

The DEC (**D**igital **E**C **C**ontroller) is a 1-quadrant amplifier for controlling electronically commutated (brushless) DC motors.

- Digital speed control
- Maximum speed: 120,000rpm (2-pole motor)
- Operates as speed control, current control or open loop speed control
- /Brake, direction and /disable input
- AUX connection: adjustable function (+5V output or input for changing speed)
- Status indicator with red and green LED
- Set value input through built-in potentiometer (several speed ranges can be selected) or through analogue set value input (0...5V)
- Maximum current limit adjustable
- Gain can be adjusted in two stages
- Adjustable speed ramp
- Protection against heat overload
- Blockage protection (current limit for blocked motor)
- Plug-in terminal clamp



Table of Contents

1	Safety Instructions	2
2	Performance Data.....	3
3	Minimum External Wiring for Different Modes of Operation	4
4	Operating Instructions.....	6
5	Inputs and Outputs	8
6	Switch Functions.....	12
7	Maximum Speed	12
8	Potentiometer Functions.....	13
9	Operating Status Display	14
10	Protection.....	15
11	EMC-compliant Installation	15
12	Block Diagram	16
13	Dimension Drawing.....	16

The latest edition of these operating instructions may be found in the internet under <http://www.maxonmotor.com> («Downloads» in the category «Service»)

1 Safety Instructions

**Skilled Personnel**

Only experienced, skilled personnel should install and start the equipment.

**Statutory regulations**

The user must ensure that the amplifier and the components belonging to it are assembled and connected according to local statutory regulations.

**Load disconnected**

For initial operation, the motor should be free running, i.e. with the load disconnected.

**Additional safety equipment**

Any electronic apparatus is, in principle, not fail-safe. Machines and apparatus must therefore be fitted with independent monitoring and safety equipment. If the equipment breaks down, if it is operated incorrectly, if the control unit breaks down or if the cables break, etc., it must be ensured that the drive or the complete apparatus is kept in a safe operating mode.

**Repairs**

Repairs may only be carried out by authorised personnel or the manufacturer. It is dangerous for the user to open the unit or carry out any repairs.

**Danger**

Ensure that no apparatus is connected to the electrical supply during installation of the DEC 50/5. After switching on, do not touch any live parts!

**Max. supply voltage**

Make sure that the supply voltage is between 10 and 50VDC. Voltages higher than 60VDC or of wrong polarity will destroy the unit.

**Short circuit and earth fault**

The amplifier is not protected against:
winding short circuits, winding short circuits against ground safety earth or Gnd!

**Electrostatic sensitive device (ESD)**

2 Performance Data

2.1 Electrical data

Supply voltage V_{CC} (Ripple <5%)	10...50VDC
Max. output voltage	$0.95 \cdot V_{CC}$
Continuous output current I_{cont}	5A
Max. output current I_{max}	10A
Switching frequency	39kHz
Max. speed (motor with 2 poles)	120,000rpm

2.2 Inputs

Speed	analogue input (0...5V) Resolution: 1,024 steps
/Disable	TTL, CMOS (5V) or switch against Gnd
Direction	TTL, CMOS (5V)) or switch against Gnd
/Brake	TTL, CMOS (5V)) or switch against Gnd
Hall sensor	1, 2, 3

2.3 Inputs / outputs

AUX (configurable)	digital input / +5VDC output
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2.4 Voltage outputs

Hall sensors supply voltage V_{CC} Hall	7...12VDC, max. 30mA
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2.5 Motor connections

Motor winding 1
Motor winding 2
Motor winding 3

2.6 Trim potentiometers

Speed 1, Speed 2 / Ramp, I_{max} , gain

2.7 LED indicator

Operating indicator: green LED
Error indicator: red LED

2.8 Ambient temperature / humidity range

Operation.....	-10 ... +45°C
Storage.....	-40 ... +85°C
No condensation	20 ... 80%

2.9 Protective functions

Heat monitoring of power stage	$T > 100^{\circ}\text{C}$
Blockage protection.....	Motor current limit, if motor shaft is blocked for longer than 1.5s

