UM3193

User manual

Getting started with the STEVAL-LVLP01 evaluation board

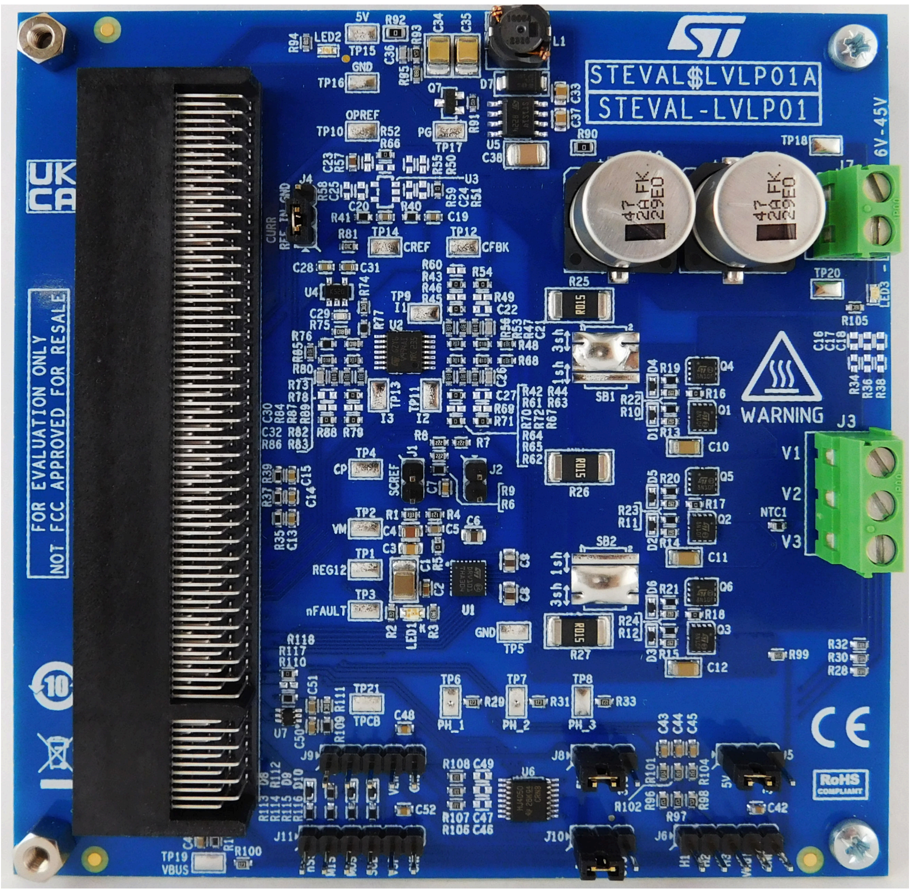
Introduction

The STEVAL-LVLP01 evaluation board is based on the STDRIVE101 three-phase gate driver and the STL8N10F7 power MOSFETs.

The STEVAL-LVLP01 embeds a power stage and circuitry for driving three-phase brushless DC motors. The board can be interfaced with different control boards based on STM32 microcontrollers through the MC Connector V2, which is a part of motor control development platform supporting ZeST and HSO Algorithms.

The STEVAL-LVLP01 can support single-shunt or three-shunt operation. The different connectors for onboard motor positioning feedback and motor phase sensing network allow implementation of sensor and sensorless algorithms for motion control.

Figure 1. STEVAL-LVLP01 evaluation board



1 Hardware description and configuration

The main components and connectors of the STEVAL-LVLP01 are shown in the figure and tables below.

Figure 2. STEVAL-LVLP01 main components and connectors

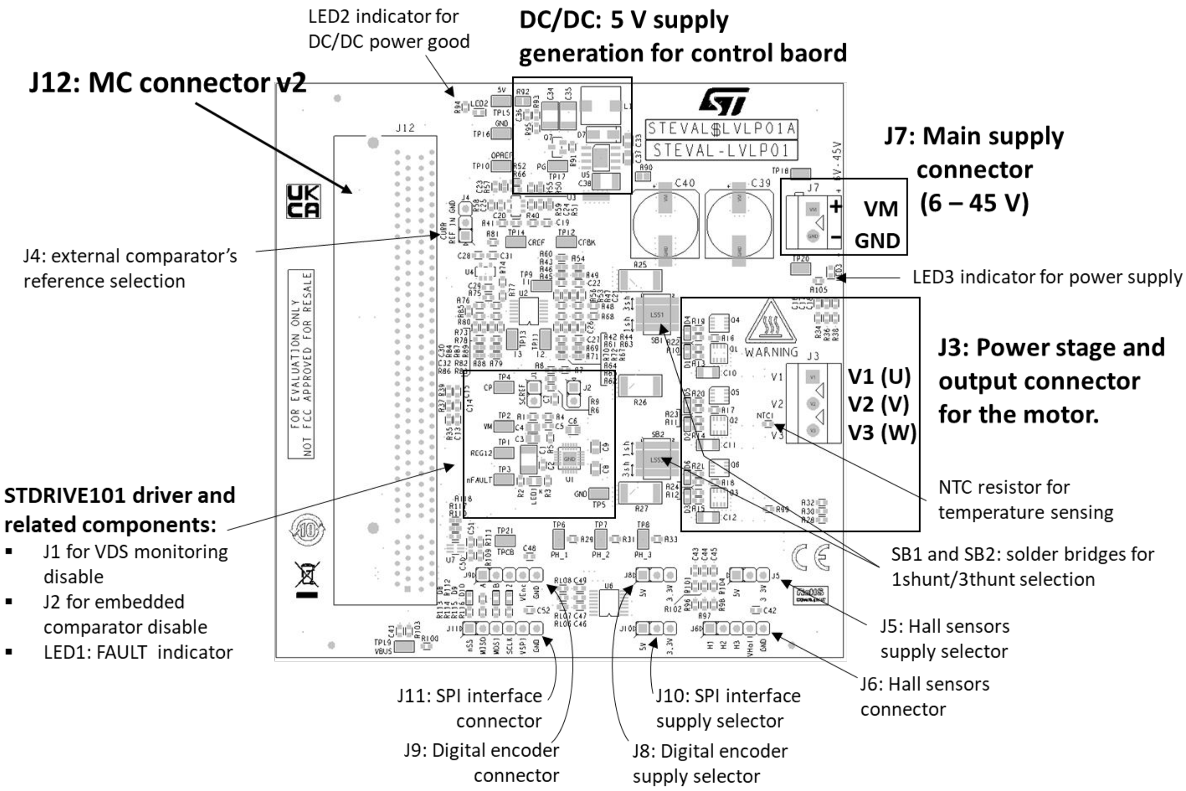


Table 1. STEVAL-LVLP01 configuration jumpers

Ref.	Label	Description	Default
J1	SCREF	Allows to short the SCREF pin of the STDRIVE101 to 3.3V, thus disabling the VDS monitoring protection (see VDS monitoring protection).	Open (VDS protection enabled)
J2		Allows to short the CP pin of the STDRIVE101 to GND, thus disabling the overcurrent protection (see Overcurrent comparator).	Open (OC protection enabled)
J4	CURR REF IN	Allows to select the reference for the current control comparator (see Comparator for current control). The reference signal can be provided externally, by removing the jumper or directly from the CURR_REF signal	Jumper on CURR_REF signal
J5		Selects the supply of the motor's Hall sensors, whether 5 V or 3.3 V (see Hall sensor connector)	Jumper on 5V selection
J8		Selects the supply of the motor's encoder, whether 5 V or 3.3 V (see Digital encoder connector)	Jumper on 5V selection
J10		Selects the supply of the Serial Peripheral Interface (SPI), whether 5 V or 3.3 V (see SPI connector)	Jumper on 5V selection
SB1 and SB2		Solder bridges to configure the shunt topology: three-shunt or single shunt configuration (see Shunt resistor configuration)	3-shunt configuration

Table 2. STEVAL-LVLP01 connectors

Ref.	Pin Label	Description
J3	V1	Phase 1 (U) of the three-phase motor.
	V2	Phase 2 (V) of the three-phase motor.
	V3	Phase 3 (W) of the three-phase motor.
J7	+ (VM)	Main power supply of the power MOSFETs and the STDRIVE101. It ranges from 6V to 45V.
	- (GND)	Reference ground terminal (negative pole) of the main power supply.
J6	H1	Motor’s Hall sensor signal 1 (digital signal).
	H2	Motor’s Hall sensor signal 2 (digital signal).
	H3	Motor’s Hall sensor signal 3 (digital signal).
	VHall	Motor’s Hall sensors supply voltage (selectable by J5).
	GND	GND reference for the motor’s Hall sensors.
J9	A	Motor’s encoder out A+ (digital signal).
	B	Motor’s encoder out B+ (digital signal).
	Z	Motor’s encoder zero feedback (digital signal).
	Venc	Motor’s encoder supply voltage (selectable by J8).
	GND	GND reference for the motor’s encoder.
J11	nSS	SPI interface: Chip Select / Slave select (active low).
	MISO	SPI interface: Master Input Slave Output
	MOSI	SPI interface: Master Output Slave Input
	SCLK	SPI interface: Serial clock
	VSPI	SPI interface supply voltage (selectable by J10).
	GND	GND reference for the SPI interface.

