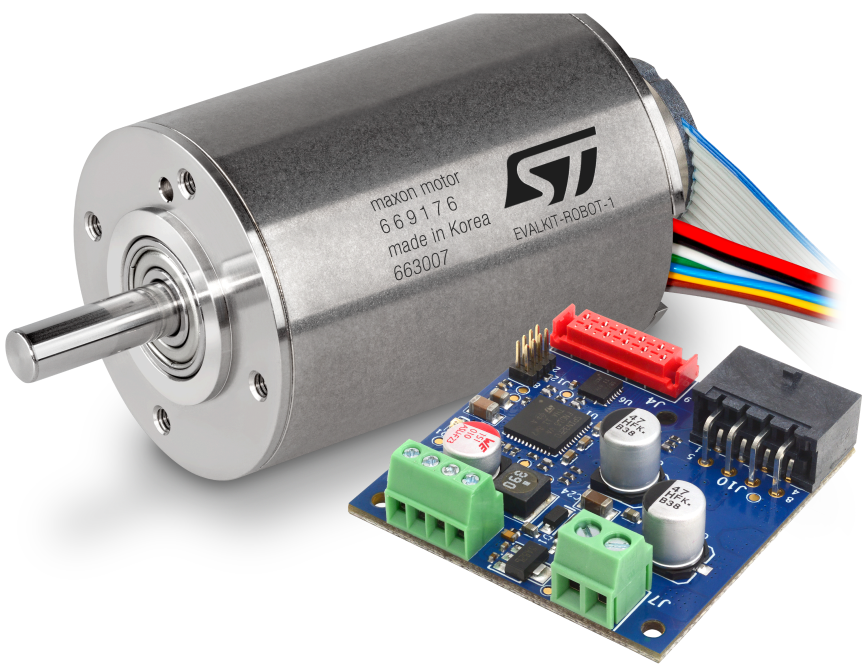
Getting started with the EVALKIT-ROBOT-1

Introduction

The EVALKIT-ROBOT-1 is an evaluation kit offering a ready-to-use brushless servomotor solution composed of a STSPIN32F0A control board and a maxon EC-i 40 brushless DC motor.

Figure 1. EVALKIT-ROBOT-1



1 Hardware and software requirements

The EVALKIT-ROBOT-1 is a ready-to-use evaluation kit for servo brushless applications.

The following material is required to make the system operative:

- A 36 V / 120 W DC power supply[(1)]
- An RS485 2-wire serial port
- A communication software based on MODBUS protocol

1. *The operating range of the control electronics is between 12 V and 45 V. However, the system provides best performance with a supply voltage of 36 V ± 20 %.*

It is also possible to customize the system operation modifying the source code. In this case the following tools are needed:

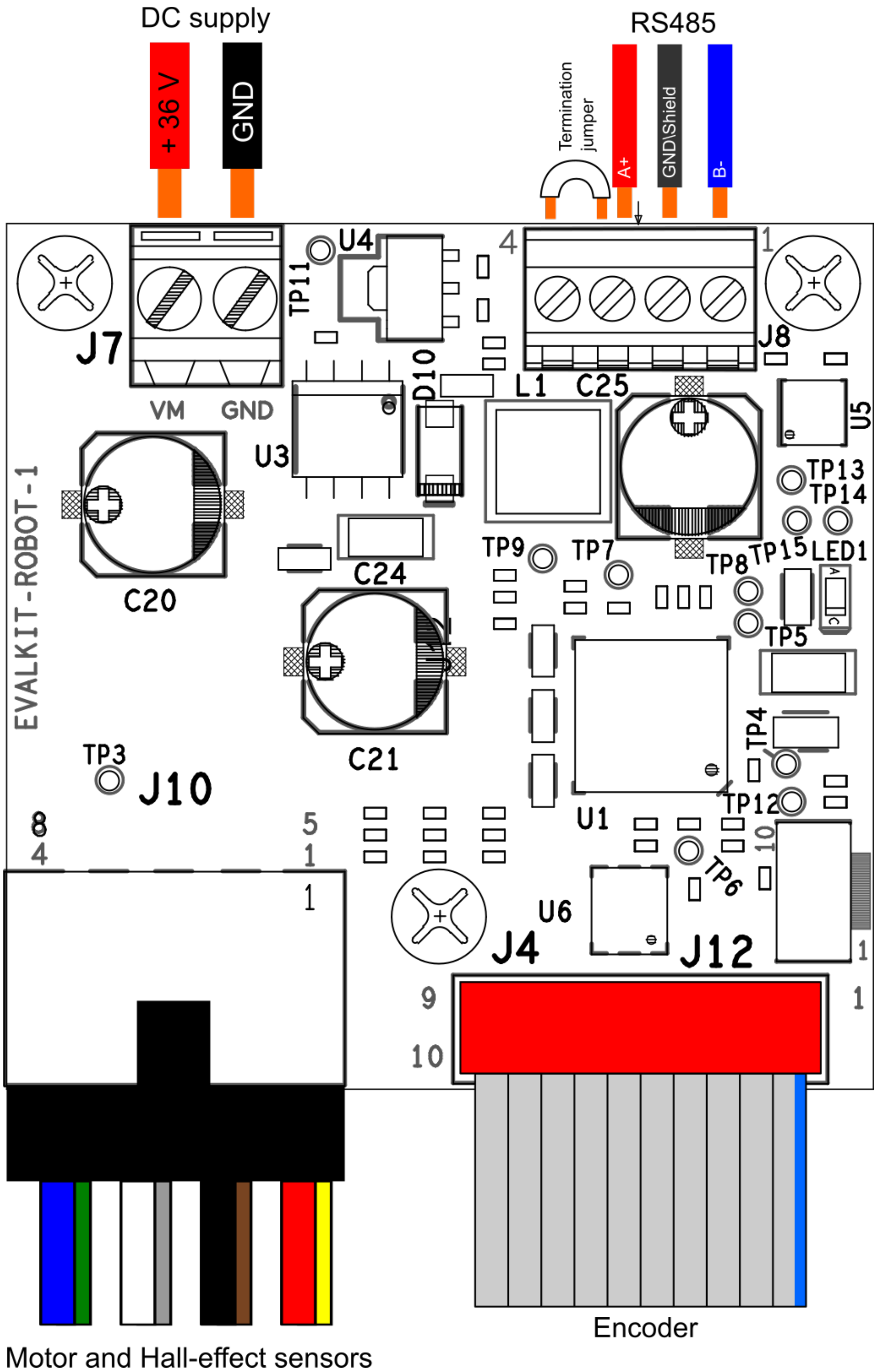
- An IDE chosen among the IAR Embedded Workbench for ARM, Keil microcontroller development kit and STM32CubeIDE.
- An SWD programmer/debugger supporting the STM32F0 family, like the STLINK-V3 from STMicroelectronics.

