***SMART MOTOR DEVICES***

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# DC brush motor controller
# BMD-40DIN ver.2

***manual***
**BMD.40.DIN.V2.001**

**2024**

## 1. Product designation

Controller BMD-20DIN ver.2 is electronic device to operate and control DC brush motors with maximum voltage 24VDC and power under 1000W. The controller is designed to control torque, speed, direction, smooth start and stop of brush motors. The motor control is carried out by both internal regulators included in the design of the device and external ones, connected additionally. BMD-40DIN ver.2 provides a motor overload protection function with regulation of the maximum permissible current supplied to the motor.

The controller performs the following functions:

- start and stop a dc brush motor motor with a button on the front panel or with an external signal;
- change of rotation direction of the motor by a button on the front panel or by an external signal;
- motor speed control;
- motor torque control;
- setting the value of acceleration and deceleration;
- protection of the motor against an overload with adjustment of peak current;
- indication of errors and operating modes of the controller;
- emergency stop function "HARD STOP" - motors stops in case of opening of the electrical circuit of the protective circuit;
- control of external electromagnetic motor brake;
- temperature protection of power stages;
- temperature protection of the brake circuit.

## 2. Technical characteristics

| | |
|---|---|
| Power supply $U_{sup}$ | 12…24 VDC, stabilized |
| Permissible supply voltage range | 8…30 VDC |
| Max. operation motor current | 40 A |
| Maximum voltage across a motor | $0.99 \cdot U_{sup}$ |
| Minimum non-zero voltage across a motor | $0.01 \cdot U_{sup}$ |
| Current consumption | < 100 mA at a supply voltage 24VDC |
| **Internal output +5V:** | |
| Voltage | 4.5 – 4.5 VDC |
| Max. load current | 50 mA |
| **External brake control:** | |
| Permissible working current of the brake connected to terminals BR+ / BR- | 1 A |
| Brake response time | 100 ms |
| **Overcurrent protection:** | |
| Hardware short-circuit protection | 100A, 15 µs |
| Motor phase current limit | set by customer, limitation range 5 – 40 A |
| Actuation time of motor phase current limiting | 5 sec |
| **Protection of an actuating mechanism:** | |
| Emergency stop (HARD_STOP) - the motor stops immediately in case the protection circuit is broken | |
| **Thermal protection:** | |
| output stage temperature rise | |
| brake circuit temperature rise | |
| **Speed/torque regulation:** | |
| Speed regulation methods | Analog current or voltage signal, internal or external potentiometer, PWM regulation |
| Input voltage range (for analog voltage signal) | -10...+10 VDC (dead zone ±100 mV);<br>0... 10 VDC (dead zone 0…100 mV); |
| Analog current signal | 4...20 mA; |
| Impedance of external potentiometer | 10 kOhm |
| PWM signal | 16 kHz, 3.3V |
| PWM duty cycle | 1% -100%. |

