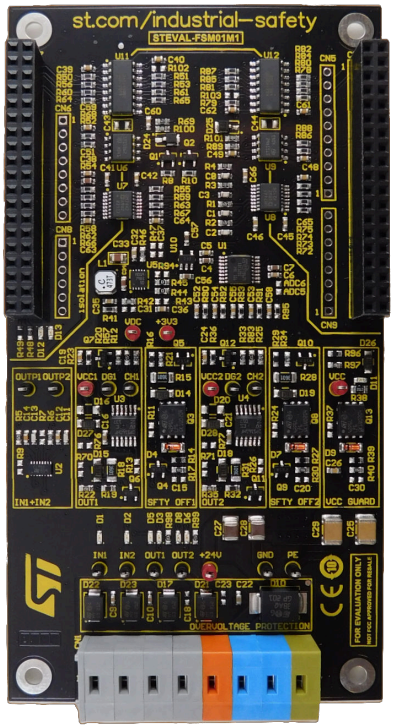
# STEVAL-FSM01M1

Data brief

## Advanced dual channel digital I/O module for safe automation




| Product summary | |
|---|---|
| Advanced dual channel digital I/O module for safe automation | STEVAL-FSM01M1 |
| Software for STEVAL-FSM01M1 | STSW-FSM01 |
| Single channel high-side switches | IPS160HFTR/ IPS161HFTR |
| Self powered digital input current limiter | CLT03-2Q3 |
| Applications | Programmable Logic Controllers |

## Features

- System design optimized for high robustness and safety
- Full flexibility for testing and in-depth evaluation of onboard ICs
- Operating range: 8 to 30 V (optionally up to 60 V)
- Digital output current rating 2 A (OUT1) and 0.5 A (OUT2)
- Dual channel digital input 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
  - Low-power dissipation ($R_{DS(on)}$=60 mΩ)
  - Fast demagnetization of inductive loads
  - Operating voltage range up to 60 V
  - Output current capability 2 A (IPS160HF) and 0.5 A (IPS161HF)
  - Fast power-up performance for safe automation
  - Integrated overcurrent/overtemperature protection and diagnostics
- Input section based on CLT03-2Q3
  - Self-powered dual channel digital input current limiter
  - Operating voltage range up to 60 V
  - Native test pulse feature allowing self-integrity verification of the IC
- Additional key onboard ICs:
  - STISO621 100 Mbps dual channel signal digital isolator
  - L7983, LDK220 60 V step-down regulator and low noise LDO
  - ADC120 12-bit/1Msps analog-digital convertor with SPI
  - STL42P6LLF6 60 V STripFET F6 power MOSFET
  - SMC30J36CA, SM6T33CA and SM2T3V3A TVS protections
- Embedded redundancy including cascade high-side switch topology
- Runtime control of IC features (cut-off limitation and test-pulse generation)
- Onboard ADC allows real-time condition monitoring and system integrity verification
- Status and diagnostic LEDs for each I/O channel
- Two additional LEDs for user defined indication
- Onboard 1 $kV_{RMS}$ galvanic isolation
- Active supply voltage reverse polarity protection
- Compatible with STM32 Nucleo development boards
- Firmware package compatible with NUCLEO-F401RE
- CE and RoHS compliant

## Description

STEVAL-FSM01M1 is a safe dual channel digital I/O expansion board compatible with the 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 the 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 that is connected on top of it by means of its onboard ST morpho extension headers.

The microcontroller pins and peripherals handling the operation of the STEVAL-FSM01M1 are physically separated from those used by other X-NUCLEO boards eventually connected to the system.

Additional expansion shields can be easily added on top of the stack to extend system functionality without introducing any overlap of the used microcontroller resources.

