SMART MOTOR DEVICES

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DC BRUSHLESS MOTOR CONTROLLER

BLD-50

User Manual

BLD.50.001

2025

1. Product designation

The controller BLD-50 is an electronic device designed to operate and control synchronous 3-phase DC brushless motors with embedded Hall sensors.

The controller performs the following functions:

- four-quadrant control of brushless motor;
- start and stop a motor with a button or an external signal;
- change of direction of rotation of the motor by a button or by an external signal;
- motor speed control using internal and external regulators;
- setting a second speed and switching to the second speed by an external signal;
- setting the value of acceleration and deceleration;
- protection of the motor against an overload with adjustment of a value of peak current;
- control of electromagnetic motor brake;
- emergency stop "HARD STOP", function in case of opening of the electrical circuit of the protective circuit;
- full-fledged PID controller with user-configurable coefficients;
- connection via USB type C for setting and monitoring drive operating parameters;
- indication of errors of the control unit;
- dissipation of the energy generated by the motor during coasting or forced rotation using the built-in braking circuit or operation with an external connected braking resistor;
- temperature protection of power stages;
- temperature protection of the brake circuit.

2. Technical characteristic

Controllers are designed to control speed, direction, smooth start and stop of brushless motors by input signals “START/STOP”, “DIR” and “HARD STOP”, analog signals, and potentiometers to control motor speed, acceleration, and current limiting.

Table 1. Technical characteristic

Basic parameters:	
Motor type	3-phase DC synchronous brushless motor with Hall sensors
Power supply	12 – 48 VDC
Own current consumption	60 mA @24VDC
Rated motor current	<= 50A
Maximum motor power	2500 W
Maximum motor speed	20000 rpm
Set acceleration/deceleration time setting	0.5 – 5 sec
Communication interface	USB Type C
Hall sensors:	
Hall sensors supply voltage	5 VDC
Hall sensors signal type	Open collector
Hall sensors angle	120 degree electrical angle
Electromagnetic brake relay parameters:	
Maximum relay voltage	220 V
Maximum relay current	2 A
Fault output parameters:	
Fault output type	NPN, open collector
Maximum voltage of the fault output	30 VDC
Maximum current of the fault output	50 mA
Brake resistor:	
Built-in braking resistor	2 x (10 Ohm, 5 W)
Minimum allowable resistance of external braking resistor	5 Ohm
Protective functions:	
Hardware short circuit protection	100 A, 15 µs
Motor current limit setting range	5 – 60 A

Motor current protection response time	5 sec
Emergency stop	protective electric circuit HARD STOP
Temperature protection	• exceeding the temperature of the output stages • exceeding the temperature of the braking circuit

Dimensions of the controller are shown in Fig. 1

Environmental Conditions:

Ambient Temperature: 0…+40°C
Humidity: 90% RH or less upon condition +25°C
Condensation and freezing: none
Pressure: 650…800 mm of mercury

