Getting started with the X-NUCLEO-OUT07A1 industrial digital output expansion board for STM32 Nucleo

Introduction
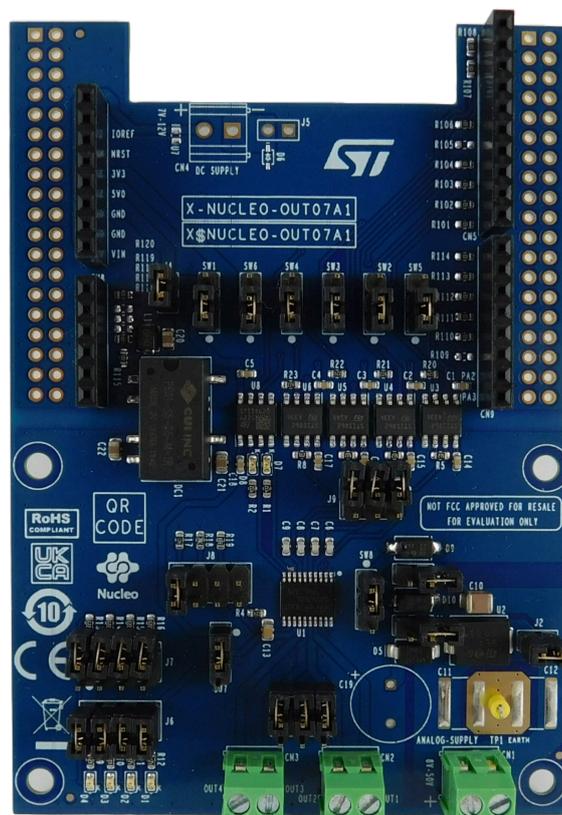
The X-NUCLEO-OUT07A1 is an industrial quad digital output expansion board for STM32Nucleo. It provides a powerful and flexible environment for the evaluation of the driving and diagnostic capabilities of the IPS4260LM quad low-side, smart power, solid-state relay in a digital output module connected to four 0.7 A industrial loads. The system is also designed to facilitate the user to configure the application as a dual digital output module for 1.0A industrial loads, or as a single digital output module for 2.0A industrial loads.

The X-NUCLEO-OUT07A1 interfaces with the microcontroller on the STM32Nucleo via STISO620 and STISO621 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 3kV 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-OUT07A1 expansion board stacked on other expansion board compatible in terms of logic signals assignments..

Figure 1. X-NUCLEO-OUT07A1 expansion board

UM3285 - Rev 1 - January 2024
For further information contact your local STMicroelectronics sales office.

www.st.com

1 Getting started

1.1 Overview

The X-NUCLEO-OUT07A1 embeds the IPS4260LM 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 by a resistor connected between the R_{ILIM} pin and the ground: the onboard connector J8 allows the easy selection of the most typical current limitation levels (0.5A, 1.0A, 2.0A). Also, the overcurrent protection can be combined with the low dissipative current limitation feature (cutoff) that limits the time duration of the overload event by a resistor mounted between R_{COD} and ground. The same connector J8 can disable the cutoff feature by closing J8[7-8], if necessary (for example, in case of high capacitive loads). The open load detection can be enabled closing J7 [1-2, 3-4, 5-6, 7-8] or disabled (J7 open).