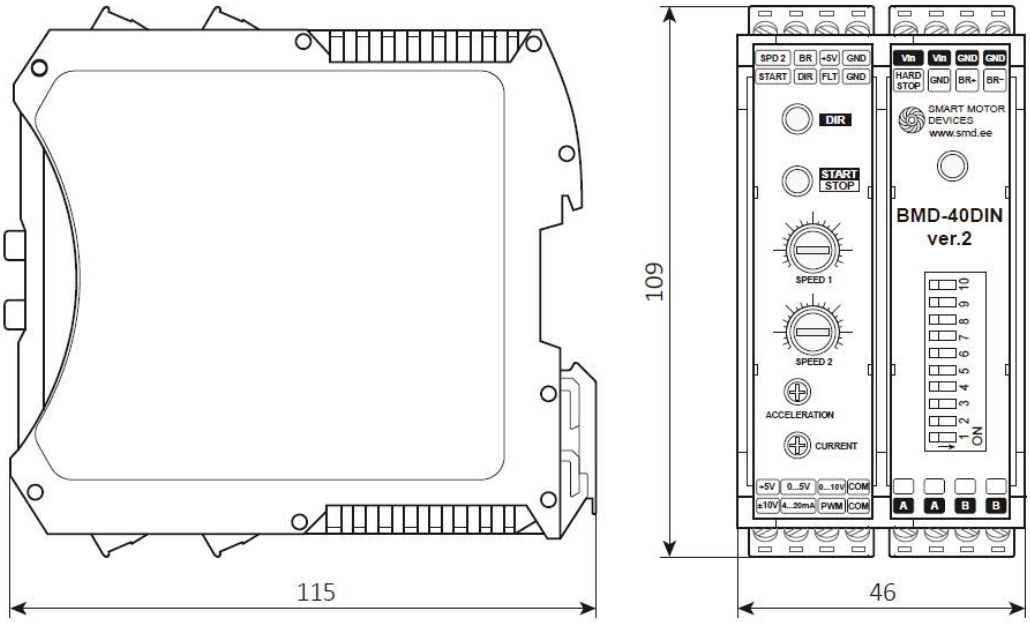



*Fig.1 Dimensions of BMD-40DIN ver.2*

Environmental conditions:

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

**Protection functions**

Current protection:

- The controller has hardware protection against short circuits - 100A, response time - 15 μs;
- The controller provides for adjustable limitation of the motor current. The limitation is set by the user within 5 - 40 A using a potentiometer on the scale drawn on the front panel. The response time of the limitation is 5 s. Then an emergency stop (HARD STOP) is performed.

Mechanics protection:

- emergency stop of the motor (HARD STOP) is provided in case of opening of the electric circuit of the protective circuit.

Temperature protection:

- output stage temperature rise
- brake circuit temperature rise

## 3. Control modes

The controller BMD-40DIN ver.2 provides control of the motor speed or torque.

### 3.1. Motor speed control modes:

- internal potentiometer;
- external potentiometer with full resistance: 10 kOhm;
- analog signal 0 - 10 V (dead zone 0 ... 100 mV);
- analog signal -10 - +10 V (dead zone ± 100 mV);
- analog signal 4 - 20 mA;
- PWM signal. PWM frequency: 16 kHz, 3.3 V. PWM duty cycle: 1% -100%.

Speed feedback is not provided.

**3.2. Engine torque control modes:**

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

Torque stabilization without speed control, by instantaneous motor current.

The control mode and the type of control signal are selected using microswitches on the front panel of the controller (refer to the section 6).

## 4. Construction

BMD-40DIN ver.2 is designed as circuit plate with electronics elements, installed on a plate and covered with a case, indicating and control elements and connection terminals on the board:

- Plastic housing designed for installation on a DIN rail.
- Circuit board with electronic components.
- Screw terminals for connecting wires: control lines, power supply and motor.
- Front panel with controls and graphic symbols.

Front panel control elements:

- status LED;
- "START" button;
- "DIR" button;
- main speed setting potentiometer;
- second speed setting potentiometer;
- current setting potentiometer;
- microswitches group for selecting the start and reverse type (by level or by edge), selecting the "SPEED" speed control mode or the "TORQUE" torque control mode, selecting the stop mode with open or closed motor terminals, BRAKE signal inversion, automatic brake application function.

## 5. Assembly and connection

Please, learn this manual carefully before connection and assembly.

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

Set the required operating mode, type and logic of control signals using microswitches SW1 – SW10 in accordance with the section 6.1.

Installation must be performed by qualified personnel. The controller is designed for installation on a standard DIN rail 35 mm width.

**Attention:** When connecting, observe the polarity of the power supply. Failure to observe the polarity, as well as exceeding the supply voltage, may damage the unit.

Due to high currents, it is recommended to locate the power supply in close proximity to the unit and use wires with a cross-section of 8.4 $mm^2$ (AWG-8). The power supply must provide a current 20% greater than the maximum possible current consumed during operation. Recommended length of supply wires depending on the peak current:

- no more than 100 cm for currents up to 10 A.
- no more than 50 cm for currents from 10 to 20 A.
- no more than 25 cm for currents from 20 to 40 A.

It is permissible to use one line of supply and phase terminals at a maximum current up to 20 A. it is necessary to use both lines of supply and phase terminals at a maximum current of more than 20 A.

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

Connection order:

1) Make sure the power supply is turned off. Please, wire just when power is off.
2) Connect the motor to the controller terminals A and B.

3) If necessary, connect external control circuits to the terminals: external speed or torque controller (potentiometer, analog signal source -10…+10V, 0…+10V, 4…20mA or PWM signal); external control signals "HARD STOP", "START/STOP", "DIR", "BR", "SPD2" to the corresponding terminals.

4) Connect the device to a power supply. The thickness of the connecting wires must correspond to the current consumed by the motor.

