FAULHABER

Brushless DC-Motors
Series
1525 … BRC
3153 … BRC

Technical Manual

EN

WE CREATE MOTION

Imprint

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This technical manual has been prepared with care.
Dr. Fritz Faulhaber GmbH & Co. KG cannot accept any liability for any errors in this technical manual or for the consequences of such errors. Equally, no liability can be accepted for direct or consequential damages resulting from improper use of the equipment.

The relevant regulations regarding safety engineering and interference suppression as well as the requirements specified in this technical manual are to be noted and followed when using the software.

Subject to change without notice.

The respective current version of this technical manual is available on FAULHABER's internet site:
www.faulhaber.com

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Table of Contents

1 Important Information

This technical manual describes the handling and operation of the following FAULHABER brushless DC motors:

1525 ... BRC

3153 ... BRC

- Please read through the complete technical manual before using the software.
- Keep this technical manual in a safe place for later use.

The information given in this technical manual refers to the standard version of the motors.
Please refer to any additional information sheet provided in the event of differences in information due to a customer-specific motor modification.

1.1 Symbols used in this technical manual

WARNING! ***Warning!***

This pictogram with the wording "Warning!" indicates an imminent danger which can result in physical injuries.

► *This arrow points out the appropriate action to take to prevent the imminent danger.*

CAUTION! ***Caution!***

This pictogram with the wording "Caution!" indicates an imminent danger which can result in slight physical injuries or material damage.

► *This arrow points out the appropriate precautions.*

REGULATION! ***Regulations, guidelines and directives***

This pictogram with the wording "Regulation" indicates a statutory regulation, guideline or directive which must be observed in the respective context of the text.

NOTE ***Note***

This "Note" pictogram provides tips and recommendations for use and handling of the component.

1 Important Information

1.2 Safety instructions

Observance of the following safety instructions is prerequisite for trouble-free and safe operation of the products. Therefore, please carefully read through all the notes and follow them when using the motors.

Intended use

The motors 1525 … BRC and 3153 … BRC are designed as drives for small mechanisms and for continuous-running applications, e.g. pump, fan or scanner drives. They may not be used for purposes such as braking or holding a mechanism (holding torque).

- The motors contains magnetic and electromagnetic components. Any effects as well as the specific relevant national regulations must be taken into account when using the motor.
- The motors may not be used in environments where contact with water, chemicals and/or dust is possible or in potentially explosive atmospheres!
- The forces, torques and accelerations acting on the motor are limited.
- Please ask the manufacturer for information about individual use under special ambient conditions.

1 Important Information

1.3 Ambient conditions

CAUTION! ***Shock loads***

The noise emitted is increased and the life of the ball bearings and therefore of the motor becomes limited if they are exposed to impacts.

- ► *The motors can still function if it is not exposed to higher shock loads than defined according to EN 60068-2-27.*
- ► *The motors may not be exposed to higher vibratory stresses than defined according to EN 60068-2-6.*

CAUTION! ***Risk of damage***

If the motors are installed on the mounting flange, the mounting flange can be damaged by high radial loads or stresses on the motor or by screws tightened with excessive torque.

- ► *Tighten the screws with maximum 40 Ncm. Note the strength of the screws!*

NOTE ***Service life***

The full life is reached if the motor is not exposed to shock or vibration loads.

CAUTION! ***Risk of damage***

The ribbon cables may be damaged if the static or dynamic load is too high.

- ► *The pull (tension) on the cable must not exceed 20 N in any direction for the 1525 … BRC and 30 N for the 3153 … BRC. If the cable is subjected to continuous tensile loading the limit is 11 N for the 1525 … BRC and 17 N for the 3153 … BRC.*
- ► *In case of frequent bending, the recommended minimum bending radius is 10 mm. The possible number of bending cycles increases with increasing bending radius.*
- ► *If the radii are small the cable may not be bent several times as otherwise the Litz wires will break. The bending radii if laid once must be larger than 1.2 mm.*
- ► *The cable may not be bent at temperatures < -10 °C.*

1 Important Information

1.4 Service / Maintenance

The brushless DC motors 1525 … BRC and 3153 … BRC are designed to be maintenance-free. No maintenance measures are necessary.

