Getting started with STEVAL-FSM01M1 safe digital I/O test board

Introduction

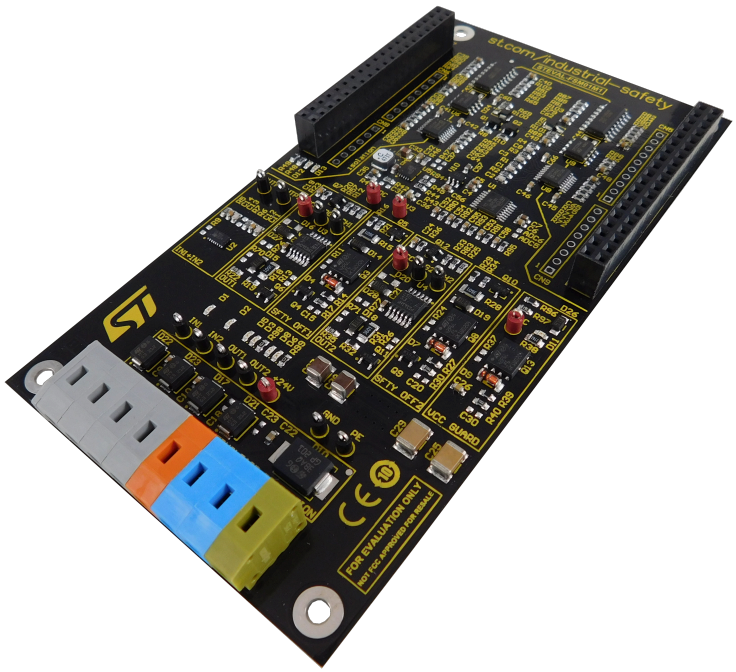
STEVAL-FSM01M1 is an industrial dual channel digital I/O board for safe automation. It provides a powerful test platform for deep technical evaluation of ST's smart power ICs for factory automation and functional safety.

The PCB provides a digital interface compatible with STM32 Nucleo boards which is galvanically isolated from the power side of the board using digital signal isolators including STISO621. The process side I/O section is based on a dual channel digital input current limiter CLT03-2Q3 and Intelligent Power Switches IPS160HF and IPS161HF. These core ICs are accompanied with many other industrial-grade ST ICs which play the critical role in providing all the needed auxiliary functions like DC voltage supply management (L7983, LDK220), onboard runtime condition monitoring ADC (ADC120) and other safety features and protections.

STEVAL-FSM01M1 (PCB, board or module in the following text) provides a high-level of flexibility and testing options thanks to a multi-level redundancy of its overall implementation. For example, the system protection scheme can be flexibly adapted in several ways by simply modifying the assembly configuration of onboard components. This allows R&D engineers to optimize and finetune design of the final product according to their exact application requirements already during the prototyping phase of development.

The board can be operated either as a standalone evaluation testbed or it can be connected in combination with an STM32 Nucleo board to provide a complete evaluation ecosystem. An associated firmware package STSW-FSM01 (available at www.st.com) provides routines to operate all functions of the PCB, plus it supports a simple user command interface allowing to control the board interactively from PC. This firmware package for STM32 is compatible with NUCLEO-F401RE however, it can be adapted to run on any other STM32 Nucleo platform.

Figure 1. STEVAL-FSM01M1



1 Architecture

1.1 Basic characteristics & features

- Design with advanced robustness and safety
- Flexible topology for agile electrical testing of onboard ICs
- Operating range: 8V to 30V (optionally to 60V)
- 2 digital outputs with current rating 2A (OUT1) resp. 0.5A (OUT2)
- 2 digital inputs compatible with IEC 61131-2 Type 1 and 3
- Output section based on IPS160HF and IPS161HF:
  - Single-channel Intelligent Power Switch (IPS) for safe automation
  - Operating voltage range up to 60V
  - Low-power dissipation ($R_{DS(on)}$ = 60 mΩ)
  - Output current capability 2A (IPS160HF) and 0.5A (IPS161HF)
  - Fast power-up performance for safe automation
  - Integrated overcurrent/overtemperature protection and diagnostics
  - Fast demagnetization of inductive loads
- Input section based on CLT03-2Q3
  - Self-powered dual channel digital input current limiter
  - Operating voltage range up to 60V
  - Integrated Test Pulse feature allowing self-integrity verification of the IC
- Additional key onboard ICs:
  - STISO621 – 100Mbps dual channel signal digital isolator
  - L7983, LDK220 – 60V step-down regulator and low noise LDO
  - ADC120 – 8-channel 12-bit/1Msps analog-digital convertor with SPI
  - STL42P6LLF6 – 60V STripFET F6 Power MOSFET
  - SMC30J, SM6T and SM2T3V3A TVS protections
- Embedded redundancy including cascade high-side switch topology
- Runtime control of all IC features (Cut-off limitation and Test-Pulse generation)
- Onboard ADC allows real-time system monitoring and integrity verification
- Status and diagnostic LEDs for each I/O channel
- Two onboard LEDs for user defined indication
- Onboard 1kV_{RMS} galvanic isolation
- Active supply voltage reverse polarity protection
- Compatible with STM32 Nucleo development boards
- Associated firmware package STSW-FSM01 for NUCLEO-F401RE providing all routines for application programming and command access from PC (through USB)
- Certification and compliance
  - CE certified
  - RoHS

1.2 Description

STEVAL-FSM01M1 is a safe dual channel digital I/O expansion board compatible with STM32 Nucleo. Its system architecture reflects our long-term experience with designing digital I/O applications to reach the highest-grade robustness and to meet the requirements on reliability of operation in the most challenging industrial environments such as Factory Automation and Functional Safety.

While majority of standard Nucleo expansion shields are usually plugged-in on top of an STM32 Nucleo board using the ARDUINO® Uno V3 connectors the STEVAL-FSM01M1, in contrary, provides the base for the Nucleo board that is connected on top of it by means of its onboard ST morpho extension headers. Hence the microcontroller pins and peripherals handling the operation of the STEVAL-FSM01M1 are physically separated from those utilized by other X-NUCLEO boards eventually connected to the system. This way additional expansion shields can be easily added on top of the stack to extend system functionality while minimizing possible overlap of utilized microcontroller resources.

The associated STM32 firmware package STSW-FSM01 is compatible with NUCLEO-F401RE however, it can be easily adapted to run on any other STM32 Nucleo platform.

In further sections of this document we describe functionality of the particular subsystems and features of the PCB in general. For complete information and detailed understanding of its implementation (schematics, BOM, layout etc.) please refer also to the documentation freely available on the webpage of the PCB and to the datasheet specifications of onboard ICs.

1.3 System structure

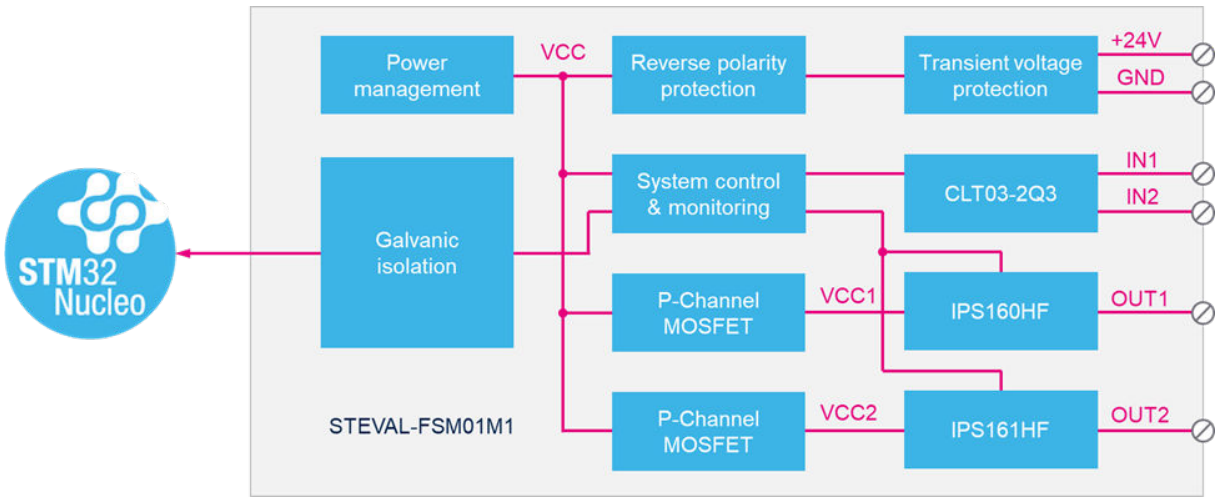
As a digital I/O board, the STEVAL-FSM01M1 translates low voltage logic level I/O signals (3.3V) provided on its digital interface and transmits them onto 0/+24V binary signals on its galvanically isolated power domain called process side.

