Engineering Data
AC Servo Actuators FHA-C Mini

Harmonic Drive AG

More information on our servo products can be found **HERE**!

Contents

1. General

About this documentation
This document contains safety instructions, technical data and operation rules for servo actuators and servo motors of Harmonic Drive AG.
The documentation is aimed at planners, project engineers, commissioning engineers and machine manufacturers, offering support during selection and calculation of the servo actuators, servo motors and accessories.

Rules for storage
Please keep this document for the entire life of the product, up to its disposal. Please hand over the documentation when re-selling the product.

Additional documentation
For the configuration of drive systems using the products of Harmonic Drive AG, you may require additional documents. Documentation is provided for all products offered by Harmonic Drive AG and can be found in pdf format on the website.

www.harmonicdrive.de

Third-party systems
Documentation for parts supplied by third party suppliers, associated with Harmonic Drive® Components, is not included in our standard documentation and should be requested directly from the manufacturers.

Before commissioning servo actuators and servo motors from Harmonic Drive AG with servo drives, we advise you to obtain the relevant documents for each device.

Your feedback
Your experiences are important to us. Please send suggestions and comments about the products and documentation to:

Harmonic Drive AG
Marketing and Communications
Hoenbergstraße 14
65555 Limburg / Lahn
Germany
E-Mail: info@harmonicdrive.de

1.1 Description of Safety Alert Symbols

Symbol	Meaning
DANGER	Indicates an imminent hazardous situation. If this is not avoided, death or serious injury could occur.
WARNING	Indicates a possible hazard. Care should be taken or death or serious injury may result.
ATTENTION	Indicates a possible hazard. Care should be taken or slight or minor injury may result.
ADVICE	Describes a possibly harmful situation. Care should be taken to avoid damage to the system and surroundings.
INFORMATION	This is not a safety symbol. This symbol indicates important information.
	Warning of a general hazard. The type of hazard is determined by the specific warning text.
	Warning of dangerous electrical voltage and its effects.
	Beware of hot surfaces.
	Beware of suspended loads.
	Precautions when handling electrostatic sensitive components.
	Beware of electromagnetic environmental compatibility.

1.2 Disclaimer and Copyright

We have checked the contents of this document. Since errors cannot be ruled out entirely, we do not accept liability for mistakes which may have occurred. Notification of any mistake or suggestions for improvements will be gratefully received and any necessary correction will be included in subsequent editions.

2. Safety and Installation Instructions

Please take note of the information and instructions in this document. Specially designed models may differ in technical detail. If in doubt, we strong recommend that you contact the manufacturer, giving the type designation and serial number for clarification.

2.1 Hazards

DANGER

Electric servo actuators and motors have dangerous live and redating parts. All work during connection, operation, repair and disposal must be carried out by qualified personnel as described in the standards EN50110-1 and IEC 60364! Before starting any work, and especially before opening covers, the actuator must be properly isolated. In addition to the main circuits, the user also has to pay attention to any auxilliary circuits.

Observing the five safety rules:
- Disconnect mains
- Prevent reconnection
- Test for absence of harmful voltages
- Ground and short circuit
- Cover or close off nearby live parts

The measures taken above must only be withdrawn when the work has been completed and the device is fully assembled. Improper handling can cause damage to persons and property. The respective national, local and factory specific regulations must be adhered to.

ATTENTION

The surface temperature of gears, motors and actuators can exceed 55 degrees Celsius. The hot surfaces should not be touched.

ADVICE

Cables must not come into direct contact with hot surfaces.

DANGER

Electric, magnetic and electromagnetic fields are dangerous, in particular for persons with pacemakers, implants or similiar. Vulnerable groups must not be in the immediate vicinity of the products themselves.

DANGER

Built-in holding brakes alone are not functional safe. Particularly with unsupported vertical axes, the functional safety and security can only be achieved with additional, external mechanical brakes.

DANGER

Danger of injury due to improper handling of batteries.

Observing of the battery safety rules:

- do not insert batteries in reverse. Observe the + and - marks on the battery and on the equipment
- do not short circuit
- do not recharge
- do not open or deform
- do not expose to fire, water or high temperature
- do not leave discharged batteries in equipment
- keep batteries out of the reach of children. In case of ingestion of a battery, seek medical assistance promptly.

WARNING

The successful and safe operation of gears, servo actuators and motors requires proper transport, storage and assembly as well as correct operation and maintenance.

ATTENTION

Use suitable lifting equipment to move and lift gears, servo actuators and motors with a weight > 20 kg.

INFORMATION

Special versions of products may differ in the specification from the standard. Further applicable data from data sheets. Catalogues and offers of the special version have to be considered.

2.2 Intended Purpose

The Harmonic Drive® Servo Actuators and Motors are intended for industrial or commercial applications. They comply with the relevant parts of the harmonised EN 60034 standards series.

Typical areas of application are robotics and handling, machine tools, packaging and food machines and similar machines.

The servo actuators and motors may only be operated within the operating ranges and environmental conditions shown in the documentation (altitude, degree of predection, temperature range, etc).

Before plant and machinery which have Harmonic Drive® Servo Actuators and Motors built into them are commissioned, the compliance must be established with the Machinery Directive, Low Voltage Directive and EMC guidelines.

Plant and machinery with inverter driven motors must satisfy the predection requirements in the EMC guidelines. It is the responsibility of the installer to ensure that installation is undertaken correctly.
Signal and power lines must be shielded. The EMC instructions from the inverter manufacturer must be observed in order that installation meets the EMC regulations.

2.3 Non Intended Purpose

The use of servo actuators and motors outside the areas of application mentioned above or, inter alia, other than in the operating areas or environmental conditions described in the documentation is considered as non-intended purpose.

ADVICE

Direct operating from the mains supply is not allowed.

The following areas of application are, inter alia, those considered as non-intended purpose:

- Aerospace
- Areas at risk of explosion
- Machines specially constructed or used for a nuclear purpose whose breakdown might lead to the emission of radio-activity
- Vacuum
- Machines for domestic use
- Medical equipment which comes into direct contact with the human body
- Machines or equipment for transporting or lifting people
- Special devices for use in annual markets or leisure parks

2.4 Declaration of Conformity

The Harmonic Drive® Servo Actuators and Motors described in the engineering data comply with the Low Voltage Directive. In accordance with the Machinery Directive, Harmonic Drive® Servo Actuators and Motors are electrical equipment for the use within certain voltage limits as covered by the Low Voltage Directive and thus excluded from the scope of the Machinery Directive. Commissioning is prohibited until the final product conforms to the Machinery Directive.

According to the EMC directive 2014/30/EU Harmonic Drive® Servo Actuators and Motors are inherently benign equipment, unable to generate electromagnetic disturbance or to be affected by such disturbance.

The conformity to the EU directives of equipment, plant and machinery in which Harmonic Drive® Servo Actuators and Motors are installed must be provided by the user before taking the device into operation.

Equipment, plant and machinery with inverter driven motors must satisfy the prediction requirements in the EMC directive. It is the responsibility of the user to ensure that the installation is undertaken correctly.

3. Technical Description

3.1 Product Description

Compact mini servo actuator with hollow shaft

FHA-C Mini Servo Actuators with a central hollow shaft comprise a synchronous servo motor, an HFUC Series Component Set, feedback sensor and a specially developed output bearing.

Available in three sizes with gear ratios of 30, 50 and 100:1 the actuators can provide maximum torques from 1.8 to 28 Nm. The output bearing with high tilting capacity often allows direct attachment of heavy payloads without the need for further support, thereby providing simple and space saving design installations.

The integrated hollow shaft can be used to feed through supply lines or services for further additional axes. The accurate positioning of the actuator guarantees stable machine characteristics and short cycle times, whilst the compact design ensures minimum installation space is required.

By combining the FHA-C Mini Actuators with the specially adapted YukonDrive® or the HA-680 Servo Controllers, it is possible to provide a single source supply for a pre-configured drive system tailored to suit your application. Alternatively, the FHA-C Mini Actuators are compatible with many common servo controllers on the market.

Compact mini servo actuator with multi-turn absolute encoder

FHA-C Mini Servo Actuators with EnDat® multi-turn absolute encoder comprise a synchronous servo motor, an HFUC Series Component Set, feedback sensor and a specially developed output bearing.

Available in three sizes with gear ratios of 30, 50 and 100:1 the actuators can provide maximum torques from 1.8 to 28 Nm. The output bearing with high tilting capacity often allows direct attachment of heavy payloads without the need for further support, thereby providing simple and space saving design installations. The accurate positioning of the actuator guarantees stable machine characteristics and short cycle times, whilst the compact design ensures minimum installation space is required.

The multi-turn absolute motor feedback system detects the absolute position of the output with the highest accuracy over more than 600 revolutions. Productivity of the driven axis is therefore improved as unproductive referencing is not required. In addition, the new fully flexible connectors enable efficient and easy assembly.

By combining the FHA-C Mini Actuator with the specially adapted YukonDrive®, it is possible to provide a single source supply for a pre-configured drive system tailored to suit your application.

3.2 Ordering Code

Table 9.1

Series	Size Version	Ratio			Motor feedback	Motor winding	Cable exit	Cable length	Special design
FHA	8C	30	50	100	D200	– E	– K	– M1	According to customer requirements
	11C	30	50	100					
	14C	30	50	100					
Ordering Code									
FHA	- 8C	- 100			- D200	- EKM1			- SP

Tabelle 9.2

Series	Size Version	Ratio			Motor feedback	Motor winding	Connector configuration	Special design
FHA	8C	30	50	100	MZE	– E	Y	According to customer requirements
	11C	30	50	100				
	14C	30	50	100				
Ordering code								
FHA	- 8C	- 100			- MZE	- Y		- SP

Table 9.3

Motor feedback system		
Ordering code	**Typ**	**Protokoll**
D200	Incremental	–
MZE	Multi-turn Absolute	EnDat® 2.2/22

Table 9.4

Motor winding		
Size Version	**Ordering code**	**Maximum DC bus voltage**
8C	–	330 VDC
11C		
14C		
8C	E	48 VDC
11C		
14C		

Explanation of the technical data can be found in the Glossary.

Table 10.1

Cable exit	
Ordering code	**Description**
–	Side cable outlet
K	Rear cable outlet

Table 10.2

Cable length	
Ordering code	**Description**
–	0.3 m
M1	1.0 m

Table 10.3

Connector configuration			
Ordering code	**Motor feedback**	**Motor**	**Motor feed-back system**
Y	MZE	9 pol. (ytec®)	12 pol. (ytec®)

3.3 Combinations

Table 11.1

Size		8C	11C	14C
Ratio	30	●	●	●
	50	●	●	●
	100	●	●	●
Motor feedback system	D200	●	●	●
	MZE [1]	●	●	●
Motor winding	–	●	●	●
	E	●	●	●
Connector configuration	Y [1]	●	●	●
Cable exit	–	●	●	●
	K	○	○	○
Cable length	–	●	●	●
	M1	●	●	●

● available ○ on request

[1] Motor feedback system MZE only available with connector configuration Y.

FHA-C Mini

FHA-C Mini MZE

3.4 Technical Data

3.4.1 General Technical Data

FHA-C Mini

Table 12.1

Insulation class (EN 60034-1)		B
Insulation resistance (500 VDC)	MΩ	100
Insulation voltage (60 s)	V_{rms}	1500
Insulation voltage (60 s) Version E	V_{rms}	500
Lubrication		Harmonic Drive® SK-2
Degree of protection (EN 60034-5)		IP44
Ambient operating temperature	° C	0 ... 40
Ambient storage temperature	° C	-20 ... 60
Altitude (a. s. l.)	m	< 1000
Relative humidity (without condensation)	%	20 ... 80
Vibration resistance (DIN IEC 68 Teil 2-6, 10 ... 500 Hz)	g	2.5
Shock resistance (DIN IEC 68 Teil 2-27, 18 ms)	g	30
Corrosion protection (DIN IEC 68 Part 2-11 salt spray test)	h	–
Temperature sensor FHA-C Mini		-

The continuous operating characteristics given in the following apply to an ambient temperature of 40 °C and an aluminium cooling surface with the following dimensions:

Table 12.2

Series	Size Version	Unit	Dimensions
FHA	8C	[mm]	150 x 150 x 6
	11C	[mm]	150 x 150 x 6
	14C	[mm]	200 x 200 x 6

3.4.2 Actuator Data

Technical Data FHA-xC-D200

Table 13.1

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor winding		-			-			-		
Motor feedback system		D200			D200			D200		
Ratio	i [ ]	30	50	100	30	50	100	30	50	100
Maximum output torque	T_{max} [Nm]	1.8	3.3	4.8	4.5	8.3	11	9	18	28
Maximum output speed	n_{max} [min^{-1}]	200	120	60	200	120	60	200	120	60
Maximum current	I_{max} [A_{rms}]	0.61	0.64	0.48	1.5	1.6	1.1	2.9	3.2	2.4
Continuous stall torque	T_0 [Nm]	0.75	1.5	2.0	1.8	2.9	4.2	3.5	4.7	6.8
Continuous stall current	I_0 [A_{rms}]	0.31	0.34	0.26	0.74	0.69	0.54	1.27	1.06	0.85
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	330			330			330		
Electrical time constant (20 °C)	τ_e [ms]	0.4			0.9			1.3		
No load current (20 °C)	I_{NLS} [A_{rms}]	0.12	0.12	0.12	0.27	0.25	0.22	0.44	0.41	0.40
No load running current constant (20 °C)	K_{INL} [$x10^{-3}$ A_{rms}/rpm]	-	-	-	-	-	-	-	-	-
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	0.14			0.14			0.15		
AC voltage constant (L-L, 20 °C, at motor)	k_{EM} [V_{eff}/1000 rpm]	9.8			9.8			10.6		
Maximum motor speed	n_{max} [rpm]	6000			6000			6000		
Rated motor speed	n_N [rpm]	3500			3500			3500		
Resistance (L-L, 20 °C)	R_{L-L} [Ω]	28.0			7.4			2.8		
Synchronous inductance	L_d [mH]	8.7			5.1			2.7		
Number of pole pairs	p [ ]	5			5			5		
Weight without brake	m [kg]	0.4			0.6			1.2		
Weight with brake	m [kg]	-			-			-		
Hollow shaft diameter	d_H [mm]	6.2			8.0			13.5		

Moment of Inertia

Table 13.2

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor feedback system		D200			D200			D200		
Ratio	i [ ]	**30**	**50**	**100**	**30**	**50**	**100**	**30**	**50**	**100**
Moment of inertia at output side										
Moment of inertia without brake	J_{out} [kgm^2]	0.0026	0.0074	0.029	0.006	0.017	0.067	0.018	0.05	0.20
Moment of inertia with brake	J_{out} [kgm^2]	–	–	–	–	–	–	–	–	–
Moment of inertia motor side										
Moment of inertia at motor without brake	J [$x10^{-4}$ kgm^2]	0.029			0.067			0.200		
Moment of inertia at motor with brake	J [$x10^{-4}$ kgm^2]	–			–			–		

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the rating tables.

