

Operating Instructions

Edition September 2010

Order Number: 353518, 353516, 353519, 353517, 350909, 352886, 370425, 370424, 353526, 353524, 350910, 352887, 370427, 370426

The EC 45 flat motor with integrated electronics is a brushless, speed-controlled 1-quadrant drive. The EC 45 flat can be supplied in a 30 watt or 50 watt version.

Functions:

- Commutation with Hall sensors
• Digital speed control
• Speed range: 200 rpm – 7000 rpm (depends on variation)
• Current restriction fixed
• Overvoltage and undervoltage switch-off
• Overvoltage protection
• Blockage protection, temperature monitoring
• Inverse polarity protection

2-wire version

- Speed proportionate to input voltage

5-wire version

- Speed set value target through analog signal 0 ... 10 V
• 2-wire operation possible
• Versions: - «Enable» TTL level compatible
- Direction pre-selection «cw/ccw» TTL level compatible
• Speed monitor supplies frequency signal proportionate to speed



Table of contents

1 Safety instructions 2
2 Technical data 3
3 Minimum wiring 7
4 Description of function inputs and outputs 5-wire version 10
5 Description of function 2-wire version 13
6 Protective functions 14
7 Assembly instructions 15
8 EMC-compliant installation 15
9 Error finding 16
10 Dimensions 17
11 Glossary 18

These instructions are available on the Internet as a PDF file at www.maxonmotor.com, under “Service & Down-

1 Safety instructions



Skilled personnel

Only skilled, experienced personnel should install and start the equipment



Statutory regulations

The user must ensure that the EC 45 flat with integrated electronics and the components belonging to it are assembled and connected according to local statutory regulations.



Additional safety equipment

Any electronic equipment is, in principle, not fail-safe. Machinery and equipment should therefore be fitted with equipment-independent monitoring and safety features. There must be guarantees that the drive or the entire piece of equipment can be run safely if the equipment fails, if it is used incorrectly, if the control unit fails, if the cable breaks etc.



Repairs

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



Danger

Users must ensure that no apparatus is connected to the electrical supply during installation of the EC 45 flat with integrated electronics! After switching on, do not touch any live parts!



Max. supply voltage

Make sure that the supply voltage is between 10 VDC and 28 VDC. Permanently switched on voltages above 30 VDC destroy the unit.



Electrostatic sensitive components

During transportation, assembly and operation, contact of the EC 45 flat with integrated electronics with electrostatically charged components or persons must be avoided. The integrated electronics can be destroyed by electrostatic discharges.



Temperature

The temperature of the housing, flange or components may exceed 60°C during operation.

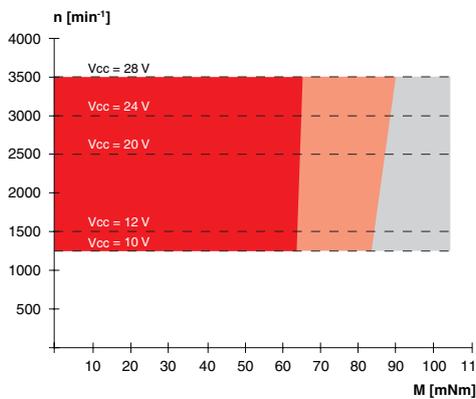
2 Technical data

2.1 Order number

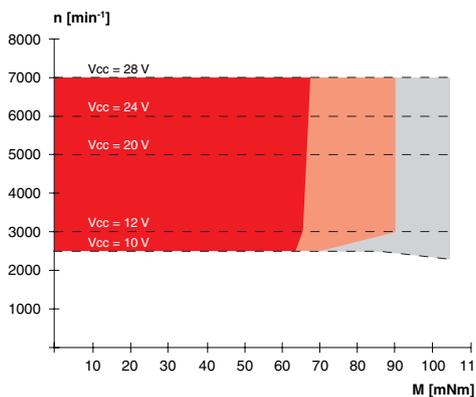
353518 (IP40), 353516 (IP00)	2-wire version, nominal speed 3000 rpm, 30 Watt
353519 (IP40), 353517 (IP00)	2-wire version, nominal speed 6000 rpm, 30 Watt
350909 (IP40), 352886 (IP00) «Enable»	5-wire version, nominal speed 6000 rpm, 30 Watt
370425 (IP40), 370424 (IP00) «CW/CCW»	5-wire version, nominal speed 6000 rpm, 30 Watt
353526 (IP40), 353524 (IP00)	2-wire version, nominal speed 3000 rpm, 50 Watt
350910 (IP40), 352887 (IP00) «Enable»	5-wire version, nominal speed 4500 rpm, 50 Watt
350910 (IP40), 352887 (IP00) «CW/CCW»	5-wire version, nominal speed 4500 rpm, 50 Watt

