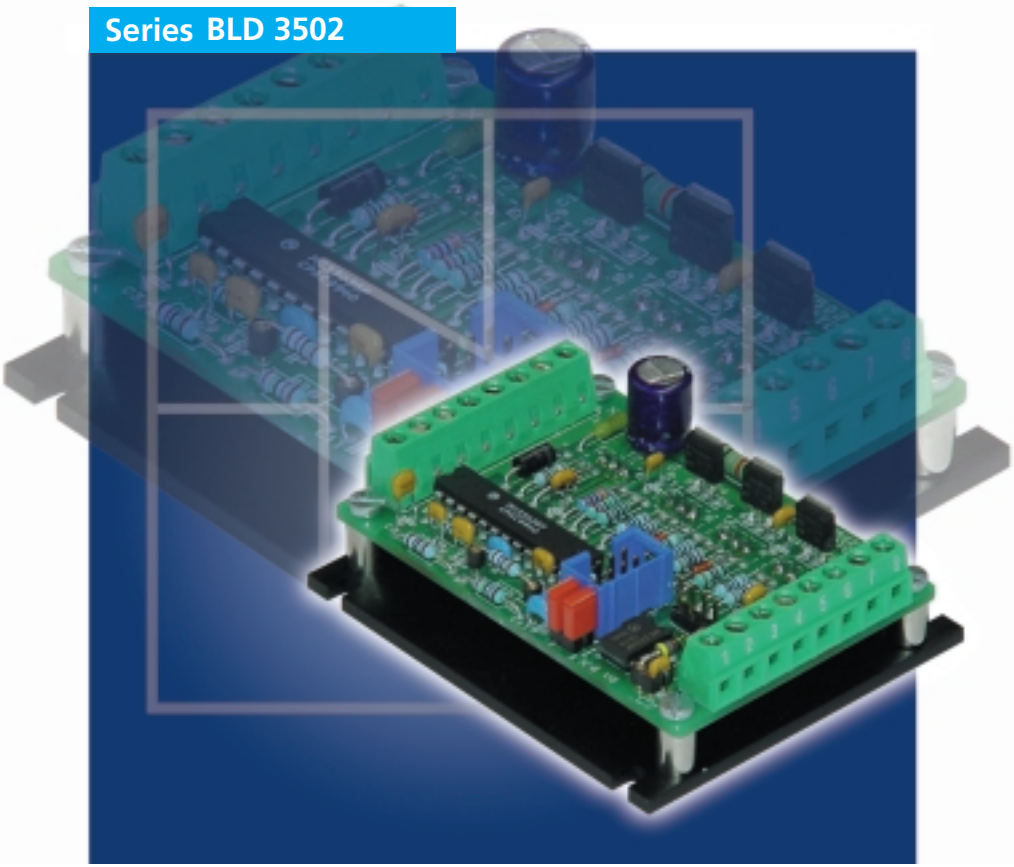
FAULHABER

Servo Amplifier

2-Quadrant PWM for Brushless DC-Servomotors

Series BLD 3502



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Operating Instructions

Index

General information

1. Description

The BLD 3502-SE2P is a 2-Quadrant PWM (Pulse-Width Modulation) Servo Amplifier suitable for speed control of our three-phase brushless DC-Servomotors, type 1628, 2036 and 2444.

The phase commutation sequence of the brushless DC-Servomotor is automatically made by the Servo Amplifier.
A specially designed frequency-to-voltage converter allows precise speed regulation (regulator type P, proportional).

Two amplifier configurations for speed control:
- Hall sensors signals for operation above 1000 rpm;
- Encoder signals for operation down to 100 rpm.

The Servo Amplifier is supplied with Hall sensor configuration as standard.
The analog speed command is a unipolar signal, from 0 to +5 V, (optional 0 to +10 V) producing a fixed speed proportional to the input voltage.
The maximum output power without additional heat sink is 50 W.