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

# 1 System structure

## 1.1 System structure

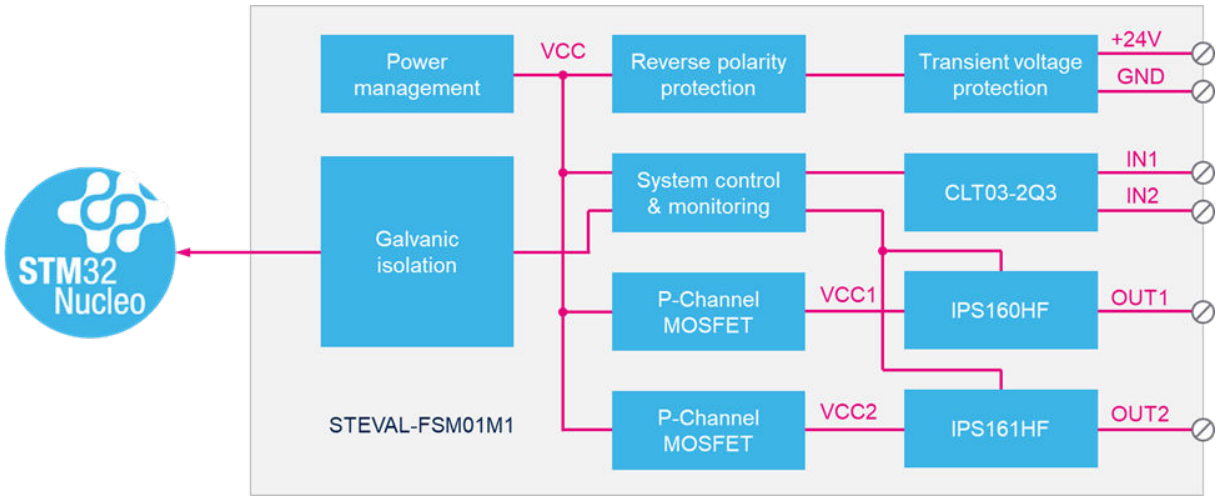
As a digital I/O board, the STEVAL-FSM01M1 translates low voltage logic level I/O signals (3.3V) provided on its digital interface and transmits them onto 0/+24V binary signals on its galvanically isolated power domain called process side.

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 1. 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 1. STEVAL-FSM01M1 block diagram**

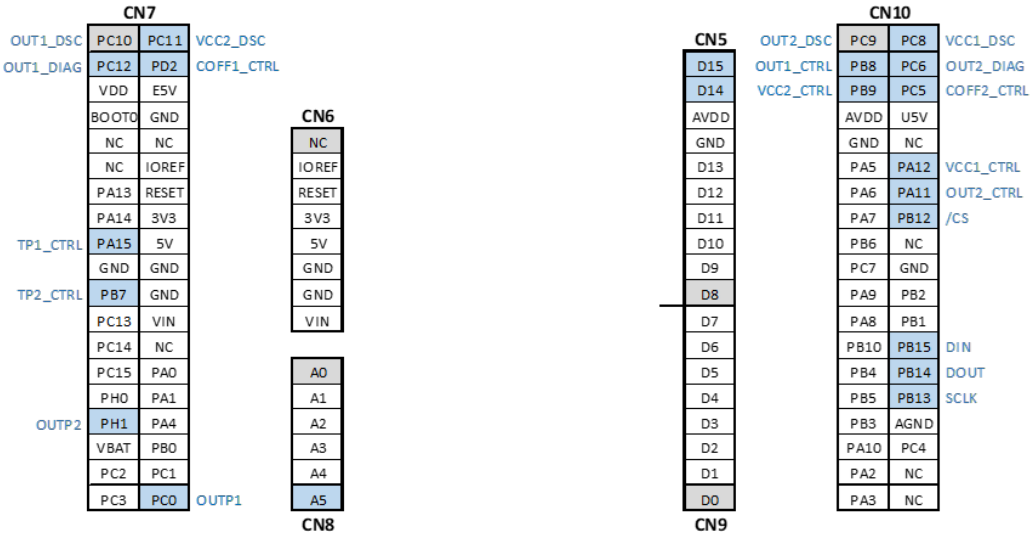


### 1.1.1 Digital interface and galvanic isolation

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 2. 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 2. Digital interface connector pin mapping**