Illustration 14.1 FHA-8C-30

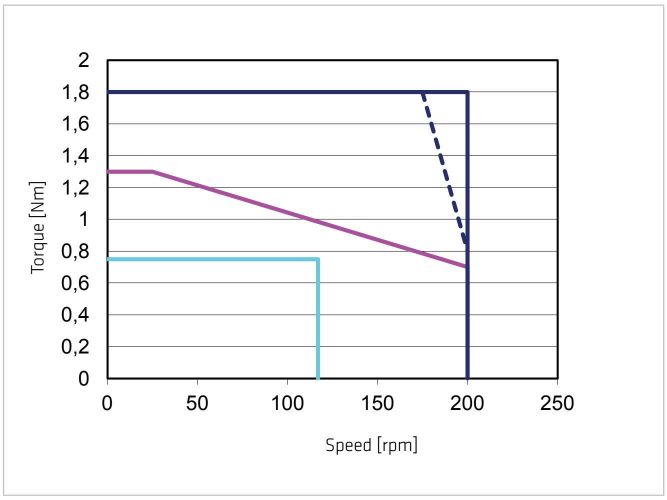


Illustration 14.2 FHA-11C-30

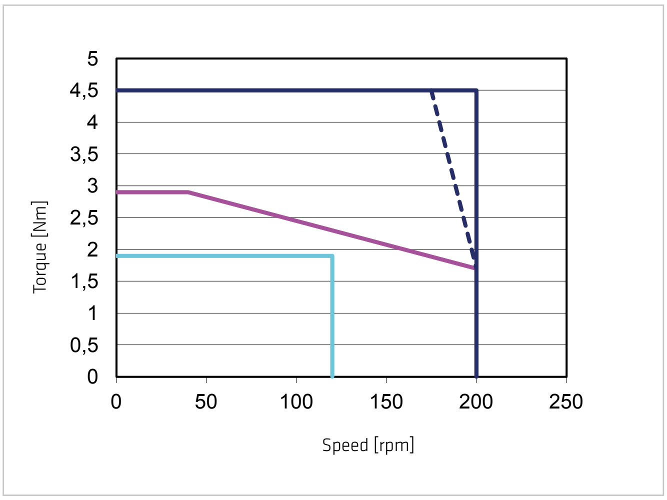


Illustration 14.3 FHA-8C-50

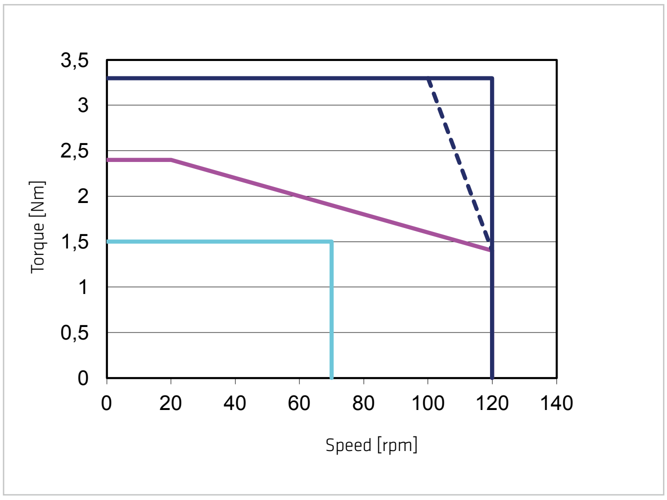


Illustration 14.4 FHA-11C-50

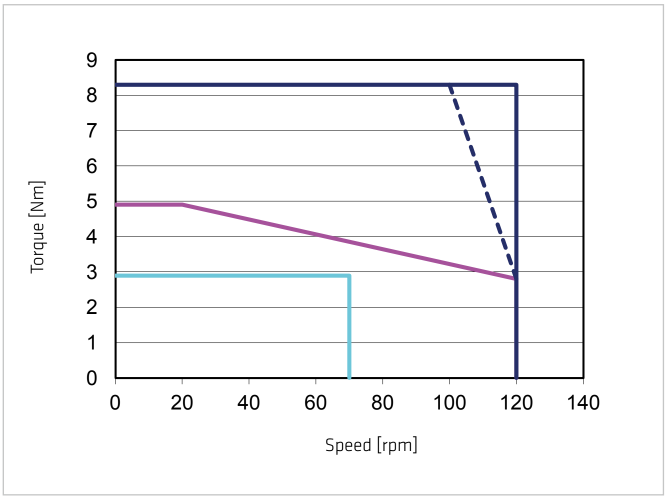


Illustration 14.5 FHA-8C-100

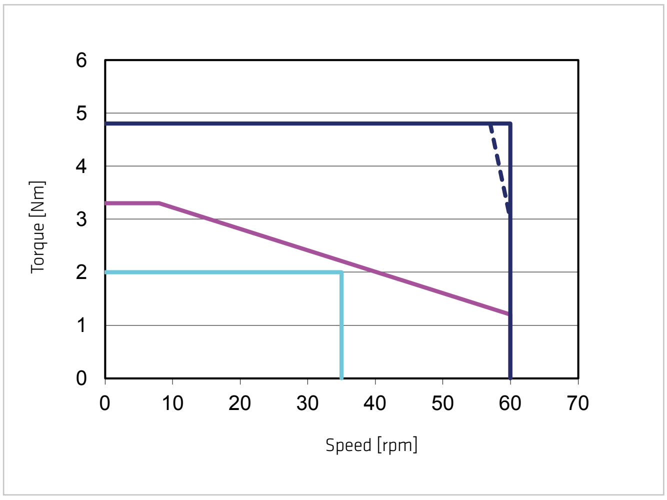
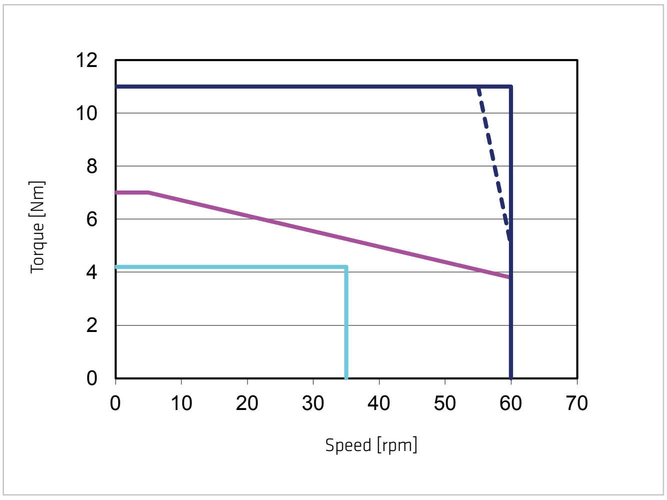


Illustration 14.6 FHA-11C-100



Legend

Intermittent duty
Continuous duty

U_M = 220 VAC
U_M = 100 VAC

S3-ED 50% (1 min)

Illustration 15.1

FHA-14C-30

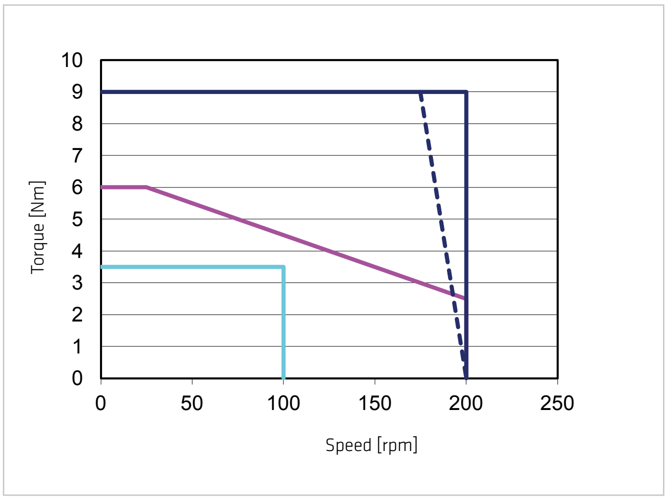


Illustration 15.2

FHA-14C-50

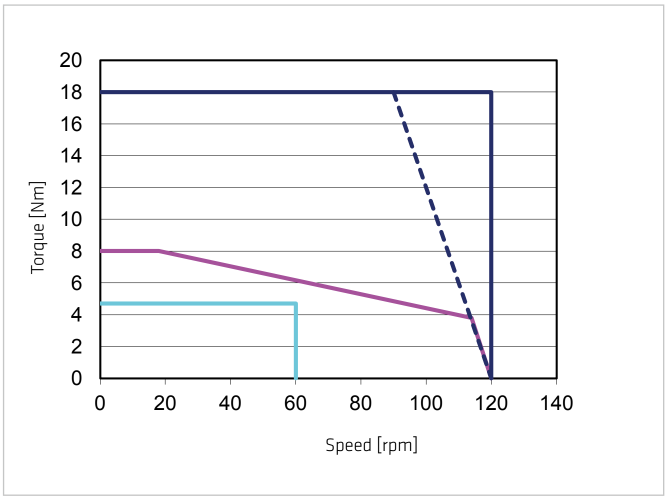
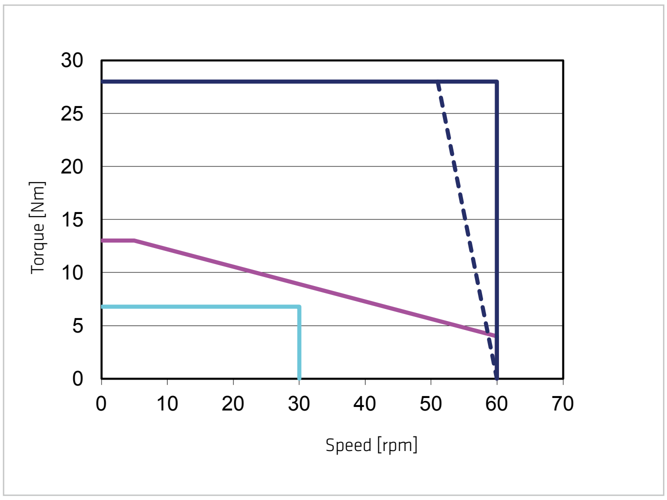


Illustration 15.3

FHA-14C-100



Legend

Intermittent duty ——— U_M = 220 VAC ——— S3-ED 50% (1 min) ———

Continuous duty ——— U_M = 100 VAC - - - - -

Technical Data FHA-xC-D200-E

Table 16.1

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor winding		E			E			E		
Motor feedback system		D200			D200			D200		
Ratio	i [ ]	30	50	100	30	50	100	30	50	100
Maximum output torque	T_{max} [Nm]	1.8	3.3	4.8	4.5	8.3	11	9	18	28
Maximum output speed	n_{max} [min^{-1}]	200	120	60	200	120	60	200	120	60
Maximum current	I_{max} [A_{rms}]	3.0	3.3	2.4	7.8	8.2	5.6	14.8	16.4	12.3
Continuous stall torque	T_0 [Nm]	0.75	1.5	2.0	1.8	2.9	4.2	3.5	4.7	6.8
Continuous stall current	I_0 [A_{rms}]	1.6	1.7	1.3	3.7	3.5	2.8	6.5	5.4	4.4
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	48			48			48		
Electrical time constant (20 °C)	τ_e [ms]	0.4			0.6			0.9		
No load current (20 °C)	I_{NLS} [A_{rms}]	0.66	0.55	0.56	1.45	1.27	1.18	2.13	2.04	2.06
No load running current constant (20 °C)	K_{INL} [$x10^{-3}$ A_{rms}/rpm]	-	-	-	-	-	-	-	-	-
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	0.027			0.026			0.029		
AC voltage constant (L-L, 20 °C, at motor)	k_{EM} [V_{eff}/1000 rpm]	2.0			1.8			2.0		
Maximum motor speed	n_{max} [rpm]	6000			6000			6000		
Rated motor speed	n_N [rpm]	3500			3500			3500		
Resistance (L-L, 20 °C)	R_{L-L} [Ω]	1.08			0.38			0.14		
Synchronous inductance	L_d [mH]	6.5			0.29			0.11		
Number of pole pairs	p [ ]	5			5			5		
Weight without brake	m [kg]	0.4			0.6			1.2		
Weight with brake	m [kg]	-			-			-		
Hollow shaft diameter	d_H [mm]	6.2			8.0			13.5		

Moment of Inertia

Table 16.2

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor feedback system		D200			D200			D200		
Ratio	i [ ]	**30**	**50**	**100**	**30**	**50**	**100**	**30**	**50**	**100**
Moment of inertia at output side										
Moment of inertia without brake	J_{out} [kgm^2]	0.0026	0.0074	0.029	0.006	0.017	0.067	0.018	0.05	0.20
Moment of inertia with brake	J_{out} [kgm^2]	–	–	–	–	–	–	–	–	–
Moment of inertia motor side										
Moment of inertia at motor without brake	J [$x10^{-4}$ kgm^2]	0.029			0.067			0.200		
Moment of inertia at motor with brake	J [$x10^{-4}$ kgm^2]	–			–			–		

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the rating tables.

Illustration 17.1 FHA-8C-30-E

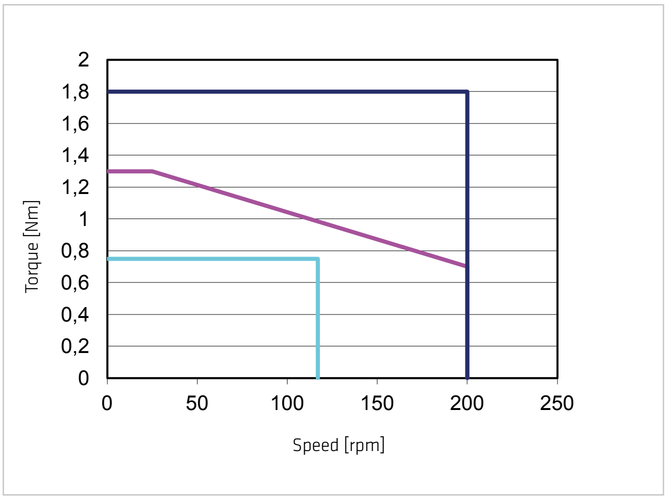


Illustration 17.2 FHA-11C-30-E

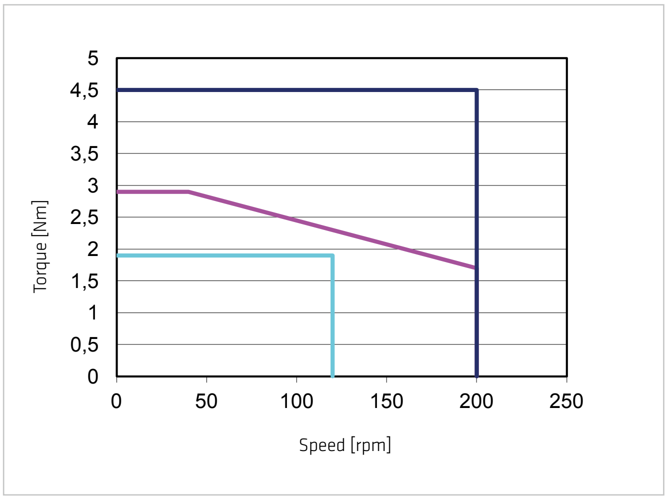


Illustration 17.3 FHA-8C-50-E

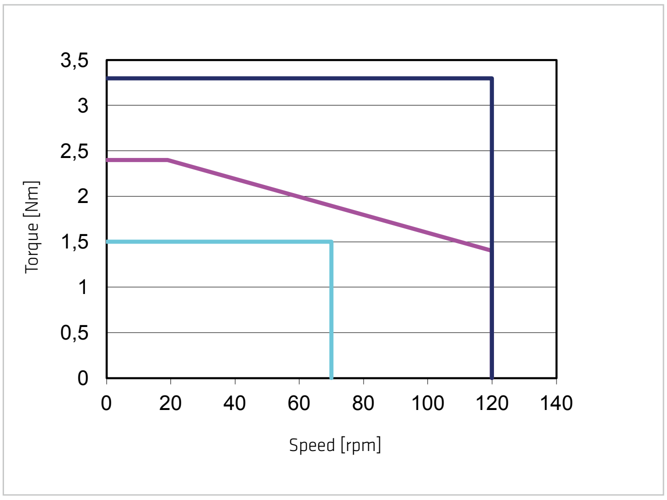


Illustration 17.4 FHA-11C-50-E

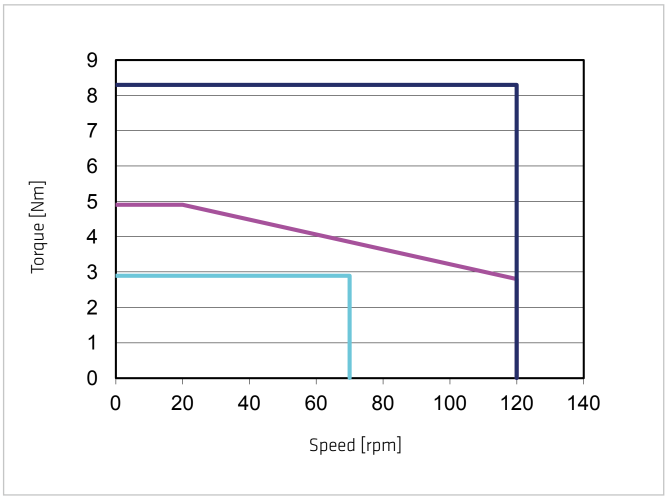


Illustration 17.5 FHA-8C-100-E

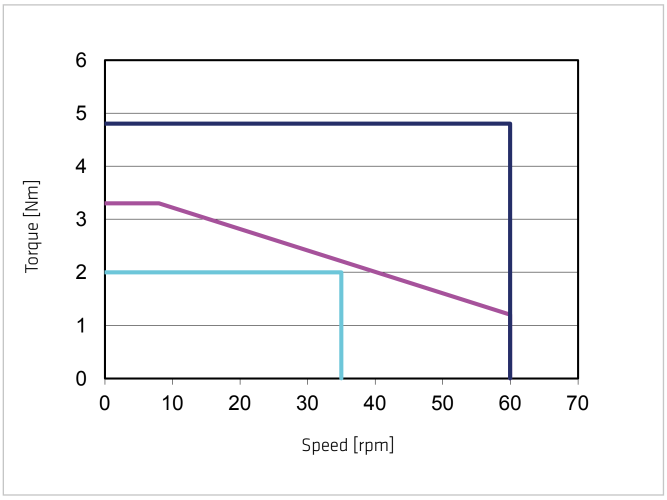
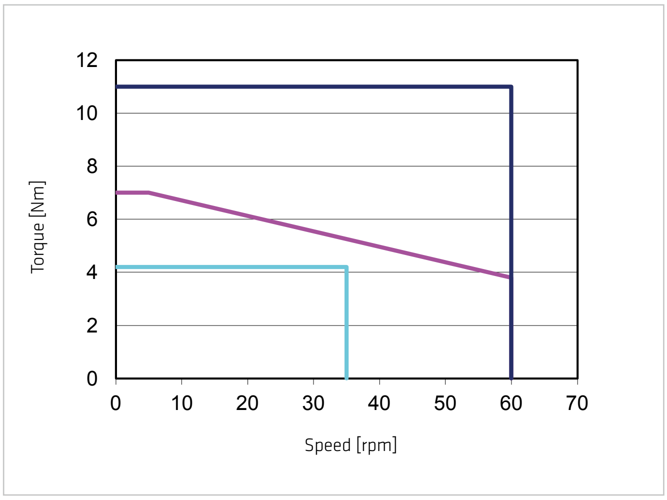


Illustration 17.6 FHA-11C-100-E



Legend

Intermittent duty
Continuous duty

U_M = 18 VAC

S3-ED 50% (1 min)

Illustration 18.1

FHA-14C-30-E

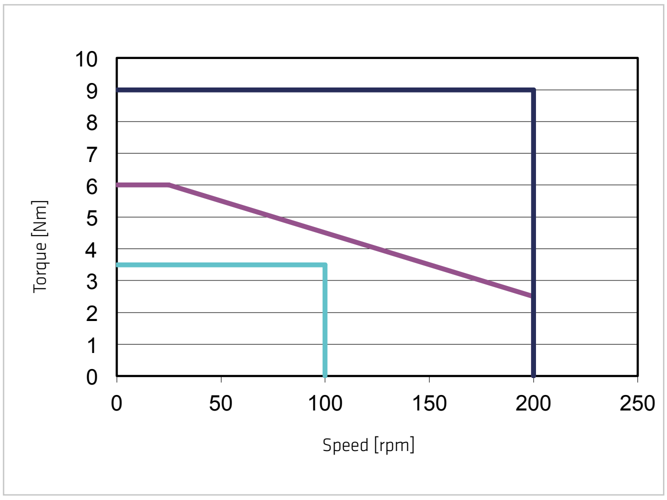


Illustration 18.2

FHA-14C-50-E

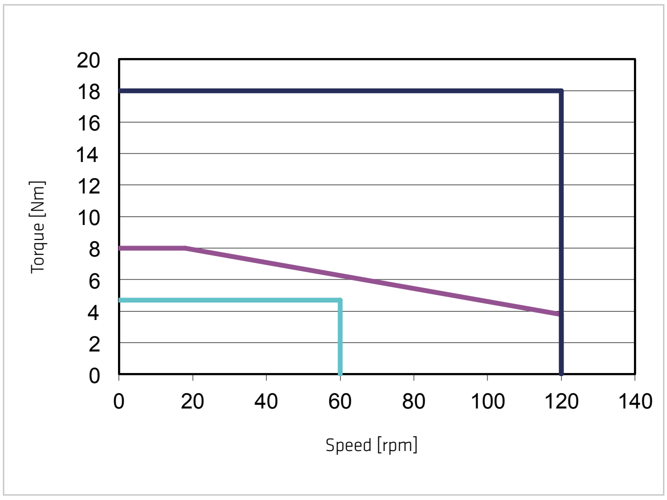
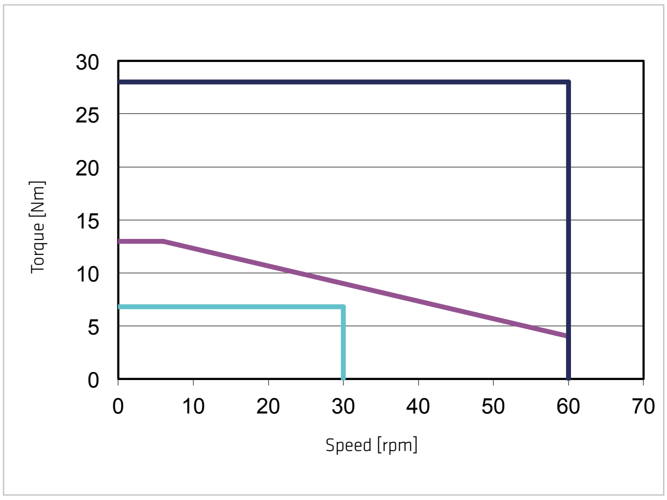


