

Getting started with X-NUCLEO-OUT05A1 industrial digital output expansion board for STM32 Nucleo

Introduction

The X-NUCLEO-OUT05A1 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 IPS1025H single high-side smart power solid state relay, in a digital output module connected to 2.5 A industrial loads.

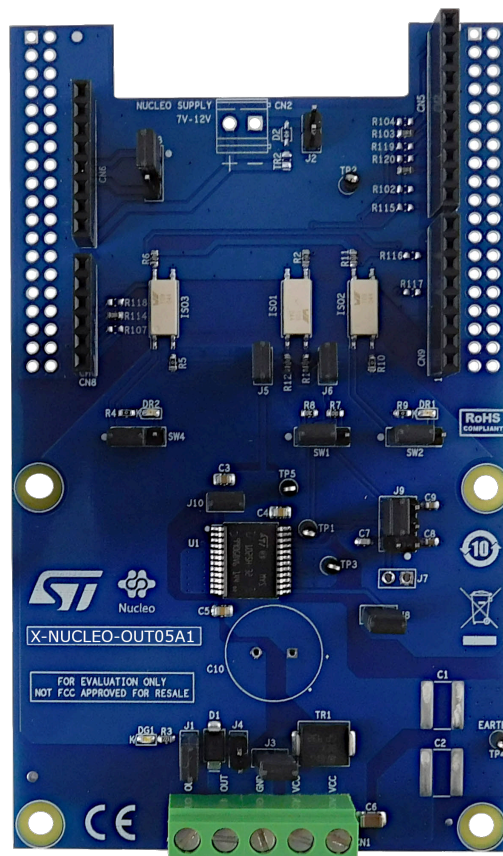
The X-NUCLEO-OUT05A1 interfaces with the microcontroller on the STM32 Nucleo via 5 kV optocouplers driven by GPIO pins and Arduino R3 connectors.

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 up to four stacked X-NUCLEO-OUT05A1 expansion boards.

As an example, a system with four X-NUCLEO-OUT05A1 expansion boards allows you to evaluate a quad channel digital output module.

Figure 1. X-NUCLEO-OUT05A1 expansion board



RELATED LINKS

[For further details on configuration resistors, refer to UM2864](#)

1 Getting started

1.1 Overview

The **X-NUCLEO-OUT05A1** embeds the **IPS1025H** 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 an optical isolation implemented through three optocouplers (ISO1, ISO2, and ISO3) for signal forward to the device and FLT pins for feedback diagnostic signals.

The expansion board features:

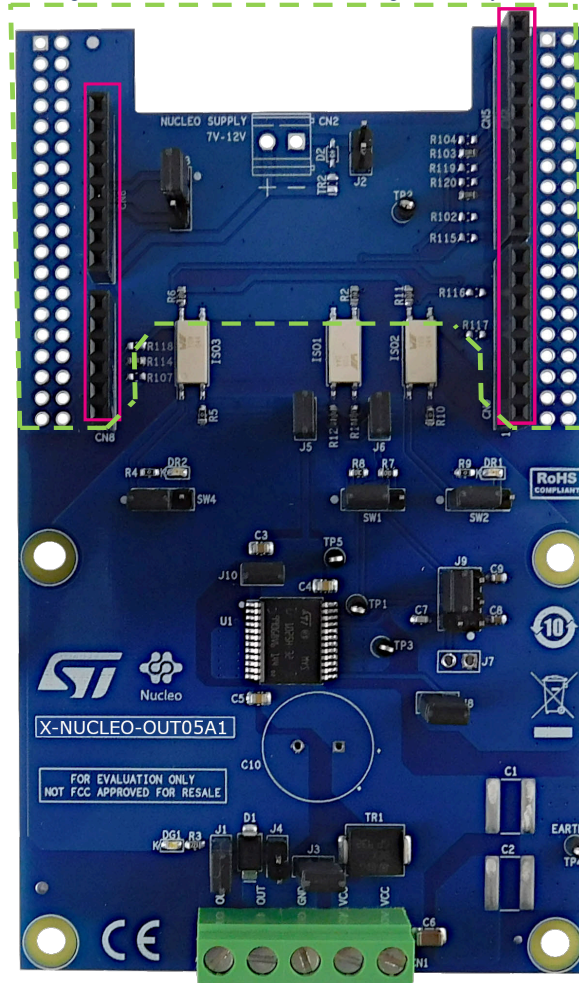
- Based on the **IPS1025H** single high-side switch, which features:
 - Operating range up to 60 V
 - Low-power dissipation ($R_{ON(MAX)} = 25 \text{ m}\Omega$)
 - Fast decay for inductive loads
 - Smart driving of capacitive loads
 - Under-voltage lock-out
 - Overload and over-temperature protection
 - 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 LED for output on/off status
- Red LEDs for overload and overheating diagnostics
- 5 kV galvanic isolation
- Supply rail reverse polarity protection
- EMC compliance with IEC61000-4-2, IEC61000-4-3, IEC61000-4-4, IEC61000-4-5, IEC61000-4-8
- Compatible with **STM32 Nucleo** development boards
- Equipped with Arduino UNO R3 connectors
- CE certified:
 - EN 55032:2015 + A1:2020
 - EN 55035:2017 + A11:2020
- 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-OUT05A1** expansion board.