The board is designed to meet the application requirements for the galvanic isolation between the user and power interfaces: the isolation is implemented through one monodirectional digital isolator (STISO620 for cumulative diagnostic signals FAULT and OL), four bidirectional digital isolators (STISO621 for INX driving signals and related per-channel overload diagnostic) and an isolated DC-DC converter (DC1, generating the 5V and 10V rails on the process stage from the 5V rail on the logic side).
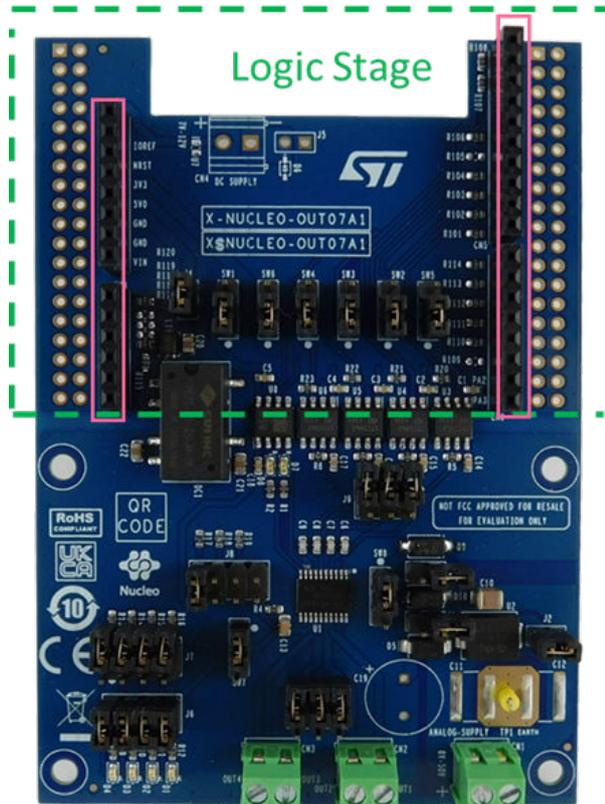
The expansion board features:

- Based on the IPS4260LM quad low-side switch, which features:
    - Operating range from 8 to 50 V
    - High Speed operation (t_{rise}, t_{fall} < 1us)
    - Process stage operating current: configurable from 350 mA (per channel) up to 2A (parallelized channels)
    - Low-power dissipation ($R_{ON(TYP)}$ = 260 mΩ)
    - Configurable low dissipative cutoff function in overload conditions
    - Per-channel overload, short circuit, and thermal junction protections
    - Fast decay for inductive loads (V_{OUT} clamp)
    - Open load detection
    - Undervoltage lock-out
    - Loss of ground protection
    - HTSSOP20 package
- Galvanic isolation between logic side and process stage by STISO620, STISO621 digital isolators and isolated DC-DC converter
- Selectable supply of the IPS4260LM from on board isolated DC-DC converter (SW7 close 1-2), or from 24 V supply rail (SW7 close 2-3)
- Process stage operating range: 10 V (SW7 close 1-2) or 10 V to 30 V (SW7 close 2-3)
- Process stage supply rail reverse polarity protections (J1 open)
- Application board logic side operating voltage 3.3 V or 5 V
- Green LEDs for outputs on/off status (J6 close 1-2, 3-4, 5-6, 7-8)
- Open load detection enable (J7 close 1-2, 3-4, 5-6, 7-8)/disable (J7 open)
- Red LEDs for overload and thermal warning (D8) and open load (D6) diagnostic
- Selectable current limitation level (J8[1-2, 3-4, 5-6])
- Cut-Off enable (J8 open 7-8)/disable (J8 close 7-8) options
- Per channel overload diagnostic available on Arduino (CN5[9,10], CN8[5, 6])
- Easy parallelization of input (J9) and output channels (J10)
- 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-OUT07A1 expansion board.

Figure 2. X-NUCLEO-OUT07A1 expansion board: digital interface section

The dotted green line indicates the whole digital interface section. The pink rectangles identify the Arduino® UNOR3 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-OUT07A1 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 CN4 connector (not mounted by default) on the expansion board and the ground loop should be closed by mounting D6 (enabling the reverse polarity protection) or by closing J5 (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 X-NUCLEO-OUT07A1 offers four connections points for the loads through the connectors CN2 and CN3. The other sides of the load are connected to the positive rail of the process stage power supply (usually +24V).

The X-NUCLEO-OUT07A1 offers the user two alternative solutions to supply the IPS4260LM (U1).

With the default solution (J7 closed 1-2), the IPS4260LM is supplied by the onboard isolated DC-DC converter DC1 that generates the 10V rail supplying the IC. In this case the user just needs to connect the process side ground of the X-NUCLEO-OUT07A1 (CN1[2]) to the reference voltage of the process stage power supply where the loads are connected.

With the alternative supply solution (J7 closed 2-3), the IPS4260LM is supplied by the same supply rail where the load are connected (CN1[1] connected to the 24V rail).