2. Illustration

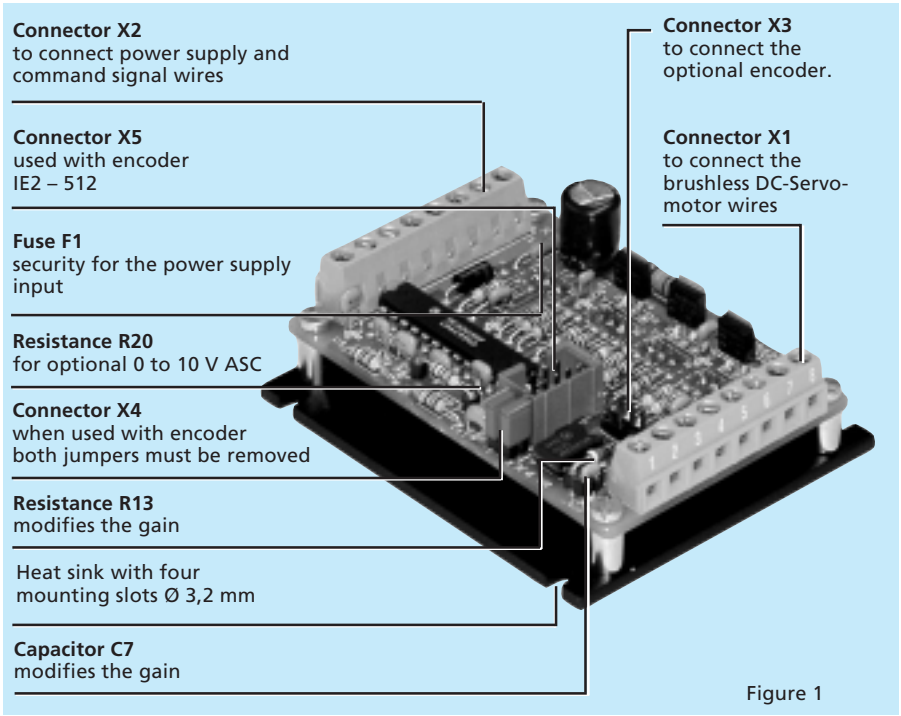


Figure 1

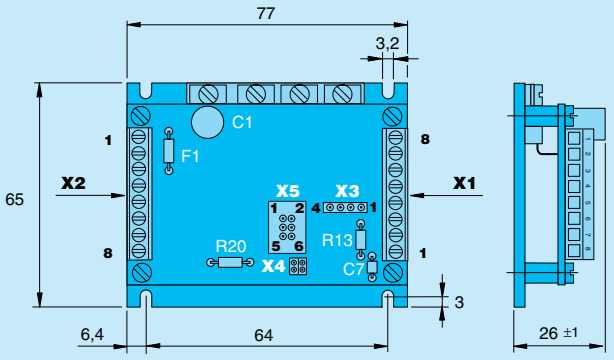
Technical data

3. Maximum ratings		
Power supply	35	V DC
Logic and analog inputs	-0,3 to +10	V DC
Continuous output current @ T_A = 22°C	1,5	A

4. Specific characteristics		
Power Stage:		
– Power supply	12 ÷ 35	V DC
– Total output voltage drop (I_{motor} =2A)	3,8	V DC
Switching frequency	25	kHz
Current limit (pulse-by-pulse current limiting)	3	A
Analog speed command: [1]		
– Voltage range	0 ÷ 5	V DC
– Input resistance	36	kΩ
– Frequency bandwidth	117	Hz
Logic inputs	TTL	
Output voltage for external use (max. load 50 mA)	5,5	V DC
Total standby current without encoder		
(Hall sensors supply included)	55	mA
Maximum controllable speed with Hall sensor [2]	60 000	rpm
Minimum controllable speed with Hall sensor [3]	1 000	rpm
Minimum controllable speed with encoder [3]	100	rpm
Temperature range:		
– Operating temperature	0 ... + 70	°C
– Storage temperature	–20 ... + 80	°C

[1] Analog speed command may be set by an external potentiometer or an external voltage.
[2] The maximum controllable speed depends on the gain of the Servo Amplifier, the power supply, the motor type and the load.
[3] The minimum controllable speed depends on the motor type and the load.

