

Getting started with X-NUCLEO-OUT10A1 industrial digital output expansion board for STM32 Nucleo

Introduction

The **X-NUCLEO-OUT10A1** industrial digital output expansion board for **STM32 Nucleo** provides an affordable and easy-to-use solution for the development of 0.5 A (typ.) digital output modules, letting you easily evaluate the **IPS161HF** driving and diagnostic capabilities with industrial loads.

The **X-NUCLEO-OUT10A1** interfaces with the microcontroller on the STM32 Nucleo via 3 kV optocouplers driven by GPIO pins and Arduino™ UNO R3 (default configuration) and ST morpho (optional, not mounted) connectors.

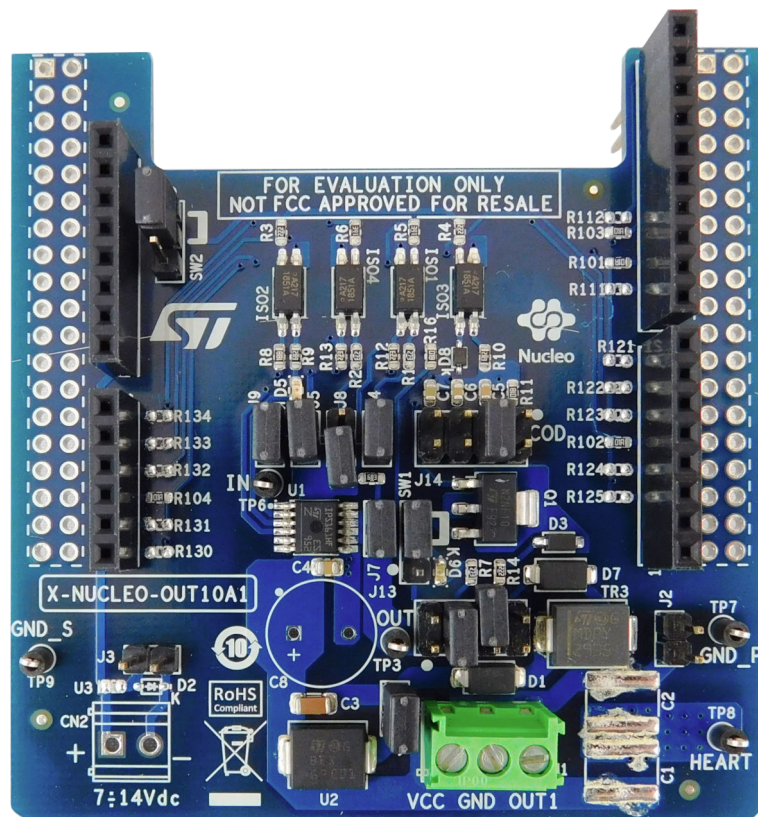
The expansion board should be connected to either a **NUCLEO-F401RE** or **NUCLEO-G431RB** development board, and can be stacked with another **X-NUCLEO-OUT10A1** or an **X-NUCLEO-OUT08A1**.

Up to four **X-NUCLEO-OUT10A1** expansion boards can be stacked to evaluate up to a quad channel digital output module with 0.5 A (typ.) capability each.

It is also possible to evaluate the typical cascade architecture of a single channel digital output module for safety applications: in this scenario, the first shield output is connected to the supply of the second one.

Dedicated on-board hardware can be enabled or disabled to activate fast discharge of high capacitive loads, output voltage sensing, and an additional surge pulse output line protection.

Figure 1. X-NUCLEO-OUT10A1 expansion board



1 Getting started

1.1 Overview

The **X-NUCLEO-OUT10A1** industrial digital output expansion board, embedding the **IPS161HF** intelligent power switch (IPS), is designed to meet the application requirement in terms of galvanic isolation between user interface (or logic side) and power interface (or process side).

