

## Getting started with the X-NUCLEO-DOL10A1 industrial digital output expansion board for STM32 Nucleo

### Introduction

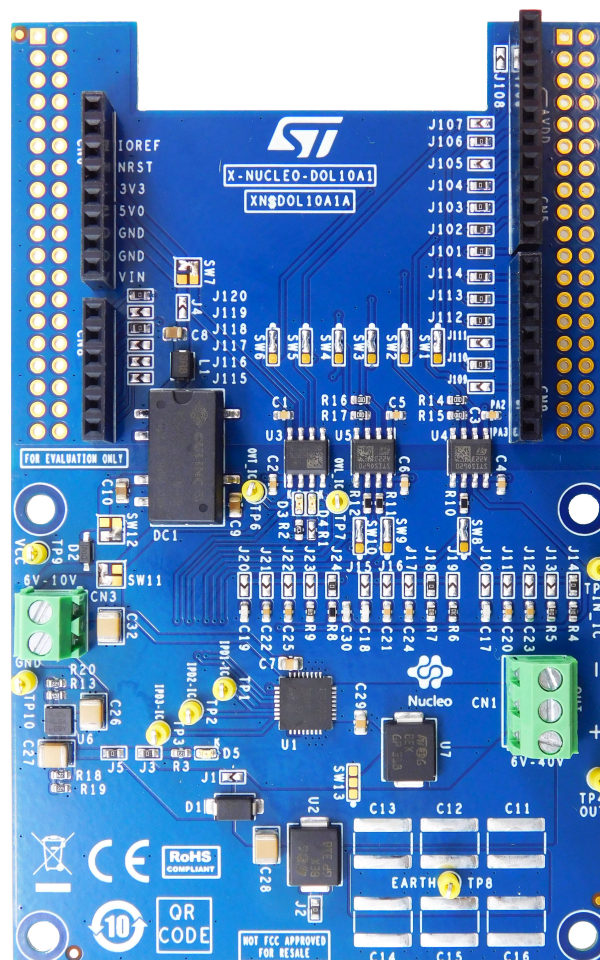
The **X-NUCLEO-DOL10A1** is an industrial single digital output expansion board for **STM32 Nucleo**. It provides a powerful and flexible environment for the evaluation of the driving and diagnostic capabilities of the **IPS1050LQ** single low-side, smart power, solid-state relay in a digital output module connected to industrial loads sinking  $\leq 5$  A steady state. The board can be configured to provide different steady state current values according to the specification of **IPS1050LQ** device.

The **X-NUCLEO-DOL10A1** interfaces with the microcontroller on the **STM32 Nucleo** via **STISO620** digital isolators, and via an isolated dc-dc converter (DC1). The galvanic isolation between the industrial field and Arduino® UNO R3 connectors is guaranteed up to 2.8 kVrms by the digital isolators and DC1.

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-DOL10A1** expansion board stacked on other expansion board compatible in terms of logic signals assignments.

**Figure 1. X-NUCLEO-DOL10A1 expansion board**



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# 1 Getting started

## 1.1 Overview

The **X-NUCLEO-DOL10A1** embeds the **IPS1050LQ** intelligent power switch (IPS), which features overcurrent and overtemperature protections for safe output load control, and open load detection. The overcurrent protection threshold can be configured through a set of jumpers and switches. This configuration can be achieved programmatically through GPIO lines of a microcontroller, or statically through resistors, or dynamically using capacitors. More details in the [Section 1.4: Board setup](#).

The board is designed to meet the application requirements for the galvanic isolation between the user and power interfaces: the isolation is implemented through mono-directional digital isolators (**STISO620**) and an isolated DC-DC converter (DC1, generating the 5 V and 10 V rails on the process stage from the 5 V rail on the logic side).

The expansion board features:

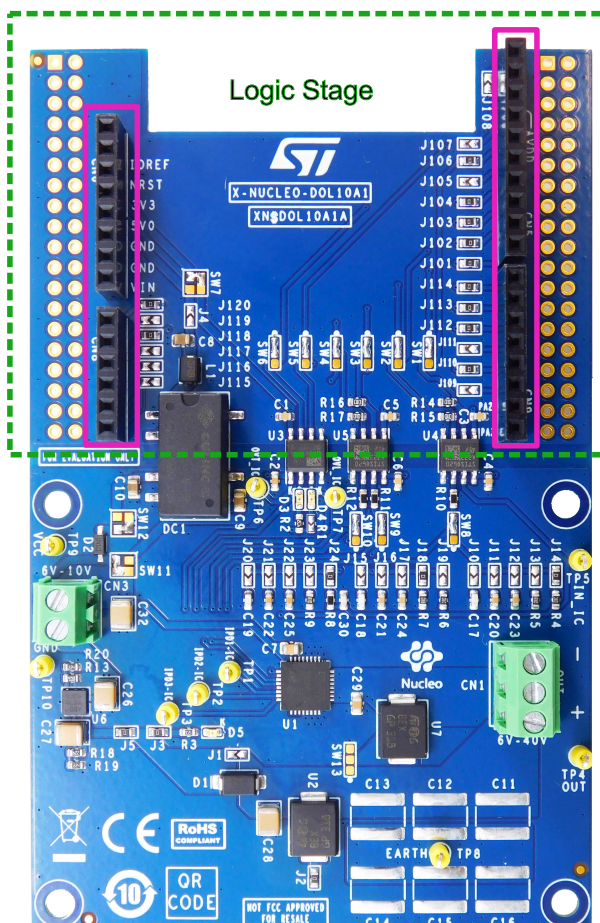
- Based on the **IPS1050LQ** single low-side switch, which features:
  - IC supply (Vcc pin) operating range 5.8 to 10 V
  - Output (OUT pin) operating range up to 60 V
  - Smart overload protection with configurable inrush and limitation levels
  - 3.3 V and 5 V compatible I/O
  - Very low On-state resistance ( $R_{DS(on)} \leq 50 \text{ m}\Omega$ )
  - Fast demagnetization of inductive loads
  - Junction over-temperature protections
  - Over-temperature diagnostic pin
  - Undervoltage lock-out
  - Loss of supply / loss of ground protection
  - Designed to meet IEC 61000-4-2, IEC61000-4-4, and IEC61000-4-5
  - QFN32L 6x6 mm package
- Galvanic isolation between logic and process sides by **STISO620** digital isolators and isolated DC-DC converter
- On board high efficiency 24 V (field rail) to 6 V LDO (**LDO40LPUR**)
- Selectable supply of the **IPS1050LQ** from field rail through U6 (SW11 = close 2-3, J5 = close) as per default setting, or from the on board isolated dc-dc converter (SW11 = close 1-2, J4 = close)
- Selectable pull-up for the diagnostic signal (OVT\_L) from U6 output rail (SW12 = close 2-3, J5 = close) as per default setting, or from the on board isolated dc-dc converter (SW12 = close 1-2, J4 = close)
- Process side supply rail reverse polarity protection (J1 = open) by **STPS1H100A**
- Application board logic side operating voltage 3.3 V (SW7 = close 1-2) or 5 V (SW7 = close 2-3)
- Supply rail surge pulse protection (J2 = close) by **SM15T39CA**
- Green LED (D5) for output on/off status (J3 closed)
- Red LED for over-temperature (D3) diagnostics
- Digital signal driving output channel (default = CN5[2])
- Digital signal for thermal diagnostic (default = CN9[6])
- Digital signals for smart overload protection configuration (default = CN5[1] and CN9[8, 7])
- Easy digital signals reconfigurability by SW1, SW2, SW3, SW4, SW5, SW6

- Smart overload protection configuration through the inrush current level setting as follows:
  - Configuration for inrush current level setting through IPDx digital signals (MCU): SW8 = close 2-3, SW9 = close 2-3, SW10 = close 2-3
  - Configuration for inrush current level "static setting" through the digital signal driving the output channel (IN\_L): SW8 = close 1-2 (for H level J14 = close, for L level J13 = close), SW9 = close 1-2 (for H level J19 = close, for L level J18 = close), SW10 = close 1-2 (for H level J24 = close, for L level J23 = close)
  - Configuration for inrush current level "dynamic setting" through the digital signal driving the output channel (IN\_L): SW8 = close 1-2, J14 = close and J10, J11, J12 setting for the proper capacitance selection, SW9 = close 1-2, J19 = close and J15, J16, J17 setting for the proper capacitance selection, SW10 = close 1-2, J24 = close and J20, J21, J22 setting for the proper capacitance selection
- Compatible with STM32 Nucleo development boards
- Equipped with Arduino® UNO R3 connectors
- RoHS and China RoHS compliant
- CE certified

### 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-DOL10A1 expansion board.

**Figure 2. X-NUCLEO-DOL10A1 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-DOL10A1** expansion board, in either direction.

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 SW7 (3v3 closing pins 1-2; 5v0 closing pins 2-3).

## 1.1.2

**Power section**

The [X-NUCLEO-DOL10A1](#) offers one connection point for the load through the connector CN1[2]. The other side of the load is connected to the positive rail of the process stage power supply (usually +24V, on CN1[1]).

The [X-NUCLEO-DOL10A1](#) offers the user two alternative solutions to supply the [IPS1050LQ](#) (U1).

