

Getting started with X-NUCLEO-OUT03A1 industrial digital output expansion board for STM32 Nucleo

Introduction

The X-NUCLEO-OUT03A1 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 IPS2050H (dual high-side smart power solid state relay) in a digital output module connected to 2.5 A (max.) industrial loads.

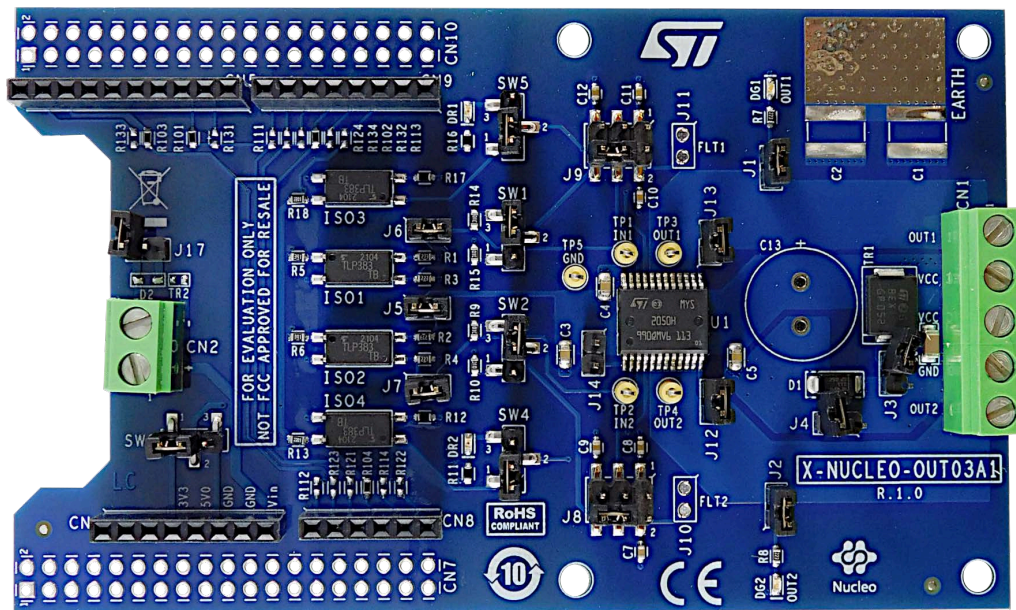
The X-NUCLEO-OUT03A1 interfaces with the microcontroller on the STM32 Nucleo via 5 kV optocouplers driven by GPIO pins, Arduino UNO R3 (default configuration) and ST morpho (optional, not mounted) connectors.

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

It is also possible to evaluate a system composed by up to four stacked X-NUCLEO-OUT03A1 expansion boards.

As an example, a system with four X-NUCLEO-OUT03A1 expansion boards allows you to evaluate an eight-channel digital output module with 2.5 A (max.) capability each.

Figure 1. X-NUCLEO-OUT03A1 expansion board



RELATED LINKS

For further details on configuration resistors, refer to UM2863

1 Getting started

1.1 Overview

The **X-NUCLEO-OUT03A1** embeds the **IPS2050H** intelligent power switch (IPS), featuring overcurrent and overtemperature protection for safe output load control.

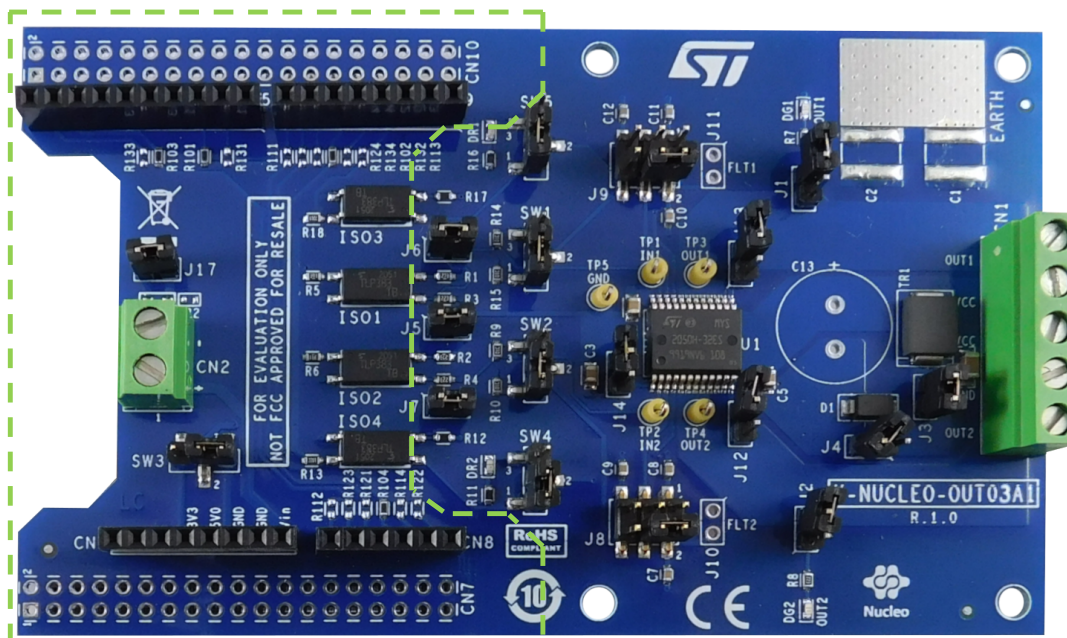
The board is designed to meet application requirements in terms of galvanic isolation between user and power interfaces. This requirement is satisfied by optical isolation implemented through four optocouplers (ISO1, ISO2, ISO3 and ISO4) for signal forward to the device and FLT pins for feedback diagnostic signals.