2.2 Motor data 30 Watt at 24VDC

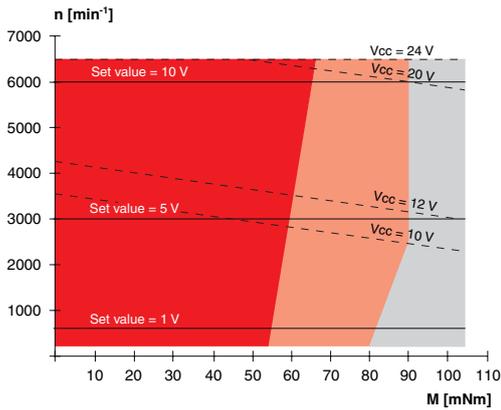
Order number IP40 (with housing)	353518	353519	350909 370425	352886 370424			
Order number IP 00 (without housing)	353516	353517					
Nominal voltage	VDC	24	24	24	24	24	24
No load speed	rpm	3000	3000	6000	6000	6000	6000
No load current	mA	105	105	222	222	222	222
Nominal speed	rpm	3000	3000	6000	6000	6000	6000
Nominal torque	mNm	65	91	67	91	67	91
Nominal current	mA	1200	1800	2400	3000	2400	3000
Max. torque	mNm	106	106	104	104	104	104
Max. current	mA	2100	2100	3600	3600	3600	3600
Max. efficiency	%	71	71	73	77	73	77



Picture 1: Operating range $n = f(M)$
2-wire version, nominal speed 3000 rpm, order number 353518, 353516



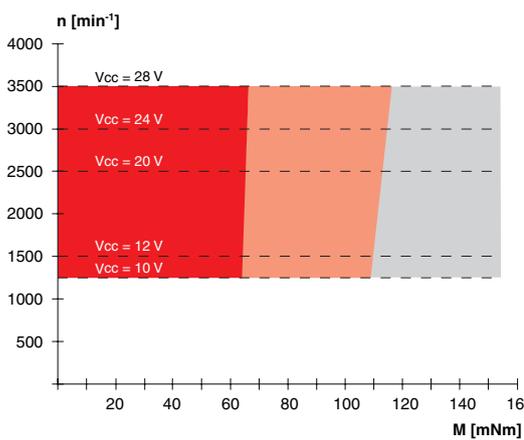
Picture 2: Operating range $n = f(M)$
2-wire version, nominal speed 6000 rpm, order number 353519, 353517



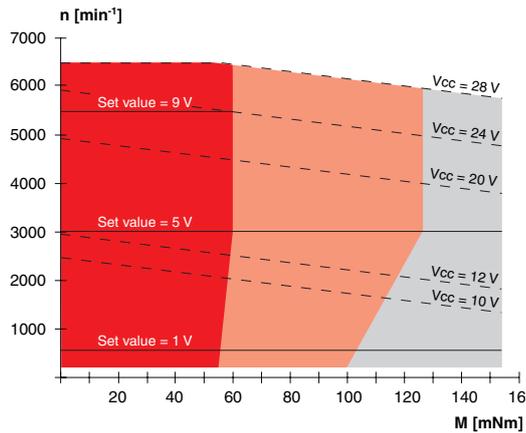
Picture 3: Operating range $n = f(M)$
 5-wire version, order number 350909, 352886, 370425, 370424
 If the supply voltage is reduced, the torque and/or speed may change.

2.3 Motor data 50 Watt at 24VDC

Order number IP40 (with housing)		353526		350910 370427	
Order number IP00 (without housing)			353524		352887 370426
Nominal voltage	VDC	24	24	24	24
No load speed	rpm	3000	3000	4500	4500
No load current	mA	127	127	192	192
Nominal speed	rpm	3000	3000	4500	4500
Nominal torque	mNm	66	123	71	116
Nominal current	mA	1200	2400	2000	3000
Max. torque	mNm	154	154	154	154
Max. current	mA	3300	3300	3800	3800
Max. efficiency	%	74	74	79	79



Picture 4: Operating range $n = f(M)$
 2-wire version, nominal speed 3000 rpm, order number 353526, 353524



Picture 5: Operating range $n = f(M)$

2-wire version, nominal speed 6000 rpm, order number 350910, 352887, 370427, 370426

2.4 Controller data

Version		2-wire 3000 rpm	2-wire 6000 rpm	5-wire 4500 rpm 6000 rpm
Nominal speed				
Control variable		speed	speed	speed
Supply voltage V_{CC}	V	10 ... 28	10 ... 28	10 ... 28
Speed set value input	V	= V_{CC}	= V_{CC}	0.33 ... 10.8
Scale speed set value input	rpm/V	125	250	600
Speed range	rpm	1250 ... 3500	2500 ... 7000	200 ... 6480
Max. acceleration	rpm/s	3000	6000	6000
Direction of rotation (CW = clockwise)		CW	CW	CW
Direction of rotation presetting «cw/ccw»				ccw/ccw

2.5 Thermal data

Version		30 Watt	50 Watt
Thermal resistance housing-ambient	K/W^{-1}	5.8 (3.5)	5.8 (2.4)
Thermal resistance winding-housing	K/W^{-1}	5	4
Thermal time constant winding	s	25	27
Thermal time constant motor	s	650 (400)	290 (116)
Max. permissible winding temperature	$^{\circ}\text{C}$	+125	+125
Max. temperature of electronics	$^{\circ}\text{C}$	+105	+105

2.6 Mechanical data (preloaded ball bearings)

Version		30 Watt	50 Watt
Rotor inertia	gcm^2	135	193
Axial play at axial load	< 2 N	0	0
	> 2 N	0.14	0.14
Radial play		preloaded	preloaded
Max. axial load	(dynamic)	6.8	6.8
Max. axial load	(static)	95	95
	static, shaft supported)	1000	1000
Max. radial load	5 mm from flange	51	54
Weight of motor	gr	226	260