Figure 2. X-NUCLEO-OUT05A1 expansion board: digital interface section

Dotted green line indicates the whole digital interface section. Pink rectangles identify Arduino UNO R3 connectors



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-OUT05A1** 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 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 V_{IN} voltage rail, it is necessary to:

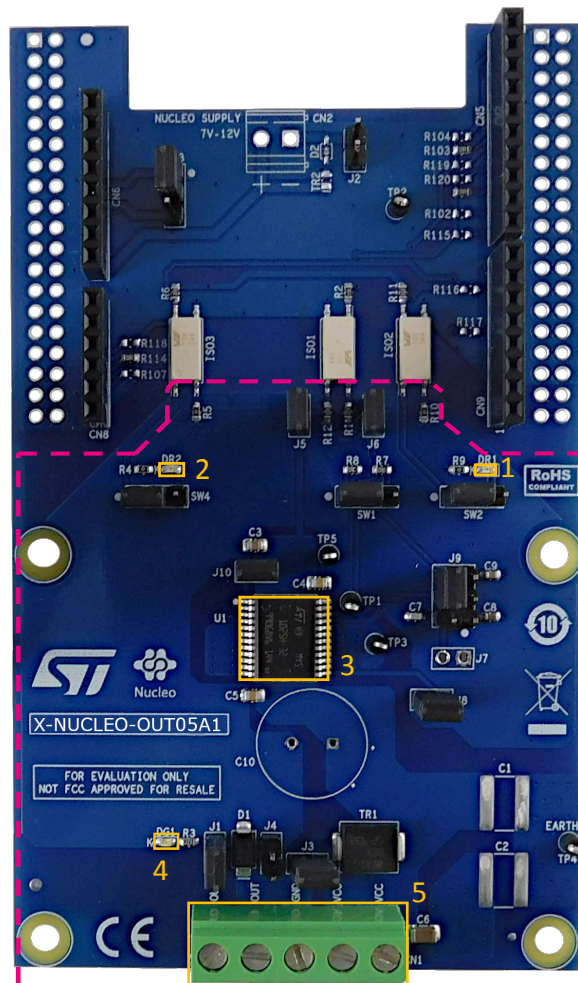
- close jumper JP5 between pins 2 and 3 and open jumper JP1 on the **NUCLEO-F401RE**;
- open jumper JP5 between pins 1 and 2 and close jumper JP5 between pins 3 and 4 on the **NUCLEO-G431RB**.

