# Engineering Data
# AC Servo Actuators FHA-C

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. |

## 1.2 Disclaimer and Copyright

## 2. Safety and Installation Instructions

Please take note of the information and instructions in this document. Specialy 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 rotating 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.

**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.

**ADVICE**

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 protection, 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 protection 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 Servo 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 article2 and article 3 Harmonic Drive® Servo Actuators and Motors are not classified as equipment, finished apparatus or fixed installation.

Harmonic Drive® Servo Actuators and Motors are classified as components which are not intended to be installed by the end-user in a finished apparatus. Harmonic Drive® Servo Actuators and Motors therefore are not within the scope of the EMC-Directive.
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 manufacturer 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 manufacturer to ensure that the installation is undertaken correctly.

# Large hollow shaft with flange mounting

FHA-C Series Hollow Shaft Servo Actuators combine a synchronous servo motor, CSD Series Component Set, feedback sensor and a specially developed output bearing.

Available in four sizes with gear ratios of 50, 100 and 160:1, the actuators can provide maximum torques from 39 to 823 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.

To adapt to your specific application, the FHA-C Series offers many possible combinations when selecting the motor winding, motor feedback, brake, various sensors and cable as well as connector options.

The integrated hollow shaft can be used to feed through supply lines or services for additional axes, enabling space saving designs with minimal installation dimensions required. The accurate positioning of the actuator ensures stable machine characteristics, lower rejection rates and consistent quality.

By combining the FHA-C Actuators with the specially adapted YukonDrive® Servo Controllers, it is possible to provide a single source supply for a pre-configured drive system tailored to suit your application. Alternatively, the flexible configuration of the actuator ensures compatibility with almost any servo controller on the market.

# 3.2 Ordering Code

Table 9.1

| Series | Size | Ratio | | | Motor winding and connector configuration | Motor feedback | Brake | Option 1 | Option 2 | Special design |
|---|---|---|---|---|---|---|---|---|---|---|
| FHA | 17C | **50** | **100** | 160 | H<br>L<br>– | C1024<br>M512P<br>M128P<br>D250<br>US250 | B | Sensor | Cable/ Connec-tor | According to customer requirements |
| | 25C | **50** | **100** | 160 | | | | | | |
| | 32C | **50** | **100** | 160 | | | | | | |
| | 40C | **50** | **100** | 160 | | | | | | |
| Ordering Code | | | | | | | | | | |
| **FHA** | **-** **17C** | **-** | **100** | **-** | **H** | **-** **C1024** | **-** **B** | **-** **EC** | **-** **K** | **-** **SP** |

Variations in **bold** print are available at short notice, subject to prior sale.

Table 9.2

| Motor winding | | |
|---|---|---|
| **Size** | **Ordering code** | **Maximum DC bus voltage** |
| 17C<br>25C<br>32C<br>40C | H | 680 VDC |
| | L | 330 VDC |
| | – | 330 VDC |

Table 9.3

| Connector configuration | | | | |
|---|---|---|---|---|
| **Ordering code** | **Motor** | **Motor feedback** | | |
| | | M128P | C1024<br>M512P | D250<br>US250 |
| H | 6 pin (M23) | 12 pin (M23) | 17 pin (M23) | – |
| L | 8 pin (M23) | | | – |
| | | | | ohne |

Table 9.4

| Motor feedback | | |
|---|---|---|
| **Ordering code** | **Type** | **Protocol** |
| C1024 | Incremental | – |
| M512P | Multi-turn absolute | EnDat® |
| M128P | Multi-turn absolute | HIPERFACE® |
| D250 | Incremental | – |
| US250 | Incremental | – |

Table 9.5

| Option 1 | |
|---|---|
| **Ordering code** | **Description** |
| EC | Single-turn absolute EnDat®<br>Encoder system at the gear output |

Table 9.6

| Option 2 | |
|---|---|
| **Ordering code** | **Description** |
| K | Cable outlet axial |
| R | Connector axial (only M512P/128P) |
| S | Connector radial (only M512P/128P) |
| – | Standard (cable outlet radial) |

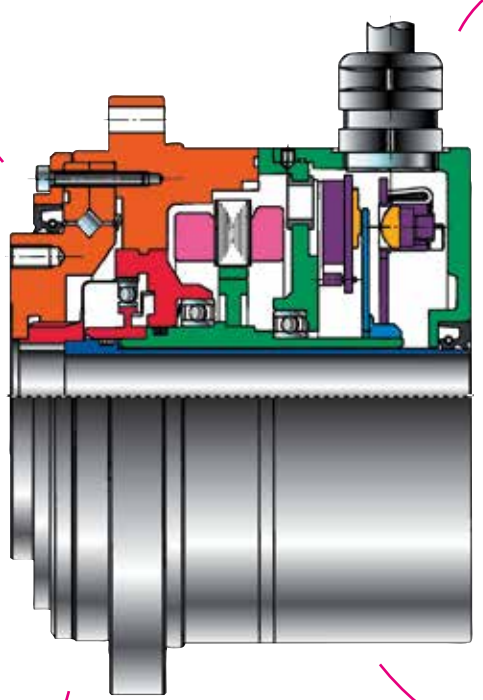
Explanation of the technical data can be found in the Glossary.

# Combinations

Table 10.1

| Size | | 17C ... 40C | 17C ... 40C | 17C ... 40C | 17C ... 40C |
|---|---|---|---|---|---|
| Motor feedback | | C1024 | M512P | M128P | D250<br>US250 |
| Ratio | 50 | ● | ● | ● | ● |
| | 100 | ● | ● | ● | ● |
| | 160 | ● | ● | ● | ● |
| Motor winding and connector configuration | L | ○ | ○ | ● | – |
| | H | ● | ● | ● | – |
| | – | – | – | – | ● |
| Brake | B | ● | ● | ● | ● |
| Option 1 (Sensor) | EC | ● | ● | ● | ● |
| Option 2 (Cable/Connector) | K | ● | – | – | ● |
| | R | – | ● | ● | – |
| | S | – | ● | ● | – |

● available ○ on request – not available



### Gear Component Set

- Zero backlash
- Hollow shaft
- Transmission accuracy better than 1 arcmin
- Repeatability better than ±6 arcsec

### Output bearing

- High load capacity
- Excellent running charactaristics

### AC Hollow shaft motor

- Sine commutated hollow shaft AC motor
- Winding for 330 VDC (L-Version)
  680 VDC (H-Version)
- Winding temperature monitoring with temperature sensor
- Maintenance free

### Motor feedback

- Incremental sine/cosine encoder
- HIPERFACE® single/multi-turn absolute encoder
- EnDat® multi-turn absolute encoder
- Incremental RS422 encoder

## 3.3 Technical Data

### 3.3.1 General Technical Data

Table 11.1

| | | |
|---|---|---|
| Insulation class (EN 60034-1) | | F |
| Insulation resistance (500VDC) | MΩ | 100 |
| Insulation voltage (1s) Version H | $V_{eff}$ | 2400 |
| Insulation voltage (1s) Version L | $V_{eff}$ | 1800 |
| Insulation voltage (1s) Version with D250/US250 | $V_{eff}$ | 1800 |
| Lubrication | | Harmonic Drive® SK-1A |
| Degree of protection (EN 60034-5) | | IP65 (C1024/M512P/M128P)<br>IP44(D250/US250) |
| 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 | 5 |
| Shock resistance (DIN IEC 68 Teil 2-27, 18 ms) | g | 30 |
| Temperature sensor FHA-C-H | | 1 x KTY 84-130 |
| Temperature sensor FHA-C-L | | 1 x PTC 116-K135-145° C |
| Temperature sensor FHA-C (D250/US250) | | ohne |

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 11.2

| Series | Size | Unit | Dimensions |
|---|---|---|---|
| FHA | 17C | [mm] | 300 x 300 x 15 |
| | 25C | [mm] | 350 x 350 x 18 |
| | 32C | [mm] | 400 x 400 x 20 |
| | 40C | [mm] | 500 x 500 x 25 |

## 3.3.2 Actuator Data

Table 12.1

| | Symbol [Unit] | FHA-17C-L | | | FHA-17C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 39 | 57 | 64 | 39 | 57 | 64 |
| Maximum output speed | $n_{max}$ [rpm] | 96 | 48 | 30 | 96 | 48 | 30 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 2.1 | 1.6 | 1.1 | 1.2 | 0.9 | 0.6 |
| Continuous stall torque | $T_0$ [Nm] | 17 | 28 | 30 | 17 | 28 | 30 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 1.0 | 0.8 | 0.6 | 0.6 | 0.5 | 0.3 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 680 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 1 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 9 | | | 11 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.21 | 0.18 | 0.17 | 0.12 | 0.10 | 0.10 |
| Torque constant (at output) | $k_{Tout}$ [$Nm/A_{rms}$] | 21 | 42 | 67 | 38 | 77 | 124 |
| Torque constant (at motor) | $k_{TM}$ [$Nm/A_{rms}$] | 0.45 | | | 0.83 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 29 | | | 53 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 430 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 13 | | | 7 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4800 | | | 4800 | | |
| Rated motor speed | $n_N$ [rpm] | 3500 | | | 3500 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 15.7 | | | 63.0 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 12 | | | 41 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 2.8 | | | 2.8 | | |
| Weight with brake | m [kg] | 3.2 | | | 3.2 | | |
| Hollow shaft diameter | $d_h$ [mm] | 18 | | | 18 | | |

## Moment of Inertia

Table 12.2

| | Symbol [Unit] | FHA-17C-L | | | FHA-17C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [$kgm^2$] | 0.2 | 0.80 | 2.04 | 0.2 | 0.80 | 2.04 |
| Moment of inertia with brake | $J_{out}$ [$kgm^2$] | 0.27 | 1.09 | 2.78 | 0.27 | 1.09 | 2.78 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [$x10^{-4}$ $kgm^2$] | 0.8 | | | 0.8 | | |
| Moment of inertia at motor with brake | J [$x10^{-4}$ $kgm^2$] | 1.1 | | | 1.1 | | |

## Technical Data Brake

Table 12.3

| | Symbol [Unit] | FHA-17C-L | | | FHA-17C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ±10% | | | 24 ±10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 25 | 49 | 78 | 25 | 49 | 78 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.0 | | | 1.0 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.15 | | | 0.15 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 13.1 FHA-17C-50-L

