 5% 1/0W 0402	Panasonic	ERJH2GJ391X
28	8	R12 R13 R14 R20 R21 R22 R23 R24	22k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 22K OHM 1% 1/10W 0603	Yageo	RC0603FR-0722KL
29	1	R17	390 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 390 OHM 1% 1/10W 0603	Yageo	RC0603FR-07390RL
30	1	R15	1k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 1K OHM 1% 1/10W 0603	Yageo	RC0603FR-071KL

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
31	8	R18 R19 R25 R26 R27 R28 R29 R30	15k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 15K OHM 1% 1/10W 0603	Yageo	RC0603FR-0715KL
32	12	R101 R102 R108 R109 R110 R111 R112 R113 R114 R116 R118 R119	100 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 100 OHM 1% 1/10W 0603	Yageo	RC0603FR-07100RP
33	0	R103 R104 R105 R106 R107 R115 R117 R120	100 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 100 OHM 1% 1/10W 0603 (not mounted)	Yageo	RC0603FR-07100RP
34	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
35	1	U1	ISO808TR PowerSO-36	Galvanic isolated octal high side smart power solid state relay	ST	ISO808TR
36	1	U2	SM15T39CA DO-214AB, SMC 1500W (1.5kW)	TVS DIODE 33.3V 69.7V SMC	ST	SM15T39CA
37	15	N/A	2.54mm	Close Jumper	Wurth Electronics Inc.	60900213421
38	0	U3	ESDA15P60-1U1M QFN-2L	TVS DIODE 13.2V 22.7V 1610	ST	ESDA15P60-1U1M

4 Board versions

Table 4. **X-NUCLEO-OUT11A1 versions**

PCB version	Schematic diagrams	Bill of materials
X$NUCLEO-OUT11A1 (1)	X$NUCLEO-OUT11A1 schematic diagrams	X$NUCLEO-OUT11A1 bill of materials

1. *This code identifies the X-NUCLEO-OUT11A1 evaluation board first version. It is printed on the board PCB.*

5 Regulatory compliance information

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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.

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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:

- ISO808 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
02-Dec-2022	1	Initial release.

Contents

1 **Getting started** 2
1.1 Overview 2
1.2 Digital section 3
1.3 Power section 4
1.4 Hardware requirements 5
1.5 System requirements 5
1.6 Board setup 6
2 **Schematic diagrams** 7
3 **Bill of materials** 9
4 **Board versions** 12
5 **Regulatory compliance information** 13
6 **References** 14
Revision history 15
List of tables 17
List of figures 18

List of tables

Table 1. NUCLEO-F401RE development board supported IDEs - bin files 6
Table 2. NUCLEO-G431RB development board supported IDEs - bin files. 6
Table 3. X-NUCLEO-OUT11A1 bill of materials 9
Table 4. X-NUCLEO-OUT11A1 versions 12
Table 5. Document revision history 15

List of figures

Figure 1. X-NUCLEO-OUT11A1 expansion board . . . 1
Figure 2. X-NUCLEO-OUT11A1 expansion board: digital interface section . . . 3
Figure 3. X-NUCLEO-OUT11A1 expansion board: power section components . . . 4
Figure 4. X-NUCLEO-OUT11A1 and STM32 Nucleo stack . . . 5
Figure 5. X-NUCLEO-OUT11A1 circuit schematic (1 of 2) . . . 7
Figure 6. X-NUCLEO-OUT11A1 circuit schematic (2 of 2) . . . 8

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