Illustration 18.3

FHA-14C-100-E



Legend

Intermittent duty
Continuous duty

U_M = 18 VAC

S3-ED 50% (1 min)

Technical Data FHAxC-MZE-Y

Table 19.1

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor winding		-			-			-		
Motor feedback system		MZE			MZE			MZE		
Ratio	i [ ]	30	50	100	30	50	100	30	50	100
Maximum output torque	T_{max} [Nm]	1.8	3.3	4.8	4.5	8.3	11	9	18	28
Maximum output speed	n_{max} [min^{-1}]	200	120	60	200	120	60	200	120	60
Maximum current	I_{max} [A_{rms}]	0.61	0.64	0.48	1.5	1.6	1.1	2.9	3.2	2.4
Continuous stall torque	T_0 [Nm]	0.75	1.5	2.0	1.8	2.9	4.2	3.5	4.7	6.8
Continuous stall current	I_0 [A_{rms}]	0.31	0.34	0.26	0.74	0.69	0.54	1.27	1.06	0.85
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	330			330			330		
Electrical time constant (20 °C)	τ_e [ms]	0.4			0.9			1.3		
No load current (20 °C)	I_{NLS} [A_{rms}]	0.12	0.12	0.12	0.27	0.25	0.22	0.44	0.41	0.40
No load running current constant (20 °C)	K_{INL} [$x10^{-3}$ A_{rms}/rpm]	-	-	-	-	-	-	-	-	-
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	0.14			0.14			0.15		
AC voltage constant (L-L, 20 °C, at motor)	k_{EM} [V_{eff}/1000 rpm]	9.8			9.8			10.6		
Maximum motor speed	n_{max} [rpm]	6000			6000			6000		
Rated motor speed	n_N [rpm]	3500			3500			3500		
Resistance (L-L, 20 °C)	R_{L-L} [Ω]	28.0			7.4			2.8		
Synchronous inductance	L_d [mH]	8.7			5.1			2.7		
Number of pole pairs	p [ ]	5			5			5		
Weight without brake	m [kg]	0.5			0.7			1.3		
Weight with brake	m [kg]	-			-			-		
Hollow shaft diameter	d_H [mm]	-			-			-		

Moment of Inertia

Table 19.2

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor feedback system		MZE			MZE			MZE		
Ratio	i [ ]	**30**	**50**	**100**	**30**	**50**	**100**	**30**	**50**	**100**
Moment of inertia at output side										
Moment of inertia without brake	J_{out} [kgm^2]	0.0026	0.0074	0.0294	0.0062	0.0173	0.0690	0.0194	0.0538	0.2150
Moment of inertia with brake	J_{out} [kgm^2]	-	-	-	-	-	-	-	-	-
Moment of inertia motor side										
Moment of inertia at motor without brake	J [$x10^{-4}$ kgm^2]	0.0294			0.0690			0.2150		
Moment of inertia at motor with brake	J [$x10^{-4}$ kgm^2]	-			-			-		

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the rating tables.

Illustration 20.1 FHA-8C-30

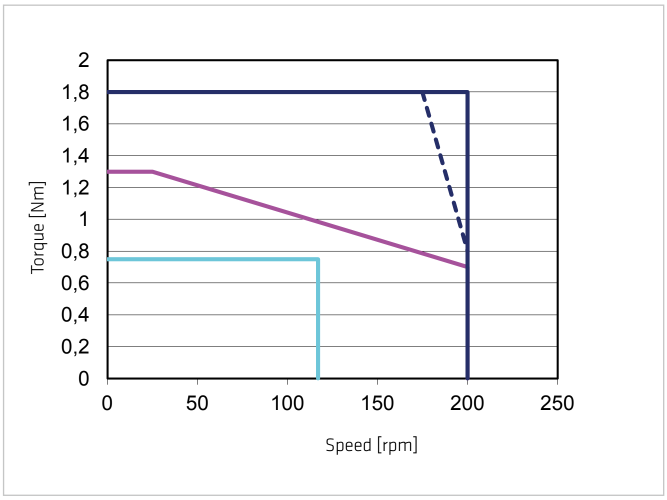


Illustration 20.2 FHA-11C-30

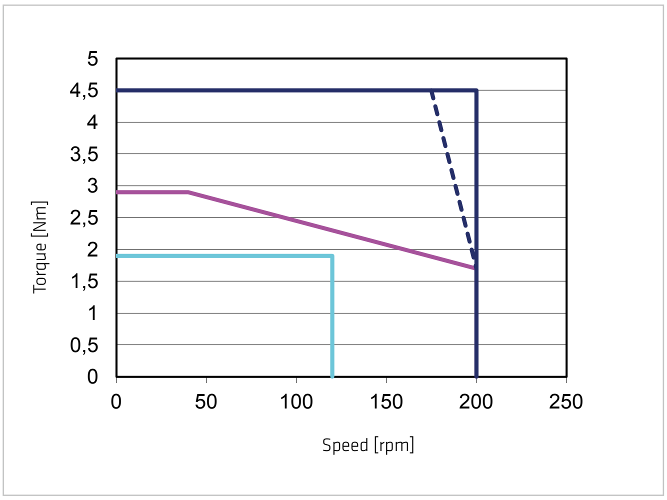


Illustration 20.3 FHA-8C-50

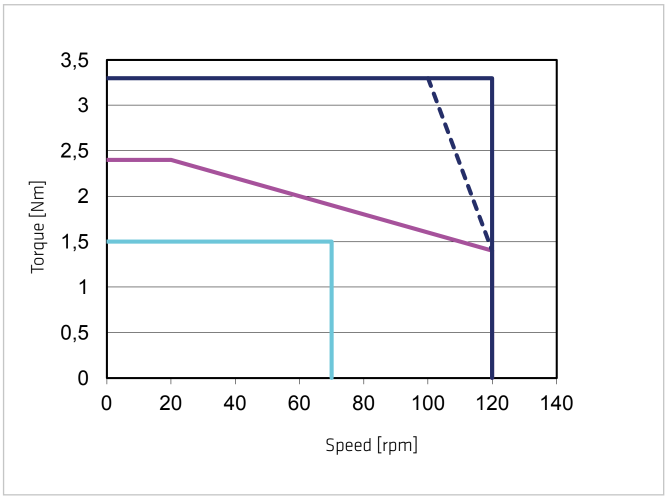


Illustration 20.4 FHA-11C-50

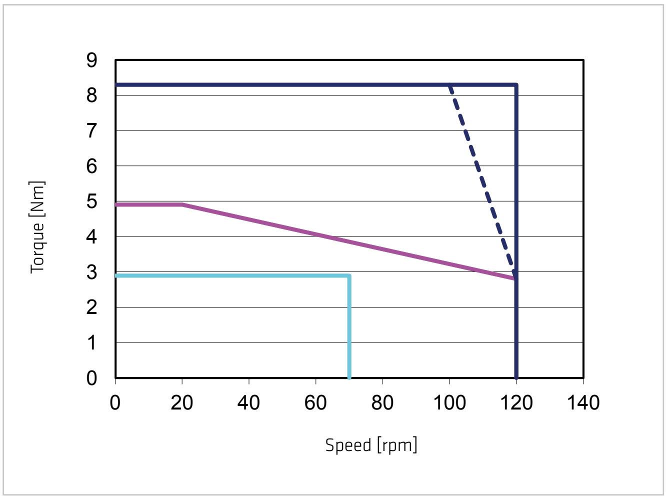


Illustration 20.5 FHA-8C-100

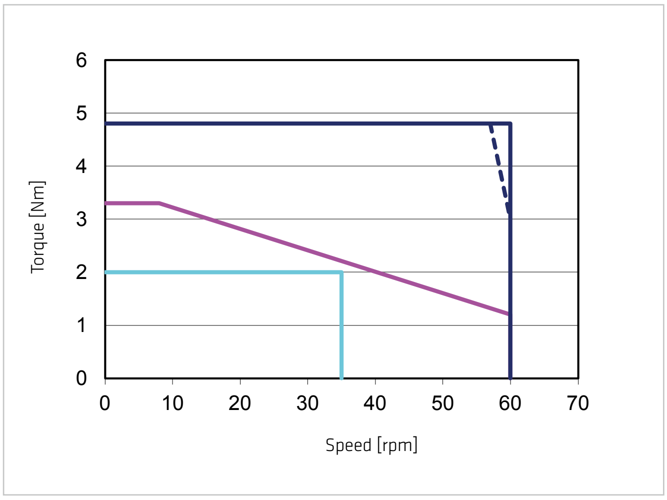
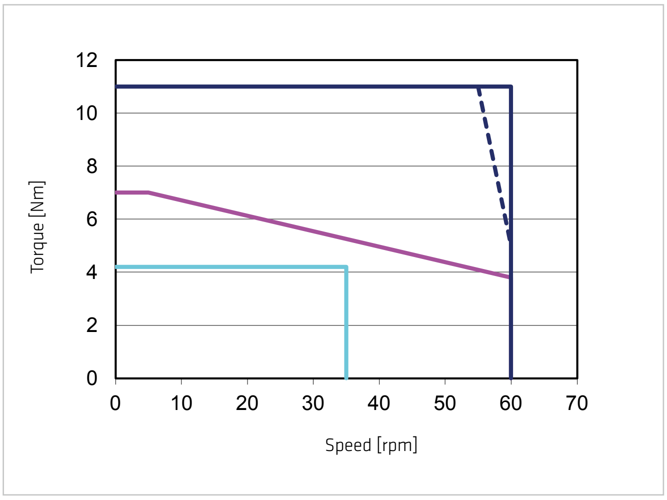


Illustration 20.6 FHA-11C-100



Legend

Intermittent duty ——— L: U_M = 220 VAC ———

Continuous duty ——— H: U_M = 100 VAC - - - - -

S3-ED 50% (1 min) ———

Illustration 21.1

FHA-14C-30

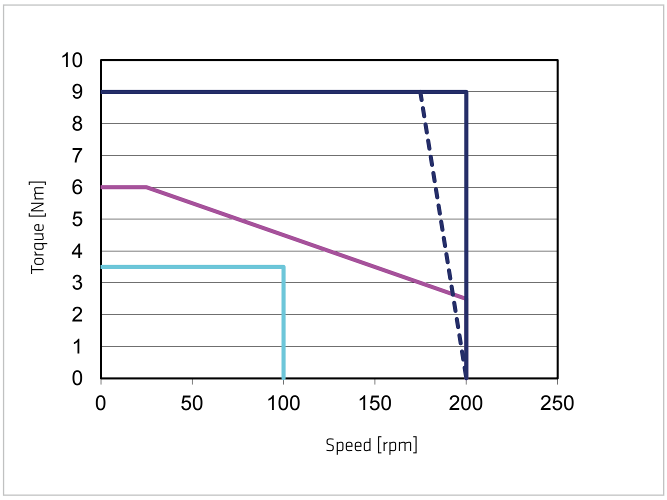


Illustration 21.2

FHA-14C-50

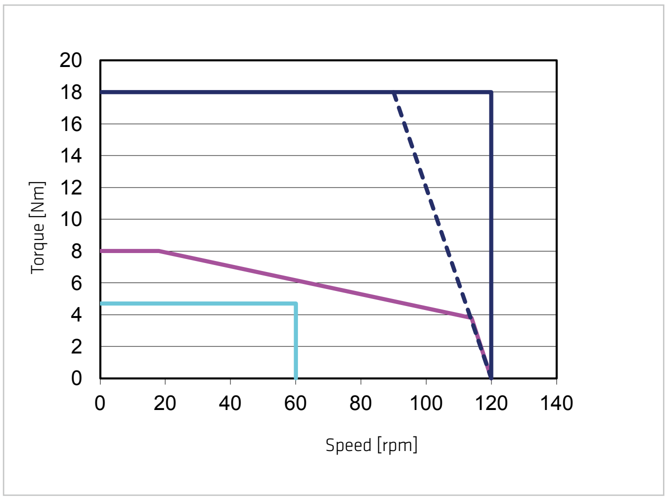
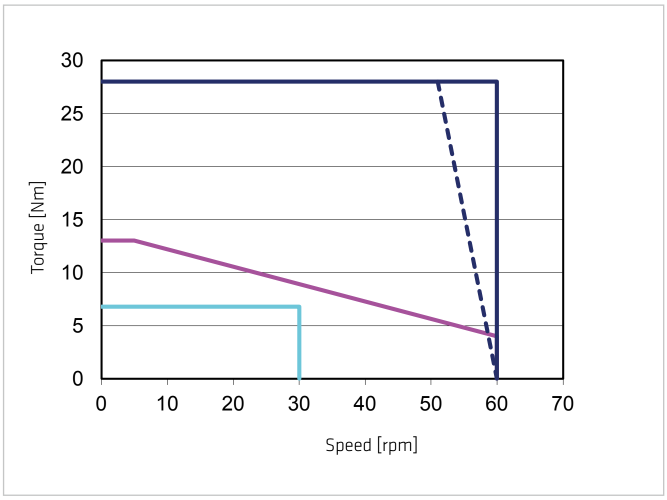


Illustration 21.3

FHA-14C-100



Legend

Intermittent duty ——— U_M = 220 VAC ——— S3-ED 50% (1 min) ———

Continuous duty ——— U_M = 100 VAC - - - - -

Technical Data FHAxC-MZE-EY

Table 22.1

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor winding		E			E			E		
Motor feedback system		MZE			MZE			MZE		
Ratio	i [ ]	30	50	100	30	50	100	30	50	100
Maximum output torque	T_{max} [Nm]	1.8	3.3	4.8	4.5	8.3	11	9	18	28
Maximum output speed	n_{max} [min^{-1}]	200	120	60	200	120	60	200	120	60
Maximum current	I_{max} [A_{rms}]	3.0	3.3	2.4	7.8	8.2	5.6	14.8	16.4	12.3
Continuous stall torque	T_0 [Nm]	0.75	1.5	2.0	1.8	2.9	4.2	3.5	4.7	6.8
Continuous stall current	I_0 [A_{rms}]	1.6	1.7	1.3	3.7	3.5	2.8	6.5	5.4	4.4
Maximum DC bus voltage	U_{DCmax} [V_{DC}]	48			48			48		
Electrical time constant (20 °C)	τ_e [ms]	0.4			0.6			0.9		
No load current (20 °C)	I_{NLS} [A_{rms}]	0.66	0.55	0.56	1.45	1.27	1.18	2.13	2.04	2.06
No load running current constant (20 °C)	K_{INL} [$x10^{-3}$ A_{rms}/rpm]	-	-	-	-	-	-	-	-	-
Torque constant (at motor)	k_{TM} [Nm/A_{rms}]	0.027			0.026			0.029		
AC voltage constant (L-L, 20 °C, at motor)	k_{EM} [V_{eff}/1000 rpm]	2.0			1.8			2.0		
Maximum motor speed	n_{max} [rpm]	6000			6000			6000		
Rated motor speed	n_N [rpm]	3500			3500			3500		
Resistance (L-L, 20 °C)	R_{L-L} [Ω]	1.08			0.38			0.14		
Synchronous inductance	L_d [mH]	6.5			0.29			0.11		
Number of pole pairs	p [ ]	5			5			5		
Weight without brake	m [kg]	0.5			0.7			1.3		
Weight with brake	m [kg]	-			-			-		
Hollow shaft diameter	d_H [mm]	-			-			-		

Moment of Inertia

Table 22.2

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Motor feedback system		MZE			MZE			MZE		
Ratio	i [ ]	**30**	**50**	**100**	**30**	**50**	**100**	**30**	**50**	**100**
Moment of inertia at output side										
Moment of inertia without brake	J_{out} [kgm^2]	0.0026	0.0074	0.0294	0.0062	0.0173	0.0690	0.0194	0.0538	0.2150
Moment of inertia with brake	J_{out} [kgm^2]	–	–	–	–	–	–	–	–	–
Moment of inertia motor side										
Moment of inertia at motor without brake	J [$x10^{-4}$ kgm^2]	0.0294			0.0690			0.2150		
Moment of inertia at motor with brake	J [$x10^{-4}$ kgm^2]	–			–			–		

Performance Characteristics

The performance curves shown below are valid for the specified ambient operating temperature if the motor terminal voltage is higher or equal to the values given in the rating tables.