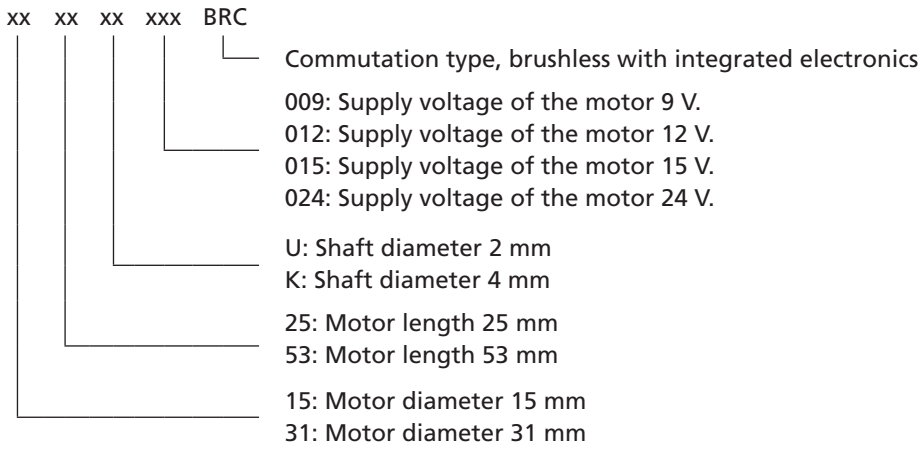
1.5 Troubleshooting

If operated as indicated in this manual, the brushless DC motors 1525 … BRC and 3153 … BRC will function trouble free. If malfunctions occur during proper intended use, please contact your responsible partner.

2 Description

2.1 General product description

Product information



The 1525 … BRC and 3153 … BRC motors are electronically commutated (brushless) DC motors. Compared to mechanically commuted electric motors, its main outstanding feature is a much longer life.

The motor is based on the self-supporting coil technology, FAULHABER system, and essentially consists of a three-phase winding (stator), a two-pole permanent magnet (rotor) as well as the electronic commutation system.

The rotor position is detected without sensors.

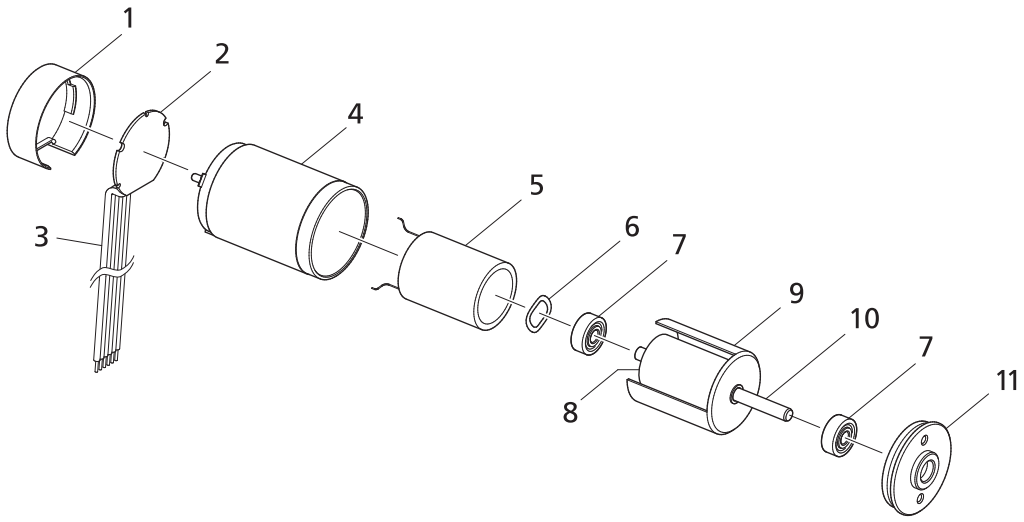
The 1525 ... BRC and the 3153 ... BRC are supplied without product-specific accessories.

The motors offers the following functions:

- Control of the speed through setpoint value input or control of the speed through the motor voltage.
- Switchover of direction of rotation via switch input.
- Reading out the speed signal via the frequency output.

2 Description

2.1 General prduct description



1 Rear Cover
2 Drive Electronics
3 Flat cable
4 Housing
5 Coil
6 Spring washer
7 Ball bearing
8 Magnet
9 Rotor back-iron
10 Shaft
11 Front flange

3 Installation

3.1 Assembly

The 1525 … BRC and the 3153 … BRC must be installed according to certain specifications to prevent malfunctions and damage.

