

## Electronic speed controller for BLDC and PMSM three phase brushless motor

### Introduction

The **STEVAL-ESC001V1** reference design for electronic speed controllers (ESC) for drones fits entry-level commercial drone designs and drives any three-phase brushless (or PMSM) motor running off 6S LiPo battery packs, or any equivalent DC supply, up to 30 A peak current.

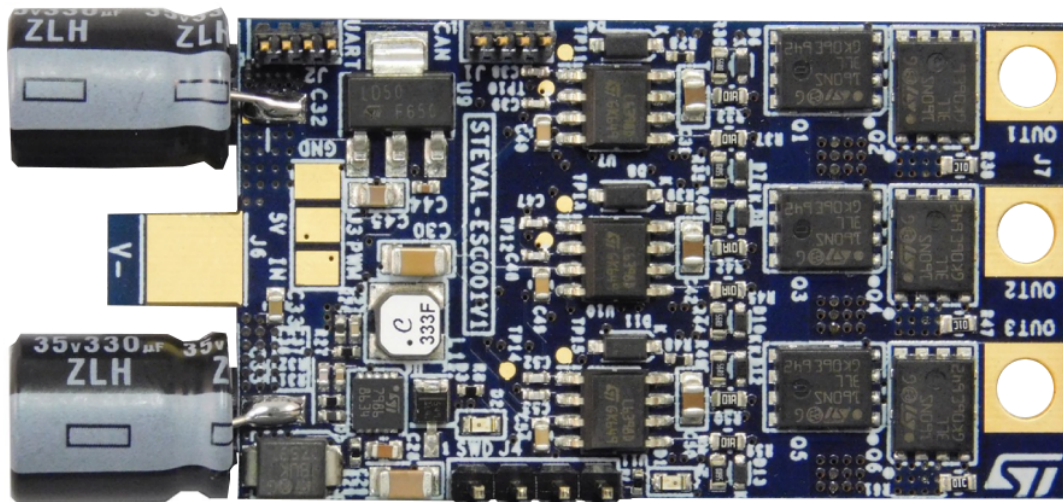
The STEVAL-ESC001V1 lets you spin a motor and its propeller in minutes thanks to a complete pre-configured firmware package (**STSW-ESC001V1**), implementing a sensorless Field Oriented Controlled algorithm with 3-shunt current reading, speed control and full active braking.

The reference design board can accept commands from a flight control unit through PWM signals; other communication bus interfaces like UART, CAN, and I<sup>2</sup>C are also available. The reference embeds a battery eliminator circuit working at 5 V, an NTC sensor for temperature measurement and circuitry for overcurrent / overvoltage protection (OCP/OVP). The compact form factor and current capability render this reference design suitable for electronic speed controllers on small and light unmanned aerial vehicles like professional drones.

The STSW-ESC001V1 firmware/software package plus STM32 PMSM FOC software development kit - MC library let you refine your electronic speed controller design by acting on the field oriented control parameters embedded in the STM32 and experiment with the ST motor profiler to rapidly retrieve the motor parameters. The ST sensorless FOC algorithm ensures longer flight times and optimal dynamic performance.

The STEVAL-ESC001V1 has been designed around the highly efficient, low  $R_{ds(on)}$  STripFET F7 power MOSFETs, the high-performance **STM32F303CBT7** microcontroller with ARM® Cortex®-M4 core and the **L6398** drivers.

**Figure 1. STEVAL-ESC001V1 evaluation board**



## 1 Main features

- Complete reference design for electronic speed controller implementing a sensorless FOC algorithm
- Designed for drones with 6S pack of LiPo batteries or systems with an equivalent suitable DC supply
- ESC ready for communication with any standard flight control unit (FCU): PWM or CAN
- Temperature overheating protection
- Nominal operating voltage range: 3S-6S Li-Po battery DC voltage level (11.1 to 22.2 V)
- Maximum RMS output current: 20 Arms
- Output peak current: 30 A
- Battery eliminator circuit (BEC): 5 V/0.5 A for external receiver or FCU
- Complete pre-configured firmware package available ([STSW-ESC001V1](#))
- Supported by ST motor control software SDK and ST motor profiler
- Compact PCB design: 29.1 x 58 mm
- Further target applications:
  - motor driving for RC vehicles: electric cars, helicopter, trucks, etc.
  - any three-phase BLDC or PMSM motor application
- RoHS and WEEE compliant

### 1.1 Target application

Motor driving for remote control vehicles, UAV drones, electrical cars and boats, etc.

**Figure 2. STEVAL-ESC001V1 target applications**



## 2 Description

The [STEVAL-ESC001V1](#) electronic speed controller (ESC) evaluation board drives a single three phase brushless motor with very high performance in sensorless mode (without position sensor).

It is designed to provide fast and efficient propulsion for remote control applications like electric cars, boats and drones and is capable of low and very high speed regulation and strong dynamic response under different load conditions.

An external signal via a communication bus between the board and a generic central unit sets the speed regulation reference and another signal reports the status of the system, including faults, which the central unit can use to trigger corrective events..

The same 6Step (or trapezoidal) control algorithm (often with no shunt resistors) drives the many different ESCs offering various motor current, size and input voltages for remote control applications.

A more sophisticated control algorithm is used in the STEVAL-ESC001V1, based on field oriented control (FOC); it features:

- better torque control
- motor current regulation in case of fast load change
- vibration reduction
- active braking function
- better efficiency
- noise reduction
- a real-time monitor of the rotor speed
- energy recovery during the deceleration

The typical system architecture pictured below shows individual ESC boards connected to single brushless motors in a quadcopter system. An external Li-Po battery powers the four boards and a wired bus carries communication between each board and an external unit such as a flight control board.

Figure 3. System structure overview

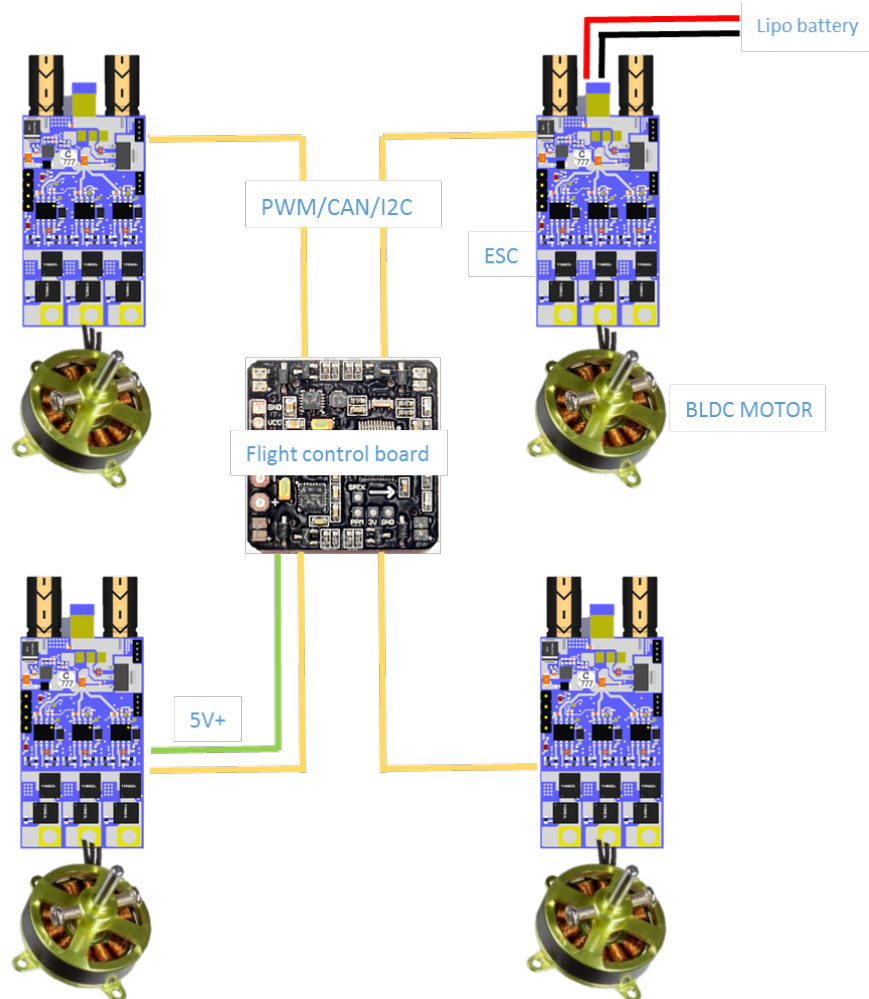
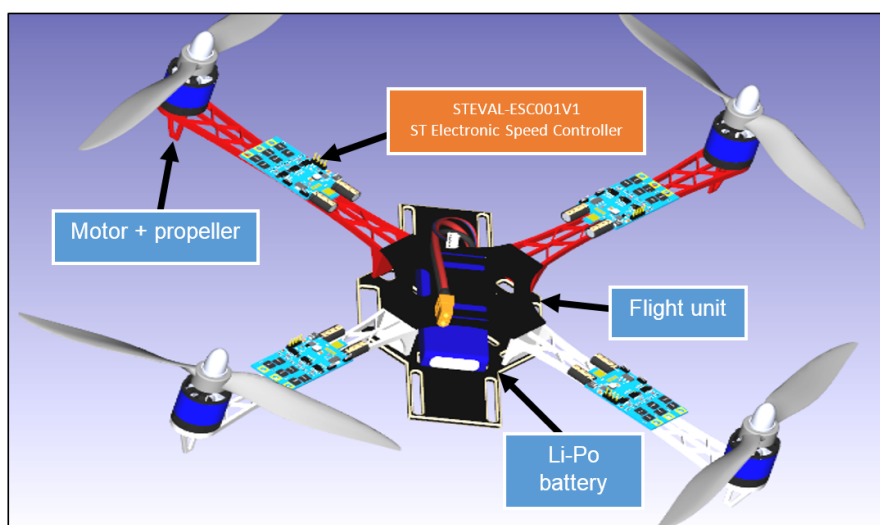