1.1.2 Power section

The power section involves the power supply voltage (CN1, pins 4 and 5 for V_{CC} , 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-OUT05A1 expansion board: power section components

1. Overtemperature red LED
2. Overload red LED
3. [IPS1025H](#)
4. Output channel - green LED
5. Output and power supply connector



For EMC:

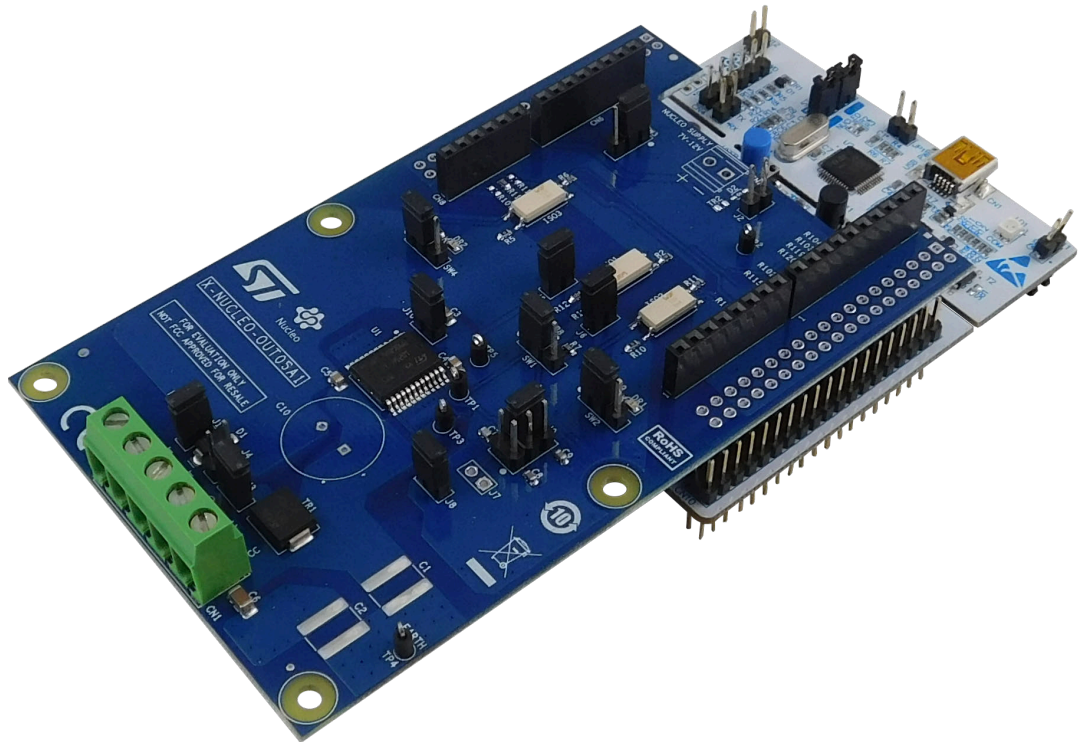
- The [SM15T39CA](#) transient voltage suppressor (TR1), enabled by closing J3, is placed between V_{CC} and GND tracks to protect the [IPS1025H](#) against surge discharge on the supply rail path up to $\pm 1 \text{ kV}/2 \Omega$ coupling;
- in common mode surge testing, two single-layer capacitors (C1 and C2 - not included) must be soldered at the predisposed locations;
- the [IPS1025H](#) 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.

1.2 Hardware requirements

The X-NUCLEO-OUT05A1 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT05A1 must be plugged onto the matching Arduino UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-OUT05A1 and STM32 Nucleo stack



1.3 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT05A1 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-OUT5 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-OUT05A1 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.

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

NUCLEO-F401RE		
IAR	Keil	STM32CubeIDE
EWARM-OUT05_06-STM32F4xx_Nucleo.bin	MDK-ARM-OUT05_06-STM32F4xx_Nucleo.bin	STM32CubeIDE-OUT05_06-STM32F4xx_Nucleo.bin

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

NUCLEO-G431RB		
IAR	Keil	STM32CubeIDE
EWARM-OUT05_06-STM32G4xx_Nucleo.bin	MDK-ARM-OUT05_06-STM32G4xx_Nucleo.bin	STM32CubeIDE-OUT05_06-STM32G4xx_Nucleo.bin

- Step 3.** Connect the [IPS1025H](#) 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.