- Based on **IPS2050H** dual high-side switch, which features:
 - Operating range up to 60 V/2.5 A
 - Low power dissipation ($R_{ON(MAX)} = 50\text{ m}\Omega$)
 - Fast decay for inductive loads
 - Smart driving of capacitive load
 - Under-voltage lock-out
 - Per-channel overload and over-temperature protection
 - PSSO24 package
- Application board operating range: 8 to 33 V/0 to 2.5 A
- Extended voltage operating range (J3 open) up to 60 V
- Green LEDs for output on/off status
- Red LEDs for per-channel diagnostic (overload and overheating)
- 5 kV galvanic isolation
- Supply rail reverse polarity protection
- EMC compliance with IEC61000-4-2, IEC61000-4-3, IEC61000-4-5
- 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 digital supply voltage to and from the [X-NUCLEO-OUT03A1](#) expansion board.

Figure 2. X-NUCLEO-OUT03A1 expansion board: digital interface components



The four Arduino UNO R3 connectors:

- allow expansion board communication with the [STM32 Nucleo](#) development board microcontroller accessing STM32 peripheral and GPIO resources;
- provide digital supply voltage between the [STM32 Nucleo](#) development board and the [X-NUCLEO-OUT03A1](#) 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 CN2 connector (not mounted by default) on the expansion board and the ground loop should be closed by mounting D2 (enable the reverse polarity protection) or by closing J17 (without reverse polarity).

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

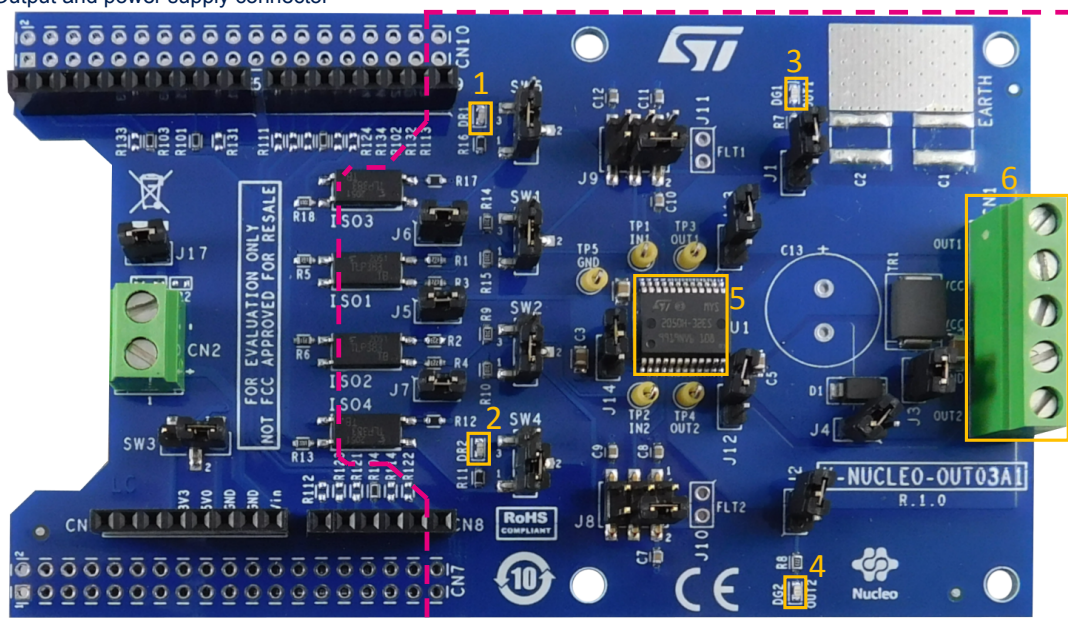
- close jumper JP5 between pins 2 and 3 and open jumper JP1 on the [NUCLEO-F401RE](#)
- open jumper JP5 between pins 1 and 2 and close jumper JP5 between pins 3 and 4 on the [NUCLEO-G431RB](#)