Illustration 23.1

FHA-8C-30-E

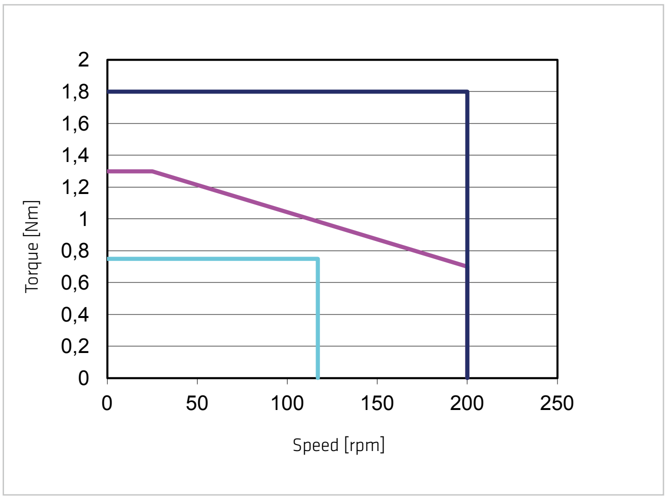


Illustration 23.2

FHA-11C-30-E

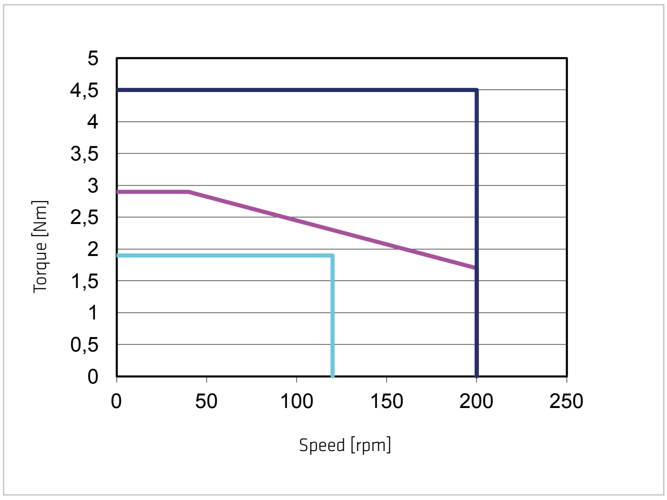


Illustration 23.3

FHA-8C-50-E

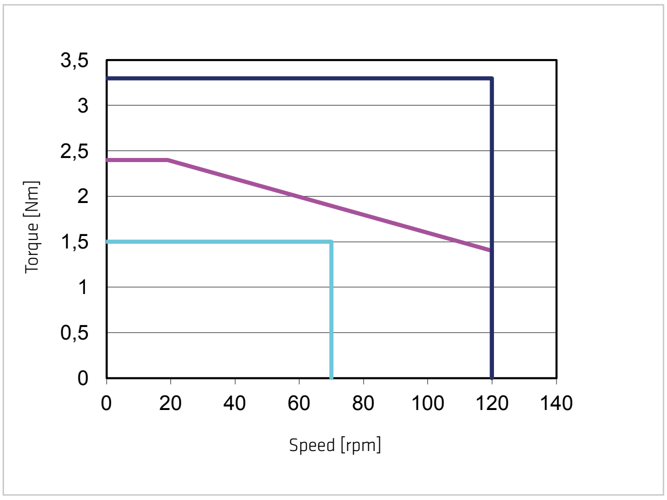


Illustration 23.4

FHA-11C-50-E

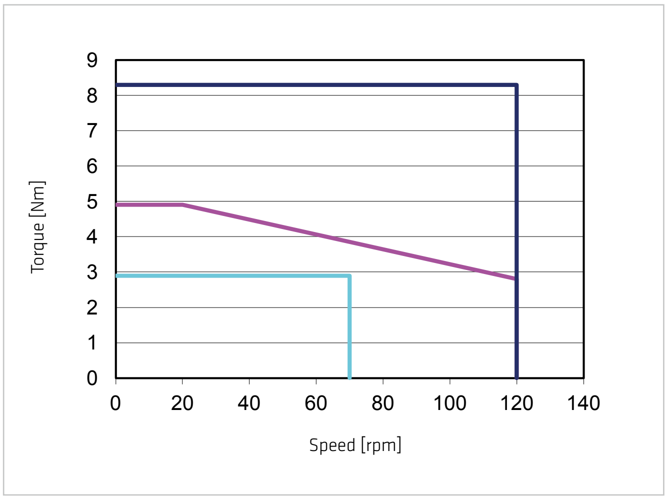


Illustration 23.5

FHA-8C-100-E

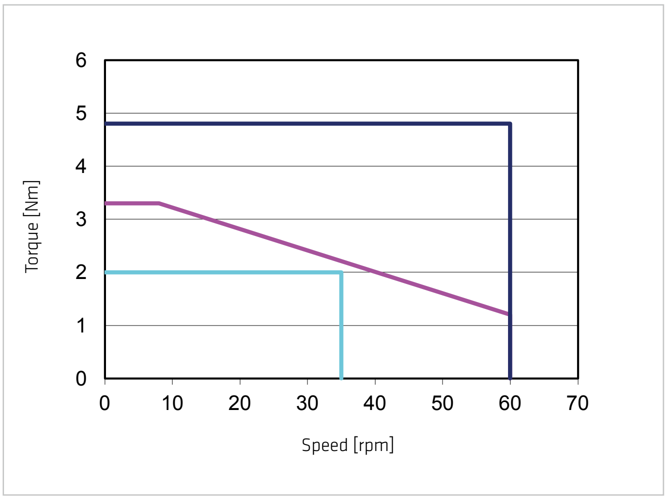
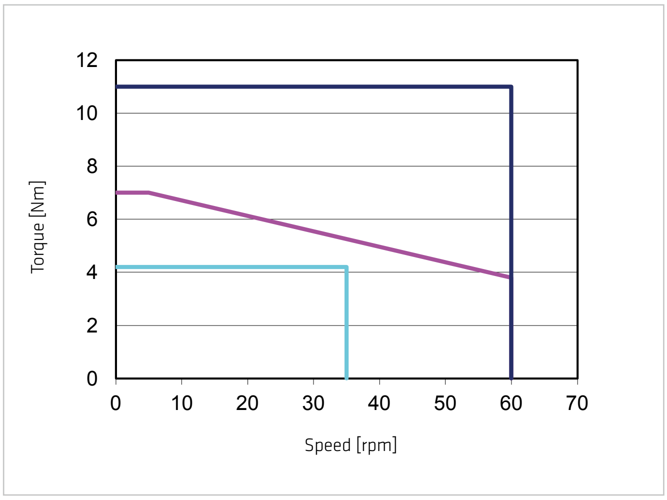


Illustration 23.6

FHA-11C-100-E



Legend

Intermittent duty
Continuous duty

U_M = 18 VAC

S3-ED 50% (1 min)

Illustration 24.1

FHA-14C-30-E

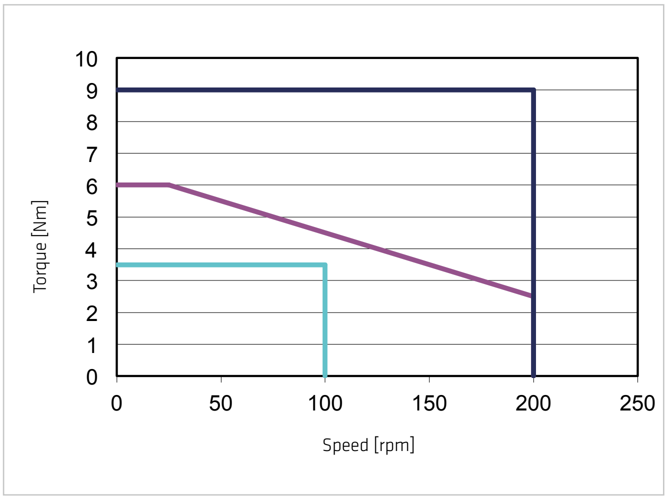


Illustration 24.2

FHA-14C-50-E

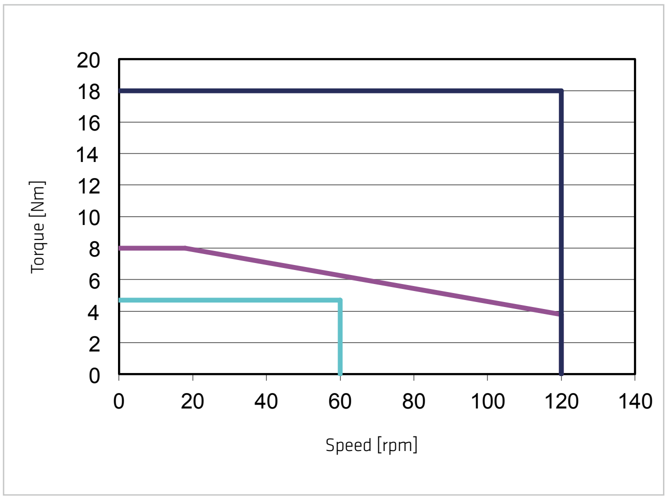
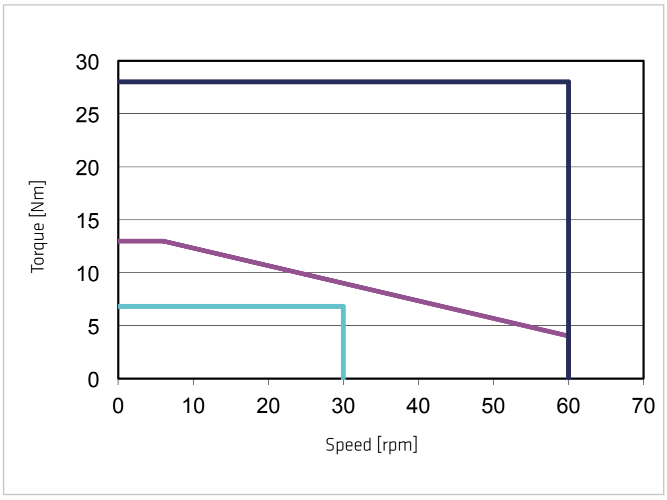


Illustration 24.3

FHA-14C-100-E



Legend

Intermittent duty

Continuous duty

U_M = 18 VAC

S3-ED 50% (1 min)

3.4.3 Dimensions

Illustration 25.1 FHA-8C Mini [mm]

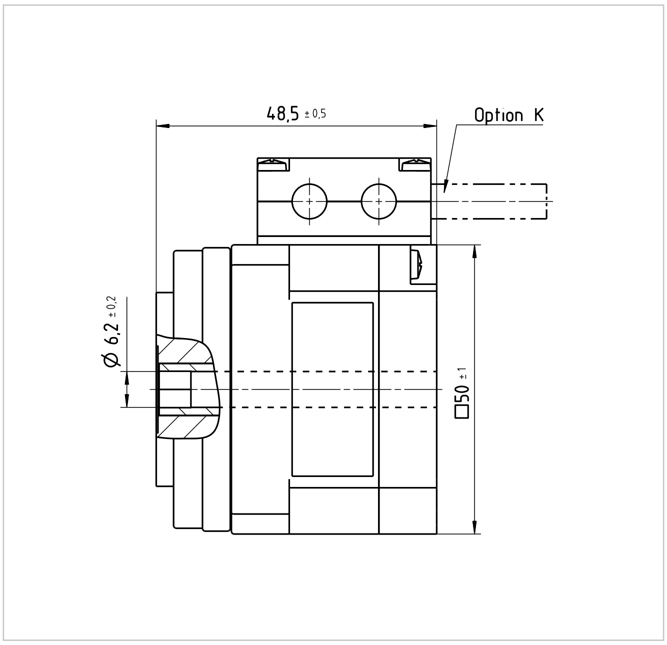


Illustration 25.2 FHA-11C Mini [mm]

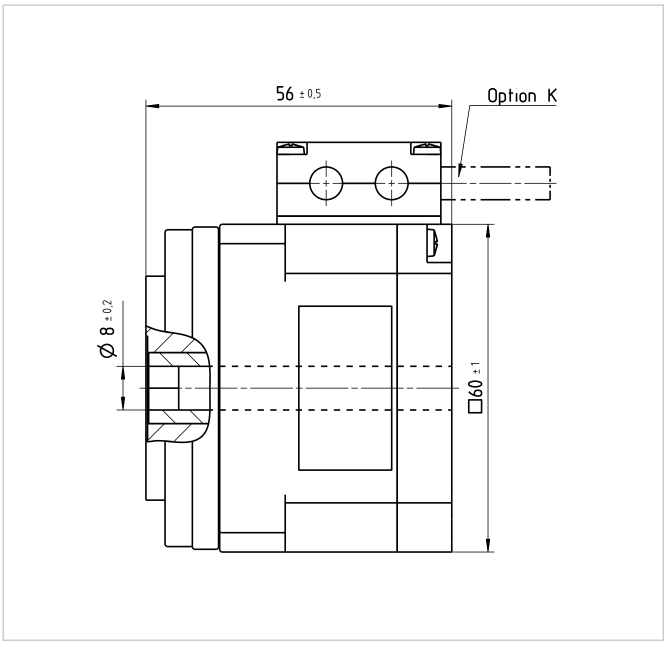
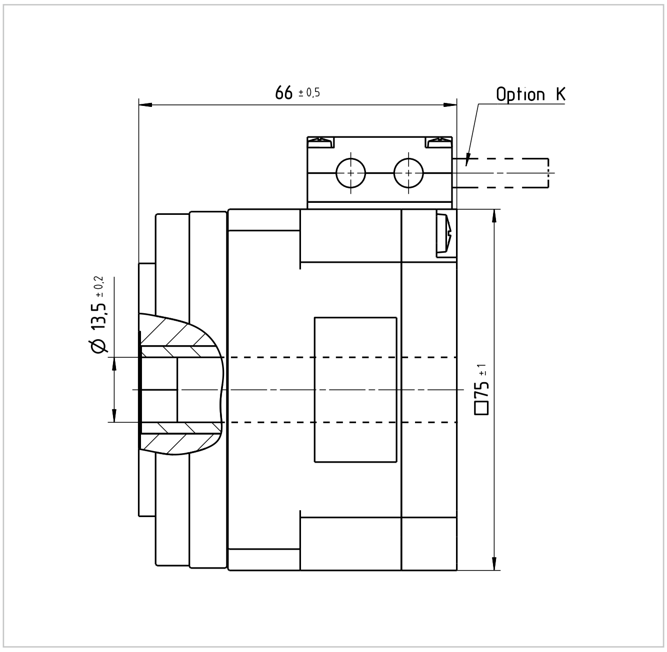


Illustration 25.3 FHA-14C Mini [mm]



Detailed 2D drawings and 3D models can be found at the following Quicklink:
QUICKLINK **www.harmonicdrive.de/CAD1030**

Illustration 26.1

FHA-8C Mini-MZE [mm]

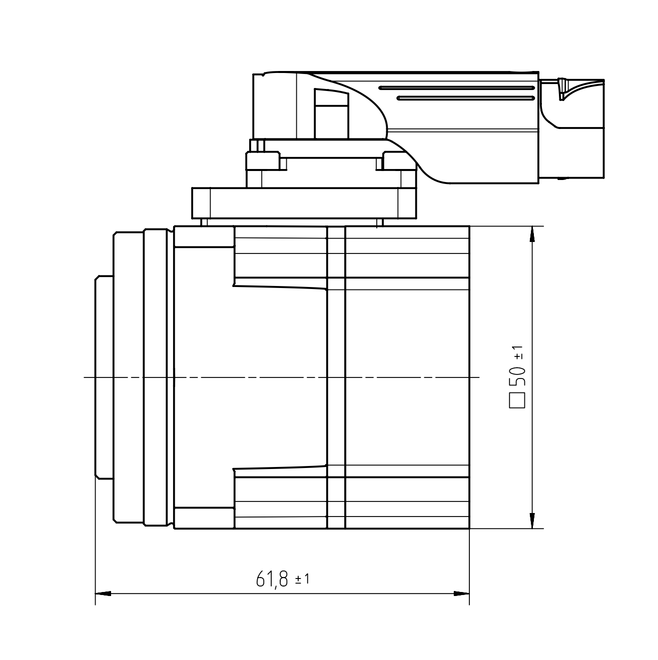


Illustration 26.2

FHA-11C Mini-MZE [mm]

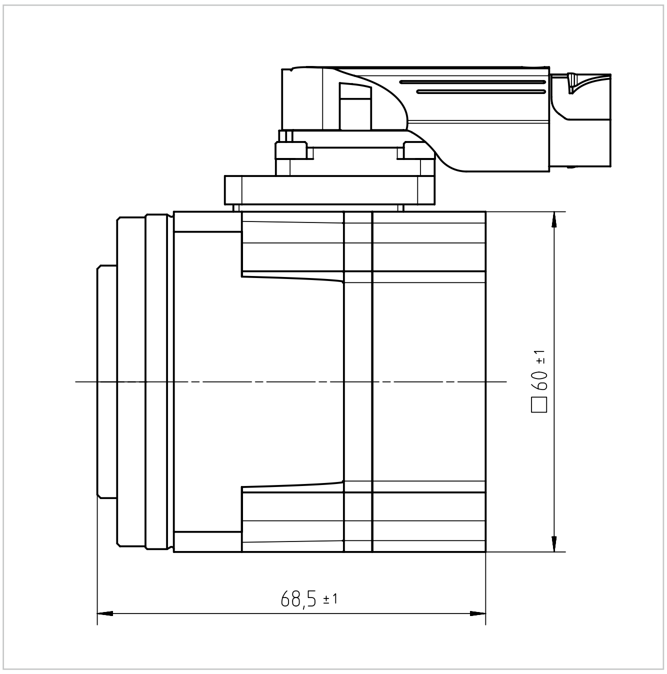
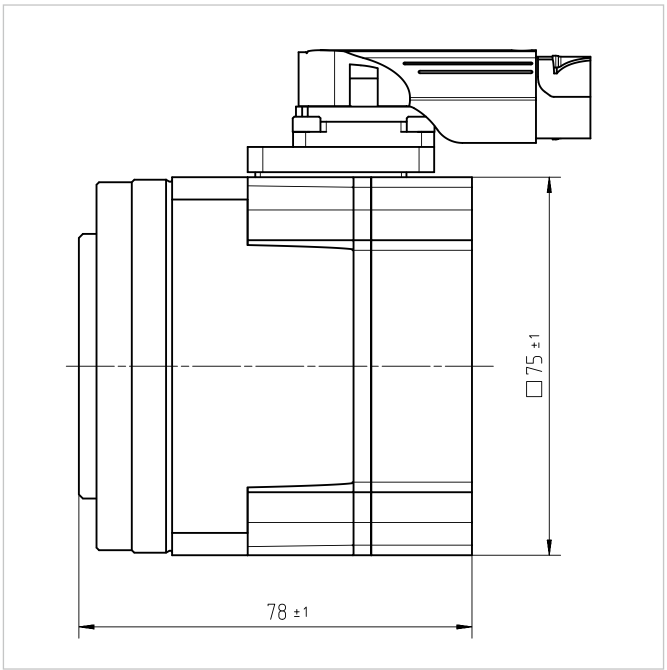


Illustration 26.3

FHA-14C Mini-MZE [mm]



ADVICE

Receptacles double connector can be turned horizontal by ±110°
Power connector: right plug side

3.4.4 Accuracy

Table 27.1

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
Ratio	i [ ]	**30**	**50**	**100**	**30**	**50**	**100**	**30**	**50**	**100**
Transmission accuracy	[arcmin]	< 2.5	< 2	< 2	< 2	< 1.5	< 1.5	< 2	< 1.5	< 1.5
Repeatability	[arcmin]	< ± 0.1	< ± 0.1	< ± 0.1	< ± 0.1	< ± 0.1	< ± 0.1	< ± 0.1	< ± 0.1	< ± 0.1
Hysteresis loss	[arcmin]	< 3	< 3	< 2	< 3	< 2	< 2	< 3	< 2	< 2
Lost Motion	[arcmin]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

3.4.5 Torsional Stiffness

Table 27.2

	Symbol [Unit]	FHA-8C			FHA-11C			FHA-14C		
T1	[Nm]	0.29			0.8			2		
T2	[Nm]	0.75			2			6.9		
Ratio	i [ ]	30	50	100	30	50	100	30	50	100
K_3	[x10^3 Nm/rad]	0.54	0.84	1.2	1.6	3.2	4.4	3.4	5.7	7.1
K_2	[x10^3 Nm/rad]	0.44	0.67	1	1.3	3	3.4	2.4	4.7	6.1
K_1	[x10^3 Nm/rad]	0.34	0.44	0.91	0.84	2.2	2.7	1.9	3.4	4.7

3.4.6 Output Bearing

FHA-C Mini Series AC hollow shaft Servo Actuators incorporate a high stiffness cross roller bearing to support output loads. This specially developed bearing can withstand high axial and radial forces as well as high tilting moments. The reduction gear is thus protected from external loads, so guaranteeing a long life and consistent performance. The integration of an output bearing also serves to reduce subsequent design and production costs, by removing the need for an additional output bearing in many applications. Furthermore, installation and assembly of the FHA-C Mini Servo Actuators are greatly simplified.