5) Use the control elements to pre-set working parameters by setting the speed, acceleration and current potentiometers to the middle positions.

6) Turn the power on, check operation and perform fine tuning using the control elements.

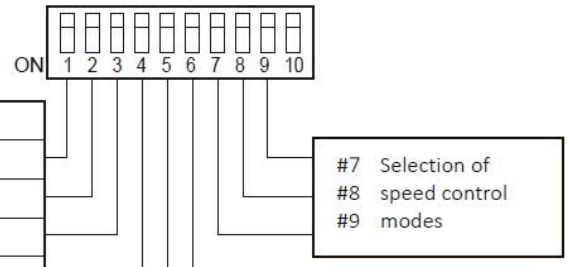
## 6. Operation

If necessary, before starting work, configure the controller operating parameters (control mode, speed, acceleration, current limitation) according to the section 6.1.

During operation, the controller monitors abnormal situations. In case of error or alarm, the controller indicates the code with LED flashing – refer to the section 6.10.

### 6.1. Setting up the controller and connecting control signals.

There is a group of microswitches SW1…SW10 on the front panel of the controller. These switches are intended for selecting the logic of start and reverse signals (by level or by edge), selecting the control mode - “SPEED” or “TORQUE”, selecting the stop mode - with open or close motor terminals, selecting brake polarity and the automatic brake application function.




| # | *Parameter* | *ON* | *OFF* |
|---|---|---|---|
| 1 | START/STOP | By level | By front |
| 2 | DIR | By level | By front |
| 3 | Control mode | By the torque | Speed |
| 4 | The phases of the motor when stopped | Open | Closed |
| 5 | Signal inversion «BRAKE» | 24V- the brake is released<br>0 V- the brake is activated | 24V- brake activated<br>0V- brake released |
| 6 | Automatic activation of the brake | ON | OFF |

Fig. 2. Purpose of microswitches SW1 – SW10

An example of connecting the controller with control from a built-in potentiometer is carried out according to the diagram shown in Fig. 3.