2.7 Connection (input/output)

Cable	Description	Connection	Value
Red	Operating voltage V_{CC}	Supply	10 ... 28 VDC
Black	Gnd	Supply	Ground
White (only 5-wire operation)	Speed set value input	Input	0.33 ... 10.8 VDC
Green (only 5-wire operation)	Monitor speed n	Output	6 counts per turn
Version Enable grey (only 5-wire operation)	«Enable»	Input	2.4 ... 28 VDC
Version Direction grey (only 5-wire operation)	«cw/ccw»	Input	2.4 ... 28 VDC
Wire size			AWG 18/24 $\hat{=}$ 0.86/0.22mm ²

2.8 Protective functions

Inverse-polarity protection	up to max. 30 VDC
blockage protection	cut off with blocked motor shaft after 2 s
Low voltage protection	cut off at $V_{CC} < 8.5 \text{ V}$
High voltage protection	cut off at $V_{CC} > 29.5 \text{ V}$
Thermal control of the power stage	$T > 100 \text{ }^\circ\text{C}$ typ.
High voltage protection (transient)	150 mWs

2.9 Ambient conditions

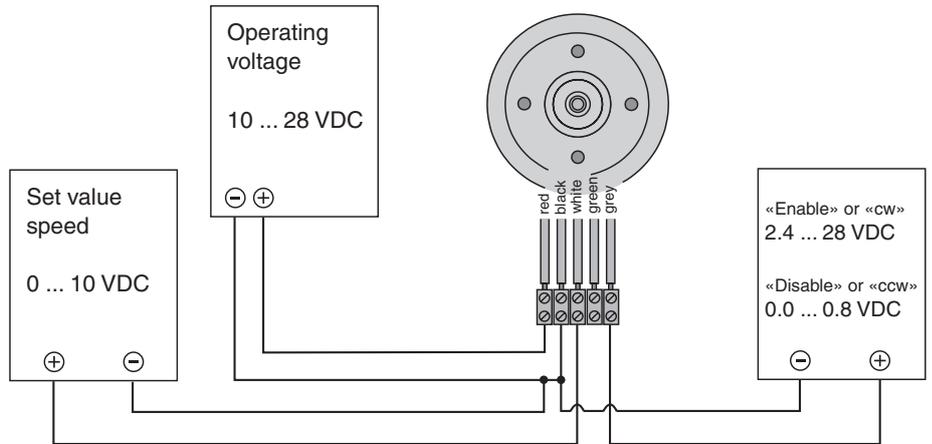
Temperature range	-40 ... +40 $^\circ\text{C}$
Range with reduced performance	+40 ... +85 $^\circ\text{C}$
Bearing temperature	-40 ... +85 $^\circ\text{C}$
Humidity range not condensed	20 ... 80 %

2.10 Voltage supply

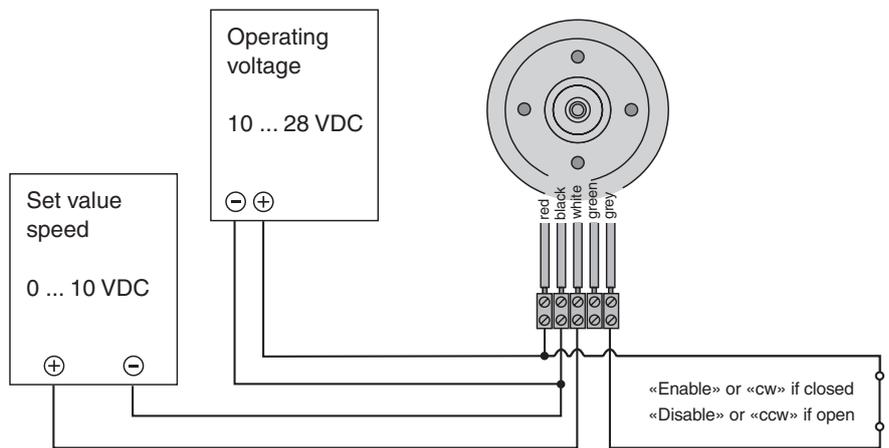
Ripple	< 5%
Output current depending on the load, recommendation	$\geq 5 \text{ A}$
Max. output voltage	29 VDC
Min. output voltage	9.5 VDC