It is important to note that:

- If default supply of IPS4260LM is selected, then the only allowed external fast demagnetization is by D9 (J8 close 1-2). In other words, setting J8 close 2-3 means to enable IPS4260LM internal fast demagnetization with the EAS limits reported in the datasheet.
- If IPS4260LM is supplied by the process stage power supply, then D9 (J8 close 1-2) or D10 (J8 close 2-3) can be used. Also, slow demagnetization can be set (J8 close 2-3 and J3 closed).

Figure 3. X-NUCLEO-OUT07A1 expansion board: power section components

1. IPS4260LM
2. Load connectors
3. DC1
4. Power stage ground and 24V rail connector
5. D9
6. D10
7. Output channels status green LEDs
8. FAULT (overload and overtemperature) and OL (open Load) red LEDs
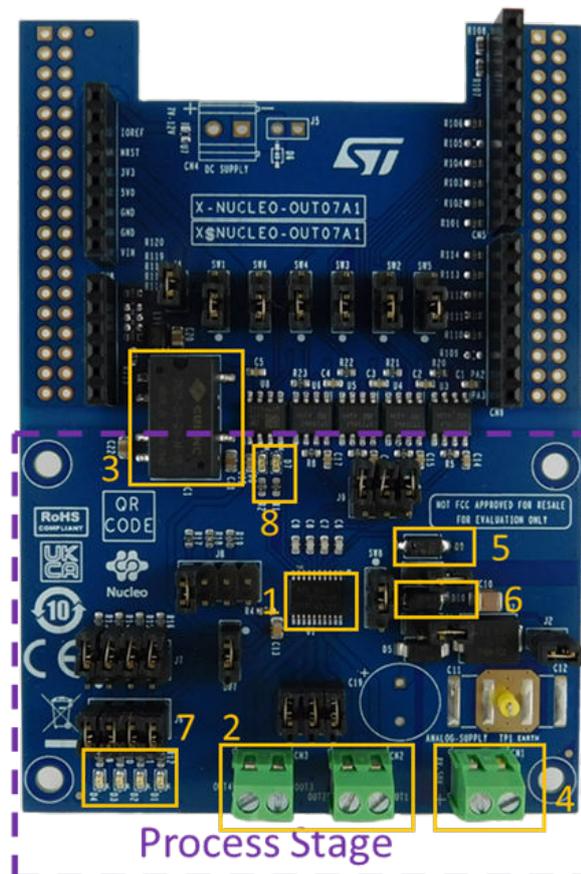
For EMC:

- the SMC30J30CA transient voltage suppressor (U2), enabled by closing J2, is placed between process stage supply rail and GND tracks to protect the IPS4260LM against surge discharge on the supply rail path up to ±500 k/2 Ω coupling;

- in the common mode surge testing, two single-layer capacitors (C11 and C12 - not included) must be soldered at the predisposed locations;

- the IPS4260LM 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-OUT07A1 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-OUT07A1 expansion board is designed to be used with the NUCLEO-F401RE or NUCLEO-G431RB STM32 Nucleo development boards.

To function correctly, the X-NUCLEO-OUT07A1 must be plugged onto the matching Arduino® UNO R3 connector pins on the STM32 Nucleo board as shown below.

Figure 4. X-NUCLEO-OUT07A1 and STM32 Nucleo stack
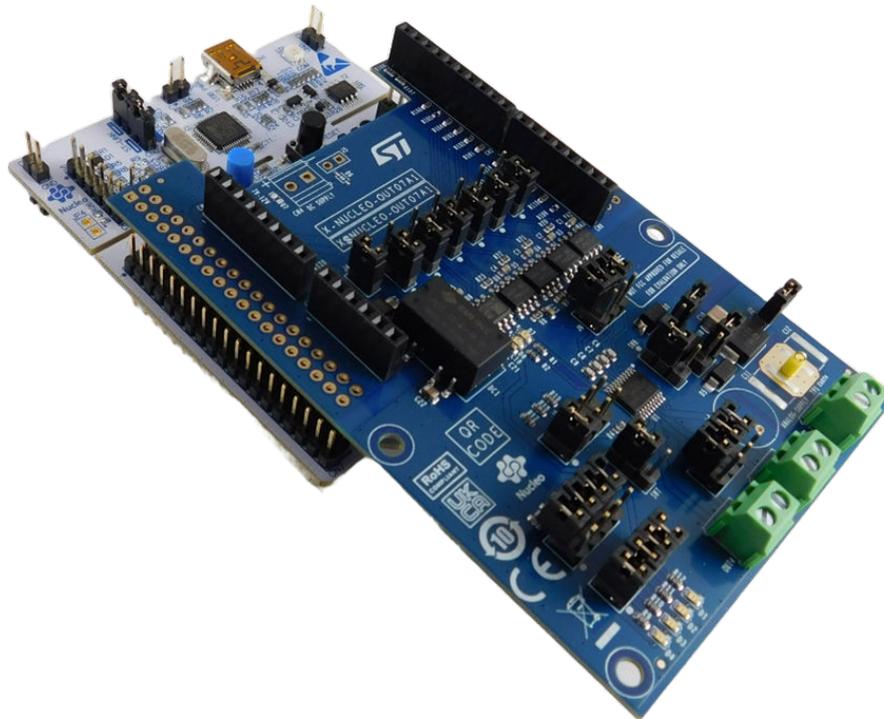
1.3 System requirements