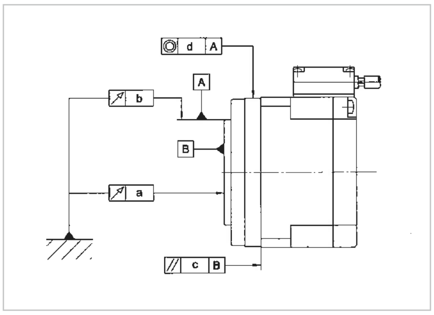
Technical Data

Table 28.1

	Symbol [Unit]	FHA-8C	FHA-11C	FHA-14C
Bearing type [1]		C	C	C
Pitch circle diameter	d_p [mm]	35.0	42.5	54.0
Offset	R [mm]	12.9	14.0	14.0
Dynamic load rating	C [N]	5800	6500	7400
Stating load rating	C_0 [N]	8000	9900	12800
Dynamic tilting moment [2]	$M_{dyn\ (max)}$ [Nm]	15	40	75
Static tilting moment [3]	$M_{0\ (max)}$ [Nm]	93	140	230
Tilting moment stiffness [5]	K_B [Nm/arcmin]	5.8	11.8	23.5
Dynamic axial load [4]	$F_{A\ dyn\ (max)}$ [N]	200	300	500
Dynamic radial load [4]	$F_{R\ dyn\ (max)}$ [N]	1163	2857	5357

[1] C=Cross roller bearing. F = Four point contact bearing
[2] These values are valid for moving gears. They are not based on the equation for lifetime of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Component Set. The values indicated in the table must not be exceeded even if the lifetime equation of the bearing permits higher values.
[3] These values are valid for gears at a standstill and for a static load safety factor f_s = 1.8 for size 14 ... 20 and f_s = 1.5 for size 25 ... 58.
[4] These data are valid for n = 15 rpm and L_{10} = 15000 h
[3)4)] These data are only valid if the following conditions are fulfilled:
for M_0: F_a=0 N; F_r=0 N
F_a: M=0 Nm; F_r=0 N
F_r: M=0 Nm; F_a=0 N
[5] Average value

Illustration 28.2



Tolerances

Table 28.3

	Symbol [Unit]	FHA-8C	FHA-11C	FHA-14C
a	[mm]	0.010	0.010	0.010
b	[mm]	0.010	0.010	0.010
c	[mm]	0.040	0.040	0.040
d	[mm]	0.040	0.040	0.040

3.4.7 Motor Feedback Systems

Design and Operation

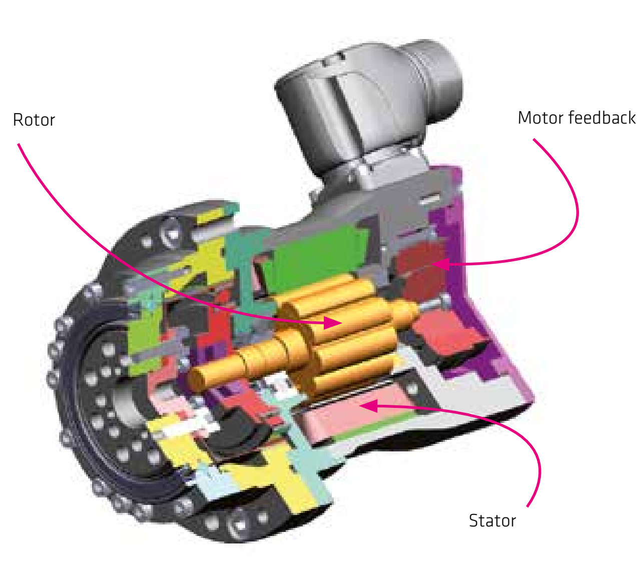
For accurate position setting, the servo motor and its control device are fitted with a measuring device (feedback), which determines the current position (e.g. the angle of redation set for a starting position) of the motor.

This measurement is effected via a redary encoder, e.g. a resolver, an incremental encoder or an absolute encoder. The position controller compares the signal from this encoder with the pre-set position value. If there is any deviation, then the motor is turned in the direction which represents a shorter path to the set value which leads to the deviation being reduced. The procedure repeats itself until the value lies incrementally or approximately within the tolerance limits. Alternatively, the motor position can also be digitally recorded and compared by computer to a set value.

Servo motors and actuators from Harmonic Drive AG use various motor feedback systems which are used as position transducers to fulfil several requirements.

Commutation

Commutation signals or absolute position values provide the necessary information about the rotor position, in order to guarantee correct commutation.



Actual Speed

The actual speed is obtained in the servo controller using the feedback signal, from the cyclical change in position information.

Actual Position

Incremental encoder
The actual signal value needed for setting the position is formed by adding up the incremental position changes. Where incremental encoders have square wave signals, definition of the edge evaluation can be quadrupled (quad counting).
Where incremental encoders have SIN / COS signals, then the definition can be increased by interpolation in the control device.

Absolute encoder
Absolute encoders deliver absolute position information about one (single turn) or several (multi-turn) rotations. This information can on the one hand provide the rotor position for commutation and on the other hand possibly a reference of travel. Where absolute encoders have additional incremental signals, then typically the absolute position information can be read at power up and the incremental signals then evaluated to determine the rotation and actual position value.
Fully digital absolute encoders as motor feedback systems have such a high definition of the absolute value that there is no need for additional incremental signals.

Resolution

In conjunction with the Harmonic Drive AG high precision gears, the output side position can be recorded via the motor feedback system without any additional angle encoders having to be used. The resolution of the motor feedback system can also be multiplied by gear ratio.

Output Side Angle Measurement Devices

Where applications place higher demands on accuracy or need torsion compensation at high torque load, the actual position can also be detected by an additional sensor mounted at the gearbox output side. The adaptation of an output side measurement sytem can be very simply realised for hollow shaft actuators.

D200

Incremental motor feedback system with square wave signals, reference signal and commutation signals (RS 422 standard)

Table 30.1

Ordering code	Symbol [Unit]	D200		
Manufacturer's designation		-		
Power supply [1]	U_b [VDC]	5 ± 5%		
Current consumption (max., without load) [1]	I [mA]	250		
Incremental signals		RS422		
Signal form		square wave		
Number of pulses	n_1 [A / B]	2000		
Commutation signals		RS422		
Signal form		square wave		
Number of pulses	n_2 [U / V / W]	5		
Reference signal	n_3 [Z]	1		
Accuracy [1]	[arcsec]	-		
Incremental resolution (motor side) [2]	[qc]	8000		
Resolution (output side) [2]		Gear ratio FHA-C Mini		
	i [ ]	30	50	100
	[arcsec]	5.4	3.3	1.7

[1] Source: Manufacturer
[2] For quadcounting

Signal Wave Form

Illustration 30.2

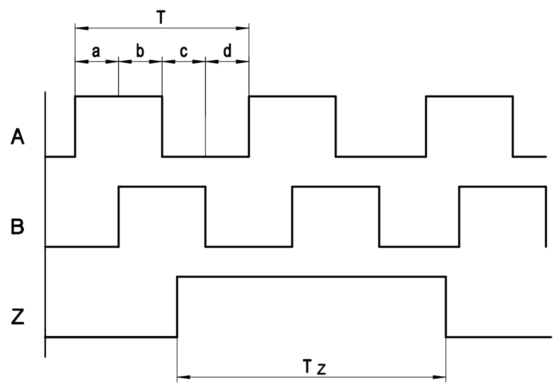
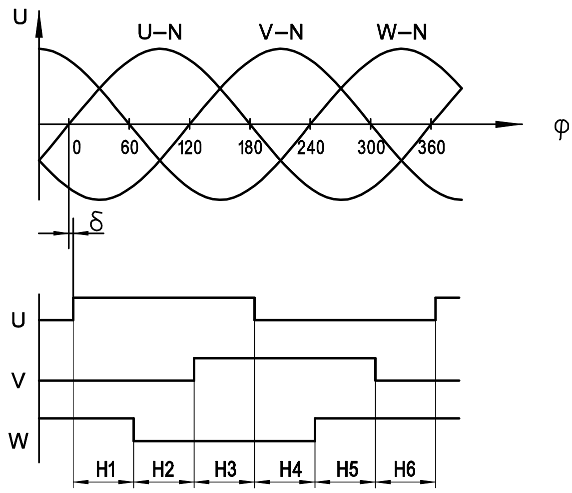


Illustration 30.3



T = 360°/2000
a, b, c, d = 0,25 T ±0,15 T
Tz = T ±0,5 T
HN = 360° / 5 / 6 = 12°
δ ≤ ±3° el.

For rotation in clockwise direction, looking at the output flange.

MZE

Multi-turn absolute motor feedback system with EnDat® 2.2/22 data interface

Tabelle 31.1

Ordering code	**Symbol [Unit]**	**MZE**		
Manufacturer's designation		EBI 1135		
Protocol		EnDat® 2.2/22		
Power supply [1]	U_b [VDC]	3.6 ... 14		
Current consumption (typically @ 5 VDC, without load) 1)	I [mA]	80		
Current consumption buffering (at 25 °C) [1 2]	I [mA]	12		
Incremental signals	u_{pp} [V_{ss}]	-		
Signal form		-		
Number of pulses	n_1	-		
Absolute position / revolution (motor side) [3]		262144 (18 bit)		
Number of revolutions		65536 (16 bit) battery back up (external battery necessary)		
Recommended buffer battery		Lithium thionyl chloride 3,6V / ≥2,0Ah Tadiran SL-760S Size: AA		
Typical battery service life [4]	[a]	10		
Battery replacement interval	[a]	10		
Accuracy [1]	[arcsec]	± 120		
Resolution at motor side	[arcsec]	4.94		
Gear ratio	i [ ]	30	50	100
Resolution of the absolute value (output side)	[arcsec]	0.165	0.099	0.049
Number of revolutions (output side)		2184	1310	655

[1] Source: Manufacturer
[2] Source: Manufacturer. Valid for power off and standstill
[3] Increasing position values
- for rotation in clockwise direction, looking at the motor shaft
- for rotation in counter clockwise direction, looking at the output flange

[4] Typical service life with 10 h/day in normal operation, battery temperature 25 °C and a self discharge of 1 %/a.

⚠ ATTENTION

In case of failure or interruption of the battery voltage and simultaneous failure or interruption of the power supply, the reported position after restarting will be wrong!
Undefined positioning can cause injury to persons or damage to the system.

ADVICE

Not compatible to Siemens servo controller SINAMICS S120!

ADVICE

An external battery power supply is necessary to operate the battery buffered multi-turn absolute motor feedback system MZE. A battery box MZE is available for this purpose. The handling of the battery box MZE and the electrical connections are described in the chapter "Battery boxes".
The typical service life of 10 years for the buffer battery applies to 10 h/day in normal operation, battery temperature 25 °C and a self-discharge of 1 %/a. To achieve a long service life of the buffer battery, the main power supply (U_b) must be connected to the encoder while connecting the backup battery, or directly thereafter, in order for the encoder to become fully initialised after having been completely powerless. Otherwise the encoder will consume a significantly higher amount of battery current until main power is supplied the first time.

3.4.8 Temperature Sensors

Due to the compact design of the FHA-C Mini Series there are no temperature sensors included.
The used controller must protect the actuator against overload.

3.4.9 Battery boxes

Battery box for multi-turn absolute motor feedback system MZE

The battery box MZE is an accessory for the multi-turn absolute motor feedback system MZE. It is used to buffer the position data when the power supply is switched off.
The battery box is intended for installation in the control cabinet. A corresponding protective circuit is integrated for protection against wiring faults.

Illustration 32.1 Battery box Mat.-no. 1024385

ADVICE

The battery is not included!

Recommended battery: Lithium thionyl chloride
3.6V / ≥ 2.0Ah / AA
e.g. Tadiran SL-760S

Illustration 32.2 Explosion view

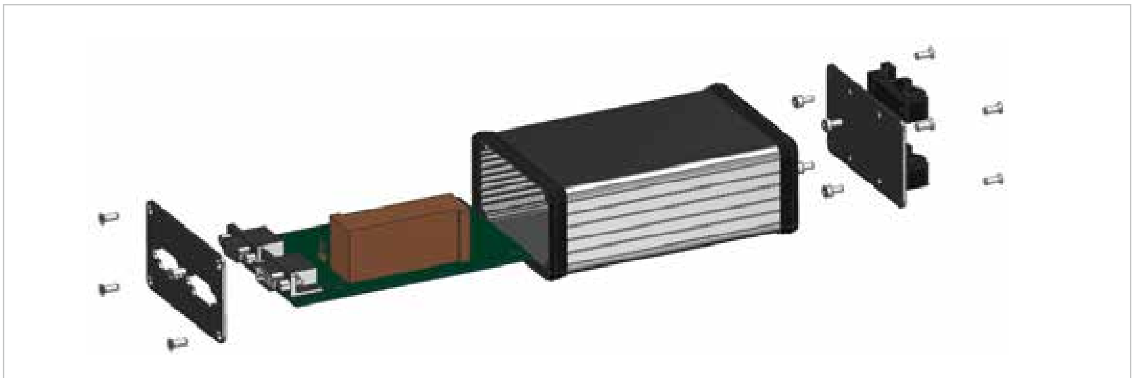
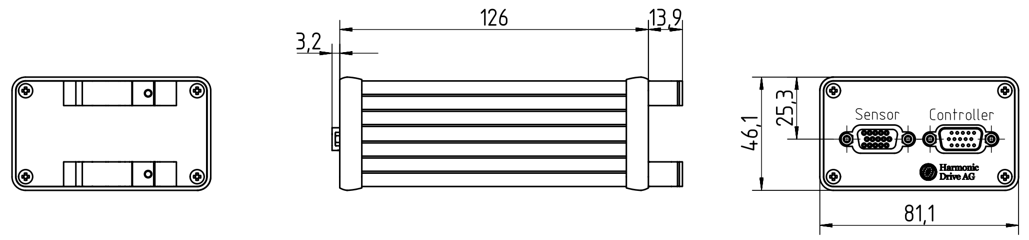


Illustration 33.1

Dimensions



Assembly: DIN mounting rail 35 mm

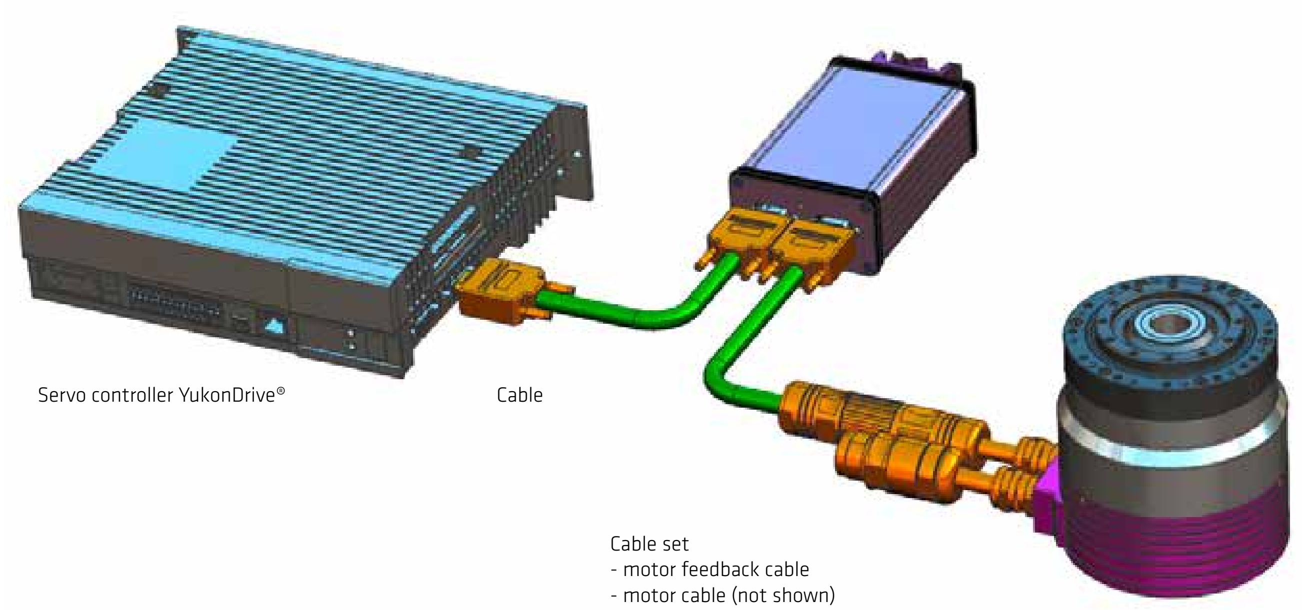
Illustration 33.2

Electrical connection

Sensor 15. pol. Sub D female		Battery	Controller 15. pol. Sub D male	
1	–		1	–
2	–		2	–
3	U_P		3	U_P
4	DATA +		4	DATA +
5	DATA -		5	DATA -
6	–		6	–
7	UBAT+	UBAT+	7	-
8	UBAT- (0V / GND)	UBAT-	8	UBAT- (0V / GND)
9	Temp -		9	Temp -
10	Temp +		10	Temp +
11	–		11	–
12	Sense +		12	Sense +
13	Sense -		13	Sense -
14	CLOCK +		14	CLOCK +
15	CLOCK -		15	CLOCK -

Illustration 33.3

Wiring motor feedback system



Connecting cable set for the connection to YukonDrive® or third party controller

The connection cable set consists of a motor power cable and a motor feedback cable. The motor feedback cable is connected to the battery box.

