Getting started with the X-NUCLEO-OUT15A1 industrial digital output expansion board for STM32 Nucleo

Introduction

The X-NUCLEO-OUT15A1 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 IPS1025HF single high-side, smart power, solid-state relay in a digital output module connected to 2.5 A industrial loads.

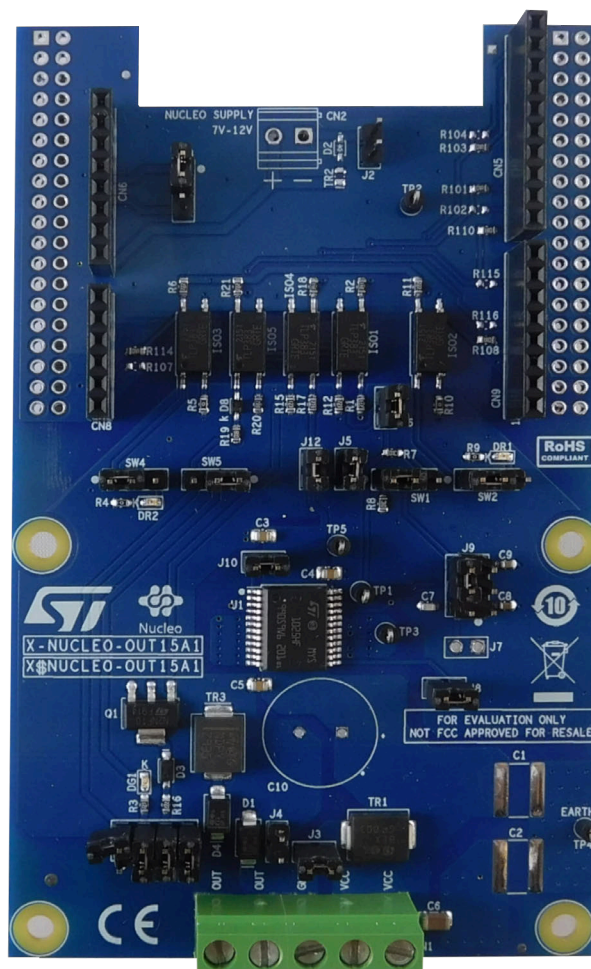The X-NUCLEO-OUT15A1 interfaces with the microcontroller on the STM32 Nucleo via 5 kV optocouplers driven by the GPIO pins and Arduino® UNO R3 connectors.

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

You can also evaluate a system consisting of an X-NUCLEO-OUT05A1 stacked on an X-NUCLEO-OUT15A1 expansion board.

Supplying the X-NUCLEO-OUT05A1 through the main supply rail and the X-NUCLEO-OUT15A1 through the output of the X-NUCLEO-OUT05A1, you can achieve the typical architecture of a single channel digital output for safety systems. The process stages of the two expansion boards result cascaded. The load connected to the X-NUCLEO-OUT15A1 output can be supplied only when both cascaded systems are properly working.

Figure 1. X-NUCLEO-OUT15A1 expansion board

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1 Getting started

1.1 Overview

The X-NUCLEO-OUT15A1 embeds the IPS1025HF intelligent power switch (IPS), which features overcurrent and overtemperature protection for safe output load control. The IPS1025HF also offers the quick activation of its output stage even at power-up. In fact, the input to the output propagation delay at startup is guaranteed ≤ 60 µs.