3 Minimum wiring

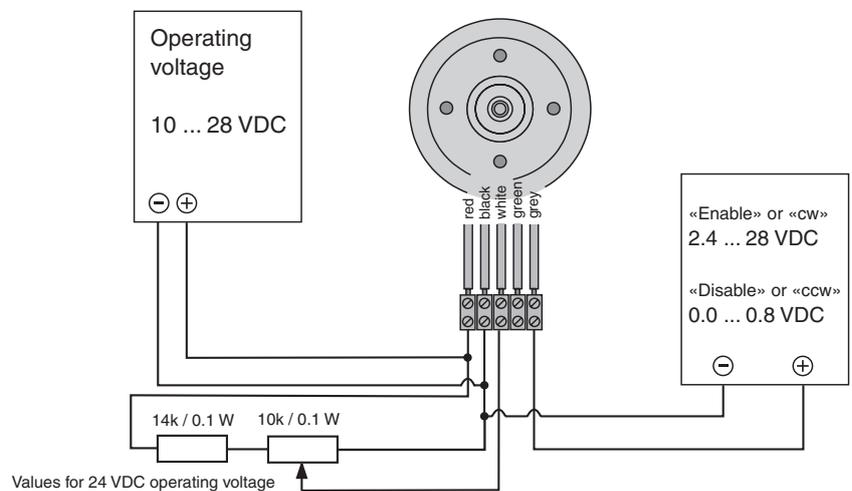
3.1 5-wire version



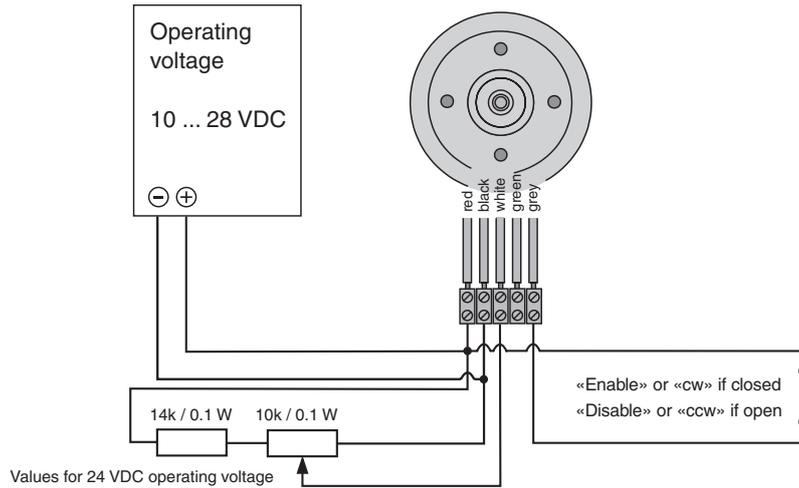
Picture 6: Example for speed set value and release «Enable» or direction «cw/ccw» (depending on the variant) through external power source.



Picture 7: Example for speed set value with external power source and release «Enable» or direction «cw/ccw» (depending on the variant) with potential-free contact.



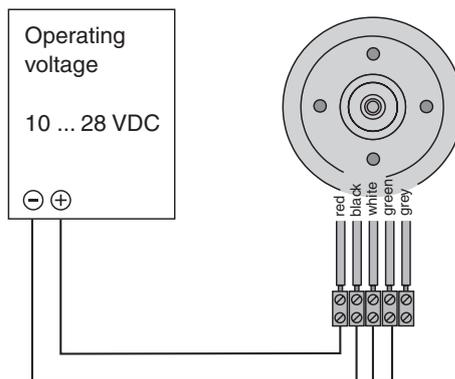
Picture 8: Example for speed set value with external potentiometer and release «Enable» or direction «cw/ccw» (depending on the variant) with external power source.



Picture 9: Example for speed set value with external potentiometer and release «Enable» or direction «cw/ccw» (depending on the variant) with potential-free contact.

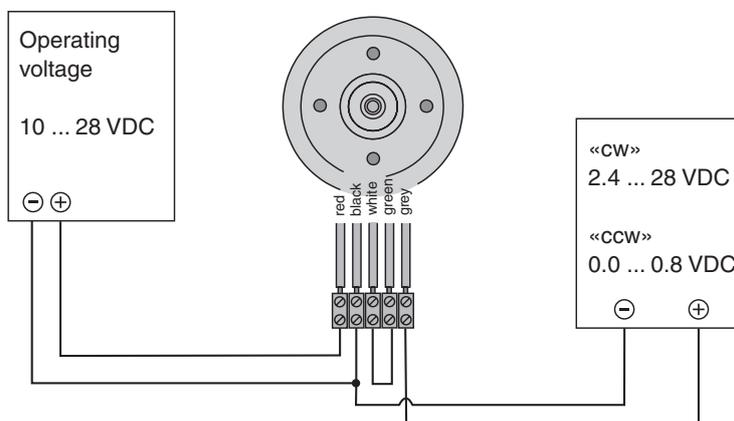
3.2 5-wire version in 2-wire operating mode

2-wire operating mode can be simulated by short-circuiting the terminals speed set value input and speed monitor output. Speed is proportionate to the supply voltage (see picture 16).



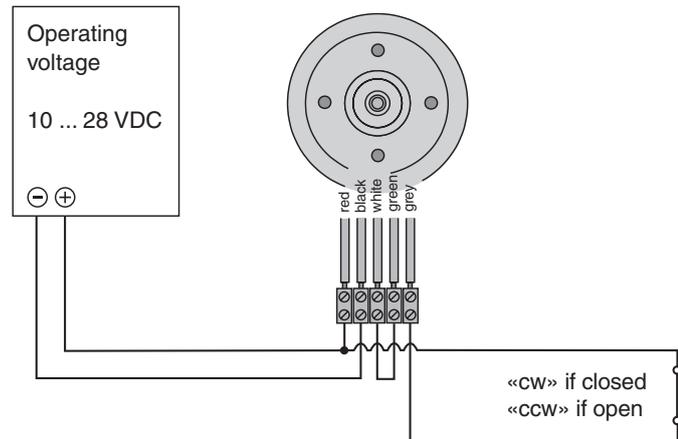
Picture 10: Example for 5-wire version in 2-wire operating mode

Version direction «cw/ccw»: the direction of rotation can be selected at the grey wire.