This requirement is satisfied by an optical isolation implemented through two couples of optocouplers:

1. The first couple includes:
 - a. ISO1: for signal forwarding to the device and
 - b. ISO2: for diagnostic signal (DIAG pin) feedback
2. The second couple includes:
 - a. ISO3: for the additional output voltage feedback signal and
 - b. ISO4: for the additional circuitry driving Q1 to allow fast discharge of the output rail

The main features of the **X-NUCLEO-OUT10A1** expansion board are:

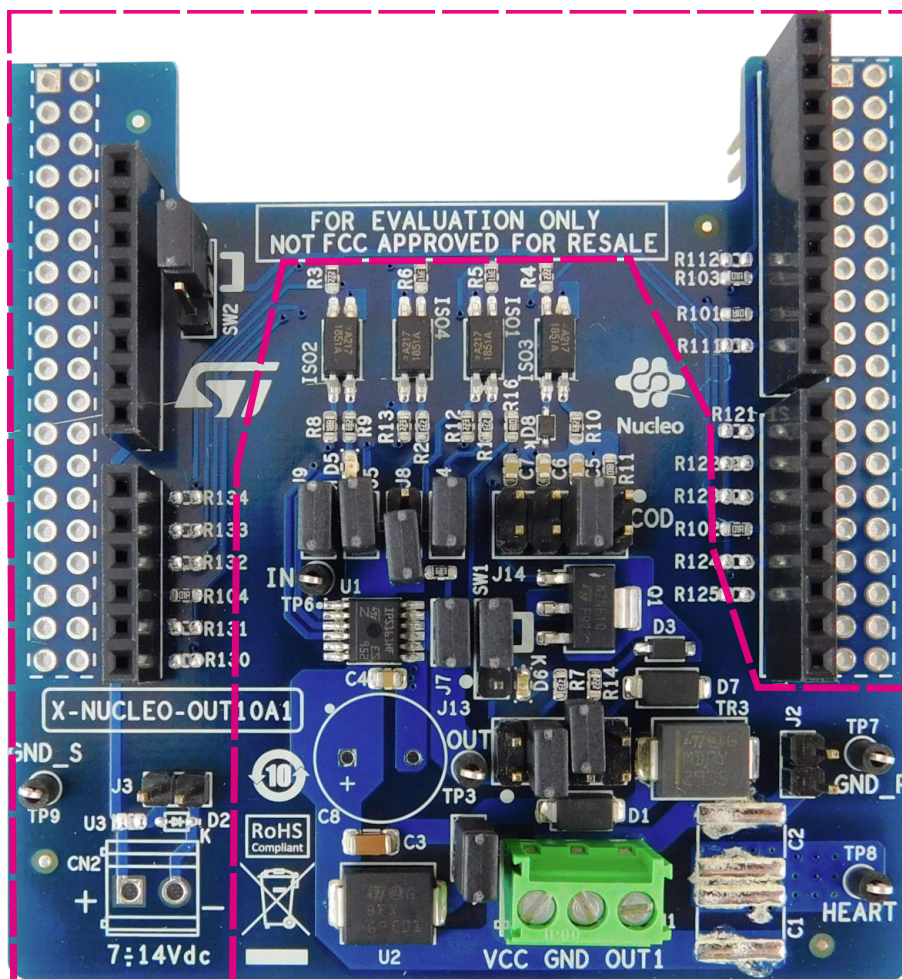
- Based on **IPS161HF** single high-side switch with the following main features:
 - Operating range up to 60 V/0.7 A
 - Low power dissipation ($R_{ON(MAX)} = 120 \text{ m}\Omega$)
 - Fast decay for inductive loads
 - Open load detection and diagnostics
 - Overload and overheating protections with thermal shut-down and cut-off
 - PowerSSO-12L package
- Application board operating range: 12 - 33 V, 0 to 0.7 A
- Extended voltage operating range (J1 open) up to 60 V
- Green LED for output ON/OFF status
- Red LED for diagnostics (open load, cut-off and overheating)
- 3 kV galvanic isolation
- Supply rail reverse polarity protection
- Ready for Safety Digital Output Architecture
- Wide application development potential in **STM32 Nucleo** development environment
- 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 digital supply voltage to and from the **X-NUCLEO-OUT10A1** expansion board.