Figure 4. Typical quadcopter architecture

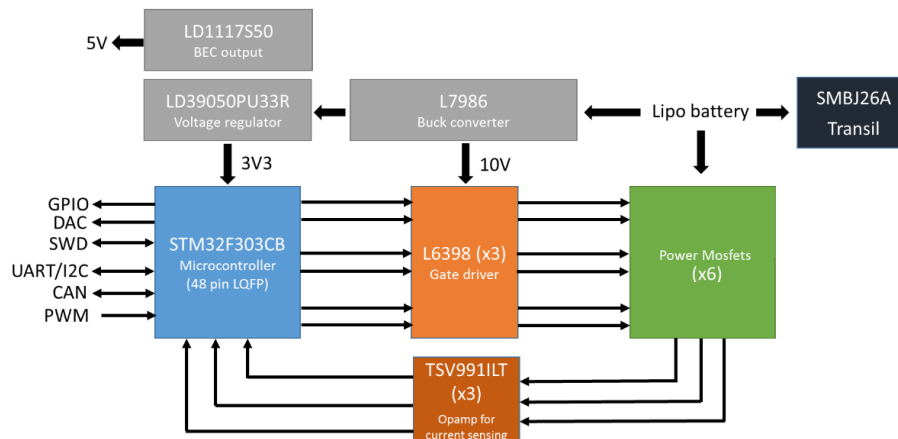


The on-board I<sup>2</sup>C, UART, PWM and CAN communication protocols provide maximum flexibility and a DC-DC converter with 5 V output connector (BEC) can supply an external control unit or sensor board.

## 2.1 STEVAL-ESC001V1 hardware overview

The STEVAL-ESC001V1 power and control platform is based on the ST componentry illustrated below.

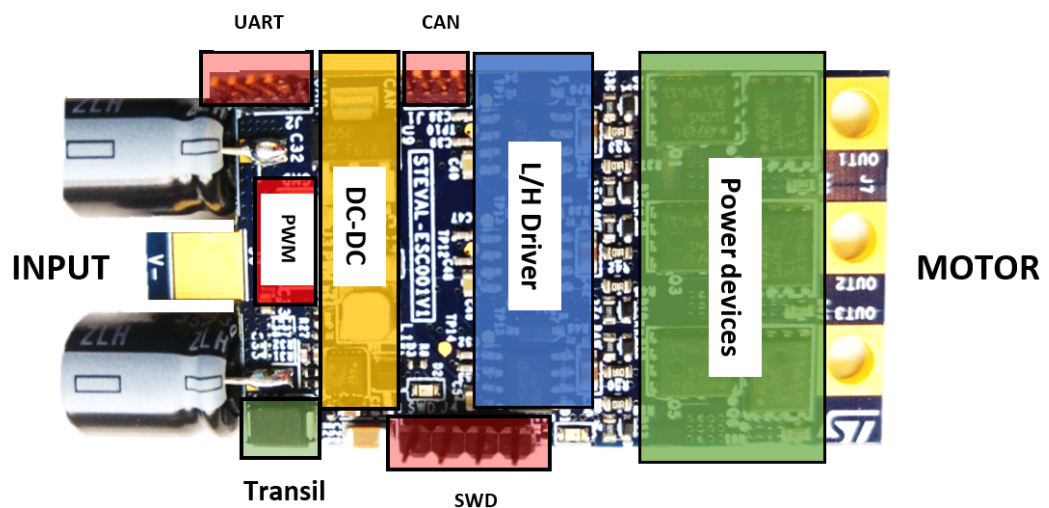
Figure 5. STEVAL-ESC001V1 block diagram



### 2.1.1 STEVAL-ESC001V1 top side components

The inverter section is formed by the L6398 gate driver and the STL160N4F7 and the Power MOSFETs.

Figure 6. Top side features



#### L6398 high voltage high and low-side driver

The L6398 is a high voltage device manufactured with the BCD™ “offline” technology. It is a single-chip half bridge gate driver for the N-channel power MOSFET or IGBT.

The high-side (floating) section is designed to stand a voltage rail up to 600 V. The logic inputs are CMOS/TTL compatible down to 3.3 V for the easy interfacing microcontroller/DSP.

Key features:

- High voltage rail up to 600 V



- dV/dt immunity  $\pm 50$  V/ns in full temperature range
- Driver current capability:
  - 290 mA source
  - 430 mA sink
- Switching times 75/35 ns rise/fall with 1 nF load
- 3.3 V, 5 V TTL/CMOS input comparators with hysteresis
- Integrated bootstrap diode
- Fixed 320 ns deadtime
- Interlocking function
- Compact and simplified layout
- Bill of material reduction
- Flexible, easy and fast design

#### STL160N4F7 160 A STripFET™ F7 Power MOSFETs

This N-channel Power MOSFET uses STripFET™ F7 technology with an enhanced trench gate structure that results in very low on-state resistance, while also reducing internal capacitance and gate charge for faster and more efficient switching.

#### L7986, LD1117S50 and LD39050PU33R

These devices provide the appropriate voltage for gate driving, BEC output and MCU power.

### 2.1.2

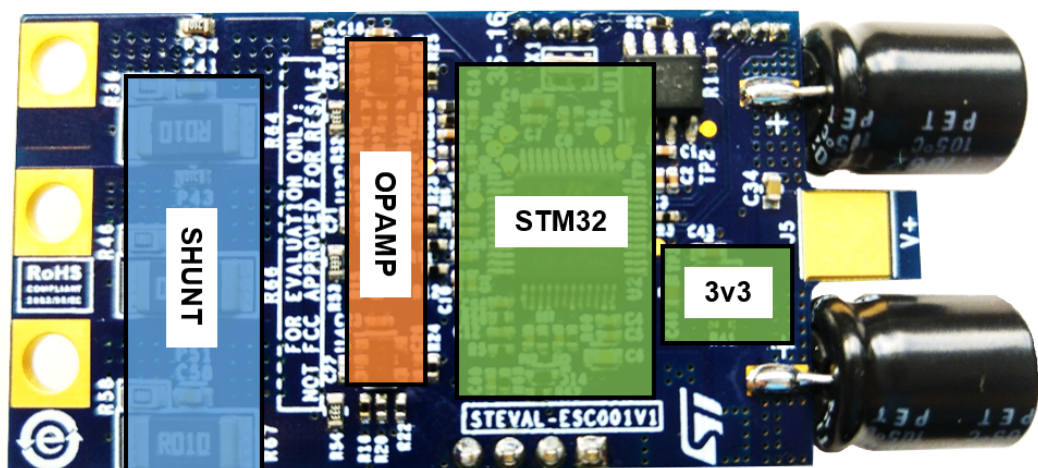
#### STEVAL-ESC001V1 bottom side components

Bottom side componentry is mainly for the digital section; featuring an STM32F303 microcontroller for three-shunt sensorless FOC control in an LQFP 48-pin package.