1.1.2 Power section

The power section involves the power supply voltage (CN1, pin 2 and 3 for V_{CC} , pin 4 for GND), load connection (between CN1 pins 1-4 and CN1 pins 5-4) and electromagnetic compatibility (EMC) protection.

Figure 3. X-NUCLEO-OUT03A1 expansion board: power stage components

1. Output channel 1 - fault red LED
2. Output channel 2 - fault red LED
3. Output channel 1 - green LED
4. Output channel 2 - green LED
5. [IPS2050H](#)
6. Output and power supply connector



For EMC:

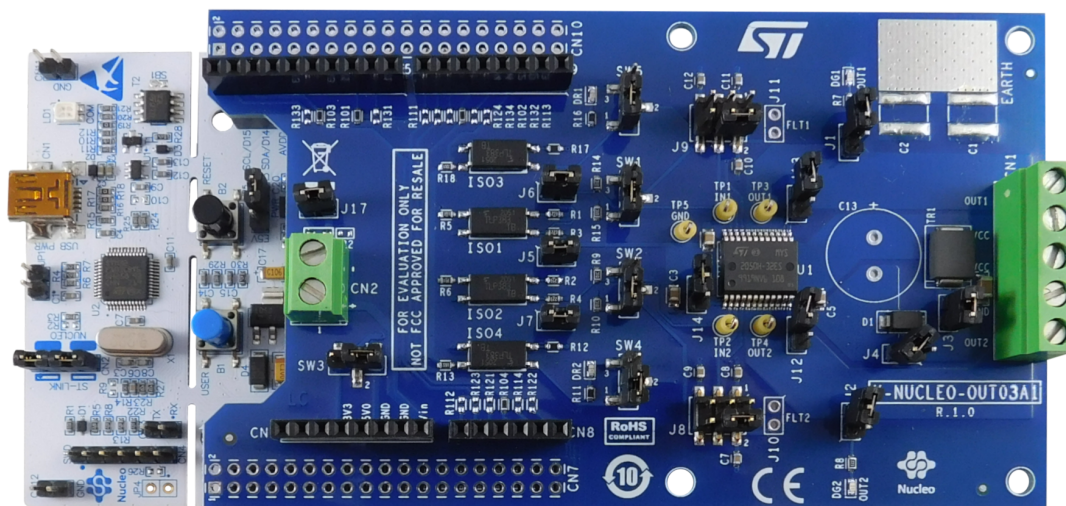
- The [SM15T39CA](#) transient voltage suppressor (TR1), enabled by closing JP3, is placed between V_{CC} and GND tracks to protect the [IPS2050H](#) against surge discharge on the supply rail path up to $\pm 1\text{kV}/2\Omega$ coupling;
- in common mode surge testing, two single-layer capacitors (C1 and C2 - not included) must be soldered at the predisposed locations;
- the [IPS2050H](#) output stages do not require additional EMC protections with respect to the IEC61000-4-2, IEC61000-4-3, IEC61000-4-5 standards.

1.2 Hardware requirements

The X-NUCLEO-OUT03A1 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT03A1 must be plugged onto the matching Arduino UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-OUT03A1 and STM32 Nucleo stack



1.3 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT03A1 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-OUT3 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-OUT03A1 with NUCLEO-F401RE or NUCLEO-G431RB development board

- Step 2.** Download the firmware (.bin or .hex) 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-OUT03_04-STM32F4xx_Nucleo.bin	MDK-ARM-OUT03_04-STM32F4xx_Nucleo.bin	STM32CubeIDE-OUT03_04-STM32F4xx_Nucleo.bin

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

NUCLEO-G431RB		
IAR	Keil	STM32CubeIDE
EWARM-OUT03_04-STM32G4xx_Nucleo.bin	MDK-ARM-OUT03_04-STM32G4xx_Nucleo.bin	STM32CubeIDE-OUT03_04-STM32G4xx_Nucleo.bin