The PCB can be used either as a standalone testboard with its logic signals provided by a user-specific hardware (custom host microcontroller board, laboratory test equipment etc.), or it can be plugged together with the NUCLEO-F401RE and operated from PC utilizing its associated firmware package STSW-FSM01.

Block diagram of the board is shown in Figure 2. It consists of the following main hardware components:

1. Digital interface and galvanic isolation
2. Process side - digital input section
3. Process side - digital output section
4. Power management and supply voltage protection
5. System control and condition monitoring

Figure 2. STEVAL-FSM01M1 block diagram

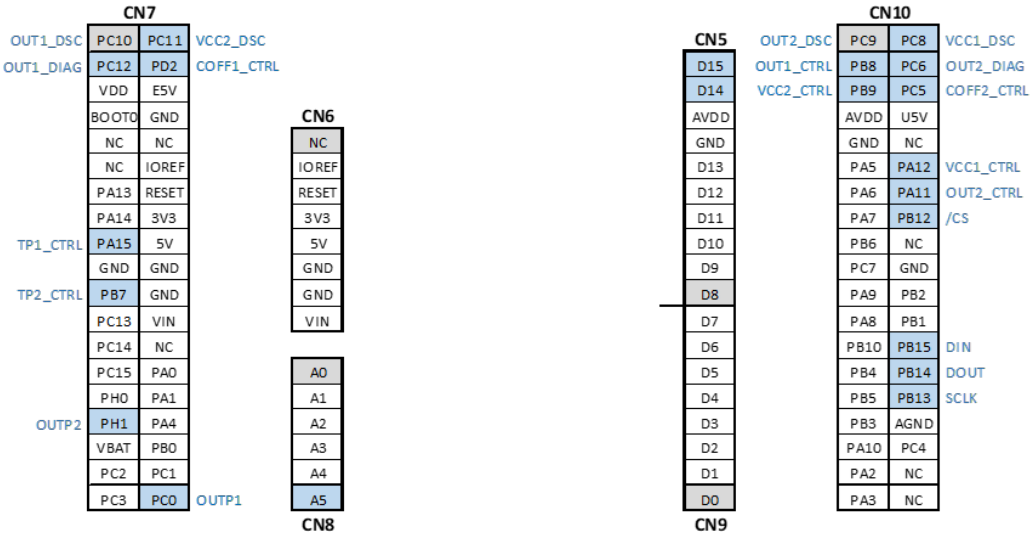


1.3.1 Digital interface and galvanic isolation

All electrical features of STEVAL-FSM01M1 are accessible through its digital interface provided by STM32 Nucleo compatible onboard ST morpho extension headers CN7 and CN10. These two connectors bring access to the two onboard user LEDs as well as to the complete functionality on the galvanically isolated process side. Pin mapping of control signals to the digital interface connectors is illustrated in Figure 3. The digital side is supplied through the pin '3V3' located on the connector CN7 and any 'GND' pin available at CN7 resp. CN10 connectors. The maximum admissible supply voltage for the digital side is 5V.

In order to decouple sensitive high-speed logic ICs from the power chips exposed to the harsh environment on process side of the I/O module, the digital interface connectors are galvanically isolated using a set of digital signal isolators including the 100 Mbps dual channel isolator STISO621.

Figure 3. Digital interface connector pin mapping

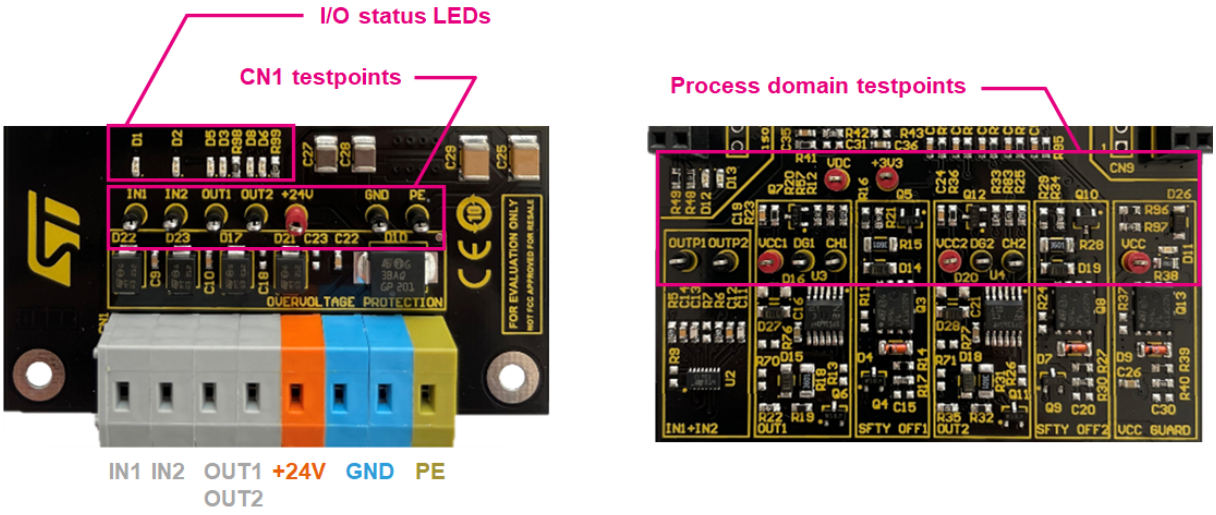


1.3.2 Process side

1.3.2.1 Process interface connector

Process side PCB terminal CN1 represents the power supply and digital I/O interface of the board. Its layout is shown in Figure 4. From the left to the right this connector provides connection of IN1 and IN2 digital input channels followed by outputs OUT1 (0.5A) and OUT2 (2A). Power supply connector is highlighted using a differentiated terminal colours. Orange terminal represents connection of positive supply (+24V) and the blue one represents the GND terminal. Blue terminal (GND) is doubled in order to provide an additional access point for connecting sensors/actuators and for laboratory test purposes. The last slot (PE, green) represents the earth connection terminal which is capacitively coupled to both positive and negative power supply lines of the PCB using high voltage 4.7nF capacitors.

Figure 4. **Process interface connector and testpoints**



To allow easy system function testing and laboratory measurements the STEVAL-FSM01M1 contains a set of onboard testpoints which provide measuring access to all the key voltage nodes in the system (power supply voltage, logic section supply and digital I/O status and diagnostics). These testpoints are also shown in Figure 4.

1.3.2.2 *Digital input section*

Two independent digital inputs compatible with Type 1 and 3 (ref. IEC 61131-2) are realized using the industry proven self-powered digital input current limiter CLT03-2Q3. This device integrates two galvanically isolated chips each of them implementing one digital input channel efficiently translating the process side voltage signals (0V or 24V) to the logic levels. CLT03-2Q3 further provides a native test-pulse generator which allows IC integrity verification during runtime. This feature can be actively controlled through the PCB's digital interface.

1.3.2.3 *Digital output section*

The output section contains an advanced protection scheme including loss of V_{CC} (resp. GND) protection, parasitic reverse polarity protection and external demagnetization bypass circuit to boost the system immunity against any potential electrical overstress. Assembly pattern of the protection components can be widely modified by the user in order to emulate various custom application scenarios.

Each digital output channel is comprised of a combination of a P-channel MOSFET power switch STL42P6LFF6 in series with a single-channel high-side switch IPS160HF (resp. IPS161HF) providing safety redundancy in each channel. This is a common topology used in safe automation output systems. First channel (OUT1) is rated for 0.5A nominal loads while the second channel (OUT2) has its nominal current 2A. Apart from the different current limitation level (resp. current limitation level setting) the two IPS ICs are identical.

IPS16xHF IC's include a cut-off limitation function which allows significant power dissipation savings in case of overload. This feature can be also actively controlled through the digital interface.

1.3.2.4 *Power management and supply voltage protection*

The onboard circuits are supplied from the +24V and GND terminals on the connector CN1. Power supply path is protected against surge and transient overvolage events by means of filtering low-ESR capacitors and Transient Voltage Supressor (TVS). Reverse polarity protection is realized based on a 60V P-channel StripFET F6 power MOSFET ST42P6LLF6 present in positive power supply path (V_{CC}). Logic circuits supply (+3.3V) is derived from the V_{CC} through a cascade of a step-down switching regulator L7983 (producing onboard V_{DC} 4V) followed by a low noise linear regulator LDK220.