The digital and power sections are isolated by 3.3 mm creepage. Communication between the two sections is guaranteed by ISO1, ISO2, ISO3 and ISO4 optocouplers.

Figure 2. X-NUCLEO-OUT10A1 expansion board: digital interface components



The four Arduino® UNO R3 connectors:

- allow expansion board communication with the [STM32 Nucleo](#) development board accessing STM32 peripheral and GPIO resources;
- provide digital supply voltage between the [STM32 Nucleo](#) development board and the [X-NUCLEO-OUT10A1](#) expansion board, in either direction.

Normally, the [STM32 Nucleo](#) development board supplies the expansion board by 3v3 or 5v0 (JP5 pins 1-2 closed) generated by the USB. You can select the preferred voltage on the expansion board via SW2 (3v3 by closing pins 1-2; 5v0 by 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 CN2 connector (not mounted by default) on the expansion board and the ground loop should be closed by mounting D2 (that enables reverse polarity protection) or by closing J3 (without reverse polarity).

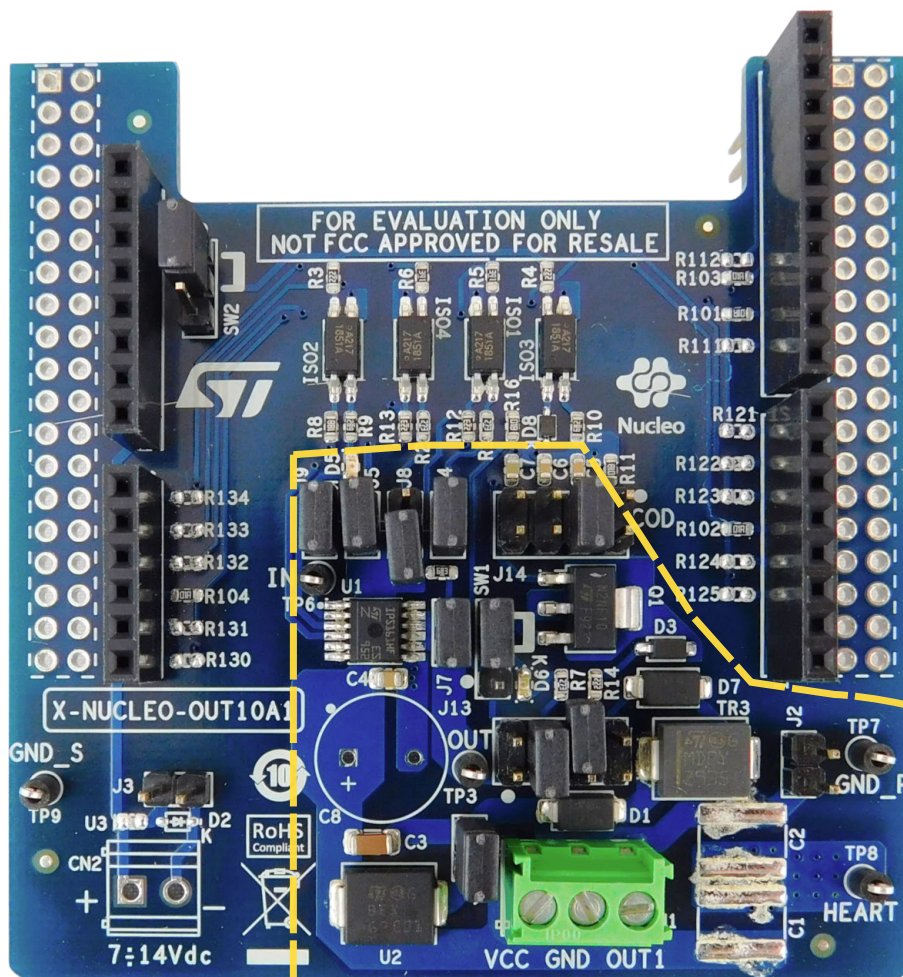
To supply the V_{IN} voltage rail is necessary to:

- close jumper JP5 between pins 2 and 3 and open jumper JP1 on the [NUCLEO-F401RE](#)
- open jumper JP5 between pins 1 and 2 and close jumper JP5 between pins 3 and 4 on the [NUCLEO-G431RB](#)

1.1.2 Power section

The power section involves the power supply voltage (CN1, pin 1 V_{CC} , pin 2 GND), load connection (between CN1 pin 3 and CN1 pin 2) and electromagnetic compatibility (EMC) protection (U2).

Figure 3. X-NUCLEO-OUT10A1 expansion board: power stage components



For EMC:

- the transient voltage suppressor (U2), enabled by closing J1, is placed between V_{CC} and GND tracks to protect the **IPS161HF** against surge discharge on the supply rail path up to ± 1 kV/2 Ω coupling;
- in common mode surge testing, two single-layer capacitors (C1 and C2 - not included) must be soldered at the predisposed locations;
- the **IPS161HF** output stages do not require additional EMC protections with respect to IEC61000-4-2 (± 10 kV contact, ± 16 kV air), IEC61000-4-4 (± 4 kV), IEC61000-4-5 (± 3.5 kV) standards.

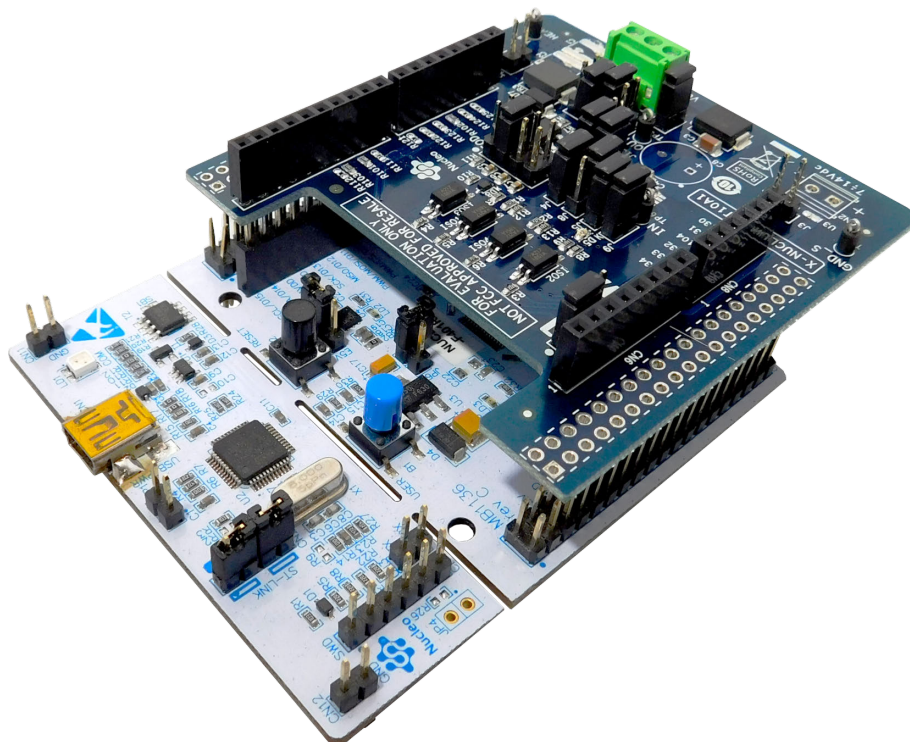
1.2

Hardware requirements

The **X-NUCLEO-OUT10A1** expansion board is designed to be used with the **NUCLEO-F401RE** or **NUCLEO-G431RB** STM32 Nucleo development boards.