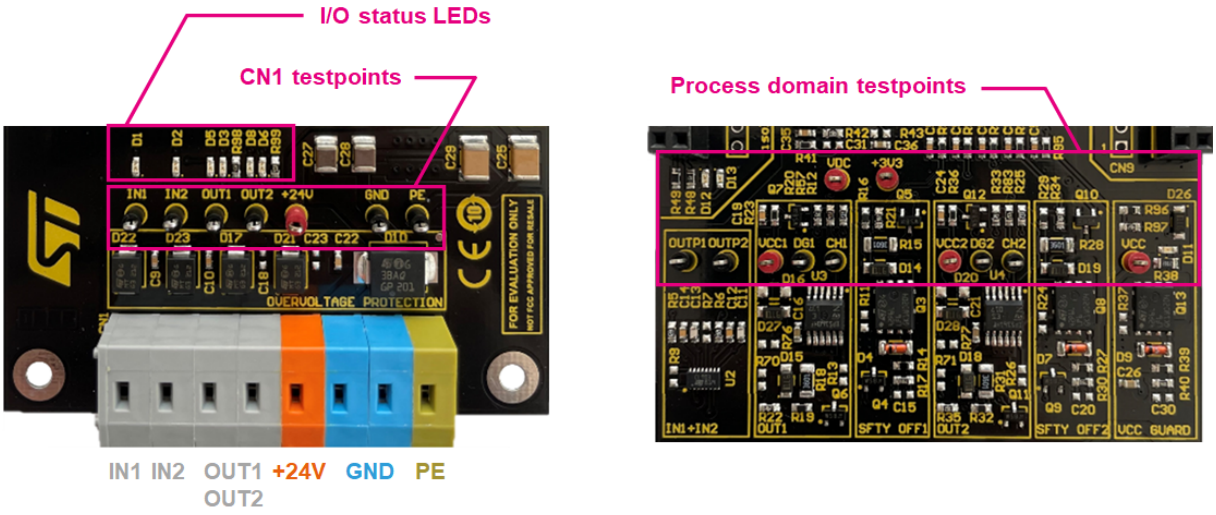



### 1.1.2 Process side

#### *1.1.2.1 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 3. 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 3. **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 3.

#### 1.1.2.2 *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.

#### 1.1.2.3 *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.

#### 1.1.2.4 *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.

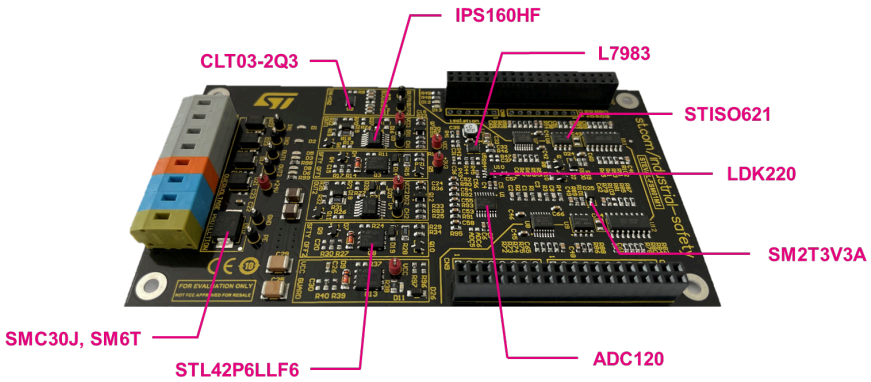
#### 1.1.2.5 *System control and condition monitoring*

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 4. 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 4. PCB components distribution**