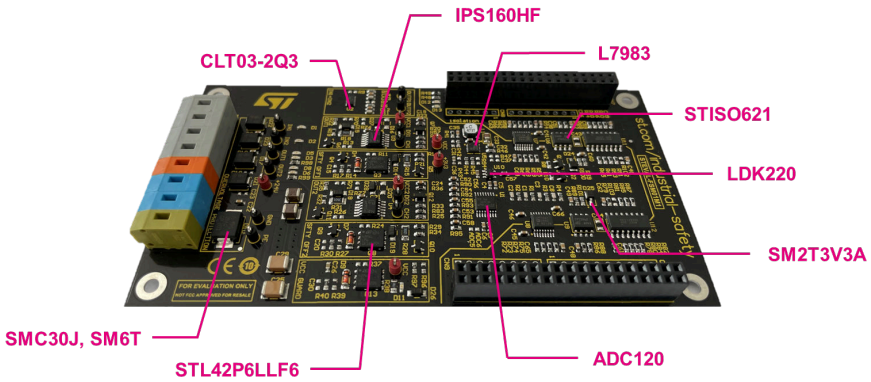
1.3.2.5 *System control and condition monitoring*

Each output channel has its own diagnostic signal indicating thermal overstress of the front-end IPS. Diagnostic signals are propagated to the isolated digital interface.

In addition to the diagnostic function integrated in the IPS16xHF drivers the STEVAL-FSM01 has an onboard 1Msps 12bit A/D converter ADC120 allowing continuous monitoring of operating conditions in all the key system nodes like V_{CC} voltage, safety P-channel MOSFET outputs (V_{CC1}, V_{CC2}) as well as the channel output voltages (OUT1, OUT2). This data is accessible during runtime via SPI. Furthermore, voltage nodes in each output channel that are subject to voltage monitoring (V_{CCx} and OUTx) are accompanied with actively controlled pull-down resistor circuits for line voltage discharge in order to allow a defined system function verification.

Distribution of integrated circuits on the PCB is illustrated in Figure 5. Complete schematics of the PCB as well as all the other associated documentation and firmware is available on the STEVAL-FSM01M1 dedicated webpage at st.com. In the following sections we will describe the particular function blocks and their application more in detail.

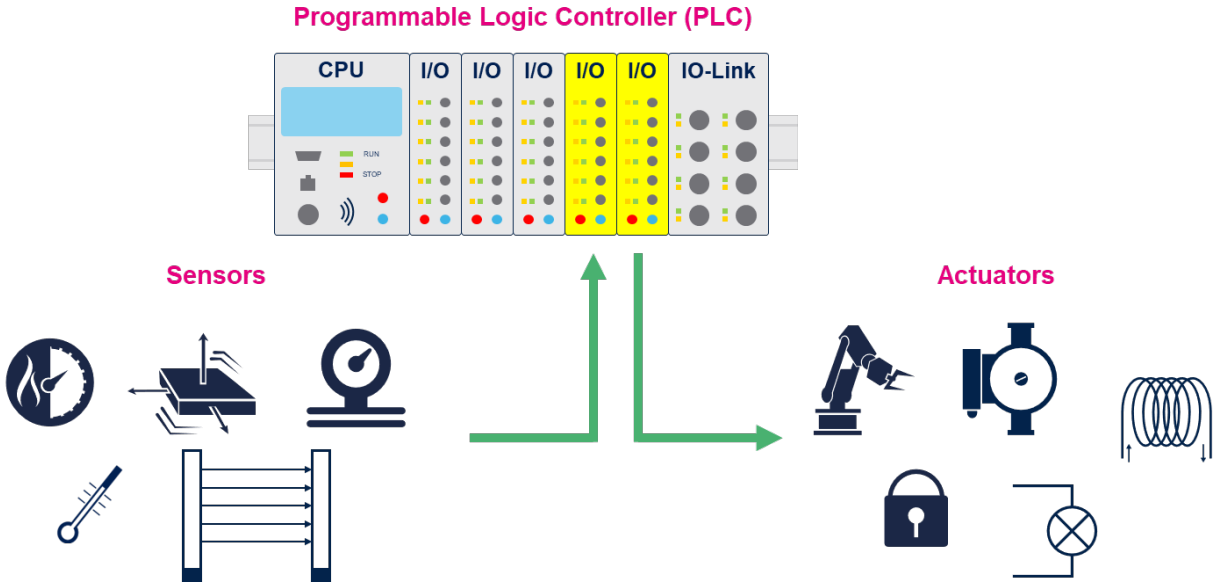
Figure 5. PCB components distribution



2 Application

The main purpose of industrial digital I/Os is interfacing with binary sensors and actuators in environments like factory automation, home & building automation technology and many other application segments like transportation infrastructure, agriculture machines or automatic PoS systems. Digital I/Os play the key role on the technological background. Digital I/O application is illustrated on the example of Programmable Logic Controller (PLC) operating in a smart factory (Figure 6).

Figure 6. Digital I/Os in factory automation



By the term Sensor we can imagine either a simple switch, a button or a smart digital sensing device like a pressure or temperature sensor, light curtains etc. Actuators are typically devices like valves, lamps or relays which perform physical actions in the automated environment.

In addition to the standard industrial I/O applications, this evaluation board is specifically designed to meet also the advanced technical requirements of Safety-critical automation. Therefore it implements additional specific features ensuring robustness, redundancy and advanced diagnostics.

This evaluation board is primarily intended for use during evaluation and prototyping phase of an application design to speed-up and simplify development of real industrial systems. It can be connected with actuators and electrical test loads (resistive, inductive or capacitive) or sensor devices with type 1 and 3 according to IEC 61131-2.

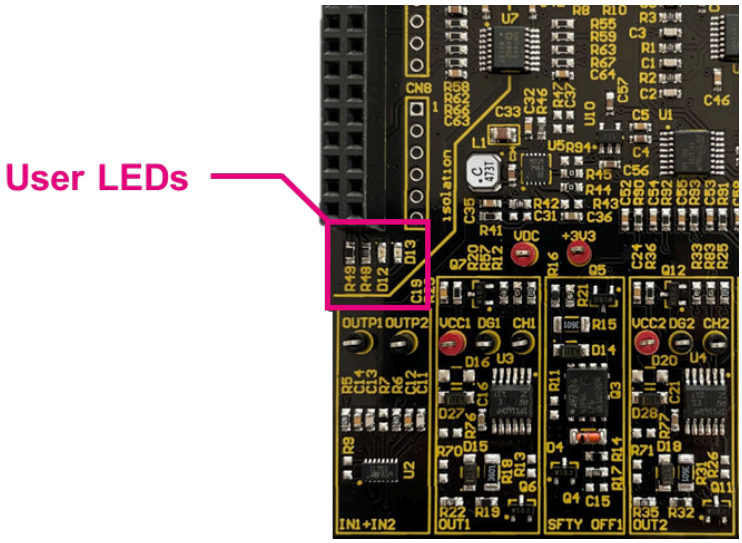
2.1 User controllable IC features

In this section we list and briefly describe all controllable functions of the PCB which can be accessed through the digital interface (Figure 3).

2.1.1 User LEDs

The PCB features two onboard LEDs D12 and D13 located on the digital side (see Figure 7) which are available for any user-specific indication purpose. The green LED (D12) is contacted to the pin PC2 and the red LED D13 is contacted to PC3, both located on connector CN7.

Figure 7. Onboard user LEDs D12, D13



2.1.2 I/O section control signals

Below we list the logic signals associated with operation of digital I/O's in particular. In addition to the elementary control signals, there are signals allowing to actively control special features of the I/O ICs. The same set of signals is available for each of the two input (resp. output) channels. Therefore, in order to simplify the notation and to avoid duplication, in the below lists we don't specify the channel identification number ('1' or '2') and instead we substitude it with 'x'. Direction of signals (seen from the microcontroller perspective) is marked in brackets by 'R' (read, input signal) or 'W' (write, control signal) together with the feature pin mapping for channel 1 and 2 (separated by ' / ').

Digital inputs

1. **OUTPx**: input signal reflecting the binary status of digital input INx [R; PC0 / PH1]
2. **TPx**: control signal enabling function of integrated test pulse generator (ref. datasheet of CLT03-2Q3) [W, PA15 / PB7]

Digital outputs

1. **OUTx_CTRL**: Control signal for digital output OUTx [W, PB8 / PA11]
2. **OUTx_DSC**: Activation of OUTx line discharge pull-down resistor [W, PC10 / PC9]
3. **OUTx_DIAG**: OUTx IPS diagnostic pin [R, PC12 / PC6]
4. **COFFx**: Cut-off limitation feature control on OUTx IPS [W, PD2 / PC5]
5. **VCCx_CTRL**: Control of safety MOSFET switch providing supply voltage for OUTx IPS [W, PA12 / PB9]
6. **VCCx_DSC**: Activation of V_{CCx} line discharge pull-down resistor [W, PC8 / PC11]

Onboard voltage monitoring

8-channel A/D converter ADC120 is used for monitoring voltages in all key nodes of the system, namely: **VCC**, **VCCx** and **OUTx**.