CAUTION! ***Material damage!***

Improper installation or installation with unsuitable fixing materials can disrupt the function and/or damage the motors.

► *Observe the following assembly instructions.*

Ambient conditions

The 1525 … BRC and 3153 … BRC may not be used in a close-fitting metal housing (tube). This can have a negative effect on the motor output.

Depending on their use, the 1525 … BRC and 3153 … BRC motors can become hot. Appropriate heat dissipation options must be provided.

Shaft loads

When pressing parts onto the motor shaft, note the maximum allowable load values given on the data sheet.

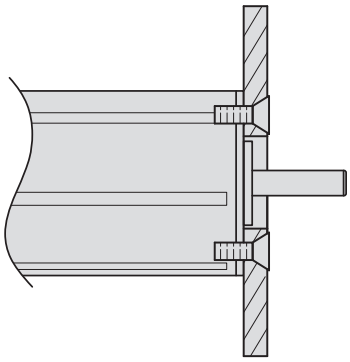
Mounting flange

The drive may only be fixed via the threaded bushes provided on the front flange. We recommend locking the screws/bolts.

Do not exceed the maximum allowable screw-in depth as given on the product data sheet.

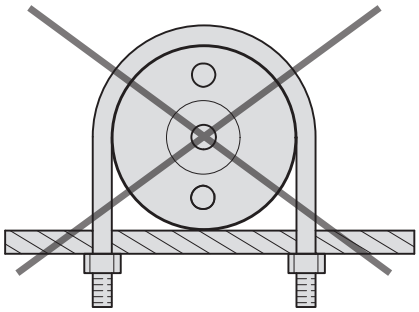
Correct

The motor is fixed by the screws on the mounting flange.



Incorrect

The motor is clamped with a U-bolt. Risk of damage to the motor housing and motor blockage!



3 Installation

3.1 Assembly

Electrical connection

It is necessary to ensure that the ribbon cable is laid without risk of damage during installation and operation, e.g. through chafing, squeezing or too small bending radii. The maximum load of the cable must be noted and observed. See section 1.3 “Ambient conditions”.

Specialised staff

These products are intended for use by trained professionals or experts in the use of small motors who are familiar with the relevant regulations and directives: **EMC Directive**, **Low Voltage Directive**, **Machinery Directive**, **VDE Regulations** or accident prevention regulations. This user’s manual should be carefully read before powering on the drive.

3 Installation

3.2 EMC compatible installation

CAUTION! ***Length of the connection leads***

The maximum length of the connection leads is limited.

► *All connection leads may not exceed a length of 3 m.*

Optimisation of performance with respect to emission and immunity requires the additional EMC measures:

- Ensuring the necessary immunity in industrial uses can require use of an EMC suppressor circuit.

Motor designation	Use environment	Interference type	Action
Brushless DC Motor	Industrial environment	Immunity	EMC suppressor circuit

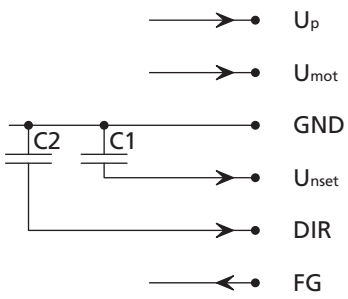
This table shows which additional EMC measures can be implemented to optimise the behaviour of the equipment in the intended environment with regard to immunity.

The units are intended for industrial use only. If the devices are used in the home, in business or in commerce or in a small business, appropriate measures must be taken to ensure that the emitted interference is below the permitted limits!

3.2.1 Description of the EMC measures

The EMC suppressor circuit

Circuit diagram 1



C1 Ceramic capacitor 220 nF
C2 Ceramic capacitor 220 nF

NOTE ***Capacitor C1:***

If the ceramic capacitor C1 is used, malfunctions can occur in $PWM_{ntarget}$ operating mode.

► *Use signal source with low internal resistance in $PWM_{ntarget}$ operating mode.*

NOTE ***Capacitor C2:***

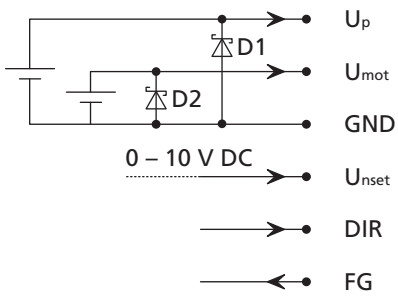
If using the ceramic capacitor C2, a firmware update with the Motion Manager PC firmware may no longer be possible.