2.10 Mechanical data

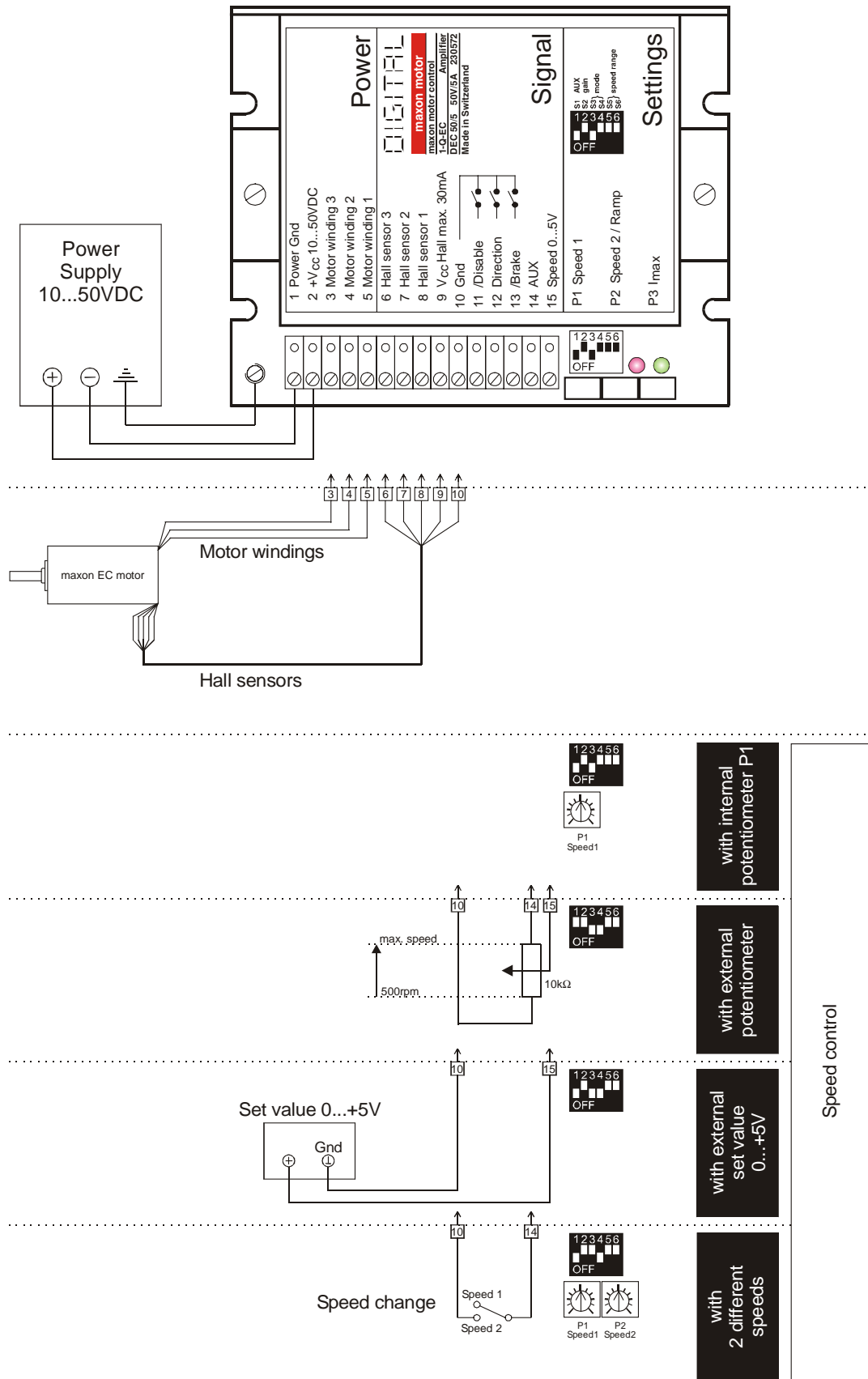
Weight	approx. 155g
Dimensions (LxWxH).....	95 x 75 x 24mm
Mounting plate.....	for 4 screws M3
Mounting hole separation	87 x 39mm