# 2 Schematic diagrams

Figure 5. **STEVAL-FSM01M1 circuit schematics (1 of 6)**

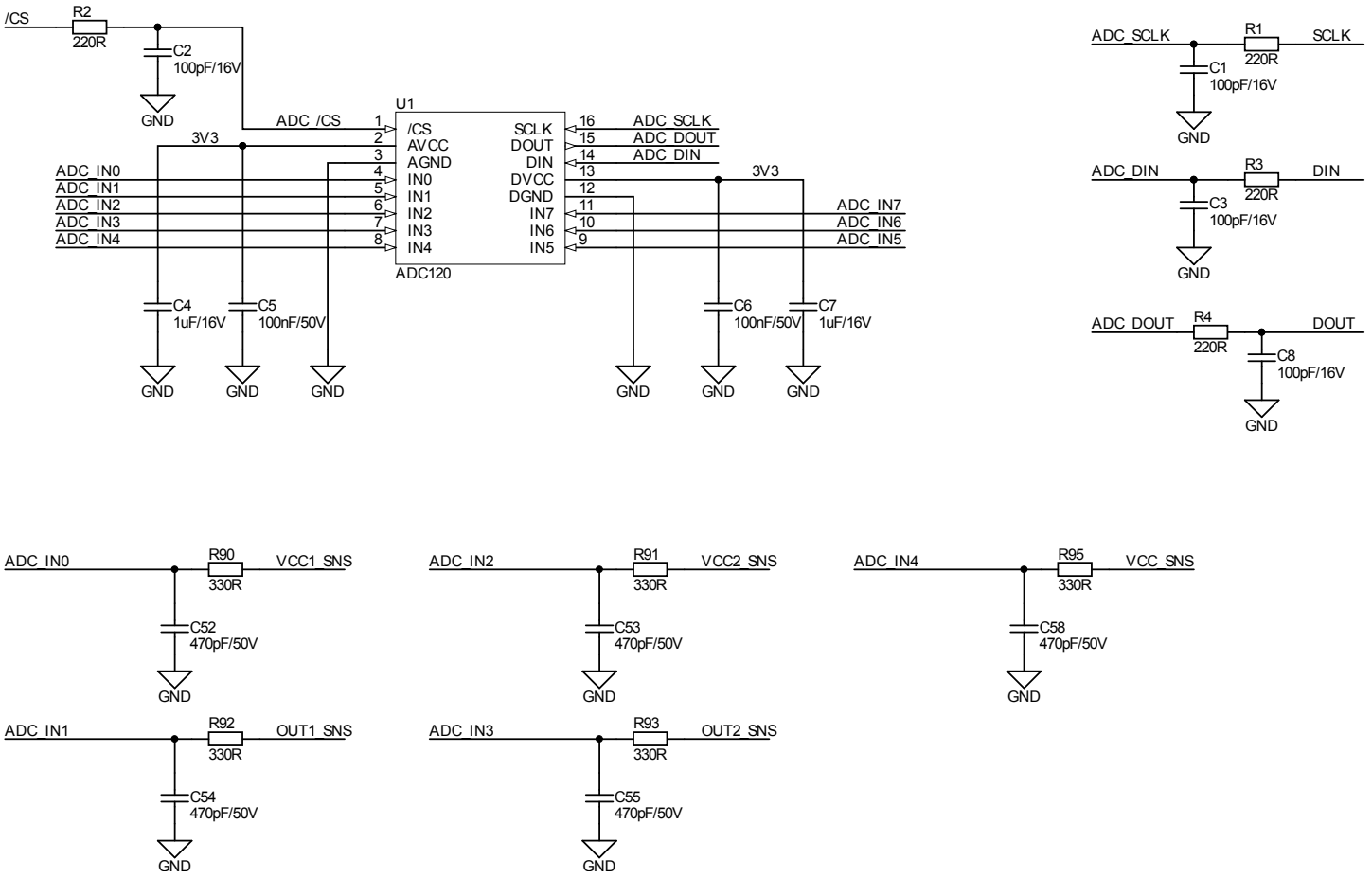
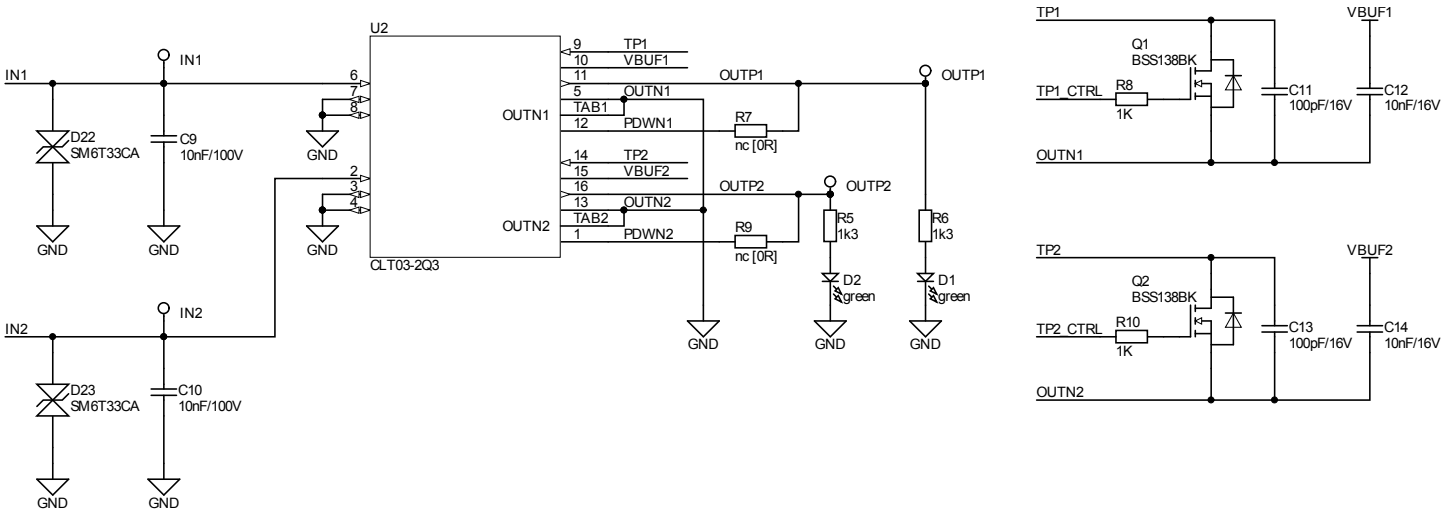