Table 34.1

Version	Mat.-no.	Length [m]
FHA-MZE-Y	1028684	3
	1028685	5
	1028686	10
	1028687	15

Connecting cable from battery box to YukonDrive® X7

Table 34.2

Version	Mat.-no.	Length [m]
MZE	1025481	0,5
	1025482	1,0
	1025483	2,0

Connecting cable with flying leads from battery box to third party controller

Table 34.3

Version	Mat.-no.	Length [m]
MZE	1025484	0.5
	1025485	1.0
	1025486	2.0

ADVICE

The connector for the battery box is mounted. The connection for the third party controller has flying leads.

Replacing the battery

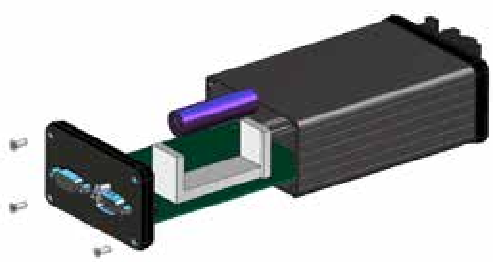
The following preconditions must be ensured in order to maintain the absolute encoder position when replacing the battery.

ADVICE

- The supply voltage of the motor feedback system is provided by the drive controller
- The motor feedback system is connected to the drive controller

⚠ ATTENTION

In case of failure or interruption of the battery voltage and simultaneous failure or interruption of the power supply, the reported position after restarting will be wrong!
Undefined positioning can cause injury to persons or damage to the system.



- Open the cover of the battery box
- Remove the circuit board with the battery
- Remove the old battery and dispose it according to the corresponding directives
- Insert new battery
- Insert the circuit board with the battery
- Close the cover of the battery box
- Reset error and warning bit

Reset error bit and warning bit

The MZE motor feedback system monitors the connected battery and provides, in addition to the position values, also an error bit and a warning bit, which are transmitted via the EnDat® interface.

- Warning „Battery change“
  ≤ 2,8 V ±0,2 V in normal operation mode
- Error message „M power failure“
  ≤ 2,2 V ±0,2 V in battery buffered operation mode (the encoder must be re-referenced)

The warning bit is set when the battery voltage reaches the critical value during operation. After the warning "Battery change" has occurred, the battery must be replaced immediately.

The error message is set with simultaneous failure or interruption of the battery voltage and the voltage supply.

Error bit and warning bit can be reseted via the EnDat® interface.

ADVICE

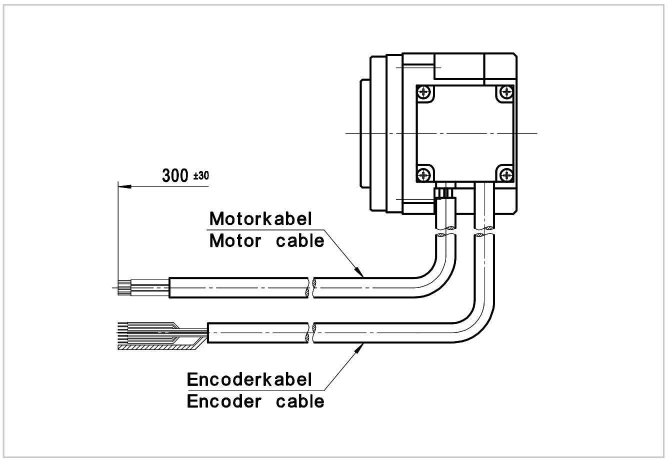
The EnDat® specification and the EnDat® "Application Notes" from Heidenhain for battery buffered measuring devices must be observed for correct control of the motor feedback system MZE (Heidenhain type EBI135).

3.4.10 Electrical Connections

FHA-xC-D200

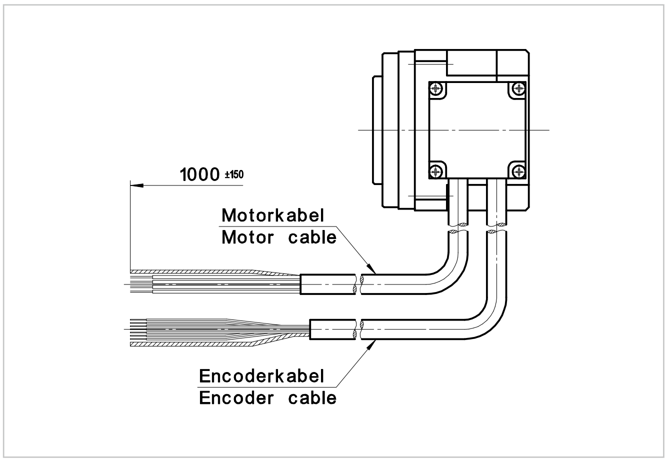
Cable Configuration Standard

Illustration 36.1



Cable Configuration "Option M1"

Illustration 36.2



ADVICE

Motor cable and encoder cable are not suitable for moving installations!

Table 36.3

Motor phase	U	V	W	PE
Colour	red	white	black	green yellow
Cross section	AWG 24 (FHA-8C / FHA-11C) AWG 20 (FHA-14C)			

Table 36.4

D200 Signal	A+	A-	B+	B-	Z+	Z-	U+	U-	V+	V-	W+	W-	GND	Up
Colour	green	dark green	grey	white	yellow	trans-parent	brown	magenta	blue	light blue	orange	rose	black	red
Cross section	AWG 29												AWG 29	

Connecting cables with flying leads and mating connectors for the actuator for the connection to YukonDrive®

Table 36.5

Version	Material-no.	Length [m]
FHA-C Mini-SP (SP = connector)	1010968 1006450 1001325	3 5 10

FHA-xC-MZE-Y

Table 37.1

Motor connector	Intercontec ytec®
Cable plug	Intercontec springtec® Housing: ESTB-202-NN00-34-0500-000 Socket: 9 x 61.251.11

Illustration 37.2

Table 37.3

	FHA-xC-MZE-Y								
Connector pin	A	B	C	PE	1	2	3	4	5
Motor phase	U	V	W	PE	–	–	–	–	–

Table 37.4

Encoder connector	Intercontec ytec®
Cable plug	Intercontec springtec® Housing: ESTB-002-NN00-33-0001-000 Socket: 12 x 60.252.11

Illustration 37.5

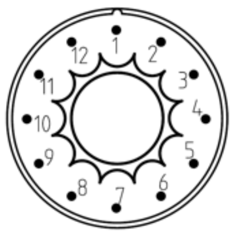


Table 37.6

Connector pin	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Signal	Up+	DATA+	DATA-	CLOCK+	CLOCK-	UBAT-	GND	–	–	–	–	UBAT+

Connecting cable for the connection to YukonDrive® and to battery box MZE

Table 37.7

Version	**Mat.-no.**	**Length [m]**
MZE-Y [1)]	1028684 1028685 1028686 1028687	3 5 10 15

[1)] The motor feedback cable can be used for the connection to the battery box! It can also be used for third party drives.

Connecting cable with flying leads

Table 37.8

Version	**Mat.-no.**	**Length [m]**
MZE-Y	– – 1031279 –	3 5 10 15

4. Actuator Selection Procedure

4.1. Selection Procedure and Calculation Example

Flowchart for actuator selection

Equation 38.1

$$T_1 = T_L + \frac{2\pi}{60} \cdot \frac{(J_{out} + J_L) \cdot n_2}{t_1}$$

Equation 38.2

$$T_2 = T_L$$

$$T_3 = T_L - (T_1 - T_L)$$

$$T_{rms} = \sqrt{\frac{T_1^2 \cdot t_1 + T_2^2 \cdot t_2 + T_3^2 \cdot t_3}{t_1 + t_2 + t_3 + t_p}}$$

Equation 38.3

$$n_{av} = \frac{\frac{|n2|}{2} \cdot t_1 + |n2| \cdot t_2 + \frac{|n2|}{2} \cdot t_3}{t_1 + t_2 + t_3 + t_p}$$

Equation 38.4

$$ED = \frac{t_1 + t_2 + t_3}{t_1 + t_2 + t_3 + t_p} \cdot 100\ \%$$

Confirm the type of servo mechanism required: linear motion or rotary motion

Calculate load torque (T_L) and moment of inertia (J_L): Equation 39.3 / Equation 39.5

Determine speed pattern from duty cycle

Tentatively select the required actuator based upon load conditions

Calculate the required acceleration torque (T_1): Equation 38.1

Is the required acceleration torque less than max. output torque of the actuator? — No (return to tentative actuator selection)

Yes

Determine the torque pattern and calculate the effective torque (T_{rms}): Equation 38.2

Calculate average Speed (n_{av}): Equation 38.3

Calculate duty factor (ED): Equation 38.4

T_{rms} and n_{av} are inside the Continuous Duty Zone — No (return to tentative actuator selection)

Yes

Confirm final selection

Pre selection conditions

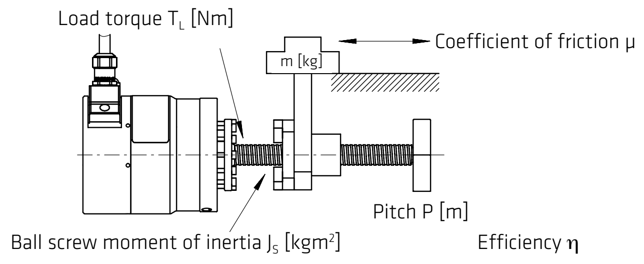
Table 39.1

Load	Confirmation	Catalogue value	Unit
Load max. rotation speed (n_2)	$\leq n_{max}$	Max. output speed	[rpm]
Load moment of inertia (J_L)	$\leq 3J_{Out}$ 1)	Moment of inertia	[kgm²]

1) $J_L \leq 3 \cdot J_{Out}$ is recommended for highly dynamic applications (high responsiveness and accuracy).

Linear horizontal motion

Illustration 39.2



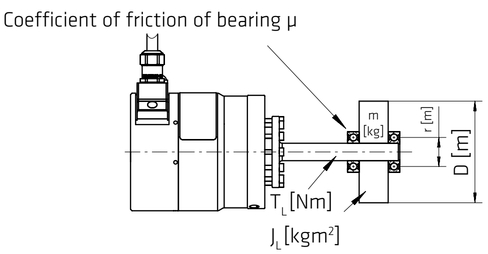
Equation 39.3

$$J_L = J_S + m \left(\frac{P}{2\pi}\right)^2 \text{ [kgm}^2\text{]}$$

$$T_L = \frac{\mu \cdot m \cdot P \cdot g}{2\pi \cdot \eta} \text{ [Nm]}$$

Rotary motion

Illustration 39.4

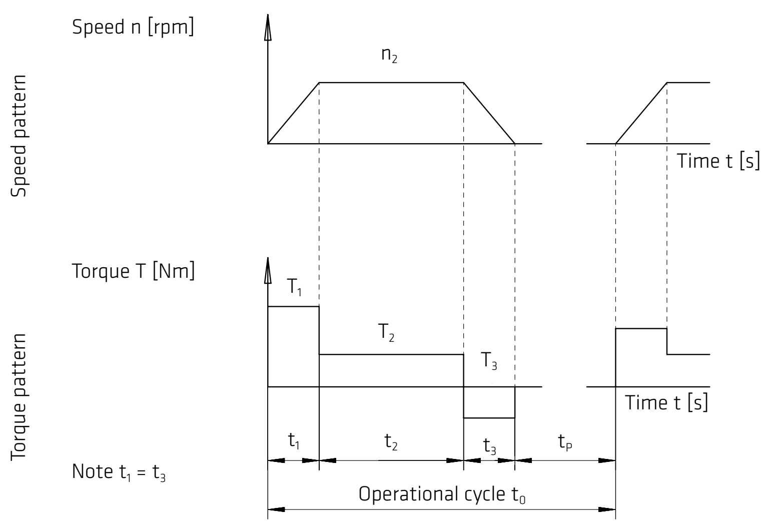


Equation 39.5

$$J_L = \frac{m}{8} \cdot D^2 \text{ [kgm}^2\text{]}$$

$$T_L = \mu \cdot m \cdot g \cdot r \text{ [Nm] } g = 9.81 \text{ [m/s}^2\text{]}$$

Illustration 39.6



Example of actuator selection

Load Conditions

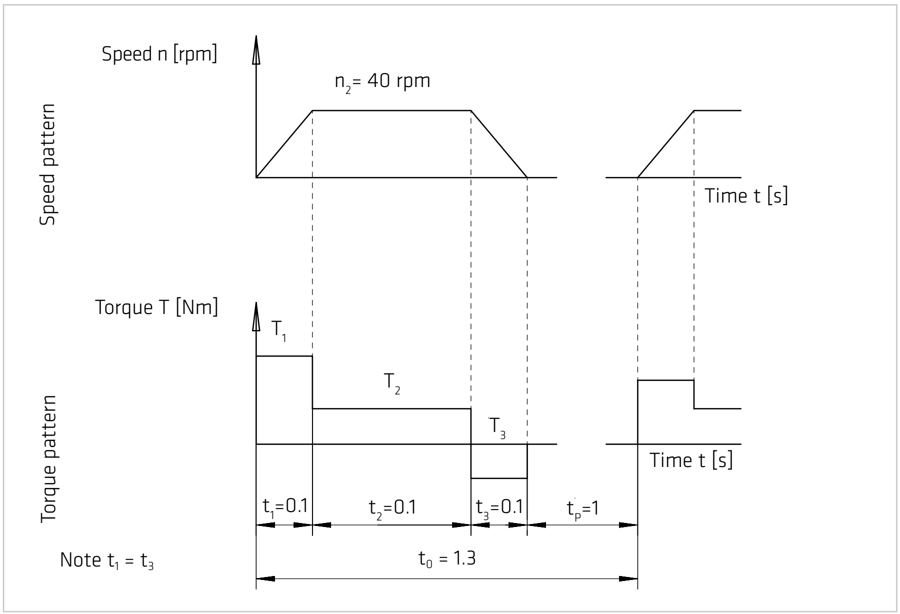
Assume servo mechanism is used to cyclically position a mass with a horizontal axis of rotation.

Table 40.1

Load rotation speed	n_2 = 40 [rpm]
Load torque (e. g. friction)	T_L = 5 [Nm]
Load inertia	J_L = 1.3 [kgm²]
Speed pattern	
Acceleration; Deceleration	$t_1 = t_3$ = 0.1 [s]
Operate with rated speed	t_2 = 0.1 [s]
Stand still	t_p = 1 [s]
Total cycle time	t_0 = 1.3 [s]

Please note: Each characteristic value should be converted to the value at the output shaft of the actuator.

Illustration 40.2



Actuator data CanisDrive-25A-50

Table 40.3

Max. Torque	T_{max} = 127 [Nm]
Max. Speed	n_{max} = 112 [rpm]
Moment of inertia	J_{Out} = 1.063 [kgm²]

Tentatively select a required actuator based upon load conditions. FHA-25C-50 meets the tentative selection requirements from catalogue value (see rating table)

$n_2 = 40$ rpm $< n_{max} = 112$ rpm
$J_L = 1.3\ kgm^2 < 3J_{out} = 3.19\ kgm^2$

Calculate required acceleration torque (T_1)

$$T_1 = 5 + \frac{2\pi}{60} \cdot \frac{(1.3 + 0.86) \cdot 40}{0.1} = 103.8\ Nm$$

Confirm: Is the required acceleration torque less than the maximum output torque of the actuator?