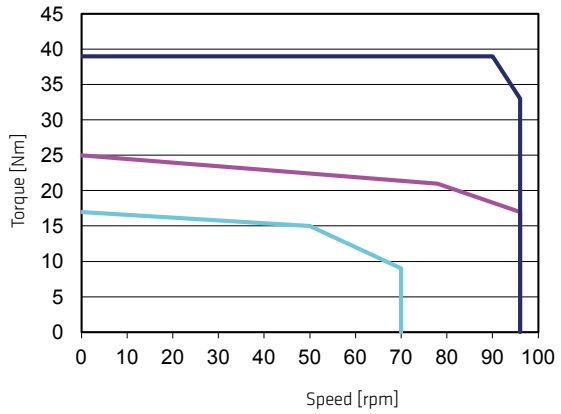



Illustration 13.2 FHA-17C-50-H

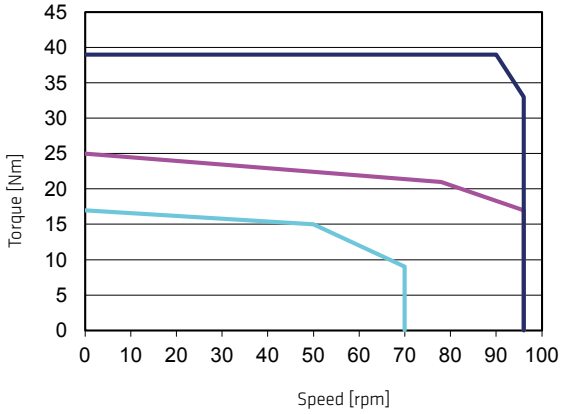



Illustration 13.3 FHA-17C-100-L

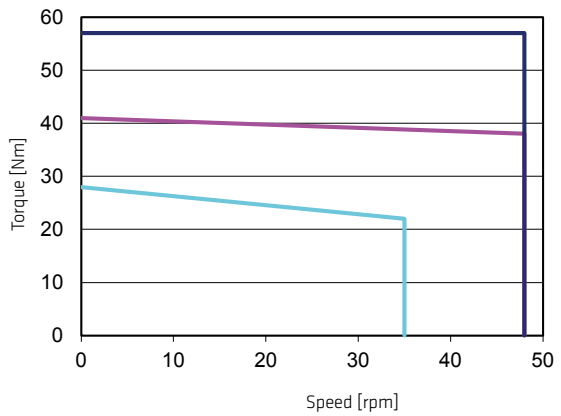



Illustration 13.4 FHA-17C-100-H

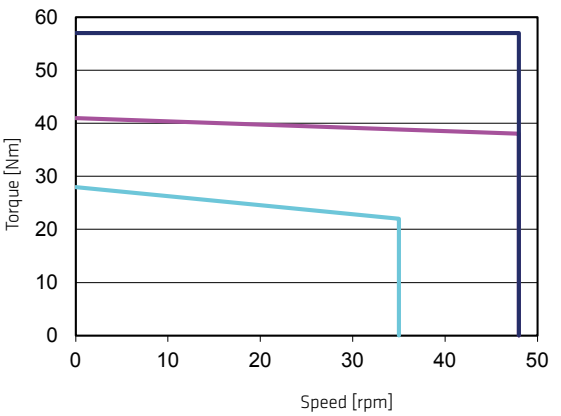



Illustration 13.5 FHA-17C-160-L

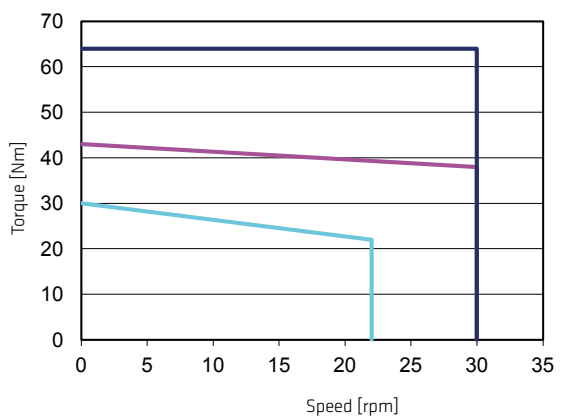
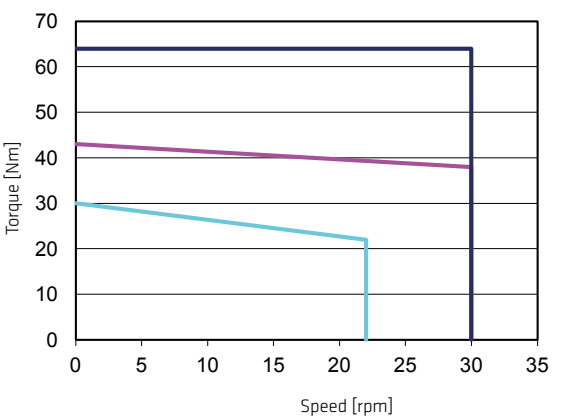



Illustration 13.6 FHA-17C-160-H




**Legend**

Intermittent duty
Continuous duty

L: $U_M$ = 220 VAC
H: $U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 14.1

| | Symbol [Unit] | FHA-25C-L | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 151 | 233 | 261 | 151 | 233 | 261 |
| Maximum output speed | $n_{max}$ [rpm] | 90 | 45 | 28 | 90 | 45 | 28 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 7.3 | 5.6 | 4.0 | 3.8 | 2.9 | 2.1 |
| Continuous stall torque | $T_0$ [Nm] | 42 | 86 | 102 | 42 | 86 | 102 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 2.2 | 2.1 | 1.6 | 1.2 | 1.1 | 0.9 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 680 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 1 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 11 | | | 13 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.55 | 0.44 | 0.41 | 0.31 | 0.26 | 0.24 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 22 | 45 | 72 | 44 | 89 | 142 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 0.48 | | | 0.95 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 31 | | | 61 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 430 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 23 | | | 12 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4500 | | | 4500 | | |
| Rated motor speed | $n_N$ [rpm] | 3000 | | | 3000 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 5.2 | | | 22.4 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 5.2 | | | 20.0 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 4.3 | | | 4.3 | | |
| Weight with brake | m [kg] | 5.1 | | | 5.1 | | |
| Hollow shaft diameter | $d_h$ [mm] | 32 | | | 32 | | |

## Moment of Inertia

Table 14.2

| | Symbol [Unit] | FHA-25C-L | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 0.86 | 3.45 | 8.82 | 0.86 | 3.45 | 8.82 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 1.09 | 4.34 | 11.1 | 1.09 | 4.34 | 11.1 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [x$10^{-4}$ kgm²] | 3.45 | | | 3.45 | | |
| Moment of inertia at motor with brake | J [x$10^{-4}$ kgm²] | 4.34 | | | 4.34 | | |

## Technical Data Brake

Table 14.3

| | Symbol [Unit] | FHA-25C-L | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ±10% | | | 24 ±10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 49 | 98 | 157 | 49 | 98 | 157 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.1 | | | 1.1 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.15 | | | 0.15 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 15.1 FHA-25C-50-L

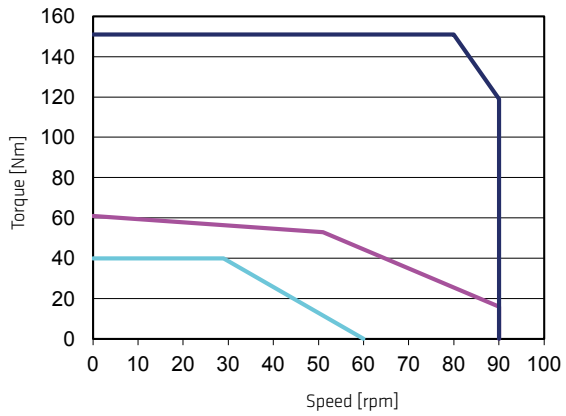



Illustration 15.2 FHA-25C-50-H

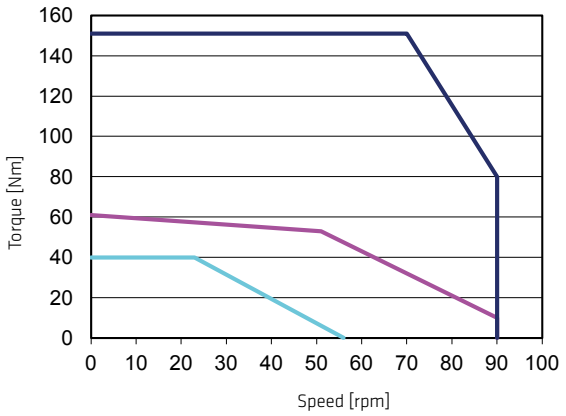



Illustration 15.3 FHA-25C-100-L

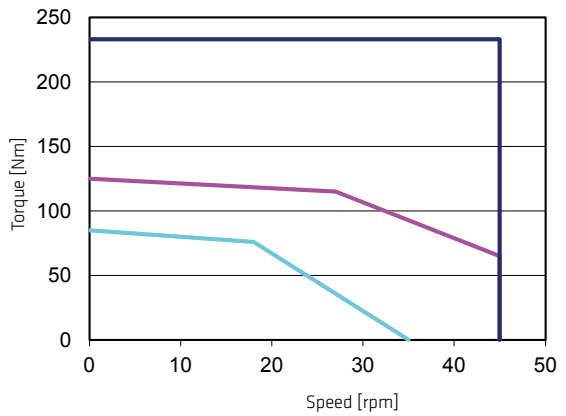



Illustration 15.4 FHA-25C-100-H

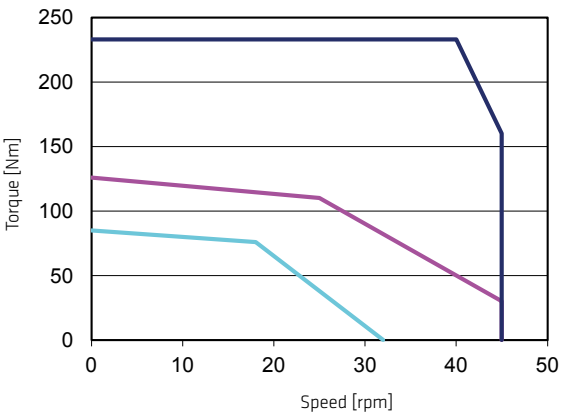



Illustration 15.5 FHA-25C-160-L

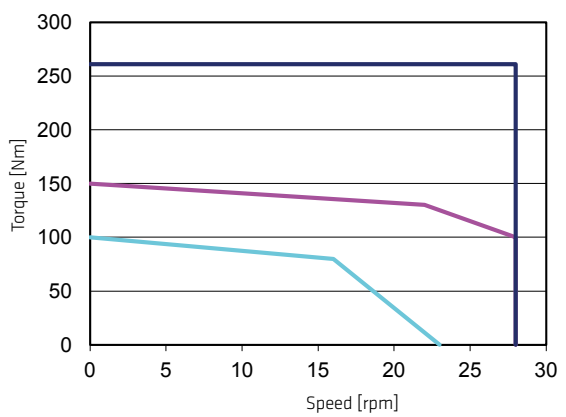
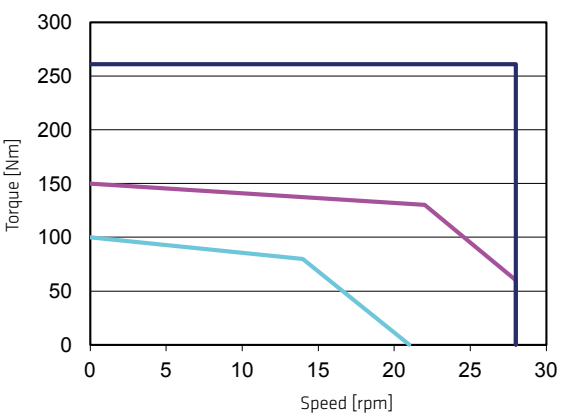



Illustration 15.6 FHA-25C-160-H




**Legend**

Intermittent duty
Continuous duty

L: $U_M$ = 220 VAC
H: $U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 16.1

| | Symbol [Unit] | FHA-32C-L | | | FHA-32C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 281 | 398 | 453 | 281 | 398 | 453 |
| Maximum output speed | $n_{max}$ [rpm] | 80 | 40 | 25 | 80 | 40 | 25 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 11.5 | 8.1 | 5.9 | 6.0 | 4.2 | 3.1 |
| Continuous stall torque | $T_0$ [Nm] | 73 | 151 | 232 | 73 | 151 | 232 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 3.2 | 3.2 | 3.0 | 1.7 | 1.7 | 1.6 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 680 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 1 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 7 | | | 7 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.87 | 0.69 | 0.65 | 0.50 | 0.41 | 0.38 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 27 | 54 | 86 | 51 | 104 | 166 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 0.58 | | | 1.11 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 35 | | | 68 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 430 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 40 | | | 20 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4000 | | | 4000 | | |
| Rated motor speed | $n_N$ [rpm] | 2500 | | | 2500 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 2.0 | | | 7.8 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 2.6 | | | 9.9 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 6.7 | | | 6.7 | | |
| Weight with brake | m [kg] | 7.6 | | | 7.6 | | |
| Hollow shaft diameter | $d_h$ [mm] | 35 | | | 35 | | |

## Moment of Inertia

Table 16.2

| | Symbol [Unit] | FHA-32C-L | | | FHA-32C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 1.87 | 7.50 | 19.2 | 1.87 | 7.50 | 19.2 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 2.20 | 8.90 | 22.8 | 2.20 | 8.90 | 22.8 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [x$10^{-4}$ kgm²] | 7.5 | | | 7.5 | | |
| Moment of inertia at motor with brake | J [x$10^{-4}$ kgm²] | 8.9 | | | 8.9 | | |

## Technical Data Brake

Table 16.3

| | Symbol [Unit] | FHA-32C-L | | | FHA-32C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ±10% | | | 24 ±10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 75 | 150 | 240 | 75 | 150 | 240 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.2 | | | 1.2 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.2 | | | 0.2 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 17.1 FHA-32C-50-L