To function correctly, the **X-NUCLEO-OUT10A1** must be plugged onto the matching Arduino® UNO R3 connector pins on the **STM32 Nucleo** board as shown below.

Figure 4. X-NUCLEO-OUT10A1 and STM32 Nucleo stack



1.3 System requirements

To use the **STM32 Nucleo** development boards with the **X-NUCLEO-OUT10A1** 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

1.4 Board setup

- Step 1.** Connect the **X-NUCLEO-OUT10A1** to the **NUCLEO-F401RE** or **NUCLEO-G431RB** development board through the Arduino connectors.
- Step 2.** Connect the **X-NUCLEO-OUT10A1** power section (see [Section 1.1.2 Power section](#)).
- Step 3.** Connect the load between CN1 pins 2 and 3.
- Step 4.** Connect the mini-USB (for **NUCLEO-F401RE**) or micro-USB (for **NUCLEO-G431RB**) cable between your PC and the **STM32 Nucleo** board.

- Step 5.** 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 tables below.

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

NUCLEO-F401RE		
IAR	Keil®	STM32CubeIDE
EWARM-OUT08_10-STM32F4xx_Nucleo.bin	MDK-ARM-OUT08_10-STM32F4xx_Nucleo.bin	STM32CubeIDE-OUT08_10-STM32F4xx_Nucleo.bin

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

NUCLEO-G431RB		
IAR	Keil®	STM32CubeIDE
EWARM-OUT08_10-STM32G4xx_Nucleo.bin	MDK-ARM-OUT08_10-STM32G4xx_Nucleo.bin	STM32CubeIDE-OUT08_10-STM32G4xx_Nucleo.bin

- Step 6.** Provide the digital supply voltage (see [Section 1.1.1 Digital section](#)).
- Step 7.** Reset the example sequence by pushing the black button on the [STM32 Nucleo](#) board.
- Step 8.** Push the blue button on [STM32 Nucleo](#) board to choose among the examples provided in the default firmware package.

1.5 Multiple board configuration

It is also possible to evaluate a four channel digital output module by stacking four [X-NUCLEO-OUT10A1](#) with shared or independent supply rail and independent loads.

In this case, the four expansion boards (board 0, 1, 2, 3 as shown in the table below) must be properly configured: for board 1, 2 and 3, it is necessary to unsolder four resistors for each board from the default position and solder them back in the alternate positions according to the following table.

Table 3. Configuration of a stack of four expansion boards

Board no.	IN1	DIAG	Nch-DRV	OUT_FB
Board 0	R101	R103	R102	R104
Board 1	R111	R112	R124	R131
Board 2	R121	R125	R130	R123
Board 3	R132	R133	R134	R122

Important: When using Board 1 and/or Board 3, two jumpers must be placed to close the morpho connectors pins in the [STM32 Nucleo](#) board:

- CN7.35-36 closed
- CN10.25-26 closed

Figure 5. X-NUCLEO-OUT10A1 circuit schematic (1 of 2)