2 Getting started

Start working with the EVALKIT-ROBOT-1 following the steps below:

1. Connect the motor to J10 (motor phases and Hall-effect sensors) and J4 (encoder).
2. Connect the DC power supply to J7 taking care of the polarity (negative connected to GND and positive connected to VM).
3. Connect the RS-485 communication line to J8 according to the indication on the bottom silkscreen.
   – If termination is needed, short A+ and TERM inputs with a wire (see Section 4.1).
4. Power-up the system.

Figure 2. Connection diagram



3 Test points and connectors description

This section lists the connector and the test points available on the board.

Table 1. Supply screw terminal (J7)

Pin	Connection
1	DC supply voltage 36 V
2	DC supply ground

Table 2. Motor and Hall-effect sensors connector (J10)

Pin	Row	Connection
1	Bottom (front view, right corner)	Hall-effect sensor 1
2	Bottom	Hall-effect sensor 2
3	Bottom	Hall-effect sensor 3
4	Bottom (front view, left corner)	Hall-effect sensors supply (+5 V)
5	Top (front view, right corner)	Motor winding 1 (U)
6	Top	Motor winding 2 (V)
7	Top	Motor winding 3 (W)
8	Top (front view, left corner)	Hall-effect sensors ground

Table 3. Encoder connector (J4)

Pin	Connection
1	Not connected
2	Encoder supply (+5 V)
3	Encoder ground
4	Not connected
5	Quadrature output channel A-
6	Quadrature output channel A+
7	Quadrature output channel B-
8	Quadrature output channel B+
9	Zero index channel I-
10	Zero index channel I+

Table 4. RS485 screw terminal (J8)

Pin	Connection
1	B- communication line
2	Ground/shield connection
3	A+ communication line

Pin	Connection
4	Termination. To be shorted to A+ (pin #3) if termination is required (see Section 4.1).

Table 5. Debug connector (J12)

Pin	Connection
1	VDD (+3.3 V)
2	SWD interface – SWDIO
3	Ground
4	SWD interface – SWCLK
5	Ground
6	Not connected
7	Not connected
8	Not connected
9	Ground
10	Reset