2.11 Terminals

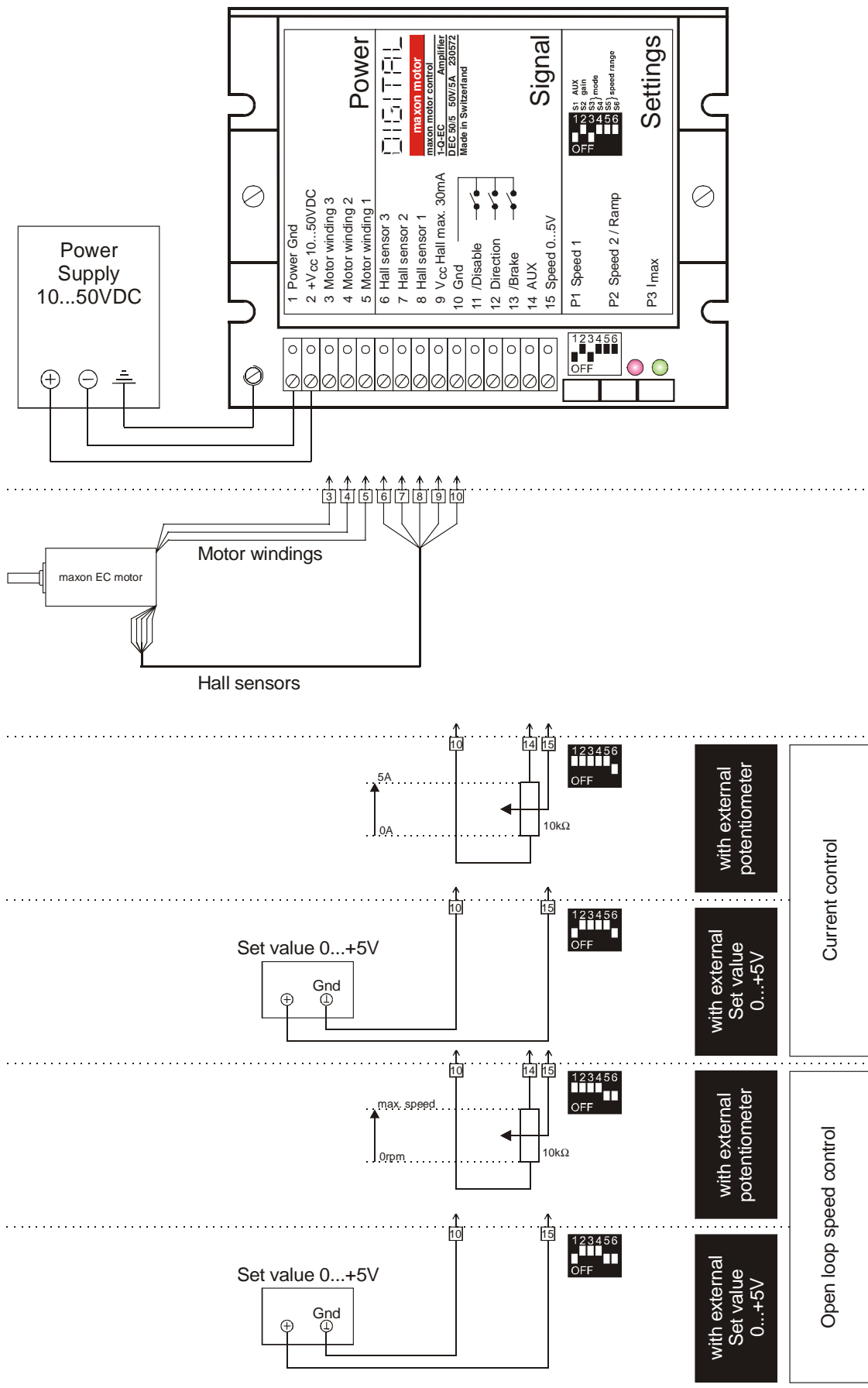
PCB clamps (plug-in terminal clamps)	15 poles
Pitch.....	3.5mm
suitable for wire cross section	0.14...1mm ² multiple-stranded or 0.14...1.3mm ² single wire AWG 16-26

3 Minimum External Wiring for Different Modes of Operation

3.1 Speed control



3.2 Current control and open loop speed control



4 Operating Instructions

4.1 Power supply layout

Any available power supply can be used, as long as it meets the minimum requirements set out below.

During set up and adjustment phases, we recommend separating the motor mechanically from the machine to prevent damage from uncontrolled motion.