To use the STM32 Nucleo development boards with the X-NUCLEO-OUT07A1 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-OUT07A1 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
NUCLEO-F401RE	Projects\STM32F401RE-Nucleo\Examples\OUT07A1\FourChannels\Binary\FourChannels.bin
NUCLEO-G431RB	Projects\STM32G431RB-Nucleo\Examples\OUT07A1\FourChannels\Binary\FourChannels.bin

Note: *Additional details are available inside the X-CUBE-IPS software package in each example project folder (Examples\OUT07A1\FourChannels\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 IPS4260LM device (see Section 1.1.2 Power section).
If SW7 = close 1-2, then you just need to connect CN1[2] to the reference (ground) of the same power supply where the loads are connected.
If SW7 = close 2-3, then connect CN1[1] and CN1[2] to the positive and reference poles of the same power supply where the loads are 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.
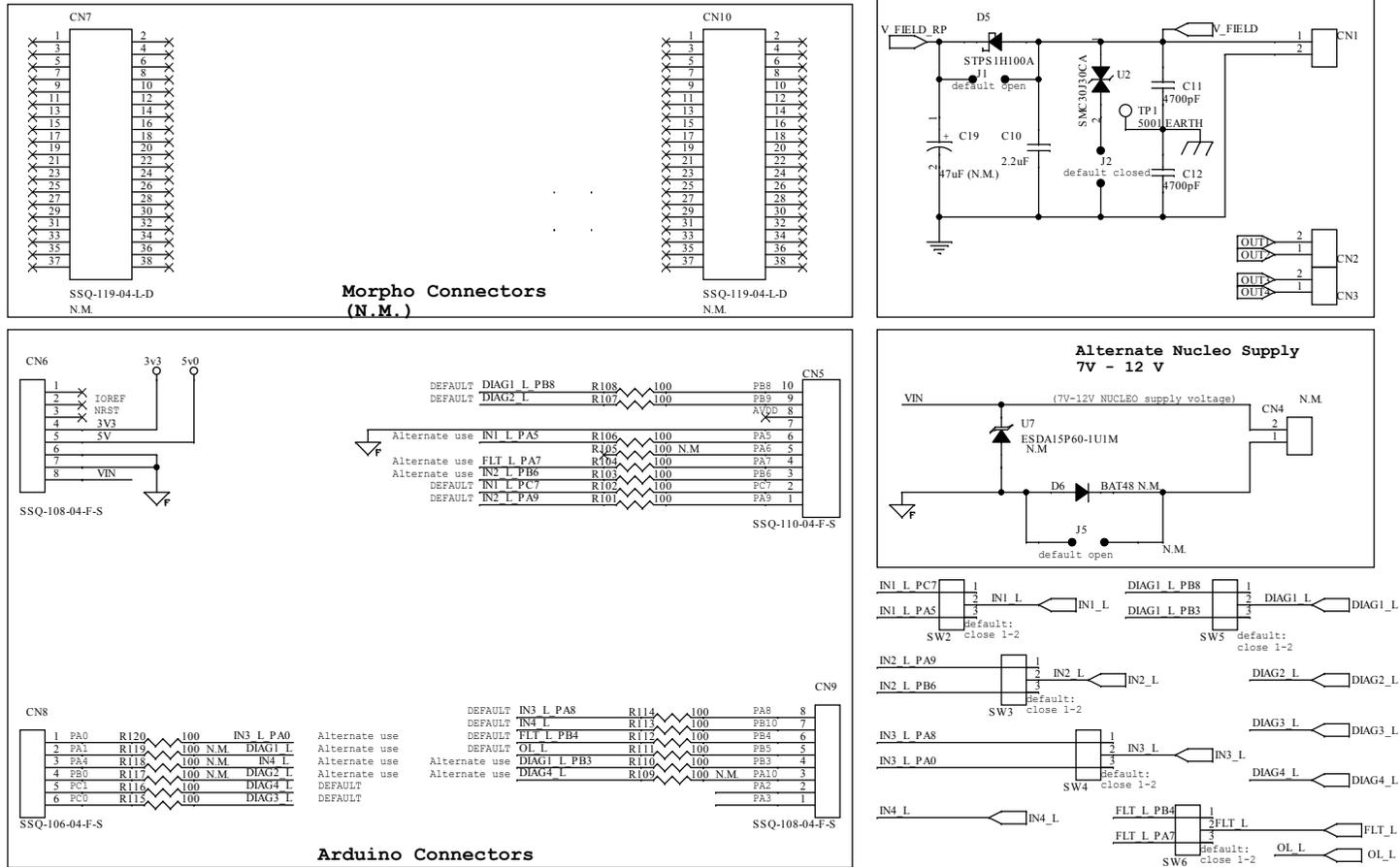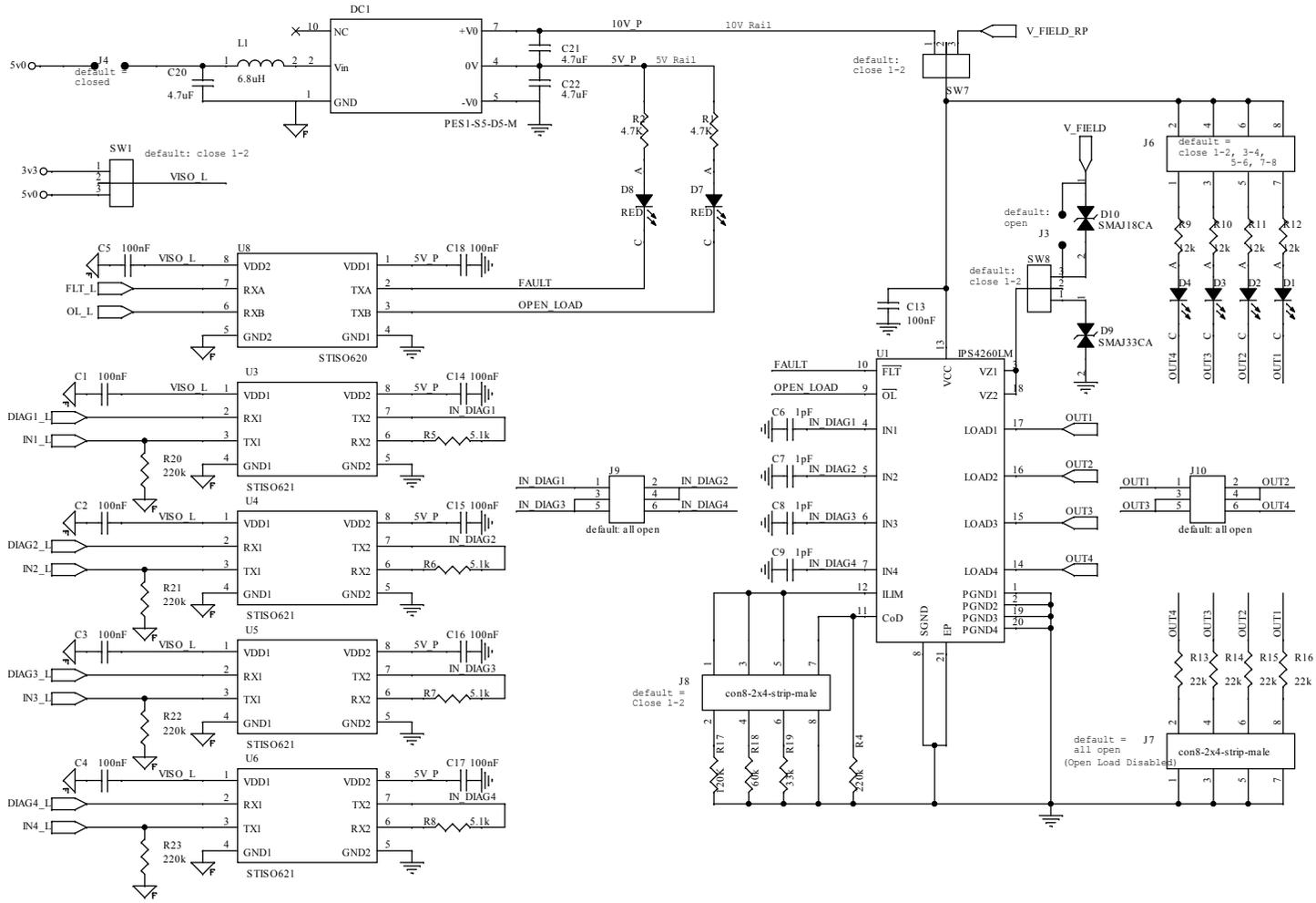
Figure 5. X-NUCLEO-OUT07A1 circuit schematic (1 of 2)