#### STM32F303xB 32-bit ARM Cortex-M4 MCU with 128 Kbytes Flash and 72 MHz CPU

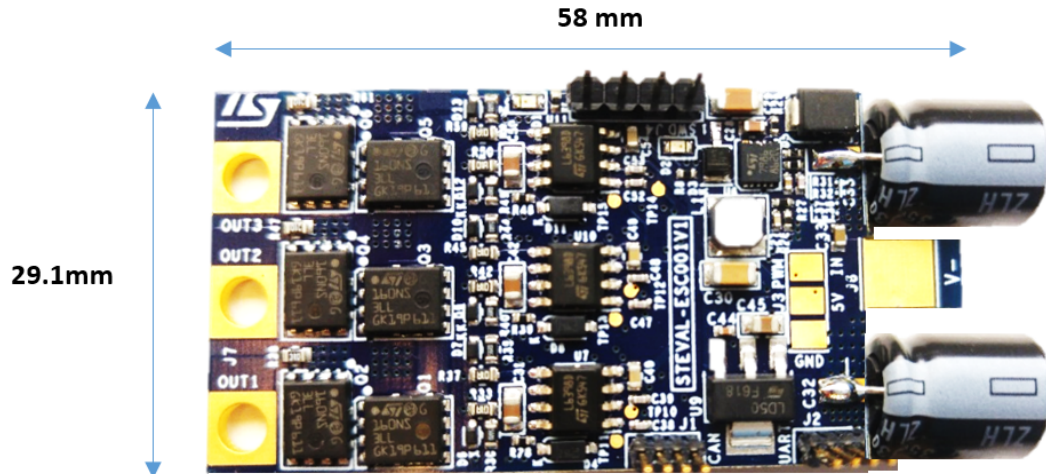
The family of microcontrollers is based on the high-performance ARM®Cortex®-M4 32-bit RISC core plus FPU operating at 72 MHz max and embedded memory protection unit (MPU).

Figure 7. Bottom side features



### 2.1.3 Board dimensions (29.1 x 58 mm)

Figure 8. STEVAL-ESC001V1 board dimensions (not including capacitors)



## 2.2 Communication, programming and command interfaces

The STEVAL-ESC001V1 features these communication interfaces:

- **CAN port (J1):** comes with an on-board transceiver; the J1 connector includes 3V3 and GND pins.
- **UART/I<sup>2</sup>C port (J2):** normally used for serial communication between the ESC board and a PC; ST MC Workbench can be connected with the STM32, adding an external circuit (requires USB/RS232 converter-3v3 level)

Figure 9. UART TX/RX (3v3 level)



- **PWM signal input (J3):** connects with an external board (e.g., flight control unit), to receive commands; the signal level (at 3v3) sets the motor speed according to the Ton duration (i.e., 1060  $\mu$ s for min. speed and 1860  $\mu$ s for max. speed). Other pins are for GND and a +5Vdc power line to supply an external board
- **SWD debug port (J4):** provides the SWD connection between the STM32 and ST-LINK programmer; other pins like 3V3 and GND are available.

## 2.3 STM32 pinout for motor control

Table 1. Main STM32 pinout for motor control

| Pin | Default       | Signal | Solder Bridge |
|-----|---------------|--------|---------------|
| 1   | VBAT          | 3V3    |               |
| 2   | PC13/TAMP/RTC | TP4    |               |
| 3   | PC14          | N.C.   |               |

| Pin | Default     | Signal               | Solder Bridge |
|-----|-------------|----------------------|---------------|
| 4   | PC15        | N.C.                 |               |
| 5   | PF0/OSC-IN  | OSC 8Mhz             |               |
| 6   | PF1/OSC-OUT | OSC 8Mhz             | R4            |
| 7   | NRST        | RESET                |               |
| 8   | VSSA/VREF-  | GND                  |               |
| 9   | VDDA/VREF+  | 3V3                  |               |
| 10  | PA0-WKUP    | Curr_fdbk1           |               |
| 11  | PA1         | Curr_fdbk2           |               |
| 12  | PA2         | Curr_fdbk3           |               |
| 13  | PA3         | Temperature feedback |               |
| 14  | PA4         | VREF, DAC1, TP8      | R6 N.M.       |
| 15  | PA5         | DAC2, TP9            |               |
| 16  | PA6         | N.C.                 |               |
| 17  | PA7         | Vshunt_1_filtered    |               |
| 18  | PB0         | Vshunt_2_filtered    |               |
| 19  | PB1         | TIM1_CH3N            |               |
| 20  | PB2         | STATUS               |               |
| 21  | PB10        | N.C.                 |               |
| 22  | PB11        | Vshunt_3_filtered    |               |
| 23  | VSS1        | GND                  |               |
| 24  | VDD1        | 3V3                  |               |
| 25  | PB12        | PHASE_1              |               |
| 26  | PB13        | VBUS                 | R5            |
| 27  | PB14        | PHASE_2              |               |
| 28  | PB15        | PHASE_3              |               |
| 29  | PA8         | TIM1_CH1             |               |
| 30  | PA9         | TIM1_CH2             | R51           |
| 31  | PA10        | TIM1_CH3             |               |
| 32  | PA11        | TIM1_CH1N            |               |
| 33  | PA12        | TIM1_CH2N            |               |
| 34  | PA13        | SWDIO                |               |
| 35  | VSS2        | GND                  |               |
| 36  | VDD2        | 3V3                  |               |
| 37  | PA14        | SWCLK                |               |
| 38  | PA15        | INPUT                |               |
| 39  | PB3         | N.C.                 |               |
| 40  | PB4         | TP3                  |               |
| 41  | PB5         | N.C.                 |               |
| 42  | PB6         | USART1_TX/I2C1_SCL   |               |
| 43  | PB7         | USART1_RX/I2C1_SDA   |               |



| Pin | Default | Signal | Solder Bridge |
|-----|---------|--------|---------------|
| 44  | BOOT0   | BOOT0  | R3            |
| 45  | PB8     | CAN_RX |               |
| 46  | PB9     | CAN_TX |               |
| 47  | VSS     |        |               |
| 48  | VDD     |        |               |

**Table 2. Input/output terminals**

| Screw Terminal | Function                          |
|----------------|-----------------------------------|
| J5/J6          | Li-Po battery power input (3S-6S) |
| J7             | 3-PH Motor connector              |

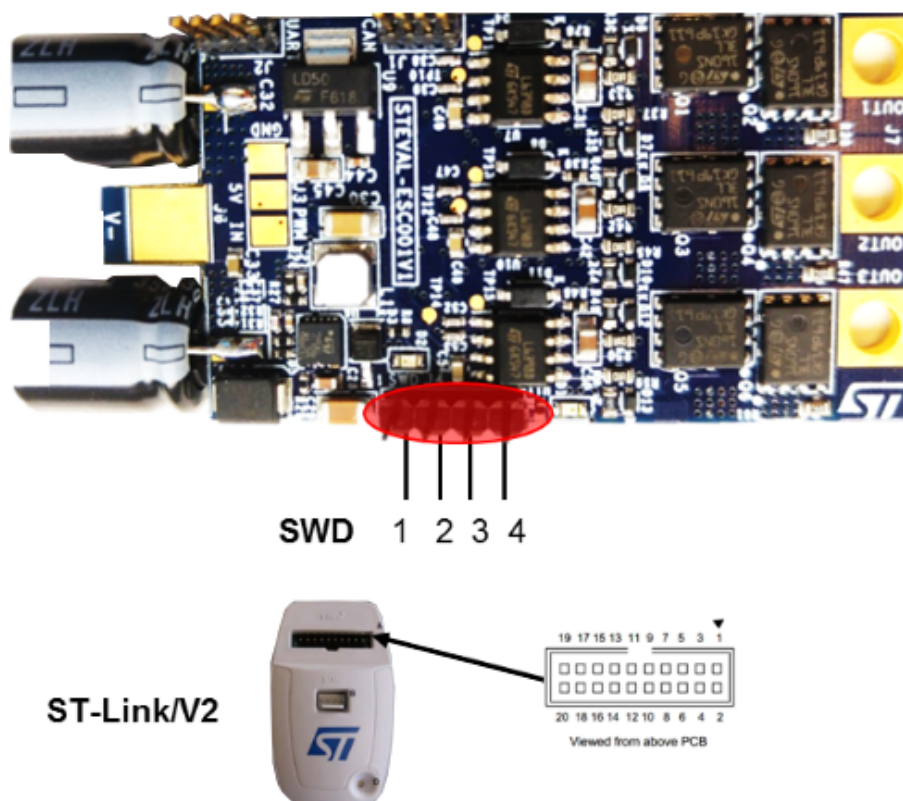
### 3 Initializing and using the STEVAL-ESC001V1 ESC board