► *Remove the C2 capacitor when updating the firmware.*

3 Installation

3.2 EMC compatible installation

Circuit diagram 2



Separate suppressor diodes (D1, D2) for U_P and U_{mot} if they have separate supply voltages.

If only one supply voltage is used, (bridge between U_P and U_{mot}), one suppressor diode (D1) is sufficient. D1 and D2 e.g. P6KE33A from STMicroelectronics

NOTE

Exceptions:

It may not be necessary to implement the additional EMC measures named. If the motor is fed e.g. from a CE-conforming power supply unit, the EMC suppressor circuit can be dispensable. In this case the power supply unit takes on the function of the EMC suppressor circuit according to circuit diagram 2.

3.3 Connector pin assignment

The 1525 … BRC and the 3153… BRC are equipped with a six position connection cable.

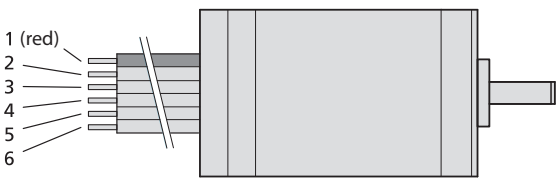
CAUTION!

Electronic damage/ESD protection

Electrostatic discharges at the connection pin assignment of the ribbon cable can result in irreparable damage to the motor.

- ▶ *It may only be processed in ESD protected workplaces.*
  Incorrect connection of the cores can cause damage to or destruction of the electronics.
- ▶ *Connect the connections in accordance with the connector pin assignment, see table.*

Connection pin assignment of the ribbon cable



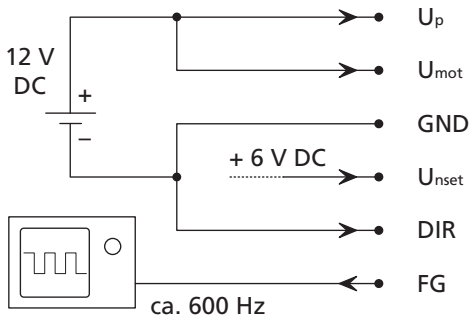
Core	Description	Function
1 (red)	U_P	elektronic supply
2	U_{mot}	coil supply
3	GND	ground
4	U_{nsoll}	speed command
5	DIR	direction of rotation
6	FG	frequency output

4 Functional Description

4.1 Connection diagram

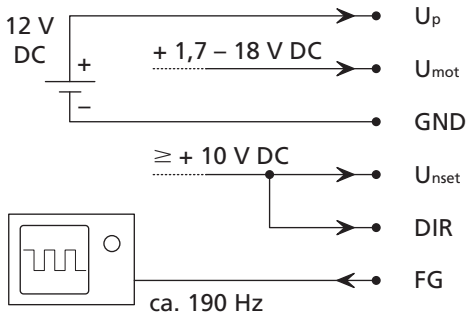
Two examples are given and are intended to clearly explain the operating modes of the brushless DC-motors. The figures given refer to a motor with a nominal voltage of 12 V.

Electronic speed control



The motor rotates counter-clockwise with approx. 12000 rpm. The speed is electronically controlled.

External speed control



The motor rotates, e.g. with approx. 3800 rpm in a clockwise direction. The speed is controlled via the motor voltage (U_{mot}). Approx. 190 Hz is measured at the frequency output (FG).

190 pulses/sec. = 63,3 U/sec.

63,3 U/sec. = 3800 rpm

4 Functional Description

4.2 Connection functions

The 1525 … BRC and the 3153 … BRC supports the following functions and/or operating modes:

- Control of the speed through the voltage at the command value input.
- Control of the speed through the coil voltage.
- Control of the direction of rotation at the switch input.
- Reading out the speed signal at the frequency output.

U_P (core 1, red)

Supply voltage for the electronics.

Voltage range: See product data sheet

U_{mot} (core 2)

Supply voltage for the motor winding.

Voltage range: See product data sheet

GND (core 3)

Common ground.

U_{nset} (core 4)

Control voltage for the target velocity.