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 five optocouplers (ISO1, ISO2, ISO3, ISO4, and ISO5) for the input signal forward to the device, the FLT diagnostic feedback signals of the device, and two additional signals for safety application optimization (Nch-DRV for the fast discharge control of the output voltage, and OUT_FB for the on/off status monitoring of the output stage).
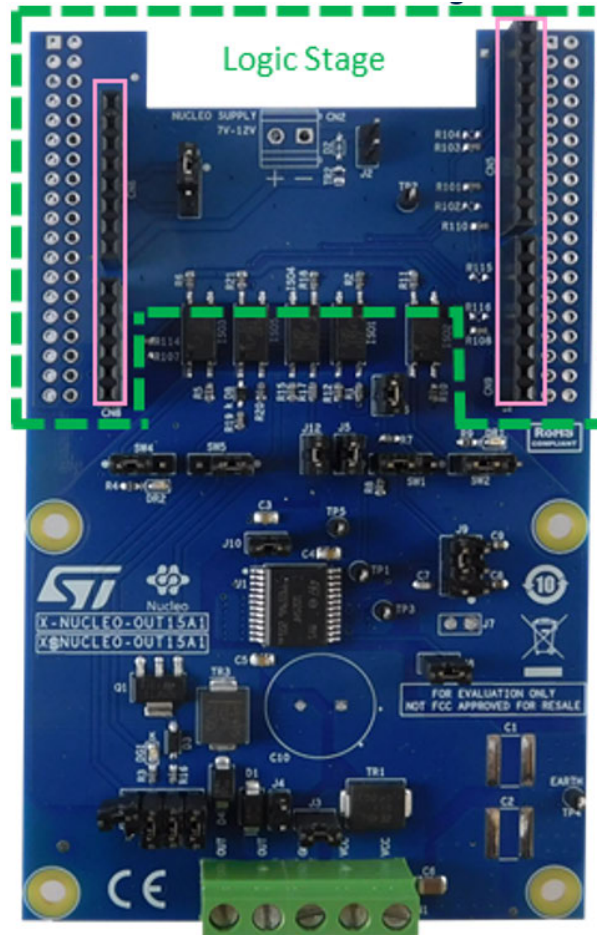
The expansion board features:

- Based on the IPS1025HF single high-side switch, which features:
  - Operating range up to 60 V
  - Low-power dissipation ($R_{ON(MAX)}$ = 25 mΩ)
  - Propagation delay at startup < 60 µs
  - Fast decay for inductive loads
  - Smart driving of capacitive load
  - Under-voltage lock-out
  - Overload and overtemperature protection
  - PowerSSO 24 package
- Application board operating range: 8-33 V/0-2.5 A
- Extended voltage operating range (J3 open) up to 60 V
- Green LED for output on/off status (J11 close 3-4 and SW5 close 1-2)
- Red LEDs for overload and overheating diagnostics (SW2 and SW4 close 2-3)
- Output voltage on/off status feedback (J11 close 1-2)
- Control signal for fast discharge of output voltage (J11 close 5-6, J12 close)
- External fast discharge circuitry for huge inductive loads (J11 close 7-8)
- 5 kV galvanic isolation
- Supply rail reverse polarity protection
- Compatible with STM32 Nucleo development boards
- Equipped with Arduino® UNO R3 connectors
- CE certified
- RoHS and China RoHS compliant

1.1.1 Digital section

The digital section is associated with the STM32 interface and the digital supply voltage to and from the X-NUCLEO-OUT15A1 expansion board.

Figure 2. X-NUCLEO-OUT15A1 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-OUT15A1 expansion board, in either direction.

Normally, 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 CN2 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 J2 (without reverse polarity).
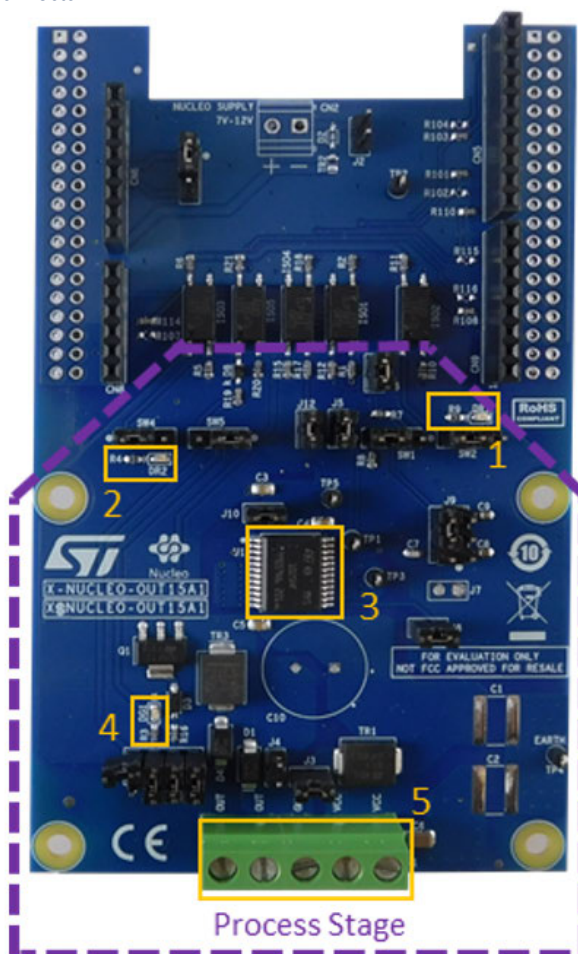
To supply the VIN voltage rail, it is necessary to:

- 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.