Power supply requirements

Output voltage	V_{cc} min. 10VDC; V_{cc} max. 50VDC
Ripple	<5%
Output current	depending on load, continuous max. 5A acceleration, short-time max. 10A

The required voltage can be calculated as follows:

Known values:

- Operating torque M_B [mNm]
- Operating speed n_B [rpm]
- Nominal motor voltage U_N [V]
- Motor no-load speed at U_N , n_0 [rpm]
- Speed/torque gradient of motor $\Delta n/\Delta M$ [rpm/mNm]

Sought values:

- Supply voltage V_{cc} [V]

Solution:

$$V_{cc} = \frac{U_N}{n_0} \cdot \left(n_B + \frac{\Delta n}{\Delta M} \cdot M_B \right) \cdot \frac{1}{0.95} + 1V$$

Choose a power supply capable of supplying this calculated voltage under load. The formula takes into account a max. PWM cycle of 95% and a 1 volt max. voltage drop at DEC 50/5.

Note:

Please note chapter 5.1.5, "/Brake" function when using the "/brake" input!

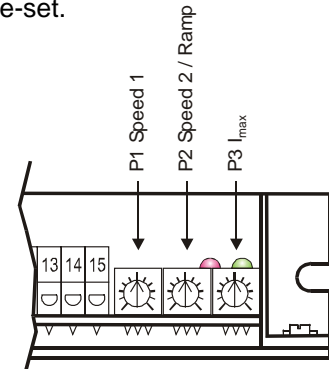
4.2 Adjusting the potentiometers

4.2.1 Pre-adjustment

With the pre-adjustment, the potentiometers are set in a preferred position.

DEC units in the original packing are already pre-set.

Pre-adjustment of potentiometers		
P1	Speed 1	50%
P2	Speed 2 / Ramp	50%
P3	I_{\max}	50%



Note:

Left end stop of potentiometers:	Minimum value
Right end stop of potentiometers:	Maximum value

4.2.2 Adjustment

Digital speed control

1. Depending on operating mode selected, predetermine set value so that required speed is reached. If necessary, adjust max. speed with switch S5 and S6 (see chapter 7, "Maximum Speed").
2. Adjust potentiometer **P3 I_{\max}** to required limiting value.
Maximum current in the 0...10A range can be adjusted in linear fashion with potentiometer P3.
3. Adjust switch **S2 gain** to required amplification
(S2 'off': gain high, S2 'on': gain low)
Important: If the motor is unsteady, vibrates or makes noises, the selected amplification is too high. Switch S2 must be set at 'on'.

Digital current control

1. Adjust potentiometer **P1 Speed 1** to required speed limit. Maximum speed in the 500rpm...25,000rpm range can be adjusted in linear fashion with potentiometer P1.
2. Predetermine set value at "Speed" input so that required torque is reached.

Note:

A set value in the 0...5V range at the "Speed" input is equal to a current adjustment range of approx. 0...5A.

Band width of current control: approx. 15Hz

Digital open loop speed control

1. Predetermine set value at "Speed" input so that required speed is reached.
2. Adjust potentiometer **P3 I_{\max}** to required limiting value.
Maximum current in the 0...10A range can be adjusted in linear fashion with potentiometer P3.

5 Inputs and Outputs

5.1 Inputs

5.1.1 Set value "Speed"

The analogue set value is predetermined at the "Speed" input.
The set value input is used for the following operating modes: speed control, current control and open loop speed control.
The "Speed" input is protected against overvoltage.

Input voltage range	0...+5V (ref: Gnd)
Input impedance	>1M Ω (in the 0...+5V range)
Continuous overvoltage protection	-50...+50V

Use of external potentiometer

When using an external potentiometer, the AUX output (switch S1 AUX 'on') can be used as +5V reference.

Recommended resistance value of potentiometer: 10k Ω

5.1.2 "/Disable"

Disabling the power stage. If the input is placed at Gnd-potential, the power stage is blocked and the motor freewheels and slows down. If the input is not wired up or the applied voltage is greater than 2.4V, the amplifier is activated. A speed ramp will be performed during acceleration.
The "/Disable" input is protected against overvoltage.

Input voltage range	0...+5V
Input impedance	33k Ω pull-up resistor at +5V
Continuous overvoltage protection	-50V...+50V
Delay time	approx. 12ms

"/Disable" active	Input open or input voltage >2.4V
"/Disable" inactive	Set input to Gnd or input voltage <0.8V

Note:

If the switch adjuster was changed, the new settings are adopted through a disable-enable procedure.