With the default supply solution (SW11 closed 2-3), the [IPS1050LQ](#) is supplied by the same supply rail where the load is connected (CN1[1] connected to the 24 V rail).

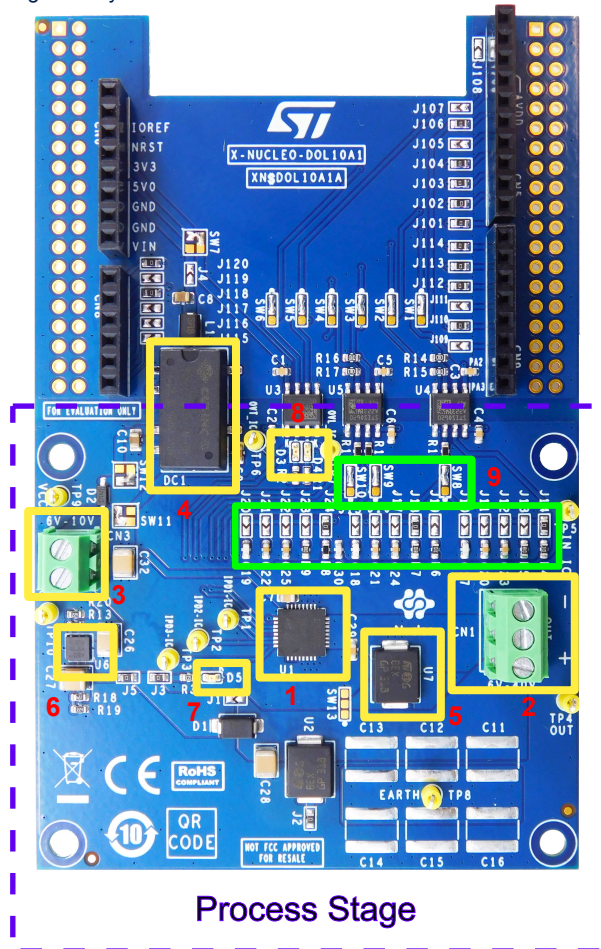
With the alternative solution (SW11 closed 1-2), the [IPS1050LQ](#) is supplied by the onboard isolated DC-DC converter DC1 that generates the 10V\_P rail supplying the IC. In this case the user just needs to connect the process side ground of the [X-NUCLEO-DOL10A1](#) (CN1[3]) to the reference voltage of the process stage power supply where the load is connected.

It is important to note that:

- If SW13 is left all open, then the [IPS1050LQ](#) internal demagnetization output clamp is selected, with the EAS limits reported in the device datasheet.
- Solutions for external fast demagnetization are also offered, if default supply of [IPS1050LQ](#) device is selected (V\_FIELD applied on CN1[1] and SW11 closed 2-3): in this case users have a TVS ([SM15T39CA](#)) which can be connected to V\_FIELD (SW13 closed 1-2) or to GND (SW13 close 2-3) for fast demagnetization purposes.

**Figure 3. X-NUCLEO-DOL10A1 expansion board: power section components**

1. IPS1050LQ (U1)
2. Power stage ground, 24V rail and Load connector
3. External Supply connector for IPS1050LQ (VCC)
4. DC1
5. SM15T39CA (U7)
6. LDO (U6)
7. Output channel status green LED (D5)
8. Over-temperature (D3) and overload (D4, for future use) red LEDs
9. Inrush current threshold setting circuitry



For EMC:

- the SM15T39CA transient voltage suppressor (U2), enabled by closing J2, is placed between process stage supply rail and GND tracks to protect the IPS1050LQ against surge discharge on the supply rail path up to  $\pm 500 \text{ k}/2 \Omega$  coupling;
- in the common mode surge testing, single-layer capacitors (C11, C12, C13 and C14, C15, C16 - not included) must be soldered at the predisposed locations;
- the IPS1050LQ 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-DOL10A1](#) are detailed below:

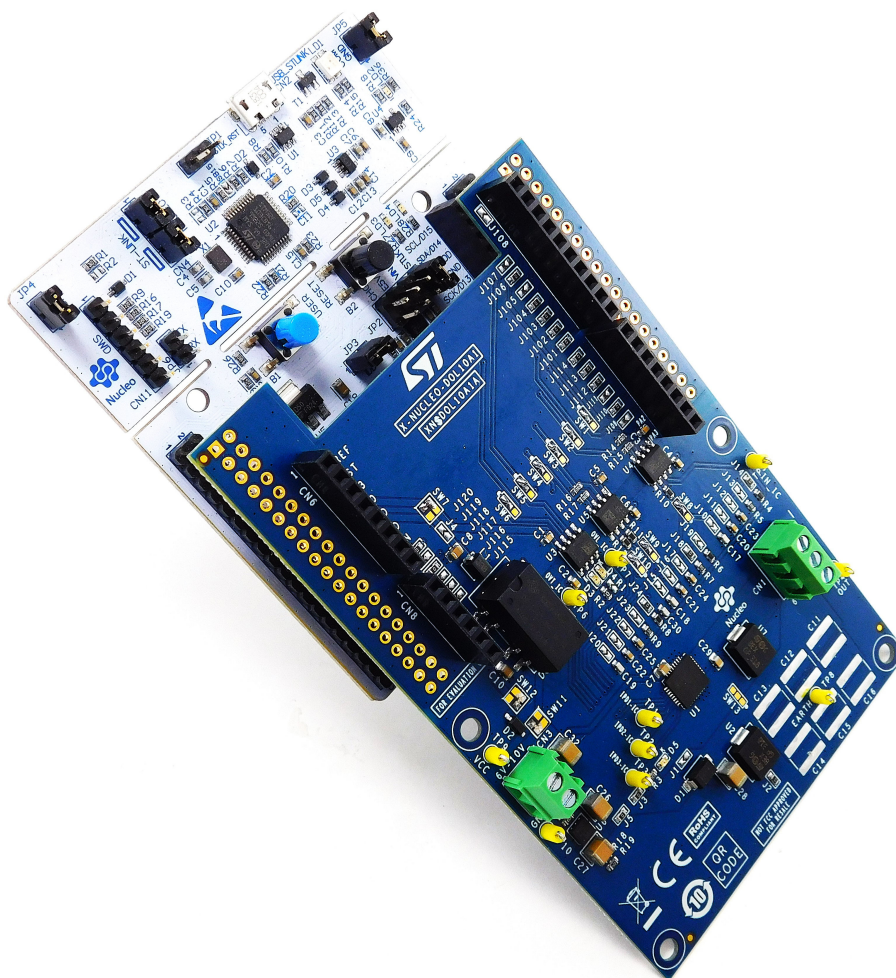
- for emission, compliance with standards:
  - EN IEC 61000-6-3:2021
  - EN 55032:2015 +A1:2020
- for immunity, compliance with standards:
  - EN IEC 61000-6-1:2019
  - EN 55035:2017 +A11:2020

## 1.2 Hardware requirements

The X-NUCLEO-DOL10A1 expansion board is designed to be used with the [NUCLEO-F401RE](#) or [NUCLEO-G431RB](#) STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-DOL10A1 must be plugged onto the matching Arduino® UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-DOL10A1 and STM32 Nucleo stack



## 1.3 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-DOL10A1 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 mini-USB or micro-USB cable to your PC to use the **X-NUCLEO-DOL10A1** with **NUCLEO-F401RE** or **NUCLEO-G431RB** development board respectively.
- Step 2.** Download the proper firmware (.bin) onto the **STM32 Nucleo** development board microcontroller through **STM32ST-LINK utility**, **STM32CubeProgrammer**, and according to your IDE environment, as detailed in the table below.

**Table 1. Nucleo development boards binary files**

| Nucleo board         | Binary path                                                                    |
|----------------------|--------------------------------------------------------------------------------|
| <i>NUCLEO-F401RE</i> | Projects\NUCLEO-F401RE\Examples\DOL10A1\OneChannel_LS\Binary\OneChannel_LS.bin |
| <i>NUCLEO-G431RB</i> | Projects\NUCLEO-G431RB\Examples\DOL10A1\OneChannel_LS\Binary\OneChannel_LS.bin |

**Note:** Additional details are available inside the **X-CUBE-IPS** software package in each example project folder (*Examples\DOL10A1\OneChannel\_LS\readme.html*)

- Step 3.** Connect the load on the output connectors (see [Section 1.1.2: Power section](#)).
- Step 4.** Provide the digital supply voltage (see [Section 1.1.1: Digital section](#)).
- Step 5.** Supply the **IPS1050LQ** device (see [Section 1.1.2: Power section](#)).  
 If SW11 = close 1-2 and J4 = close, then you just need to connect CN1[3] to the reference (ground) of the same power supply where the load is connected.  
 If SW11 = close 2-3 and J5 = close, then connect CN1[1] and CN1[3] to the positive and reference poles of the same power supply where the load is connected.
- Step 6.** Reset the example sequence using the black push button.
- Step 7.** Push the blue button on the **STM32 Nucleo** board to choose among the examples provided in the firmware package.