Figure 6. **STEVAL-FSM01M1 circuit schematics (2 of 6)**



## Figure 7. STEVAL-FSM01M1 circuit schematics (3 of 6)

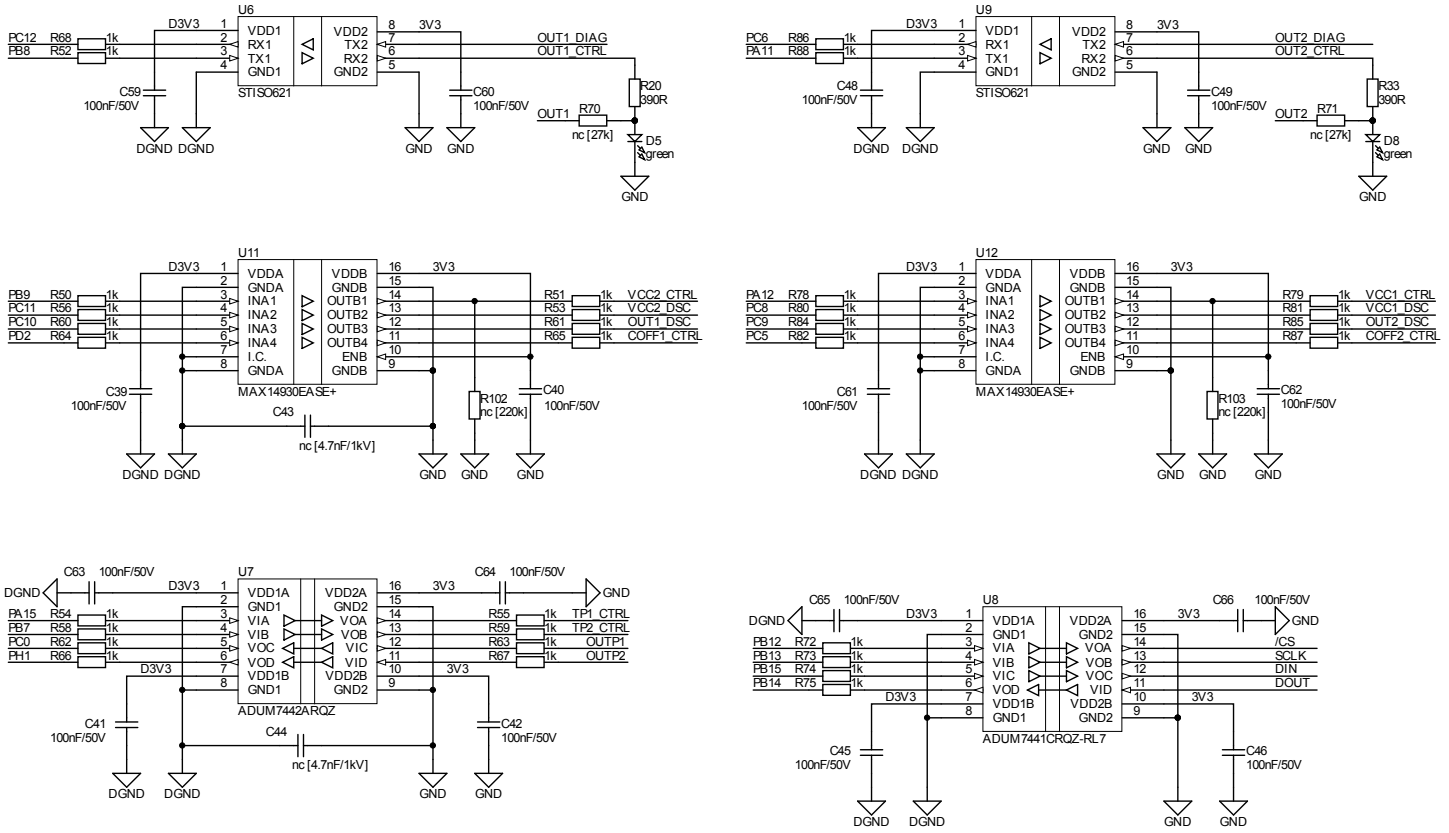