Table 3. STEVAL-LVLP01 test points

Ref.	Label	Description
TP1	REG12	Test point connected to the REG12 pin of the STDRIVE101; it is the output of the embedded linear regulator and the supply of the gate drivers.
TP2	VM	Voltage supply of the motor and the STDRIVE101. TP2 is placed next to the STDRIVE101.
TP3	nFAULT	Test point connected to the nFAULT pin of the STDRIVE101. This pin indicates a failure condition detected by the device.
TP4	CP	Test point connected to the CP pin of the STDRIVE101. It is the input of the embedded comparator used for overcurrent protection
TP5	GND	Power GND. Close to the power stage.
TP6	PH_1	Voltage of the phase V1 (U) of the motor, rescaled and filtered.
TP7	PH_2	Voltage of the phase V2 (V) of the motor, rescaled and filtered.
TP8	PH_3	Voltage of the phase V3 (W) of the motor, rescaled and filtered.
TP9	I1	Amplified signal related to the current flowing in the phase V1 of the motor.
TP10	OPREF	Reference voltage provided to the operational amplifiers.
TP11	I2	Amplified signal related to the current flowing in the phase V2 of the motor.
TP12	CFBK	Amplified signal used by the comparator implementing the current control (Comparator for current control).
TP13	I3	Amplified signal related to the current flowing in the phase V3 of the motor.
TP14	CREF	Reference signal used to set the current threshold of the current control (Comparator for current control).

Ref.	Label	Description
TP15	5V	5 V output of the DC/DC Buck converter. 5 V supply is used to supply the control board connected to the MC connector V2.
TP16	GND	Signal ground, reference for the DC/DC and the MC connector V2. The control board is referred to this GND.
TP17	PG	Power good indicator of the DC/DC Buck converter.
TP18	VM	Voltage supply of the motor and the STDRIVE101. TP2 is placed next to the main power connector J7.
TP19	VBUS	Bus voltage VM rescaled and filtered.
TP20	GND	Power GND. Close to the main power connector J7.
TP21	TPCB	Temperature signal measured by the NTC resistor.

1.1 MC connector V2

The Motor Control connector V2 is used to connect a compatible control board to the STEVAL-LVLP01. The insertion slot of this 164-pin edge-card connector presents two rows of contacts: the row on the bottom has an "A", and the row on top has a "B" (see Figure 3) at the beginning and the end of the pin numbering sequence.

The signal mapping is reported in Table 4, which indicates:

- The category of the pin according to the functional block associated
- The direction of the signal, whether from the power board STEVAL-LVLP01 to the control board (P → C) or vice-versa (P → C)
- The description of the signal function

The pins of the connector not reported in Table 4 can be associated to other functions or signals present on the control board, but are unused by the STEVAL-LVLP01.

Figure 3. MC connector V2 footprint and pin numbering (top view)

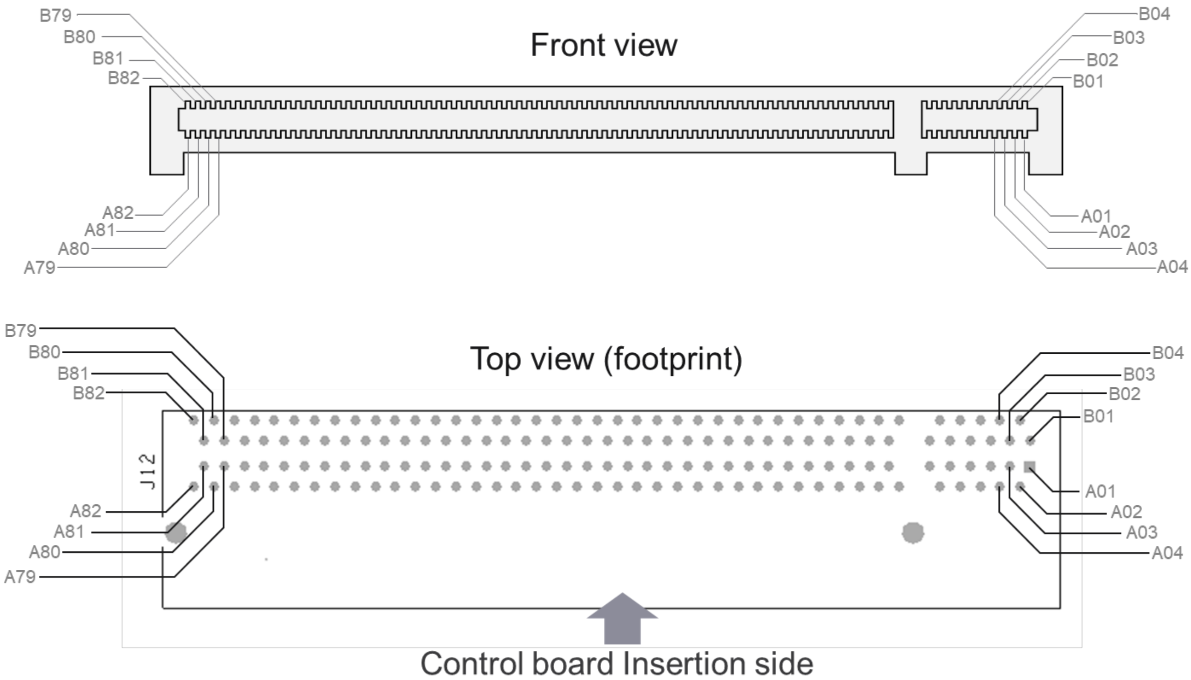


Table 4. Pin mapping of the MC connector V2

Pin No.	Category	Direction	Signal Name	Description
A01	SPI	C → P	SPI_nSS	nSS signal generated by the SPI peripheral (Master) on the control board.
B01		P → C	SPI_MISO	MISO signal generated by the slave device connected to J11 on the STEVAL-LVLP01.
A02		C → P	SPI_SCK	Serial clock signal generated by the SPI peripheral (Master) on the control board.
B02		C → P	SPI_MOSI	MOSI signal generated by the SPI peripheral (Master) on the control board.
A05	Power	P → C	5V	+ 5V Supply voltage generated by the DC/DC converter on the STEVAL-LVLP01
B05				
A06		C → P	VDD	+3.3V Supply voltage generated on the control board.
B06		--	VREF+	Reference voltage for the analog circuitry
A07		--	GND	Reference GND
B07				
A08	Board ID	C → P	ID ENABLE	Selects the analog signal to be sent on TEMP/ID pin (A28): Set to 0: board ID Set to 1: temperature sensor
B08	Power	--	GND	Reference GND
A12	Motor Feedback	P → C	nFAULT	STDRIVE101 fault indicator (active low): connection to BKIN input of the timer.
B12				STDRIVE101 fault indicator (active low): connection to BKIN2 input of the timer (default).
A13	Motor control	C → P	INH1	INH1/IN1 control Signal for the half bridge 1 (see Working mode selection).
B13		C → P	INL1	INL1/EN1 control Signal for the half bridge 1 (see Working mode selection).
A14		C → P	INH2	INH2/IN2 control Signal for the half bridge 2 (see Working mode selection).
B14		C → P	INL2	INL2/EN2 control Signal for the half bridge 2 (see Working mode selection).
A15		C → P	INH3	INH3/IN3 control Signal for the half bridge 3 (see Working mode selection).
B15		C → P	INL3	INL3/EN3 control Signal for the half bridge 3 (see Working mode selection).
B16	Motor Feedback	P → C	ENCA	A+ signal from the motor digital encoder
A17		P → C	ETR	ETR signal from the current control comparator (see Comparator for current control).
B17		P → C	ENCB	B+ signal from the motor digital encoder
A18		P → C	H1	Hall sensor 1 digital signal
B18		P → C	ENCZ	Zero feedback signal from the motor digital encoder
A19		P → C	H2	Hall sensor 2 digital signal
B19		P → C	H3	Hall sensor 3 digital signal
A20	Power	--	GND	Reference GND
B20				
A21	Motor Feedback	P → C	ISNS1P	Current sensing signal (positive) related to motor’s phase 1 (U) (see Operational amplifiers).
B21		P → C	ISNS1N	Current sensing signal (negative) related to motor’s phase 1 (U) (see Operational amplifiers).
A22		P → C	ISNS2P	Current sensing signal (positive) related to motor’s phase 2 (V) (see Operational amplifiers).
B22		P → C	ISNS2N	Current sensing signal (negative) related to motor’s phase 2 (V) (see Operational amplifiers).
A23		P → C	ISNS3P	Current sensing signal (positive) related to motor’s phase 3 (W) (see Operational amplifiers).

Pin No.	Category	Direction	Signal Name	Description
B23	Motor Feedback	P → C	ISNS3N	Current sensing signal (negative) related to motor's phase 3 (W) (see Operational amplifiers).
A24	Power	--	GND	Reference GND
B24				
A25	Motor Feedback	P → C	VSNS1	Voltage of the motor's phase 1 (U) rescaled and filtered.
B25		--	GND	Reference GND
A26		P → C	VSNS2	Voltage of the motor's phase 2 (V) rescaled and filtered.
B26		--	GND	Reference GND
A27		P → C	VSNS3	Voltage of the motor's phase 3 (W) rescaled and filtered.
B27		--	GND	Reference GND
A28		P → C	TEMP/ID	Analog signal representing the board ID or the temperature (see Temperature sensor and board ID).
B28	Motor control	C → P	CURR_REF	Reference signal used to set the current control (see Comparator for current control).
A29	Motor Feedback	P → C	VBUS	Power stage bus voltage (VM) rescaled and filtered
A31	Power	--	GND	Reference GND
B31				
A32				
B32				
A45				
B45				
A49				
B49				
A56				
B56				
A65				
B65				

1.2 Getting started

Table 5 summarizes the maximum ratings of the STEVAL-LVLP01. To run the motor follows the points below:

Step 1. Plug a compatible control board in the MC Connector V2 (J12), programmed with the target firmware

Step 2. Connect a power supply (voltage between 6V and 45V) to J7, taking care to connect the positive pole to VM pin and the negative one to GND pin (see Figure 2)

Step 3. Connect the three-phase brushless motor to J3 taking care of the motor phase sequence

Step 4. In case motor sensors are needed (disregard this point if the application does not require them):

- **Step 4a.** Select which supply to use for the Hall sensors using J5 and connect the Hall sensors and their supply to J6
- **Step 4b.** Select which supply to use for the encoder using J8 and connect the encoder and its supply to J9

Step 5. Power up the voltage supply connected to J7 and start the application.