**Step 1.** Connect the ST-LINK/V2 programmer to the J4 connector on the board.

**Table 3.** Relationship between the STEVAL board SWD pinout and SWD on ST-Link/V2 programmer

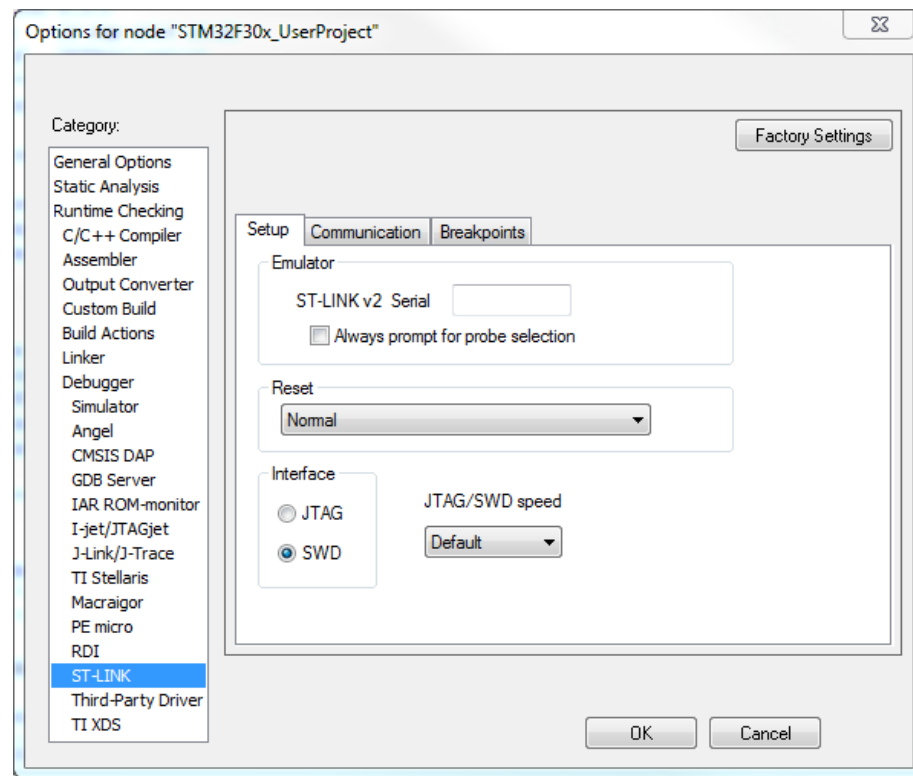
| Pin no. in STLINK | ST-LINK/V2 connector | ST-LINK/V2 function | Target connection (SWD) | Pin no. in STEVAL-ESC001V1 (J4 connector) |
|-------------------|----------------------|---------------------|-------------------------|-------------------------------------------|
| 1                 | VAPP                 | Target VCC          | MCU VDD                 | 1                                         |
| 2                 | VAPP                 | Target VCC          | MCU VDD                 | 1                                         |
| 6                 | GND                  |                     |                         | 4                                         |
| 7                 |                      | SW IO               | SWDIO                   | 3                                         |
| 9                 |                      | SW CLK              | SWCLK                   | 2                                         |

**Figure 10.** STEVAL-ESC001V1 connection for MCU programming



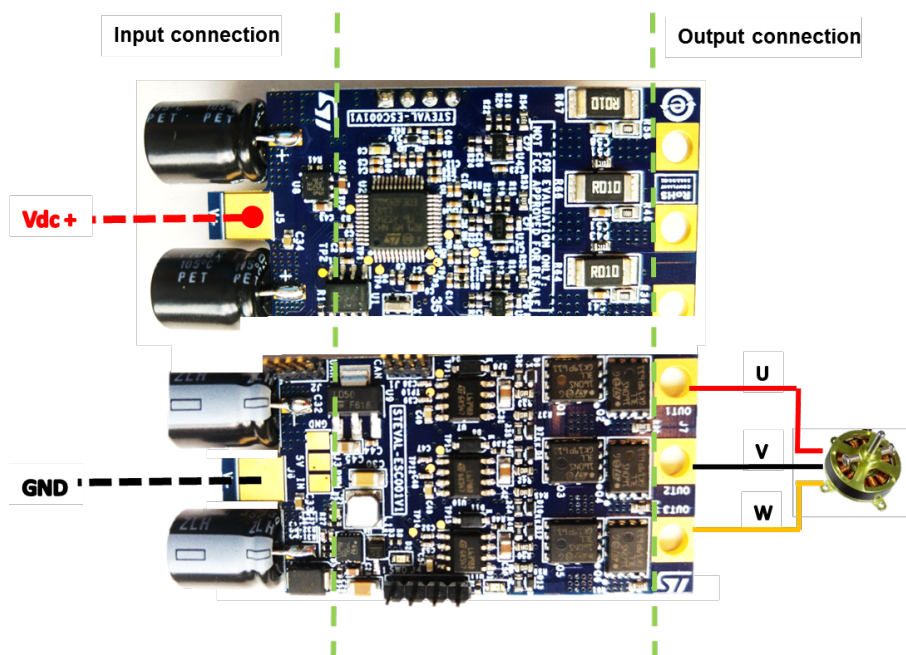
**Step 2.** Set the SWD interface in the IDE tool

Figure 11. Sample SWD configuration on IAR tool



- Step 3.** Solder the three motor wires U,V,W at the motor connector with no particular color sequence. As shown in [Figure 12. STEVAL-ESC001V1 input/output connection](#), the right side is for the motor connection with three pads provided for soldering.
- Step 4.** Solder the PWM input at J3 connector.  
The INPUT pin level must not exceed 3V3.
- Step 5.** Connect the [STEVAL-ESC001V1](#) with a Li-Po battery (or DC power supply: min 3S – max 6S) with the right polarity and turn ON.  
The input connector has two large pads for soldering: the top layer for GND and bottom for Vdc+. A transil device prevents damage in case of reverse polarity.

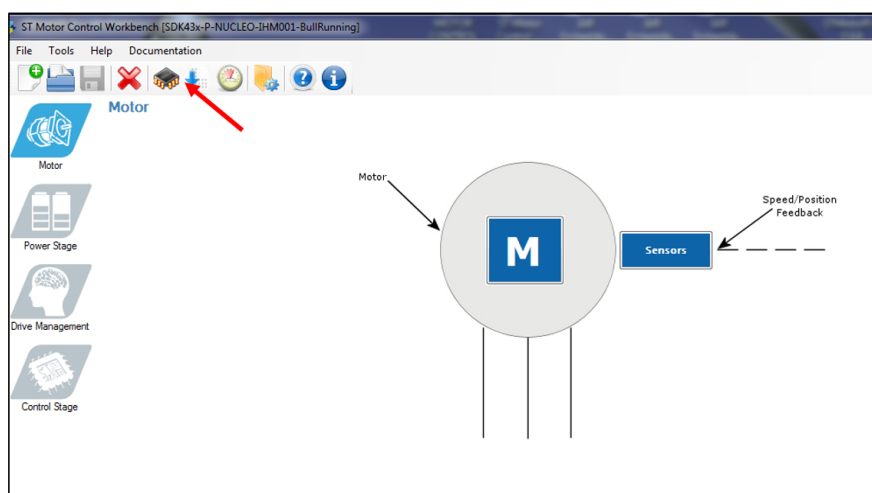
Figure 12. STEVAL-ESC001V1 input/output connection