1.1.2 Power section

The power section involves the power supply voltage (CN1, pins 4 and 5 for VCC, pin 3 for GND), load connection (a load can be connected between pins CN1.1 and CN1.3 or CN1.2, and CN1.3; both output pins are connected to the single output channel as shown in Section 2 Schematic diagrams) and electromagnetic compatibility (EMC) protection.

Figure 3. X-NUCLEO-OUT15A1 expansion board: power section components

1. Overtemperature red LED
2. Overload red LED
3. IPS1025HF
4. Output channel - green LED
5. Output and power supply connector

For EMC:

- the SM15T39CA transient voltage suppressor (TR1), enabled by closing J3, is placed between VCC and GND tracks to protect the IPS1025HF 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 (C1 and C2 - not included) must be soldered at the predisposed locations;
- the IPS1025HF 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.

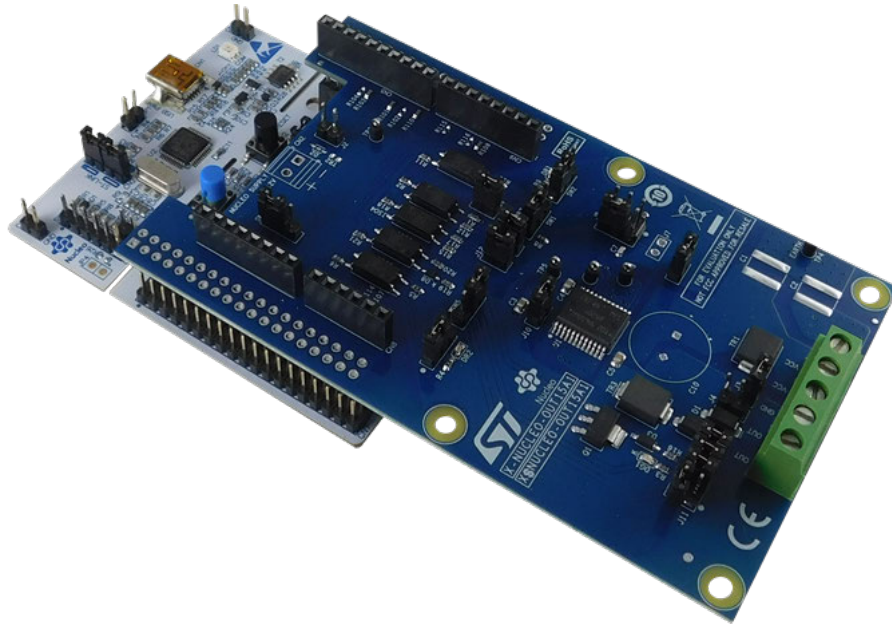The EMC performances of the X-NUCLEO-OUT15A1 are detailed below:

- 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

1.2 Hardware requirements

The X-NUCLEO-OUT15A1 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT15A1 must be plugged onto the matching Arduino® UNO R3 connector pins on the STM32 Nucleo development board as shown below.

Figure 4. X-NUCLEO-OUT15A1 and STM32 Nucleo stack

1.3 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT15A1 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 development board to the PC when using a NUCLEO-F401RE development board
- a type A to micro-B USB cable to connect the STM32 Nucleo development board to the PC when using a NUCLEO-G431RB development board
- the X-CUBE-IPS firmware and software package installed on your PC/laptop

1.4   Board setup

Step 1. Connect the micro-USB or mini-USB cable to your PC to use the X-NUCLEO-OUT15A1 with NUCLEO-F401RE or NUCLEO-G431RB development board.