This ADC is accessible through SPI available at the following pins of connector CN10:

1. **/CS**: Chip Select [W, PB12]
2. **SCLK**: SPI clock signal [W, PB13]
3. **DIN**: SPI MOSI signal [W, PB15]
4. **DOUT**: SPI MISO signal [R, PB14]

3 Getting started

In this section we will describe how to easily setup the basic hardware configuration allowing to operate the PCB in combination with NUCLEO-F401RE and its associated firmware package STSW-FSM01.

We focus mainly on the description of hardware part of the system in this documet. All needed information related to software part of the system is available at st.com in a dedicated documentation (UM3176) of STSW-FSM01.

3.1 Hardware components

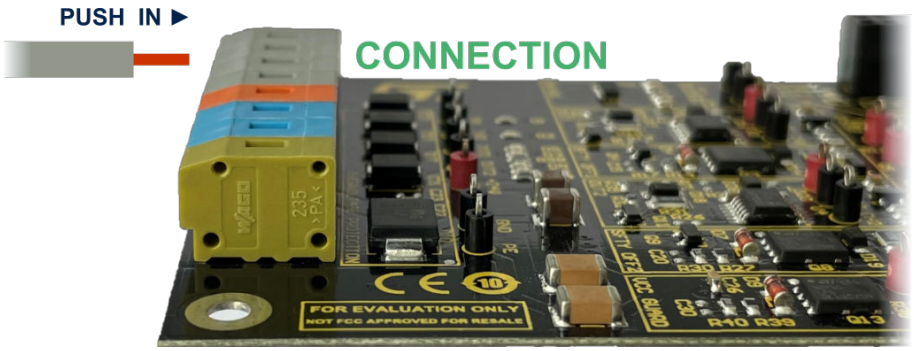
The following hardware components are required:

1. STM32 Nucleo board NUCLEO-F401RE
2. USB cable (type A to Mini-B USB) to connect the STM32 Nucleo and PC
3. +24V DC power supply with connection wires to supply the STEVAL-FSM01M1 expansion board
4. Windows PC

3.2 Process side connector operation

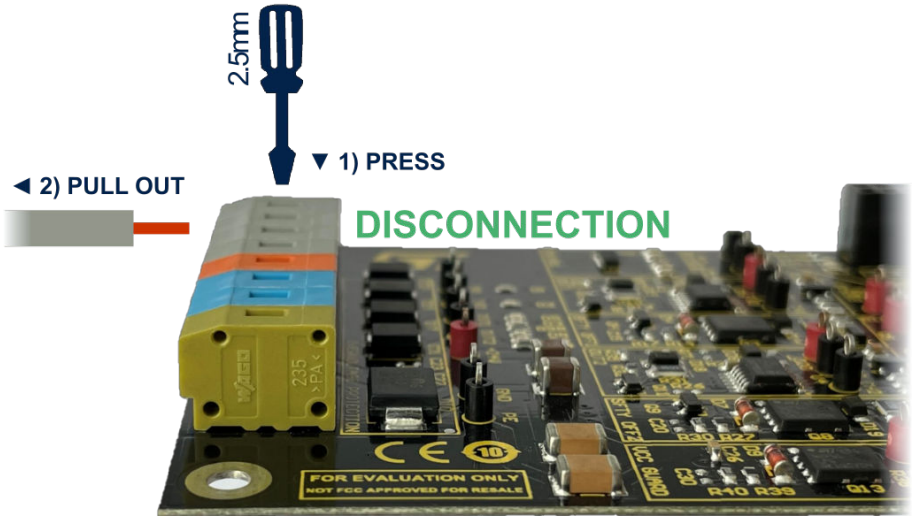
CN1 terminal allows connecting all process side components (sensors, actuators, and supply wiring) in a quick and easy way. You can plug a counductor by simply pushing it as shown inFigure 8.

Figure 8. CN1 conductor connection



Disconnection of a conductor is also easy by gently pressing the corresponding terminal slot using a screwdriver and then pulling the conductor out according to Figure 9.

Figure 9. CN1 conductor connection



3.3 System setup and connection

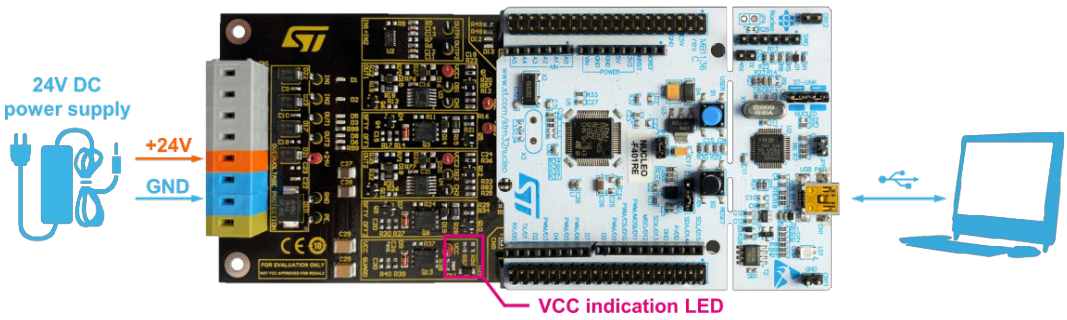
In order to ensure correct operation of the evaluation system please verify that the Nucleo board is in correct hardware configuration as follows (default HW setup):

- JP5 on U5V for firmware flashing
- JP1 open
- JP6 closed
- CN2 : closed 1-2, 3-4
- CN3 open
- CN4 open
- CN11 open
- CN12 open

Nucleo board shall be flashed with the code available in the firmware package STSW-FSM01. Nucleo board programming can be done either by downloading a binary file into the microcontroller flash memory using the STM32CubeProg, or it can be carried out using an IDE (e.g. STM32CubeIDE). All the above-mentioned tools can be found and downloaded at www.st.com.

Now with all components collected and set correctly the system can be plugged together as shown in Figure 10.

Figure 10. STEVAL-FSM01M1 system setup



If the above evaluation setup is correctly connected and supplied, it indicates presence of process side V_{CC} voltage by a red LED D11 as also highlighted in Figure 10 and it's time to play the program.

Note: Rated voltage to supply the board is +24V, however, the onboard firmware is configured to operate in range of V_{CC} from 21.6V. Lower supply voltage will be detected by the system monitoring routines as undervoltage and in such case the PCB operation is automatically disabled.

3.4 Program functionality

After power-up or reset of the digital side (Nucleo), the onboard firmware performs an initialization routines and verifies functionality of the system by toggling onboard LEDs and digital outputs. This procedure takes around 5 seconds and its runtime is indicated by a green LED LD2 located on the Nucleo board. When PCB initialization procedure finishes successfully, the LD2 is blicking continuously and the red user LED D13 is off. If the inicialization doesn't finish succesfully (e.g. due to undervoltage), this is indicated by the D13 continuously on.

Digital outputs can now be toggled simultaneously using a blue button and signal presence on the digital inputs is indicated by toggling the user LEDs D12 (IN1) and D13 (IN2). Further functions can be examined utilizing a command access from PC via USB as described in UM3176.