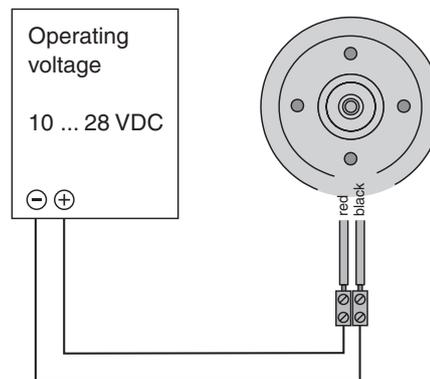
Picture 11: Example for 5-wire version direction «cw/ccw» in 2-wire operating mode.

Version direction «cw/ccw»: the direction of rotation can be selected at the grey wire.



Picture 12: Example for 5-wire version direction «cw/ccw» in 2-wire operating mode.

3.3 2-wire version



Picture 13: Example for 2-wire version

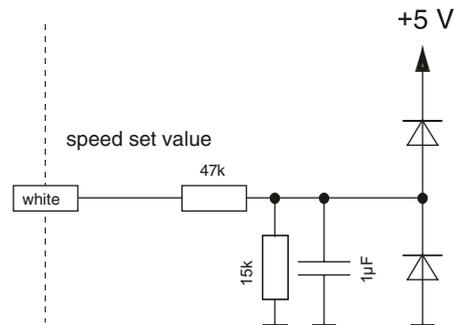
4 Description of function inputs and outputs 5-wire version

4.1 Speed set value input

Motor speed is set with an analog voltage at the speed set value input.

The speed set value input is protected against overvoltage.

Pin allocation	Cable white
Input voltage range	0 ... +10.8 V (based on GND)
Input impedance	62 k Ω (range 0 ... +21.9 V) 47 k Ω (range 21.9 V... +30 V)
Continuous overvoltage protection	-30 V ... +30 V



Picture 14: Wiring speed set value

The speed set value is set with the voltage at the speed set value input. The set speed is controlled by the amplifier. Changes to speed set value are restricted by the maximum acceleration (see section 2.4).

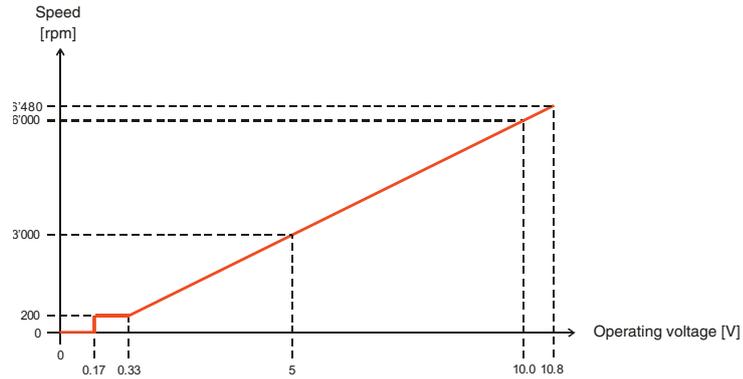
To activate the output stage in the «enable» version, the voltage at the enable input must be higher than 2.4 V, while the speed set value must be above 0.17 V.

With the «cw/ccw» direction pre-selection version, the output stage is activated when the speed set value is higher 0.17 V.

Set value input area	Function	Comments
0 V ... 0.17 V	«Disable»	Power stage switched off.
0.17 V ... 0.33 V	Operation at minimum speed (200 rpm)	If «enable» higher than 2.4 V for version «Enable».
0.33 V ... 10.8 V	Linear speed setting between 200 rpm and 6480 rpm	If «enable» higher than 2.4 V. In speed range between 200 rpm and 300 rpm, control accuracy of the speed controller is restricted. The speed can vary from the specified set value depending on the load and supply voltage.

$$V_{target} = \frac{n_{target}}{600}$$

V_{target} = Set value voltage
 n_{target} = Desired speed



Picture 15: Speed as function of specified set value voltage.

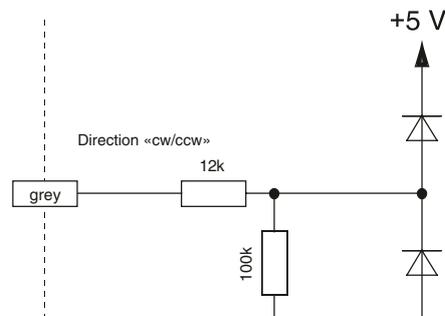
Option

By connecting (short-circuiting) the two wires speed monitor (green wire) and set speed value (white wire), control is set into 2-wire operating mode. It has to be connected before the supply voltage is switched on.

4.2 «Enable»

The power stage is activated with the digital input enable. The input enable is protected against overvoltage.

Pin allocation	Cable grey
Input voltage range	0 ... +5.0 V (based on GND)
Input impedance	112 k Ω (range 0 ... +5.9 V) 12 k Ω (range 5.9 V... +30 V)
Continuous overvoltage protection	-30 V ... +30 V



Picture 16: Enable wiring.