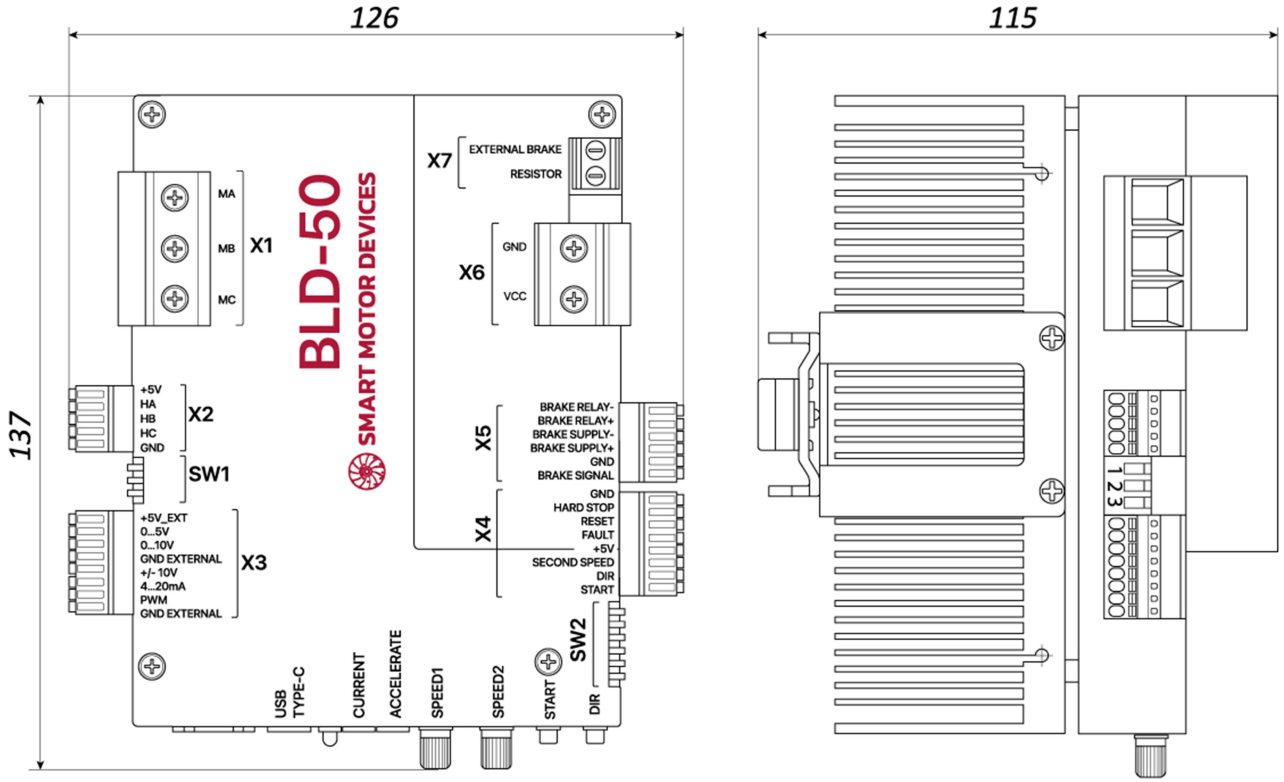


Fig.1. Dimensions

3. Speed control modes

The controller BLD-50 provides several speed control methods:

- built-in potentiometer;
- external potentiometer with full resistance: 10 kOhm;
- analog signal 0 - 5 V, dead zone 0…50 mV;
- analog signal 0 - 10 V, dead zone 0…50 mV;
- analog signal -10 … +10 V, dead zone 0…100 mV;
- analog signal 4 - 20 mA;
- PWM signal. PWM frequency: 16 kHz, 3.3 V. PWM duty cycle: 1% -100%.

The type of control signals is selected by switches DIP1…DIP3 in group SW1.

Table 2. Selecting the control signal type

Control signal	Switch (SW1)			Connection diagram
	DIP1	DIP2	DIP3	
Built-in potentiometer	OFF	OFF	OFF	Fig.2.1
0...5 V	OFF	OFF	ON	
0...10 V	OFF	ON	OFF	Fig.2.2
-10...+10 V	ON	OFF	OFF	Fig.2.3
Current loop, 4...20 mA	ON	ON	OFF	Fig.2.4
PWM 3.3V, 16 kHz	OFF	ON	ON	Fig.2.5

The control signals are connected to the contacts of group X3 in accordance with the connection diagrams in Fig. 2.

Speed control with built-in potentiometer

When controlling the motor speed with the built-in potentiometer "SPEED 1", no additional connections of the control signal are required. The extreme clockwise position corresponds to the maximum motor speed. The extreme counterclockwise position corresponds to stopping the motor. This speed control mode allows switching to the second speed «SPEED 2» using an external discrete signal.

Speed control with external potentiometer

When controlling the motor speed with an external potentiometer, the maximum speed corresponds to the extreme position of the potentiometer, at which a voltage 5 V is applied to the input. The motor stop corresponds to the position of the potentiometer, at which a voltage of 0 V is applied to the input. Recommended resistance of the external potentiometer is 10 kOhm.

The connection diagram is in the fig. 2.1.

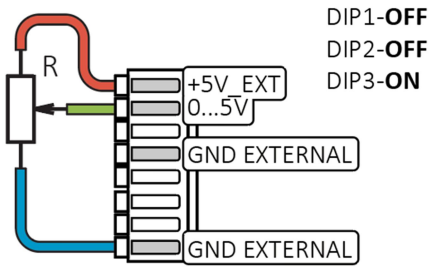


Fig.2.1. Speed control with external potentiometer

Speed control with an analog voltage signal 0 – 5 V

When an external signal of 0…5V is applied to the input «0…5V», the maximum speed corresponds to the signal 5V. The motor stops at the signal 0V.

The connection diagram is in the fig. 2.2.

The dead zone is 0…50 mV

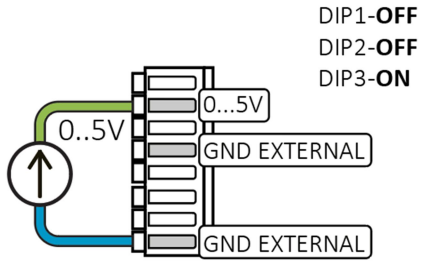


Fig.2.2. Speed control with voltage signal 0..5V

Speed control with an analog voltage signal 0 – 10 V

When an external signal 0…10V is applied to the input «0…10V», the maximum speed corresponds to the signal level 10V. The motor stop corresponds to the level 0V.