1.5 Multiple board configuration

It is also possible to evaluate a four channel digital output module by stacking four [X-NUCLEO-OUT05A1](#) 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 three 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	FLT1	FLT2
Board 0	R101	R103	R114
Board 1	R102	R104	R117
Board 2	R115	R116	R107
Board 3	R120	R119	R118

2 Schematic diagrams

Figure 5. X-NUCLEO-OUT05A1 circuit schematic (1 of 2)

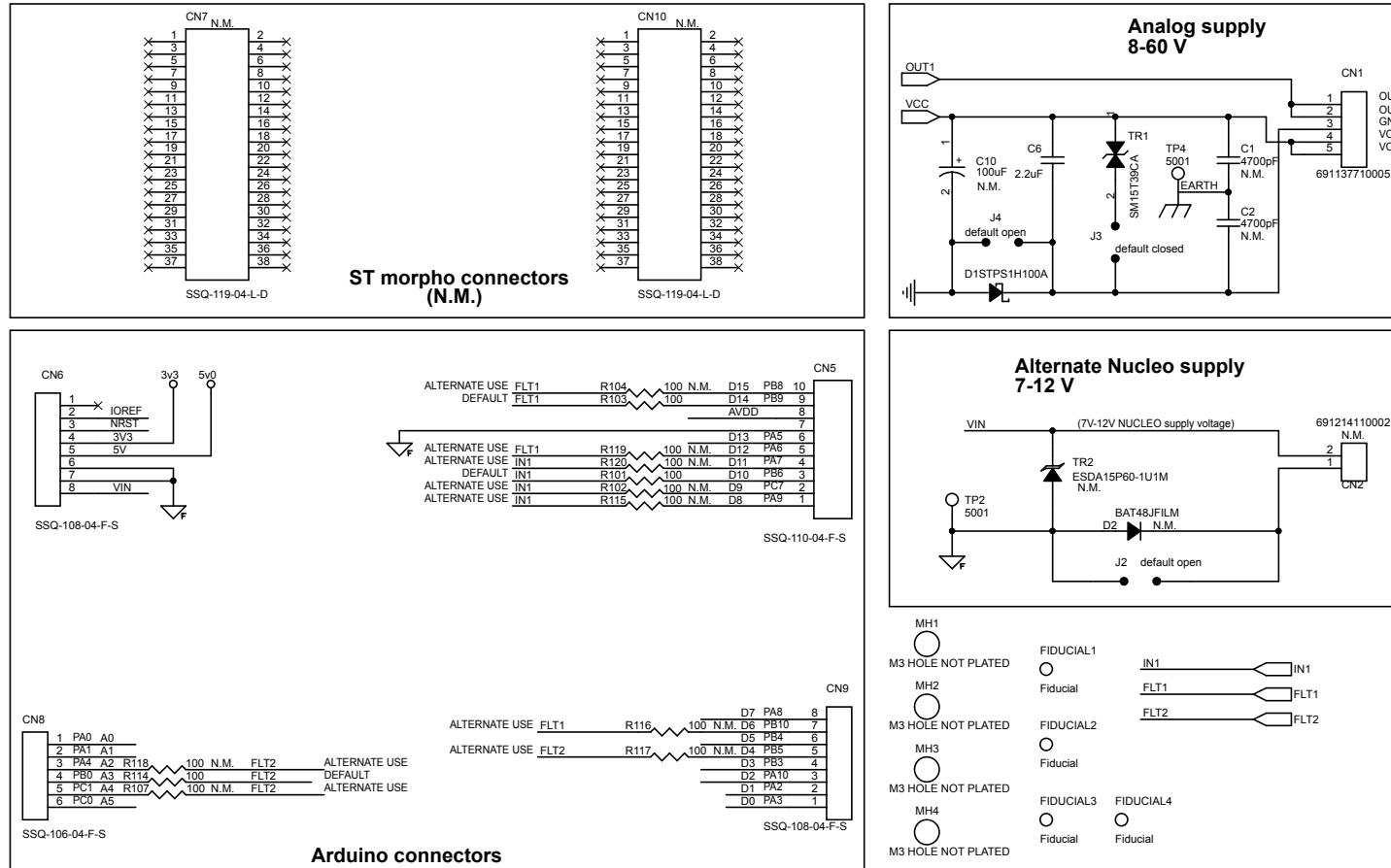
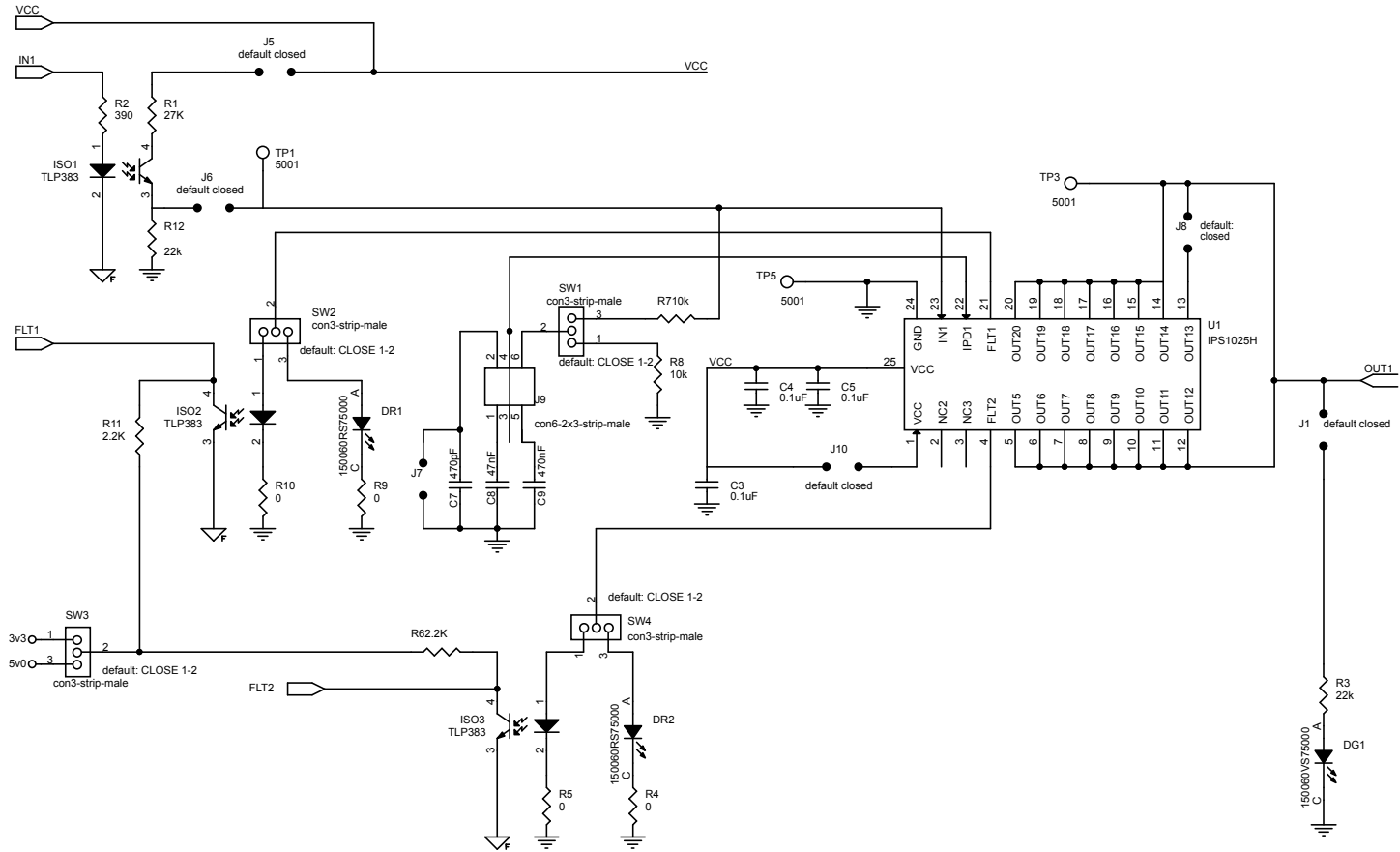