Figure 3. Test points positioning

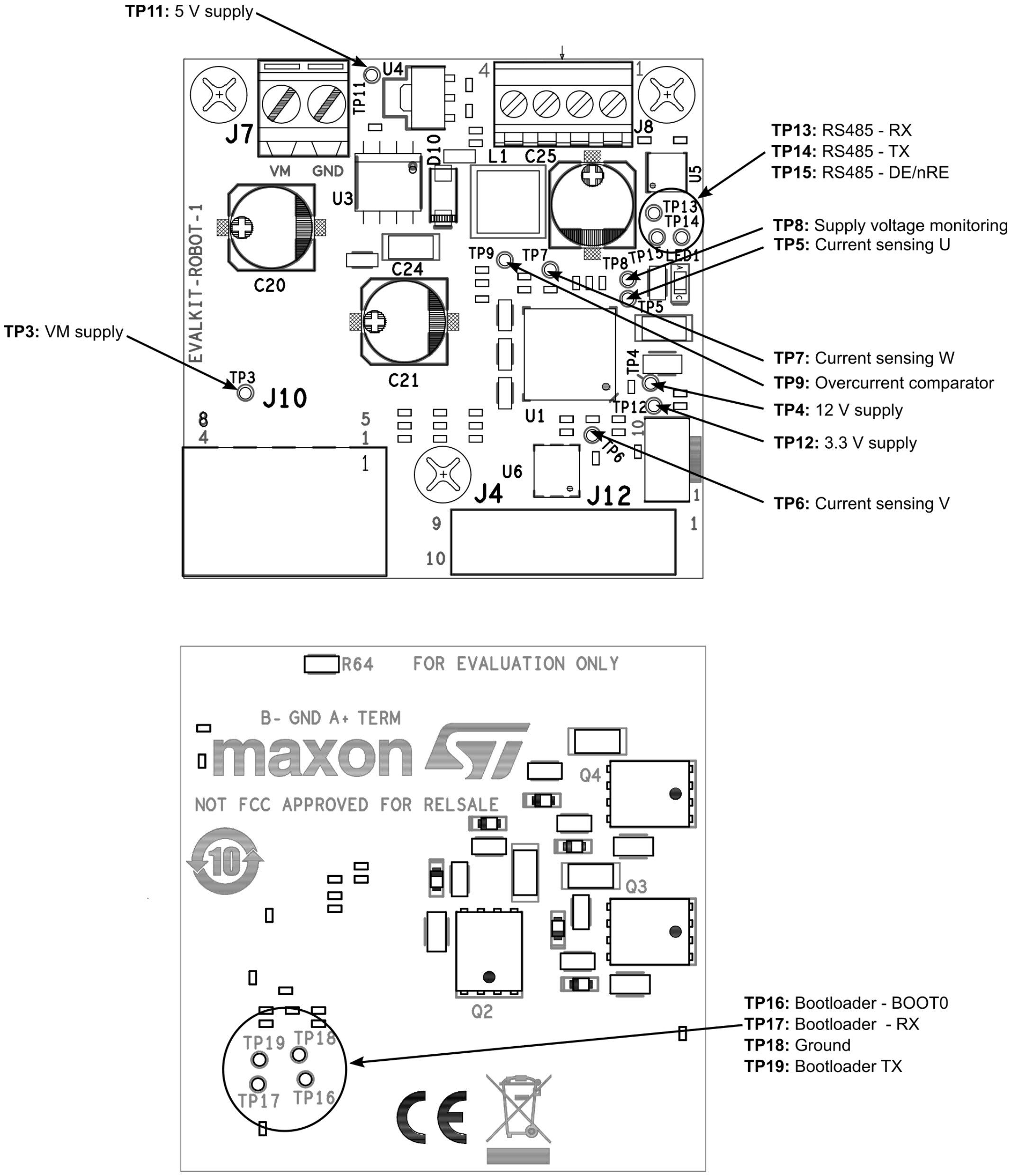


Table 6. Test points list

Pin	Connection
TP3	VM supply voltage (36 V)
TP4	Gate driver supply voltage (12 V)
TP5	Motor phase U current sensing (winding 1)
TP6	Motor phase V current sensing (winding 2)
TP7	Motor phase W current sensing (winding 3)
TP8	Supply voltage monitoring
TP9	Overcurrent comparator input
TP11	Encoder and Hall-effect sensors supply (5 V)

Pin	Connection
TP12	Logic supply voltage (3.3 V)
TP13	RS485 RX signal
TP14	RS485 TX signal
TP15	RS485 DE/nRE signal
TP16	Bootloader – BOOT0
TP17	Bootloader – RX line
TP18	Ground
TP19	Bootloader – TX line

4 Operation

The following paragraphs describe the details about the operation of the EVALKIT-ROBOT-1 reference design.

4.1 Power-up sequence

As soon as the EVALKIT-ROBOT-1 powers up, i.e. when all the supply voltages are asserted and the MCU initializations are completed, the motor position is initialized using the zero-index signal from the encoder.

When the system ends the initialization, the discrete input bit 1 at address 0 is set high (see Section 4.3.1).

4.2 Sending a new motion command

Sending a new motion command requires the following steps:

- **Step 1** Check if the previous command had been completed reading the discrete input bit 0 at address 0 (see Section 4.3.1).
- **Step 2** Write the target position and the expected positioning time in the respective holding registers (see Section 4.3.2).
- **Step 3** Set the coil bit 0 at address 0 high to start the motion (see Section 4.3.3). The discrete input bit 0 at address 0 is forced low during operation.

4.2.1 Motion profile

Starting from the target position and the motion duration, the algorithm calculates a trajectory pattern in order to obtain a smooth movement divided into 3 phases of the same duration (see Figure 4):

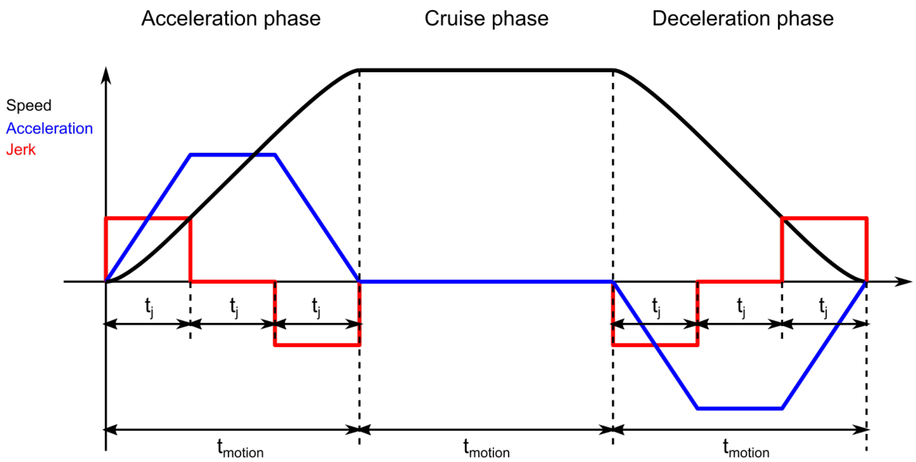
1. Acceleration
2. Cruise
3. Deceleration

During the acceleration phase the speed of the motor is increased in an S shape way. This means there is no abrupt acceleration variation, but the acceleration value is constantly increased according to the use of a jerk. The jerk is calculated in order to divide the acceleration phase in 3 equal sub-phases as shown in Figure 4.