The connection diagram is in the fig. 2.3.

The dead zone is 0…50 mV

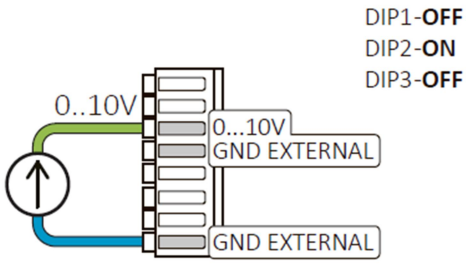


Fig.2.3. Speed control with voltage signal 0..10 V

Speed control with an analog voltage signal 0 – ±10 V

When controlling the speed with a signal of -10…+10V, the motor stops at a signal level of 0V. The maximum speed in the forward direction corresponds to a level of +10V. The maximum speed in the reverse direction corresponds to a level of -10V.

The connection diagram is in the fig. 2.4.

The dead zone is 0…100 mV

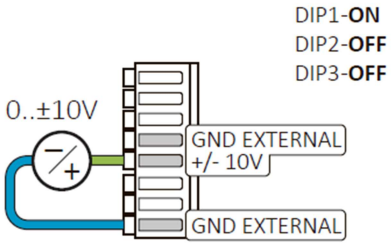


Fig.2.4. Speed control with voltage signal 0..±10 V

Speed control with an analog current signal 4 .. 20 mA

When controlling the speed with a 4…20 mA current signal (current loop), the maximum speed corresponds to a signal level of 20 mA. The motor stops at a level of 4 mA.

The connection diagram is in the fig. 2.5.

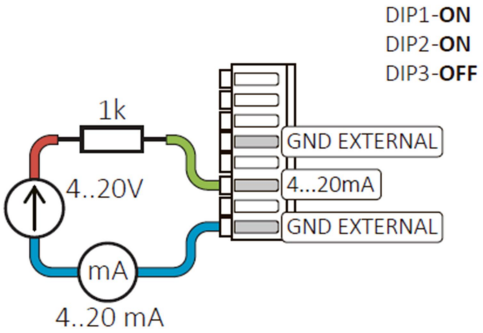


Fig.2.5. Speed control with current signal 4..20 mA

Speed control with PWM signal

When controlling the speed with a 16 kHz PWM signal 3.3 V, the minimum starting speed corresponds to a duty cycle of 1%. The maximum speed corresponds to a duty cycle of 100%. Stopping the motor corresponds to a duty cycle of 0%.

The connection diagram is in the fig. 2.6.

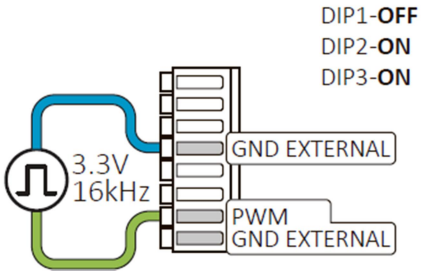


Fig.2.6. Speed control with PWM signal 3.3 V, 16 kHz

4. Control signals and auxiliary functions

4.1. Configuring and connection of external signals

The controller has external discrete control signals to provide main and auxiliary control functions. Control signals are connected to the terminal group X4 (figure 3).

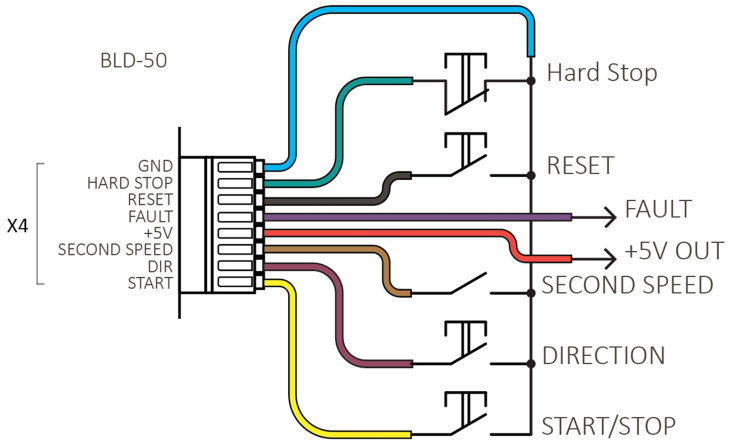


Fig.3. Connecting external control signals

The controller has a group of switches SW2 for configuring some signals and operation functions. A user can select the logic of start and reverse signal (by level or by edge), the braking mode with open or close motor coils, brake setting, and the automatic brake application function. The signal settings are shown in the table 3 below.