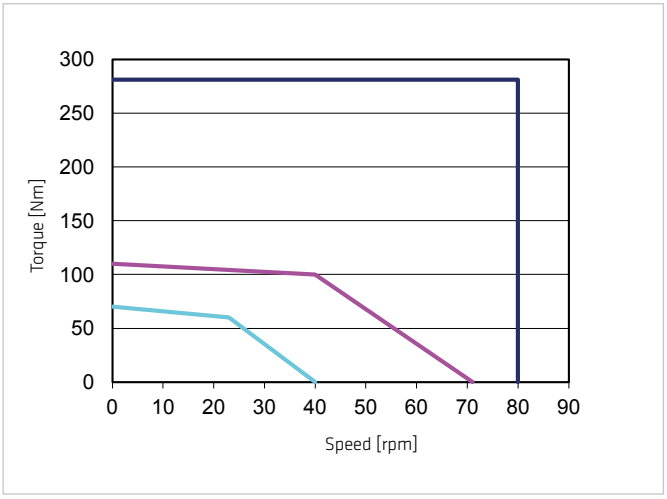



Illustration 17.2 FHA-32C-50-H

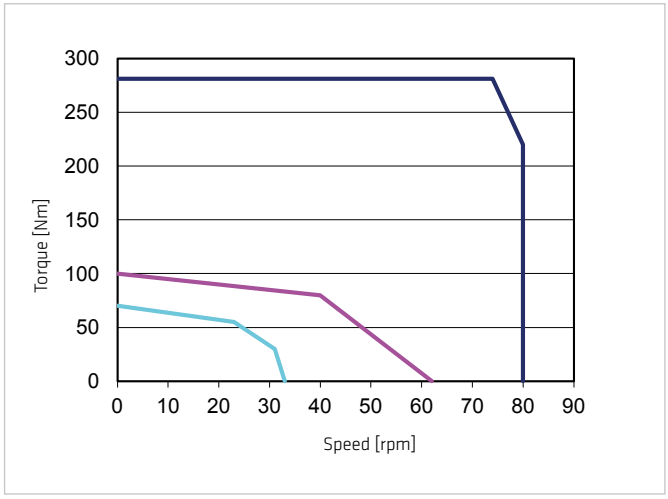



Illustration 17.3 FHA-32C-100-L

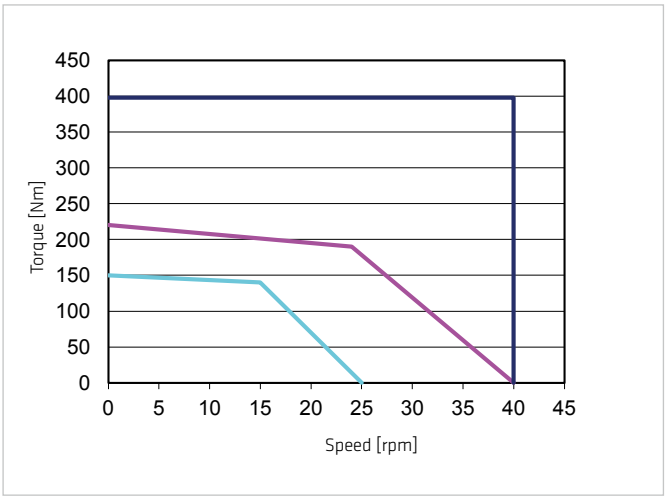



Illustration 17.4 FHA-32C-100-H

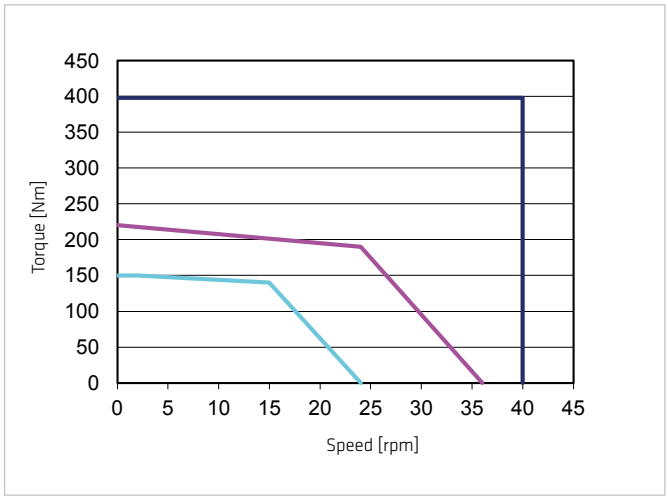



Illustration 17.5 FHA-32C-160-L

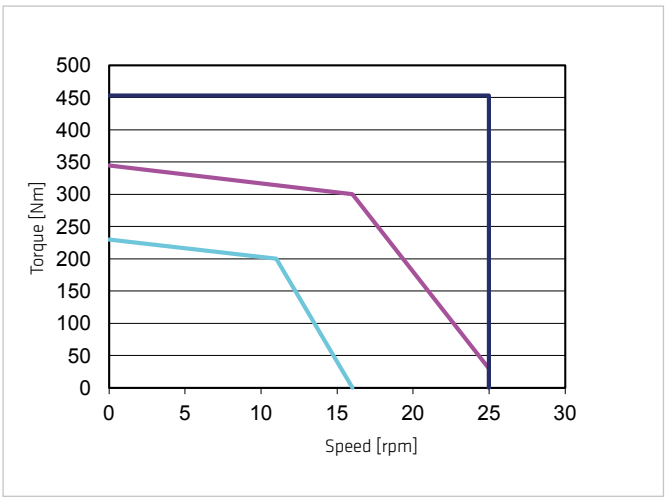
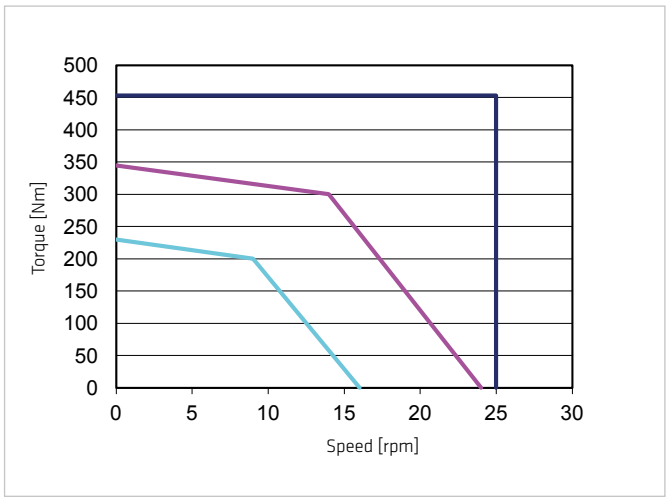



Illustration 17.6 FHA-32C-160-H




**Legend**

Intermittent duty
Continuous duty

L: $U_M$ = 220 VAC
H: $U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 18.1

| | Symbol [Unit] | FHA-40C-L | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 430 | 690 | 823 | 430 | 690 | 823 |
| Maximum output speed | $n_{max}$ [rpm] | 70 | 35 | 22 | 70 | 35 | 22 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 15.0 | 11.8 | 9.0 | 8.9 | 6.1 | 4.7 |
| Continuous stall torque | $T_0$ [Nm] | 122 | 256 | 354 | 122 | 256 | 354 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 4.5 | 4.5 | 3.9 | 2.4 | 2.4 | 2.1 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 680 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 2 | | | 2 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 9 | | | 10 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 1.29 | 1.02 | 0.95 | 0.72 | 0.58 | 0.54 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 31 | 64 | 102 | 61 | 124 | 199 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 0.68 | | | 1.33 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 44 | | | 85 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 430 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 45 | | | 23 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 3500 | | | 3500 | | |
| Rated motor speed | $n_N$ [rpm] | 2500 | | | 2500 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 1.5 | | | 5.6 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 2.9 | | | 11.1 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 12.2 | | | 12.2 | | |
| Weight with brake | m [kg] | 14.2 | | | 14.2 | | |
| Hollow shaft diameter | $d_h$ [mm] | 45 | | | 45 | | |

## Moment of Inertia

Table 18.2

| | Symbol [Unit] | FHA-40C-L | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | C1024 | | | C1024 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 5.0 | 20.0 | 51.2 | 5.0 | 20.0 | 51.2 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 5.7 | 22.6 | 57.9 | 5.7 | 22.6 | 57.9 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [x$10^{-4}$ kgm²] | 20 | | | 20 | | |
| Moment of inertia at motor with brake | J [x$10^{-4}$ kgm²] | 22.6 | | | 22.6 | | |

## Technical Data Brake

Table 18.3

| | Symbol [Unit] | FHA-40C-L | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ± 10% | | | 24 ± 10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 75 | 150 | 240 | 75 | 150 | 240 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.2 | | | 1.2 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.2 | | | 0.2 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 19.1 FHA-40C-50-L

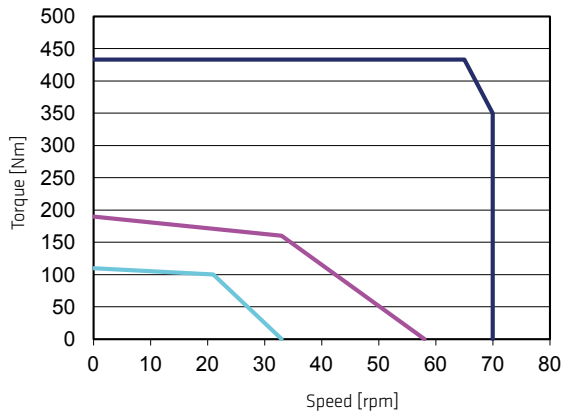



Illustration 19.2 FHA-40C-50-H

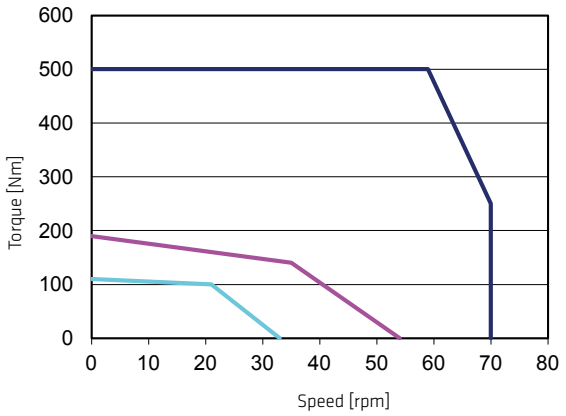



Illustration 19.3 FHA-40C-100-L

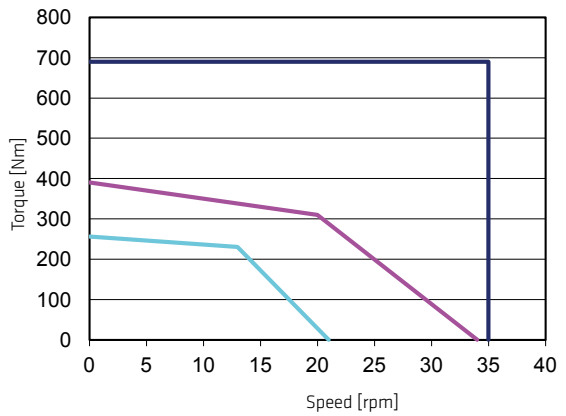



Illustration 19.4 FHA-40C-100-H

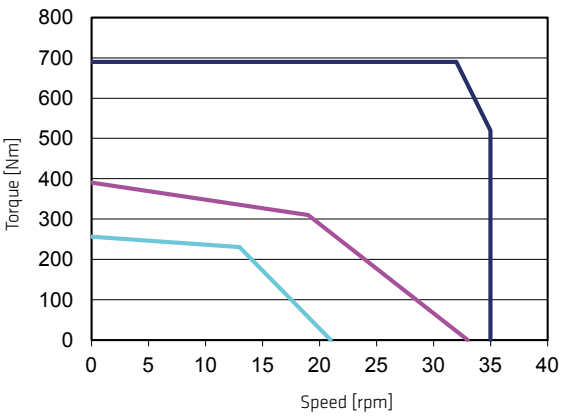



Illustration 19.5 FHA-40C-160-L

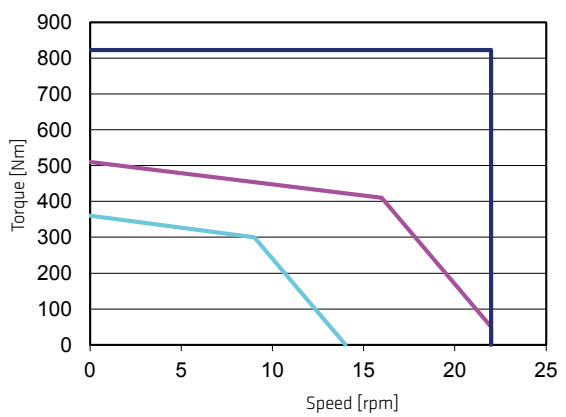
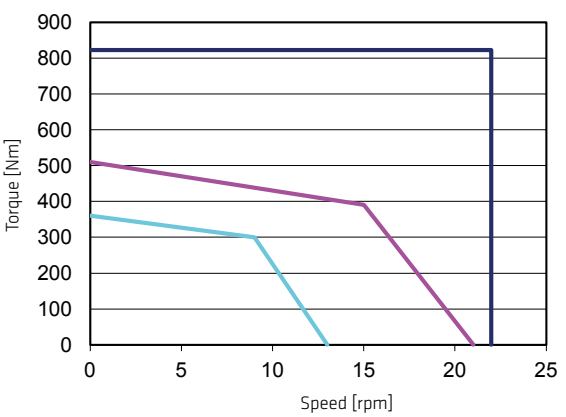