Step 2. Download the firmware (.bin) onto the STM32 Nucleo development board microcontroller through the STM32ST-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-OUT15-STM32F4xx_Nucleo.bin	MDK-ARM-OUT15-STM32F4xx_Nucleo.bin	STM32CubeIDE-OUT15-STM32F4xx_Nucleo.bin

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

NUCLEO-G431RB		
IAR	**Keil®**	**STM32CubeIDE**
EWARM-OUT15-STM32G4xx_Nucleo.bin	MDK-ARM-OUT15-STM32G4xx_Nucleo.bin	STM32CubeIDE-OUT15-STM32G4xx_Nucleo.bin

Step 3. Connect the IPS1025HF device supply voltage via CN1 (see Section 1.1.2 Power section).

Step 4. Provide the digital supply voltage (see Section 1.1.1 Digital section).

Step 5. Connect the load on the output connector (see Section 1.1.2 Power section).

Step 6. Reset the example sequence using the black push button.

Step 7. Push the STM32 Nucleo blue button to select the example provided in the firmware package.

2 Schematic diagrams
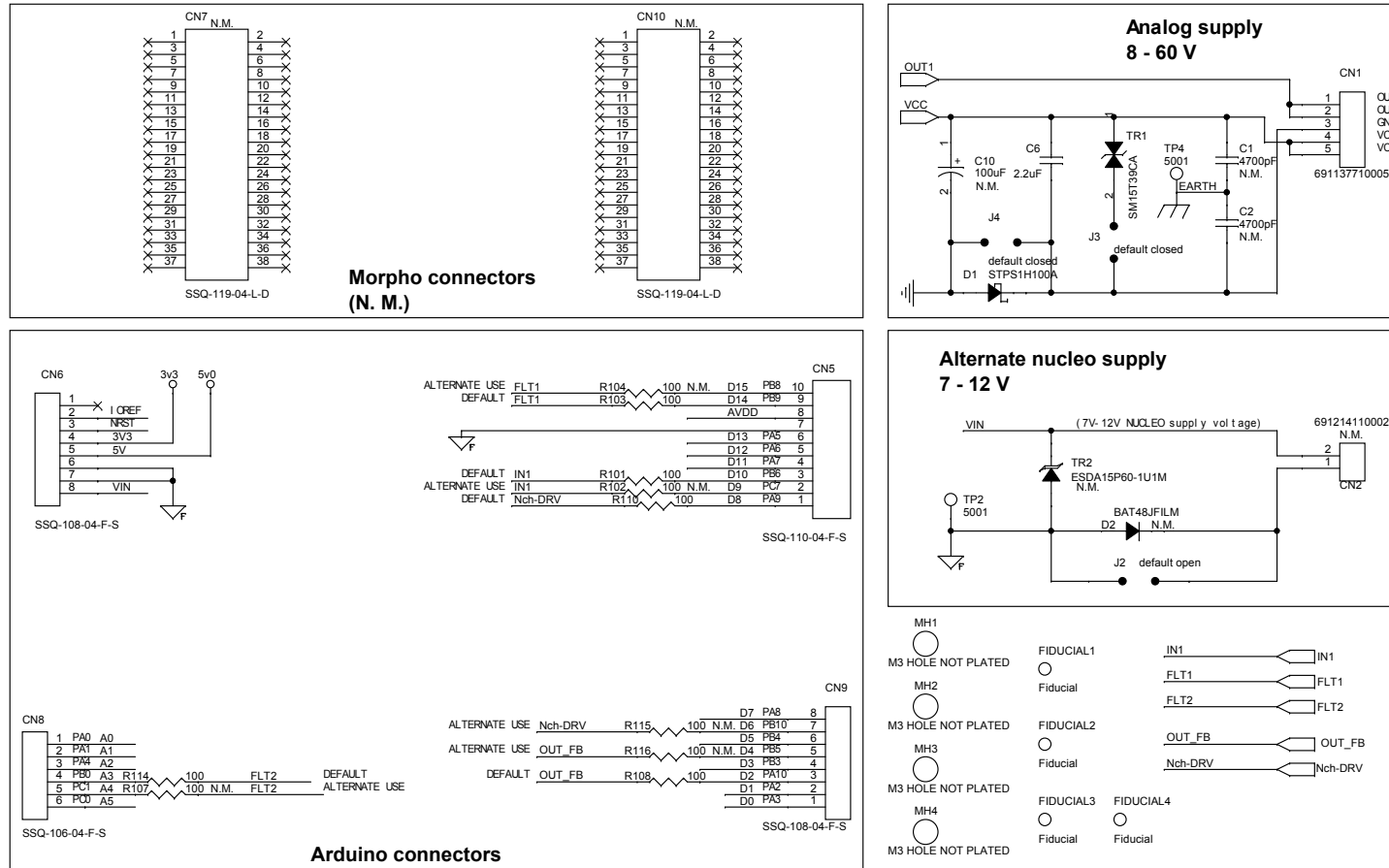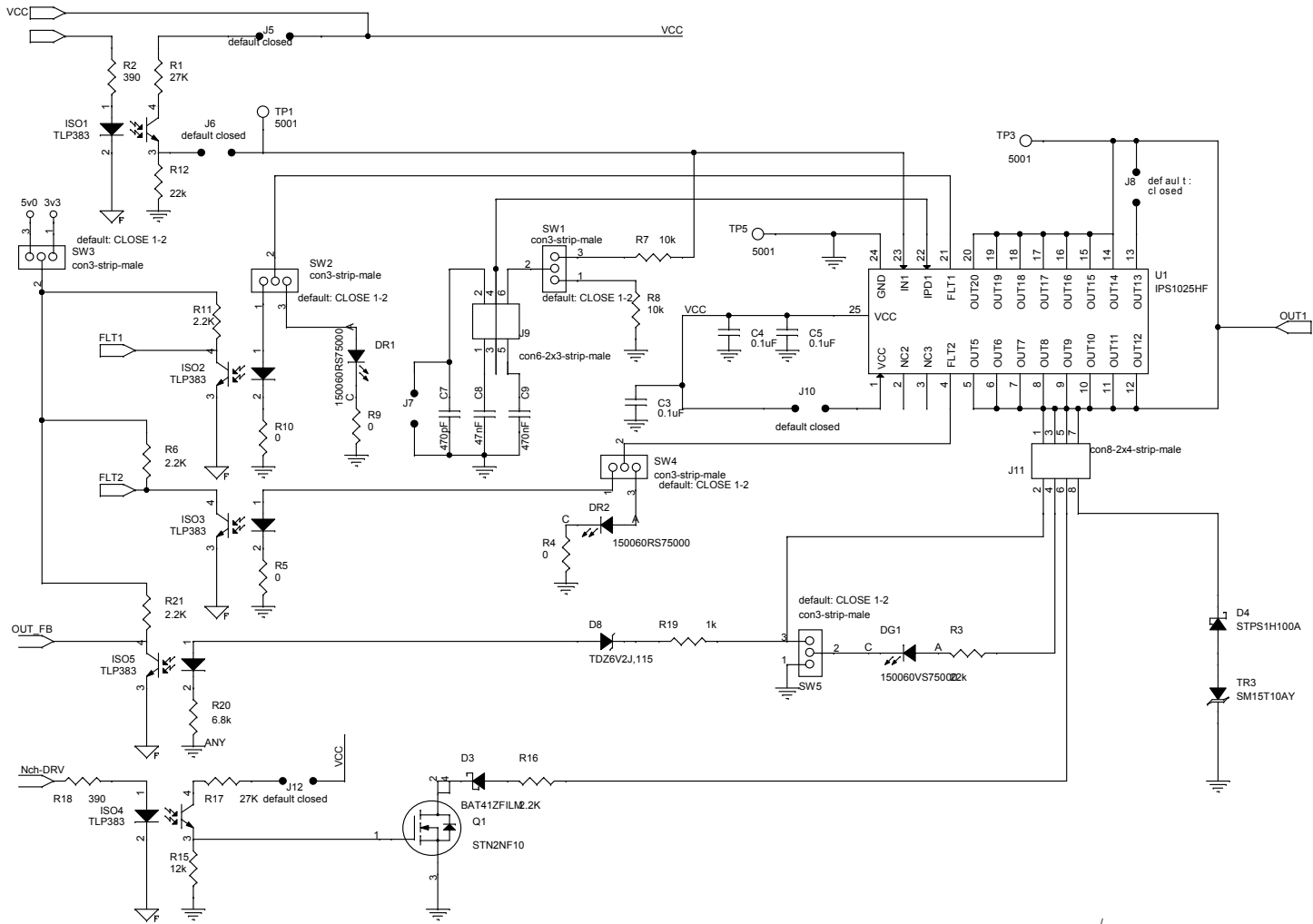
Figure 5. **X-NUCLEO-OUT15A1 circuit schematic (1 of 2)**