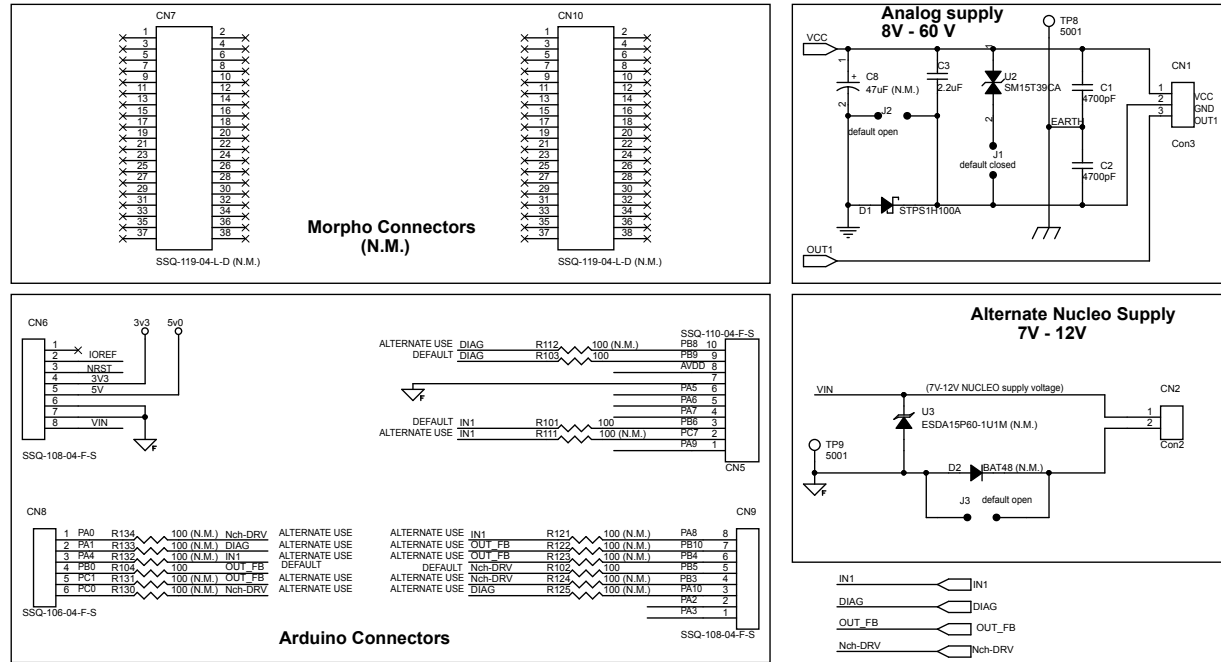
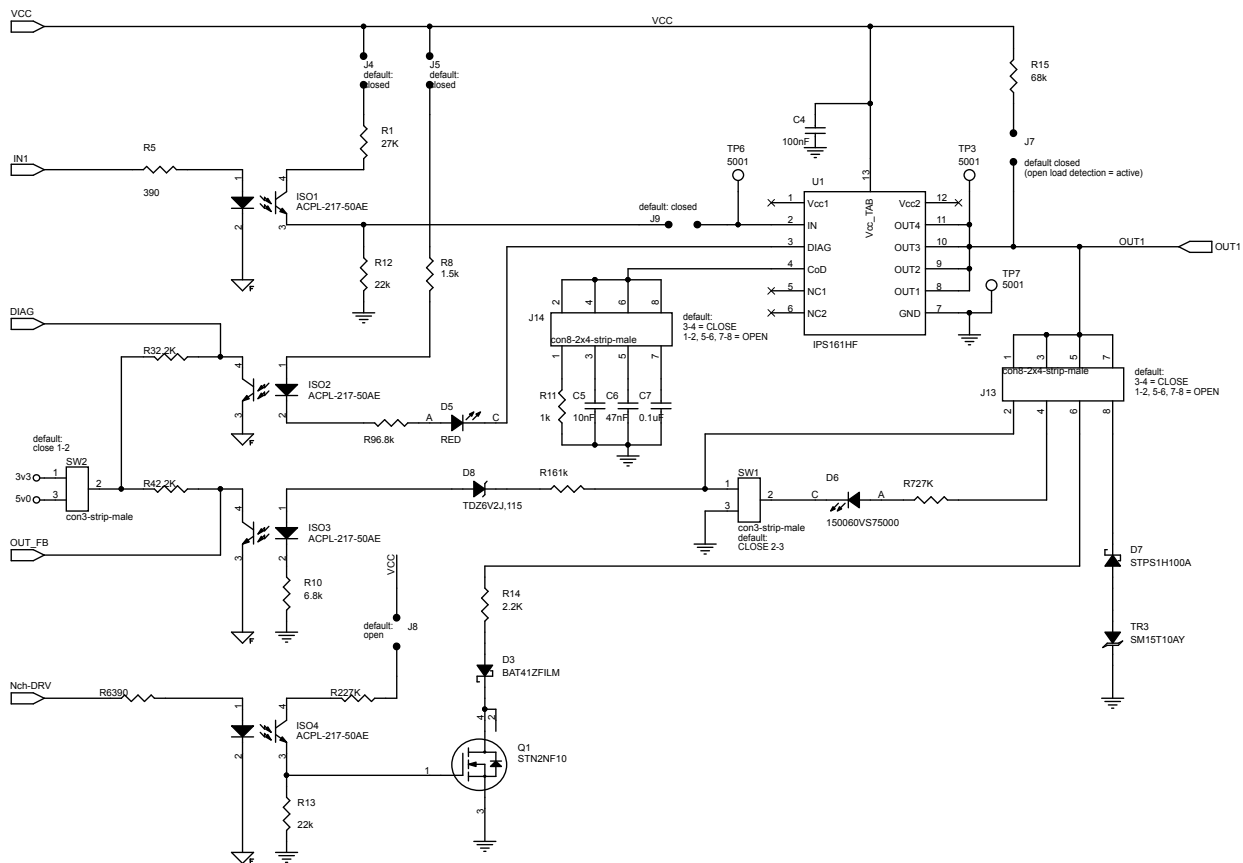