Table 5. STEVAL-LVLP01 operative conditions

Parameter		Value
Supply voltage	Nominal	From 6 V to 45 V
Maximum phase current	Continuous[(1)]	5 Arms
	Peak (OC protection enabled – J2 open)	20 Amax

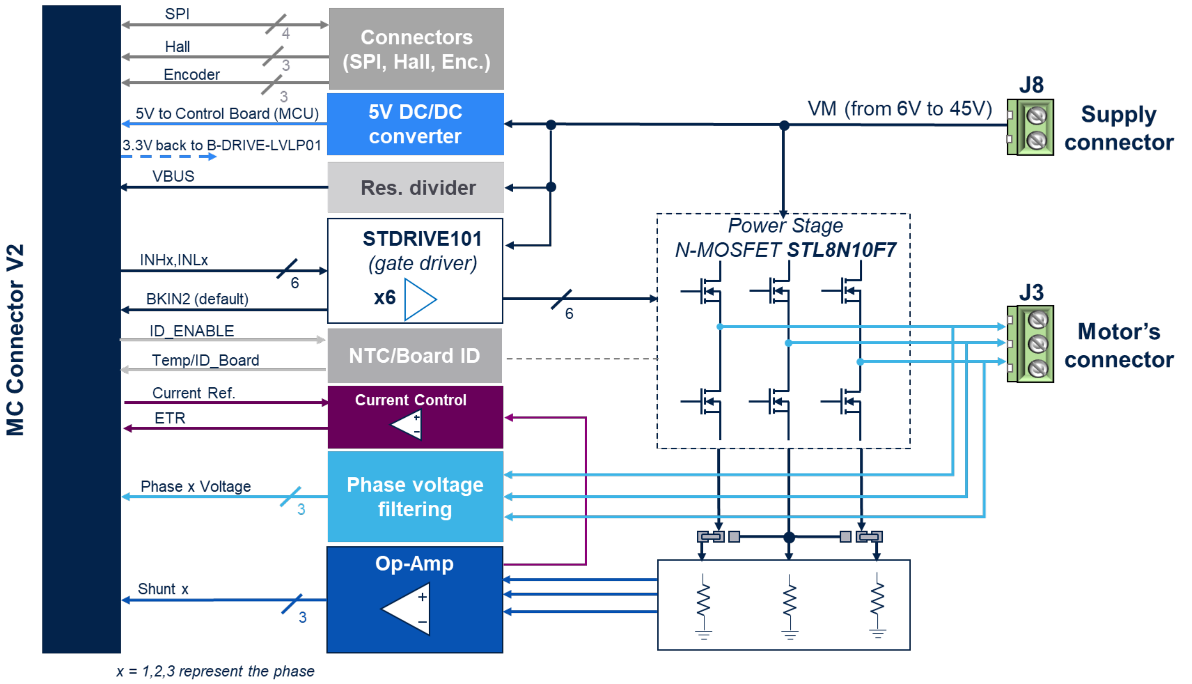
1. *Actual maximum current could be limited by power dissipation*

2 Hardware and functional blocks description

The STEVAL-LVLP01 is based on the STDRIVE101 three-phase gate driver. The power stage is based on six N-channel STL8N10F7 power MOSFETs in the 3.3 x 3.3 powerFLAT package. The digital control signals and the feedback signals are routed on the MC connector V2, which acts as interface for the control board.

The STEVAL-LVLP01 can be configured in single-shunt or three-shunt and it can support FOC, six-step, ZeST, and HSO algorithms. Each part of the Figure 4 block diagram is described in the following sections.

Figure 4. STEVAL-LVLP01 block diagram



2.1 DC-DC buck converter

The ST1S14 is a DC/DC buck converter present on the STEVAL-LVLP01, which generates a 5 V output, starting from the motor supply VM provided on J7. The external components are sized in order to guarantee a maximum current capability of 1.5 A. The 5 V voltage is brought on the MC connector V2, in order to provide the supply the microcontroller present on the control board. The step down from 5 V to 3.3 V is usually done by a linear regulator. The 5 V can also supply the motor sensors connected to the STEVAL-LVLP01 (see Motor position feedback interfaces)

If needed, the extended current capability of the DC/DC allows the user to connect other external loads, in addition to the other circuitries mentioned above. The 5 V voltage provided by the DC/DC is present on the test point TP15; a “Power Good” signal present on TP17 indicates whether the 5V is ok or there are some issues in regulation. Moreover, the “power good” is also indicated by the LED2 (green).

2.2 Current sensing

This section describes how the STEVAL-LVLP01 performs the current sensing, flowing in each phase of the motor. The current sensing is a critical point because most of the motion control algorithms are based on this information.

2.2.1 Shunt resistor configuration

The STEVAL-LVLP01 can be used in both three-shunt or single shunt configurations. By default, the board is configured in three-shunt configuration. Every phase has a shunt resistor of 15 mΩ. It is possible to change from three-shunt to single shunt, by changing the configuration of the solder bridges SB1 and SB2 as shown in Figure 5 and Figure 6.

Figure 5. **Solder bridges configuration for three-shunt operation**

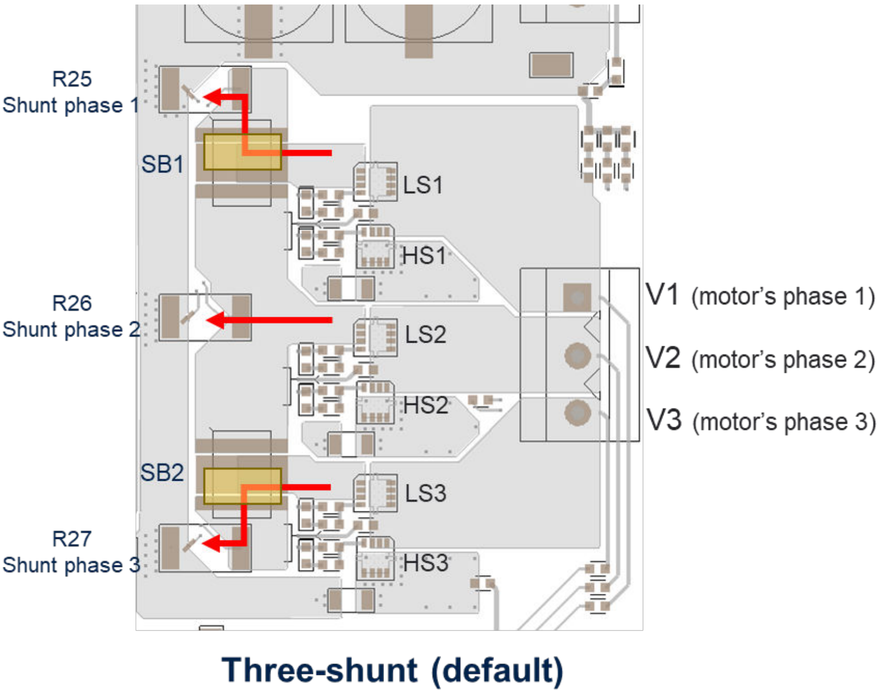
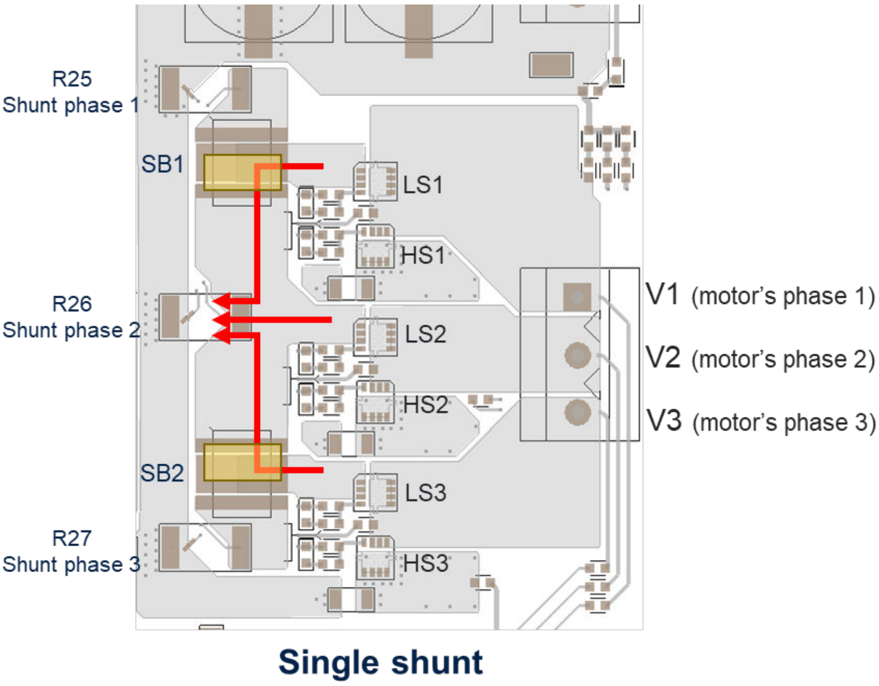


Figure 6. **Solder bridges configuration for single shunt operation**



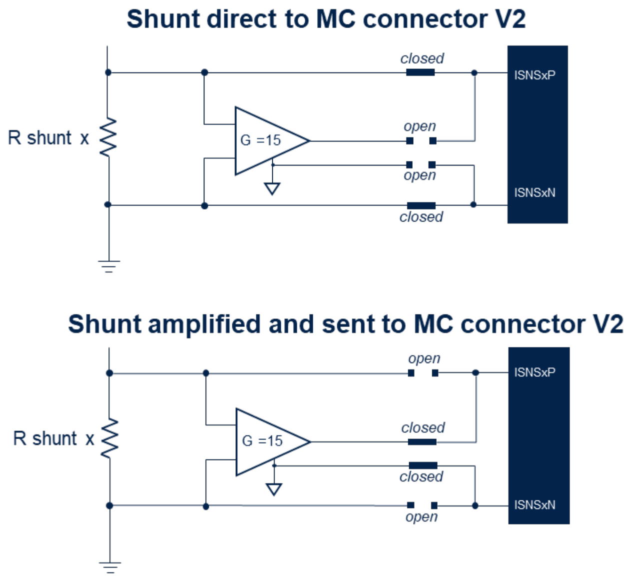
In case of single shunt operation (Figure 6) the solder bridges redirect the current of the three phases to flow in the shunt resistor of the phase 2 (R26); the readout of the current must be performed on the ISNS2P and ISNS2N signal; A22 and B22 pins of the MC connector V2, respectively.