5. Dimensions and weight



Scale reduced

Dimensions
length 77 mm
width 65 mm
height 26 mm

Weight 100 g

Figure 2

General characteristics

6. General characteristics

6.1 Analog Speed command

The speed command is given by an external voltage from 0 to +5 V (optional 0 to +10 V) or by a potentiometer connected directly to the Servo Amplifier (see fig. 5). The total potentiometer resistance must be between 10 kΩ and 47 kΩ.

Furthermore, a PWM signal with a maximum amplitude of 5 V and a minimum frequency of 1 kHz, can be used as speed command.

To control the Servo Amplifier using an analogue speed command voltage **from 0 to +10 V**, it is necessary to change the **R20** resistance value from 18 kΩ (standard) to 5,6 kΩ.

6.2 Direction

The direction of rotation is reversed using either a logic high or low input signal.
If not connected (internal pull-up resistance) or a high input signal is applied, the motor runs in CW direction.
If a low input signal is applied, the motor runs in CCW direction.

6.3 Enable

A high logic at this input causes the motor run.
If not connected (internal pull-up resistance) the Servo Amplifier is enabled.

6.4 Brake

A logic low state (connect to GND) at this input allows the motor to run.

6.5 Power supply internal fuse

An internal **F1** fuse is provided on the print board to protect the Servo Amplifier against:
- power supply polarity inversion
- over-load (over-current).

Fuse specification:
2A / 125V - subminiature fuse / Littelfuse type 251.002HE

6.6 Encoder feedback

The option with encoder allows the two incremental encoder channels to be used to control the motor speed down to 100 rpm.
To use this speed control configuration it is necessary to remove the two jumpers on X4.
Refer to the start-up procedure point 7.3.