Illustration 19.6 FHA-40C-160-H




**Legend**

Intermittent duty
Continuous duty

L: $U_M$ = 220 VAC
H: $U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 20.1

| | Symbol [Unit] | FHA-17C-H | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/M128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 39 | 57 | 64 | 151 | 233 | 261 |
| Maximum output speed | $n_{max}$ [rpm] | 96 | 48 | 30 | 90 | 45 | 28 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 1.2 | 0.9 | 0.6 | 3.8 | 2.9 | 2.1 |
| Continuous stall torque | $T_0$ [Nm] | 17 | 28 | 30 | 42 | 86 | 102 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 0.6 | 0.5 | 0.3 | 1.2 | 1.1 | 0.9 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 680 | | | 680 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 1 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 28 | | | 17 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.12 | 0.10 | 0.10 | 0.31 | 0.26 | 0.24 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 38 | 77 | 124 | 44 | 89 | 142 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 0.83 | | | 0.95 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 53 | | | 61 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 430 | | | 430 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 7 | | | 12 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4800 | | | 4500 | | |
| Rated motor speed | $n_N$ [rpm] | 3500 | | | 3000 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 63.0 | | | 22.4 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 41 | | | 20.0 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 3.8 | | | 5.3 | | |
| Weight with brake | m [kg] | 4.2 | | | 6.1 | | |
| Hollow shaft diameter | $d_h$ [mm] | 18 | | | 32 | | |

## Moment of Inertia

Table 20.2

| | Symbol [Unit] | FHA-17C-H | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/M128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 0.50 | 2.00 | 5.12 | 1.15 | 4.60 | 11.8 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 0.57 | 2.30 | 5.88 | 1.09 | 4.34 | 11.1 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [x$10^{-4}$ kgm²] | 2 | | | 4.6 | | |
| Moment of inertia at motor with brake | J [x$10^{-4}$ kgm²] | 2.3 | | | 5.5 | | |

## Technical Data Brake

Table 20.3

| | Symbol [Unit] | FHA-17C-H | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ± 10% | | | 24 ± 10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 25 | 49 | 78 | 49 | 98 | 157 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.0 | | | 1.1 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.15 | | | 0.15 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 21.1 FHA-17C-50-H-M512P

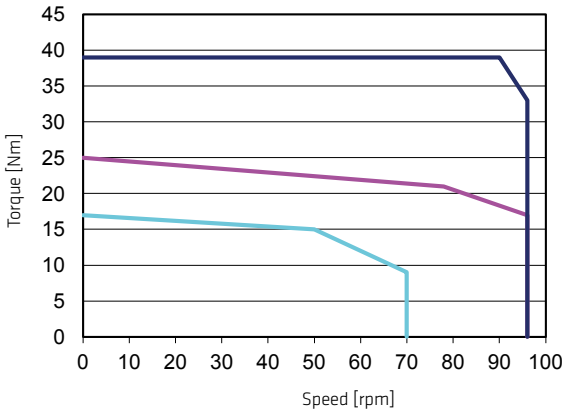



Illustration 21.2 FHA-25C-50-H-M512P

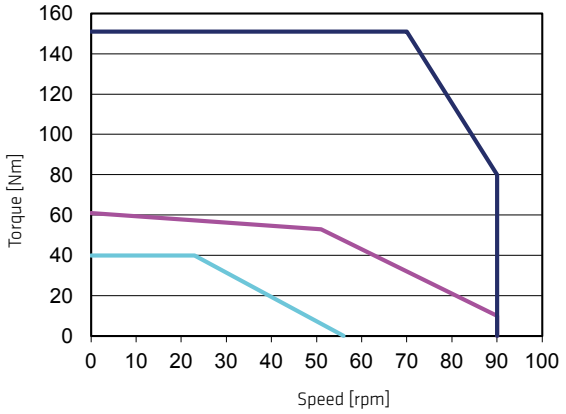



Illustration 21.3 FHA-17C-100-H-M512P

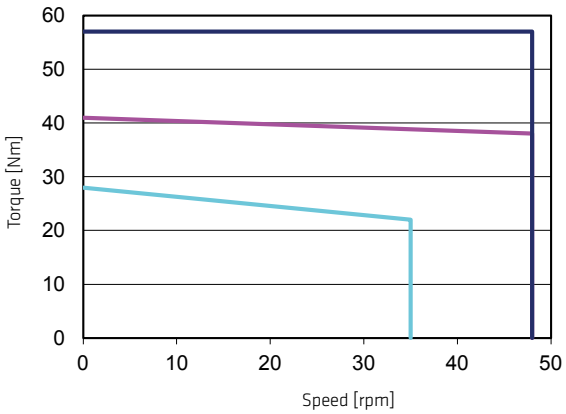



Illustration 21.4 FHA-25C-100-H-M512P

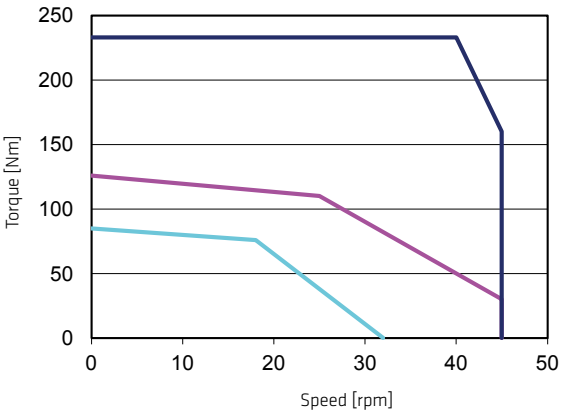



Illustration 21.5 FHA-17C-160-H-M512P

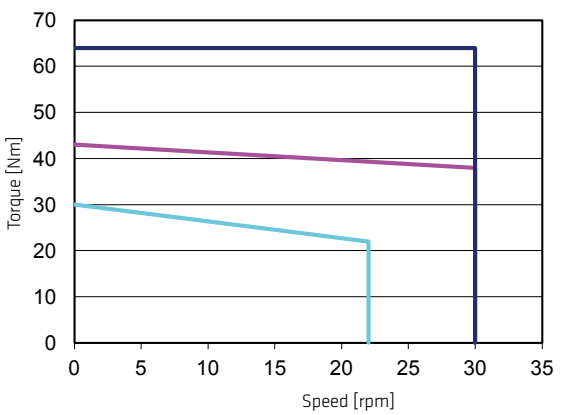
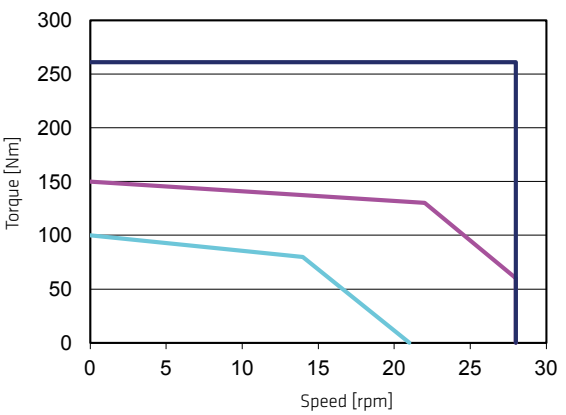



Illustration 21.6 FHA-25C-160-H-M512P




**Legend**

Intermittent duty
Continuous duty

$U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 22.1

| | Symbol [Unit] | FHA-32C-H | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 281 | 398 | 453 | 430 | 690 | 823 |
| Maximum output speed | $n_{max}$ [rpm] | 80 | 40 | 25 | 70 | 35 | 22 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 6.0 | 4.2 | 3.1 | 8.9 | 6.1 | 4.7 |
| Continuous stall torque | $T_0$ [Nm] | 73 | 151 | 232 | 122 | 256 | 354 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 1.7 | 1.7 | 1.6 | 2.4 | 2.4 | 2.1 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 680 | | | 680 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 2 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 8 | | | 10 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.50 | 0.41 | 0.38 | 0.72 | 0.58 | 0.54 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 51 | 104 | 166 | 61 | 124 | 199 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 1.11 | | | 1.33 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 68 | | | 85 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 430 | | | 430 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 20 | | | 23 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4000 | | | 3500 | | |
| Rated motor speed | $n_N$ [rpm] | 2500 | | | 2500 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 7.8 | | | 5.6 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 9.9 | | | 11.1 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 7.7 | | | 13.2 | | |
| Weight with brake | m [kg] | 8.6 | | | 15.2 | | |
| Hollow shaft diameter | $d_h$ [mm] | 35 | | | 45 | | |

## Moment of Inertia

Table 22.2

| | Symbol [Unit] | FHA-32C-H | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/M128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 2.20 | 8.80 | 22.5 | 5.2 | 21.0 | 53.7 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 2.50 | 10.2 | 26.1 | 5.9 | 23.6 | 60.4 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [x$10^{-4}$ kgm²] | 8.8 | | | 21 | | |
| Moment of inertia at motor with brake | J [x$10^{-4}$ kgm²] | 10.2 | | | 23.6 | | |

## Technical Data Brake

Table 22.3

| | Symbol [Unit] | FHA-32C-H | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ± 10% | | | 24 ± 10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 75 | 150 | 240 | 75 | 150 | 240 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.2 | | | 1.2 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.2 | | | 0.2 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 23.1 FHA-32C-50-H-M512P

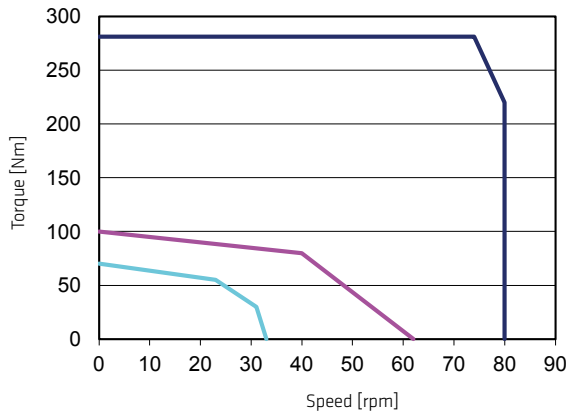



Illustration 23.2 FHA-40C-50-H-M512P

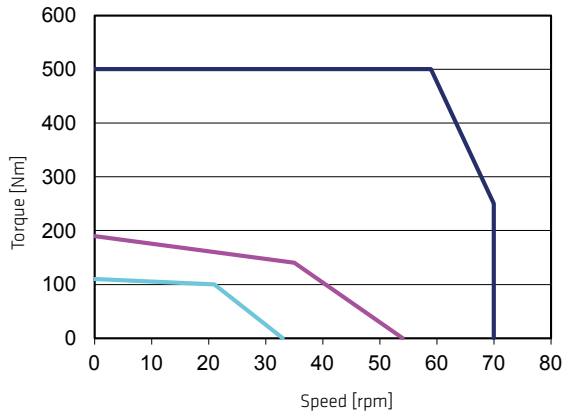



Illustration 23.3 FHA-32C-100-H-M512P

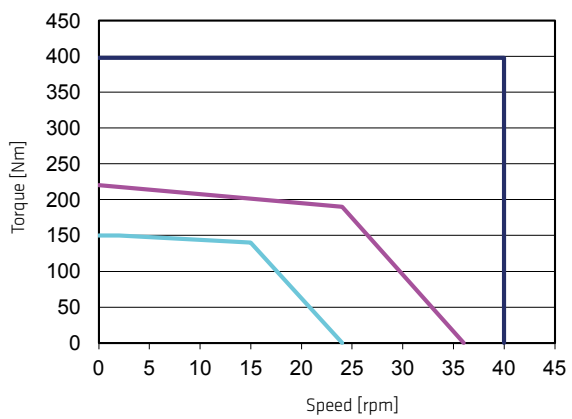



Illustration 23.4 FHA-40C-100-H-M512P

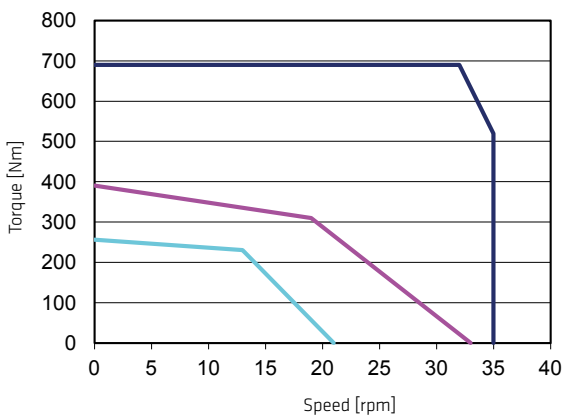



Illustration 23.5 FHA-32C-160-H-M512P

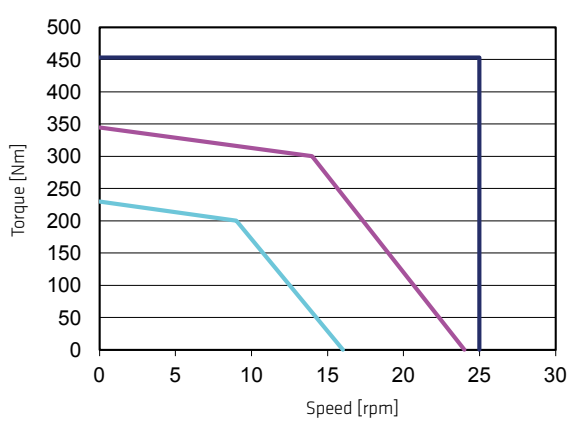
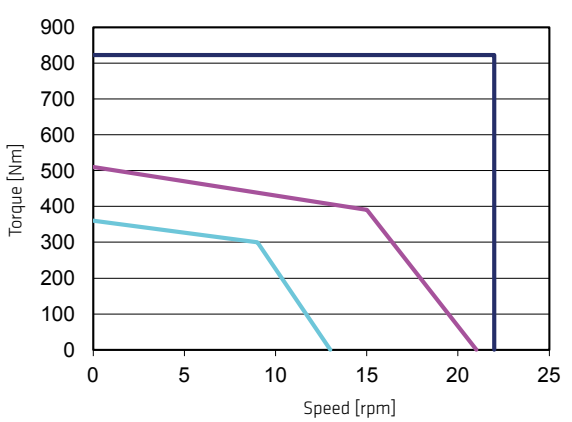