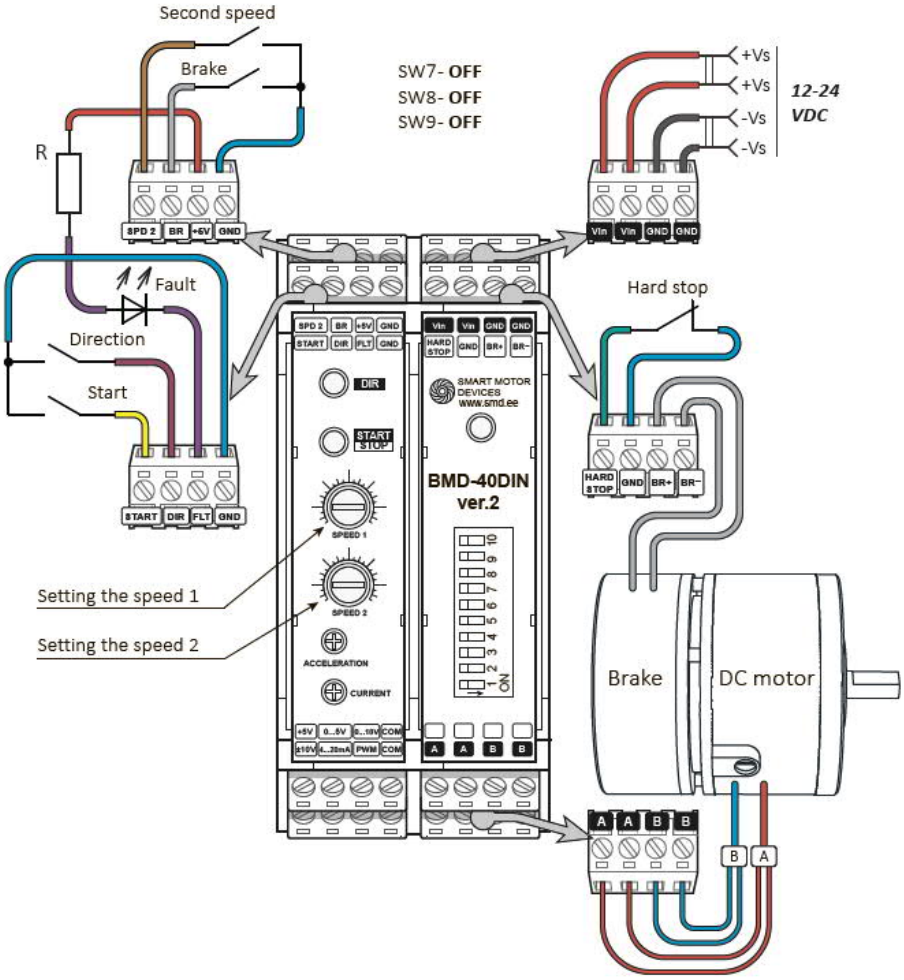



Fig. 3. Connection diagram for control with the built-in potentiometer

The control signal type is set the microswitches SW7, SW8 and SW9. Set the desired position of the microswitches and, if necessary, connect the external control signal according to the diagram in Fig. 4.

**Attention:** after changing the type of control signals using microswitches SW7, SW8 and SW9, it is necessary to reboot the controller for the changes to take effect.