4 Schematic diagrams

Figure 11. **STEVAL-FSM01M1 circuit schematics (1 of 6)**

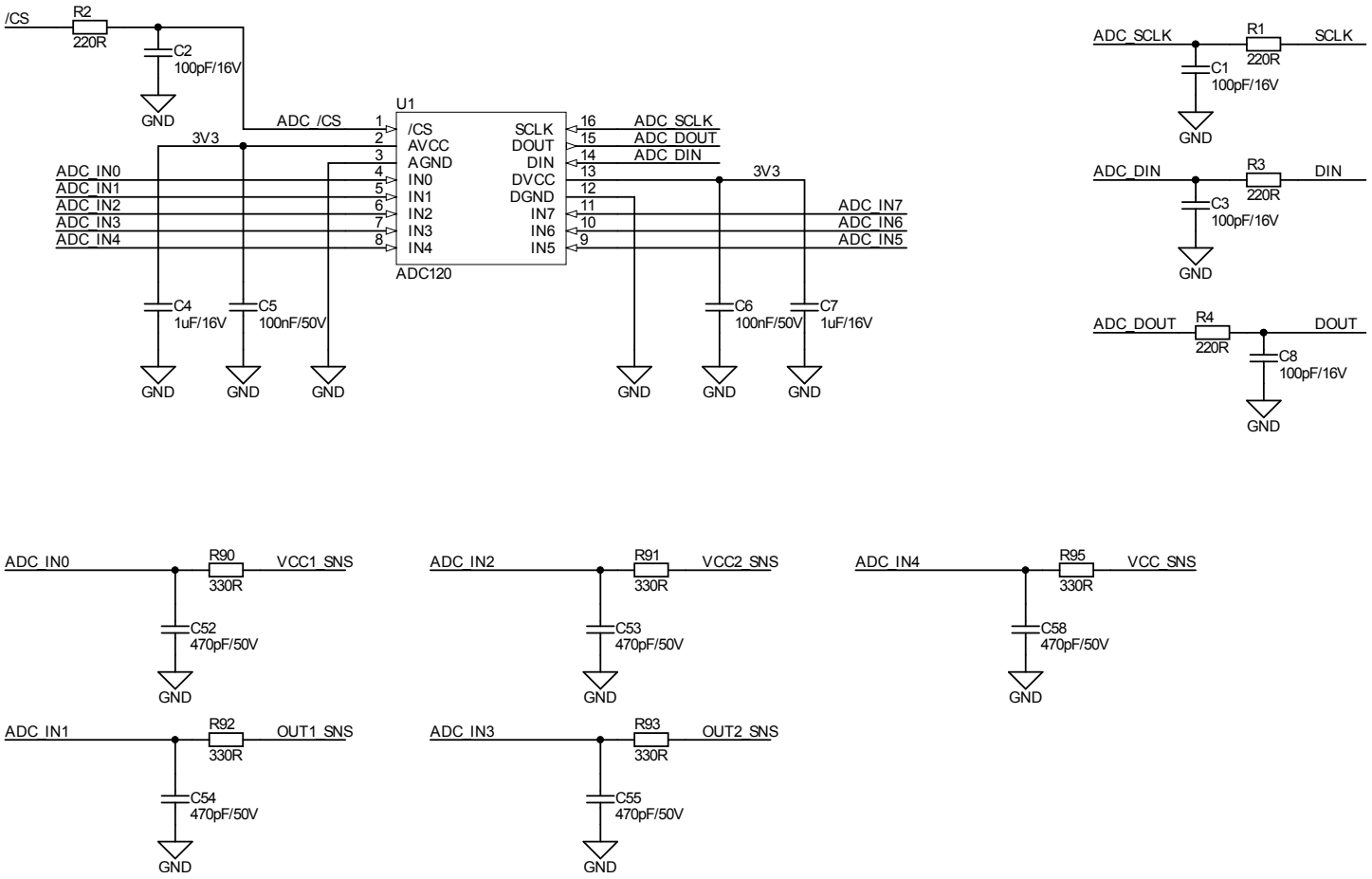


Figure 12. **STEVAL-FSM01M1 circuit schematics (2 of 6)**

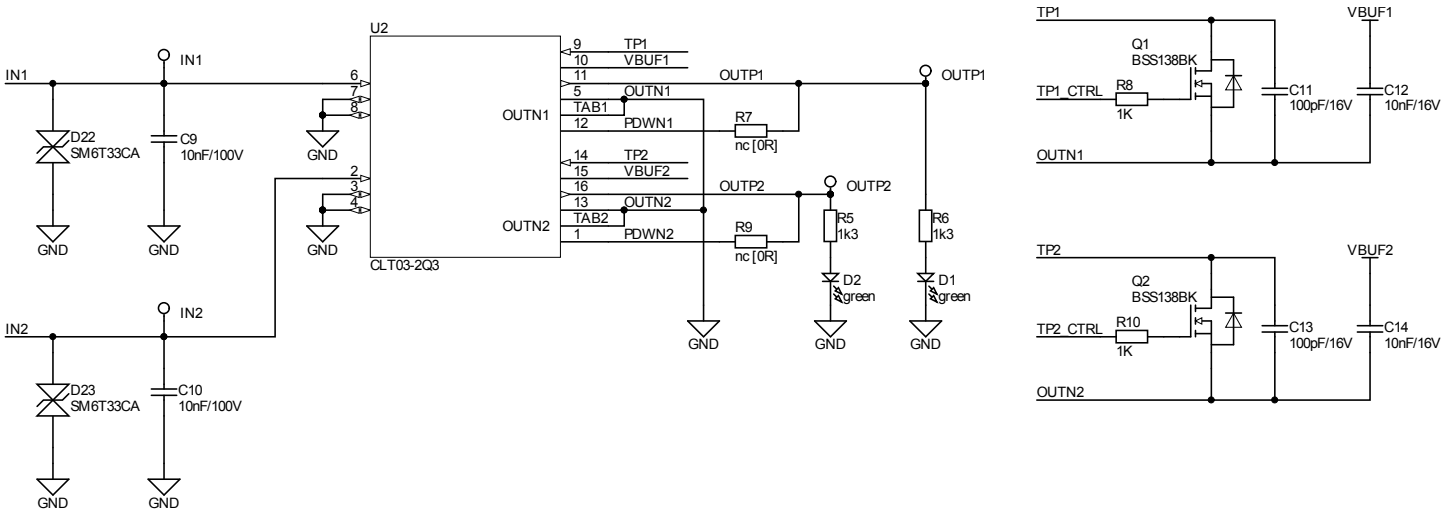


Figure 13. STEVAL-FSM01M1 circuit schematics (3 of 6)