2.2.2 Operational amplifiers

By default, the shunt resistors are directly connected to the MC connector V2: the amplification can be done exploiting the operational amplifiers embedded in the microcontroller on the control board. However, it is possible to change this configuration and use the operational amplifiers present on the STEVAL-LVLP01. The signal of each shunt resistor has a dedicated op-amp, which implements a differential amplifier with a gain of 15. The topology used enables the rejection of the common mode, resulting in a more accurate output signal. There is the possibility to add a RC low pass filter at the output of each op-amp; by default, no filter is mounted. The TSV994 mounted on the STEVAL-LVLP01 embeds the three operational amplifiers (one for each shunt), together with a fourth op-amp used for current control (see Comparator for current control).

By configuring the 0-Ohm resistors/solder bridges as reported in Table 6, the raw signal coming from the shunt resistor is amplified before sending it the MC connector V2.

Figure 7. Shunt and op-amp connections by solder bridges / 0-ohm resistors



x = 1,2,3 (representing the motor's phase)

Table 6. Configuration for the shunt resistors amplification

Shunt resistor	Direct to MC conn. V2 (default)	To op-amp and then to MC connector V2
R25 (Phase 1)	R43, R54 mounted/closed R46, R49 open	R43, R54 open R46, R49 mounted/closed
R26 (Phase 2)	R62, R71 mounted/closed R65, R69 open	R62, R71 open R65, R69 mounted/closed
R27 (Phase 3)	R79, R88 mounted/closed R83, R86 open	R79, R88 open R83, R86 mounted/closed

2.2.3 Comparator for current control

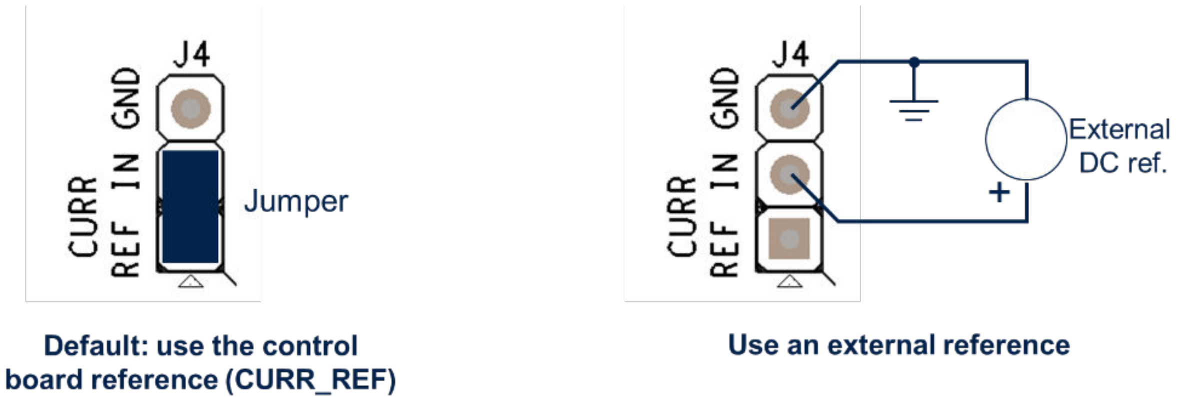
The current control feature is implemented using the ETR pin of the microcontroller: this pin acts directly on the timer driving the gate drivers of the STDRIVE101. The ETR signal is triggered when the value of the current reaches the selected threshold. For this purpose, the comparator TS3021 compares a signal proportional to the current with a reference signal representing the current threshold.

As the current is measured on the shunt R26, a single shunt topology should be used (as explained in Shunt resistor configuration). The current control is particularly suitable for six-step algorithms, where only positive voltages are used for the control. The voltage on R26 is then amplified, filtered and provided on the positive input of the comparator (CFBK on Test point TP12). The amplification is performed by the fourth op amp of the TSV994 (see Operational amplifiers), implementing a differential amplifier with a gain equal to 22. The CREF signal (Test point TP14) is connected to the negative input of the comparator and set the threshold of the current control. Therefore, the current of the power stage is controlled at the peak level I_{ctrl} that is:

$$I_{ctrl} = \frac{V_{CREF}}{22 \cdot R_{shunt}} = \frac{V_{CREF}}{330\Omega}$$

The voltage on CREF (V_{CREF}) can be generated directly by the control board or provided externally (see Figure 8). The reference signal generated by the control board (CURR_REF) could be an analog signal or a PWM signal with a duty cycle proportional to the target voltage. The low pass-filter (R81 and C31) filters the PWM, providing a stable V_{CREF}.

Figure 8. current threshold selector



2.3 Motor phase voltage

The voltage present on each motor's phase is rescaled and filtered, so it can be monitored by the microcontroller on the control board. The attenuation of the resistor divider is about 25.3, ensuring that even at the maximum supply VM, the signals are within the operative range of the microcontroller's inputs. The bandwidth of the low pass filter is 518 Hz.

The signals related to the motor's phase voltages are available on the test points TP6, TP7, TP8 and on the MC connector V2 as listed here below:

- Motor's phase 1 signal: VSNS1 on TP6 and MC connector V2 pin A25
- Motor's phase 2 signal: VSNS2 on TP7 and MC connector V2 pin A26
- Motor's phase 3 signal: VSNS3 on TP8 and MC connector V2 pin A27

2.4 Temperature sensor and board ID

The two analog signals related to the temperature monitoring and to the board ID are mapped on the same line connected to the MC connector V2 (TEMP_ID). An analog multiplexer selects which signal is sent to the MC connector V2, according to the digital line ID_ENALBLE set by the control board:

- ID_ENABLE = 0 → board ID signal on the MC connector V2
- ID_ENABLE = 1 → temperature signal on the MC connector V2

2.4.1 Board ID

The board ID provides a voltage level which identifies the STEVAL-LVLP01; this analog voltage is obtained with a resistor divider referred to the VDD, which is 3.3 V typical and it is also the supply of the microcontroller on the control board. The voltage level identifying the STEVAL-LVLP01 is approximately 1.03 V.

2.4.2 Temperature sensor

The temperature measurement is implemented using an NTC resistor placed on the STEVAL-LVLP01, between the power MOSFETs and the output connector J3. A voltage proportional to the temperature is generated by the resistor divider given by NTC1 and R109 and it is available on TP21.

The NTC resistance decreases when the temperature increases with a non-linear relation (Figure 9): it is not possible to obtain a linear behavior on the entire temperature range. R109 is sized in order to get a linear behavior in the most critical temperature range, between 50°C and 120°C (Figure 10). The relation to find the temperature, only valid for temperatures between 50°C and 120°C is:

$$T[°C] = 45.7 \cdot V_{TP21}[V] + 23.6$$

Figure 9. **NTC resistance value with respect to temperature**

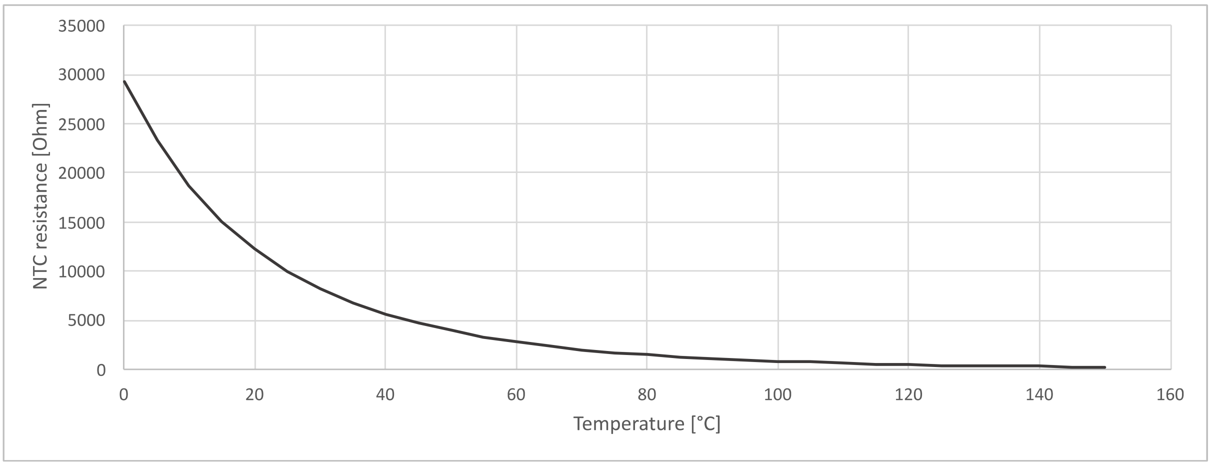
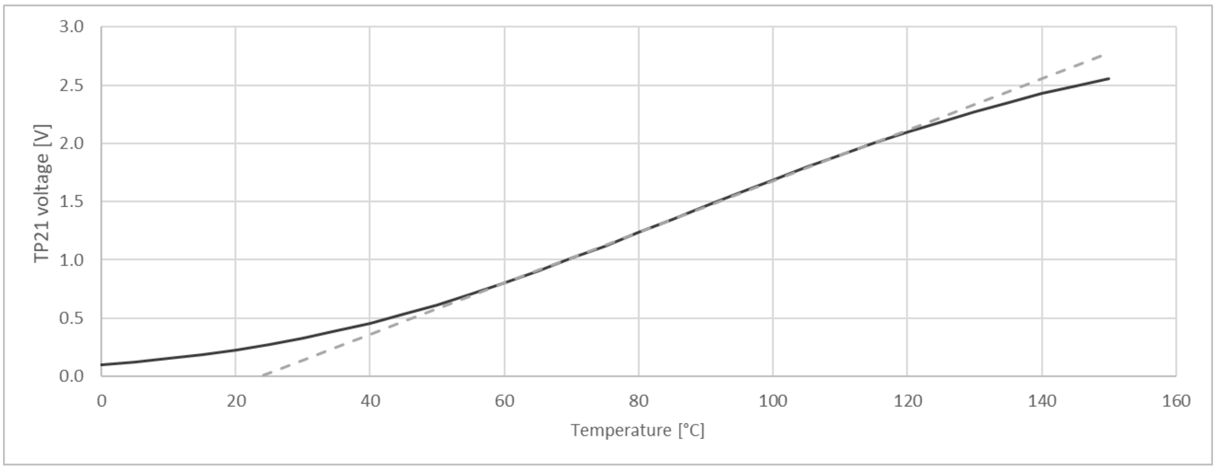


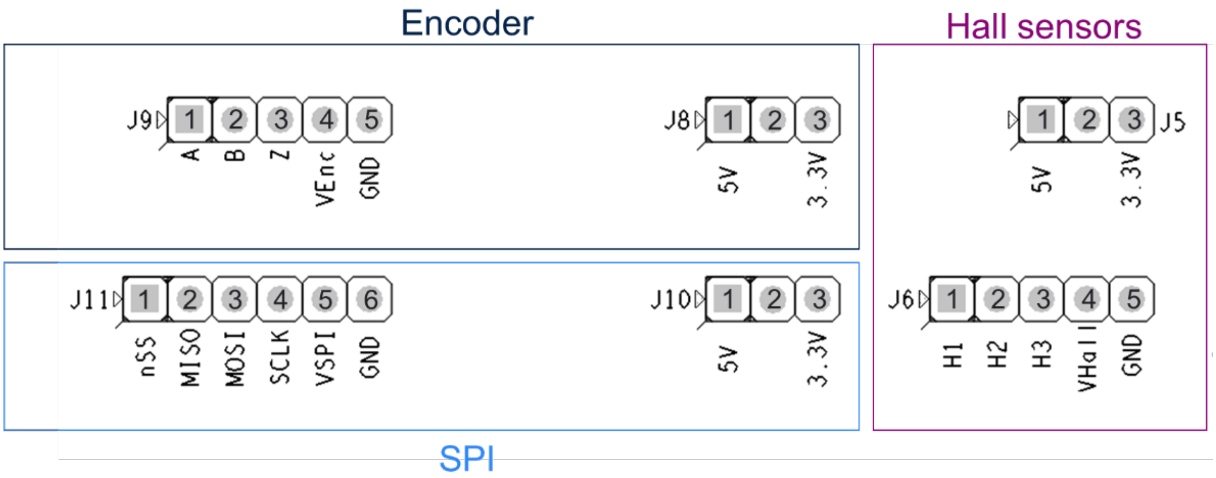
Figure 10. **Voltage on TP21 with respect to temperature**



2.5 Motor position feedback interfaces

The STEVAL-LVLP01 embeds three different interfaces (Figure 11) to acquire the motor sensors and send them through the MC connector V2 to the control board. These signals are then managed by the microcontroller to implement the motion control algorithms.

Figure 11. **Strip connectors for motor sensor feedback**



2.5.1 Hall sensor connector

The Hall sensor connector J6 supports digital Hall sensors with open drain output. The 4.7 kΩ pull-up resistors (R96, R97, R98) connected to VDD shift the input signals to a level compatible with the microcontroller's inputs range. A low pass filter is also present to reduce the noise during transitions. Refer to Table 2 for the connector J6 pinout. The order of sensors' outputs H1, H2 and H3 must be coherent with the related motor's phases connected to the output connector J3. The Hall sensors supply ("VHall" label) is provided on the pin 4 of the J6 connector: both the 5 V and the 3.3 V supplies are supported and the selection is made by J5:

- Jumper between the pin 1 and pin 2: sensors powered by 5 V supply
- Jumper between the pin 2 and pin 3: sensors powered by 3.3 V supply (VDD)

2.5.2 Digital encoder connector

The encoder connector J9 supports a quadrature encoder with push-pull outputs. The encoder's signals are shifted to a level compatible with the microcontroller's inputs range. Refer to Table 2 for the connector J9 pinout. The encoder supply ("VEnc" label) is provided on pin 4 of the J9 connector: both the 5 V and the 3.3 V are supported; the selection is made by J8:

- Jumper between the pin 1 and pin 2: sensors powered by 5 V supply
- Jumper between the pin 2 and pin 3: sensors powered by 3.3 V supply (VDD)

2.5.3 SPI connector

The Serial Peripheral Interface (SPI) is a general purpose interface and can be used to connect a generic digital sensor supporting this interface (e.g. a digital absolute encoder). The SPI is mapped on J11; refer to Table 2 for the connector's pinout. The device connected to J11 can act only as slave in the communication. The SPI supply ("VSPI" label) is provided on pin 5 of the J11 connector: both the 5 V and the 3.3 V are supported; the selection is made by J10:

- Jumper between the pin 1 and pin 2: sensors powered by 5 V supply
- Jumper between the pin 2 and pin 3: sensors powered by 3.3 V supply (VDD)

2.6 Bus voltage monitoring

The bus voltage VM (HS MOSFETs supply) is rescaled and filtered, so it can be monitored by the microcontroller on the control board. The attenuation of the resistor divider is about 25.3, ensuring that even at the maximum supply VM, the signals are within the operative range of the microcontroller inputs. The bandwidth of the low pass filter is 518 Hz. The signal related to the bus voltages is available on the test point TP19 and on the MC connector V2 on the pin A29. The green LED3 indicates the presence of the supply VM.

3 STDRIVE101 feature descriptions

3.1 Overcurrent comparator

The STDRIVE101 integrates a comparator, which disables the power stage whenever the voltage on its input (CP pin) exceed the internal threshold VREF,DRV (about 0.5V). The values of the currents in each phase are acquired and combined through a resistors' network: the resulting signal, connected to CP is proportional to the current .

The resistors R7, R8, R9 have the same value and act as a voltage adder, while the R6 introduces a shift on the resulting signal. Defining a ratio α equal to:

$$\alpha = \frac{R7}{R6} = \frac{R8}{R6} = \frac{R9}{R6} = \frac{2.2k\Omega}{5.1k\Omega} = 0.43$$

The current threshold which triggers the comparator is:

$$I_{OC} = \frac{1}{R_{shunt}} \cdot (3V_{REF} + \alpha V_{REF} - \alpha V_{DD}) = \frac{1}{15m\Omega} \cdot (1.5V + 0.215V - 1.42V) \approx 19.7A$$

The C7 capacitor filters the signal, which is directly modulated by the PWM switching of the power stage. Therefore, there is a delay in the intervention time of the comparator.

The overcurrent comparator can be disabled shorting the CP pin to GND, closing strip J2 with a jumper.

3.2 VDS monitoring protection

The STDRIVE101 embeds a protection which measures the voltage between the drain and the source of each MOSFET (VDS) and compares it with a specified threshold. When the MOSFET is turned on and its VDS is greater than the threshold, the VDS monitoring protection is triggered after a deglitch time. The threshold is set on the SCREF pin of the STDRIVE101 through the divider given by R1 and R4: it is approximately 0.88 V.

Note: The drop on the LS MOSFETs is measured between their drain and GND, so the drop on the respective shunt resistor contributes to the measurement. For further information, refer to STDRIVE101 datasheet.

The VDS monitoring protection can be disabled closing with a jumper the pins of J1.

3.3 Embedded 12 V linear regulator

The STDRIVE101 embeds a linear regulator which supplies the gate drivers. The voltage generated by the linear regulator is available on the REG12 pin connected to the test point TP1.

3.4 Working mode selection

The STDRIVE101 has two input strategies, which can be selected by changing the resistor R5 connected to the DT/MODE pin of the device. The default value of R5 is 0 Ω (short to GND), meaning that the STDRIVE101 works in direct mode: the status of each driver is determined by the status of its related input signal: INHx for the high-side MOSFET and INLx for the low-side MOSFET, with x = 1,2 or 3.

Changing the value of R5 with a resistor in the range between 50 kΩ and 250 kΩ, the STDRIVE101 works in enable/input mode: the half bridge "x" is enabled or disabled by ENx signal and its status is determined by INx signal. The deadtime between the HS and LS switching depends on the value of the R5 resistor. Table 7 summarizes the function of each digital input according to the configuration. For further information, refer to the STDRIVE101 datasheet.