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Schematic diagrams

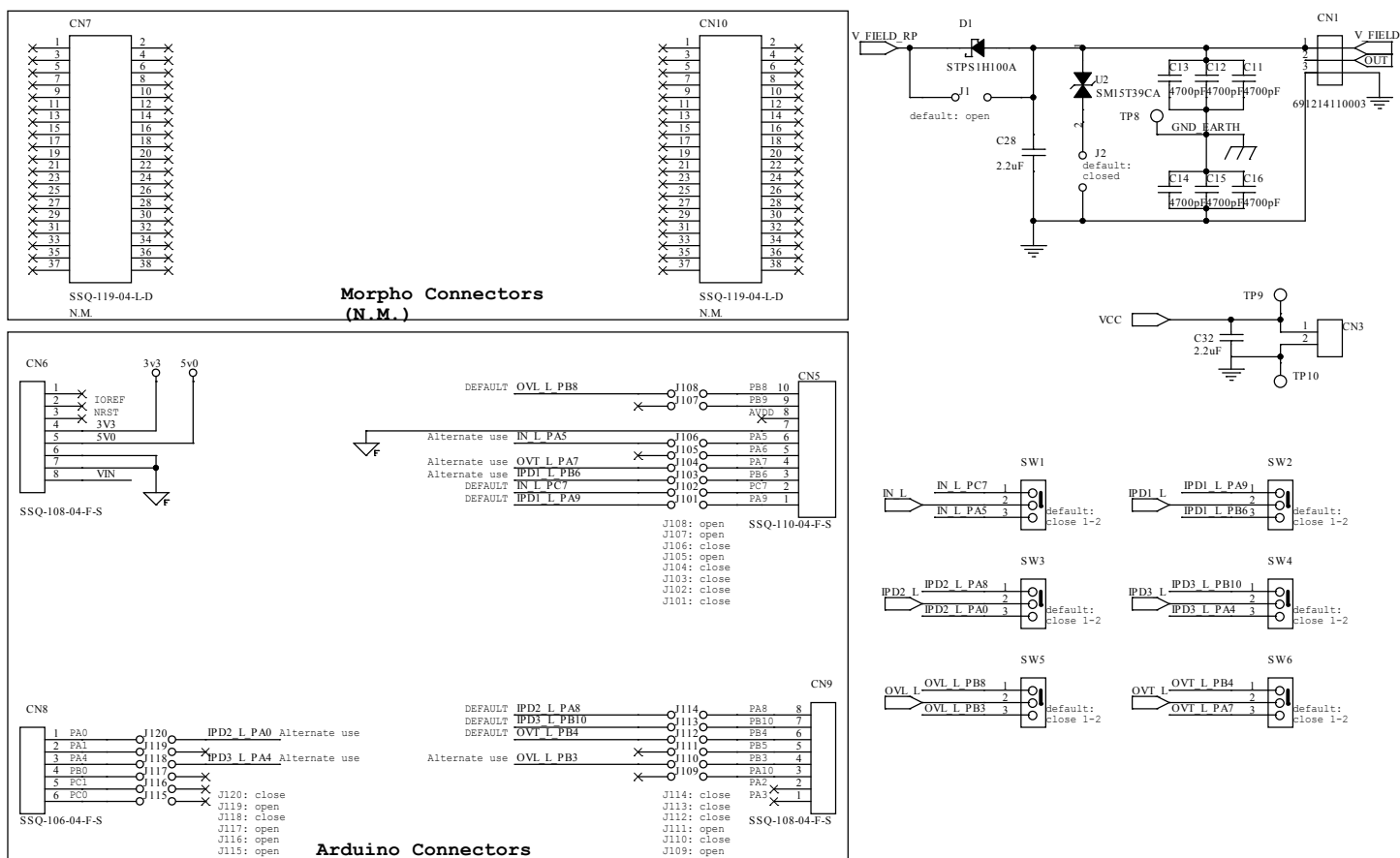
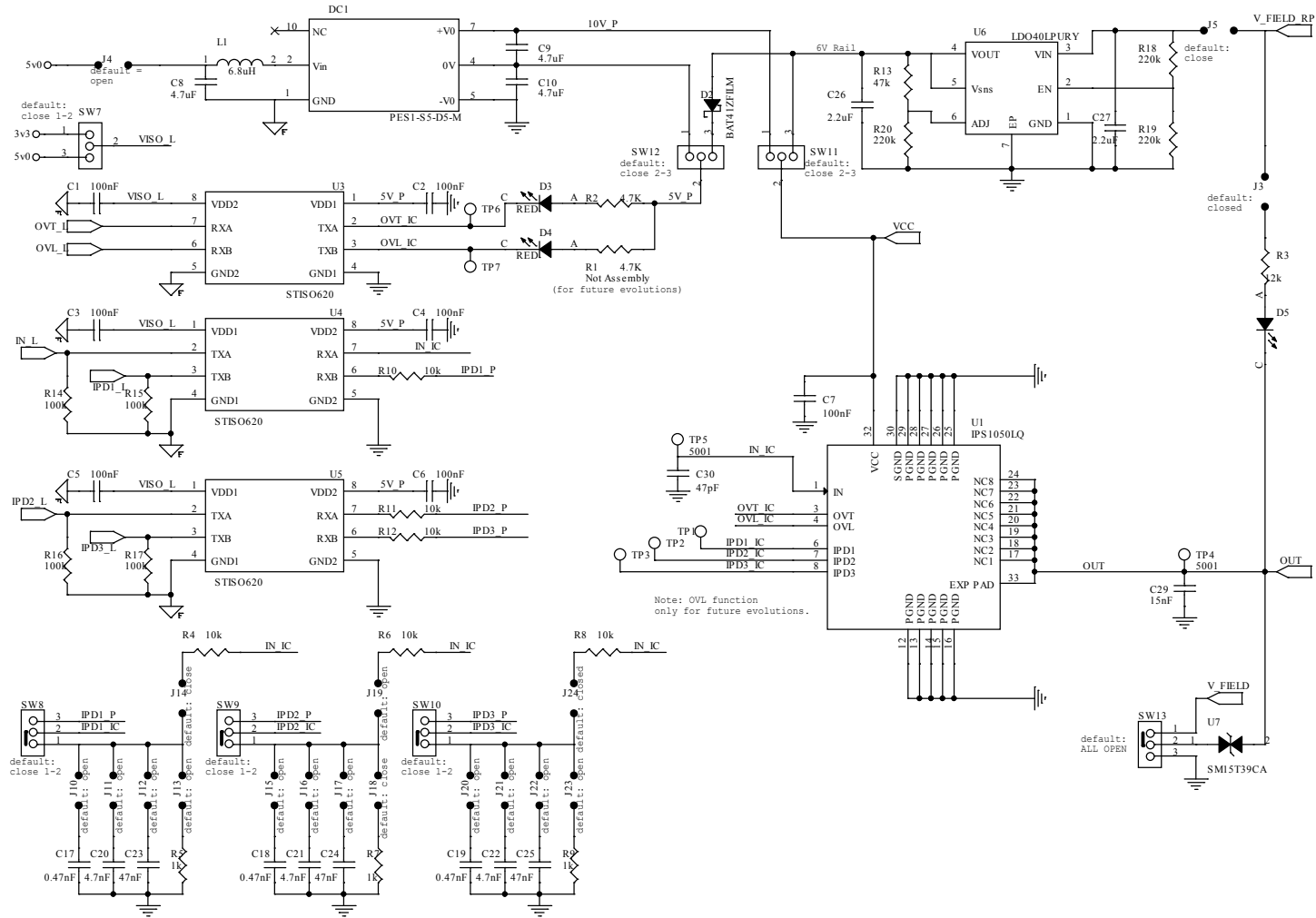