Figure 6. X-NUCLEO-OUT05A1 circuit schematic (2 of 2)



3 Bill of materials

Table 4. X-NUCLEO-OUT05A1 bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	0	C1 C2	4700 pF 1825 (4564 metric) 3000 V (3kV) $\pm 10\%$ X7R	Ceramic capacitors (not mounted)	Vishay Vitramon	HV1825Y472KXHATHV
2	3	C3 C4 C5	0.1 μ F 0805 (2012 metric) 100 V $\pm 10\%$ X7R	Ceramic capacitors	Würth Elektronik	885012207128
3	1	C6	2.2 μ F 1206 (3216 metric) 100 V $\pm 10\%$ X7R	Ceramic capacitor	AVX Corporation	12061C225KAT2A
4	1	C7	470 pF 0603 (1608 metric) 50 V $\pm 5\%$ COG/NP0	Ceramic capacitor	Würth Elektronik	885012006061
5	1	C8	47 nF 0603 (1608 metric) 50 V $\pm 10\%$ X7R	Ceramic capacitor	Murata Electronics North America	GCM188R71H473KA55D
6	1	C9	470 nF 0603 (1608 metric) 25 V $\pm 10\%$ X7R	Ceramic capacitor	Würth Elektronik	885012206075
7	0	C10	100 μ F radial, can 100 V $\pm 20\%$	Ceramic capacitor (not mounted)	Würth Elektronik	860130878011
8	1	CN1	5 positions, side entry, 5 mm	Terminal block	Würth Elektronik	691137710005
9	0	CN2	2 positions, 7.4X7 pitch 3.5 mm, side entry	Terminal block (not mounted)	Würth Elektronik	691214110002
10	1	CN5	TH 2.54 mm	10 ways, 1 row	Samtec Inc. 4UCONN	ESQ-110-14-T-S 17896
11	2	CN6 CN9	TH 2.54 mm	8 ways, 1 row	Samtec Inc. 4UCONN	ESQ-108-14-T-S 15782
12	0	CN7 CN10	38 positions, 0.1 mm, gold PCB	Connector receptacles (not mounted)	Any	Any
13	1	CN8	TH 2.54 mm	6 ways, 1 row	Samtec Inc. 4UCONN	ESQ-106-04-T-S 15781
14	1	D1	STPS1H100A, SMA	100 V, 1 A power Schottky rectifier	ST	STPS1H100A
15	0	D2	BAT48JFILM, SOD323	40 V, 350 mA axial general purpose signal Schottky diode (not mounted)	ST	BAT48JFILM
16	1	DG1	0603 (1608 metric) 20 mA SMD	Green LED	Würth Elektronik	150060GS75000
17	2	DR1 DR2	0603 (1608 metric) 20 mA SMD	Red LEDs	Würth Elektronik	150060RS75000
18	3	ISO1 ISO2 ISO3	LSOP04, 5 kV	Optoisolators	Würth Elektronik	140109146000
19	8	J1 J2 J3 J4 J5 J6 J8 J10	JUMPER-con2-strip-male TH 2.54 mm	Jumpers	Würth Elektronik	61300211121
20	0	J7	JUMPER-con2-strip-male	Jumper (not mounted)		
21	1	J9	con6-2x3-strip-male	Connector header	Würth Elektronik	61300621121
22	1	R1	27 K 0603 (1608 metric) 0.1 W, 1/10 W $\pm 1\%$ SMD	Resistor	Yageo	RC0603FR-0727KL