Morpho Connectors (N.M.)

CN7 — SSQ-119-04-L-D N.M.

CN10 — SSQ-119-04-L-D N.M.

V_FIELD_RP   D5   STPS1H100A   J1 default open   SMC30J30CA U2   TP1 500 EARTH   V_FIELD   CN1
C11 4700pF   C19 47uF (N.M.)   C10 2.2uF   J2 default closed   C12 4700pF
OUT / OUT CN2
OUT / OUT CN3

Arduino Connectors

CN6 — SSQ-108-04-F-S
1
2 IOREF
3 NRST
4 3V3
5 5V
6
7
8 VIN
3v3 5v0

CN5 — SSQ-110-04-F-S
DEFAULT DIAG1_L_PB8   R108 100   PB8 10
DEFAULT DIAG2_L   R107 100   PB9 9
                                    AVDD 8
                                         7
Alternate use IN1_L_PA5   R106 100   PA5 6
               R105 100 N.M. PA6 5
Alternate use FLT_L_PA7   R104 100   PA7 4
Alternate use IN2_L_PB6   R103 100   PB6 3
DEFAULT IN1_L_PC7   R102 100   PC7 2
DEFAULT IN2_L_PA9   R101 100   PA9 1

CN8 — SSQ-106-04-F-S
1 PA0   R120 100   IN3_L_PA0   Alternate use
2 PA1   R119 100 N.M.   DIAG1_L   Alternate use
3 PA4   R118 100 N.M.   IN4_L   Alternate use
4 PB0   R117 100 N.M.   DIAG2_L   Alternate use
5 PC1   R116 100   DIAG4_L   DEFAULT
6 PC0   R115 100   DIAG3_L   DEFAULT

CN9 — SSQ-108-04-F-S
DEFAULT IN3_L_PA8   R114 100   PA8 8
DEFAULT IN4_L   R113 100   PB10 7
DEFAULT FLT_L_PB4   R112 100   PB4 6
DEFAULT OL_L   R111 100   PB5 5
Alternate use DIAG1_L_PB3   R110 100   PB3 4
Alternate use DIAG4_L   R109 100 N.M. PA10 3
                                    PA2 2
                                    PA3 1

Alternate Nucleo Supply 7V - 12 V

VIN   (7V-12V NUCLEO supply voltage)   CN4 N.M.
U7 ESDA15P60-1U1M N.M.
D6 BAT48 N.M.
J5 default open N.M.