$T_1 = 103.8\ Nm < T_{max} = 127\ Nm$

No

Yes

Calculate effective torque (T_{rms})

$T_1 = 103.8\ Nm$
$T_2 = T_L = 5\ Nm$
$T_3 = T_L - (T_1 - T_L) = -93.8\ Nm$

$$T_{rms} = \sqrt{\frac{103.8^2 \cdot 0.1 + 5^2 \cdot 0.1 + (-93.8)^2 \cdot 0.1}{1.3}} = 38.8\ Nm$$

Calculation of the average speed

$$n_{av} = \frac{\frac{40}{2} \cdot 0.1 + 40 \cdot 0.1 + \frac{40}{2} \cdot 0.1}{1.3}$$

$n_{av} = 6$ rpm

Calculation of the duty factor

$$ED = \frac{0.1 + 0.1 + 0.1}{1.3} \cdot 100\%$$

$ED = 23\,\%$

$T_{rms} = 38.8\ Nm$
$n_{av} = 6$ rpm

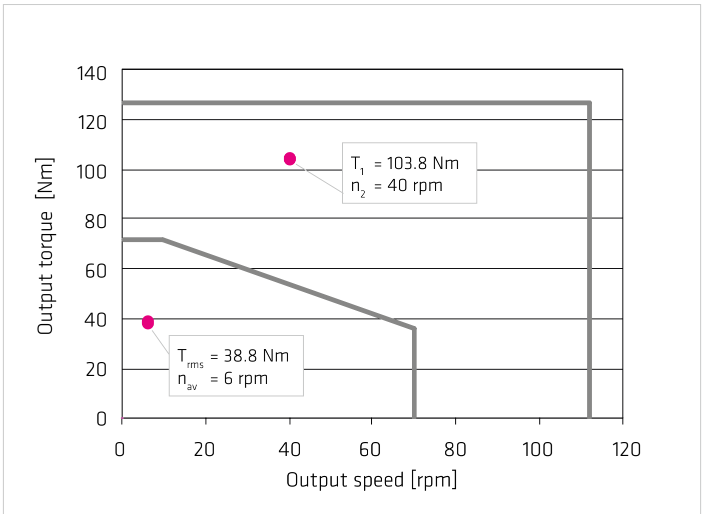
Check according to the performance characteristics

T_{rms} and n_{av} are inside the continuous duty zone

Confirm final selection

Illustration 41.1

CanisDrive-25A-50



4.2 Calculation of the Torsion Angle

Equation 42.1

$$T \leq T_1$$

$$\varphi = \frac{T}{K_1}$$

Equation 42.2

$$T_1 < T \leq T_2$$

$$\varphi = \frac{T_1}{K_1} + \frac{T - T_1}{K_2}$$

Equation 42.3

$$T > T_2$$

$$\varphi = \frac{T_1}{K_1} + \frac{T_2 - T_1}{K_2} + \frac{T - T_2}{K_3}$$

φ = Angle [rad]
T = Torque [Nm]
K = Stiffness [Nm/rad]

Example

$T = 60\ \text{Nm}$ $K_1 = 6.7 \cdot 10^4\ \text{Nm/rad}$

$T_1 = 29\ \text{Nm}$ $K_2 = 1.1 \cdot 10^5\ \text{Nm/rad}$

$T_2 = 108\ \text{Nm}$ $K_3 = 1.2 \cdot 10^5\ \text{Nm/rad}$

$$\varphi = \frac{29\ \text{Nm}}{6.7 \cdot 10^4\ \text{Nm/rad}} + \frac{60\ \text{Nm} - 29\ \text{Nm}}{11 \cdot 10^4\ \text{Nm/rad}}$$

$$\varphi = 7.15 \cdot 10^{-4}\ \text{rad}$$

$$\varphi = 2.5\ \text{arc min}$$

Equation 42.4

$$\varphi\ [\text{arc min}] = \varphi\ [\text{rad}] \cdot \frac{180 \cdot 60}{\pi}$$

4.3 Output Bearing

4.3.1 Lifetime calculation

For oscillating motion

The operating life at oscillating motion can be calculated using equation 43.1.

Equation 43.1

$$L_{OC} = \frac{10^6}{60 \cdot n_1} \cdot \frac{180}{\varphi} \cdot \left(\frac{C}{f_w \cdot P_C}\right)^B$$

with:

L_{OC} [h] = Operating life for oscillating motion

n_1 [cpm] = Number of oscillations/minute*

C [N] = Dynamic load rating. See table "Output Bearing" in the appropriate product chapter

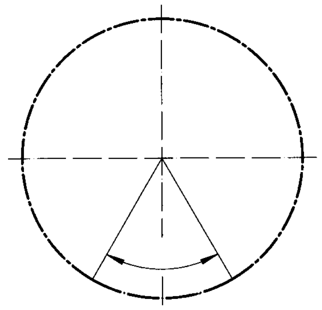
P_C [N] = Dynamic equivalent load

φ [Degree] = Oscillating angle

f_W = Operating factor (Table 43.5)

* one oscillation means 2φ

Illustration 43.2 Oscillating angle



At oscillating angles < 5° fretting corrosion may occur due to insufficient lubrication. In this case please contact our sales engineer for counter-measures.

Bearing type of selected products see chapter 3.4.6 "Technical Data Output Bearing".

Table 43.3

Type of bearing	B
Cross roller bearing	10/3
Four point bearing	3

For continuous operation

The operating life of the output bearing can be calculated using equation 43.3.

Equation 43.4

$$L_{10} = \frac{10^6}{60 \cdot n_{av}} \cdot \left(\frac{C}{f_w \cdot P_C}\right)^B$$

with:

L_{10} [h] = Operating life

n_{av} [rpm] = Average output speed

C [N] = Dynamic load rating, see table "Output Bearing Ratings"

P_C [N] = Dynamic equivalent load

f_W = Operating factor (Table 43.5)

Average output speed

$$n_{av} = \frac{|n_1| t_1 + |n_2| t_2 + \ldots + |n_n| t_n}{t_1 + t_2 + \ldots + t_n + t_p}$$

Table 43.5

Load conditions	f_W
No impact loads or vibrations	1 ... 1.2
Normal rotating, normal loads	1.2 ... 1.5
Impact loads and/or vibrations	1.5 ... 3

Dynamic equivalent load

Equation 44.1

$$P_C = x \cdot \left(F_{rav} + \frac{2M}{dp}\right) + y \cdot F_{aav}$$

Equation 44.2

$$F_{rav} = \left(\frac{|n_1| \cdot t_1 \cdot (|F_{r1}|)^B + |n_2| \cdot t_2 \cdot (|F_{r2}|)^B + \ldots + |n_n| \cdot t_n \cdot (|F_{rn}|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{1/B}$$

Equation 44.3

$$F_{aav} = \left(\frac{|n_1| \cdot t_1 \cdot (|F_{a1}|)^B + |n_2| \cdot t_2 \cdot (|F_{a2}|)^B + \ldots + |n_n| \cdot t_n \cdot (|F_{an}|)^B}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \ldots + |n_n| \cdot t_n} \right)^{1/B}$$

with:

F_{rav} [N]	=	Radial force
F_{aav} [N]	=	Axial force
d_p [m]	=	Pitch circle
x	=	Radial load factor (Table 44.4)
y	=	Axial load factor (Table 44.4)
M	=	Tilting moment

Table 44.4

Load factors	x	y
$\frac{F_{aav}}{F_{rav} + 2 \cdot M / dp} \leq 1.5$	1	0.45
$\frac{F_{aav}}{F_{rav} + 2 \cdot M / dp} > 1.5$	0.67	0.67

Illustration 44.5

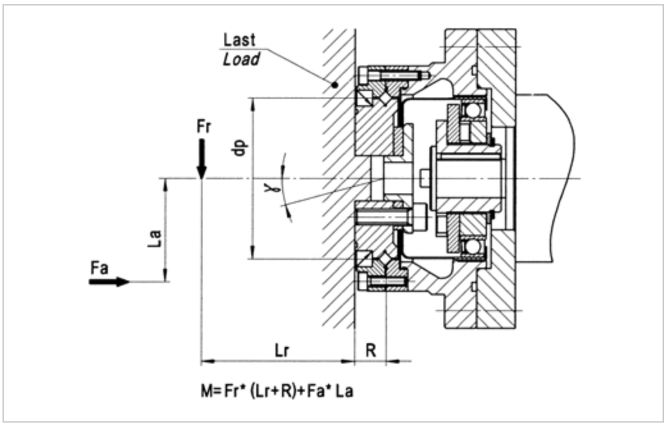
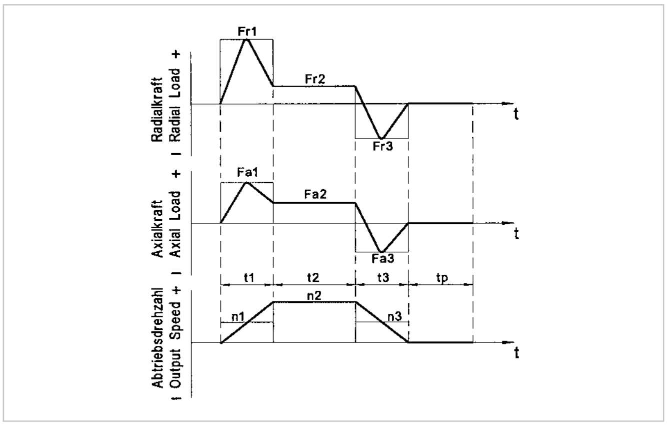


Illustration 44.6



Please note:
F_{rx} represents the maximum radial force.
F_{ax} represents the maximum axial force.
t_p represents the pause time between cycles.

4.3.2 Angle of Inclination

The angle of inclination of the output flange, as a function of the tilting moment acting on the output bearing, can be calculated by means of equation 45.1:

Equation 45.1

$$\gamma = \frac{M}{K_B}$$

with:

γ [arcmin]	=	Angle of inclination of the output flange
M [Nm]	=	Tilting moment acting on the output bearing
K_B [Nm/arcmin]	=	Moment stiffness of the output bearing

5. Installation and Operation

5.1 Transport and Storage

The transportation of the servo actuators and motors should always be in the original packaging.

If the servo actuators and motors are not put into operation immediately after delivery, they should be stored in a dry, dust and vibration free environment. Storage should be for no longer than 2 years at room temperatures (between +5 °C ... +40 °C) so that the grease life is preserved.

INFORMATION

Tensile forces in the connecting cable must be avoided.

ADVICE

Lithium metal batteries are dangerous goods according to UN3090. Therefore they are generally subject to transport regulations, depending on the transport mode.
The batteries installed in the motor feedback systems do not contain more than 1 g of lithium or lithium alloy and are exempt from dangerous goods regulations.

5.2 Installation

Check the performance and protection and check the suitability of the conditions at the installation site. Take suitable constructive measures to ensure that no liquid (water, drilling emulsion, coolant) can penetrate the output bearing or encoder housing.

ADVICE

The installation must be protected against impact and pressure on the gear.

The mounting must be such that heat loss can be adequately dissipated.

No radial forces and axial forces may act to the protection sleeve of the hollow shaft actuator.

During installation, the actuator must be fitted ensuring the machine housing can be rotated without terminals. Already low terminals may affect the accuracy of the gear and, should this be the case, the installation of the machine housing should be checked.

5.3 Mechanical Installation

The data necessary for mounting the actuator and for connecting to the load are given in the following table.

Table 47.1

	Symbol [Unit]	FHA-8C	FHA-11C	FHA-14C
Load assembly				
Number of screws		6	6	6
Screw size		M3	M4	M5
Screw quality		12.9	12.9	12.9
Pitch circle diameter	[mm]	25.5	33	44
Screw tightening torque	[Nm]	2	4.5	9
Housing assembly				
Number of screws		4 x Ø3.4	4 x Ø4.5	4 x Ø5.5
Screw size		M3	M4	M5
Screw quality		8.8	8.8	8.8
Pitch circle diameter	[mm]	58	70	88
Screw tightening torque	[Nm]	1.2	2.7	5.4

Data valid for completely degreased connecting interfaces (friction coefficient $\mu = 0.15$). Screws to be secured against loosening. We recommend LOCTITE 243 to secure screws.

5.4 Electrical Installation

All work should be carried out with power off.

DANGER

Electric servo actuators and motors have dangerous live and rotating parts. All work during connection, operation, repair and disposal must be carried out only by qualified personnel as described in the standards EN50110-1 and IEC 60364! Before starting any work, and especially before opening covers, the actuator must be properly isolated. In addition to the main circuits, the user also has to pay attention to any auxilliary circuits.

Observing the five safety rules:
- Disconnect mains
- Prevent reconnection
- Test for absence of harmful voltages
- Ground and short circuit
- Cover or close off nearby live parts

The measures taken above must only be withdrawn when the work has been completed and the device is fully assembled. Improper handling can cause damage to persons and property. The respective national, local and factory specific regulations must be adhered to.

DANGER

Due to the fact that the motor contains permanent magnets, a voltage is generated at the motor terminals when the rotor is turned.

ADVICE

- The connecting leads should be suitable for the type of use, as well as the voltages and amperages concerned.
- The protective earth must be connected to the terminal marked PE.
- All cables used should be provided with a shield and in addition, the encoder cable should feature twisted pair leads.
- The power supply is switched off before connecting and disconnecting the power connection and signal connections.

ADVICE

Encoders and sensors contain electrostatically sensitive components, observe the ESD measures!

5.5 Commissioning

NOTE

Commissioning must be executed in accordance with the documentation of Harmonic Drive AG.

Before commissioning, please check that:

- The actuator is properly mounted
- All electrical connections and mechanical connections are designed according to requirements
- The protective earth is properly connected
- All attachments (brakes, etc) are operational
- Appropriate measures have been taken to prevent contact with moving and live parts
- The maximum speed n_{max} is specified and cannot be exceeded
- The set up of the drive parameters has been executed
- The commutation is adjusted correctly

⚠ ATTENTION

Check the direction of rotation of the load uncoupled.

In the event of changes in the normal operating behaviour, such as increased temperature, noise or vibration, switch the actuator off. Determine the cause of the problem and contact the manufacturer if necessary. Even if the actuator is only on test, do not put safety equipment out of operation.

This list may not be complete. Other checks may also be necessary.

ADVICE

Due to heat generation from the actuator itself, tests outside the final mounting position should be limited to 5 minutes of continuous running at a motor speed of less than 1000 rpm.

These values should not be exceeded in order to avoid thermal damage to the actuator.

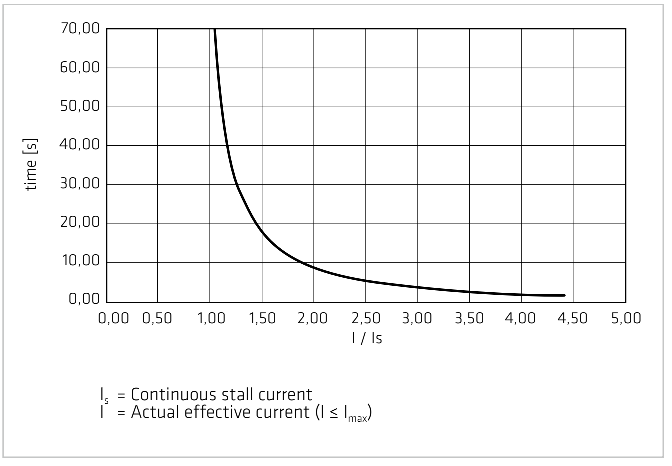
5.6 Overload Protection

To protect the servo actuators and motors from temperature overload sensors are integrated into the motor windings. The temperature sensors alone do not guarantee motor protection. Protection against overload of the motor winding is only possible with an input speed > 0. For special applications (eg. load at standstill or very low speed) is an additional overload protection by limiting the overload period.

The built specification of the integrated temperature sensors can be found in the technical data.

In addition, it is recommended to protect the motor winding against overload by the use of I^2t monitoring integrated in the controller. The graph shows an example of the overload characteristic for the I^2t monitoring. The overload factor is the ratio between the actual RMS current and continuous stall current.

Illustration 49.1 Over load characteristic



5.7 Protection against Corrosion and Penetration of Liquids and Debris

The product is fully protected provided that the connectors are correctly attached. Corrosion from the ambient atmosphere (condensation, liquids and gases) at the running surface of the output shaft seal is prevented.

Contact between sharp edged or abrasive objects (cutting chips, splinters, metallic or minerals dusts, etc.) and the output shaft seal must be prevented. Permanent contact between the output shaft seal and a permanent liquid covering should also be prevented.
A change in the operating temperature of a completely sealed actuator can lead to a pressure differential between the outside and the inside temperature of the actuator. This can cause any liquid covering the output shaft seal to be drawn into the housing which could cause corrosive damage.

As a countermeasure, we recommend the use of an additional shaft seal (to be provided by the user) or the maintenance of a constant pressure inside the actuator. Please contact Harmonic Drive AG for further information.

ADVICE

Specification sealing air: constant pressure in the actuator as described above; the supplied air must be dry and filtered with pressure at not more than 10^4 Pa.

5.8 Shutdown and Maintenance

In case of malfunctions or maintenance measures, or to shutdown the motors, proceed as follows:

1. Follow the instructions in the machine documentation.
2. Bring the actuator on the machine to a controlled standstill.
3. Turn off the power and the control voltage on the controller.
4. For motors with a fan unit; turn off the motor protection switch for the fan unit.
5. Turn off the mains switch of the machine.
6. Secure the machine against accidental movement and against unauthorised operation.
7. Wait for the discharge of electrical systems then disconnect all the electrical connections.
8. Secure the motor, and possibly the fan unit, before disassembly against falling or movement then pay attention to the mechanical connections.

DANGER

Risk of death by electric voltages. Work in the area of live parts is extremely dangerous.

- Work on the electrical system may only be performed by qualified electricians. The use of a power tool is absolutely necessary.

Observing the five safety rules:
• Disconnect mains
• Prevent reconnection
• Test for absence of harmful voltages
• Ground and short circuit
• Cover or close off nearby live parts

- Before starting work check with a suitable measuring instrument if there are any parts under residual voltage.(e.g. capacitors, etc.). Wait until the residual voltage is within a save range.

The measures taken above must only be withdrawn when the work has been completed and the device is fully assembled. Improper handling can cause damage to persons and property. The respective national, local and factory specific regulations must be adhered to.

ATTENTION

Burns from hot surfaces with temperatures of over 100°C

Let the motors cool down before starting work. Cooling times of up to 140 minutes may be necessary.
Wear protective gloves.
Do not work on hot surfaces!

WARNING

Persons and property during maintenance and operation

Never perform maintenance work on running machinery. Secure the system during maintenance against re-starting and unauthorised operation.

Cleaning

Excessive dirt, dust or chips may adversely affect the operation of the device and can, in extreme cases, lead to failure. At regular intervals (latest after one year) you should therefore, clean the device to ensure a sufficient dissipation of the surface heat. Insufficient heat emissions can have undesirable consequences. The lifetime of the device is reduced if temperature overloads occures. Overtemperature can lead to the shutdown of the device.

Checking of electric connections

DANGER

Lethal electric shock by touching live parts!

In any case of defects of the cable sheath the system must be shut down immediately and the damaged cable should be replaced. Do not make any temporary repairs on the connection cables.

- Connection cord should be periodically checked for damage and replaced if necessary.
- Check optionally installed power chains for defects.
- Protective conductor connections should be in a good condition and tightness checked at regular intervals. Replace if necessary.

Control of mechanical fasteners

The fastening screws and the load of the housing must be checked regularly.

Maintenance intervals for battery backed motor feedback systems

ADVICE

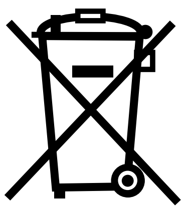
Please note the information on battery life time in the chapter "Motor Feedback Systems"!
Regardless of the results from the theoretical battery life time calculation, we specify to change the complete motor feedback system latest 10 years after delivery.