Table 7. STDRIVE101 digital input functions according to R5 (DT/MODE pin)

STDRIVE101 Pin name (number)	Direct Mode (R5 = 0 Ω)	EN/IN Mode (50kΩ < R5 < 250 kΩ)
INH1/IN1 (7)	INH1 (digital control input for the HS driver on half bridge 1)	IN1 (level of half bridge 1: HS or LS on, with deadtime insertion)
INH2/IN2 (8)	INH2 (digital control input for the HS driver on half bridge 2)	IN2 (level of half bridge 2: HS or LS on, with deadtime insertion)
INH3/IN3 (9)	INH3 (digital control input for the HS driver on half bridge 3)	IN3 (level of half bridge 3: HS or LS on, with deadtime insertion)
INL1/EN1 (10)	INL1 (digital control input for the LS driver on half bridge 1)	EN1 (digital control of the half bridge 1: enable/high impedance)

STDRIVE101 Pin name (number)	Direct Mode (R5 = 0 Ω)	EN/IN Mode (50kΩ < R5 < 250 kΩ)
INL2/EN2 (11)	INL2 (digital control input for the LS driver on half bridge 2)	EN2 (digital control of the half bridge 2: enable/high impedance)
INL3/EN3 (12)	INL3 (digital control input for the LS driver on half bridge 3)	EN3 (digital control of the half bridge 3: enable/high impedance)

3.5 Fault monitoring

When a protection of the STDRIVE101 is triggered (overcurrent, VDS monitoring, UVLO or overtemperature), the internal open drain MOSFET of the nFAULT pin is turned on. A red LED (LED1) is present and it is activated and the status can be read also on the test point TP3.

The nFAULT signal can be mapped on two different pins of the MC connector V2: by default it is mapped on B12: in this case the nFAULT signal triggers the BKIN2 input of the timer peripheral in the microcontroller on the control board. Mounting R117 and removing the R118 instead, the nFAULT pin will be redirected on A12 pin of the MC connector V2, thus triggering the BKIN input of the timer peripheral.

4 Schematic diagrams

Figure 12. **STEVAL-LVLP01 circuit schematic (1 of 6)**

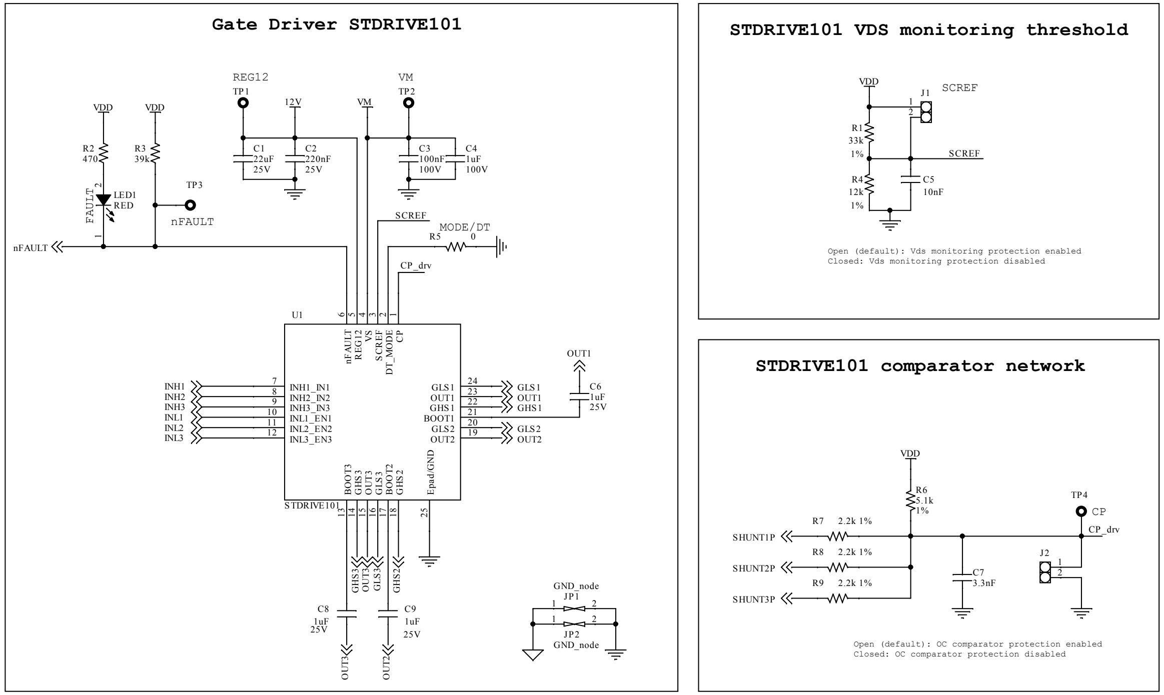


Figure 13. STEVAL-LVLP01 circuit schematic (2 of 6)

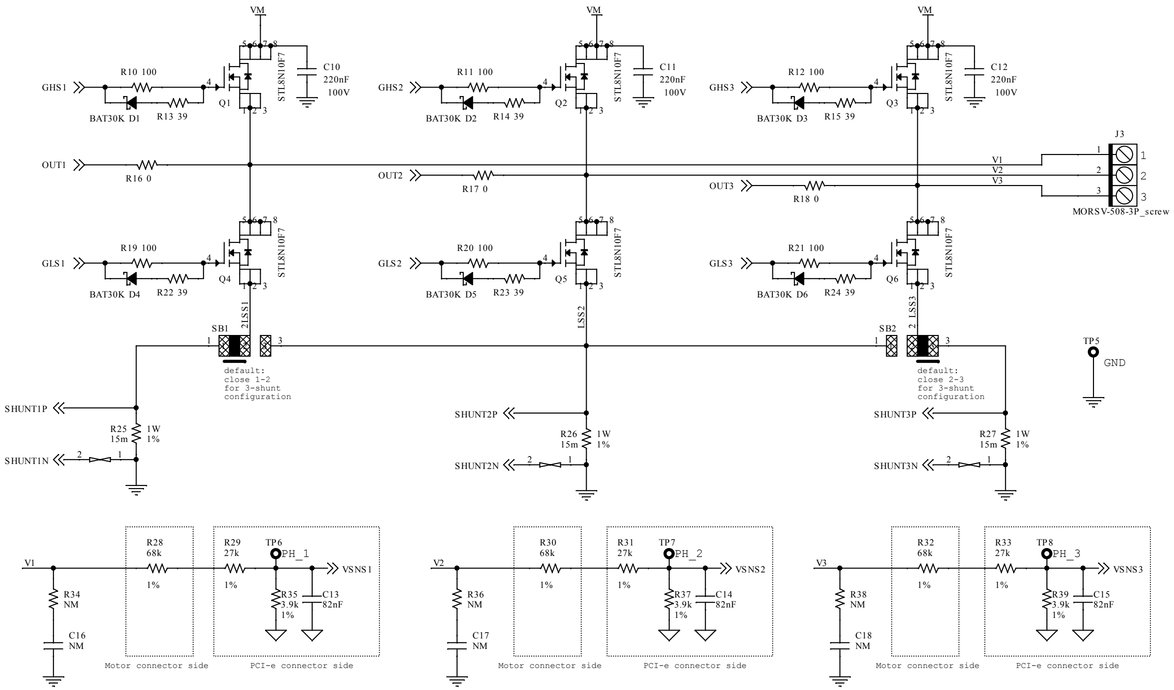


Figure 14. STEVAL-LVLP01 circuit schematic (3 of 6)