The cruise is a constant speed motion phase.

The final deceleration phase is complementary to the acceleration and ends when the target point is achieved.

Figure 4. Motion trajectory



4.3 MODBUS RTU inputs, coils and holding registers list

The EVALKIT-ROBOT-1 firmware is controlled using MODBUS RTU standard.

The default slave address is #1, but it can be easily modified in the source code of the firmware.

4.3.1 Discrete inputs

The device provides 2 discrete inputs at address 0 (bits 0 and 1).

Table 7. Discrete input address 0

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
X	X	X	X	X	X	ALIGN	DONE

ALIGN (BIT 1) indicates if the initial alignment procedure succeeded:
- 1 => alignment procedure completed
- 0 => alignment procedure not completed

DONE (BIT 0) indicates if the target position is achieved:
- 1 => target position reached
- 0 => target position not achieved

4.3.2 Holding registers

The device provides 3 holding registers used for defining the next motion command.

Table 8. Holding registers

Address	Connection
0	Target position in degrees (least significant bytes)
1	Target position in degrees (most significant bytes)
2	Movement duration in milliseconds (1)

1. *The target movement duration should be multiple of 9 (e.g. 45, 9000, 999, etc.)*

4.3.3 Coils

The device provides 1 coil at address 0 (bits 0).

Table 9. Discrete input address 0

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
X	X	X	X	X	X	X	DONE

Setting high the MOVE (BIT 0) coil executes the motion command defined into the holding registers.

4.4 RS485 communication

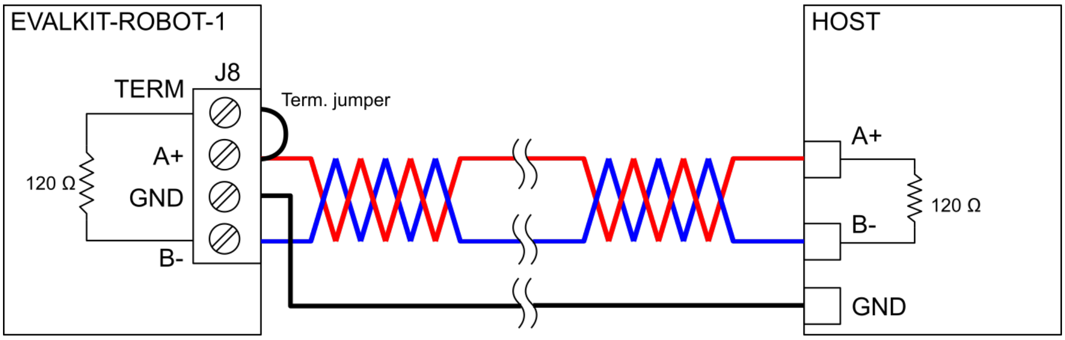
The RS-485 is a differential serial interface widespread in industrial environment. The 2-wire implementation provided by the EVALKIT-ROBOT-1 allows half-duplex communication with high data rate through long cables.

4.4.1 Point-to-point connection

In point-to-point configuration the EVALKIT-ROBOT-1 is the only slave connected to the host device (master).

In this case, both sides of the communication line must be terminated using a 120 Ω resistor. To use the termination resistance embedded in the EVALKIT-ROBOT-1, the TERM pin of J8 must be shorted with A+ through a wire jumper

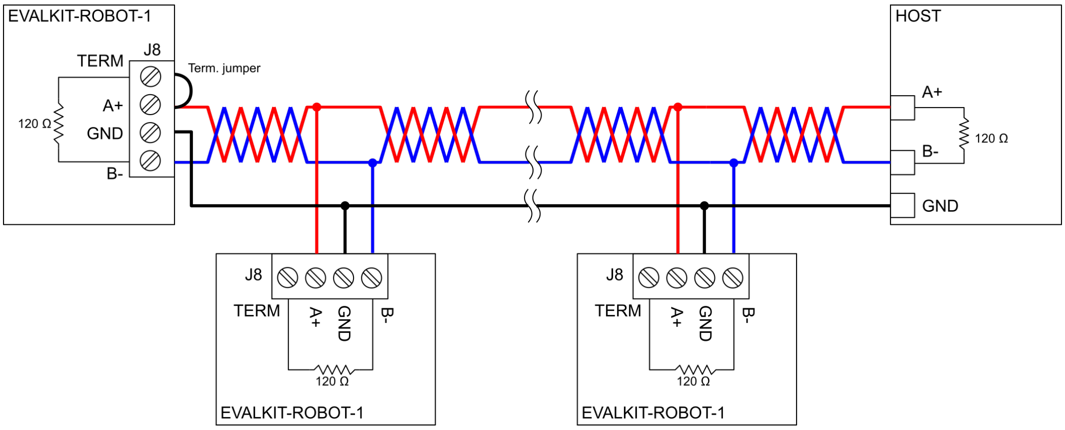
Figure 5. **RS-485 point-to-point connection**



4.4.2 Daisy-chain connection

Multiple devices can be connected on the same RS-485 bus using daisy chain configuration. In this case, only the first and the last devices of the chain must be terminated.