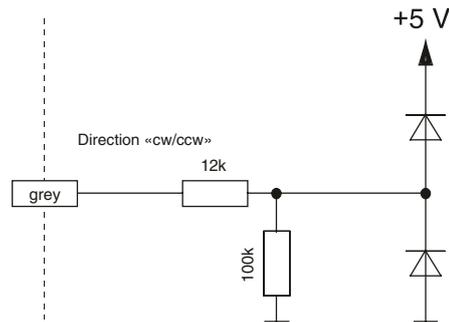
The power stage is activated by a voltage of more than 2.4 V. Speed is dependent on the connected voltage at the speed set value input. The power stage is switched off by a voltage of less than 0.8 V, the motor gradually slows down, irrespective of the connected voltage at the speed set value input.

Input voltage range	Function	Comments
0 V ... 0.8 V	«Disable»	Power stage switched off
2.4 V ... 5.0 V	«Enable»	Power stage switched on if set value higher than 0.17 V.

4.3 «Enable» and direction version «cw/ccw»

The output stage is activated with the speed set value input. The output stage is activated if the speed set value is higher than 0.17 V. The «CW/CCW» direction is determined with the direction pre-selection digital input.

Pin allocation	Cable grey
Input voltage range	0 ... +5.0 V (based on GND)
Input impedance	112 k Ω (range 0 ... +5.9 V) 12 k Ω (range 5.9 V ... +30 V)
Continuous overvoltage protection	-30 V ... +30 V



Picture 17: Direction wiring

The «cw» direction is activated by a voltage of more than 2.4 V. Speed is dependent on the applied voltage at the speed set value input. If the direction is changed during operation, the motor will run down to minimum speed and then accelerates in requested direction.

Input Voltage range	Function	Comments
0 V ... 0.8 V	Sense of rotation «ccw»	Motor turns direction «ccw»
2.4 V ... 5.0 V	Sense of rotation «cw»	Motor turns direction «cw»

4.4 Speed monitor «Monitor n»

The actual speed of the motor shaft can be monitored at the speed monitor output of the electronics. The actual speed is available as a digital signal (high/low) and supplies 6 output pulses per mechanical revolution.

Pin allocation	Cable green
Output voltage range	0 or +5 V (based on GND)
Output resistance	4.1 k Ω
Low level	max. 0.5 V
High level	max. 4.2 V
Pulse-width modulation	50%
Continuous overvoltage protection	-30 V ... +30 V

Frequency at speed monitor output

$$f_{\text{Monitor } n} = \frac{n_{\text{actual}}}{10}$$

$$n_{\text{actual}} = 10 \cdot f_{\text{Monitor } n}$$

$f_{\text{Monitor } n}$ = Frequency at speed monitor output [Hz]

n_{actual} = speed [rpm]

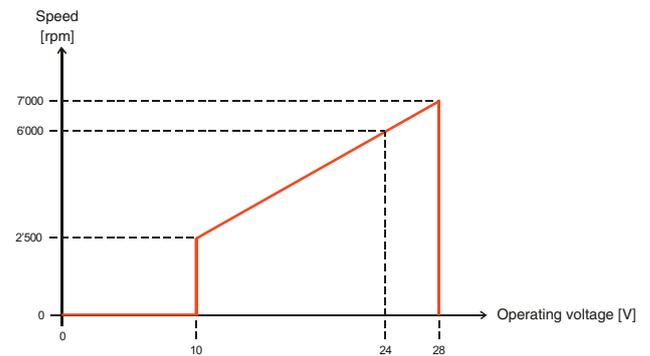
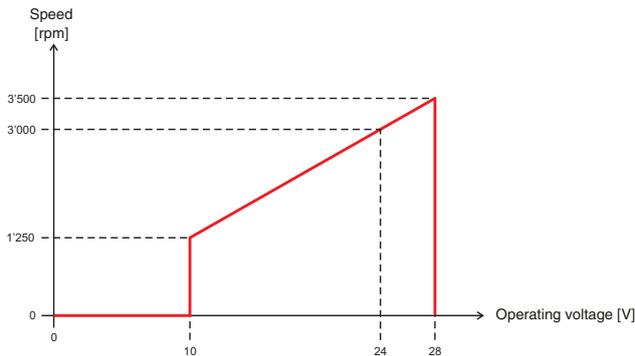
Note:

The speed monitor output also works in «disable» mode.

5 Description of function 2-wire version

5.1 Speed proportional to supply voltage V_{CC}

- Motor speed is proportional to the supply voltage, independent of torque.
- Supply voltage can be varied within the permitted range.
- Speed at 24V supply voltage is:
3000 rpm for versions 353518 und 353516
6000 rpm for versions 353519 und 353517



Picture 18: 3000 rpm as function of the supplied voltage.

Picture 19: 6000 rpm as function of the supplied voltage.

6 Protective functions

6.1 Inverse polarity protection

The EC 45 flat with integrated electronics is protected against polarity reversal of the supply voltage V_{CC} . This means that the negative input voltage must not exceed the maximum permitted supply voltage V_{CC} .

6.2 Undervoltage switch-off

The power stage is switched off if the supply voltage V_{CC} falls below approx. 8.5 V to prevent the EC 45 flat with integrated electronics operating off the specification.

As soon as the supply voltage exceeds the restart threshold of approx. 9 V, the EC 45 flat with integrated electronics is ready for operation.