Figure 6. X-NUCLEO-OUT10A1 circuit schematic (2 of 2)



3 Bill of materials

Table 4. X-NUCLEO-OUT10A1 bill of materials

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	0	C1 , C2	4700 pF 1825 (4564 Metric) 3000 V (3kV) ±10%	Ceramic capacitors (not mounted)	Vishay Vitramon	HV1825Y472KXHATHV
2	1	C3	2.2 µF SMD 1206 (3216 Metric) 100 V	Ceramic capacitor	AVX	12061C225KAT2A
3	1	C4	100 nF SMD 0805 (2012 Metric) 100 V	Ceramic capacitor	Wurth Electronics Inc.	885012207128
4	1	C5	10 nF 10000 PF X7R 0603 (1608 Metric) 50 V ±10%	Ceramic capacitor	Wurth Electronics Inc.	885382206002
5	1	C6	47 nF X7R 0603 (1608 Metric) 50 V ±10%	Ceramic capacitor	Wurth Electronics Inc.	885012206093
6	1	C7	0.1 µF X7R 0603 (1608 Metric) 50 V ±10%	Ceramic capacitor	Wurth Electronics Inc.	885012206095
7	0	C8	47 µF radial, Can 100 V ±20%	Ceramic capacitor (not mounted)	Wurth Electronics Inc.	860040875002
8	1	CN1	Con3 10.5X7.4 pitch 3.5 mm	Terminal block	Wurth Electronics Inc.	691214110003
9	0	CN2	Con2 7.4X7 pitch 3.5 mm	Terminal block (not mounted)	Wurth Electronics Inc.	691214110002
10	1	CN5	SSQ-110-04-F-S	Connector	Samtec Inc.	SSQ-110-04-F-S
11	2	CN6, CN9	SSQ-108-04-F-S	Connectors	Samtec Inc.	SSQ-108-04-F-S
12	0	CN7, CN10	SSQ-119-04-L-D	Connectors	Samtec Inc.	SSQ-119-04-L-D
13	1	CN8	SSQ-106-04-F-S	Connector	Samtec Inc.	SSQ-106-04-F-S
14	2	D1, D7	DO-214AC, SMA 1 A 100 V	Power Schottky rectifier	ST	STPS1H100A
15	0	D2	SOD-323F, SC-90	Axial general purpose ginal Schottky diode (not mounted)	ST	BAT48JFILM
16	1	D3	SOD-123 1 V @ 200 mA (DC)	Surface mount general purpose ginal Schottky diode	ST	BAT41ZFILM
17	1	D5	SMD 0603 (1608 Metric) 20 mA	Red LED	Wurth Electronics Inc.	150060RS75000
18	1	D6	SMD 0603 (1608 Metric) 20 mA	Green LED	Wurth Electronics Inc.	150060VS75000
19	1	D8	SMD, SOD-323F, SC-90 6.2 V 500 mA 500 mW	Zener diode	Nexperia USA Inc.	TDZ6V2J,115
20	4	ISO1, ISO2, ISO3, ISO4	3KV, ACPL-217-50AE 4-SOIC (0.173", 4.40 mm width)	Optocouplers	Broadcom Limited	ACPL-217-50AE
21	8	J1, J2, J4, J5, J7, J8, J9	con2-strip-male	Jumpers	Any	Any
21a	0	J3	con2-strip-male	Jumpers (not mounted)	Any	Any