General characteristics

6.7 Basic block diagram for speed control with Hall sensor feedback

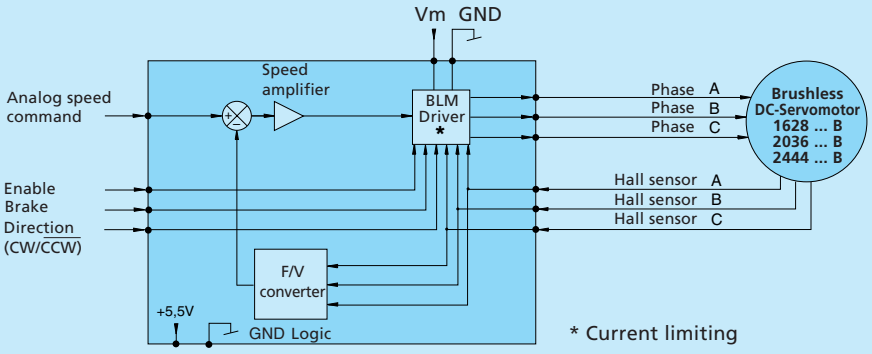


Figure 3

6.8 Basic block diagram for speed control with encoder feedback

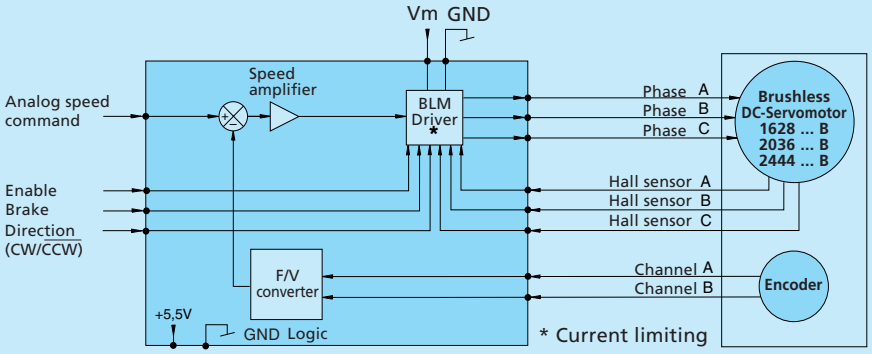


Figure 4

Start-up procedure

7. Start-up procedure

7.1 Brushless DC-Servomotor with Hall sensor feedback (standard)

Procedure	References
- Connect the Servo Amplifier	7.2 Connection diagram
- Connect Brake Pin 7 with GND Logic Pin 3	7.5 Speed range selection
- Select **R13** resistance	
- Power the Servo Amplifier	
- Verify the operation	

7.2 Connection diagram

Figure 5

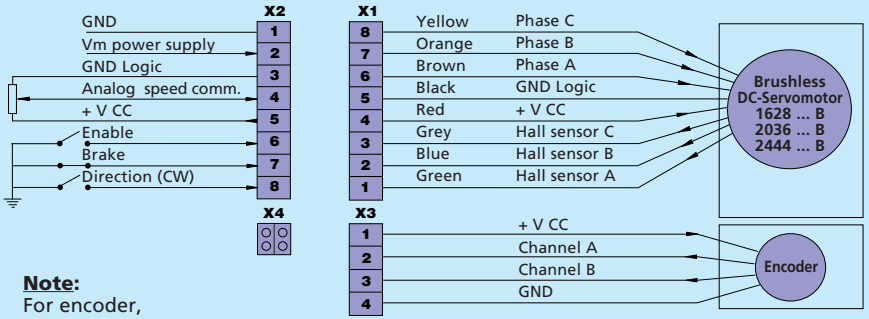
Important: Before connecting it is recommended to read chapter 8.

Start-up procedure

7.3 Brushless DC-Servomotor with encoder feedback (optional)

Procedure	References
- Connect the Servo Amplifier	7.4 Connection diagram
- Connect Brake Pin 7 with GND Logic Pin 3	
- Connect the encoder	
- remove the two jumpers on **X4**	7.6 Speed range selection
- Select **R13** resistance and **C7** capacitor	
- Power the Servo Amplifier	
- Verify the operation	

7.4 Connection diagram



Note:
For encoder, jumpers on **X4** must be removed.

Figure 6

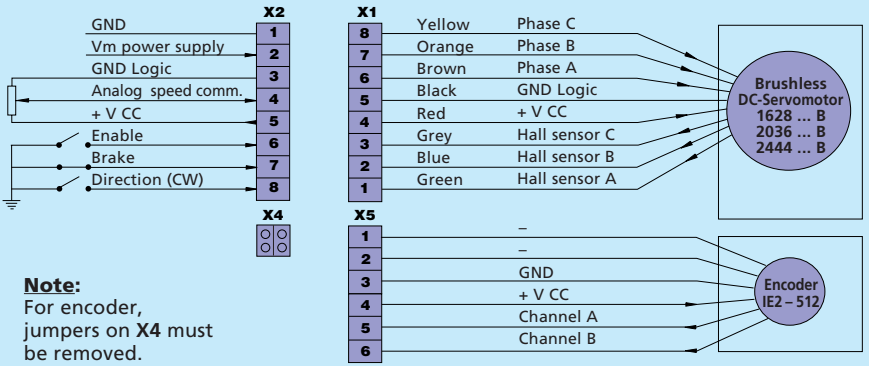
Important: Before connecting it is recommended to read chapter 8.

Start-up procedure

7.5 Brushless DC-Servomotor with encoder IE2 – 512

Procedure	References
- Connect the Servo Amplifier	7.4 Connection diagram
- Connect Brake Pin 7 with GND Logic Pin 3	
- Connect the encoder	
- remove the two jumpers on **X4**	7.6 Speed range selection
- Select **R13** resistance and **C7** capacitor	
- Power the Servo Amplifier	
- Verify the operation	

7.6 Connection diagram



Note:
For encoder, jumpers on **X4** must be removed.