**Step 6.** Verify if the green led is turned on.

**Step 7.** Open ST MC

Figure 13. ST MC Workbench



**Step 8.** Fill in the motor parameters

Figure 14. ST MC Workbench – electrical motor parameters

Motor - Parameters

Motor Sensors

Magnetic structure Surface Mounted PMSM

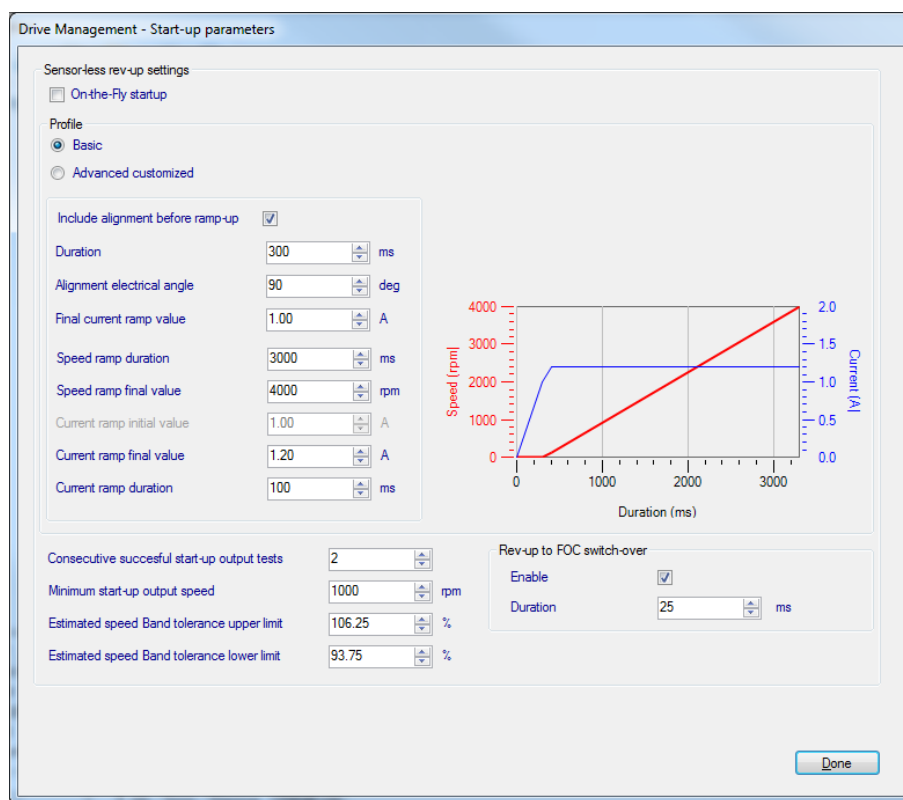
Electrical parameters

|                        |       |                     |
|------------------------|-------|---------------------|
| Pole Pairs             | 7     |                     |
| Max. Application Speed | 15000 | rpm                 |
| Nominal Current        | 1.20  | Apk                 |
| Nominal DC Voltage     | 10.0  | V                   |
| Rs                     | 0.11  | Ohm                 |
| Ls                     | 0.018 | mH                  |
| B-Emf constant         | 0.4   | Vrms/krpm           |
| Inertia                | 0.222 | uN*m*s <sup>2</sup> |
| Friction               | 1.101 | uN*m*s              |

Save parameters Done

**Step 9.** Fill in the startup parameters

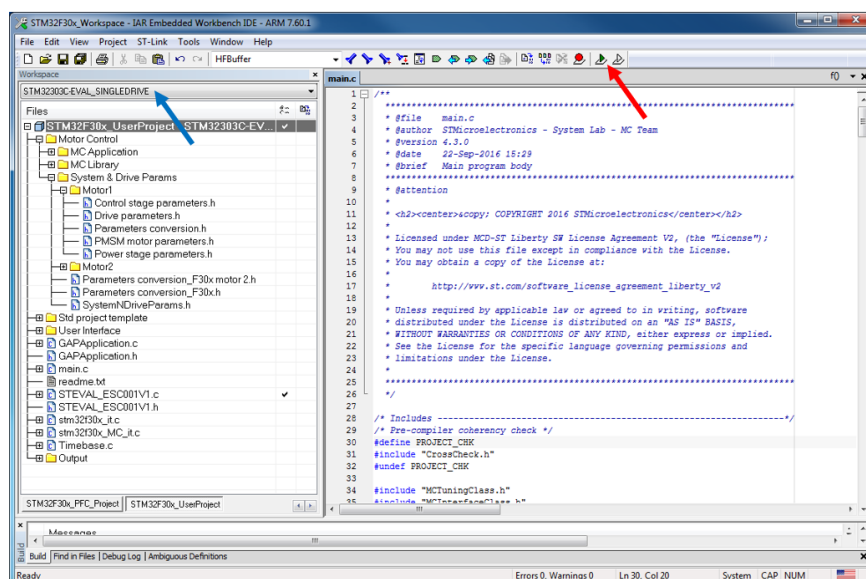
Figure 15. ST MC Workbench – startup parameters



**Step 10.** Open the correct workspace in your IAR IDE tool (STM32F30x\_Workspace)

**Step 11.** Select the STM32303C-EVAL\_SINGLEDRIIVE project configuration (blue arrow), compile the source code and upload the binary to the MCU (red arrow)

Figure 16. IAR tool select, compile and upload

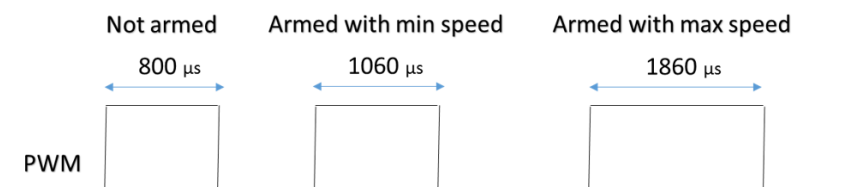


**Step 12.** Generate a PWM signal at 490 Hz and duty cycle between 1060  $\mu$ s and 1860  $\mu$ s  
The ESC is not armed (no driving signals generated) if the duty cycle is lower than 1060  $\mu$ s.



If the motor is already started, a blank time of 1500 ms on the PWM signal switches the system off (ESC turned OFF).

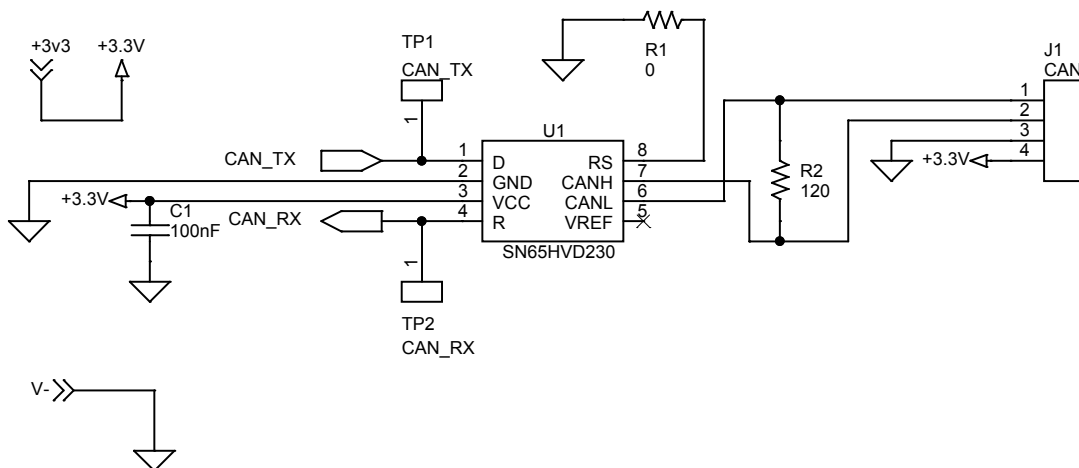
**Figure 17. PWM input signal for motor speed regulation**