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
22	2	J13, J14	con8-2x4-strip-male pitch 2.54 mm	Connector headers	Würth Electronics Inc.	61300821121
23	1	Q1	TO-261-4, TO-261AA 100 V 3.3 W (Tc)	StripFET power MOSFET in SOT-223 package	ST	STN2NF10
24	2	R1, R2	SMD 27 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistors	Yageo	RC0603FR-0727KL
25	2	R3, R4	SMD 2.2 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistors	Yageo	RC0603FR-072K2L
26	2	R5, R6	SMD 390 Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistors	Yageo	RC0603FR-07390RL
27	1	R7	SMD 27 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistor	Yageo	RC0603FR-0727KL
28	1	R8	SMD 1.5 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistor	Yageo	RC0603FR-071K5L
29	2	R9, R10	SMD 6.8 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistors	Yageo	RC0603FR-076K8L
30	1	R11	SMD, 1 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistor	Yageo	RC0603FR-071KL
31	2	R12, R13	SMD, 22 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistors	Yageo	RC0603FR-0722KL
32	1	R14	SMD, 2.2 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistor	Yageo	RC0603FR-072K2L
33	1	R15	SMD, 68 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistor	Yageo	RC0603FR-0768KL
34	1	R16	SMD, 1 K Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistor	Yageo	RC0603FR-071KL
35	4	R101, R102, R103, R104	SMD, 100 Ohm 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistors	Yageo	RC0603FR-07100RP
36	0	R111, R112, R121, R122, R123, R124, R125, R130, R131, R132, R133, R134	100 Ohm, SMD, 0603 (1608 Metric), 0.1 W, 1/10 W $\pm 1\%$	Resistors (not mounted)	Yageo	RC0603FR-07100RP
37	2	SW1, SW2	con3-strip-male	Connection headers	Würth	61300311121
38	5	TP3, TP6, TP7, TP8, TP9	5001 0.100" Dia x 0.180" L (2.54 mm x 4.57 mm)	Test points	Keystone Electronics	5001
39	1	TR3	DO-214AB, SMC 1500W (1.5 kW)	Automotive 1500 W TVS in SMC	ST	SM15T10AY
40	1	U1	PowerSSO12 Exposed Pad	IC power switch	ST	IPS161HF
41	1	U2	DO-214AB, SMC 1500 W (1.5 kW)	1500 W, TVS in SMC	ST	SM15T39CA

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
42	0	U3	2-UDFN	High-power transient voltage suppressor (not mounted)	ST	ESDA15P60-1U1M

Revision history

Table 5. Document revision history

Date	Revision	Changes
12-Jun-2020	1	Initial release.
23-Nov-2022	2	Updated introduction, Section 1.1 Overview , Section 1.3 System requirements , and Section 1.4 Board setup . Added Section 1.5 Multiple board configuration .

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