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
23	1	R2	390 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistor	Yageo	RC0603FR-07390RL
24	2	R3 R12	22 k 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistors	Yageo	RC0603FR-0722KL
25	4	R4 R5 R9 R10	0 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistors	Panasonic Electronic Components	ERJ-3GEY0R00V
26	2	R6 R11	2.2 K 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistors	Yageo	RC0603FR-072K2L
27	1	R7	100k 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistor	Yageo	RC0603FR-07100KL
28	1	R8	10 k 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistor	Yageo	RC0603FR-0710KL
29	3	R101 R103 R114	100 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistors	Yageo	RC0603FR-07100RP
30	0	R102 R104 R107 R115 R116 R117 R118 R119 R120	100 0603 (1608 metric) 0.1 W, 1/10 W ±1% SMD	Resistors (not mounted)	Yageo	RC0603FR-07100RP
31	4	SW1 SW2 SW3 SW4	con3-strip-male TH 2.54 mm	Connector headers	Würth Elektronik	61300311121
32	5	TP1 TP2 TP3 TP4 TP5	5001 0.100" diameter 0.180" L (2.54 mm x 4.57 mm)	Test points	Keystone Electronics	5001
33	1	TR1	SM15T39CA, SMC C2	1500 W, 33.3 V TVS in SMC	ST	SM15T39CA
34	0	TR2	ESDA15P60-1U1M, QFN-2L	High-power transient voltage suppressor (not mounted)	ST	ESDA15P60-1U1M
35	1	U1	IPS1025H, PSSO24	High-side switch with smart driving for capacitive loads	ST	IPS1025H
36	13	-	2.54 mm	Jumpers	Würth Elektronik	60900213421

4 References

Freely available on www.st.com:

1. [IPS1025H datasheet](#)
2. [UM2864: "Getting started with X-CUBE-OUT5 industrial digital output software for STM32 Nucleo"](#)
3. [NUCLEO-F401RE datasheet](#)
4. [NUCLEO-G431RB datasheet](#)

5 Board versions

Table 5. X-NUCLEO-OUT05A1 versions

Finished good	Schematic diagrams	Bill of materials
X\$NUCLEO-OUT05A1 ⁽¹⁾	X\$NUCLEO-OUT05A1 schematic diagrams	X\$NUCLEO-OUT05A1 bill of materials

1. This code identifies the X-NUCLEO-OUT05A1 evaluation board first version.

6 Regulatory compliance information

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.

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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).

Revision history

Table 6. Document revision history

Date	Revision	Changes
24-Mar-2022	1	Initial release.

Contents

1	Getting started	2
1.1	Overview	2
1.1.1	Digital section	2
1.1.2	Power section	4
1.2	Hardware requirements	5
1.3	System requirements	5
1.4	Board setup	5
1.5	Multiple board configuration	6
2	Schematic diagrams	7
3	Bill of materials	9
4	References	11
5	Board versions	12
6	Regulatory compliance information	13
	Revision history	14
	Contents	15
	List of tables	16
	List of figures	17

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.	Configuration of a stack of four expansion boards	6
Table 4.	X-NUCLEO-OUT05A1 bill of materials	9
Table 5.	X-NUCLEO-OUT05A1 versions	12
Table 6.	Document revision history	14

List of figures

Figure 1.	X-NUCLEO-OUT05A1 expansion board.	1
Figure 2.	X-NUCLEO-OUT05A1 expansion board: digital interface section	3
Figure 3.	X-NUCLEO-OUT05A1 expansion board: power section components	4
Figure 4.	X-NUCLEO-OUT05A1 and STM32 Nucleo stack.	5
Figure 5.	X-NUCLEO-OUT05A1 circuit schematic (1 of 2)	7
Figure 6.	X-NUCLEO-OUT05A1 circuit schematic (2 of 2)	8

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