Figure 8. **STEVAL-FSM01M1 circuit schematics (4 of 6)**

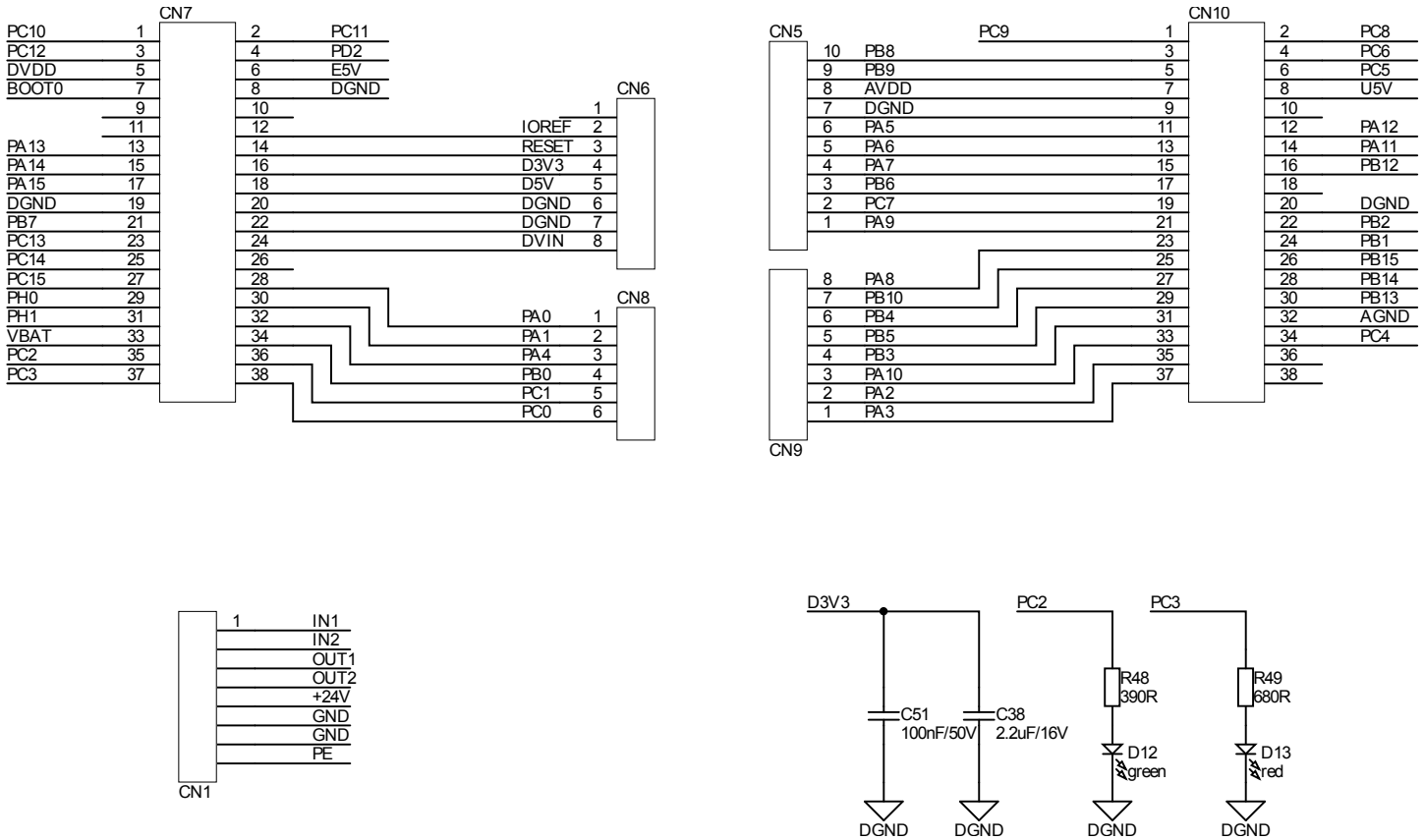


**Figure 9. STEVAL-FSM01M1 circuit schematics (5 of 6)**

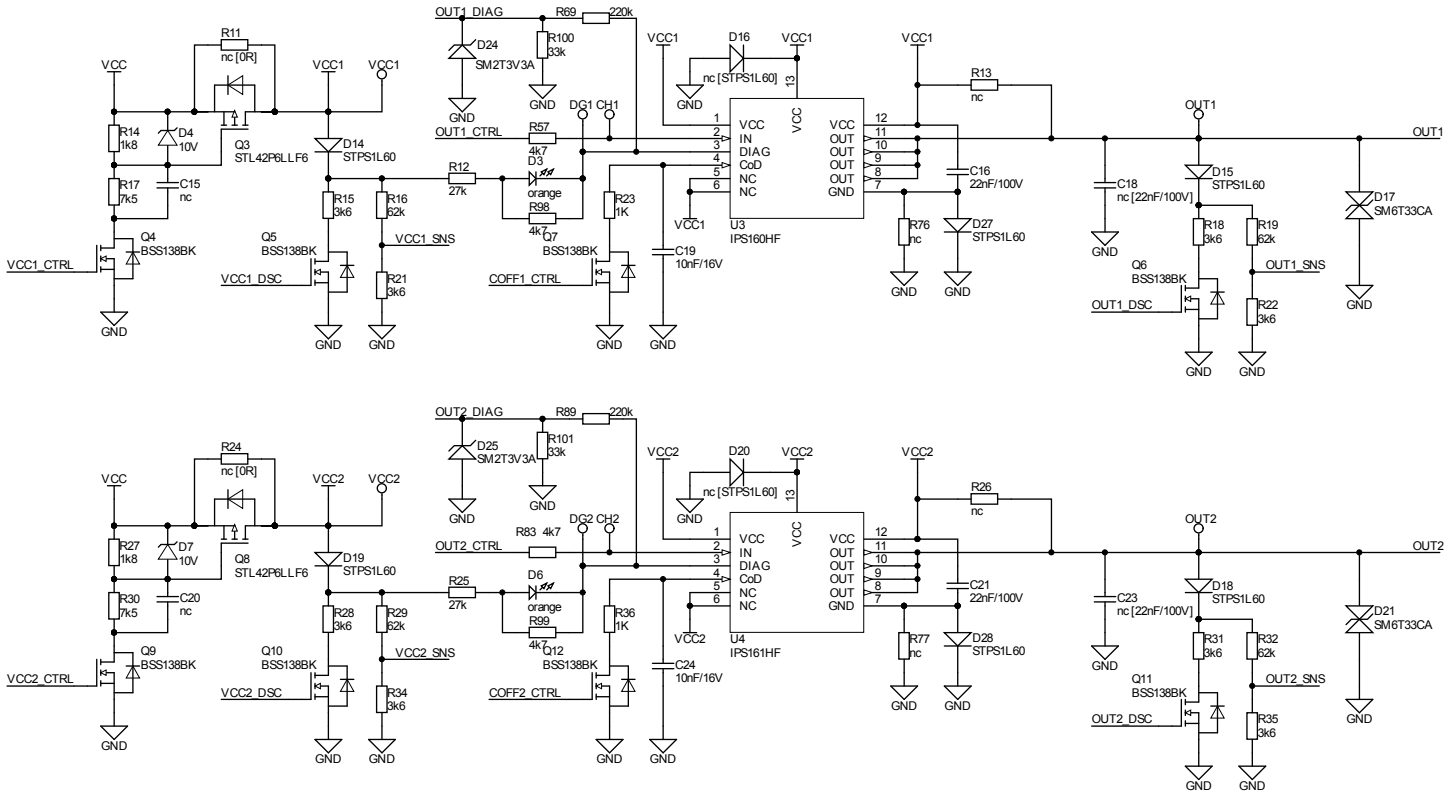