Table 3. Assignment of switches DIP1…DIP5 (SW2)

Function	Signal name	DIP switch in the group SW2	DIP position	
			ON	OFF
Motor start and stop	START/STOP	DIP1	Signal is processed by level	Signal is processed by front
Rotation direction/reverse	DIR	DIP2	Rotation direction – the signal is processed by level	Reverse – the signal is processed by front
Motor phases during braking	-	DIP3	Motor phases open	Motor phases close
Holding brake inversion	BRAKE	DIP4	No inversion	Brake signal inversion
Automatic brake operation	-	DIP5	Auto brake on	Auto brake off

4.2. Motor acceleration control

Use the trimmer resistor "ACCELERATE" to set the acceleration and deceleration time. The extreme counterclockwise position corresponds to the maximum acceleration time (minimum acceleration). The extreme clockwise position corresponds to the minimum acceleration time (maximum acceleration). The acceleration time to maximum speed varies in the range from 0.5 to 5 sec. The acceleration time can be monitored in the ACC_DECC_TIME register.

Note: if, as a result of acceleration, the controller arises error #2 or #6, it is necessary to increase the acceleration time.

4.3. Setting the peak current limit

The internal potentiometer "CURRENT" is used to set the peak power supplied to the motor. The extreme clockwise position corresponds to a motor current limit of 60 A, counterclockwise - to a current limit of 5 A. When the limit is reached, if the current does not decrease within 5 seconds, an emergency stop of the motor (HARD STOP) is performed. The controller displays the HARD_STOP error.

4.4. Motor rotation control

The controller has the ability to configure the logic for processing the control signals "START/STOP" and "DIR". The control signals are processed by the edge or by the level, depending on the position of the DIP1 (START/STOP signal) and DIP2 (DIR) microswitches in the SW2 group (see the table 3).

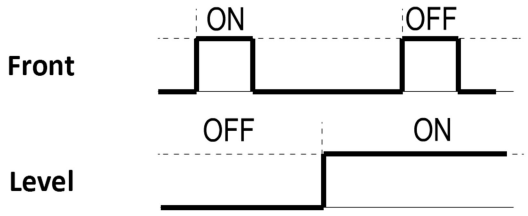


Fig.4. Logic of control signals START/STOP and DIR – processing as per a front or as per a level of the signal

The OFF position of the corresponding DIP microswitch determines the processing of the signal by a front, the ON position – by a level of the signal.

Start/Stop signal

The motor is started and stopped by the built-in "START/STOP" button or by an external signal, when the line connected to the "START" terminal is closed to the signal ground "GND". The buttons are responsible for controlling the start and change of direction of the motor and work when the button is released. Fig. 5 shows a diagram of the speed change when controlled by the external "START/STOP" signal by level (DIP1 = ON) and the built-in button.

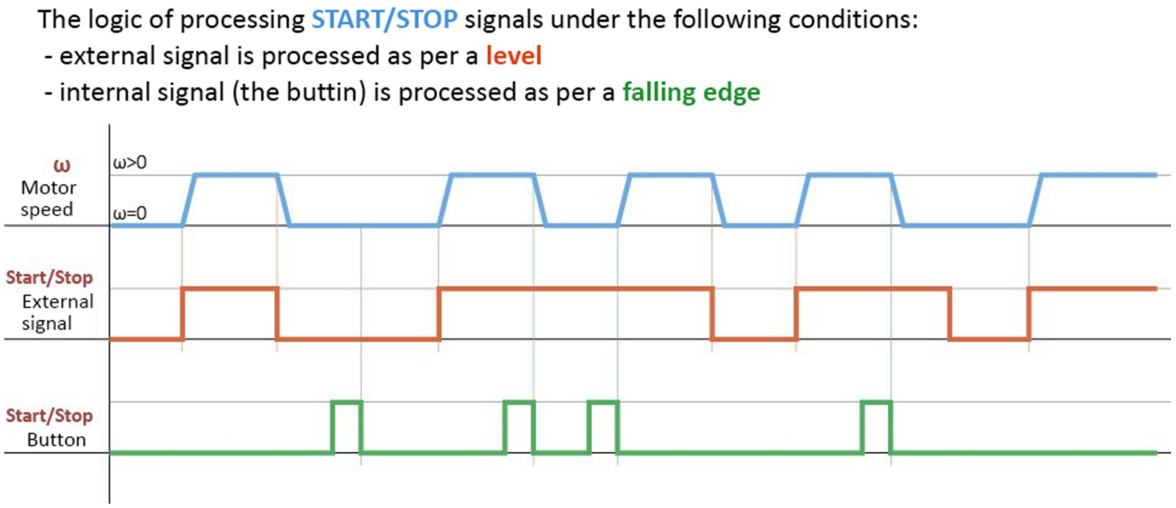


Fig. 5. Diagram of the coordinated operation of the external signal "START/STOP" and the built-in button.