Illustration 23.6 FHA-40C-160-H-M512P




**Legend**

Intermittent duty
Continuous duty

$U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 24.1

| | Symbol [Unit] | FHA-17C-L | | | FHA-25C-L | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/M128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 39 | 57 | 64 | 151 | 233 | 261 |
| Maximum output speed | $n_{max}$ [rpm] | 96 | 48 | 30 | 90 | 45 | 28 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 2.1 | 1.6 | 1.1 | 7.3 | 5.6 | 4.0 |
| Continuous stall torque | $T_0$ [Nm] | 17 | 28 | 30 | 42 | 86 | 102 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 1.0 | 0.8 | 0.6 | 2.2 | 2.1 | 1.6 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 330 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 1 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 9 | | | 17 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.21 | 0.18 | 0.17 | 0.55 | 0.44 | 0.41 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 21 | 42 | 67 | 22 | 45 | 72 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 0.45 | | | 0.48 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 29 | | | 61 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 220 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 13 | | | 23 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4800 | | | 4500 | | |
| Rated motor speed | $n_N$ [rpm] | 3500 | | | 3000 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 15.8 | | | 5.2 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 12 | | | 5.2 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 3.8 | | | 5.3 | | |
| Weight with brake | m [kg] | 4.2 | | | 6.1 | | |
| Hollow shaft diameter | $d_h$ [mm] | 18 | | | 32 | | |

## Moment of Inertia

Table 24.2

| | Symbol [Unit] | FHA-17C-H | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/M128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 0.50 | 2.00 | 5.12 | 1.15 | 4.60 | 11.8 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 0.57 | 2.30 | 5.88 | 1.09 | 4.34 | 11.1 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [x$10^{-4}$ kgm²] | 2 | | | 4.6 | | |
| Moment of inertia at motor with brake | J [x$10^{-4}$ kgm²] | 2.3 | | | 5.5 | | |

## Technical Data Brake

Table 24.3

| | Symbol [Unit] | FHA-17C-H | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ± 10% | | | 24 ± 10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 25 | 49 | 78 | 49 | 98 | 157 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.0 | | | 1.1 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.15 | | | 0.15 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 25.1 FHA-17C-50-L-M512P/M128P

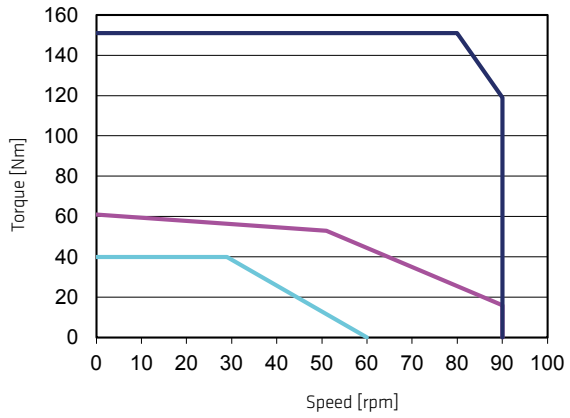



Illustration 25.2 FHA-25C-50-L-M512P/M128P

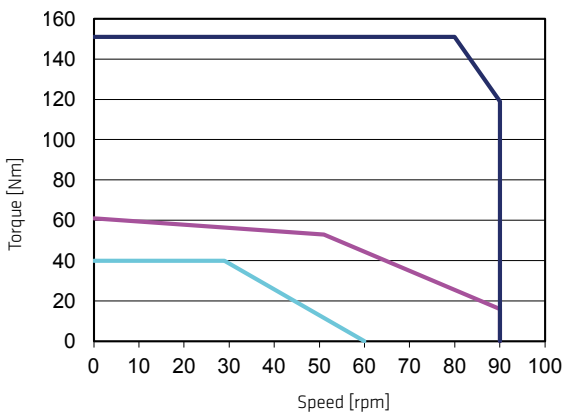



Illustration 25.3 FHA-17C-100-L-M512P/128P

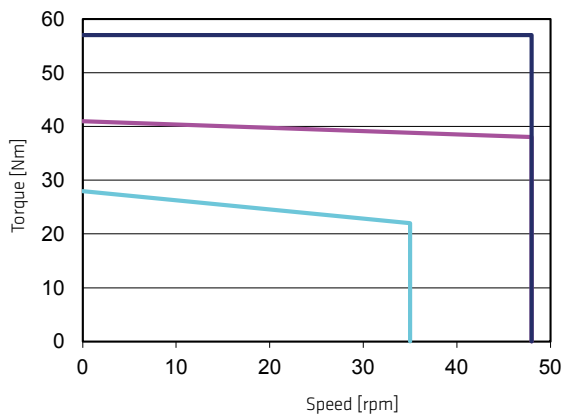



Illustration 25.4 FHA-25C-100-L-M512P/128P

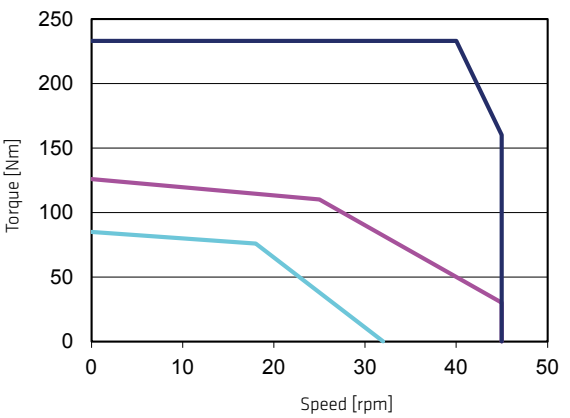



Illustration 25.5 FHA-17C-160-L-M512P/128P

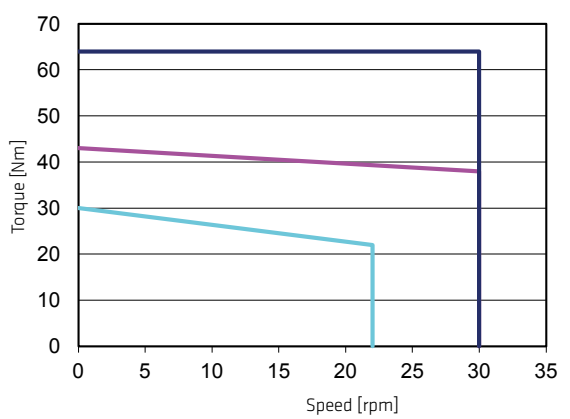
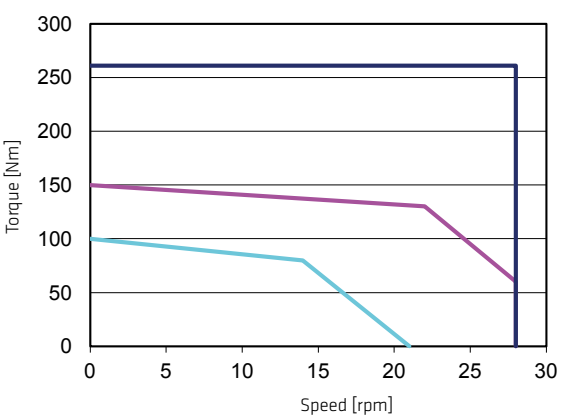



Illustration 25.6 FHA-25C-160-L-M512P/128P




**Legend**

Intermittent duty
Continuous duty

$U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 26.1

| | Symbol [Unit] | FHA-32C-L | | | FHA-40C-L | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 281 | 398 | 453 | 430 | 690 | 823 |
| Maximum output speed | $n_{max}$ [rpm] | 80 | 40 | 25 | 70 | 35 | 22 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 11.5 | 8.1 | 5.9 | 15.0 | 11.8 | 9.0 |
| Continuous stall torque | $T_0$ [Nm] | 73 | 151 | 232 | 122 | 256 | 354 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 3.2 | 3.2 | 3.0 | 1.3 | 1.0 | 1.0 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 330 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 2 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 7 | | | 9 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.87 | 0.69 | 0.65 | 1.29 | 1.02 | 0.95 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 27 | 54 | 86 | 31 | 64 | 102 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 0.58 | | | 0.68 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 35 | | | 44 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 220 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 40 | | | 45 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4000 | | | 3500 | | |
| Rated motor speed | $n_N$ [rpm] | 2500 | | | 2500 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 2.0 | | | 1.5 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 2.6 | | | 2.9 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 7.7 | | | 13.2 | | |
| Weight with brake | m [kg] | 8.6 | | | 15.2 | | |
| Hollow shaft diameter | $d_h$ [mm] | 35 | | | 45 | | |

## Moment of Inertia

Table 26.2

| | Symbol [Unit] | FHA-32C-H | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | M512P/M128P | | | M512P/M128P | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 1.80 | 7.10 | 18.1 | 4.90 | 19.5 | 50.0 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 2.10 | 8.40 | 22.0 | 5.50 | 22.0 | 57 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [$x10^{-4}$ kgm²] | 7.1 | | | 3.2 | | |
| Moment of inertia at motor with brake | J [$x10^{-4}$ kgm²] | 8.4 | | | 4.1 | | |

## Technical Data Brake

Table 26.3

| | Symbol [Unit] | FHA-32C-H | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ± 10% | | | 24 ± 10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 75 | 150 | 240 | 75 | 150 | 240 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.2 | | | 1.2 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.2 | | | 0.2 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 27.1 FHA-32C-50-L-M512P/M128P