**Step 13.** The motor starts to rotate between the minimum and maximum speed.

## 4

**Figure 18. STEVAL-ESC001V1 circuit schematic (1 of 4)**



**Figure 19. STEVAL-ESC001V1 circuit schematic (2 of 4)**

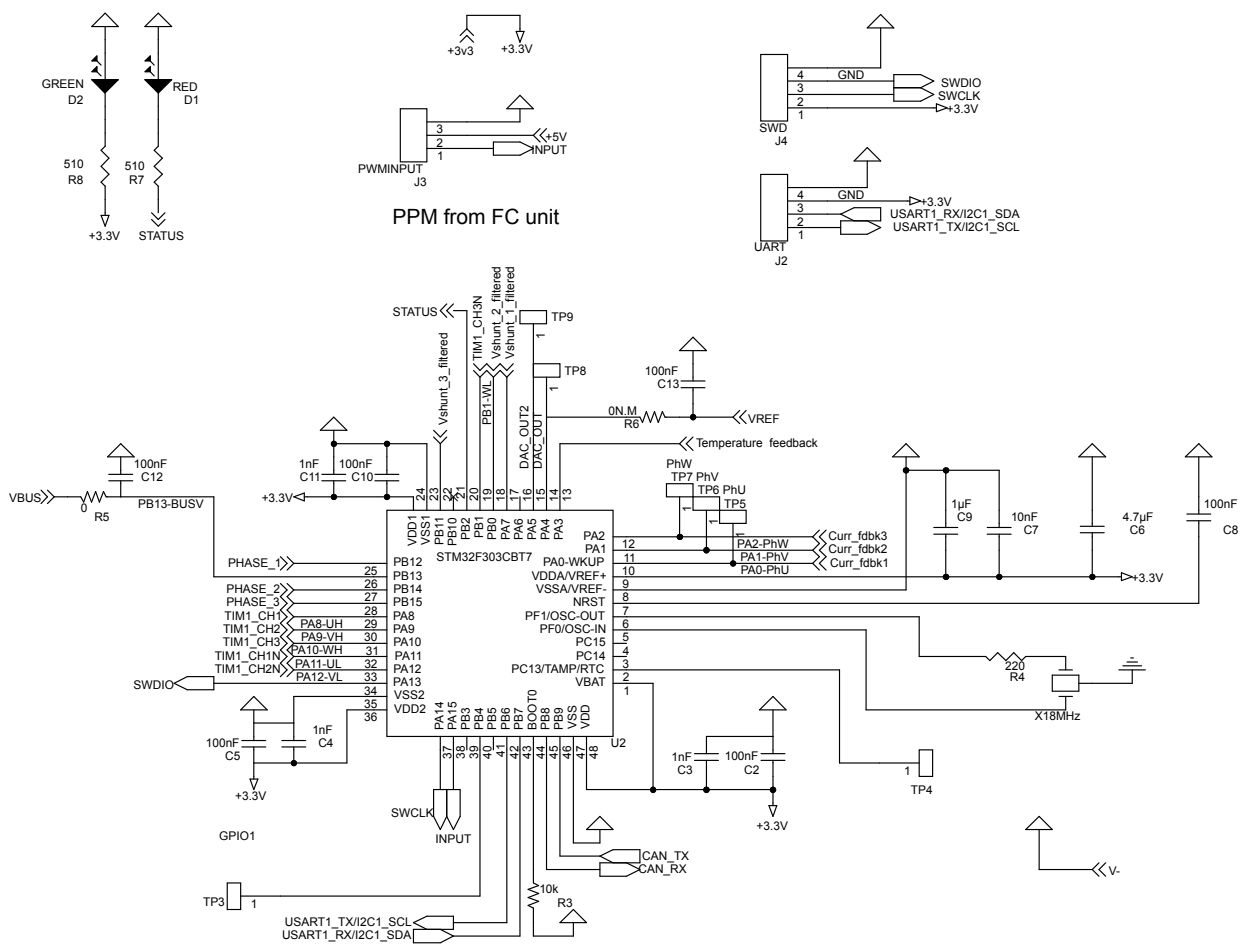


Figure 20. STEVAL-ESC001V1 circuit schematic (3 of 4)

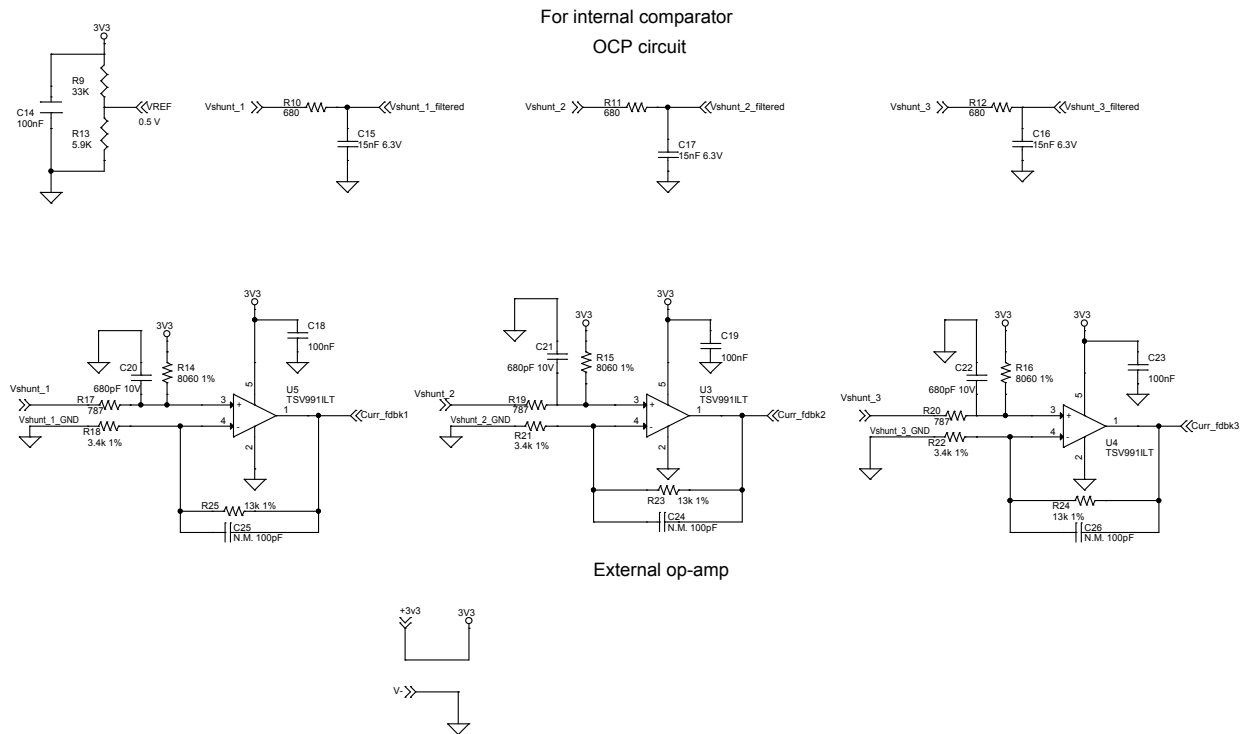
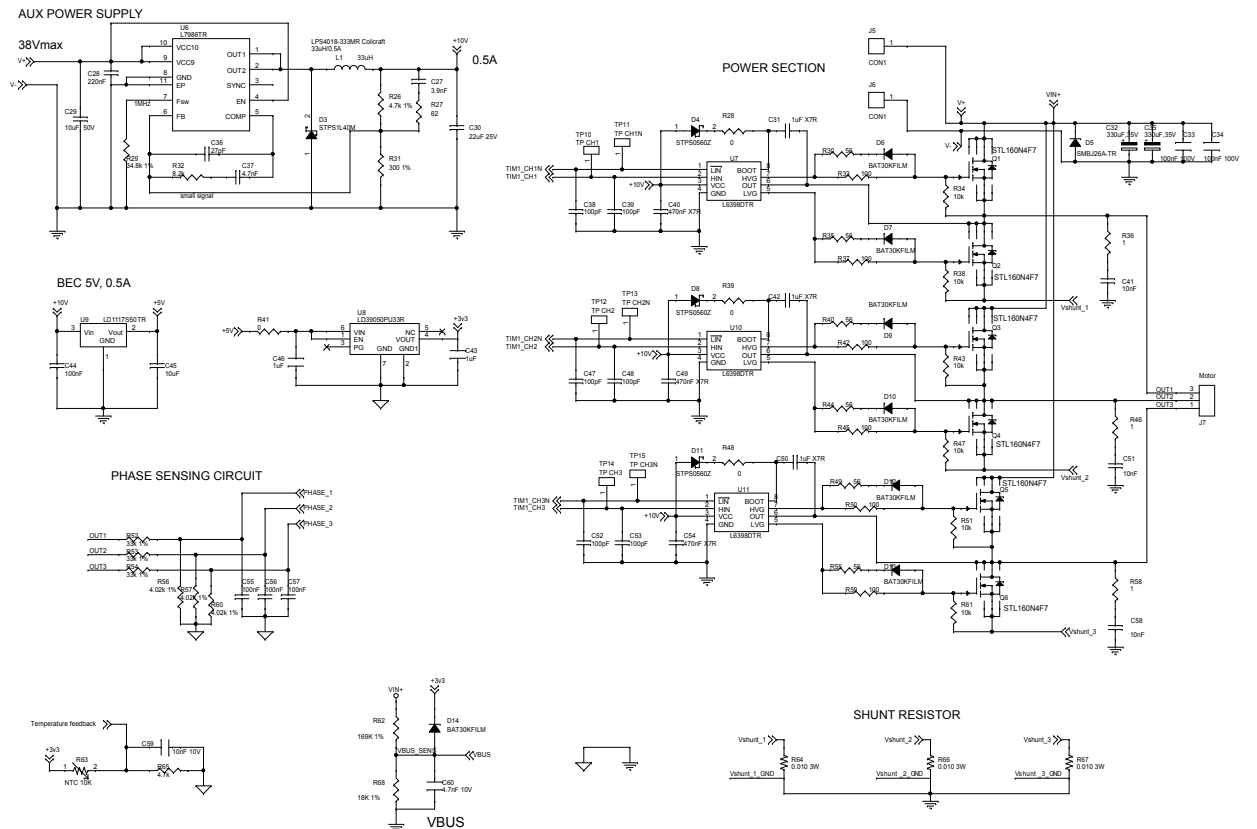