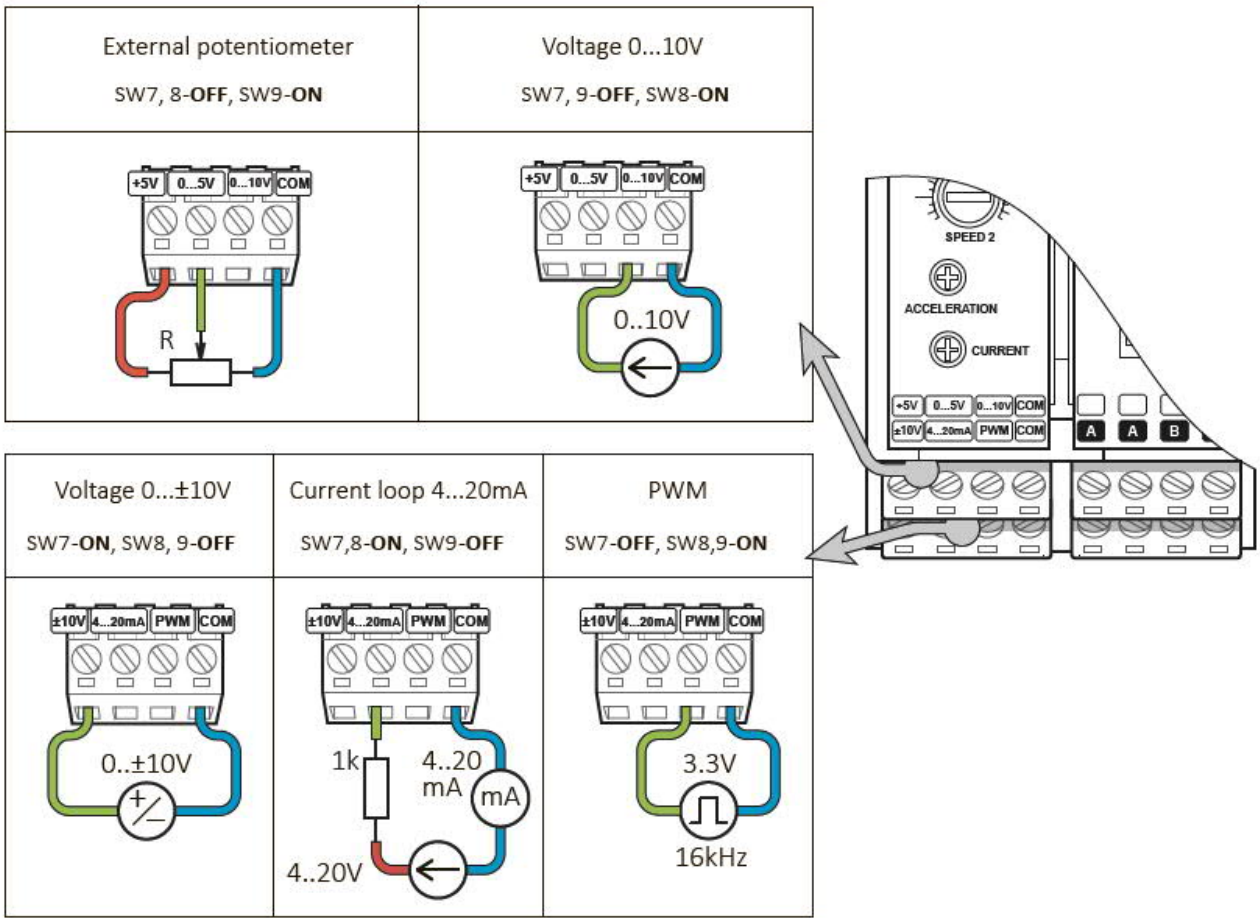



Fig.4. Connecting external speed and torque control signals

### 6.2. Selecting the operating mode - speed or torque control

Regulation of motor speed or torque with the controller BMD-40DIN ver.2 is carried out with an analog signal. The control mode is selected using the SW3 microswitch on the front panel of the controller: SW3 = ON - speed control, SW3 = OFF - torque control. The control methods for both modes are similar.

**Speed control mode (SW3 = OFF).** Speed setting is carried out with an analog signal. Type of the signal is selected with microswitches SW7, SW8, SW9. Motor acceleration rate depends on position of the built-in potentiometer “Acceleration”. Motor current doesn’t exceed the current limit value set by the built-in potentiometer “Current”. The function “Second speed” is available in this speed control mode. Switch from the main speed to the second speed is realized by closing the "SPD 2" input to the "GND" terminal. Speed stabilization is not provided.

**Torque control mode (SW3 = ON)**. In the torque control mode, the maximum voltage is applied to the motor windings until the current reaches the set value. Then the controller reduces the voltage on the motor windings so that the motor current does not exceed the set value.

### 6.3 Setting operating parameters

#### 6.3.1. Motor speed control (SW3 = OFF)

Select the speed setting signal type according to the diagram in Fig. 4:

- internal potentiometer;
- external potentiometer with impedance: 10 kOhm;
- analog signal 0 - 10 V (dead zone 0…100 mV)
- analog signal -10 - +10 V (dead zone ±100 mV)
- analog signal 4 - 20 mA
- PWM signal.

**Built-in potentiometer**. When controlling the 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.

**External potentiometer**. In case of controlling the speed with an external potentiometer, the maximum speed will correspond to the extreme position of the potentiometer, at which a voltage of 5 V is applied to the "SPEED" input. Stopping the motor will correspond to the potentiometer position, at which a voltage of 0 V is applied to the "SPEED" input. External potentiometer parameters: 10 kOhm.

**Analog signal 0...10 V**. In case of applying an external analog signal 0...10 V to the "SPEED" input, the maximum speed corresponds to a signal level of 10 V. Motor stop corresponds to a level of 0 V. Dead zone is 0…100 mV

**Analog signal 4…20 mA**. When controlling the speed with an external current signal 4…20 mA, the maximum speed corresponds to a signal level of 20 mA. The motor stops at a signal level 4 mA.

**Analog signal -10…+10 V**. When controlling the speed with a -10…+10 V analog signal, the motor stops at a signal level of 0 V. The maximum speed in the forward direction corresponds to the signal level +10 V. The maximum speed in the reverse direction corresponds to the signal level -10 V. Dead zone is ±100 mV.

**PWM signal**. When controlling the speed with a PWM signal with a frequency of 16 kHz, the minimum start speed corresponds to a duty cycle of 1%. The maximum speed corresponds to a duty cycle of 100%. The motor stops at a duty cycle of 0%.

### 6.3.2. Motor torque control (SW3 = ON)

Select the torque setting signal type according to the diagram in Fig. 4:

- internal potentiometer;
- external potentiometer with impedance: 10 kOhm;
- analog signal 0 - 10 V (dead zone 0…100 mV)
- analog signal -10 - +10 V (dead zone ±100 mV)
- analog signal 4 - 20 mA
- PWM signal.

**Built-in potentiometer**. When controlling the torque 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 torque and motor current 40A. The extreme counterclockwise position corresponds to the minimum torque and motor current 5A.

**External potentiometer**. In case of controlling the torque with an external potentiometer, the maximum torque and motor current will correspond to the extreme position of the potentiometer, at which a voltage of 5 V is applied to the "SPEED" input. The minimum torque and motor current 5A corresponds to the potentiometer position, at which a voltage of 0 V is applied to the "SPEED" input. External potentiometer parameters: 10 kOhm.