Figure 6. **RS-485 daisy-chain connection**



5 Motor and encoder data

Table 10. **Motor specifications**

Parameter		Value
Nominal voltage		36 V
Speed	Nominal	3950 rpm
	No load	4550 rpm
Torque	Nominal	207 mNm
	Stall	3160 mNm
Current	Nominal	2.72 A
	Stall	42.2 A
Phase resistance		0.853 Ω
Phase inductance		0.675 mH
Rotor inertia		44 gcm2
Pole pairs		7
Hall-effect sensors supply voltage		4.5 V to 24 V

Figure 7. **Motor operating range**

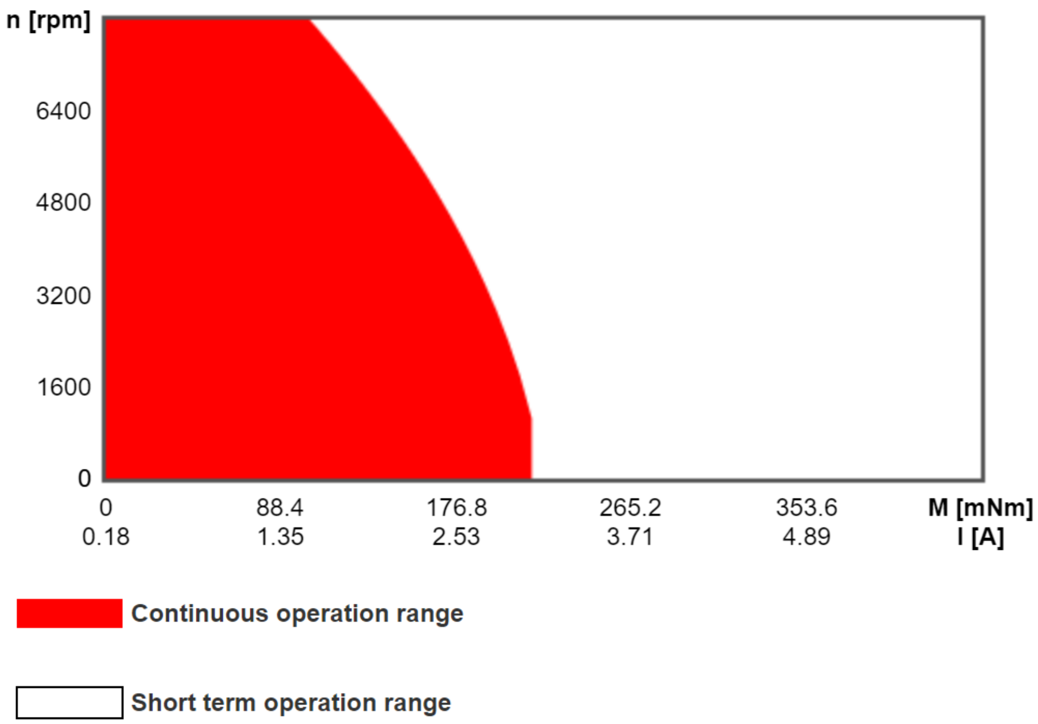


Table 11. **Encoder specifications**

Parameter	Value
Supply voltage	5 V
Supply current	22 mA
Pulses per turn	1024
Max. speed	30 krpm