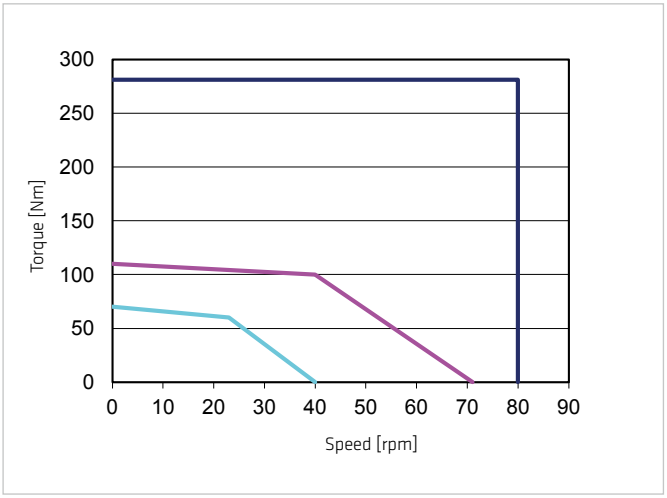



Illustration 27.2 FHA-40C-50-L-M512P/M128L

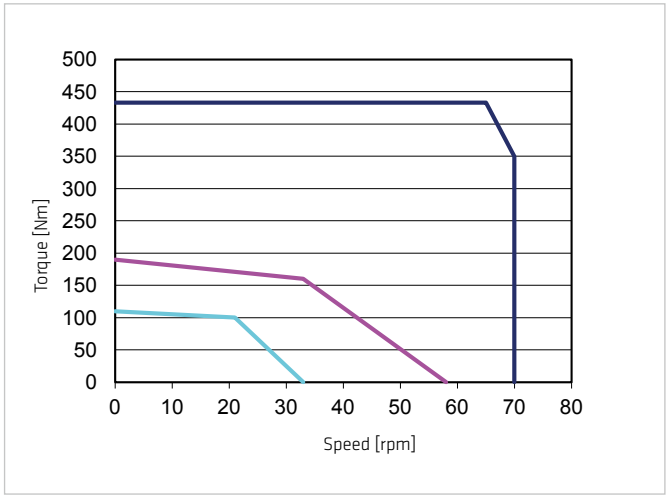



Illustration 27.3 FHA-32C-100-L-M512P/M128P

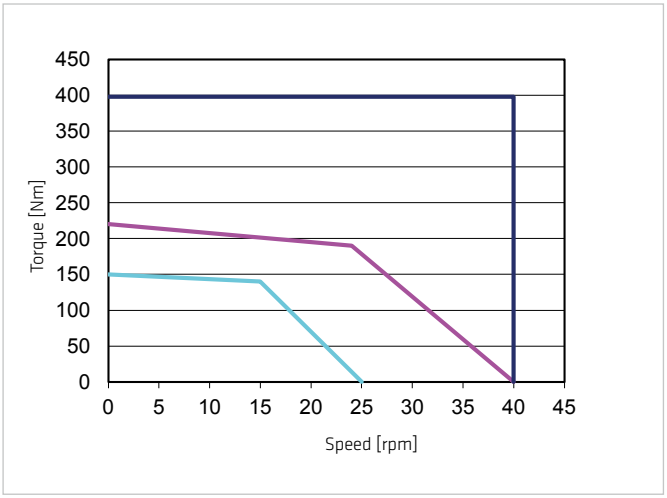



Illustration 27.4 FHA-40C-100-L-M512P/M128P

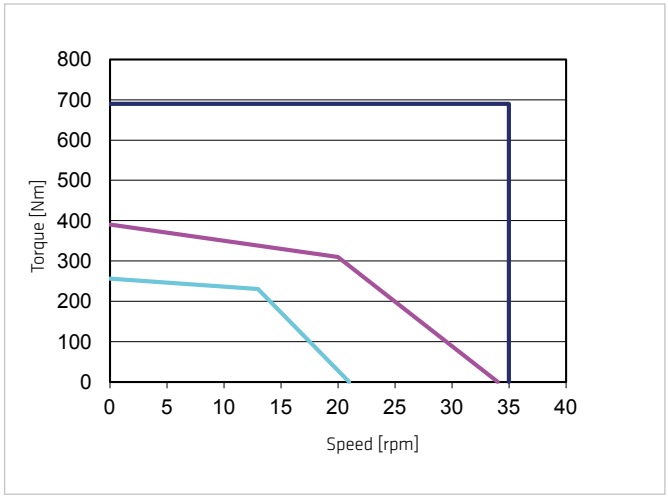



Illustration 27.5 FHA-32C-160-L-M512P/128P

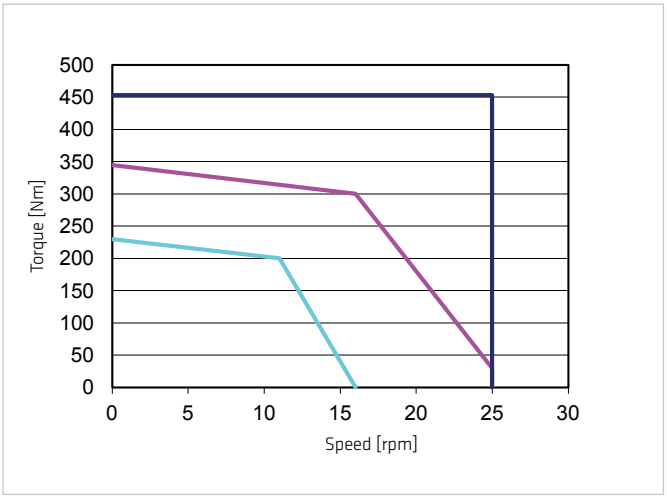
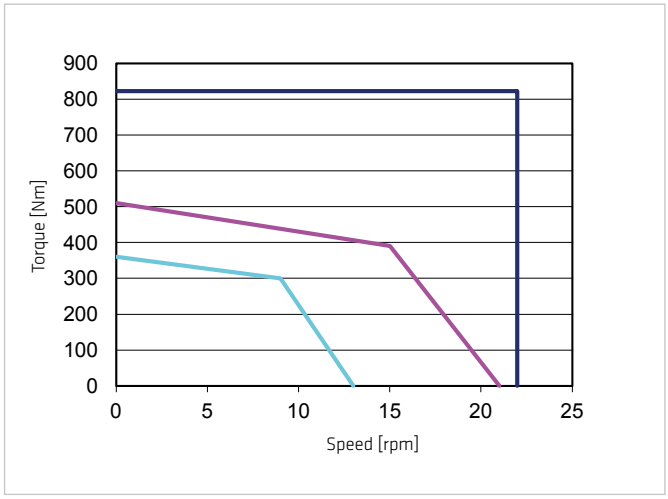



Illustration 27.6 FHA-40C-160-L-M512P/128P




**Legend**

Intermittent duty
Continuous duty

$U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 28.1

| | Symbol [Unit] | FHA-17C | | | FHA-25C | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | D250/US250 | | | D250/US250 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 39 | 57 | 64 | 151 | 233 | 261 |
| Maximum output speed | $n_{max}$ [rpm] | 96 | 48 | 30 | 90 | 45 | 28 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 2.1 | 1.6 | 1.1 | 7.3 | 5.6 | 4.0 |
| Continuous stall torque | $T_0$ [Nm] | 17 | 28 | 30 | 42 | 86 | 102 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 1.0 | 0.8 | 0.6 | 2.2 | 2.1 | 1.6 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 330 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 1 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 9 | | | 17 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.21 | 0.18 | 0.17 | 0.55 | 0.44 | 0.41 |
| Torque constant (at output) | $k_{Tout}$ [Nm/$A_{rms}$] | 21 | 42 | 67 | 22 | 45 | 72 |
| Torque constant (at motor) | $k_{TM}$ [Nm/$A_{rms}$] | 0.45 | | | 0.48 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 29 | | | 61 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 220 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 13 | | | 23 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4800 | | | 4500 | | |
| Rated motor speed | $n_N$ [rpm] | 3500 | | | 3000 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 15.8 | | | 5.2 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 12 | | | 5.2 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 2.5 | | | 4.0 | | |
| Weight with brake | m [kg] | 2.9 | | | 4.8 | | |
| Hollow shaft diameter | $d_n$ [mm] | 18 | | | 32 | | |

## Moment of Inertia

Table 28.2

| | Symbol [Unit] | FHA-17C-H | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | D250/US250 | | | D250/US250 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [kgm²] | 0.17 | 0.67 | 1.70 | 0.8 | 3.20 | 8.30 |
| Moment of inertia with brake | $J_{out}$ [kgm²] | 0.24 | 0.96 | 2.50 | 1.00 | 4.10 | 10.60 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [$x10^{-4}$ kgm²] | 0.67 | | | 3.2 | | |
| Moment of inertia at motor with brake | J [$x10^{-4}$ kgm²] | 0.96 | | | 4.1 | | |

## Technical Data Brake

Table 28.3

| | Symbol [Unit] | FHA-17C-H | | | FHA-25C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ± 10% | | | 24 ± 10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 25 | 49 | 78 | 49 | 98 | 157 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.0 | | | 1.1 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.15 | | | 0.15 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 29.1 FHA-17C-50-D250/US250

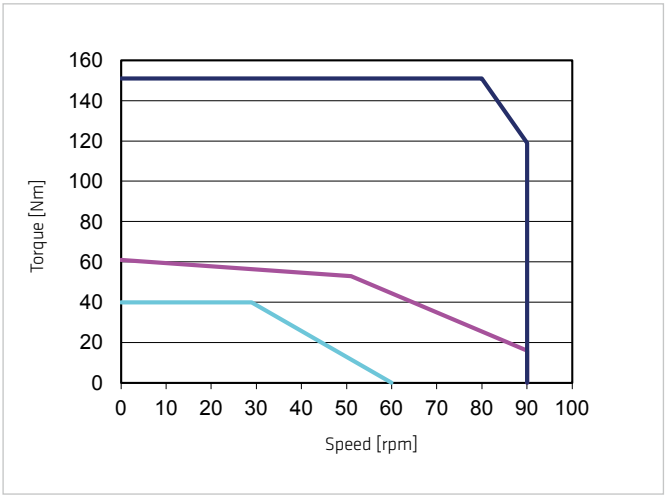



Illustration 29.2 FHA-25C-50-D250/US250

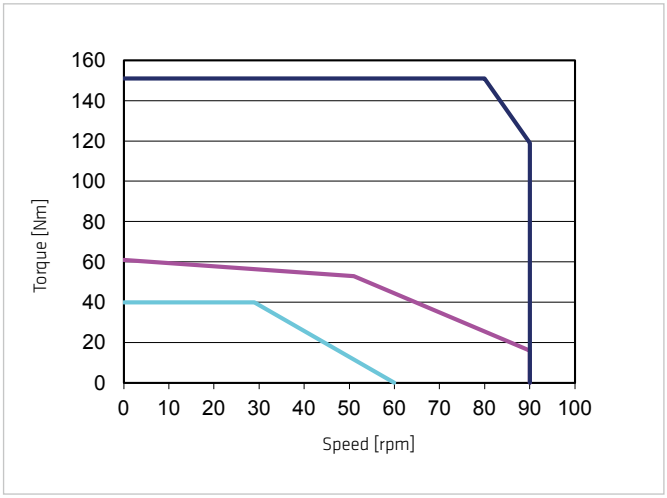



Illustration 29.3 FHA-17C-100-D250/US250

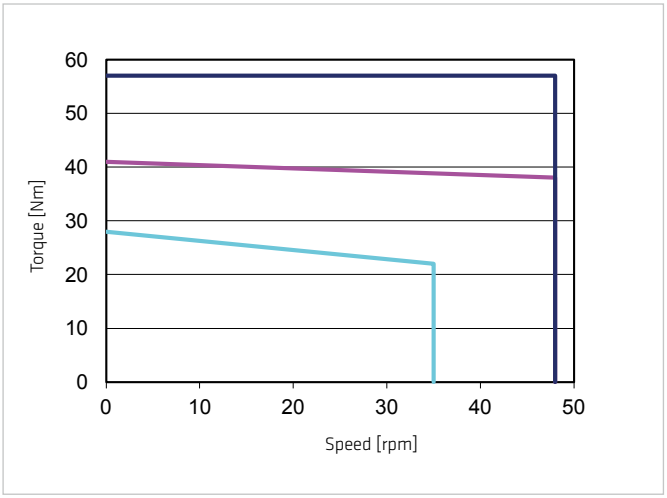



Illustration 29.4 FHA-25C-100-D250/US250

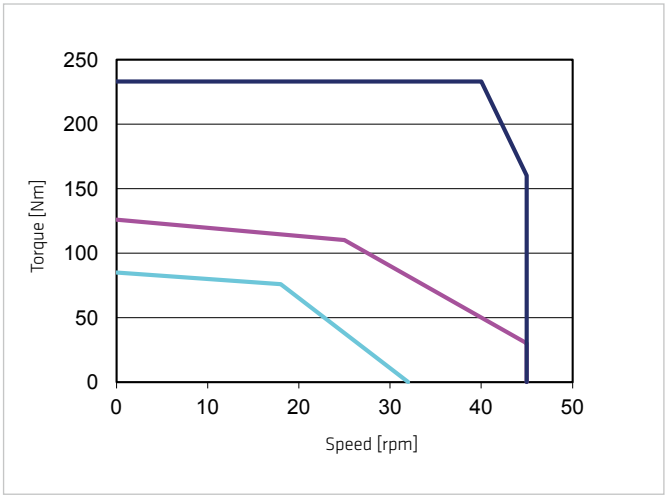



Illustration 29.5 FHA-17C-160-D250/US250

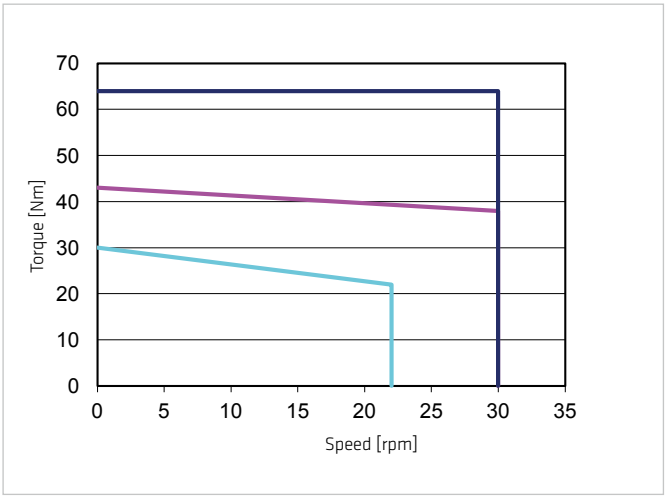
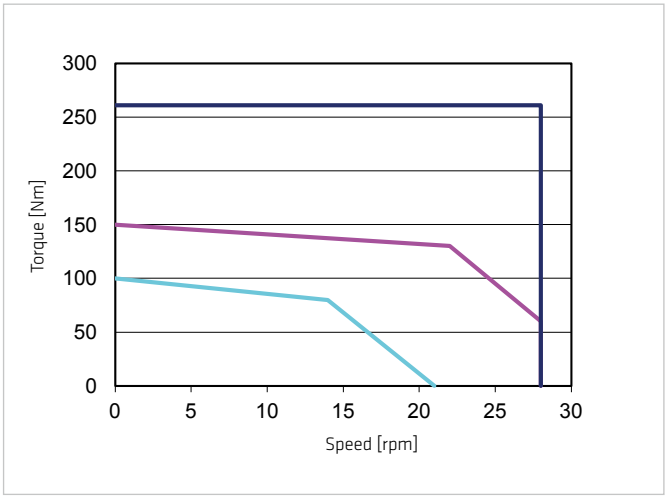