Figure 7

Important: Before connecting it is recommended to read chapter 8.

Start-up procedure

7.7 Speed range selection with Hall sensor feedback

Select **R13** resistance adapted to the specific application also taking the motor characteristics into consideration.

n_{max} [rpm]	**R13** [kΩ]	**Gain** [rpm/V]
60 000	9,1	12 270
50 000	10	10 250
40 000	14	7 720
30 000	16	6 400
26 500	**20**	**5 300**
20 000	27	4 100
15 000	36	2 970
10 000	56	1 970

R13 resistance mounted originally: **20 kΩ / 0,6W / ± 1%**
C7 capacitor mounted originaly: **10 nF / 100V / ± 10%**

n_{max} [rpm] – max. controllable speed (indicatives values)
Gain [rpm/V] – gain factor of Servo Amplifier (tolerance ± 15%); it corresponds to ratio between motor speed and analog speed command voltage.

Application example:

Brushless DC Servomotor type 2444 S 024 B; max. speed of motor requested in this application n_{max} = 12 000 rpm.

1. Selection of **R13** resistance:
   R13 = 36 kΩ; resulting in a max. controllable speed of approx. 15 000 rpm, slightly higher than 12 000 rpm, which allows a wide speed range operation of the motor.

   Note: A resistance value selected between 36 kΩ (15 000 rpm) and 56 kΩ (10 000 rpm) would better define the speed range.

2. The gain value allows to calculate the analog input command for a given speed (speed command = speed / gain).

   Example: For 6 000 rpm the speed command is approx 2 V (speed command = 6 000 / 2 970).

Start-up procedure

7.8 Speed range selection with encoder feedback

Select **R13** resistance and **C7** capacitor adapted to the specific application taking both the motor and encoder characteristics into consideration.

n_{max} [rpm]	**R13** [kΩ]	**C7 [nF]**	**Gain** [rpm/V]
7 700 000 / CPR	2,7	0,18	1 490 000 / CPR
3 800 000 / CPR	6,8	0,18	750 000 / CPR
2 100 000 / CPR	6,8	0,47	400 000 / CPR
1 150 000 / CPR	13	0,47	224 000 / CPR

$n_{max.}$ [rpm] – max. controllable speed;
CPR [-] – number of encoder pulses per revolution;
Gain [rpm/V] – gain factor of servo amplifier; corresponds to ratio between motor speed and speed command voltage.

N.B.: The max. motor speed must not exceed the encoder speed range, i.e.:

$$n_{max.}\,[\text{rpm}] \leq \frac{f_{max}\,[\text{Hz}] \bullet 60}{\text{CPR}\,[\text{-}]}$$

f_{max} [Hz] – max. encoder frequency response.

Notice of use

8. Notice of use

8.1 Power supply

Any unstabilized DC power supply voltage within the servo amplifier range (12 V ≤ Vm ≤ 35 V) may be used, although it is advisable to keep this voltage as low as possible in order to minimize the EMI noise.

Thus the optimum power supply is given by the following relation:

$$V_m\ [V] \approx 5\ [V] + R\ [\Omega] \cdot I_{max}\ [A] + k_E\ [V/rpm] \cdot n_{max}\ [rpm]$$

with: R, k_E = Terminal resistance (phase to phase) and Back-EMF constant of the motor.
I_{max}, n_{max} = Maximum current and speed reached by the motor in your specific application.

8.2 Wiring

A well known disadvantage of Pulse Width Modulation (PWM) is the large amount of interferences generated. This has two consequences, namely perturbations to the environment and self-perturbations.
The EMI is generated by the motor power leads and induced in the Hall sensor wires. The smooth running of the motor is therefore perturbated and even in some cases, the motor will not run at all.

In order to reduce the effect of these perturbations, the following basic rules must be followed:

- Use wires as short as possible;
- Avoid to run signal wires (logic and analog commands, Hall sensor and encoder signals) in close proximity to power lead wires (power supply and motor phases);
- Connect shielded wires to ground at one end only to avoid ground loops.