Figure 8. **Motor and encoder connectors drawings**

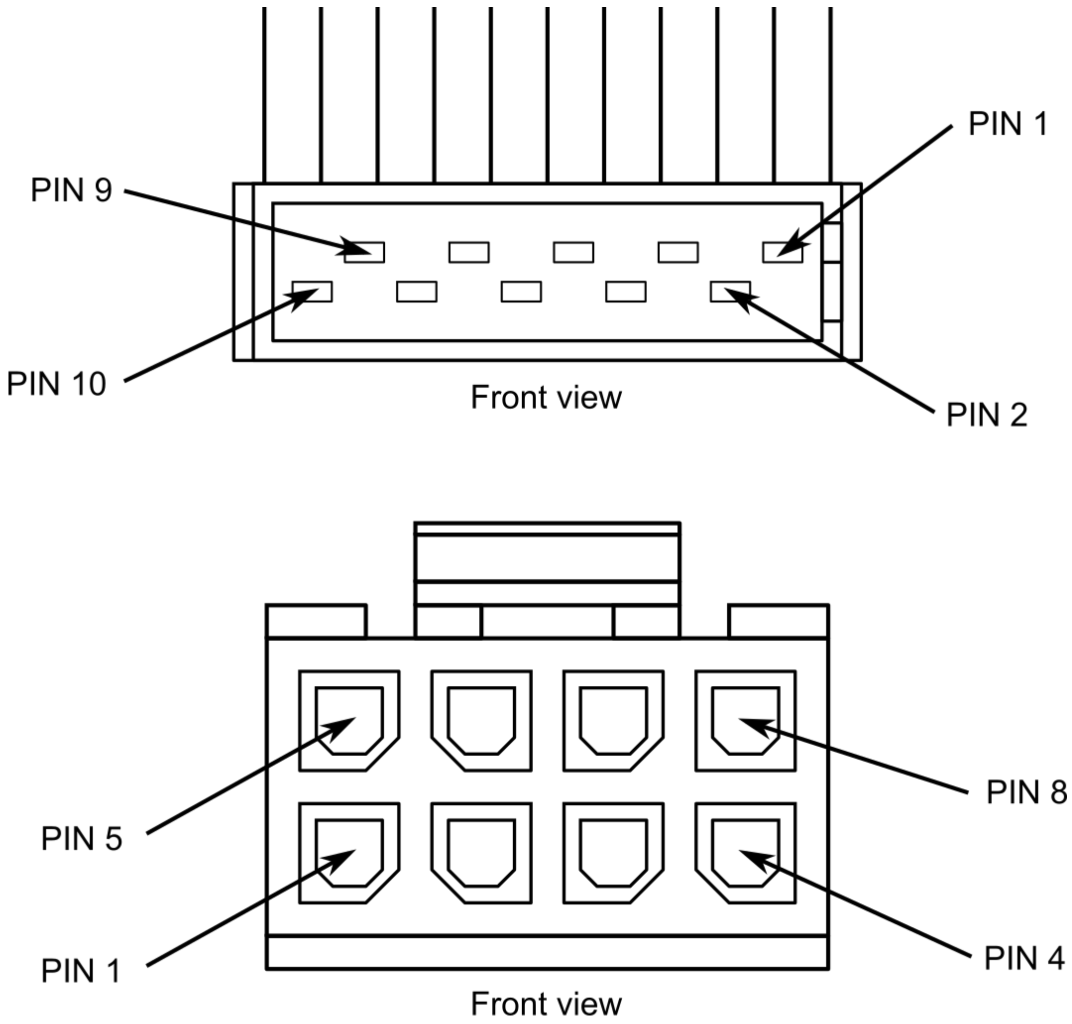


Table 12. Motor and Hall-effect sensors connector

Pin	Connection
1	Hall-effect sensor 1
2	Hall-effect sensor 2
3	Hall-effect sensor 3
4	Hall-effect sensors supply
5	Motor winding 1
6	Motor winding 2
7	Motor winding 3
8	Hall-effect sensors ground

6 Bill of material

Table 13. **EVALKIT-ROBOT-1 bill of material**

Item	Q.ty	Ref.	Description	Part/Value	Order code	Manufact.
1	3	C1, C7, C10	SMT ceramic capacitor	100 nF		
2	1	C2	SMT ceramic capacitor	10 µF		
3	1	C3	SMT ceramic capacitor	10 µF		
4	3	C4, C5, C6	SMT ceramic capacitor	470 nF		
5	2	C8, C11	SMT ceramic capacitor	10 nF		
6	2	C9, C19	SMT ceramic capacitor	1 nF		
7	3	C12, C14, C16	SMT ceramic capacitor	33 pF		
8	3	C13, C15, C17	SMT ceramic capacitor	150 nF		
9	1	C18	SMT ceramic capacitor	2.2 nF		
10	2	C20, C21	SMT electrolytic capacitor	47 µF	865080645012 or equivalent	Wurth Elektronik
11	2	C22, C28	SMT ceramic capacitor	100 nF		
12	1	C23	SMT ceramic capacitor	1.7 pF		
13	1	C24	SMT ceramic capacitor	4700 nF		
14	1	C25	SMT electrolytic capacitor	150 µF	865080243008 or equivalent	Wurth Elektronik
15	1	C26	SMT ceramic capacitor	330 nF		
16	2	C27, C29	SMT ceramic capacitor	100 nF		
17	3	C30, C31, C32	SMT ceramic capacitor	220 pF		
18	6	D4, D5, D6, D7, D8, D9	Small signal Schottky Diode	BAT30	BAT30KFILM or equivalent	STMicroelectronics
19	1	D10	Schottky Rectifier	STPS0560Z	STPS0560Z	STMicroelectronics
20	1	J4	WR-MM female connector with latch w/o polarization 10 poles	Flat connector 10 pole	690367191072	Wurth Elektronik
21	1	J7	Horizontal terminal block pitch 3.50 mm	Terminal 2P_screw p3.5mm	691214110002	Wurth Elektronik

Item	Q.ty	Ref.	Description	Part/Value	Order code	Manufact.
22	1	J8	Terminal block T.H. 4 positions, 2.54 mm	Terminal 4P_screw p2.54mm	691210910004	Wurth Elektronik
23	1	J10	WR-MPC3 - 3.00MM male dual-row right angle 8 poles	Connector 8 pole w polarization	66200821022	Wurth Elektronik
24	1	J12	WR-PHD 1.27 mm Dual Pin Header, H=3.80 mm	Header 10x2	62101021021	Wurth Elektronik
25	1	LED1	WL-SMCW SMT Red LED	Red	150060RS75000	Wurth Elektronik
26	1	L1	WE-TPC SMD Tiny Power Inductor	39 µH	744043390 or equivalent	Wurth Elektronik
27	3	Q2, Q3, Q4	Dual N-channel 60 V, 35 mΩ typ., 6.5 A STripFET™ F3 Power MOSFET	STL7DN6LF3	STL7DN6LF3	STMicroelectronics
28	1	R1	SMT resistor	330 Ω		
29	1	R2	SMT resistor	100 kΩ		
30	4	R3, R6, R60, R62	SMT resistor	12 kΩ		
31	1	R14	SMT resistor	10 kΩ		
32	3	R15, R24, R33	SMT resistor	10.5 kΩ		
33	3	R16, R29, R40	Thick film chip resistors	0.100 Ω	ERJ8BWFR100V	Panasonic
34	6	R17, R22, R26, R30, R35, R39	SMT resistor	21 kΩ		
35	6	R18, R20, R27, R28, R36, R38	SMT resistor	2.4 kΩ		
36	6	R21, R23, R32, R34, R42, R44	SMT resistor	100 Ω		
37	3	R43, R45, R49	SMT resistor	2.2 kΩ		
38	1	R46	SMT resistor	180 kΩ		
39	1	R47	SMT resistor	18 kΩ		
40	1	R50	SMT resistor	10 kΩ		
41	1	R51	SMT resistor	187 kΩ		
42	1	R52	SMT resistor	60.4 kΩ		
43	1	R53	SMT resistor	NP	NP	
44	1	R54	SMT resistor	0 Ω		
45	3	R59, R61, R63	SMT resistor	1 kΩ		
46	1	R64	SMT resistor	120 Ω		
47	16	TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19	40 mils PAD	TP-SMD-diam1_016 mm		