6.3 Overvoltage switch-off

The power stage is switched off if the supply voltage V_{CC} exceeds approx. 29.5 V to prevent the EC 45 flat with integrated electronics operating of the specification.

As soon as the supply voltage falls below the restart threshold of approx. 28.5 V, the EC 45 flat with integrated electronics is ready for operation.

6.4 Blockage protection

The power stage is switched off if the rotor is blocked continuously for more than 2 seconds.

The EC 45 flat with integrated electronics automatically attempts to restart after 4 seconds.

6.5 Temperature monitoring

The power stage is switched off if the PCB temperature exceeds approx. 100°C. As soon as the PCB temperature has fallen below approx. 90°C, the EC 45 flat with integrated electronics is ready for operation.

6.6 Current limiting

The winding current is limited electronically to approx. 650 mA. The maximum load torque is also limited accordingly.

If the motor shaft slows down completely due to current limitation, the blockage protection switches off after 2 s.

6.7 Overvoltage protection

The overvoltage protection comprises a bi-directional transzorb diode (over-voltage protection diode) that can take a maximum peak energy of 150 mWs. Continuous power loss is 1 W. Threshold voltage is 36 V, independent of polarity.

7 Mounting instructions

- Max. torque of flange screws is 1.1 Nm (screw fastening class 8.8).
- Cooling improvement through mounting a large metallic part.
- Cable outlet preferably downwards.

8 EMC compliant installation

8.1 Cable length \leq 300 mm

- Normally no shielding is required.
- Star wiring if several EC 45 flat with integrated electronics are supplied by a common supply voltage.

8.2 Cable length $>$ 300 mm

- The voltage drop in the connection cable must be minimised by choosing a large enough wire cross section.
- The use of shielded cables connected to ground can improve immunity against interference in electromagnetically harsh environments.
- Release cable shielding on one side if 50/60 Hz interference problems occur.
- The irradiance surface for interference can be reduced by shortening the unshielded original connection cable.
- Immunity against interference and speed stability when loads fluctuate can be achieved by routing the set speed value signal separately in a shielded cable that is put to ground both sides. In addition to the set speed value signal, a second ground (GND) line must also be carried in this separate cable, but only connected on the motor side. The external speed set value signal must be potential-free.

9 Trouble shooting

9.1 2-wire version

- Is the supply voltage set between 10.0 and 28.0 VDC?
- Is the supply voltage connected to the red and black wire and switched on?
- Is the voltage at the red motor wire positive compared to voltage at the black wire?
- Is the power supply source in the current limitation?
- Is the motor blocked mechanically?

9.2 5-wire version

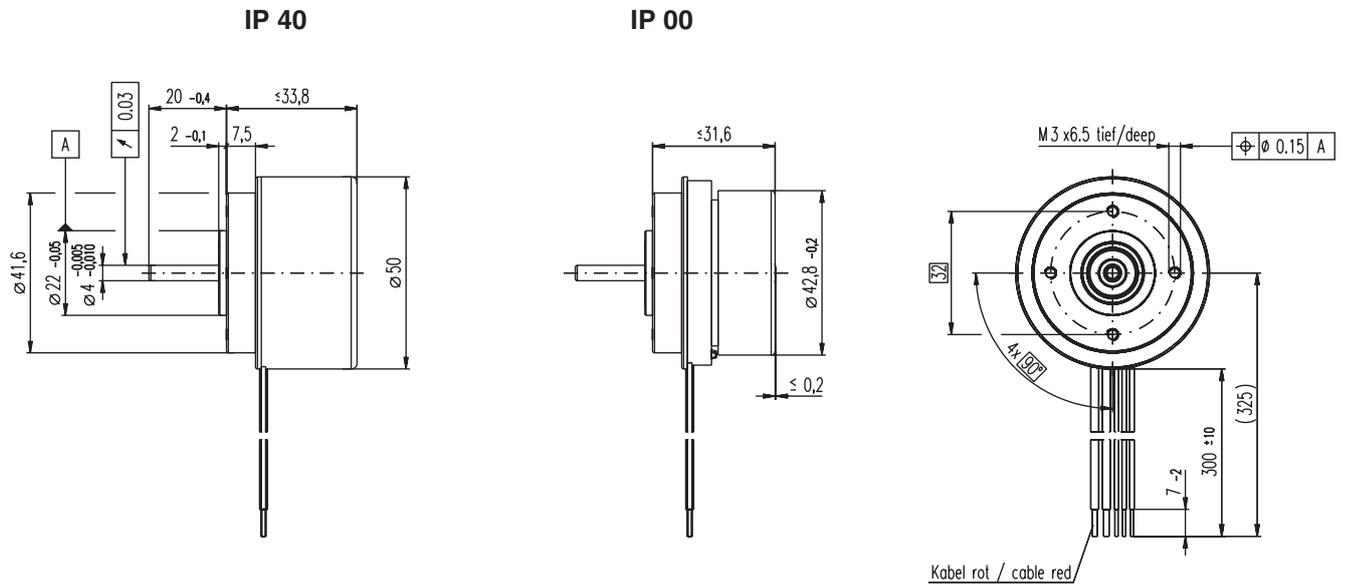
- Is the supply voltage set between 10.0 and 28.0 V?
- Is the supply voltage connected to the red and black wire and switched on?
- Is the voltage at the red motor wire positive compared to voltage at the black wire?
- Is the speed set value voltage set between 0.33 and 10.0 V?
- Is the speed set value voltage connected and set at the white and black wire?
- Is the voltage at the white motor wire positive compared to voltage at the black wire?
- **«Enable» through power supply (only for version «Enable»)**
 - Is the enable voltage set between 2.4 and 28.0 VDC?
 - Is the enable voltage connected to the grey and black wire and switched on?
 - Is the voltage at the grey motor wire positive compared to voltage at the black wire?
- **«Enable» through potential-free contact (only for version «Enable»)**
 - Is the grey enable connected directly to the red supply voltage wire?
 - Is the grey enable wire connected through a switch with the red supply voltage wire?
 - Is the switch or loop closed?
- Is the power supply source in the current limitation?
- Is the motor blocked mechanically?
- The green wire does not have to be connected!