Illustration 29.6 FHA-25C-160-D250/US250




**Legend**

Intermittent duty
Continuous duty

$U_M$ = 430 VAC

S3-ED 50% (1 min)

Table 30.1

| | Symbol [Unit] | FHA-32C | | | FHA-40C | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | D250/US250 | | | D250/US250 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Maximum output torque | $T_{max}$ [Nm] | 281 | 398 | 453 | 430 | 690 | 823 |
| Maximum output speed | $n_{max}$ [rpm] | 80 | 40 | 25 | 70 | 35 | 22 |
| Maximum current | $I_{max}$ [$A_{rms}$] | 11.5 | 8.1 | 5.9 | 15.0 | 11.8 | 9.0 |
| Continuous stall torque | $T_0$ [Nm] | 73 | 151 | 232 | 122 | 256 | 354 |
| Continuous stall current | $I_0$ [$A_{rms}$] | 3.2 | 3.2 | 3.0 | 4.0 | 4.0 | 3.8 |
| Maximum DC bus voltage | $U_{DCmax}$ [$V_{DC}$] | 330 | | | 330 | | |
| Electrical time constant (20° C) | $t_e$ [ms] | 1 | | | 2 | | |
| Mechanical time constant (20° C) | $t_m$ [ms] | 7 | | | 9 | | |
| No load current | $I_{NLS}$ [$A_{rms}$] | 0.87 | 0.69 | 0.65 | 1.29 | 1.02 | 0.95 |
| Torque constant (at output) | $k_{Tout}$ [$Nm/A_{rms}$] | 27 | 54 | 86 | 31 | 64 | 102 |
| Torque constant (at motor) | $k_{TM}$ [$Nm/A_{rms}$] | 0.58 | | | 0.68 | | |
| AC voltage constant (L-L, 20° C, at motor) | $k_{EM}$ [$V_{rms}$/1000 rpm] | 35 | | | 44 | | |
| Motor terminal voltage (fundamental wave only) | $U_M$ [$V_{rms}$] | 220 | | | 220 | | |
| Demagnetisation current | $I_E$ [$A_{rms}$] | 40 | | | 45 | | |
| Maximum motor speed | $n_{max}$ [rpm] | 4000 | | | 3500 | | |
| Rated motor speed | $n_N$ [rpm] | 2500 | | | 2500 | | |
| Resistance (L-L, 20° C) | $R_{L-L}$ [Ω] | 2.0 | | | 1.5 | | |
| Inductance (L-L) | $L_{L-L}$ [mH] | 2.6 | | | 2.9 | | |
| Number of pole pairs | p [ ] | 6 | | | 6 | | |
| Weight without brake | m [kg] | 6.5 | | | 12 | | |
| Weight with brake | m [kg] | 7.4 | | | 14 | | |
| Hollow shaft diameter | $d_h$ [mm] | 35 | | | 45 | | |

## Moment of Inertia

Table 30.2

| | Symbol [Unit] | FHA-32C | | | FHA-40C | | |
|---|---|---|---|---|---|---|---|
| Motor feedback system | | D250/US250 | | | D250/US250 | | |
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| **Moment of inertia at outputside** | | | | | | | |
| Moment of inertia without brake | $J_{out}$ [$kgm^2$] | 1.80 | 7.10 | 18.1 | 4.90 | 19.5 | 50.0 |
| Moment of inertia with brake | $J_{out}$ [$kgm^2$] | 2.10 | 8.40 | 22.0 | 5.50 | 22.0 | 57 |
| **Moment of inertia at motor** | | | | | | | |
| Moment of inertia at motor without brake | J [$x10^{-4}$ $kgm^2$] | 7.1 | | | 19.5 | | |
| Moment of inertia at motor with brake | J [$x10^{-4}$ $kgm^2$] | 8.4 | | | 20.0 | | |

## Technical Data Brake

Table 30.3

| | Symbol [Unit] | FHA-32C-H | | | FHA-40C-H | | |
|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | **50** | **100** | **160** | **50** | **100** | **160** |
| Brake voltage | $U_{Br}$ [$V_{DC}$] | 24 ± 10% | | | 24 ± 10% | | |
| Brake holding torque (at output) | $T_{Br}$ [Nm] | 75 | 150 | 240 | 75 | 150 | 240 |
| Brake current to open | $I_{OBr}$ [$A_{DC}$] | 1.2 | | | 1.2 | | |
| Brake current to hold | $I_{HBr}$ [$A_{DC}$] | 0.2 | | | 0.2 | | |
| Number of brake cycles at n = 0 rpm | | 10000000 | | | 10000000 | | |
| Emergency brake cycles | | 200 | | | 200 | | |
| Opening time | $t_O$ [ms] | 150 | | | 150 | | |
| Closing time | $t_C$ [ms] | 100 | | | 100 | | |

## 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 ratings table.

Illustration 31.1 FHA-32C-50-D250/US250

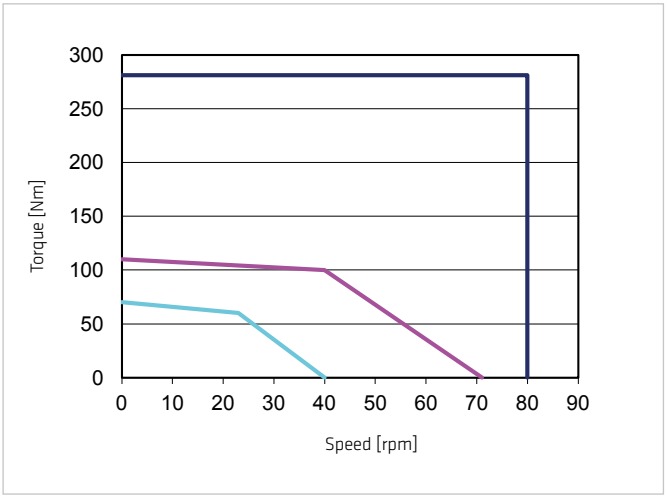



Illustration 31.2 FHA-40C-50-D250/US250

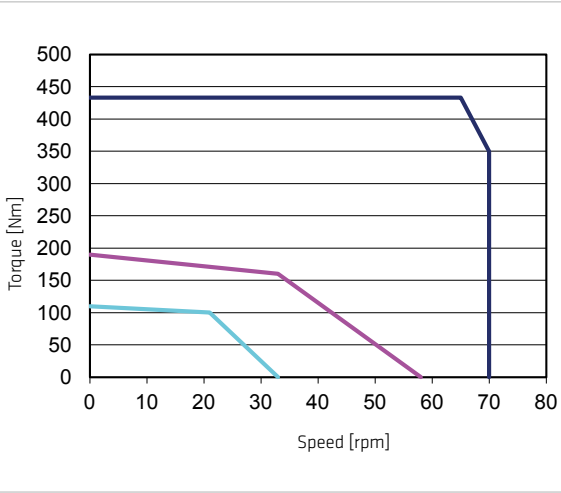



Illustration 31.3 FHA-32C-100-D250/US250

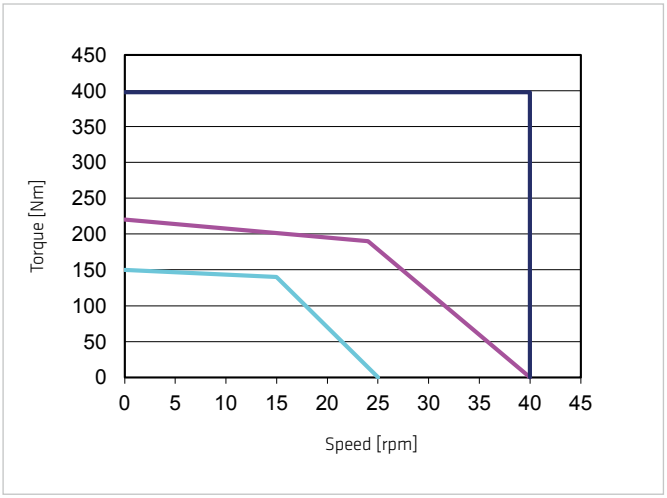



Illustration 31.4 FHA-40C-100-D250/US250

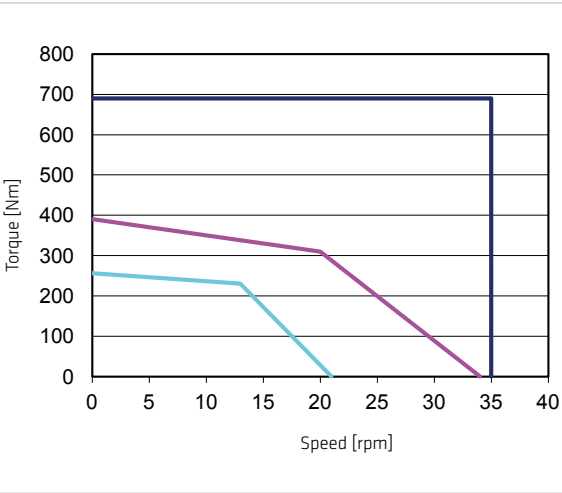



Illustration 31.5 FHA-32C-160-D250/US250

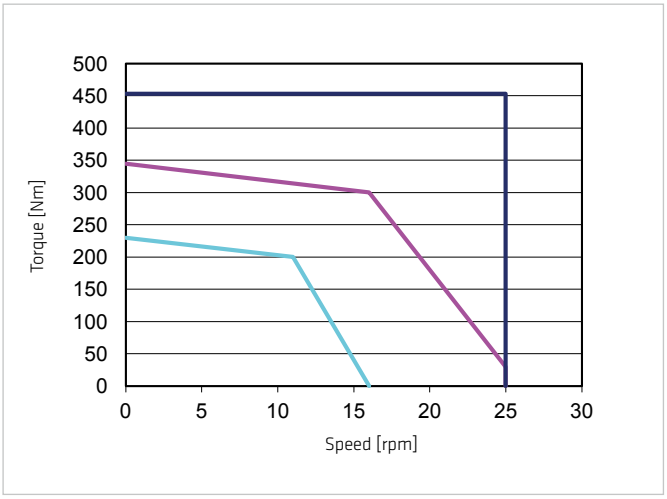
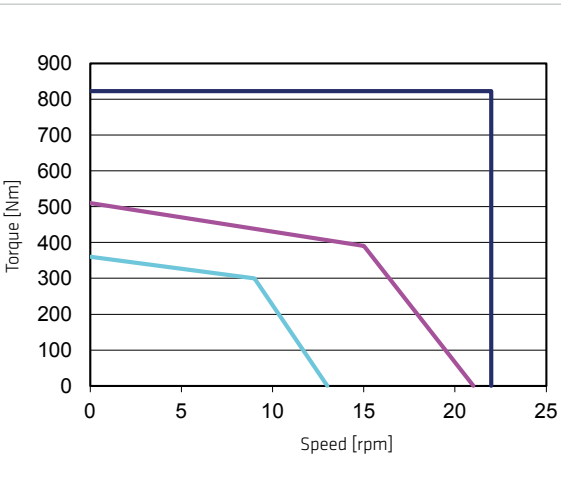



Illustration 31.6 FHA-40C-160-D250/UD250




**Legend**

Intermittent duty — $U_M$ = 430 VAC — S3-ED 50% (1 min)
Continuous duty

## 3.3.3 Dimensions

Detailed 2D drawings and 3D models can be found at the following Quicklink:
QUICKLINK **www.harmonicdrive.de/CAD1020**

Illustration 32.1 FHA-17C [mm]