- Step 3.** Connect the [IPS2050H](#) 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 by pushing the black button on the [STM32 Nucleo](#) board.
- Step 7.** 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 an eight channel digital output module by stacking four [X-NUCLEO-OUT03A1](#) 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	IN2	FLT1	FLT2
Board 0	R101	R102	R103	R104
Board 1	R131	R132	R133	R134
Board 2	R111	R112	R113	R114
Board 3	R121	R122	R123	R124

Important:

When using Board 2 and Board 3, two jumpers must close the morpho connectors pins in the [STM32 Nucleo](#) board:

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

Figure 5. X-NUCLEO-OUT03A1 circuit schematic (1 of 2)

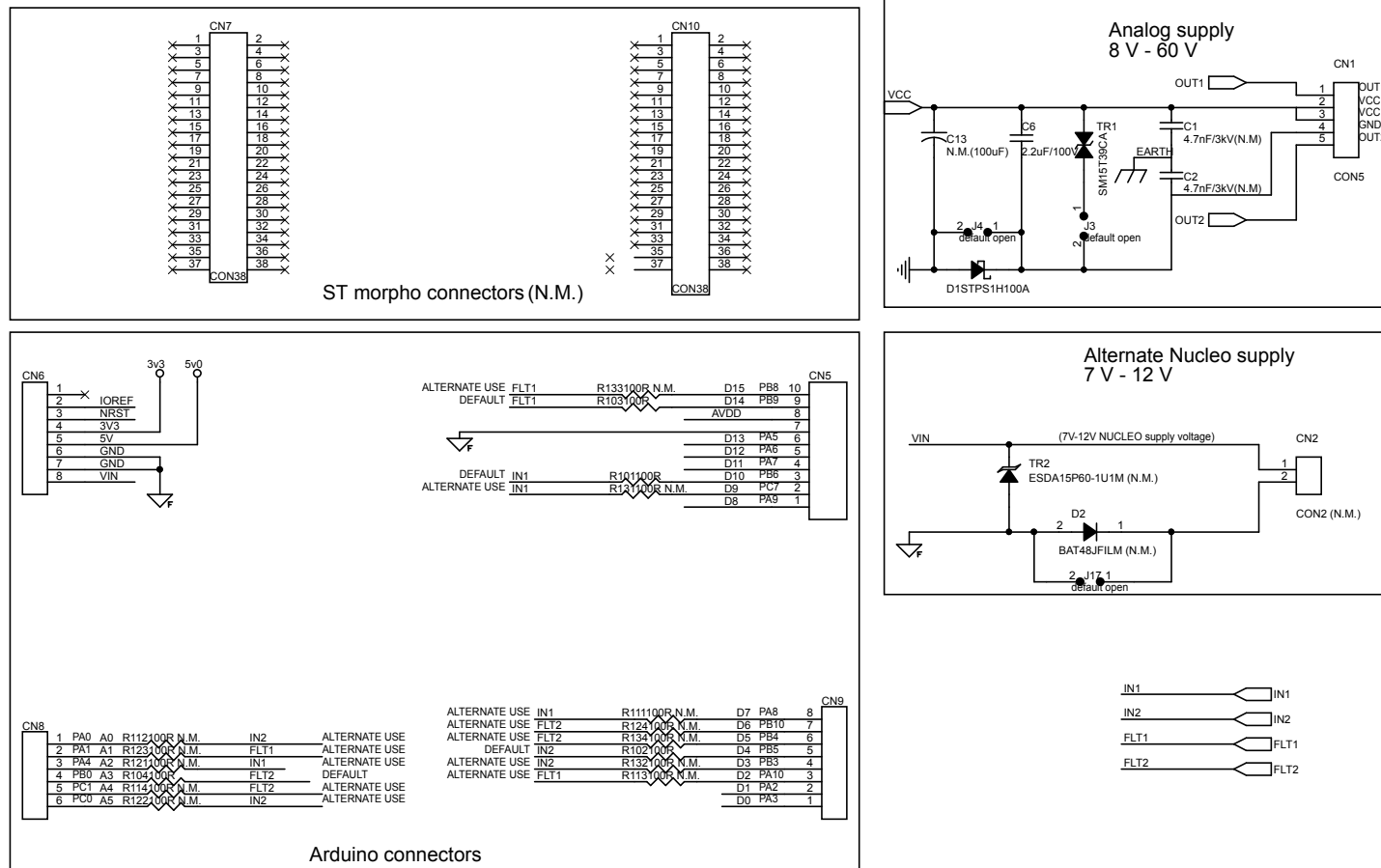
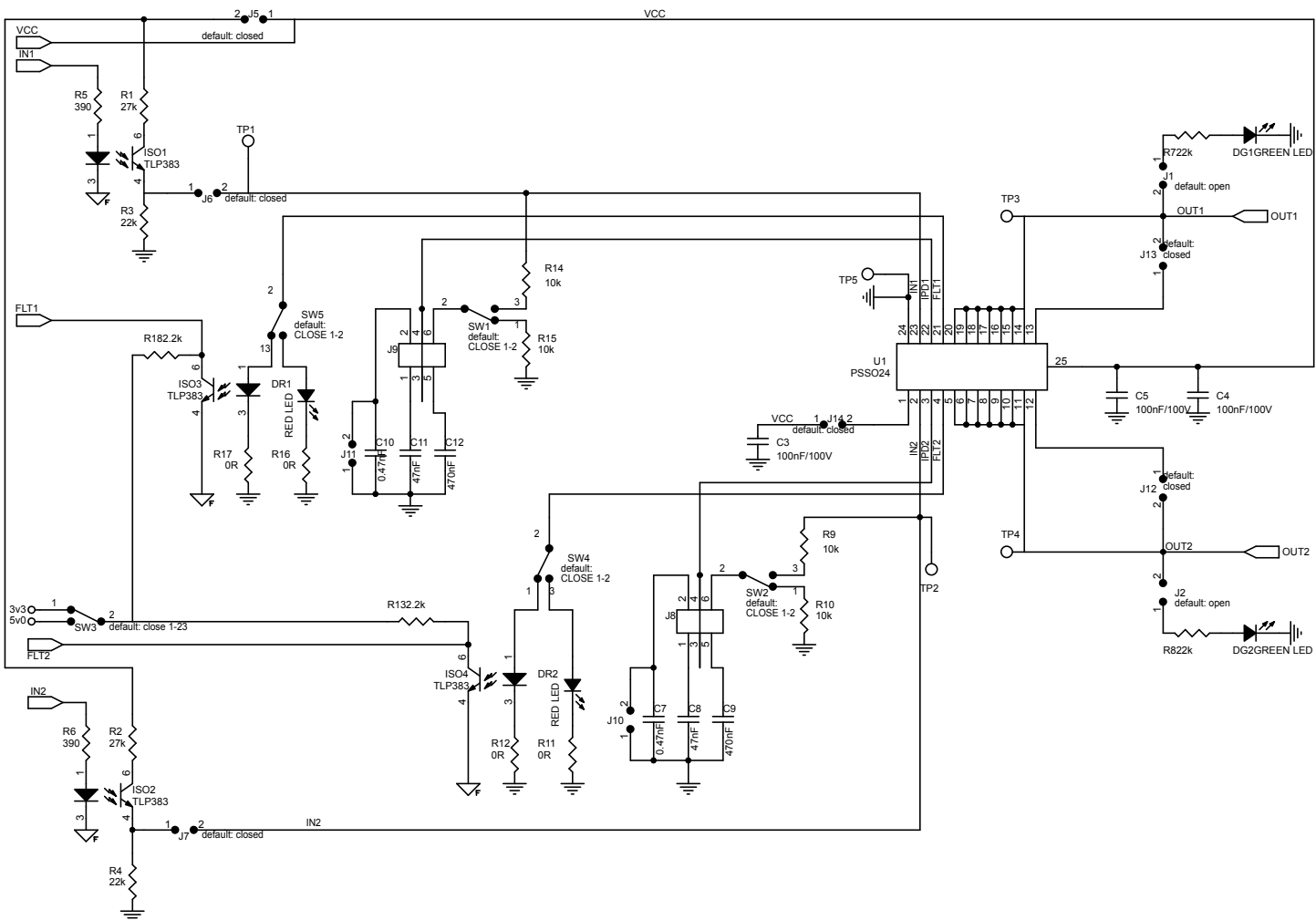


Figure 6. X-NUCLEO-OUT03A1 circuit schematic (2 of 2)