6. Decommissioning and Disposal

The gears, servo actuators and motors from Harmonic Drive AG contain lubricants for bearings and gears as well as electronic components and printed circuit boards. Since lubricants (greases and oils) are considered hazardous substances in accordance with health and safety regulations, it is necessary to dispose of the products correctly. Please ask for safety data sheet where necessary.

ADVICE

- Batteries do not contain hazardous materials according to EC directives 91/157/EEC, 93/86/EEC, and 2011/65/EU (RoHS directive)
- EC battery directive 2006/66/EC has been implemented by most EC member states,
- According to the EU Battery Directive, Lithium batteries are marked with the symbol of the crossedout wheeled bin (see figure). The symbol reminds the end user that batteries are not permitted to be disposed of with household waste, but must be collected separately.
- A disposal service is offered upon request by Harmonic Drive AG.



7. Glossary

7.1 Technical Data

AC Voltage constant k_{EM} [V_{rms} / 1000 rpm]

Effective value of the induced motor voltage measured at the motor terminals at a speed of 1000 rpm and an operating temperature of 20 °C.

Ambient operating temperature [°C]

The intended operating temperature for the operation of the drive.

Average input speed (grease lubrication) $n_{av\ (max)}$ [rpm]

Maximum permissible average gear input speed for grease lubrication. The applications average input speed must be lower than the permitted average input speed of the gear.

Average input speed (oil lubrication) $n_{av\ (max)}$ [rpm]

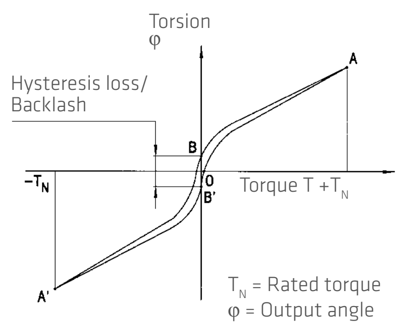
Maximum permissible average gear input speed for oil lubrication. The applications average input speed must be lower than the permitted average input speed of the gear.

Average torque T_A [Nm]

When a variable load is applied to the gear, an average torque should be calculated for the complete operating cycle. This value should not exceed the specified T_A limit.

Backlash (Harmonic Planetary Gears) [arcmin]

When subjected to the rated torque, Harmonic Planetary Gears display characteristics shown in the hysteresis curve. When a torque is applied to the output shaft of the gear with the input shaft locked, the torque-torsion relationship can be measured at the output. Starting from point 0 the graph follows successive points A-B-A'-B'-A where the value B-B' is defined as the backlash or hysteresis.



Brake closing time t_C [ms]

Delay time to close the brake.

Brake current to hold I_{HBr} [A_{DC}]

Current for applying the brake.

Brake current to open I_{OBr} [A_{DC}]

Current required to open the brake.

Brake holding torque T_{BR} [Nm]

Torque the actuator can withstand when the brake is applied, with respect to the output.

Brake opening time t_O [ms]

Delay time for opening the brake.

Brake voltage U_{Br} [VDC]

Terminal voltage of the holding brake.

Continuous stall current I_0 [A_{rms}]

Effective value of the motor phase current to produce the stall torque.

Continuous stall torque T_0 [Nm]

Allowable actuator stall torque.

Demagnetisation current I_E [A_{rms}]

Current at which rotor magnets start to demagnetise.

Dynamic axial load $F_{A\ dyn\ (max)}$ [N]

With the bearing rotating, this is the maximum allowable axial load with no additional radial forces or tilting moments applied.

Dynamic load rating C [N]

Maximum dynamic load that can be absorbed by the output bearing before permanent damage may occur.

Dynamic radial load $F_{R\ dyn\ (max)}$ [N]

With the bearing rotating, this is the maximum allowable radial load with no additional axial forces or tilting moments applied.

Dynamic tilting moment $M_{dyn\ (max)}$ [Nm]

With the bearing rotating, this is the maximum allowable tilting moment with no additional axial forces or radial forces applied. This value is not based on the equation for lifetime calculation of the output bearing but on the maximum allowable deflection of the Harmonic Drive® Component Set. This value must not be exceeded even if the lifetime calculation of the bearing permits higher values.

Electrical time constant τ_e [s]

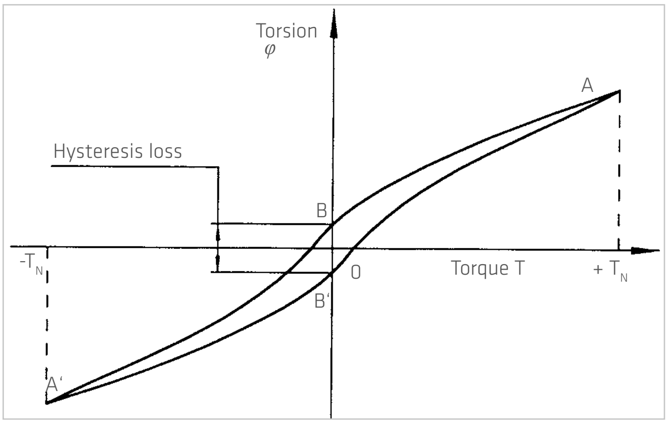
The electrical time constant is the time required for the current to reach 63 % of its final value.

Hollow shaft diameter d_H [mm]

Free inner diameter of the axial hollow shaft.

Hysteresis loss (Harmonic Drive® Gears)

When a torque is applied to the output of a Harmonic Drive® Gear with the input locked, the torque-torsion relationship measured at the output typically follows, starting from point 0, the successive points the hysteresis curve A-B-A'-B'-A (see figure). The value of the displacement B-B' is defined as the hysteresis loss.



T_N = Rated output torque
φ = Output rotation angle

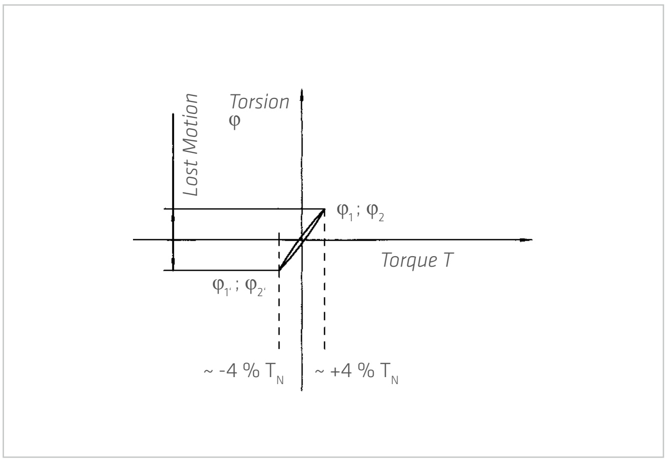
Inductance (L-L) L_{L-L} [mH]

Terminal inductance calculated without taking into account the magnetic saturation of the active motor parts.

Lost Motion (Harmonic Drive® Gears) [arcmin]

Harmonic Drive® Gears exhibit zero backlash in the teeth. Lost motion is the term used to characterise the torsional stiffness in the low torque region.

The illustration shows the angle of rotation φ measured against the applied output torque as a hysteresis curve with the Wave Generator locked. The lost motion measurement of the gear is taken with an output torque of about ± 4 % of the rated torque.



Maximum current I_{max} [A]

The maximum current is the maximum current that can be applied for a short period.

Maximum DC bus voltage $U_{DC\,(max)}$ [VDC]

The maximum DC bus power supply for the correct operation of the actuator. This value may only be exceeded for a short period during the braking or deceleration phase.

Maximum hollow shaft diameter $d_{H\,(max)}$ [mm]

For gears with a hollow shaft, this value is the maximum possible diameter of the axial hollow shaft.

Maximum input speed (grease lubrication) $n_{in\,(max)}$ [rpm]

Maximum allowable input speed with grease lubrication for short period. The maximum input speed can be applied as often as desired, as long as the application's average speed is lower than the permitted average input speed of the gear.

Maximum input speed (oil lubrication) $n_{in\,(max)}$ [rpm]

Maximum allowable input speed for gearing with oil lubrication for short period. The maximum input speed can be applied as often as desired, as long as the application's average speed is lower than the permitted average input speed of the gear.

Maximum motor speed n_{max} [rpm]

The maximum allowable motor speed.

Maximum output speed n_{max} [rpm]

The maximum output speed. Due to heating issues, this may only be momentarily applied during the operating cycle. The maximum output speed can occur any number of times as long as the calculated average speed is within the permissible continuous operation duty cycle.

Maximum output torque T_{max} [Nm]

Specifies the maximum allowable acceleration and deceleration torques. For highly dynamic processes, this is the maximum torque available for a short period. The maximum torque can be parameterised by the control unit where the maximum current can be limited. The maximum torque can be applied as often as desired, as long as the calculated average torque is within the permissible continuous operation duty cycle.

Maximum power P_{max} [W]

Maximum power output.

Mechanical time constant τ_m [s]

The mechanical time constant is the time required to reach 63 % of its maximum rated speed in a no-load condition.

Momentary peak torque T_M [Nm]

In the event of an emergency stop or collision, the Harmonic Drive® Gear may be subjected to a brief momentary peak torque. The magnitude and frequency of this peak torque should be kept to a minimum and under no circumstances should the momentary peak torque occur during the normal operating cycle. The allowable number of momentary peak torque events can be calculated with the equations given in chapter "selection procedure".

Moment of inertia J [kgm^2]

Mass moment of inertia at motor side.

Moment of inertia J_{in} [kgm^2]

Mass moment of inertia of the gear with respect to the input.

Moment of inertia J_{out} [kgm^2]

Mass moment of inertia with respect to the output.

Motor terminal voltage (Fundamental wave only) U_M [V_{rms}]

Required fundamental wave voltage to achieve the specified performance. Additional power losses can lead to restriction of the maximum achievable speed.

Nominal Service Life L_n [h]

When loaded with rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_n with 50 % propability of failure. For different load conditions the service life of the Wave Generator Bearing can be calculated using the equations in chapter "selection procedure".

Number of pole pairs p

Number of magnetic pole pairs on the rotor of the motor.

Offset R [m]

Distance between output 's center plane and contact point of the load.

Pitch circle diameter d_p [m] or [mm]

Pitch circle diameter of the output bearing rolling element raceway.

Protection class IP

The degree of protection according to EN 60034-5 provides suitability for various environmental conditions.

Rated current I_N [A]

RMS value of the sinusoidal current when driven at rated torque and rated speed.

Rated motor speed n_N [rpm]

The motor speed which can be continuously maintained when driven at rated torque T_N, when mounted on a suitably dimensioned heat sink.

Rated power P_N [W]

Output power at rated speed and rated torque.

Rated speed n_N [rpm], Servo

The output speed which can be continuously maintained when driven at rated torque T_N, when mounted on a suitably dimensioned heat sink.

Rated speed n_N [rpm], Mechanical

The rated speed is a reference speed for the calculation of the gear life. When loaded with rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_n with 50 % propability of failure. The rated speed n_N is not used for the dimensioning of the gear.

Product series	**Unit**	**n_N**
CobaltLine®, HFUC, HFUS, CSF, CSG, CSD, SHG, SHD	[rpm]	2000
PMG size 5	[rpm]	4500
PMG size 8 to 14	[rpm]	3500
HPG, HPGP, HPN	[rpm]	3000

Rated torque T_N [Nm], Servo

The output torque which can be continuously transmitted when driven at rated input speed, when mounted on a suitably dimensioned heat sink.

Rated torque T_N [Nm], Mechanical

The rated torque is a reference torque for the calculation of the gear life. When loaded with rated torque and running at rated speed the Wave Generator Bearing will reach the nominal service life L_n with 50 % propability of failure. The rated torque T_N is not used for the dimensioning of the gear.

Rated voltage U_N [V_{rms}]

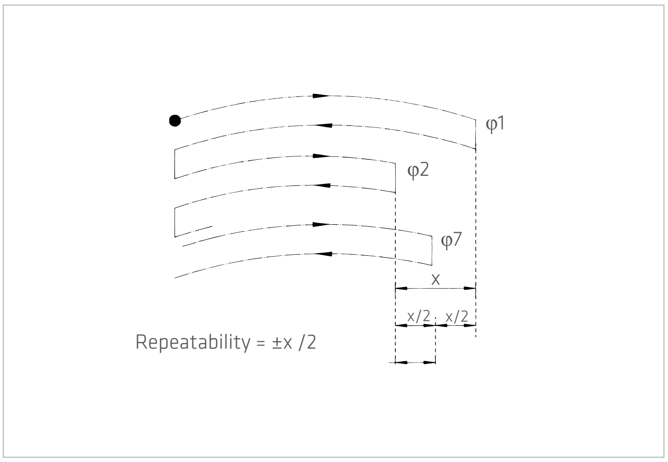
Supply voltage for operation with rated torque and rated speed.

Ratio i [ ]

The ratio is the reduction of input speed to the output speed.
Note for Harmonic Drive® Gears: In the standard drive arrangement, the Wave Generator is the drive element while the Flexspline is the driven element and the Circular Spline is fixed to the housing. Since the direction of rotation of the input (Wave Generator) is opposite to the output (Flexspline), a negative ratio must be considered.

Repeatability [arcmin]

The repeatability of the gear describes the position difference measured during repeated movement to the same desired position from the same direction. The repeatability is defined as half the value of the maximum difference measured, preceded by a ± sign.



Repeated peak torque T_R [Nm]

Specifies the maximum allowable acceleration and deceleration torque. During the normal operating cycle the repeated peak torque T_R must not be exceeded. The repeated peak torque can be applied as often as desired, as long as the application's average torque is lower than the permitted average torque of the gear.

Resistance (L-L, 20 °C) R_{L-L} [Ω]

Winding resistance measured between two conductors at a winding temperature of 20 °C.

Size

1) Actuators / Gears with Harmonic Drive® Gears or Harmonic Planetary Gears
The frame size is derived from the pitch circle diameter of the gear teeth in inches multiplied by 10.

2) CHM Servo Motor Series
The size of the CHM Servo Motors is derived from the stall torque in Ncm.

3) Direct drives from the TorkDrive® Series
The size of the TorkDrive® Series is the outer diameter of the iron core of the stator.

Static load rating C_0 [N]

Maximum static load that can be absorbed by the output bearing before permanent damage may occur.

Static tilting moment M_0 [Nm]

With the bearing stationary, this is the maximum allowable radial load with no additional axial forces or tilting moments applied.

Synchronous inductance L_d [mH]

Sum of air gap inductance and leakage inductance in relation to the single-phase equivalent circuit diagram of the synchronous motor.

Tilting moment stiffness K_B [Nm/arcmin]

The ratio of the tilting angle of the output bearing and the applied moment load.

Torque constant (motor) k_{TM} [Nm/A_{rms}]

Quotient of stall torque and stall current.

Torque constant (output) k_{Tout} [Nm/A_{rms}]

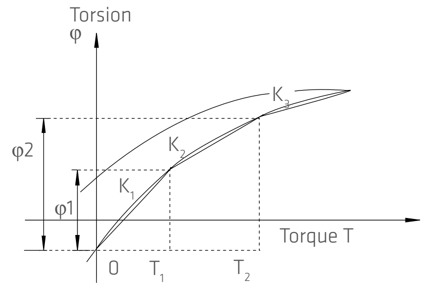
Quotient of stall torque and stall current, taking into account the transmission losses.

Torsional stiffness (Harmonic Drive® Gears) K_1, K_2, K_3 [Nm/rad]

The amount of elastic rotation at the output for a given torque with the Wave Generator blocked. The torsional stiffness may be evaluated by dividing the torque-torsion curve into three regions. The torsional stiffness values K_1, K_2 and K_3 are determined by linearization of the curve.

K_1:	low torque region	$0 \sim T_1$
K_2:	middle torque region	$T_1 \sim T_2$
K_3:	high torque region	$> T_3$

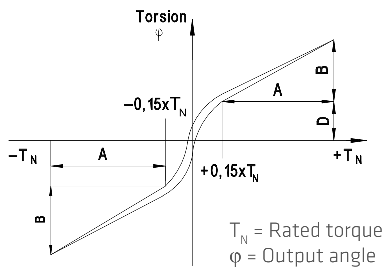
The values given for the torsional stiffness K_1, K_2 and K_3 are average values that have been determined during numerous tests. The limit torques T_1 and T_2 and an calculation example for the torsional angle can be found in chapter "torsional stiffness" and "calculation of the torsion angle" of this documentation.



K_1, K_2, K_3 = Torsional stiffness, w = Output angle
φ1 = Torsion angle, with output torque T_1
φ2 = Torsion angle, with output torque T_2

Torsional stiffness (Harmonic Planetary Gears) K_3 [Nm/rad]

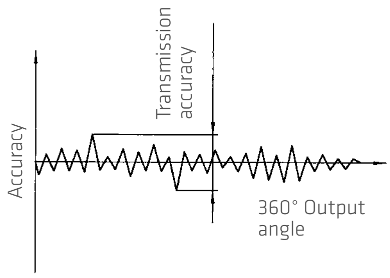
The amount of elastic rotation at the output for a given torque and blocked input shaft. The torsional rigidity of the Harmonic Planetary Gear describes the rotation of the gear above a reference torque of 15 % of the rated torque. In this area the torsional stiffness is almost linear.



T_N = Rated torque
φ = Output angle

Transmission accuracy [arcmin]

The transmission accuracy of the gear represents the linearity error between input and output angle. The transmission accuracy is measured for one complete output revolution using a high resolution measurement system. The measurements are carried out without direction reversal. The transmission accuracy is defined as the sum of the maximum positive and negative differences between the theoretical and actual output rotation angles.



Weight m [kg]

The weight specified in the catalogue is the net weight without packing and only applies to standard versions.

7.2 Labelling, Guidelines and Regulations

CE-Marking

With the CE marking, the manufacturer or EU importer declares in accordance with EU regulation, that the product meets the applicable requirements of the EU harmonization legislation.

REACH Regulation

REACH is a European Community Regulation on chemicals. REACH stands for Registration, Evaluation, Authorization and Restriction of Chemicals.

RoHS EU Directive

The RoHS EU Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Germany
Harmonic Drive AG
Hoenbergstraße 14
65555 Limburg/Lahn

T +49 6431 5008-0
F +49 6431 5008-119

info@harmonicdrive.de
www.harmonicdrive.de

Subject to technical changes.

1018855 07/2019 V05