Rotation direction

The motor rotation direction control is performed with the built-in "DIR" button or with an external signal “DIR”. Signal “DIR” is active when the line connected to the "DIR" terminal is closed to the signal ground "GND".

If the speed control mode -10…+10V is selected, the "DIR" button and the external "DIR" signal are not active. In this control mode, the rotation direction depends on the speed voltage signal polarity.

Setting the external "DIR" signal is similar to the "START/STOP" signal. The OFF position of the DIP2 microswitch determines the processing of the DIR signal by a front, the ON position – by a level (sea fig. 4).

4.5. Motor phases during braking

The controller allows to select the braking mode with open or closed windings. The braking mode is selected by the DIP3 switch in the SW2 group: DIP3 = ON - braking with open terminals, DIP3 = OFF - braking with closed terminals.

4.6. Emergency stop

The "HARD_STOP" signal is used for emergency stop of the motor. Operation is permitted when the "HARD_STOP" contact is closed to the signal ground "GND". If the contact is disconnected, the controller switches to emergency mode, the motor stops abruptly and the corresponding error is indicated.

Getting out from the emergency mode is performed by resetting the supply voltage or by the "RESET" signal.

4.7. Brake control

The controller provides the ability to use an electromagnetic brake. The electromagnetic brake can be activated automatically

when the motor starts rotating or by the external signal "BRAKE SIGNAL". When the "BRAKE SIGNAL" and "GND" contacts are closed, the relay is triggered, switching the "BRAKE SUPLY" and "BRAKE RELAY" contacts.

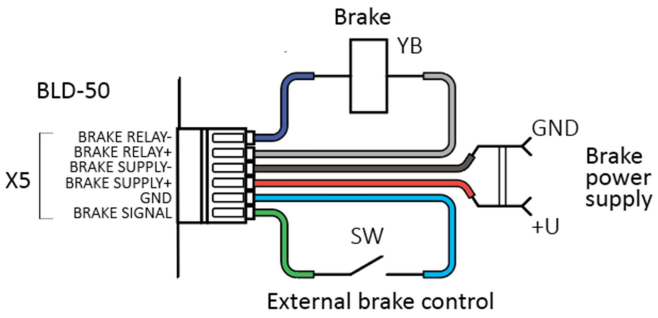


Fig. 6. Brake connection

A normally closed brake holds the motor shaft when there is no voltage on its windings. Voltage must be applied to the electric brake to release the rotor.

A normally open brake operates according to the reverse logic - a motor shaft is fixed when voltage is applied to the brake, a motor shaft rotates freely when supply voltage is not applied to the brake.

Brake control depends on settings of DIP4 and DIP5 (in the SW2 group). Brake can be controlled with the external signal “BRAKE SIGNAL” or automatically. The logic of electromagnetic brake control is shown in Table 4.

Automatic brake control

Automatic brake control is activated by switch DIP5=ON. The signal “BRAKE SIGNAL” is not гыув when automatic brake control is selected.

Table 4. The logic of electromagnetic brake control.

DIP4 (SW2) Brake inversion	DIP5 (SW2) Automatic brake control	«BRAKE SIGNAL » External brake control signal	Motor state	BR+\BR- Brake connection output voltage
OFF	OFF	OFF	OFF	$U_{BRAKE\ SUPLY}$
OFF	OFF	OFF	ON	$U_{BRAKE\ SUPLY}$
OFF	OFF	ON	OFF	0
OFF	OFF	ON	ON	0
OFF	ON	OFF	OFF	0
OFF	ON	OFF	ON	$U_{BRAKE\ SUPLY}$
OFF	ON	ON	OFF	0
OFF	ON	ON	ON	$U_{BRAKE\ SUPLY}$
ON	OFF	OFF	OFF	0
ON	OFF	OFF	ON	0
ON	OFF	ON	OFF	$U_{BRAKE\ SUPLY}$
ON	OFF	ON	ON	$U_{BRAKE\ SUPLY}$
ON	ON	OFF	OFF	$U_{BRAKE\ SUPLY}$
ON	ON	OFF	ON	0
ON	ON	ON	OFF	$U_{BRAKE\ SUPLY}$
ON	ON	ON	ON	0

4.8. Second speed

The controller provides the function of switching to a second speed. The second speed value is adjusted by the potentiometer "SPEED 2". The second speed is switched on by a signal at the input "SECOND SPEED". The signal is active if the corresponding

contact terminal is closed to the signal ground "GND". The function is available only in the speed control mode from the built-in potentiometer (SW1: DIP1=OFF, DIP2=OFF, DIP3=OFF)

4.9. Braking resistor

The controller has two built-in braking resistors rated at 10 Ohm and 5 W. If necessary, an external braking resistor can be connected to the "EXTERNAL BRAKE RESISTOR" terminals in the group X7.