9.3 5-wire version, 2-wire operating mode

- Is the white and green wire directly connected together?
- Was there a direct connection between the white and green wire before the supply voltage has been connected?
- Are there any more connections to the green or white wire?
- Is the supply voltage set between 10.0 and 28.0 VDC?
- Is the supply voltage connected and switched on?
- Is the voltage at the red motor wire positive compared to the voltage at the black wire?
- In «enable» version, the grey cable does not require to be connected.
- In «cw/ccw» direction pre-selection version, the grey cable can be used to define the direction (see 3.2).
- Is the power supply source in the current limitation?
- Is the motor blocked mechanically?

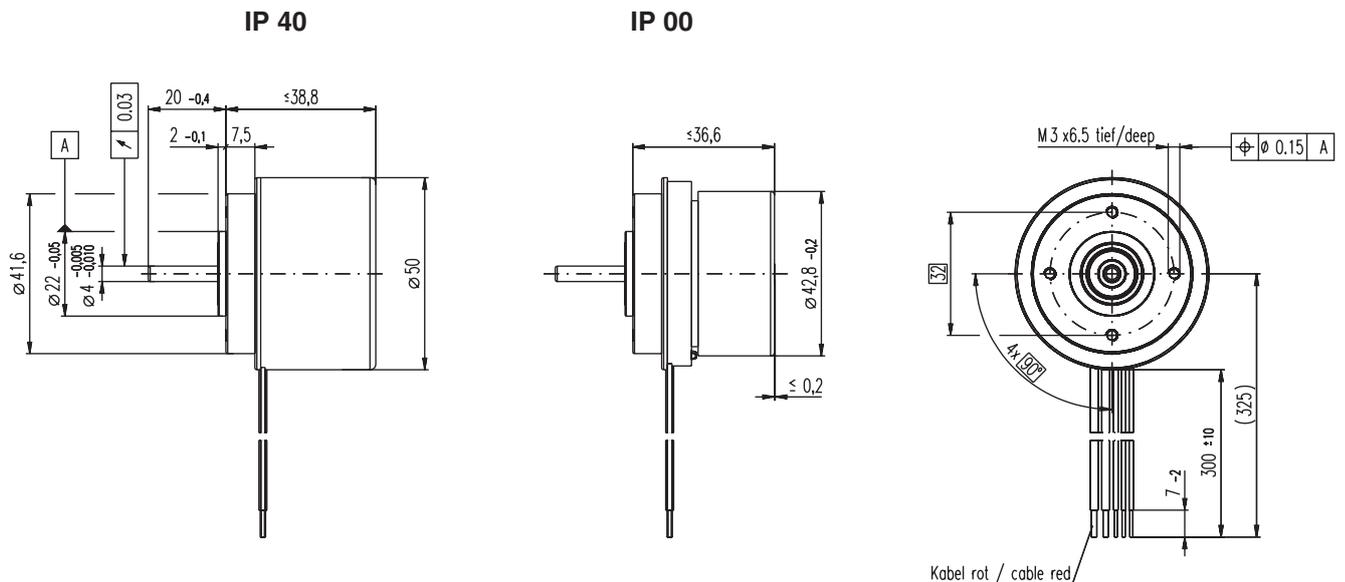
10 Dimensions

10.1 30 Watt Version



Picture 20: Dimensional drawing 30 Watt Version

10.2 50 Watt Version



Picture 21: Dimensional drawing 50 Watt Version

11 Glossary

1-Q speed controller

The motor produces positive torque in the selected or programmed direction. The load is not actively decelerated when the speed set value is reduced or the direction changed (direction pre-selection version). The speed control enters again as soon as the load has reduced its speed through friction to the level specified by the speed set value.

Max. torque [mNm]

The peak torque by the motor can deliver intermittently. It is restricted by the electronics overload protection.

Max. current [A]

Supply current with which the peak torque is generated at nominal voltage. With an active speed controller, the supply current is not proportional to the torque, but also depends on the supply voltage. As a result, this value only applies at nominal voltage.

IP 00

No protection against access to dangerous parts. No protection against water.

IP 40

Protected against access to dangerous parts with a wire, tool or similar $\geq \text{Ø}1$ mm.
Protected against fixed foreign objects $\geq \text{Ø}1$ mm.
No protection against water.

Rotation CW/CCW

cw = clockwise
ccw = counter-clockwise
(seen on the flange side)