Voltage range: See product data sheet

Resolution:

2000 rpm per 1 V, (for 1525 … BRC) and 1000 rpm per1 V (for 3153 … BRC) limited by the no-load speed at U_N.

If U_{nset} > 10 V DC, the speed control is deactivated. The speed of the motor can then be influenced by changing the motor voltage (U_{mot}). In this configuration the motor is operated with full control.

The input impedance of this cable is approx. ≥5 kΩ.

DIR (core 5)

Switch input for the motor's direction of rotation.

To earth or U < 0.5 V anti-clockwise, U > 3.0 V = clockwise. Maximum allowable level = U_{Pmax}.

FG (core 6)

Frequency output

Frequency output for reading out the actual motor speed.

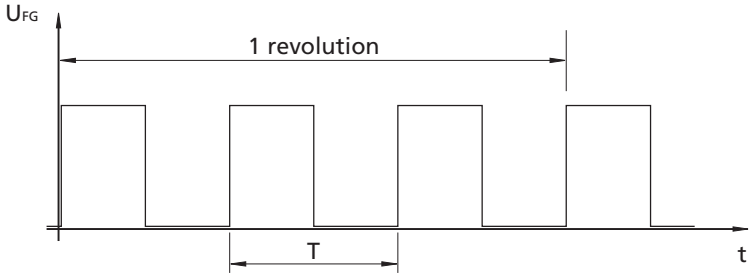
Output voltage: max. U_P.

Current carrying capacity: max. 15 mA.

4 Functional Description

4.2 Connection functions

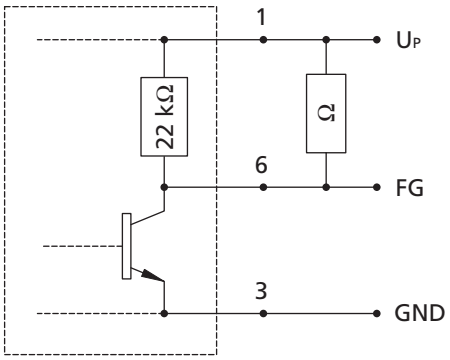
Signal setup: 3 pulses per motor revolution.



NOTE

Pull-up resistance

An additional, external pull-up resistance can be connected to increase the edge steepness. The maximum loadability of the digital output must be noted and observed. See circuit diagram:



Due to the coupling of the internal pull-up resistance between FG and the supply voltage U_P, conducted electromagnetic RF interference, which affect the supply voltage, can drastically worsen the frequency signal.

If operated properly and as intended, the speed and direct of rotation of the motor are not impaired by this interference.

4 Functional Description

4.2 Connection functions

4.2.1 I²t current limiting

The 1525 ... BRC and the the 3153 ... BRC are equipped with current limiting which enables a certain degree of motor protection to be achieved.

How the current limiting works:

When the motor starts, the peak current is preset as the set-point value for the current controller. As the load increases, the current in the motor constantly increases until it finally reaches the peak current. The current controller then comes into operation and limits the current to this set-point.

A thermal current model operating in parallel calculates a temperature from the actual flowing current. If this model temperature exceeds a critical value, continuous current is switched to and the motor current is regulated to this. Only when the load becomes so small th at the temperature falls below the critical model temperature is peak current permitted again.

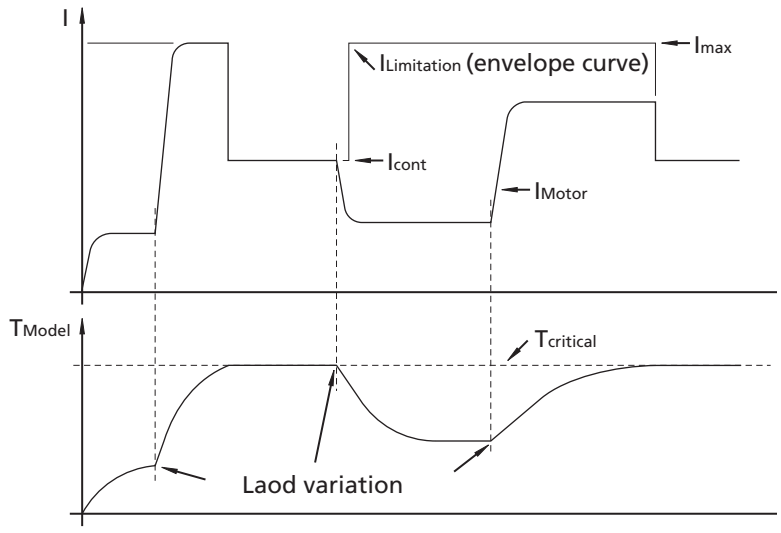
The following diagram shows how the current limiting functions by means of an envelope curve ($I_{limiting}$). The current may not rise above the values along this envelope curve The aim of this so-called I²t current limiting is not to heat the motor above the thermally allowable temperature by selecting a suitable continuous current. On the other hand, a high load should be temporarily possible in order to enable very dynamic movements.