5.1.3 "Direction"

When the level changes, the motor slows down in an uncontrolled fashion (as windings are short-circuited, see also chapter 5.1.5, "/Brake" function) and accelerates in the opposite direction, until the nominal speed is reached again. A speed ramp is only used during acceleration.

The "Direction" input is protected against overvoltage.

Input voltage range	0...+5V
Input impedance	33kΩ pull-up resistor at +5V
Continuous overvoltage protection	-50V...+50V
Delay time	approx. 12ms

Clockwise (CW)	Input open or input voltage >2.4V
Counter-clockwise (CCW)	Set input to Gnd or input voltage <0.8V



If the direction is changed with a rotating motor shaft, the limitations described in chapter 5.1.5, "/Brake" function" must be observed, or the amplifier may be damaged.

5.1.4 Ramp function

The ramp function enables the motor speed to have a controlled run-up when it starts up and if set values change.

Acceleration time is adjusted at the potentiometer P2 Ramp and relates to the maximum speed in the currently chosen speed range (see chapter 7, "Maximum Speed").

adjustable acceleration time on the potentiometer P2 Ramp	approx. 20ms...approx. 10s
Left end stop	approx. 20ms
Right end stop	approx. 10s
Pitch	linear approx. 1.0s / pitch

Example:

Potentiometer P2 Ramp: 40%

Change in „Speed“ set value: 0V to 3V

Acceleration time to rated speed

$$\text{Acceleration time} = \frac{3V}{5V} \cdot 40\% \cdot 10s = \text{approx. } 2.4s$$

Note:

The minimum acceleration time can only be reached if the gain is high and the drive sufficiently dynamic.

5.1.5 "/Brake" function

When the /brake function is activated, the motor shaft slows down to a halt, short-circuiting the motor windings. The motor windings remains short-circuited until the /brake function is deactivated.

The /brake function is also used with an active /disable function.

The "/Brake" input is protected against overvoltage.

Input voltage range	0...+5V
Input impedance	33kΩ pull-up resistor at +5V
Continuous overvoltage protection	-50V...+50V
Max. brake current	30A
Delay time	approx. 12ms
"/Brake" inactive	Input open or input voltage >2.4V
"/Brake" active	Set input to Gnd or input voltage <0.8V.

The maximum permitted brake speed is limited by the maximum permitted short-circuit current and maximum kinetic energy:

- $I \leq 30A$
- $W_k \leq 20Ws$

the values can be calculated as follows:



max. permitted brake speed limited by brake current ($I = 30A$)

The maximum permitted brake speed can be calculated from the motor data:

$$n_{\max} = 30A \cdot k_n \cdot (R_{ph-ph} + 0.05\Omega) \quad [rpm]$$

k_n = Speed constant [rpm/V]

R_{Ph-Ph} = Terminal resistance phase-phase [Ω]



max. permitted brake speed limited by kinetic energy ($W_k = 20Ws$)

With the given moment of inertia, the maximum speed can be determined using the following formula:

$$n_{\max} = \sqrt{\frac{36.5 \cdot 10^9}{J_R + J_L}} \quad [rpm]$$

J_R = Rotor inertia [$g \cdot cm^2$]

J_L = Load inertia [$g \cdot cm^2$]

5.1.6 "AUX"

The "AUX" terminal can be used as input or output, depending on the switch position.
The "AUX" terminal is only protected against overvoltage if switch S1 is open.

Switch S1 closed	Function	Voltage output
	Output voltage	+5VDC $\pm 5\%$
	Internal resistance	220 Ω
	Output current, designed for an external potentiometer $\geq 10\text{k}\Omega$	500 μA
Switch S1 opened	Function	Speed change
	Input voltage range	0...+5V
	Input impedance	33k Ω pull-up resistor at +5V
	Continuous overvoltage protection	-50V...+50V
	Speed setting with potentiometer Speed 1	Input open or input voltage >4.0V
	Speed setting with potentiometer Speed 2	Set input to Gnd or input voltage <1.0V.

5.1.7 "Hall sensor 1", "Hall sensor 2", "Hall sensor 3"

Hall sensors are needed for detecting rotor position.
"Hall sensor" inputs are protected against overvoltage.