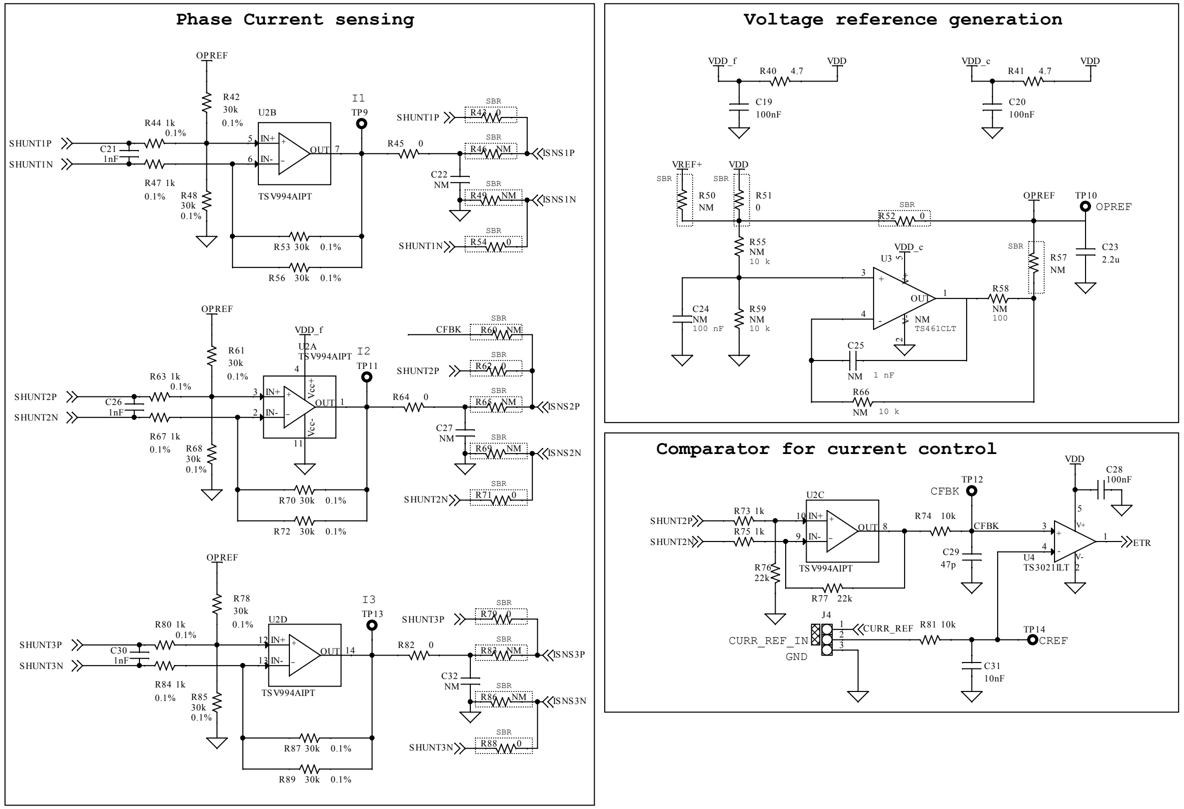


Figure 15. **STEVAL-LVLP01 circuit schematic (4 of 6)**

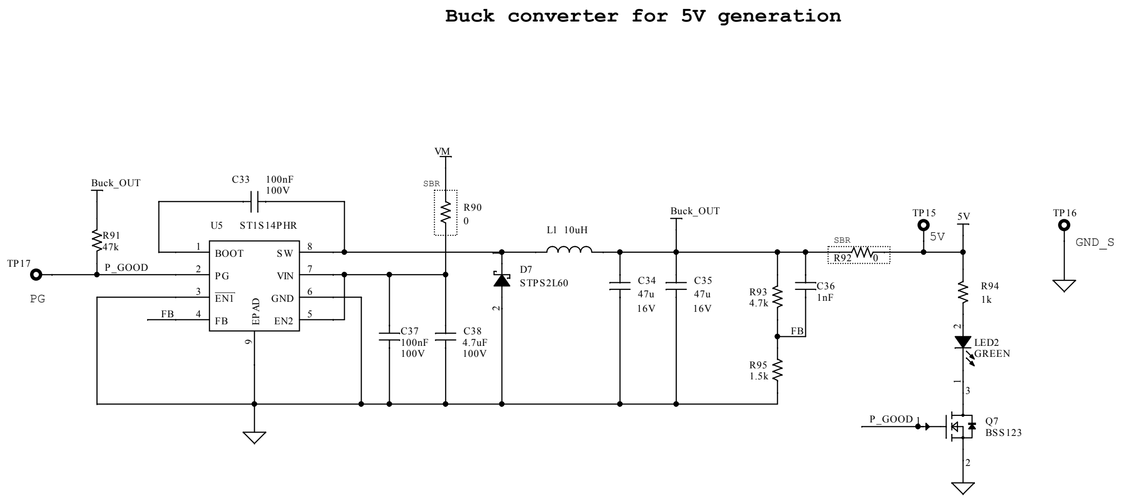


Figure 16. STEVAL-LVLP01 circuit schematic (5 of 6)

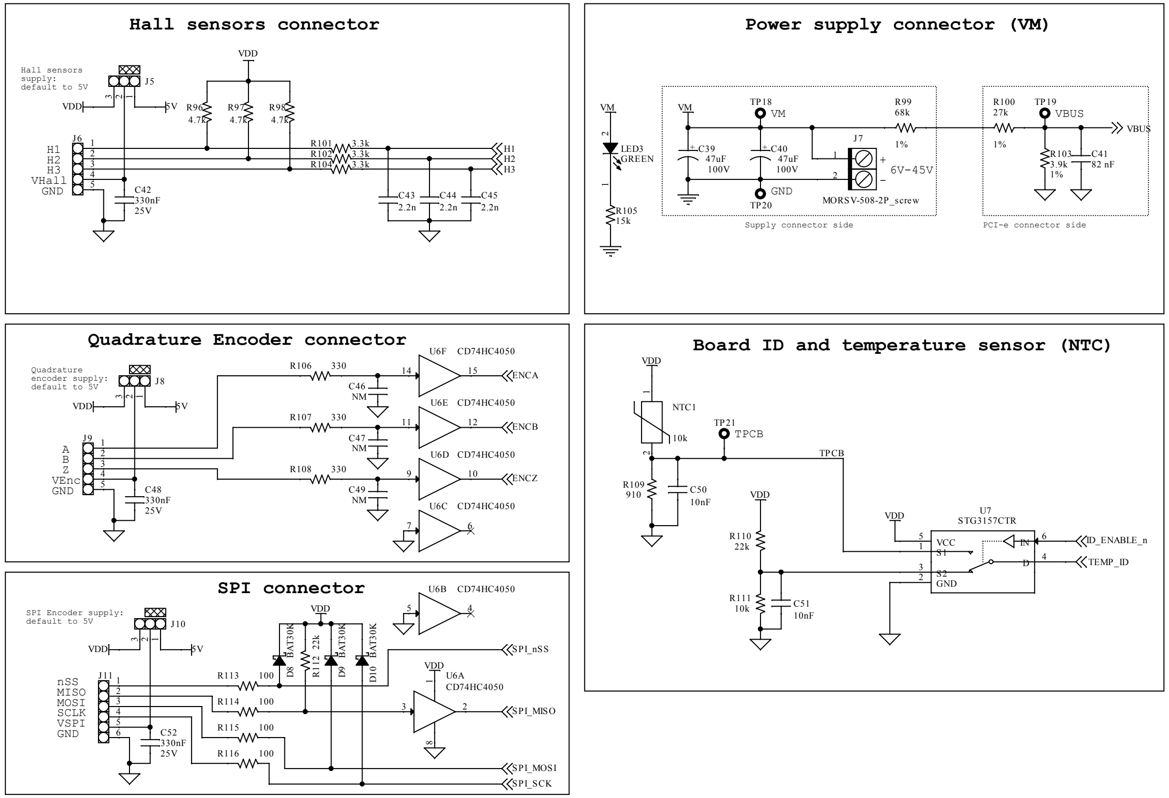
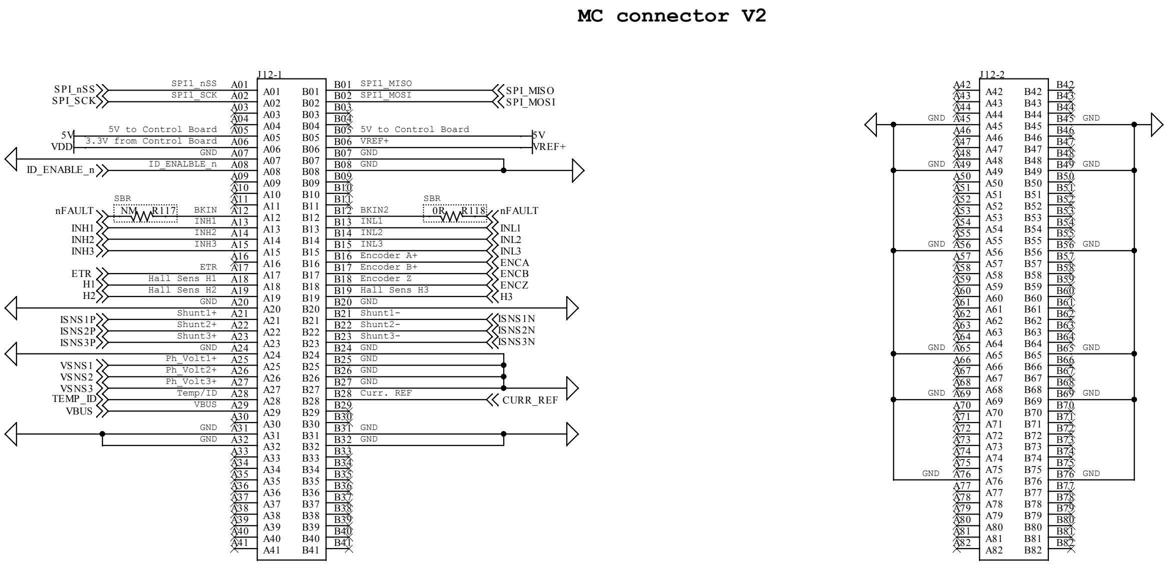


Figure 17. STEVAL-LVLP01 circuit schematic (6 of 6)