4.10. Four-quadrant control mode

The controller supports four-quadrant motor phases control. This control mode ensures stable and precise maintaining of the specified rotation speed for any variants of the motor rotation direction and load action. Four-quadrant phases commutation is effective in the range of operating speed from 100 rpm to 2000 rpm and maximum motor speed of 4000 rpm (register MAX_SPEED = 4000). The FOUR_QUADRANT register is used to enable/disable the four-quadrant control function.

The response time depends on the difference in load speed (external applied force) and the speed of the brushless motor. The greater the difference, the shorter the response time.

To operate in four-quadrant control mode, an external braking resistor must be used.

4.11. Error indication

The LED indicator displays the status of the controller. In case of normal operation, the indicator color is green. During motor rotation, the green LED flashes with a period of one second. If during operation the red LED lights up and remains lit, this means that the maximum speed has been reached and further increase in speed is impossible. In case of detection of errors, the indicator displays the error code by flashing the red LED.

Table 5. Error indication.

Error code	Indication	Error
0	Green light	Normal operation
0	Red light	Maximum speed has been reached, further increase is impossible
1	Single red flashes	Hall sensors data error
2	Series of 2 red flashes	Current exceeds 100A
3	Series of 3 red flashes	Supply voltage exceeds the allowed range
4	Series of 4 red flashes	Brake resistors overheat
5	Series of 5 red flashes	Power transistors overheat
6	Series of 6 red flashes	Motor current exceeds the set value for more than 5 seconds, or the HARD_STOP circuit is open

If errors are detected, the indicator displays the error code with a series of red flashes (Table 5) and the output signal indicating the emergency condition "FAULT" is triggered. The "FAULT" output operates according to the following principle: when an error occurs, the transistor with an open collector switches the output to "GND".

5. Connection and configuring

Please, learn this manual carefully before connection and assembly.

Please, wire just when the power is off. Do not attempt to change wiring while the power is ON.

Please, provide a reliable contact in connection terminals. During wiring, please, observe the polarity and wire management.

Due to high currents, it is recommended to locate the power supply in close proximity to the controller. The power supply must provide 20% more current than the maximum possible consumed during operation. The cross-section of the power supply wires of the controller and of the motor must correspond to the consumed current.

The cross-section of the signal wires and the Hall sensor wires must not exceed 0.5 mm^2.

1. Connect the power supply to the terminals: "VCC" and "GND" observing the polarity.
2. Connect the motor. An example of connection is shown in Figure 7. Motor phases must be connected to terminals MA, MB, MC of the connector X1. Hall sensor signals must be connected to terminals HA, HB, HC of the connector X2. GND of HALL sensors must be connected to the terminal GND and supply of HALL sensor signals must be connected to the terminal +5V of the connector X2.

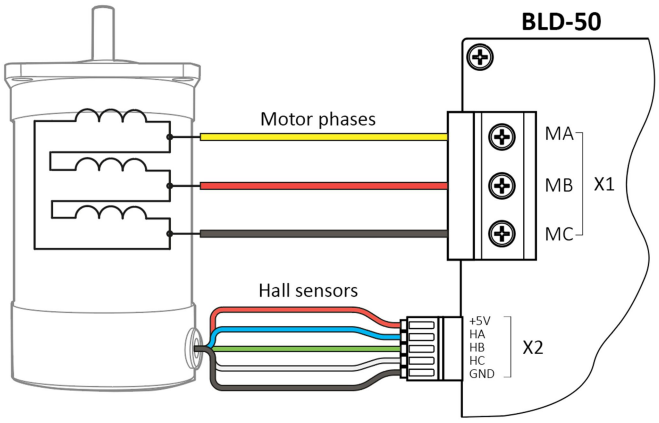


Fig.7 Motor connection diagram.

It is recommended to place the Hall sensor wires and the motor phase wires separately from each other for correct operation.