Item	Q.ty	Ref.	Description	Part/Value	Order code	Manufact.
48	1	U1	STSPIN32F0A 3-phase controller with MCU	STSPIN32F0A	STSPIN32F0A	STMicroelectronics
49	1	U3	Up to 3 A step-down switching regulator	ST1S14PHR	ST1S14PHR	STMicroelectronics
50	1	U4	Positive Voltage Regulator	L78L33ABUTR	L78L33ABUTR	STMicroelectronics
51	1	U5	3.3 V RS485 compatible with 1.8 V I/Os and selectable speed 20 Mbps or 250 kbps	STR485	STR485LV	STMicroelectronics
52	1	U6	Quadruple differential line receiver	AM26LV32E	AM26LV32EIRGYR	TI

7 EVALKIT-ROBOT-1 schematic diagram

Figure 9. EVALKIT-ROBOT-1 schematic diagram 1

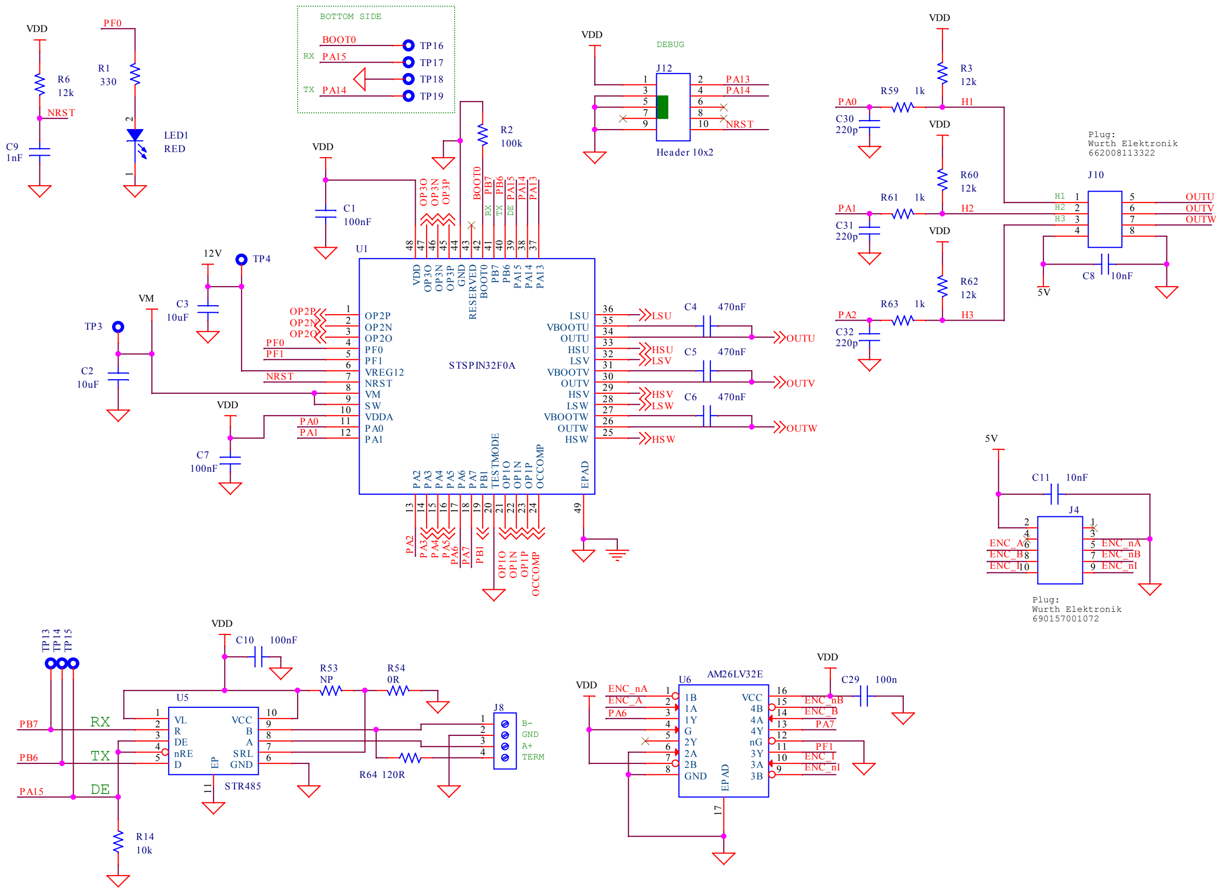


Figure 10. EVALKIT-ROBOT-1 schematic diagram 2

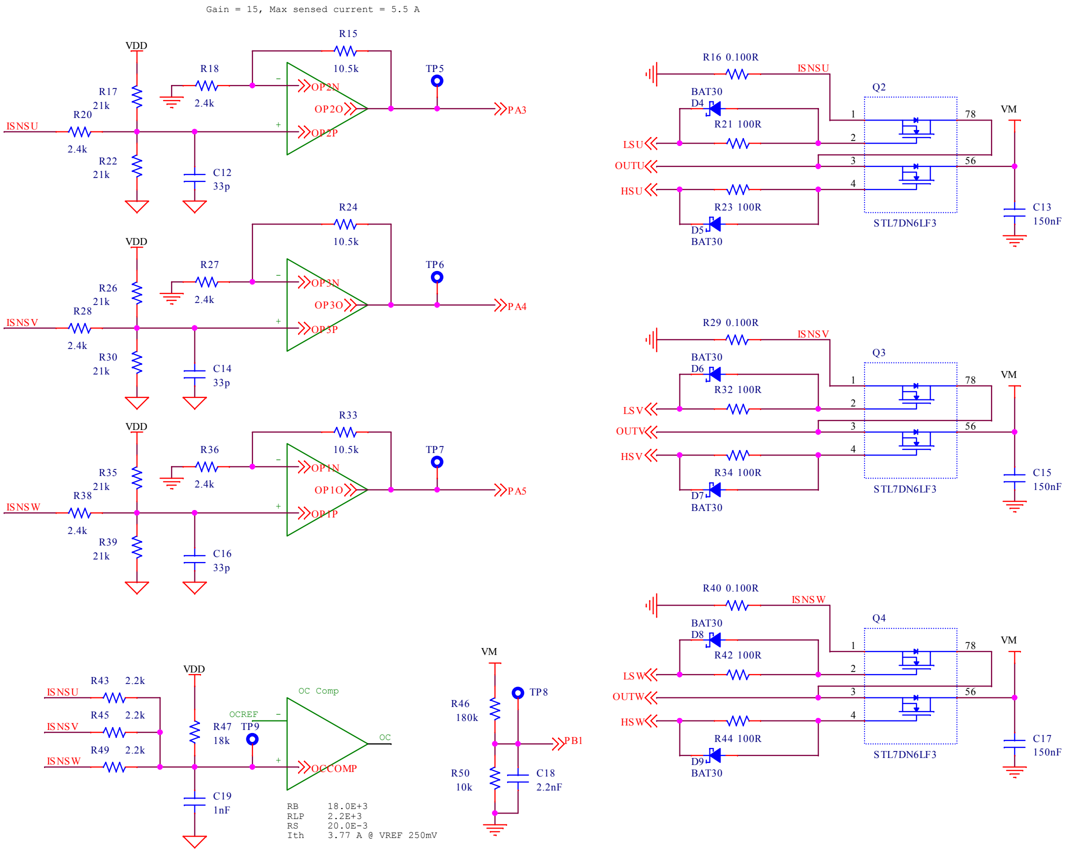
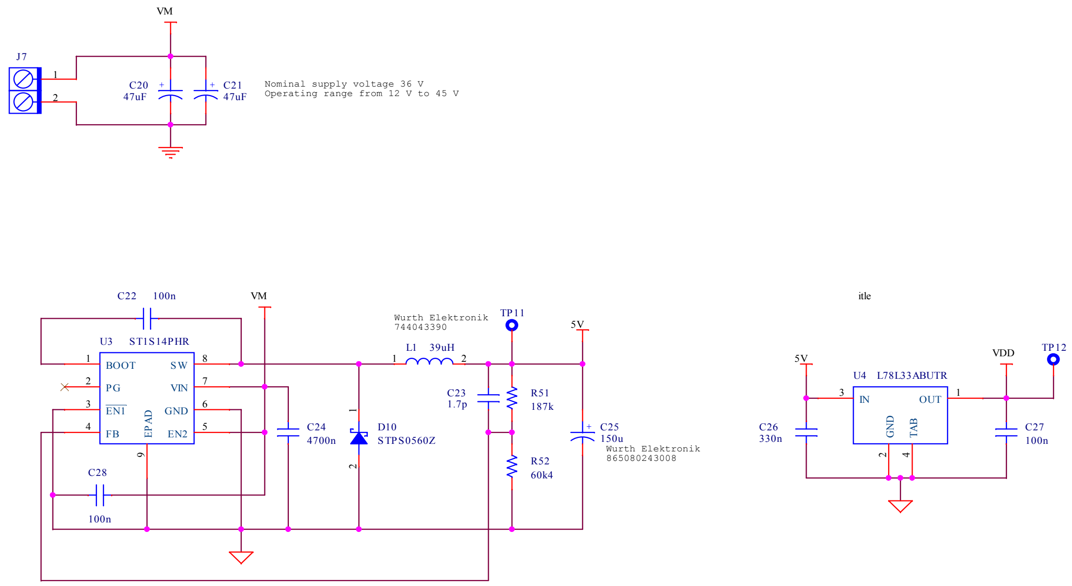


Figure 11. EVALKIT-ROBOT-1 schematic diagram 3



Revision history

Table 14. **Document revision history**

Date	Version	Changes
20-Nov-2019	1	Initial release.

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