3 Bill of materials

Table 4. X-NUCLEO-OUT03A1 bill of materials

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	U1	IPS2050H PSSO24	Dual high-side smart power solid state relay	ST	IPS2050H-TR
2	1	CN1	5 ways, 1 row 24 A TH 5 mm	Connector	WURTH	691137710005
3	0	C1,C2	4.7 nF 3kV 1825	Connectors (not mounted)	Vishay	HV1825Y472KXHATHV
4	1	TR1	1.5 kW Vbr = 39 V Vcl = 53.9 V SMC	1500 W, 33.3 V TVS in SMC	ST	SM15T39CA
5	1	D1	1 A, 100 V SMA	100 V, 1 A power Schottky rectifier	ST	STPS1H100A
6	11	J1, J2, J3, J4, J5, J6, J7, J12, J13, J14 J17	2 ways, 1 row TH 2.54 mm	Jumpers	WURTH	61300211121
7	0	J10, J11	TH 2.54 mm	Jumpers (not mounted)	Any	Any
8	3	C3, C4, C5	100 nF 100 V 0805 X7R	Capacitors	WURTH	885012207128
9	1	C6	2.2 µF 100 V 1206 X7R	Capacitor	AVX	12061C225KAT2A
10	2	C7, C10	470pF 16V 0603 X7R	Capacitors	WURTH	885012206032
11	2	C8, C11	47nF 16V 0603 X7R	Capacitors	WURTH	885012206044
12	2	C9, C12	470nF 25V 0603 X7R	Capacitors	WURTH	885012206075
13	0	C13		Capacitor (not mounted)	Any	Any
14	4	ISO1, ISO2 ISO3, ISO4	VCE = 80V VISO=5kV 11-4P1A	Optocouplers	TOSHIBA	TLP383
					WURTH	140100146000
15	2	R1, R2	27 kΩ 0.1 W 0603	Resistors	MULTICOMP	MCMR06X2702FTL
16	2	R3, R4	22 kΩ 0.1 W 0603	Resistors	VISHAY	CRCW060322K0FKEA
17	2	R5, R6	390 Ω 0.1 W 0603	Resistors	YAGEO	RC0603FR-07390RL
18	2	DG1, DG2	150060GS75000	Green LEDs	WURTH	150060GS75000
19	2	R7, R8	22 kΩ 0.2 W 0603	Resistors	TE-CONN	CRGH0603J22K
20	2	DR1, DR2	150060RS75000	Red LEDs	WURTH	150060RS75000
21	2	J8, J9	6 ways, 2 rows connector SMD 2.54 mm	Jumpers	WURTH	61030621121
22	4	R9, R10, R14, R15	10kΩ 0.1W ±1% 0603	Resistors	Bourns	CR0603-FX-1002ELF
23	4	R11, R12, R16, R17	0Ω 0.1W 0603	Resistors	MULTICOMP	MCWR06X000 PTL
24	2	R13, R18	2.2kΩ 0.1W 0603	Resistors	MULTICOMP	MCMR06X2201FTL
25	4	R101, R102, R103, R104	100Ω 0.1W ±0.5% 0603	Resistors	Panasonic	ERJ3BD1000V

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
26	0	R111, R121, R131 R112, R122, R32 R113, R123, R133 R114, R124, R134	603	Resistors (not mounted)	Any	Any
27	5	SW1, SW2, SW3, SW4, SW5	3 ways, 1 row SMD 2.54 mm	Connectors	TE-CONN	1241150-3
28	1	CN2	2 ways, 1 row TH 5mm	Connector	WURTH	691137710002
29	0	D2 (DNM)	0.35 A, 40 V SOD-323	General purpose signal Schottky diode	ST	BAT48JFILM
30	0	TR2	1200 W Vbr = 6.8 V Vcl = 10.2 V 1610	High power transient voltage suppressor	ST	ESDA15P60-1U1M
31	1	CN5	10 ways, 1 row TH 2.54 mm	Connector	SAMTEC	ESQ-110-14-T-S
					4UCON	17896
32	2	CN6, CN9	8 ways, 1 row TH 2.54 mm	Connectors	SAMTEC	ESQ-108-14-T-S
					4UCON	15782
33	1	CN8	6 ways, 1 row TH 2.54 mm	Connector	SAMTEC	ESQ-106-04-T-S
					4UCON	15781
34	0	CN7, CN10	TH 2.54 mm	Connectors (not mounted)	SAMTEC	ESQ-119-14-T-D
35	5	TP1, TP2, TP3, TP4, TP5	TH d = 1mm	Test points	RS	262-2034
36	18		2.54 mm	Jumper	WURTH	60900213421

Revision history

Table 5. Document revision history

Date	Revision	Changes
04-Aug-2021	1	Initial release.

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