Figure 6. X-NUCLEO-DOL10A1 circuit schematic (2 of 2)



### 3 Bill of materials

**Table 2. X-NUCLEO-DOL10A1 bill of materials**

| Item | Q.ty | Ref.                         | Part/Value                                      | Description                                | Manufacturer           | Order code                 |
|------|------|------------------------------|-------------------------------------------------|--------------------------------------------|------------------------|----------------------------|
| 1    | 6    | C1 C2 C3 C4, C5, C6          | 100nF, 0603 (1608 Metric), 16V, +/-10%          | CAPACITOR CERAMIC SMD 0603                 | Würth Electronics Inc. | 885012206046               |
| 2    | 1    | C7                           | 0.1uF, 0805 (2012 Metric), 100V, +/-10%         | CAP CER 0.1UF 100V X7R 0805                | Würth Electronics Inc. | 885012207128               |
| 3    | 3    | C8, C9, C10                  | 4.7uF, 0805 (2012 Metric), 10V, +/-10%          | CAP CER 4.7UF 10V X7R 0805                 | Würth Electronics Inc. | 885012207025               |
| 4    | 0    | C11, C12, C13, C14, C15, C16 | 4700pF, 1825 (4564 Metric), 3000V (3kV), +/-10% | CAP CER 4700PF 3KV X7R 1825 (not mounted)  | Vishay Vitramon        | HV1825Y472KXHATHV          |
| 5    | 3    | C17, C18, C19                | 470pF, 0603, 16V                                |                                            | Würth Electronics Inc. | 885012006061               |
| 6    | 3    | C20, C21, C22                | 4.7nF, 0603, 16V                                |                                            | Würth Electronics Inc. | 885012206038               |
| 7    | 3    | C23, C24, C25                | 47nF, 0603, 16V                                 |                                            | Würth Electronics Inc. | 885012206044               |
| 8    | 4    | C26, C27, C28, C32           | 2.2uF, 1210 (3225 Metric), 100V, +/-10%         | CAP CER 2.2UF 100V X7R 1210                | Würth Electronics Inc. | 885012209071               |
| 9    | 1    | C29                          | 15nF, 0805, 100V, +/-10%                        |                                            | Würth Electronics Inc. | 885012207123               |
| 10   | 1    | C30                          | 47pF, 0603 (1608 Metric), 16V                   | CAPACITOR CERAMIC SMD 0603                 | Würth Electronics Inc. | 885012006021               |
| 11   | 1    | CN1                          | 3 ways screw connector                          |                                            | Würth Electronics Inc. | 691214110003               |
| 12   | 1    | CN3                          | 2 ways screw connector, 7.4X7 pitch 3.5         | TERM BLK 2POS SIDE ENT 3.5MM PCB           | Würth Electronics Inc. | 691214110002               |
| 13   | 1    | CN5                          | SSQ-110-04-F-S                                  | CONN RCPT 10POS 0.1 GOLD PCB               | Samtec Inc.            | SSQ-110-04-F-S             |
| 14   | 2    | CN6, CN9                     | SSQ-108-04-F-S                                  | CONN RCPT 8POS 0.1 GOLD PCB                | Samtec Inc.            | SSQ-108-04-F-S             |
| 15   | 0    | CN7, CN10                    | SSQ-119-04-L-D                                  | CONN RCPT 38POS 0.1 GOLD PCB (not mounted) | Samtec Inc.            | SSQ-119-04-L-D             |
| 16   | 1    | CN8                          | SSQ-106-04-F-S                                  | CONN RCPT 6POS 0.1 GOLD PCB                | Samtec Inc.            | SSQ-106-04-F-S             |
| 17   | 1    | DC1                          | PES1-S5-D5-M, 10-SMD Module, 6 Leads            | DC DC CONVERTER +/-5V 1W                   | CUI Inc.               | PES1-S5-D5-M-TR            |
| 18   | 1    | D1                           | STPS1H100A, DO-214AC, SMA, 1A                   | DIODE SCHOTTKY 100V 1A SMA                 | ST                     | <a href="#">STPS1H100A</a> |
| 19   | 1    | D2                           | BAT41ZFILM, SOD-123, 200 mA                     | DIODE SCHOTTKY 100V 0.2A SOD-123           | ST                     | <a href="#">BAT41ZFILM</a> |
| 20   | 2    | D3, D4                       | 150060RS75000, 0603 (1608 Metric), 20mA         | LED RED CLEAR 0603 SMD                     | Würth Electronics Inc. | 150060RS75000              |