Special care should be given to the motor connection. The following table shows the different solutions:

Notice of use

Action	To	From	Self	Length
1. No special care	no	no	no	0.3 m
2. Twisted wires (see figure 7)	slightly	slightly	slightly	1.0 m
3. Shielded Hall sensor wires (see figure 8)	no	yes	yes	5.0 m
4. Shielded Hall sensor and phases wires (see figure 9)	yes	yes	yes	5.0 m

To: perturbations To environment reduced
From: perturbations From environment reduced
Self: self-perturbations reduced
Length: maximum cable length

Encoder wiring
For wires less than 1.0 m long no particular precautions are required.
For wires longer than 1.0 m the use of shielded cable (as for the Hall sensors) is recommended.

If wires are longer than 0.3 m, it is recommended to use the following cable sections:

Phase, brushless DC-Servomotors type 1628: 0.5 mm^2 / AWG 20;
Phase, brushless DC-Servomotors type 2036: 1.0 mm^2 / AWG 18;
Phase, brushless DC-Servomotors type 2444: 1.0 mm^2 / AWG 18;
Hall sensors or Encoder for DC-Servomotors type 1628, 2036 and 2444: 0.5 mm^2 / AWG 20;

Note: If wires are longer than 5 m please consult us.

Twisted wires

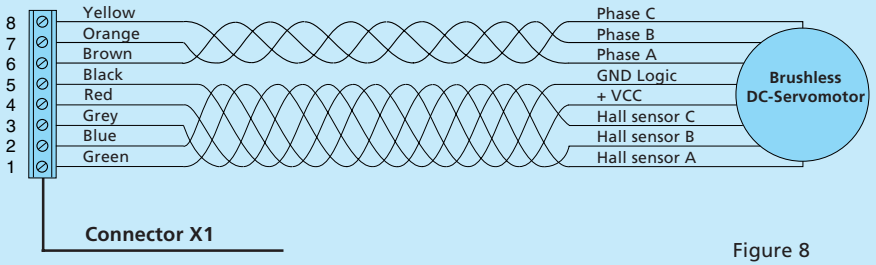


Figure 8

Shielded Hall sensor wires

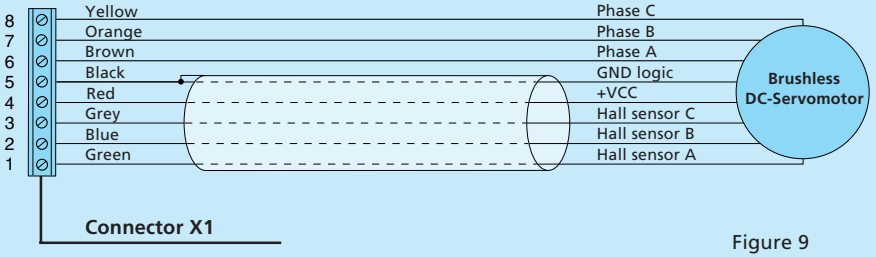


Figure 9

Shielded phase and Hall sensor wires

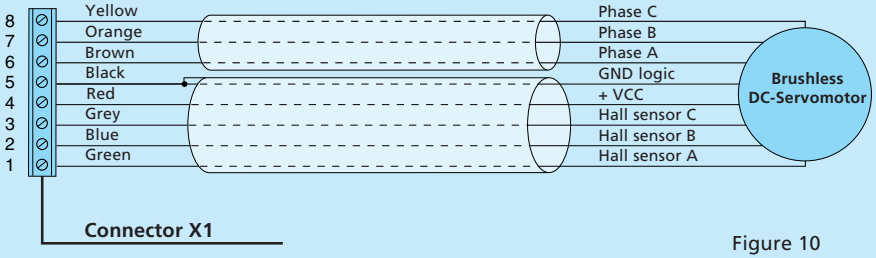


Figure 10

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