Input voltage range	0...+5V
Input impedance	15k Ω pull-up resistor at +5V
Voltage value „low“	max. 0.8V
Voltage value „high“	min. 2.4V
Continuous overvoltage protection	-50V...+50V

Suitable for Hall effect sensors IC using Schmitt trigger and open collector output.













5.2 Outputs

5.2.1 "V_{cc} Hall"





Powering the Hall sensors.

Output voltage	7V...12VDC
Max. output current	30mA (current limited)

6 Switch Functions





				speed range (motor with 2 poles)
500rpm ... 6,000rpm	500rpm ... 25,000rpm	500rpm ... 60,000rpm	500rpm ... 120,000rpm	
				mode
Speed control with 2 different speeds	Speed control with internal potentiometer P1	Speed control with external set value	Current control or open loop speed controller	
	Gain ¹⁾			gain
low			high	
1) Gain is only adjustable in mode "speed control"				
	Connection AUX			AUX
Input: Speed change between 2 speeds			Output: +5V	

7 Maximum Speed

Switch S5 and S6	Type of motor		
	Motor with 2 poles	Motor with 8 poles	Motor with 16 poles
	6,000rpm	1,500rpm	750rpm
	25,000rpm	6,250rpm	3,125rpm
	60,000rpm	15,000rpm	7,500rpm
	120,000rpm	30,000rpm	15,000rpm



8 Potentiometer Functions

The following table shows which potentiometer is active in which operating mode.

Function of potentiometers	Mode							
	Speed control (closed loop)				Current control		Open loop speed control	
	Set value with internal potentiometer P1	Set value with external potentiometer	With external set value 0...+5V	With 2 different speeds	Set value with external potentiometer	With external set value 0...+5V	Set value with external potentiometer	With external set value 0...+5V
 P1 Speed1	✓			✓	✓	✓		
 P2 Speed2				✓				
 P2 Ramp	✓	✓	✓					
 P3 I_{max}	✓	✓	✓	✓			✓	✓

9 Operating Status Display

Red and green LEDs show the operating status.




Definition	
	LED on
	LED off

9.1 No LED

Reason:

- No supply voltage
- Fuse blown
- Wrong polarity of supply voltage
- Hall sensors supply voltage V_{cc} Hall is short-circuited

9.2 Green LED

Flashing type (green LED)	Operating status
 LED on	Amplifier active
	/Disable function active
	/Brake function active

9.3 Red LED flickers or flashes intermittently





The controller recognises invalid conditions in the Hall sensor inputs.

Reason:

- Hall sensors not connected or incorrectly connected
- Intermittent Hall sensor supply lines
- Excessive interference to Hall sensor supply lines
(Solution: change supply line feeds, use shielded cable)
- Faulty Hall sensors in motor

9.4 Red LED flashes regularly

The following error messages can be distinguished depending on flashing type:

Flashing type (red LED)	Error message
	Thermal overload protection is active
	<ul style="list-style-type: none"> • Motor shaft is blocked • Load too great • I_{max} setting too low • No winding connection
	When switched on, the controller recognises invalid conditions in the Hall sensor inputs => check Hall sensor wiring and Hall sensor signals
	An invalid operating mode was set on switches S3-S6

10 Protection

10.1 Protection against heat overload

If the power stage temperature exceeds a limit of around 100°C for longer than 1.5s, the output stage is switched off.

The error mode is shown in diagram form (see chapter 9 "Operating Status Display").

If the power stage temperature falls below 80°C, the motor is restarted. A speed ramp will be performed during acceleration.

10.2 Blockage protection

If the motor shaft is blocked for longer than 1.5s, the current limit is set at 4.2A, provided the current limit was not set at a lower value via the I_{\max} potentiometer.

Note:

The blockage protection is not active in current control mode.

11 EMC-compliant Installation

HF blocking

HF current blocking generally improves resistance to interference compared to external interference couplings by means of a ferrite toroidal core in a line (power or signal line).

Shield earthing

The earth impedance must have the lowest possible resistance. A taphole on the amplifier's housing is suitable for this purpose.

Connecting cable

Power and signal lines must generally be installed as screened lines on a low-coupling basis and without looping.