3. Connect speed control signal (refer to the section 3) and select the speed reference signal type using switches DIP1…DIP3 (switch group SW1), according to the table 2.
4. Connect external control signals to the terminals in the group X4 if necessary (refer to the section 4 and fig. 3).
5. Connect electromagnetic brake of the motor to the terminals in the group X5 if necessary (refer to the section 4.7 and fig.6).
6. Connect external braking resistor to the terminals in the group X7 if necessary (refer to the section 4.9).
7. Set the logic of the "START" and "DIR" signals using microswitches DIP1 and DIP2 (switch group SW3) in accordance with Fig. 4.
8. Connect USB cable to the TYPE-C connector for configuring the motor and operating parameters*
9. Turn on the power supply - the LED should light up green.
10. Configure the motor and operating parameters*.

By default, the following settings are used for communication:

- Slave ID: 1
- Baud rate: 115200
- Parity: even
- Data bit: 8
- Stop bit: 1

10.1. Set the motor parameters: number of poles, maximum rotation speed in the corresponding registers.
10.2. Using the trimmer resistor for setting the current, set the current 20% more than consumed by the motor. The set value is displayed in the ADJUSTED_CURRENT register.
10.3. If necessary, adjust the remaining operating parameters (see Section 6 "Registers of the controller").
10.4. Save the settings to non-volatile memory using the FLAG_SAVE_SETTINGS register.

*. Connection to a PC and parameter settings are required for the first connection of the motor. After saving the operating parameters, connection to a PC and configuration are not required.

11. Set the required motor speed.
12. Start the motor using the "START" button or an external signal.
13. If the motor does not start and the controller displays error 2 or error 6, it is necessary to increase the limiting current value.
14. If the set rotation direction in the ADJUSTED_DIRECTION register does not match the detected value in the ACTUAL_DIRECTION register, it is necessary to set the Hall sensor code inversion bit in the HALL_INV register.

Attention: Starting the motor with an incorrectly specified Hall sensor code inversion bit may result in uncontrolled acceleration of the motor to maximum speed.

DIN rail mounting

The controller provides two options for DIN rail mounting– fig.8.

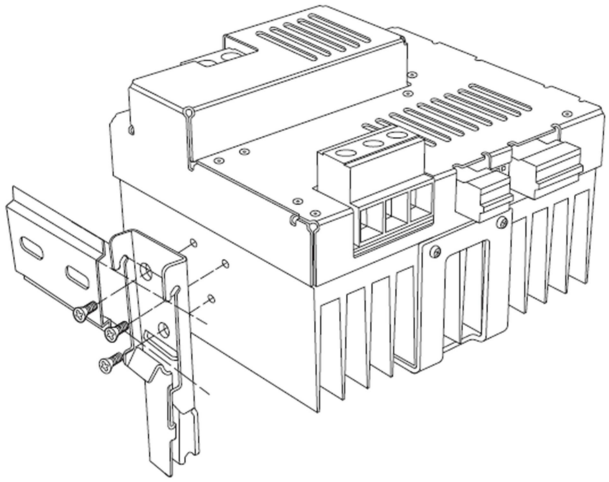


Fig.8.1. DIN rail mounting – option 1

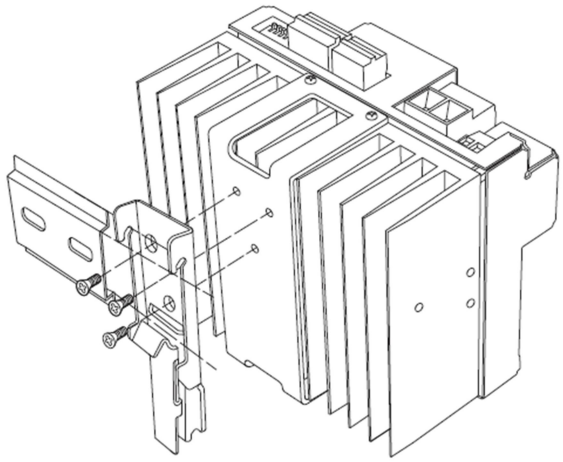
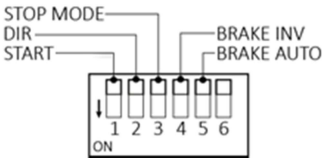