Figure 21. STEVAL-ESC001V1 circuit schematic (4 of 4)



## 5 Bill of materials

**Table 4. STEVAL-ESC001V1 bill of materials**

| Item | Q.ty | Ref.                                                                        | Part / Value             | Description              | Manufacturer | Order code          |
|------|------|-----------------------------------------------------------------------------|--------------------------|--------------------------|--------------|---------------------|
| 1    | 15   | C1, C2, C5, C8, C10<br>C12, C13, C14, C18<br>C19, C23, C44, C55<br>C56, C57 | 100 nF 25 V<br>±10% X7R  | Ceramic capacitor        | any          |                     |
| 2    | 3    | C3, C4, C11                                                                 | 1 nF 50 V<br>±10% X7R    | Ceramic capacitor        | any          |                     |
| 3    | 1    | C6                                                                          | 4.7 µF 10 V<br>±10% X5R  | Ceramic capacitor        | Murata       | GRM188R61A475KE15D  |
| 4    | 2    | C7, C59                                                                     | 10 nF 50 V<br>±10% X7R   | Ceramic capacitor        | any          |                     |
| 5    | 3    | C9, C43, C46                                                                | 1 µF 16 V<br>±10% X7R    | Ceramic capacitor        | TDK          | C1608X7R1C105K080AC |
| 6    | 3    | C15, C16, C17                                                               | 15 nF 10 V<br>±10% X7R   | Ceramic capacitor        | any          |                     |
| 7    | 3    | C20, C21, C22                                                               | 680 pF 10 V<br>±5% C0G   | Ceramic capacitor        | any          |                     |
| 8    | 3    | C24, C25, C26                                                               | 100 pF ±0%               | Capacitors (not mounted) |              |                     |
| 9    | 1    | C27                                                                         | 3.9 nF 50 V<br>±10% X7R  | Ceramic capacitor        | any          |                     |
| 10   | 1    | C28                                                                         | 220 nF 50 V<br>±10% X7R  | Ceramic capacitor        | any          |                     |
| 11   | 1    | C29                                                                         | 10 µF 50 V<br>±10% X5R   | Ceramic capacitor        | any          |                     |
| 12   | 1    | C30                                                                         | 22 µF 25 V<br>±10% X5R   | Ceramic capacitor        | any          |                     |
| 13   | 3    | C31, C42, C50                                                               | 1 µF X7R 50 V<br>±10%    | Ceramic capacitor        | any          |                     |
| 14   | 2    | C32, C35                                                                    | 330 µF, 35 V<br>±20%     | Electrolytic capacitor   | Rubycon      | 35ZLH330MEFC10X12.5 |
| 15   | 2    | C33, C34                                                                    | 100 nF 100 V<br>±10% X7R | Ceramic capacitor        | any          |                     |
| 16   | 1    | C36                                                                         | 27 pF 50 V<br>±5% C0G    | Ceramic capacitor        | any          |                     |
| 17   | 2    | C37, C60                                                                    | 4.7 nF 16 V<br>±10% X7R  | Ceramic capacitor        | any          |                     |
| 18   | 6    | C38, C39, C47<br>C48, C52, C53                                              | 100 pF 16 V<br>±10% X7R  | Ceramic capacitor        | any          |                     |
| 19   | 3    | C40, C49, C54                                                               | 470 nF 25 V<br>±10% X7R  | Ceramic capacitor        | any          |                     |
| 20   | 3    | C41, C51, C58                                                               | 10 nF 100 V<br>±10% X7R  | Ceramic capacitor        | any          |                     |
| 21   | 1    | C45                                                                         | 10 µF 25 V<br>±10% X7R   | Ceramic capacitor        | Murata       | GRM21BR61E106KA73L  |

| Item | Q.ty | Ref.                             | Part / Value                | Description                                            | Manufacturer | Order code                    |
|------|------|----------------------------------|-----------------------------|--------------------------------------------------------|--------------|-------------------------------|
| 22   | 1    | D1                               |                             | Red LED                                                | Lite-on      | LTST-C193KRKT-5A              |
| 23   | 1    | D2                               |                             | Red LED                                                | Lite-on      | LTST-C193KGKT-5A              |
| 24   | 1    | D3                               | 40 V 1 A                    | Low drop power Schottky diode                          | ST           | <a href="#">STPS1L40M</a>     |
| 25   | 3    | D4, D8, D11                      | 60V/0.5A                    | Power Schottky diode                                   | ST           | <a href="#">STPS0560Z</a>     |
| 26   | 1    | D5                               |                             | Transil                                                | ST           | <a href="#">SMBJ26A-TR</a>    |
| 27   | 7    | D6, D7, D9, D10<br>D12, D13, D14 | 30V, 0.3A                   | Schottky diode                                         | ST           | <a href="#">BAT30KFILM</a>    |
| 28   | 2    | J1, J2                           |                             | CAN, UART: 4 WAYS<br>STRIP LINE - MALE<br>1.27mm       | any          |                               |
| 29   | 1    | J3                               |                             | PWM INPUT: 3 way<br>wires welding                      |              |                               |
| 30   | 1    | J4                               |                             | SWD: 4-way strip line<br>- male 2.54mm                 | any          |                               |
| 31   | 2    | J5, J6                           |                             | CON1 - Input power<br>connector: 1-way<br>wire welding |              |                               |
| 32   | 1    | J7                               |                             | Motor Connetor: 3-<br>way wire welding                 |              |                               |
| 33   | 1    | L1                               | 33 $\mu$ H 0.5 A            | Power inductor                                         | Coilcraft    | LPS4018-333MRB                |
| 34   | 6    | Q1, Q2, Q3                       | 30 V, 160 A                 | Power MOSFETs                                          | ST           | <a href="#">STL160NS3LLH7</a> |
|      |      | Q4, Q5, Q6                       | 40 V, 160 A                 |                                                        |              | <a href="#">STL160N4F7</a>    |
| 35   | 6    | R1, R5, R28<br>R39, R41, R48     | 0 62.5 mW<br>$\pm 5\%$      | SMD resistor                                           | any          |                               |
| 36   | 1    | R2                               | 120 62.5 mW<br>$\pm 5\%$    | SMD resistor                                           | any          |                               |
| 37   | 1    | R3                               | 10 k 62.5 mW<br>$\pm 5\%$   | SMD resistor                                           | any          |                               |
| 38   | 1    | R4                               | 220 62.5 mW<br>$\pm 5\%$    | SMD resistor                                           | any          |                               |
| 39   | 1    | R6                               | 62.5 mW $\pm 5\%$           | SMD resistor                                           | any          |                               |
| 40   | 2    | R7, R8                           | 510 62.5 mW<br>$\pm 5\%$    | SMD resistor                                           | any          |                               |
| 41   | 1    | R9                               | 33 K 62.5 mW<br>$\pm 5\%$   | SMD resistor                                           | any          |                               |
| 42   | 3    | R10, R11, R12                    | 680 62.5 mW<br>$\pm 5\%$    | SMD resistor                                           | any          |                               |
| 43   | 1    | R13                              | 5.9 K 62.5 mW<br>$\pm 5\%$  | SMD resistor                                           | any          |                               |
| 44   | 3    | R14, R15, R16                    | 8.06 k 62.5<br>mW $\pm 1\%$ | SMD resistor                                           | Vishay       | CRCW04028K06FKED              |
| 45   | 3    | R17, R19, R20                    | 787 62.5 mW<br>$\pm 1\%$    | SMD resistor                                           | Panasonic    | ERJ2RKF7870X                  |
| 46   | 3    | R18, R21, R22                    | 3.4 k 62.5 mW<br>$\pm 1\%$  | SMD resistor                                           | Panasonic    | ERJ2RKF3401X                  |