| Item | Q.ty | Ref.                                                                                                                                                                                                                  | Part/Value                                    | Description                                                                                                                                                                                                                                                       | Manufacturer           | Order code        |
|------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------------|
| 21   | 1    | D5                                                                                                                                                                                                                    | 150060VS75000, 0603 (1608 Metric), 20mA       | LED GREEN CLEAR 0603 SMD                                                                                                                                                                                                                                          | Würth Electronics Inc. | 150060VS75000     |
| 22   | 40   | J1, J2, J3, J4, J5, J10, J11, J12, J13, J14, J15, J16, J17, J18, J19, J20, J21, J22, J23, J24, J101, J102, J103, J104, J105, J106, J107, J108, J109, J110, J111, J112, J113, J114, J115, J116, J117, J118, J119, J120 | jumper_0603_drop                              | DROP JUMPER 0603,<br><br>OPEN: J1, J4, J10, J11, J12, J13, J15, J16, J17, J19, J20, J21, J22, J23, J105, J107, J108, J109, J111, J115, J116, J117, J119<br><br>CLOSE: J2, J3, J5, J14, J18, J24, J101, J102, J103, J104, J106, J110, J112, J113, J114, J118, J120 |                        |                   |
| 23   | 1    | L1                                                                                                                                                                                                                    | 74476406, 6.8uH, 0.18A, +/-10%                | INDUCTOR, 6.8UH, 10%, 0.18A, 43MHZ                                                                                                                                                                                                                                | Würth Electronics Inc. | 74476406          |
| 24   | 0    | R1                                                                                                                                                                                                                    | 4.7kΩ, 0603 (1608 Metric), 0.1W, 1/10W, +/-1% | RES SMD 4.7K OHM 1% 1/10W 0603 (not mounted)                                                                                                                                                                                                                      | YAGEO                  | SR0603FR-7T4K7L   |
| 25   | 1    | R2                                                                                                                                                                                                                    | 4.7kΩ, 0603 (1608 Metric), 0.1W, 1/10W, +/-1% | RES SMD 4.7K OHM 1% 1/10W 0603                                                                                                                                                                                                                                    | YAGEO                  | SR0603FR-7T4K7L   |
| 26   | 1    | R3                                                                                                                                                                                                                    | 12kΩ, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%  | RES SMD 12K OHM 1% 1/10W 0603                                                                                                                                                                                                                                     | RHOM                   | SFR03EZPF1202     |
| 27   | 3    | R5, R7, R9                                                                                                                                                                                                            | 1kΩ, 0603, 0.1W, +/-1%                        | RES SMD 1K OHM 1% 0.1W 0603                                                                                                                                                                                                                                       | YAGEO                  | RC0603FR-101KL    |
| 28   | 6    | R4, R6, R8, R10, R11, R12                                                                                                                                                                                             | 10kΩ, 0603, 0.1W, +/-1%                       | RES SMD 10K OHM 1% 1/10W 0603                                                                                                                                                                                                                                     | YAGEO                  | RC0603FR-0710KA   |
| 29   | 1    | R13                                                                                                                                                                                                                   | 47kΩ, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%  | RES SMD 47K OHM 1% 1/10W 0603                                                                                                                                                                                                                                     | YAGEO                  | RT0603FRE0747KL   |
| 30   | 4    | R14, R15, R16, R17                                                                                                                                                                                                    | 100kΩ, 0603, 0.1W, +/-1%                      | RES SMD 100K OHM 1% 1/10W 0603                                                                                                                                                                                                                                    | VISHAY                 | RCA0603100KFKEC   |
| 31   | 3    | R18, R19, R20                                                                                                                                                                                                         | 220kΩ, 0603 (1608 Metric), 0.1W, 1/10W, +/-1% | CHIP RESISTOR SMD 1% 1/10W 0603                                                                                                                                                                                                                                   | BURNS                  | CR0603-FX-2203ELF |
| 32   | 13   | SW1, SW2, SW3, SW4, SW5, SW6, SW7, SW8, SW9, SW10, SW11, SW12, SW13                                                                                                                                                   | jumper_0603_3pin_drop                         | DROP JUMPER 0603 3pin,<br><br>SW1 to SW10: CLOSE 1-2<br>SW11 to SW12: CLOSE 2-3<br>SW13: all open                                                                                                                                                                 |                        |                   |
| 33   | 10   | TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10                                                                                                                                                                     | 5001, 0.100" Dia x 0.180" L (2.54mm x 4.57mm) | TEST POINT PC MINI .040"D BLACK                                                                                                                                                                                                                                   | Keystone Electronics   | 5001              |
| 34   | 1    | U1                                                                                                                                                                                                                    | IPS1050LQ QFN32L (6x6 mm) , 60V / 5A          | Single Channel Low Side IPS                                                                                                                                                                                                                                       | ST                     | IPS1050LQ         |

| Item | Q.ty | Ref.       | Part/Value                                    | Description                                                                 | Manufacturer | Order code                 |
|------|------|------------|-----------------------------------------------|-----------------------------------------------------------------------------|--------------|----------------------------|
| 35   | 2    | U2, U7     | SM15T39CA,<br>SMC, 1.5kW                      | TVS surge suppressor                                                        | ST           | <a href="#">SM15T39CA</a>  |
| 36   | 3    | U3, U4, U5 | STISO620, 8-SOIC<br>(0.268", 6.81mm<br>Width) | Dual Channel Digital Isolator                                               | ST           | <a href="#">STISO620</a>   |
| 37   | 1    | U6         | LDO40LPURY,<br>DFN8                           | 400 mA, 38 V low-dropout<br>regulator, with 45 $\mu$ A<br>quiescent current | ST           | <a href="#">LDO40LPURY</a> |

## 4 Board versions

**Table 3. X-NUCLEO-DOL10A1 versions**

| PCB version                 | Schematic diagrams                              | Bill of materials                              |
|-----------------------------|-------------------------------------------------|------------------------------------------------|
| XN\$DOL10A1A <sup>(1)</sup> | <a href="#">XN\$DOL10A1A schematic diagrams</a> | <a href="#">XN\$DOL10A1A bill of materials</a> |

1. This code identifies the X-NUCLEO-DOL10A1 evaluation board first version. It is printed on the board PCB.

## 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).

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## 6 References

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Freely available on [www.st.com](http://www.st.com):

1. [IPS1050LQ 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 4. Document revision history

| Date        | Revision | Changes          |
|-------------|----------|------------------|
| 04-Sep-2025 | 1        | Initial release. |

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