**Analog signal 0...10 V**. In case of applying an external analog signal 0...10 V to the "SPEED" input, the maximum torque and motor current 40A corresponds to a signal level of 10 V. The minimum torque and motor current 5A corresponds to a level 0 V. Dead zone is 0…100 mV

**Analog signal 4…20 mA**. When controlling the torque with an external current signal 4…20 mA, the maximum torque and current 40A corresponds to a signal level of 20 mA. The minimum torque and motor current 5A corresponds to a signal level 4 mA.

**Analog signal -10…+10 V**. When controlling the torque with a -10…+10 V analog signal, the minimum torque and motor current 5A corresponds to a signal level of 0 V. The maximum torque and current value 40A and movement in the forward direction corresponds to the level of +10V. The maximum torque and current value 40A and movement in the reverse direction corresponds to the level of -10V. Dead zone is ±100 mV.

**PWM signal**. When controlling the torque with a PWM signal with a frequency of 16 kHz, the minimum motor torque corresponds to a duty cycle of 0%. The maximum torque corresponds to a duty cycle of 100%.

### 6.3.3. Setting the motor acceleration

Use the built-in potentiometer "Acceleration" 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.

In the torque control mode, the acceleration potentiometer changes only the deceleration time.

Note: if, as a result of acceleration, the controller switches to the alarm state with the error code #2 (refer to the table 2), it is necessary to increase the acceleration time.

### 6.3.4. 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 40 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.

## 6.4. Motor rotation control

After switching on the supply voltage, the device is ready for operation. The LED located on the board is continuously green.

Start/stop and reverse of the motor are carried out by external signals or by pressing buttons on the front panel of the controller. The buttons are activated when released, externals signals can be configured to be activated according to the front or level of the signal.

The controller has the ability to configure the logic for processing the control signals "START/STOP" and "DIR". The control signals are processed by a front or by a level, depending on the position of the microswitches SW1 (START/STOP signal) and SW2 (DIR) on the front panel (see the diagram in Fig. 2).

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

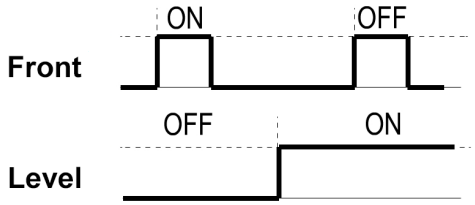



Fig. 5. Control signals START/STOP and DIR – front and level types

### 6.4.1. Motor start / stop

The motor is started and stopped by the "START/STOP" button on the front panel of the controller or by an external signal, when the line connected to the "START" terminal is closed to the signal ground GND. The buttons on the front panel of the device, responsible for controlling the start and change of direction of the motor, operate when the button is released. Fig. 6 shows a diagram of the speed change when controlled by an external "START/STOP" signal by level (SW1 = ON) and a built-in button.

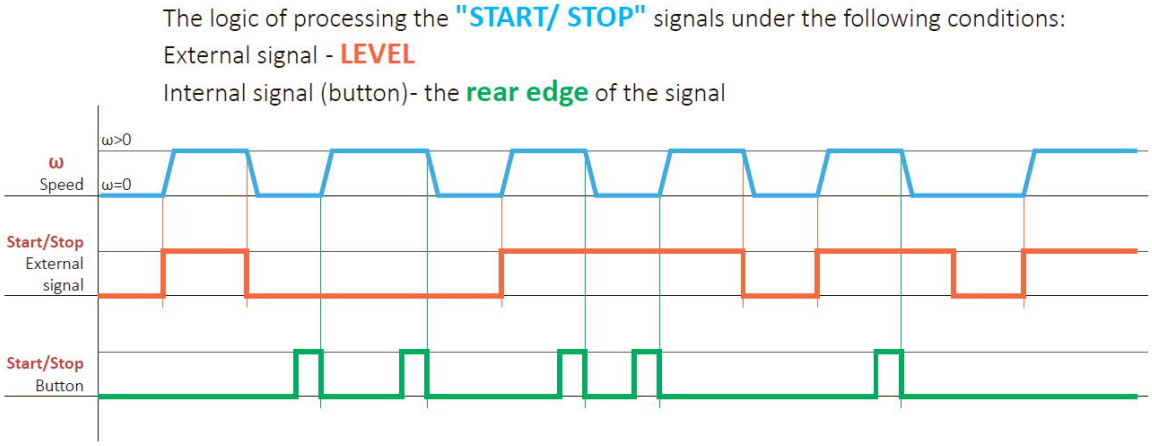



Fig. 6. Diagram of the coordinated operation of the external signal “START/STOP” and the built-in button.