"Power" terminal clamps

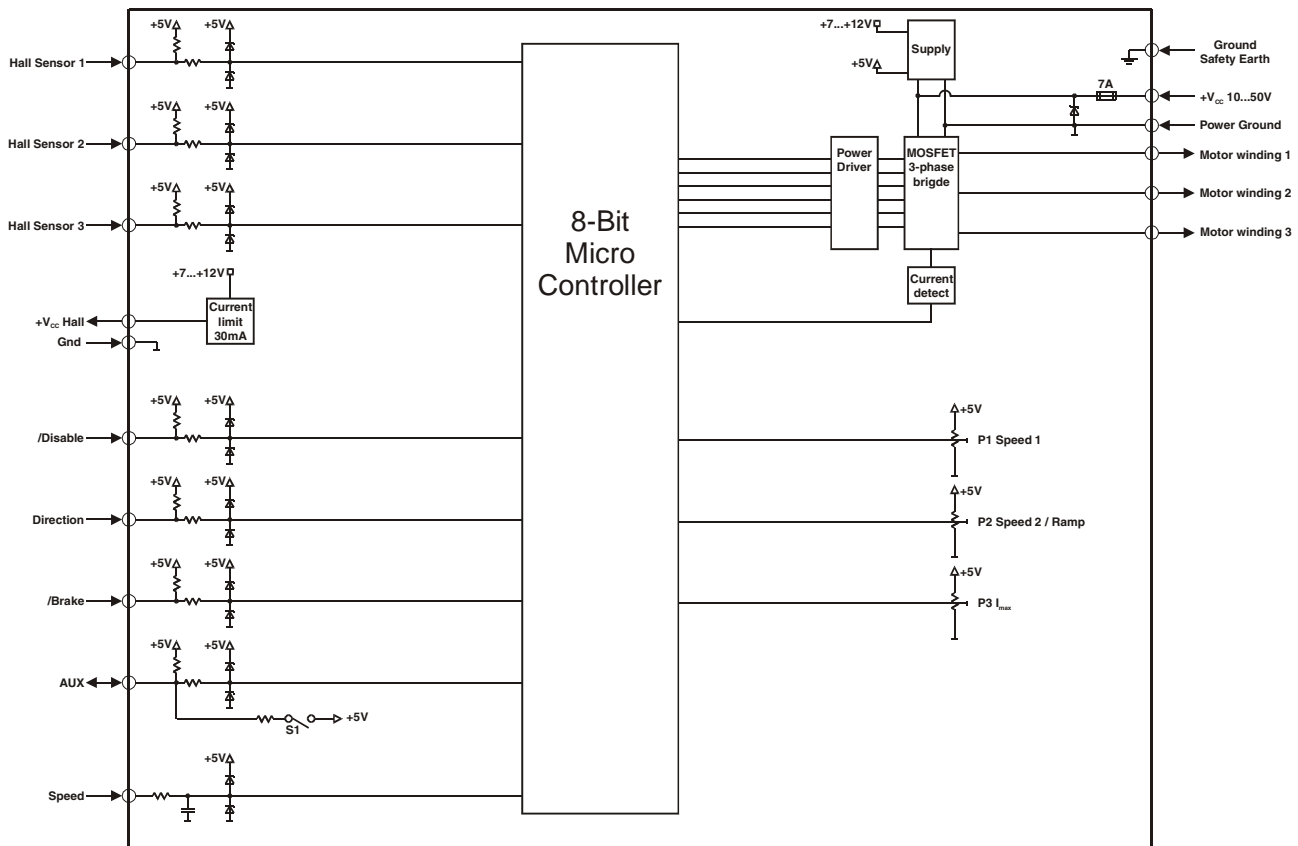
A screened cable should be used to minimise noise emissions. The screen must be connected to the amplifier side and also coupled with the motor on the motor side, via the plug casing wherever possible.

"Signal" terminal clamps

Signal lines for sensitive analogue signals must also be screened. The signal lines' screen should be earthed on one side, the amplifier's side.

In practical terms, only the complete unit, comprising all individual components (motor, amplifier, power supply unit, EMC filter, cabling etc) can be subjected to an EMC test in order to ensure noise-free and CE-approved operation.

12 Block Diagram



13 Dimension Drawing

Dimensions in [mm]