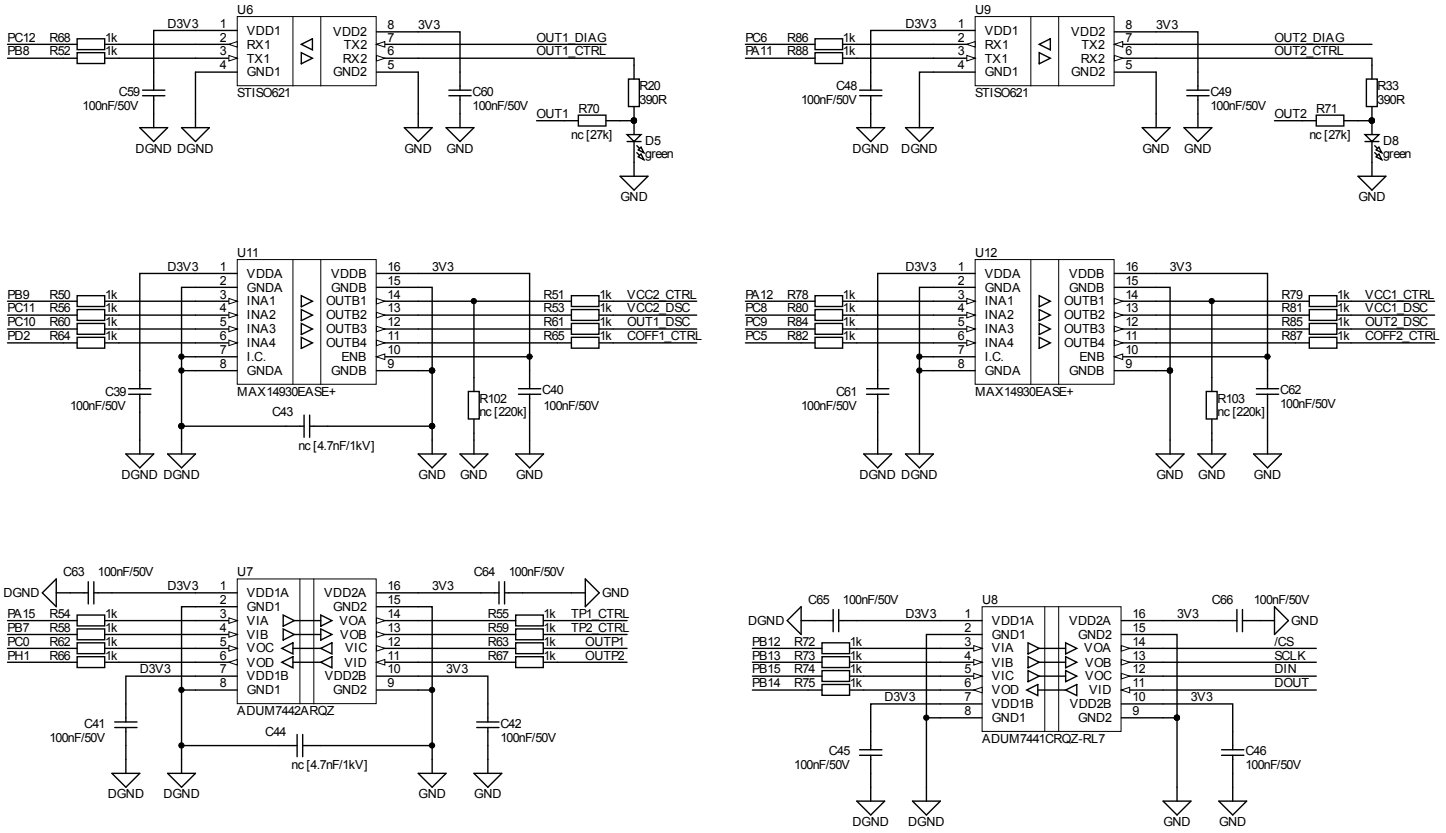


Figure 14. **STEVAL-FSM01M1 circuit schematics (4 of 6)**

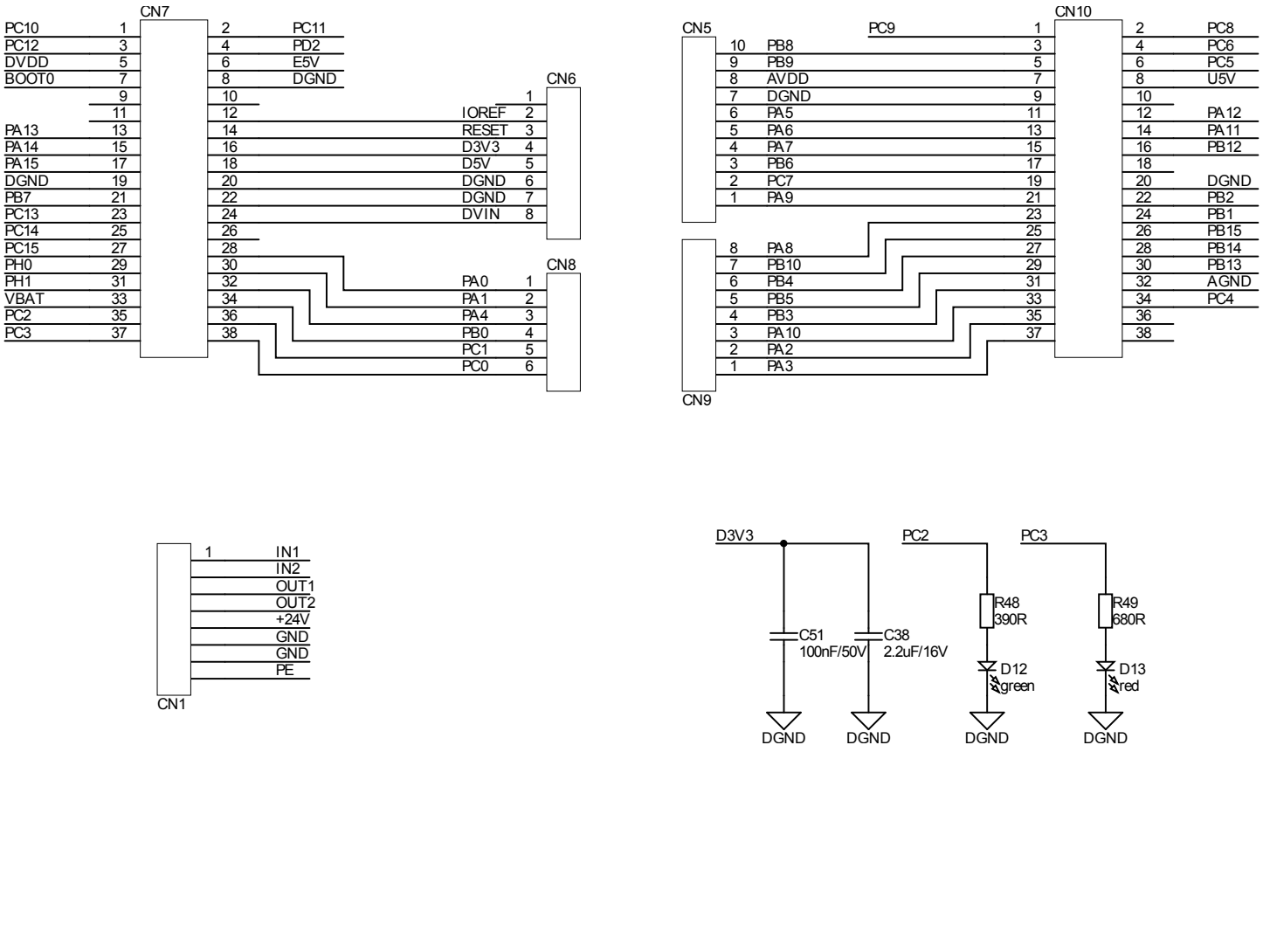


Figure 15. STEVAL-FSM01M1 circuit schematics (5 of 6)

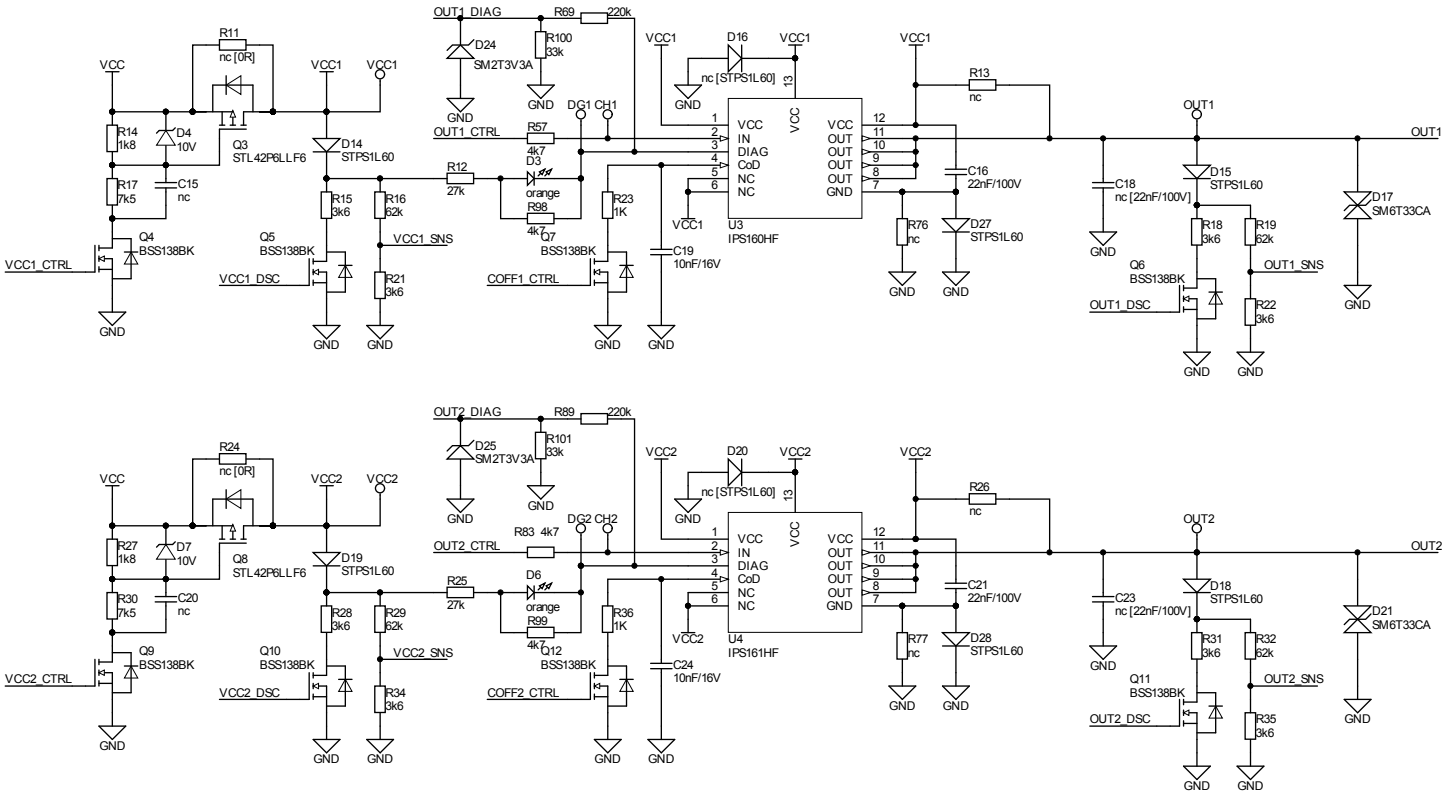
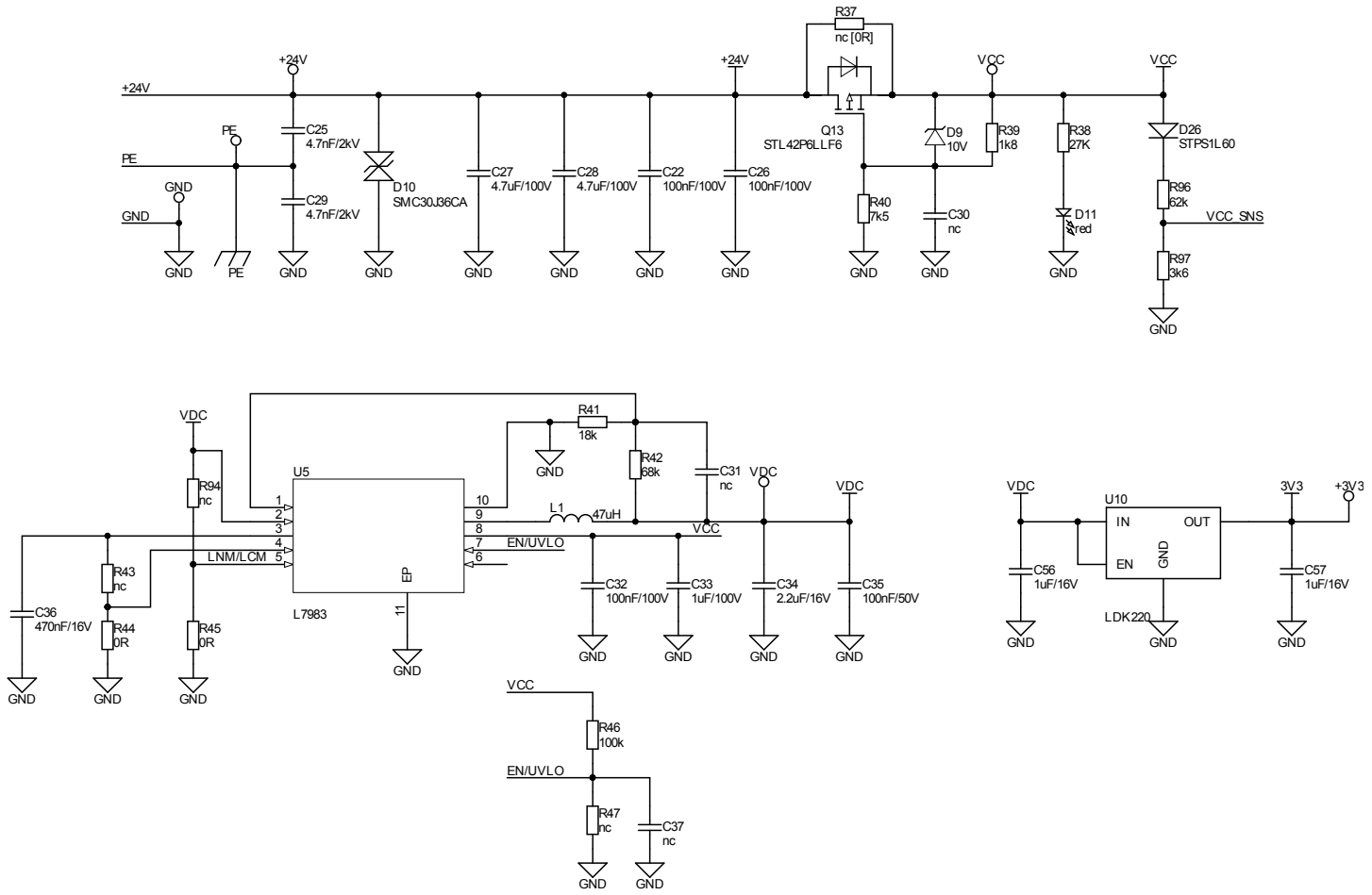