### 6.4.2. Motor direction

The motor rotation direction is changed by the "DIR" button on the front panel of the controller or by an external signal, when the line connected to the "DIR" terminal is closed to the GND signal ground. In the -10…+10V control mode, the DIR button and the external DIR signal are not active. In this case, the direction of rotation is changed by changing the polarity of the voltage. Setting the external "DIR" signal is similar to the START/STOP signal - (see Fig. 2, item 6.4. Fig. 5). The DIR button and signal operate according to the OR logical circuit.

### 6.5 Motor stop method

By default, the controller uses the stop mode with the rotor closed on itself. Stopping with the rotor closed on itself allows to stop the motor rotation in a short period of time. It is possible to use the stop mode with the motor rotor open, the so-called "stop mode with open motor terminals". The mode is switched on by switch SW4 on the front panel: SW4 = ON - stop with open terminals, SW4 = OFF - stop with closed terminals.

### 6.6. 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 GND signal ground. If the contact is disconnected, the controller switches to the emergency mode, the motor stops abruptly and the corresponding error is indicated (refer to the section.6.10).

Exit from the emergency mode is performed by switching off and then on the supply voltage.

### 6.7. Brake control

The controller provides control of a motor electromagnetic brake. When the "BRAKE" signal is applied, the power supply voltage is applied or removed from the "BR+" and "BR-" terminals, depending on the brake type. The brake type is selected by the SW5 microswitch on the front panel.

A normally closed brake holds the motor shaft when there is no voltage on the windings; to release the rotor of the electric motor, it is necessary to apply supply voltage to the electric brake. A normally open brake operates according to the reverse logic: when voltage is applied to the brake windings, the shaft is fixed; when the voltage is removed, the shaft rotates freely.

### 6.8. Automatic brake activation

The controller provides the function to automatically apply the brake. When the motor stops, the brake is automatically applied; when the motor starts running, it is automatically disengaged. Automatic brake application is activated by switch SW6 on the front panel of the device. In the automatic brake application mode (SW6 = ON), the BRAKE signal is not active.

### 6.9. Second speed

The controller has the ability to turn on a preset second speed. The second speed value is adjusted using the "SPEED 2" potentiometer. The second speed is turned on by closing the SECOND SPEED terminal to the GND signal ground. The function is only available in the speed control mode with the built-in potentiometer regulation (SW7=OFF, SW8=OFF, SW9=OFF).

### 6.10. Indication of operating modes and errors

The LED indicator on the front panel displays the controller state.

After applying the supply voltage in the normal mode:

- When the motor is off, the indicator lights up green constantly.
- When the motor is on, the indicator flashes green with a period of approximately 1 sec.

If the red LED lights up and remains lit during operation, this means that the maximum speed has been reached and further speed increasing is impossible.

If some error is detected, the indicator displays the error code with a series of red flashes (Table 2).

Table 2. Status indication.

| Error code | Indication | Description |
|---|---|---|
| 0 | Green on | Normal operation (motor off) |
| 0 | Green flashing | Normal operation (motor on) |
| 1 | Single red flashes | Out of range of internal 12V converter voltage |
| 2 | Series of 2 red flashes | Short circuit in phase |
| 3 | Series of 3 red flashes | Overheating of internal braking circuit |
| 4 | Series of 4 red flashes | Overheating of power keys |
| 5 | Series of 5 red flashes | Emergency stop of the motor (HARD_STOP) |
| 6 | Series of 6 red flashes | Test firmware version |

Note: If a short circuit of the motor phases occurs or its current exceeds 100A for 15 µs, the controller switches to emergency mode with the motor switched off and LED indication.

Note: If the controller switches to the alarm state with the error code #2 as a result of acceleration, it is necessary to increase the acceleration time.

## 7. Delivery in complete sets

DC brush motor controller BMD-40DIN ver.2 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 repair or modifications are performed by the manufacturer or an authorized company.**
The manufacturer guarantees the failure-free operation of the controller for 12 months since date of sale when the operation conditions are satisfied.

The manufacturer sales department address:
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Tallinn Science Park Tehnopol, Akadeemia tee 21/6, 12618, Tallinn, Estonia,
Phone: + 372 6559914,
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Date of sale:

Last modified: 02.10.2024