Figure 6. X-NUCLEO-OUT15A1 circuit schematic (2 of 2)

3 Bill of materials

Table 3. **X-NUCLEO-OUT15A1 bill of materials**

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
1	0	C1 C2	4700pF, 1825 (4564 Metric), 3000V (3kV), +/-10%	CAP CER 4700PF 3KV X7R 1825 (not mounted)	Vishay Vitramon	HV1825Y472KXHATHV
2	3	C3 C4 C5	0.1uF, 0805 (2012 Metric), 100V, +/-10%	CAP CER 0.1UF 100V X7R 0805	Würth Elektronik	885012207128
3	1	C6	2.2uF, 1206 (3216 Metric), 100V, +/-10%	CAP CER 2.2UF 100V X7R 1206	AVX Corporation	12061C225KAT2A
4	1	C7	470pF, 0603 (1608 Metric), 50V, +/-5%	CAP CER 470PF 50V C0G/NP0 0603	Wurth Electronics Inc.	885012006061
5	1	C8	47nF, 0603 (1608 Metric), 16V, +/10%	CAP CER 0.047UF 16V X7R 0603	Wurth Electronics Inc.	885012206044
6	1	C9	470nF, 0603 (1608 Metric), 25V, +/-10%	CAP CER 0.47UF 25V X7R 0603	Wurth Electronics Inc.	885012206075
7	0	C10	100uF, Radial, Can, 100V, +/-20%	CAP 100 UF 20% 100 V (not mounted)	Würth Elektronik	860130878011
8	1	CN1	691137710005	TERM BLK 5POS SIDE ENTRY 5MM PCB	Würth Elektronik	691137710005
9	0	CN2	691214110002, 7.4X7 pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB (not mounted)	Wurth Electronics Inc.	691214110002
10	1	CN5	SSQ-110-04-F-S	CONN RCPT 10POS 0.1 GOLD PCB	Samtec Inc.	SSQ-110-04-F-S
11	2	CN6 CN9	SSQ-108-04-F-S	CONN RCPT 8POS 0.1 GOLD PCB	Samtec Inc.	SSQ-108-04-F-S
12	0	CN7 CN10	SSQ-119-04-L-D	CONN RCPT 38POS 0.1 GOLD PCB (not mounted)	Samtec Inc.	SSQ-119-04-L-D
13	1	CN8	SSQ-106-04-F-S	CONN RCPT 6POS 0.1 GOLD PCB	Samtec Inc.	SSQ-106-04-F-S
14	2	D1 D4	STPS1H100A, SMA	100 V, 1 A power Schottky rectifier	ST	STPS1H100A
15	0	D2	BAT48JFILM,SOD -323	40 V, 350 mA axial general purpose Signal Schottky diode (not mounted)	ST	BAT48JFILM

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
16	1	D3	BAT41ZFILM, SOD-123	100 V, 200 mA surface mount general purpose signal Schottky diode (not mounted)	ST	BAT41ZFILM
17	1	D8	TDZ6V2J,115, SC-90, SOD-323F, 1.1V @ 100mA, 3uA @ 4V, 500mW	DIODE ZENER 6.2V 500MW SOD323F	Nexperia USA Inc.	TDZ6V2J,115
18	1	DG1	150060VS75000, 0603 (1608 Metric), 20mA	LED GREEN CLEAR 0603 SMD	Wurth Electronics Inc.	150060VS75000
19	2	DR1 DR2	150060RS75000, 0603 (1608 Metric), 20mA	LED RED CLEAR 0603 SMD	Wurth Electronics Inc.	150060RS75000
20	5	ISO1 ISO2 ISO3 ISO4 ISO5	TLP383, 6-SOIC (0.173", 4.40mm Width), 4 Leads	OPTOISO 5KV TRANSISTOR SO6L	Toshiba Semiconductor and Storage	TLP383(GR-TPL,E
22	8	J2 J3 J4 J5 J6 J8 J10 J12	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS	Wurth Electronics Inc.	61300211121
23	0	J7	JUMPER-con2-strip-male	JUMPER-CONN HEADER 100 STR 2POS (not mounted)	Wurth Electronics Inc.	61300211121
25	1	J9	con6-2x3-strip-male	CONN HEADER .100 DUAL STR 6POS	Wurth Electronics Inc.	61300621121
26	1	J11	con8-2x4-strip-male	CONN HEADER .100 DUAL STR 8POS	Wurth Electronics Inc.	61300821121
27	1	Q1	STN2NF10, SOT-223	N-channel 100 V, 0.23 Ohm, 2.4 A STripFET II power MOSFET	ST	STN2NF10
28	2	R1 R17	27K, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 27K OHM 1% 1/10W 0603	Yageo	RC0603FR-0727KL
29	2	R2 R18	390, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 390 OHM 1% 1/10W 0603	Yageo	RC0603FR-07390RL
30	2	R3 R12	22k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 22K OHM 1% 1/10W 0603	Yageo	RC0603FR-0722KL
31	4	R4 R5 R9 R10	0603 (1608 Metric), 0.1W, 1/10W, Jumper	RES SMD 0 OHM JUMPER 1/10W 0603	Panasonic Electronic Components	ERJ-3GEY0R00V
32	4	R6 R11 R16 R21	2.2K, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 2.2K OHM 1% 1/10W 0603	Yageo	RC0603FR-072K2L
33	2	R7 R8	10k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 10K OHM 1% 1/10W 0603	Yageo	RC0603FR-0710KL