IN1_L_PC7   1
IN1_L_PA5   2 IN1_L   IN1_L
            3 default: close 1-2   SW2

DIAG1_L_PB8 1
DIAG1_L_PB3 2 DIAG1_L   DIAG1_L
             3 default: close 1-2   SW5

IN2_L_PA9   1
IN2_L_PB6   2 IN2_L   IN2_L
            3 default: close 1-2   SW3

DIAG2_L   DIAG2_L

IN3_L_PA8   1
IN3_L_PA0   2 IN3_L   IN3_L
            3 default: close 1-2   SW4

DIAG3_L   DIAG3_L

IN4_L   IN4_L

DIAG4_L   DIAG4_L

FLT_L_PB4   1
FLT_L_PA7   2 FLT_L   FLT_L
            3 default: close 1-2   SW6

OL_L   OL_L

Figure 6. **X-NUCLEO-OUT07A1 circuit schematic (2 of 2)**

3 Bill of materials

Table 2. X-NUCLEO-OUT07A1 bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	10	C1 C2 C3 C4 C5 C14 C15 C16 C17 C18	100nF, 0603 (1608 Metric), 16V, +/-10%	CAPACITOR CERAMIC SMD 0603	Wurth Electronics Inc.	885012206046
2	4	C6 C7 C8 C9	1pF, 0603 (1608 Metric), 50V	CAPACITOR CERAMIC SMD 0603	Wurth Electronics Inc.	885012006045
3	0	C19	47uF (N.M.), Radial, Can, 100V, +/-20%	CAP 47 UF 20% 100 V (not mounted)	Wurth Electronics Inc.	860040875002
4	1	C10	2.2uF, 1210 (3225 Metric), 100V, +/-10%	CAP CER 2.2UF 100V X7R 1210	Wurth Electronics Inc.	885012209071
5	0	C11 C12	4700pF, 1825 (4564 Metric), 3000V (3kV), +/-10%	CAP CER 4700PF 3KV X7R 1825 (not mounted)	Vishay Vitramon	HV1825Y472KXHATHV
6	1	C13	0.1uF, 0805 (2012 Metric), 100V, +/-10%	CAP CER 0.1UF 100V X7R 0805	Wurth Electronics Inc.	885012207128
7	3	C20, C21, C22	4.7u, F 0805 (2012 Metric), 10V, +/-10%	CAP CER 4.7UF 10V X7R 0805	Wurth Electronics Inc.	885012207025
8	1	L1	6.8uH, 0.18A, +/-10%	INDUCTOR, 6.8UH, 10%, 0.18A, 43MHZ	Wurth Electronics Inc.	74476406
9	1	DC1	PES1-S5-D5-M, 10-SMD Module, 6 Leads, 1W	DC DC CONVERTER +/-5V 1W	CUI Inc.	PES1-S5-D5-M-TR
10	3	CN1 CN2 CN3	691214110002, 7.4X7 pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB	Wurth Electronics Inc.	691214110002
11	0	CN4	691214110002, 7.4X7 pitch 3.5	TERM BLK 2POS SIDE ENT 3.5MM PCB (not mounted)	Wurth Electronics Inc.	691214110002
12	1	CN5	SSQ-110-04-F-S	CONN RCPT 10POS 0.1 GOLD PCB	Samtec Inc.	SSQ-110-04-F-S
13	2	CN6 CN9	SSQ-108-04-F-S	CONN RCPT 8POS 0.1 GOLD PCB	Samtec Inc.	SSQ-108-04-F-S
14	0	CN7 CN10	SSQ-119-04-L-D	CONN RCPT 38POS 0.1 GOLD PCB (not mounted)	Samtec Inc.	SSQ-119-04-L-D
15	1	CN8	SSQ-106-04-F-S	CONN RCPT 6POS 0.1 GOLD PCB	Samtec Inc.	SSQ-106-04-F-S