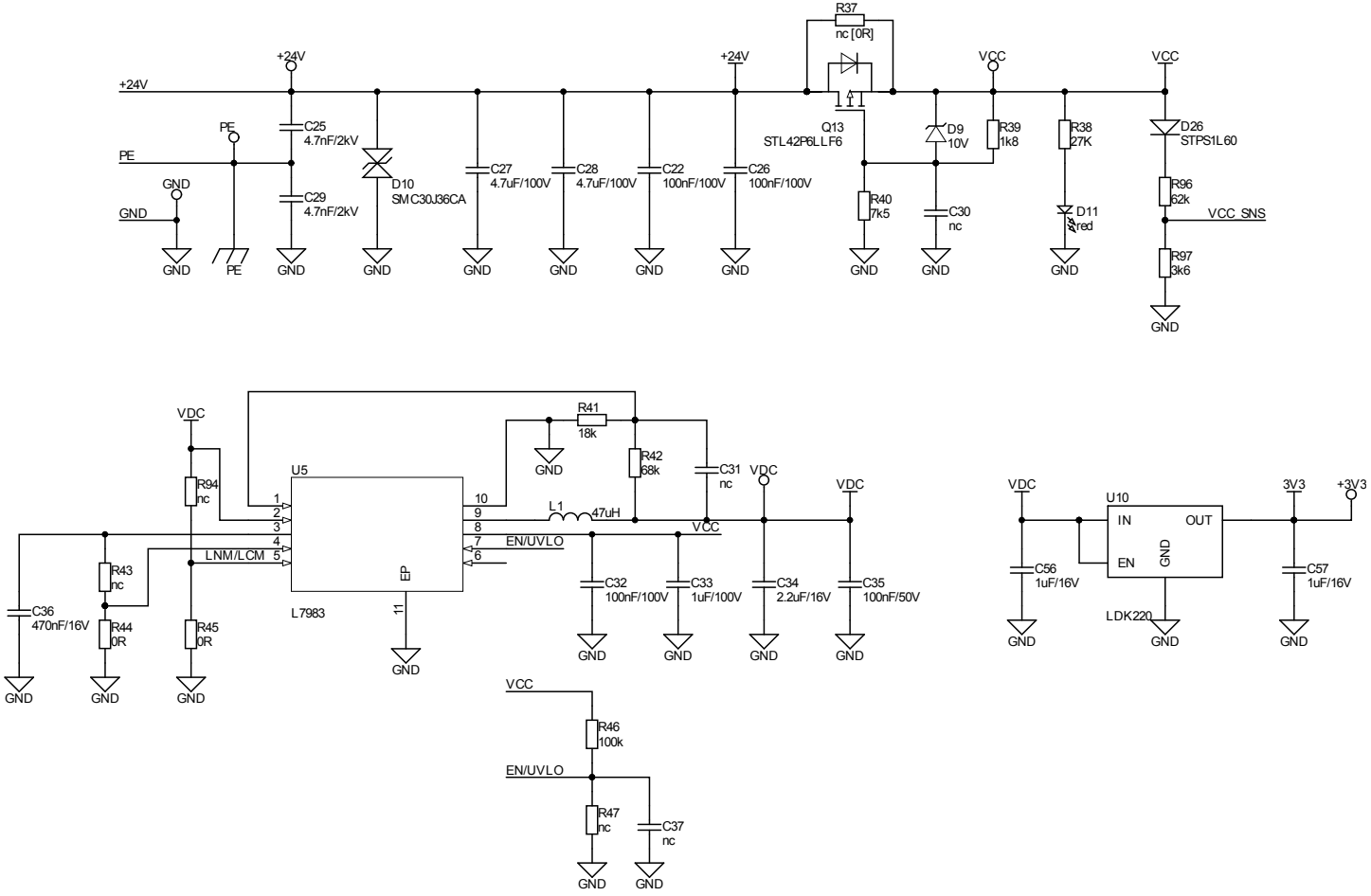


**Figure 10. STEVAL-FSM01M1 circuit schematics (6 of 6)**



# 3 Board versions

**Table 1. 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.*

## Revision history

Table 2. **Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 29-May-2023 | 1 | Initial release. |