Figure 16. **STEVAL-FSM01M1 circuit schematics (6 of 6)**



5 Bill of materials

Table 1. **BOM**

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	6	+3V3 +24V VDC VCC VCC1 VCC2	Test Point Red hole diam. 1,6mm	Test point - red	KEYSTONE	5000
2	12	CH1 CH2 DG1 DG2 GND IN1 IN2 OUT1 OUT2 OUTP1 OUTP2 PE	Test Point Black hole diam. 1,02mm	Test point - black	KEYSTONE or RS Pro	5001 or 262-2179
3	6	C1 C2 C3 C8 C11 C13	100pF	CAP CER, 100 pF, 16 V, ± 1%	WURTH ELEKTRONIK	885012006023
4	4	C4 C7 C56 C57	1uF	CAP CER, 1 µF, 16 V, ± 10%, X7R	TDK	CGA3E1X7R1C105K080AC
5	20	C5 C6 C35 C39 C40 C41 C42 C45 C46 C48 C49 C51 C59 C60 C61 C62 C63 C64 C65 C66	100nF	CAP CER, 0.1 µF, 16 V, ± 5%, X7R	WURTH ELEKTRONIK	885012206095
6	2	C9 C10	10nF	CAP CER, 10000 pF, 100 V, ± 5%, X7R	WURTH ELEKTRONIK	885012206114
7	4	C12 C14 C19 C24	10nF	CAP CER, 10000 pF, 16 V, ± 10%, X7R	WURTH ELEKTRONIK	885012206040
8	5	C52 C53 C54 C55 C58	470pF	CAP CER, 470 pF, 50 V, ± 10%, X7R	WURTH ELEKTRONIK	885012206081
9	5	C15 C20 C30 C31 C37			n.a.	n.a.
10	3	C22 C26 C32	100nF	CAP CER, 0.1 µF, 100 V, ± 10%, X7R	WURTH ELEKTRONIK	885012206120
11	2	C16 C21	22nF	CAP CER, 22000 pF, 100 V, ± 10%, X7R	KEMET or Murata	C0603C223K1RACTU or GRM188R72A223KAC4D
12	2	C18 C23	22nF	CAP CER, 22000 pF, 100 V, ± 10%, X7R	KEMET or Murata	C0603C223K1RACTU or GRM188R72A223KAC4D
13	2	C25 C29	4.7nF	CAP CER, High Voltage, 4700 pF, 2 kV, ± 10%, X7R	WURTH ELEKTRONIK	885342211008
14	2	C27 C28	4.7nF	CAP CER, 4.7 µF, 100 V, ± 10%, X7S	TDK or Taiyo Yuden	CGA6M3X7S2A475K200AB or HMK325C7475KMHPE
15	1	C33	1uF	CAP CER, 1 µF, 100 V, ± 10%, X7S	MURATA or TDK	GRJ21BC72A105KE11L or CGA4J3X7S2A105K125AB
16	2	C34 C38	2.2uF	CAP CER, 2.2 µF, 16 V, ± 10%, X7S	TDK	CGA3E1X7S1C225K080AC
17	1	C36	470nF	CAP CER, 0.47 µF, 16 V, ± 10%, X7R	TDK	C1608X7R1C474K080AC

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
18	2	C43 C44	4.7nF	CAP CER, ArcShield™, 4700 pF, 1 kV, ± 10%, X7R	KEMET	C0805V472KDRACTU
19	4	R1 R2 R3 R4	220	SMD Chip Resistor, 220 ohm, ± 1%, 100 mW	MULTICOMP PRO or Yageo	MCWR06X2200FTL or RC0603FR-07220RL
20	2	R5 R6	1k3	SMD Chip Resistor, 1.3 kohm, ± 1%, 100 mW	Vishay	CRCW06031K30FKEA
21	5	R7 R9 R11 R24 R37	0	Zero Ohm Resistor, Thick Film, 100 mW, 1 A	MULTICOMP PRO or Yageo	MC0603SAF0000T5E or RC0603JR-070RL
22	36	R8 R10 R23 R36 R50 R51 R52 R53 R54 R55 R56 R58 R59 R60 R61 R62 R63 R64 R65 R66 R67 R68 R72 R73 R74 R75 R78 R79 R80 R81 R82 R84 R85 R86 R87 R88	1k	SMD Chip Resistor, 1 kohm, ± 0.5%, 100 mW	Panasonic	ERJ3RBD1001V
23	7	R13 R26 R43 R47 R76 R77 R94			n.a.	n.a.
24	3	R14 R27 R39	1k8	SMD Chip Resistor, 1.8 kohm, ± 1%, 100 mW	MULTICOMP PRO or Vishay	MCWR06X1801FTL or CRCW06031K80FKEA
25	1	R38	27k	SMD Chip Resistor, 27 kohm, ± 1%, 125 mW	Vishay	CRCW080527K0FKEA
26	2	R12 R25	27k	SMD Chip Resistor, 27 kohm, ± 1%, 100 mW	BOURNS or Yageo	CR0603-FX-2702ELF or RC0603FR-0727KL
27	2	R70 R71	27k	SMD Chip Resistor, 27 kohm, ± 1%, 100 mW	BOURNS or Yageo	CR0603-FX-2702ELF or RC0603FR-0727KL
28	4	R15 R18 R28 R31	3k6	SMD Chip Resistor, 3.6 kohm, ± 1%, 250 mW	YAGEO or Vishay	RC1206FR-073K6L or CRCW12063K60FKEA
29	5	R16 R19 R29 R32 R96	62k	SMD Chip Resistor, 62 kohm, ± 1%, 100 mW	Vishay	CRCW060362K0FKEA
30	3	R17 R30 R40	7k5	SMD Chip Resistor, 7.5 kohm, ± 1%, 100 mW	MULTICOMP PRO or Vishay	MCWR06X7501FTL or CRCW06037K50FKEAC
31	1	R42	68k	SMD Chip Resistor, 68 kohm, ± 1%, 100 mW	MULTICOMP PRO or Yageo	MCWR06X6802FTL or RC0603FR-0768KL
32	3	R20 R33 R48	390	SMD Chip Resistor, 390 ohm, ± 1%, 100 mW	MULTICOMP PRO or Yageo	MCWR06X3900FTL or RC0603FR-07390RL
33	5	R21 R22 R34 R35 R97	3k6	SMD Chip Resistor, 3.6 kohm, ± 1%, 100 mW	Vishay or Yageo	CRCW06033K60FKEA or RC0603FR-073K6L