5 Bill of materials

Table 8. **STEVAL-LVLP01 bill of materials**

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	1	C1	22uF	SMT ceramic capacitor (X7R)	Taiyo Yuden	TMK325B7226KM-PR
2	1	C2	220nF	SMT ceramic capacitor (X7R)	Murata	GCM188R71E224KA55D
3	3	C3, C33, C37	100nF	SMT ceramic capacitor (X7R)	Kemet	C0805C104K1RACTU
4	1	C4	1uF	SMT ceramic capacitor (X7R or X7S)	TDK	CGA4J3X7S2A105K125AE
5	4	C5, C31, C50, C51	10nF	SMT ceramic capacitor (X7R)	Murata	GCM188R72A103KA37D
6	3	C6, C8, C9	1uF	SMT ceramic capacitor (X7R)	Kemet	C0805C105K3RACTU
7	1	C7	3.3nF	SMT ceramic capacitor (X7R)	Wurth Elektronik	885012206037
8	3	C10, C11, C12	220nF	SMT ceramic capacitor (X7R)	Murata	GCM31MR72A224KA37L
9	4	C13, C14, C15, C41	82nF	SMT ceramic capacitor (X7R)	Murata	GRM188R71E823KA01D
10	3	C16, C17, C18	NM	SMT ceramic capacitor	N.A.	Not Mounted
11	3	C19, C20, C28	100nF	SMT ceramic capacitor (X7R)	Kemet	C0603C104K3RACTU
12	4	C21, C26, C30, C36	1nF	SMT ceramic capacitor (C0G)	Kemet	C0603C102J3GACTU
13	4	C22, C25, C27, C32	NM	SMT ceramic capacitor	N.A.	Not Mounted
14	1	C23	2.2uF	SMT ceramic capacitor (X7S or X5R)	TDK	C1608X5R1C225M080AB
15	1	C24	NM	SMT ceramic capacitor	N.A.	Not Mounted
16	1	C29	47pF	SMT ceramic capacitor (NP0)	Yageo	AC0603JRNPO9BN470
17	1	C34, C35	47uF	SMT ceramic capacitor (X6S or X5R)	Murata	GRM32EC81C476KE15L
18	1	C38	4.7uF	SMT ceramic capacitor (X7R)	AVX	12101C475KAT2A
19	2	C39, C40	47uF	SMT electrolytic capacitor	Panasonic	EEVFK2A470Q
20	3	C42, C48, C52	330nF	SMT ceramic capacitor (X7R)	Kemet	C0603C334K4RACTU
21	3	C43, C44, C45	2.2nF	SMT ceramic capacitor (X7R)	06035C222KAZ2A	AVX
22	3	C46, C47, C49	NM	SMT ceramic capacitor	N.A.	Not mounted

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
23	9	D1, D2, D3, D4, D5, D6, D8, D9, D10	BAT30K, SOD-523	Small signal Schottky diodes	STMicroelectronics	BAT30KFILM
24	1	D7	STPS2L60, SMA	Low drop power Schottky rectifier	STMicroelectronics	STPS2L60A
25	2	JP1, JP2	GND_node	PCB shape	N.A.	N.A.
26	3	JP3, JP4, JP5	CurrentSense	PCB shape	N.A.	N.A.
27	2	J1, J2	STRIP 1x2	Strip connector 2 pos, 2.54 mm	WURTH ELEKTRONIK	61300211121
28	1	J3	MORSV-508-3P_screw	Horizontal Entry Modular w. Rising Cage Clamp, Serie 2135 - 5.08 mm	WURTH ELEKTRONIK	691213510003
29	4	J4, J5, J8, J10	STRIP 1x3 + Jumper	Strip connector 3 pos, 2.54 mm + Jumper	WURTH ELEKTRONIK	61300311121
30	2	J6, J9	STRIP 1x5	Strip connector 5 pos, 2.54 mm	WURTH ELEKTRONIK	61300511121
31	1	J7	MORSV-508-2P_screw	Horizontal Entry Modular w. Rising Cage Clamp, Serie 2135 - 5.08 mm	WURTH ELEKTRONIK	691213510002
32	1	J11	STRIP 1x6	Strip connector 6 pos, 2.54 mm	WURTH ELEKTRONIK	61300611121
33	1	J12	MC connector V2	PCI & PCI Express Connectors, Board-to-Board, 164 Position, .039 in [1 mm] Centerline, Right Angle, Black, Height 9.4 mm [.37 in]	TE Connectivity	1761465-4
34	1	LED1	RED	SMT 0805 Red LED	WURTH ELEKTRONIK	150080RS75000
35	2	LED2, LED3	GREEN	WL-SMCW SMT Mono-color Chip LED Waterclear	WURTH ELEKTRONIK	150060GS75000
36	1	L1	10uH	Wound Ferrite inductor	TDK	CLF7045NIT-100M-D
37	1	NTC1	10k	NTC Thermistor	Vishay	NTCS0603E3103FMT
38	6	Q1, Q2, Q3, Q4, Q5, Q6	STL8N10F7, PowerFLAT 3.3x3.3	N-channel 100 V, 17 mO typ., 8 A STripFET™ F7 Power MOSFET	STMicroelectronics	STL8N10F7
39	1	Q7	BSS123	N-CHANNEL ENHANCEMENT MODE FIELD EFFECT TRANSISTOR	Nexperia	BSS123-7-F
40	1	R1	33k	SMT resistor	TE Connectivity	CRG0603F33K
41	1	R2	470	SMT resistor	TE Connectivity	CRG0603F470R
42	1	R3	39k	SMT resistor	TE Connectivity	CRG0603F39K
43	1	R4	12k	SMT resistor	Panasonic	ERJU03F1202V

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
44	16	R5, R16, R17, R18, R43, R45, R51, R52, R54, R62, R64, R71, R79, R82, R88, R118	0	SMT resistor	TE Connectivity	CRG0603ZR
45	1	R6	5.1k	SMT resistor	Vishay	CRCW06035K10FKEA
46	3	R7, R8, R9	2.2k	SMT resistor	TE Connectivity	CRG0603F2K2
47	10	R10, R11, R12, R19, R20, R21, R113, R114, R115, R116	100	SMT resistor	Panasonic	ERJPA3F1000V
48	6	R13, R14, R15, R22, R23, R24	39	SMT resistor	TE Connectivity	CRGP0603F39R
49	3	R25, R26, R27	15m	SMT resistor	Bourns	CRF2512-FZ-R015ELF
50	4	R28, R30, R32, R99	68k	SMT resistor	Vishay	CRCW060368K0FKEA
51	4	R29, R31, R33, R100	27k	SMT resistor	Panasonic	ERJU03F2702V
52	3	R34, R36, R38	NM	SMT resistor	N.A.	Not Mounted
53	4	R35, R37, R39, R103	3.9k	SMT resistor	Vishay	CRCW06033K90FKEA
54	2	R40, R41	4.7	SMT resistor	Vishay	CRCW06034R70FKEA
55	12	R42, R48, R53, R56, R61, R68, R70, R72, R78, R85, R87, R89	30k	SMT resistor	Yageo	RT0603BRD0730KL
56	6	R44, R47, R63, R67, R80, R84	1k	SMT resistor	Yageo	RT0603BRE071KL
57	10	R46, R49, R50, R57, R60, R65, R69, R83, R86, R117	NM	SMT resistor	N.A.	Not Mounted
58	3	R55, R59, R66	NM	SMT resistor	N.A.	Not Mounted
59	1	R58	NM	SMT resistor	N.A.	Not Mounted
60	3	R73, R75, R94	1k	SMT resistor	TE Connectivity	CRG0603F1K0
61	2	R74, R81, R111	10k	SMT resistor	Bourns	CR0603-FX-1002ELF
62	4	R76, R77, R110, R112	22k	SMT resistor	Vishay	CRCW060322K0FKEA

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
63	2	R90, R92	0	SMT resistor	TE Connectivity	CRG0805ZR
64	1	R91	47k	SMT resistor	Vishay	CRCW060347K0FKEA
65	1	R95	1.5k	SMT resistor	TE Connectivity	CRG0603F1K5
66	4	R93, R96, R97, R98	4.7k	SMT resistor	Bourns	CR0603-FX-4701ELF
67	3	R101, R102, R104	3.3k	SMT resistor	TE Connectivity	CRG0603F3K3
68	1	R105	15k	SMT resistor	TE Connectivity	CRGP0603F15K
69	3	R106, R107, R108	330	SMT resistor	TE Connectivity	CRG0603F330R
70	1	R109	910	SMT resistor	Vishay	CRCW0603910RFKEA
71	1	SB1	Solder bridge (CLOSED 1-2)	2 ways power solder briodge	N.A.	Solder Brifge on PCB
72	1	SB2	Solder bridge (CLOSED 2-3)	2 ways power solder briodge	N.A.	Solder Brifge on PCB
73	21	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21	NM	65x128 mils SMD Hardware Test Points	HARWIN	S1751-46R or Equivalent
74	1	U1	STDRIVE101, QFN-24L	Three-phase gate driver	STMicroelectronics	STDRIVE101
75	1	U2	TSV994A, TSSOP-14L	Rail-to-rail input/ output 20 MHz GBP operational amplifiers	STMicroelectronics	TSV994AIPT
76	1	U3	NM, SOT23-5L	Rail-to-rail input/ output 12 MHz GBP operational amplifiers	STMicroelectronics	TS461CLT
77	1	U4	TS3021ILT, SOT23-5L	Rail-to-rail 1.8 V high-speed comparator	STMicroelectronics	TS3021ILT
78	1	U5	ST1S14PHR, PowerSO-8	Up to 3 A step-down switching regulator	STMicroelectronics	ST1S14PHR
79	1	U6	CD74HC4050	High-Speed CMOS Logic Hex Buffers, Inverting and Non-Inverting	TEXAS INSTRUMENTS	CD74HC4050PW
80	1	U7	STG3157CTR, SOT323-6L	Analog switch SPDT	STMicroelectronics	STG3157CTR
81	2	MECH2	screw	Steel Pan Head M3 screw, 5mm length	RS Pro	908-7668

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
82	2	MECH3	spacer stud M/F	WA-SBRIE Brass Spacer Stud internal/ external M3 thread, 5mm	WURTH ELEKTRONIK	971050324
83	4	MECH4	spacer stud F/F	WA-SBRII Brass Spacer Stud internal/ external M3 thread, 10mm	WURTH ELEKTRONIK	970100354

6 Board versions

Table 9. STEVAL-LVLP01 versions

Finished good	Schematic diagrams	Bill of materials
STEVAL$LVLP01A [1]	STEVAL$LVLP01A schematic diagrams	STEVAL$LVLP01A bill of materials

1. *This code identifies the STEVAL-LVLP01 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).

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).

Revision history

Table 10. Document revision history

Date	Version	Changes
24-Oct-2023	1	Initial release.

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