| Item | Q.ty | Ref.                                                                                    | Part / Value          | Description                                                        | Manufacturer | Order code                    |
|------|------|-----------------------------------------------------------------------------------------|-----------------------|--------------------------------------------------------------------|--------------|-------------------------------|
| 47   | 2    | R23, R24, R25                                                                           | 13 k 62.5 mW<br>±1%   | SMD resistor                                                       | any          |                               |
| 48   | 1    | R26                                                                                     | 4.7 k 62.5 mW<br>±1%  | SMD resistor                                                       | any          |                               |
| 49   | 1    | R65                                                                                     | 4.7 k 62.5 mW<br>±5%  | SMD resistor                                                       | any          |                               |
| 50   | 1    | R27                                                                                     | 62 62.5 mW<br>±1%     | SMD resistor                                                       | any          |                               |
| 51   | 1    | R29                                                                                     | 34.8 k 62.5 mW<br>±1% | SMD resistor                                                       | any          |                               |
| 52   | 6    | R30, R35, R40<br>R44, R49, R55                                                          | 56 0.1 W ±5%          | SMD resistor                                                       | any          |                               |
| 53   | 1    | R31                                                                                     | 300 62.5 mW<br>±1%    | SMD resistor                                                       | any          |                               |
| 54   | 1    | R32                                                                                     | 8.2 k 62.5 mW<br>±1%  | SMD resistor                                                       | any          |                               |
| 55   | 6    | R33, R37, R42<br>R45, R50, R59                                                          | 100 0.1 W<br>±5%      | SMD resistor                                                       | any          |                               |
| 56   | 6    | R34, R38, R43<br>R47, R51, R61                                                          | 10 k 0.1 W<br>±5%     | SMD resistor                                                       | any          |                               |
| 57   | 3    | R36, R46, R58                                                                           | 1 0.125 W<br>±5%      | SMD resistor                                                       | any          |                               |
| 58   | 3    | R52, R53, R54                                                                           | 33 k 0.1 W<br>±1%     | SMD resistor                                                       | any          |                               |
| 59   | 3    | R56, R57, R60                                                                           | 4.02 k 62.5 mW<br>±1% | SMD resistor                                                       | any          |                               |
| 60   | 1    | R62                                                                                     | 169 K 62.5 mW<br>±1%  | SMD resistor                                                       | any          |                               |
| 61   | 1    | R63                                                                                     | NTC 10 K<br>±1%       | NTC Thermistor                                                     | TDK          | NTCG103JF103F                 |
| 62   | 3    | R64, R66, R67                                                                           | 0.01 3 W ±1%          | 10 mOhm shunt resistor                                             | Bourns       | CRA2512-FZ-R010ELF            |
|      |      |                                                                                         |                       |                                                                    | KOA Speer    | TLR3APDTE10L0F50              |
| 63   | 1    | R68                                                                                     | 18 K 62.5 mW<br>±1%   | SMD resistor                                                       | any          |                               |
| 64   | 1    | TP1, TP2, TP3, TP4<br>TP5, TP6, TP7, TP8<br>TP9, TP10, TP11<br>TP12, TP13, TP14<br>TP15 | SMD PAD 1 mm<br>±0%   | Test point                                                         | any          |                               |
| 65   | 1    | U1                                                                                      |                       | CAN transceiver                                                    | TI           | SN65HVD230D                   |
| 66   | 1    | U2                                                                                      |                       | 32bit MCU                                                          | ST           | <a href="#">STM32F303CBT7</a> |
| 67   | 3    | U3, U4, U5                                                                              |                       | Rail-to-rail input/<br>output 20 MHz GBP<br>operational amplifiers | ST           | <a href="#">TSV991ILT</a>     |
| 68   | 1    | U6                                                                                      |                       | 3 A step-down<br>switching regulator                               | ST           | <a href="#">L7986TR</a>       |
| 69   | 3    | U7, U10, U11                                                                            |                       | High voltage high<br>and low-side driver                           | ST           | <a href="#">L6398D</a>        |

| Item | Q.ty | Ref. | Part / Value | Description                | Manufacturer | Order code                   |
|------|------|------|--------------|----------------------------|--------------|------------------------------|
| 70   | 1    | U8   |              | Low drop voltage regulator | ST           | <a href="#">LD39050PU33R</a> |
| 71   | 1    | U9   |              | Low drop voltage regulator | ST           | <a href="#">LD1117S50TR</a>  |
| 72   | 1    | X1   |              | Resonators 8 Mhz           | Murata       | CSTCE8M00G55-R0              |



## Revision history

**Table 5. Document revision history**

| Date        | Version | Changes                                                                                                   |
|-------------|---------|-----------------------------------------------------------------------------------------------------------|
| 07-Apr-2017 | 1       | Initial release.                                                                                          |
| 13-Nov-2018 | 2       | Updated Introduction and <a href="#">Section 5 Bill of materials</a> .<br>Added references to STL160N4F7. |

## Contents

|          |                                                                   |           |
|----------|-------------------------------------------------------------------|-----------|
| <b>1</b> | <b>Main features .....</b>                                        | <b>2</b>  |
| 1.1      | Target application .....                                          | 2         |
| <b>2</b> | <b>Description .....</b>                                          | <b>3</b>  |
| 2.1      | STEVAL-ESC001V1 hardware overview .....                           | 5         |
| 2.1.1    | STEVAL-ESC001V1 top side components .....                         | 5         |
| 2.1.2    | STEVAL-ESC001V1 bottom side components .....                      | 6         |
| 2.1.3    | Board dimensions (29.1 x 58 mm). ....                             | 6         |
| 2.2      | Communication, programming and command interfaces.....            | 7         |
| 2.3      | STM32 pinout for motor control .....                              | 7         |
| <b>3</b> | <b>Initializing and using the STEVAL-ESC001V1 ESC board .....</b> | <b>10</b> |
| <b>4</b> | <b>Schematic diagrams .....</b>                                   | <b>16</b> |
| <b>5</b> | <b>Bill of materials.....</b>                                     | <b>18</b> |
|          | <b>Revision history .....</b>                                     | <b>22</b> |

## List of figures

|                   |                                                                       |    |
|-------------------|-----------------------------------------------------------------------|----|
| <b>Figure 1.</b>  | STEVAL-ESC001V1 evaluation board . . . . .                            | 1  |
| <b>Figure 2.</b>  | STEVAL-ESC001V1 target applications . . . . .                         | 2  |
| <b>Figure 3.</b>  | System structure overview . . . . .                                   | 4  |
| <b>Figure 4.</b>  | Typical quadcopter architecture . . . . .                             | 4  |
| <b>Figure 5.</b>  | STEVAL-ESC001V1 block diagram . . . . .                               | 5  |
| <b>Figure 6.</b>  | Top side features . . . . .                                           | 5  |
| <b>Figure 7.</b>  | Bottom side features . . . . .                                        | 6  |
| <b>Figure 8.</b>  | STEVAL-ESC001V1 board dimensions (not including capacitors) . . . . . | 7  |
| <b>Figure 9.</b>  | UART TX/RX (3v3 level) . . . . .                                      | 7  |
| <b>Figure 10.</b> | STEVAL-ESC001V1 connection for MCU programming . . . . .              | 10 |
| <b>Figure 11.</b> | Sample SWD configuration on IAR tool . . . . .                        | 11 |
| <b>Figure 12.</b> | STEVAL-ESC001V1 input/output connection . . . . .                     | 12 |
| <b>Figure 13.</b> | ST MC Workbench . . . . .                                             | 12 |
| <b>Figure 14.</b> | ST MC Workbench – electrical motor parameters . . . . .               | 13 |
| <b>Figure 15.</b> | ST MC Workbench – startup parameters . . . . .                        | 14 |
| <b>Figure 16.</b> | IAR tool select, compile and upload . . . . .                         | 14 |
| <b>Figure 17.</b> | PWM input signal for motor speed regulation . . . . .                 | 15 |
| <b>Figure 18.</b> | STEVAL-ESC001V1 circuit schematic (1 of 4). . . . .                   | 16 |
| <b>Figure 19.</b> | STEVAL-ESC001V1 circuit schematic (2 of 4). . . . .                   | 16 |
| <b>Figure 20.</b> | STEVAL-ESC001V1 circuit schematic (3 of 4). . . . .                   | 17 |
| <b>Figure 21.</b> | STEVAL-ESC001V1 circuit schematic (4 of 4). . . . .                   | 17 |

## List of tables

|                 |                                                                                            |    |
|-----------------|--------------------------------------------------------------------------------------------|----|
| <b>Table 1.</b> | Main STM32 pinout for motor control . . . . .                                              | 7  |
| <b>Table 2.</b> | Input/output terminals . . . . .                                                           | 9  |
| <b>Table 3.</b> | Relationship between the STEVAL board SWD pinout and SWD on ST-Link/V2 programmer. . . . . | 10 |
| <b>Table 4.</b> | STEVAL-ESC001V1 bill of materials. . . . .                                                 | 18 |
| <b>Table 5.</b> | Document revision history . . . . .                                                        | 22 |

**IMPORTANT NOTICE – PLEASE READ CAREFULLY**

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2018 STMicroelectronics – All rights reserved