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
34	1	R41	18k	SMD Chip Resistor, 18 kohm, ± 1%, 100 mW	MULTICOMP PRO or Panasonic	MCWR06X1802FTL or ERJ3EKF1802V
35	2	R44 R45	0	Zero Ohm Resistor, Thick Film, 100 mW, 1 A	MULTICOMP PRO or Yageo	MC0603SAF0000T5E or RC0603JR-070RL
36	1	R46	100k	SMD Chip Resistor, 100 kohm, ± 1%, 100 mW	MULTICOMP PRO or Yageo	MCMR06X1003FTL or RC0603FR-07100KL
37	1	R49	680	SMD Chip Resistor, 680 ohm, ± 1%, 100 mW	MULTICOMP PRO or Vishay	MCWR06X6800FTL or CRCW0603680RFKEA
38	4	R57 R83 R98 R99	4k7	SMD Chip Resistor, 4.7 kohm, ± 1%, 100 mW	MULTICOMP PRO or Vishay	MCMR06X4701FTL or SRMCF0603FT4K70
39	2	R69 R89	220k	SMD Chip Resistor, 220 kohm, ± 1%, 100 mW	MULTICOMP PRO or Yageo	MCWR06X2203FTL or RC0603FR-07220KL
40	2	R102 R103	220k	SMD Chip Resistor, 220 kohm, ± 1%, 100 mW	MULTICOMP PRO or Yageo	MCWR06X2203FTL or RC0603FR-07220KL
41	5	R90 R91 R92 R93 R95	330	SMD Chip Resistor, 330 ohm, ± 1%, 100 mW	MULTICOMP PRO or Panasonic	MCWR06X3300FTL or ERJ3EKF3300V
42	2	R100 R101	33k	SMD Chip Resistor, 33 kohm, ± 1%, 100 mW	MULTICOMP PRO or Yageo	MCWR06X3302FTL or RC0603FR-0733KL
43	3	D4 D7 D9	BZV55-C10,115	Zener Diode, 10 V, 500 mW, SOD-80C	NEXPERIA	BZV55-C10,115
44	7	D14 D15 D18 D19 D26 D27 D28	STPS1L60ZF, SOD123Flat	60 V, 1 A low drop power Schottky rectifier	STMicroelectronics	STPS1L60ZF
45	2	D16 D20	STPS1L60ZF, SOD123Flat	60 V, 1 A low drop power Schottky rectifier	STMicroelectronics	STPS1L60ZF
46	1	D10	SMC30J36CA, SMC	3000 W, 36 V TVS in SMC	STMicroelectronics	SMC30J36CA
47	4	D17 D21 D22 D23	SM6T33CA, SMB	600W TVS in SMB package	STMicroelectronics	SM6T33CA
48	2	D24 D25	SM2T3V3A, STmite	200 W, 3.3 V TVS in STmite	STMicroelectronics	SM2T3V3A
49	3	Q3 Q8 Q13	STL42P6LLF6, PowerFLAT 5x6	P-channel 60V MOSFET	STMicroelectronics	STL42P6LLF6
50	1	U1	ADC120IPT, TSSOP-16L	8-Channel, 50ksps to 1Msps, 12-Bit A/D Converter	STMicroelectronics	ADC120IPT
51	1	U2	CLT03-2Q3, QFN-16L	Self powered digital input current limiter	STMicroelectronics	CLT03-2Q3
52	1	U3	IPS160HFTR, PowerSSO 12	Single-channel IPS	STMicroelectronics	IPS160HFTR
53	1	U4	IPS161HFTR, PowerSSO 12	Single-channel IPS	STMicroelectronics	IPS161HFTR
54	1	U5	L7983PUR, DFN 3X3X0.8 10L PITCH 0.5	60 V, 300 mA synchronous DCDC	STMicroelectronics	L7983PUR

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
55	1	U10	LDK220M33R, SOT23-5L	200mA Low noise LDO	STMicroelectronics	LDK220M33R
56	2	U6 U9	STISO621, SO-8	Dual channel digital isolator	STMicroelectronics	STISO621
57	2	U11 U12	MAX14930EASE+	4-channel digital isolator	Maxim Integrated	MAX14930EASE+
58	1	U7	ADUM7442ARQZ	1 kV RMS Quad-Channel Digital Isolator	ANALOG DEVICES	ADUM7442ARQZ-RL7
59	1	U8	ADUM7441CRQZ	1 kV RMS Quad-Channel Digital Isolator	ANALOG DEVICES	ADUM7441CRQZ-RL7
60	10	Q1 Q2 Q4 Q5 Q6 Q7 Q9 Q10 Q11 Q12	BSS138BK,215	Power MOSFET, N Channel, 60 V, 360 mA, 1 ohm, SOT-23	NEXPERIA	BSS138BK,215
61	1	L1	LPS4018-473MRC	Inductor, 47 µH, LPS4018, 3.9mm x 3.9mm x 1.7mm	Coilcraft	LPS4018-473MRC
62	1	CN1_0-4	PCB Terminal block (GRAY)	4-pole Wago connector 235-404	Wago	235-404
63	1	CN1_5	PCB Terminal block (ORANGE)	1-pole Wago connector 235-746	Wago	235-746
64	2	CN1_6-7	PCB Terminal block (BLUE)	1-pole Wago connector 235-744	Wago	235-744
65	1	CN1_8	PCB Terminal block (GREEN)	1-pole Wago connector 235-747	Wago	235-747
66	1	CN5	Female Connector 1x10	CON, 2.54 mm, 1 Rows, 10 Contacts, 2212S	MULTICOMP PRO or Amtek	2212S-10SG-85 or PS1S85-110-GBL 10P
67	2	CN6 CN9	Female Connector 1x8	CON, 2.54 mm, 1 Rows, 8 Contacts, 2212S	MULTICOMP PRO or Amtek	2212S-08SG-85 or PS1S85-108GB-L
68	2	CN7 CN10	Female header 2x19	CON, 2.54 mm, 2 Rows, 38 Contacts, SSW	SAMTEC or 4UCON	SSW-119-01-T-D or 19744
69	1	CN8	Female Connector 1x6	CON, 2.54 mm, 1 Rows, 6 Contacts, 2212S	MULTICOMP PRO or Amtek	2212S-06SG-85 or PS1S85-106GB-L
70	5	D1 D2 D5 D8 D12	Led green	LED, Green, SMD, 20 mA, 2 V, 570 nm	Wurth Elektronik	150060VS75020
71	2	D3 D6	Led orange	LED, Amber, SMD, 20 mA, 2 V, 605 nm	Wurth Elektronik	150060AS75020
72	2	D11 D13	Led red	LED, Red, SMD, 20 mA, 2 V, 625 nm	Wurth Elektronik	150060RS75020
73	1	PCB Not Reference	FR4-4 Layer	FR4-4 Layer copper thickess 35 micron ext/Inter Layer	n.a.	n.a.

6 Board versions

Table 2. **STEVAL-FSM01M1 versions**

Finished good	Schematic diagrams	Bill of materials
STEVAL$FSM01M1A (1)	STEVAL$FSM01M1A schematic diagrams	STEVAL$FSM01M1A bill of materials

1. *This code identifies the STEVAL-FSM01M1 evaluation board first version.*

7 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). Compliance to EMC standards in Class A (industrial intended use).

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). Compliance to EMC standards in Class A (industrial intended use).

Revision history

Table 3. **Document revision history**

Date	Revision	Changes
26-May-2023	1	Initial release.

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