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
16	1	D5	STPS1H100A, DO-214AC, SMA, 1A	DIODE SCHOTTKY 100V 1A SMA	ST	STPS1H100A
17	0	D6	BAT48JFILM, SC-76, SOD-323, 750mV @ 200mA 350mA (DC)	DIODE SCHOTTKY 40V 350MA SOD323 (not mounted)	ST	BAT48JFILM
18	4	D1 D2 D3 D4	150060VS75000, 0603 (1608 Metric), 20mA	LED GREEN CLEAR 0603 SMD	Wurth Electronics Inc.	150060VS75000
19	2	D7 D8	150060RS75000, 0603 (1608 Metric), 20mA	LED RED CLEAR 0603 SMD	Wurth Electronics Inc.	150060RS75000
20	4	J1 J2 J3 J4	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS	Wurth Electronics Inc.	61300211121
21	0	J5	JUMPER-con2-strip-male	JUMPER-CONN HEADER .100 STR 2POS (not mounted)	Wurth Electronics Inc.	61300211121
22	3	J6 J7 J8	con8-2x4-strip-male	CONN HEADER .100 DUAL STR 8POS	Wurth Electronics Inc.	61300821121
23	2	J9 J10	con6-2x3-strip-male	CONN HEADER .100 DUAL STR 6POS	Wurth Electronics Inc.	61300621121
24	2	R1 R2	4.7k, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 4.7K OHM 1% 1/10W 0603	ANY	ANY
25	5	R4 R20 R21 R22 R23	220k 0603 (1608 Metric) 0.1W, 1/10W 1%	CHIP RESISTOR SMD 1% 1/10W 0603	ANY	ANY
26	4	R5 R6 R7 R8	5.1k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 5.1K OHM 1% 1/10W 0603	ANY	ANY
27	4	R9 R10 R11 R12	12k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 12K OHM 1% 1/10W 0603	ANY	ANY
28	4	R13 R14 R15 R16	22k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 22K OHM 1% 1/10W 0603	ANY	ANY
29	1	R17	120k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 120K OHM 1% 1/10W 0603	ANY	ANY
30	1	R18	60k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 60K OHM 1% 1/10W 0603	ANY	ANY

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
31	1	R19	33k 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 33K OHM 1% 1/10W 0603	ANY	ANY
32	15	R101 R102 R103 R104 R106 R107 R108 R110 R111 R112 R113 R114 R115 R116 R120	100, 0603 (1608 Metric), 0.1W, 1/10W, +/-1%	RES SMD 100 OHM 1% 1/10W 0603	ANY	ANY
33	0	R105 R109 R117 R118 R119	100 0603 (1608 Metric) 0.1W, 1/10W 1%	RES SMD 100 OHM 1% 1/10W 0603 (not mounted)	ANY	ANY
34	8	SW1 SW2 SW3 SW4 SW5 SW6 SW7 SW8	con3-strip-male	CONN HEADER VERT 3POS 2.54MM MALE	Würth Elektronik	61300311121
35	1	TP1	5001 0.100" Dia x 0.180" L (2.54mm x 4.57mm)	TEST POINT PC MINI .040"D BLACK	Keystone Electronics	5001
36	1	U1	IPS4260LM IPS4260L, 20-TSSOP (0.173", 4.40mm Width)	QUAD LOW-SIDE INTELLIGENT POWER	ST	IPS4260LM, IPS4260L
37	1	U2	SMC30J30CA, SMC, 3kW	TVS DIODE 33.3V 48.4V SMC	ST	SMC30J30CA
38	4	U3 U4 U5 U6	STISO621, 8-SOIC (0.268", 6.81mm Width)	Dual Channel Digital Isolator	ST	STISO621
39	1	U8	STISO620, 8-SOIC (0.268", 6.81mm Width)	Dual Channel Digital Isolator	ST	STISO620
40	0	U7	ESDA15P60-1U1M, 2-UDFN	TVS DIODE 13.2V 22.7V 1610 (not mounted)	ST	ESDA15P60-1U1M
41	1	D9	SMAJ33CA, SMA (Jedec DO214-AC)	TVS DIODE 36.7V 53.3V	ST	SMAJ33CA
42	1	D10	SMAJ18CA, SMA (Jedec DO214-AC)	TVS DIODE 20.0V 29.2V	ST	SMAJ18CA
43	27	N/A	Shunt, 2.54mm	Close jumper	Wurth Electronics Inc.	60900213421

4   Board versions

Table 3. X-NUCLEO-OUT07A1 versions

PCB version	Schematic diagrams	Bill of materials
X$NUCLEO-OUT07A1 [1]	X$NUCLEO-OUT07A1 schematic diagrams	X$NUCLEO-OUT07A1 bill of materials

1. This code identifies the X-NUCLEO-OUT07A1 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).

6 References

Freely available on www.st.com:

1. IPS4260LM 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
25-Jan-2024	1	Initial release.

Contents

List of tables

List of figures

IMPORTANT NOTICE – READ CAREFULLY