Item	Quantity	Reference	Part/value	Description	Manufacturer	Order code
34	1	R15	12k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 12K OHM 1% 1/10W 0603	Yageo	RC0603FR-0712KL
35	1	R19	1k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 1K OHM 1% 1/10W 0603	Yageo	RC0603FR-071KL
36	1	R20	6.8k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	CHIP RESISTOR SMD 1% 1/10W 0603	Yageo	RC0603FR-D76K8L
37	5	R101 R103 R108 R110 R114	100, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 100 OHM 1% 1/10W 0603	Yageo	RC0603FR-07100RP
38	0	R102 R104 R107 R115 R116	100, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 100 OHM 1% 1/10W 0603 (not mounted)	Yageo	RC0603FR-07100RP
39	5	SW1 SW2 SW3 SW4 SW5	con3-strip-male	CONN HEADER .100 STR 3POS	Wurth Electronics Inc.	61300311121
40	5	TP1 TP2 TP3 TP4 TP5	5001, 0.100" Dia x 0.180" L (2.54mm x 4.57mm)	TEST POINT PC MINI .040"D BLACK	Keystone Electronics	5001
41	1	TR1	SM15T39CA, SMC	1500 W, 33.3 V TVS in SMC	ST	SM15T39CA
42	0	TR2	ESDA15P60-1U1M, QFN-2L	High-power transient voltage suppressor (not mounted)	ST	ESDA15P60-1U1M
43	1	TR3	SM15T10AY, SMC	Automotive 1500 W, 8.55 V TVS in SMC	ST	SM15T10AY
44	1	U1	IPS1025HF, PowerSSO 24	High efficiency, high-side switch with extended diagnostics, smart driving for capacitive loads, and short propagation delay at power-on	ST	IPS1025HF
45	16	N/A	2.54 mm	Close jumper	Wurth Electronics Inc.	60900213421

4   Board versions

Table 4. X-NUCLEO-OUT15A1 versions

PCB version	Schematic diagrams	Bill of materials
X$NUCLEO-OUT15A1 [1]	X$NUCLEO-OUT15A1 schematic diagrams	X$NUCLEO-OUT15A1 bill of materials

1. This code identifies the X-NUCLEO-OUT15A1 evaluation board first version. It is printed on the board PCB.

5 Regulatory compliance

Formal Notice Required by the U.S. Federal Communications Commission

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.

Formal Product Notice Required by Industry Canada Innovation, Science and Economic Development

Canada compliance:

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).

Formal product notice required by EU

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

6 References

Freely available on www.st.com:

1. IPS1025HF datasheet
2. UM3035: "Getting started with X-CUBE-IPS industrial digital output software for STM32 Nucleo"
3. NUCLEO-F401RE documentation
4. NUCLEO-G431RB documentation

Revision history

Table 5. Document revision history

Date	Revision	Changes
09-Jun-2022	1	Initial release.
20-Jun-2022	2	Updated Section 1.1.2 Power section.

Contents

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