Fig.8.2. DIN rail mounting – option 2

6. Registers of the controller

Table 6. Registers map

Address (HEX)	Register name	Read/write orerations	Description
State registers			
8009	STATUS_MOTOR	Read only	Motor state 0 - stop 1 – forward rotation 2 – braking, forward direction 3 - backward rotation 4 - braking, backward direction
800A	ADJUSTED_CURRENT	Read only	Specified motor current, mA
800B	ACTUAL_CURRENT	Read only	Actual motor current, mA
800C	PWM_MOTOR	Read only	Actual motor PWM duty cycle (0 - 4500). 0 – 0% 4500 – 100%
800D	ADJUSTED_SPEED	Read only	speed value, rpm (set with the potentiometer or external signal)
800E	ADJUSTED_DIRECTION	Read only	Specified direction (set with button or external signas) 0 – FORWARD 1 – REVERSE
800F	ACTUAL_SPEED	Read only	Actual motor speed, rpm
8010	ACTUAL_DIRECTION	Read only	Actual motor rotation direction 0 – STOP 1 – FORWARD 2 – REVERSE
8011	ACC_DECC_TIME	Read only	Acceleration/deceleration time to the speed specified in the MAX_SPEED register, ms
8012	CONTROL_SIGNAL_TYPE	Read only	Selected speed reference signal type 0 – built-in potentiometer 1 – 0...5V 2 – -0...10V 3 – +/-10V 4 – 4...20mA 5 – PWM

8013	ERROR_MASK	Read only	Controller error 0 – no error 1 – Hall sensors data error 2 –Motor current exceeds the value 100A or phase short circuit 3 – Supply voltage exceeds the allowed range (9 – 52V) 4 – Brake resistors overheat 5 – Power transistors overheat 6 – Motor current exceeds the set value for more than 5 seconds, or the HARD_STOP circuit is open 7 – Demo version of the firmware. The controller operation time is limited to 10 minutes.	
8014	SIGNAL_START	Read only	State of the external signal START 0 – no signal 1 – signal is active	
8015	SIGNAL_DIR	Read only	State of the external signal DIR 0 – no signal 1 – signal is active	
8016	SIGNAL_HARD_STOP	Read only	State of the circuit HARD_STOP 0 – open 1 – close	
8017	SIGNAL_BRAKE	Read only	State of the brake control external signal BRAKE_SIGNAL 0 – no signal 1 – signal is active	
8018	SIGNAL_SECOND_SPEED	Read only	State of the external signal SECOND_SPEED 0 – no signal 1 – signal is active	
8019	START_SWITCH	Read only	The logic of the external START signal (setting SW2 – DIP1) 0 – front 1 – level	
801A	DIR_SWITCH	Read only	The logic of the external DIR signal (setting SW2 – DIP2) 0 – front 1 – level	
801B	STOP_MODE_SWITCH	Read only	Selected motor braking mode (setting SW2 – DIP3) 0 – coils closed 1 – coils opened	
801C	BRAKE_INV_SWITCH	Read only	BRAKE signal inversion (setting SW2 – DIP4) 0 – brake releases when power is applied to the brake 1 – brake releases when the brake is deenergized	
801D	AUTO_BRAKE_SWITCH	Read only	Automatic brake control (setting SW2 – DIP5) 0 – OFF 1 – ON	
Drive parameters				
5004	NUMBER_POLE_PAIRS	Read/Write	Number of motor pole pairs, 1 -12	
5005	MAX_SPEED	Read/Write	Maximum motor speed (rpm) Maximum value - 20000 rpm	

5006	HALL_INV	Read/Write	Inversion of the code order from Hall sensors 0 - OFF 1 - ON The parameter must be set so that when motor rotates without a load, the signs of speed values in the registers ADJUSTED_SPEED and ACTUAL_SPEED coincide	
5007	FOUR_QUADRANT	Read/Write	Four-quadrant control mode 0 - OFF 1 - ON	
500A	FLAG_SAVE_SETTINGS	Read/Write	Saving parameters to the controller non-volatile memory is performed when writing 1 to the register	
500B	FLAG_RESTART	Read/Write	Writing 1 to the register reboots the controller.	
500C	PID_P	Read/Write	PID proportional gain	**Attention:** changing the PID controller coefficients is allowed only with a full understanding of the actions being performed. Abrupt changes in the coefficient values are not recommended. Changing the PID controller coefficients may result in deterioration of the motor performance.
500E	PID_I	Read/Write	PID integral gain	
5010	PID_D	Read/Write	PID differential gain	

7. Reset to factory settings

To reset the settings to factory values, set the potentiometers "SPEED 1" and "SPEED 2" to the extreme counterclockwise positions. Press and hold the START and DIR buttons for at least 8 seconds. After releasing the buttons, the green LED will go out, and the red LED will blink 6 times. The Hall sensors and the "HARD_STOP" jumper must be connected.

8. Delivery in complete sets

The brushless motor controller BLD-50 1 pcs.

9. Manufacturer information

Smart Motor Devices adheres to the line of continuous development and reserves the right to make changes and improvements in the design and software of the product without prior notice.

The information contained in this manual is subject to change at any time and without prior notice.

10. Warranty

Any repairs or modifications are performed by the manufacturer or an authorized company.

The manufacturer guarantees the failure-free operation of the controller for 12 months from the date of sale when the operation conditions are satisfied.

The manufacturer's sales department address:

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