- **Peak current (I_{max})**

The current is limited to the peak current as long as the thermal current model calculates a non-critical temperature.

- **Continuous current (I_{cont})**

If the thermal current model reaches a critical temperature the motor is switched to continuous current.



The aim of this so-called I²t current limiting is not to heat the motor above the thermally allowable temperature by selecting a suitable continuous current. On the other hand, short-term high load should be possible to enable very dynamic movements to be realised.

4 Functional Description

4.2 Connection functions

4.2.2 Overtemperature cut-off

The motor is deactivated if the temperature of the electronics exceeds the specified limit value.

The following condition must be fulfilled to reactivate the motor:

- Temperature below the specified limit value.

4.2.3 Effect of pulse width modulation (PWM)

The power output stage of the 1525 ... BRC and the 3153 ... BRC operates with so-called pulse-width modulation (PWM). Here, at a fixed frequency (the PWM frequency), the duty cycle between the on-time and off-time (make-break time) is set according to the controller output value.

The advantage of this technique is that the losses that occur in the control electronics are very low. By contrast, the losses in a linear output stage can be very high and it becomes hot.

When PWM is used the motor's inductance is used as a filter for the current. The PWM frequency should therefore be high enough to filter the current adequately. A PWM frequency that is too low for a certain motor causes the motor to operate with a poorer efficiency than would be the case in direct voltage mode.

5 Operation

5.1 Powering on

Before starting up the 1525 … BRC or the 3153 … BRC together with a mechanism, the following points must be checked:

- The drive has been installed according to the specifications.
- The ribbon cable of the motor is connected according to the requirements (risk of polarity reversal!) and is laid so that it cannot be damaged during operation. The maximum load values must be noted and observed (see section 1.3 “Ambient conditions”).
- Lengthening the connection leads can affect the function and properties with respect to EMC. All connection leads may not exceed a length of 3 m.
- The connected mechanism is installed free of blockages.
- The loads and stresses on the shaft (axial, radial and torques) are within the specified values.

CAUTION! ***Risk of injuries***

A risk of injuries can result from protruding rotating or moving parts of the driven mechanism.

► *Cover rotating and moving parts with appropriate devices.*

CAUTION! ***Risk of injuries***

Depending on the load and ambient temperature, very high temperatures can occur on the surface of the unit.

► *Contact protection must be provided if necessary.*

6 EC Product Safety Directives

REGULATION! The following EC Product Saftey Directives are important for users of the described products:

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Machinery Directive (2006/42/EC):

Due to their small size, small standard electrical drives cannot cause any noteworthy risk of injuries to people.

Therefore, the Machinery Directive does not apply to our products.

The products described here are not “part machines” or “incomplete machines”.

Therefore, Faulhaber does not provide a standard Declaration of Incorporation.

Low-Voltage Directive (2006/95/EC):

It applies to all electrical equipment with a nominal voltage from 75 to 1 500 V DC, or from 50 to 1 000 V AC. The products described in this technical manual do not fall within the scope of this Directive as they are designed for smaller voltages.

EMC Directive (2014/30/EU):

The Electromagnetic Compatibility (EMC) Directive applies to all electronic and electrical equipment, plant and systems sold to end users (consumers). In addition, CE marking can be undertaken for built-in components according to the EMC Directive. Compliance is documented by the Declaration of Conformity.

7 Warranty

Note

Dr. Fritz Faulhaber GmbH & Co. KG products are produced to state of the art production methods and are subject to strict quality control.

All sales and deliveries made exclusively on the basis of our general Terms and Conditions of Business. These are available to view and download on the FAULHABER homepage at www.faulhaber.com/agb.

Notes

Notes

FAULHABER

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