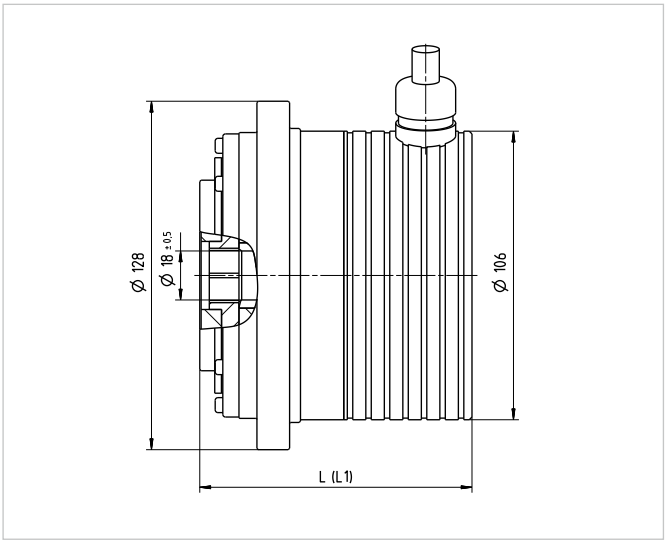



Illustration 32.2 FHA-25C [mm]

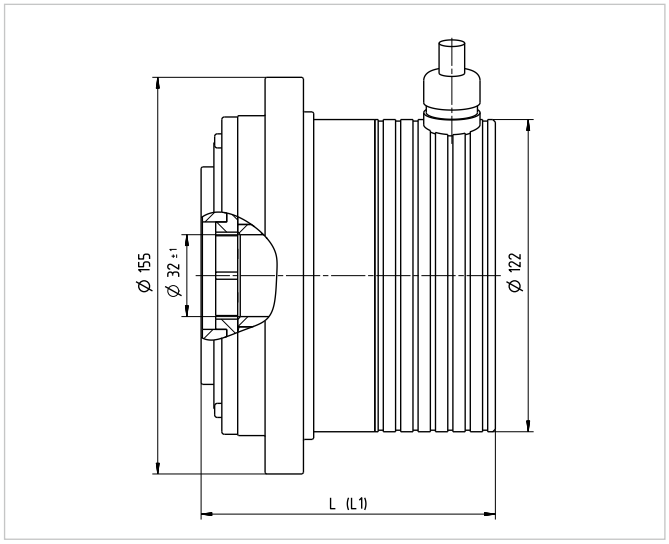



Table 32.3

| | Symbol [Unit] | FHA-17C-L/H | FHA-25C-L/H |
|---|---|---|---|
| Motor feedback system | | C1024 | C1024 |
| Length (without brake) | L [mm] | 100 | 115 |
| Length (with brake) | L1 [mm] | 115.5 | 134.5 |
| Cable length | L [mm] | 1.0 ... 1.1 | 1.0 ... 1.1 |

Illustration 32.4 FHA-32C [mm]

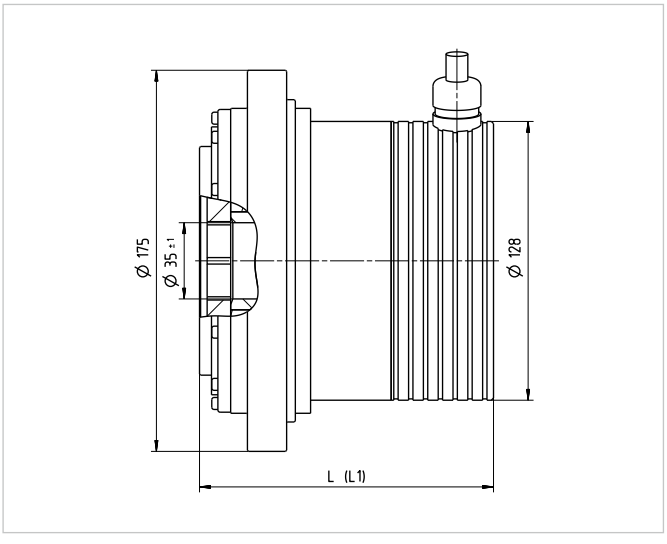



Illustration 32.5 FHA-40C [mm]

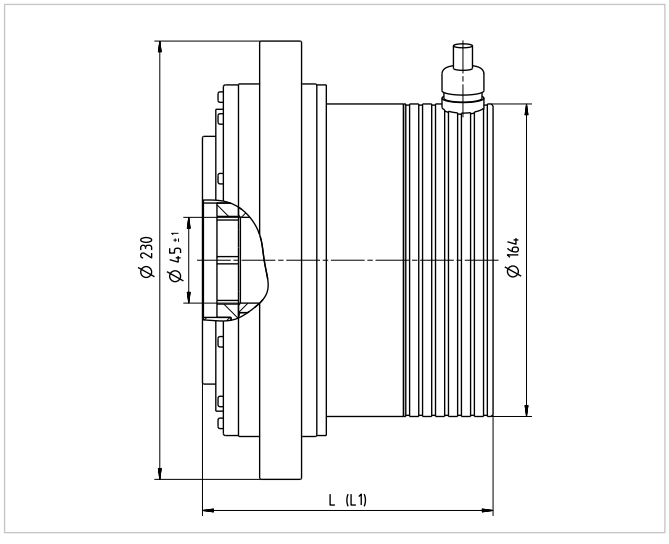



Table 32.6

| | Symbol [Unit] | FHA-32C-L/H | FHA-40C-L/H |
|---|---|---|---|
| Motor feedback system | | C1024 | C1024 |
| Length (without brake) | L [mm] | 135 | 152.5 |
| Length (with brake) | L1 [mm] | 155.5 | 173.5 |
| Cable length | L [mm] | 1.0 ... 1.1 | 1.0 ... 1.1 |

Illustration 33.1 FHA-17C-M512P [mm]

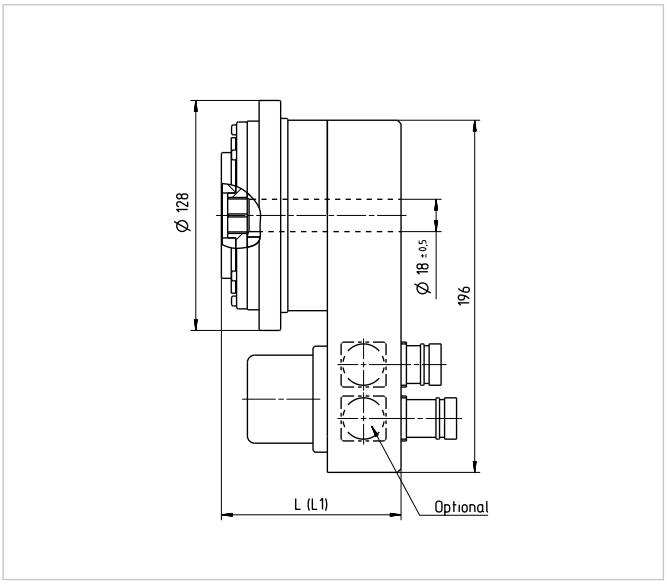



Illustration 33.2 FHA-25C-M512P

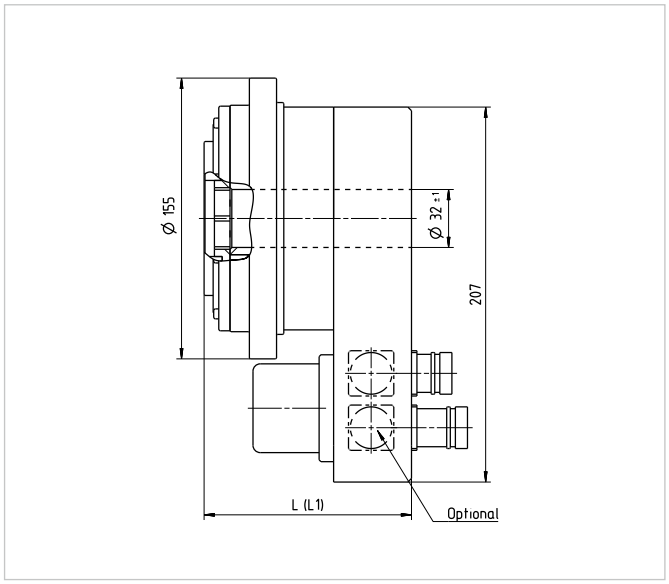



Table 33.3

| | Symbol [Unit] | FHA-17C | FHA-25C |
|---|---|---|---|
| Motor feedback system | | M512P/M128P | M512P/M128P |
| Length (without brake) | L [mm] | 100 | 114.5 |
| Length (with brake) | L1 [mm] | 115.5 | 134.5 |

Illustration 33.4 FHA-32C-M512P [mm]

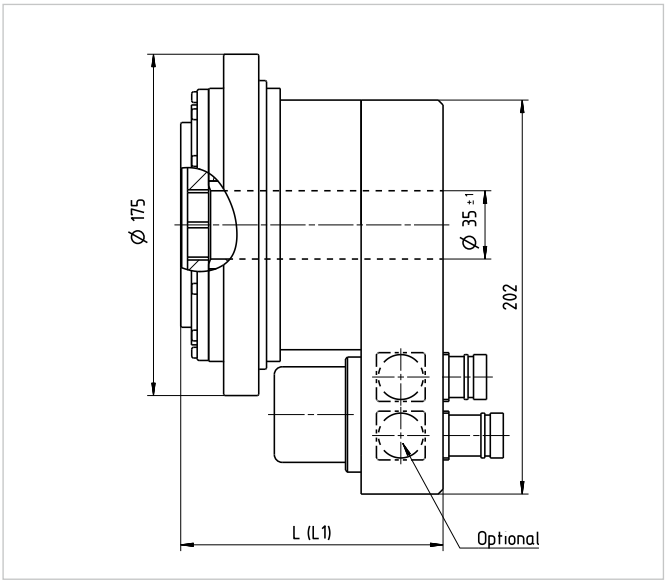



Illustration 33.5 FHA-40C-M512P

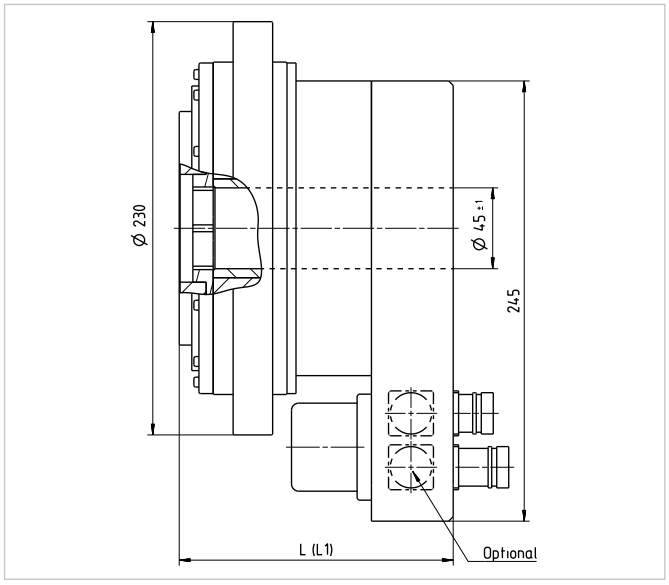



Table 33.6

| | Symbol [Unit] | FHA-32C | FHA-40C |
|---|---|---|---|
| Motor feedback system | | M512P/M128P | M512P/M128P |
| Length (without brake) | L [mm] | 134.5 | 152.5 |
| Length (with brake) | L1 [mm] | 155 | 173.5 |

Illustration 34.1 FHA-17C-D250/US250 [mm]

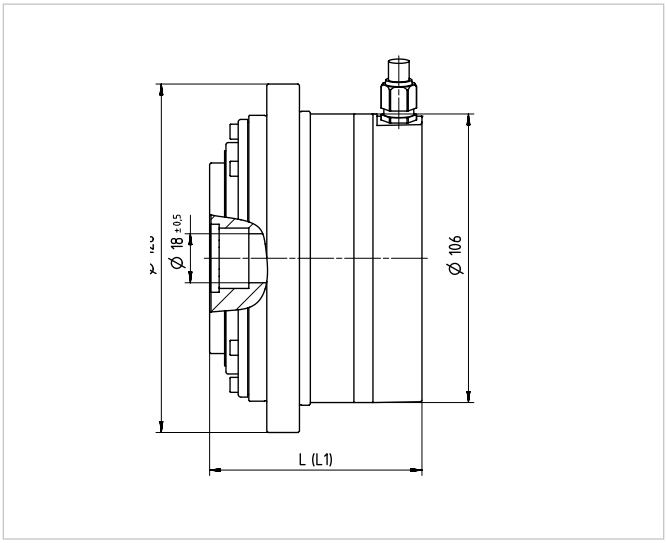



Illustration 34.2 FHA-25C-D250/US250 [mm]

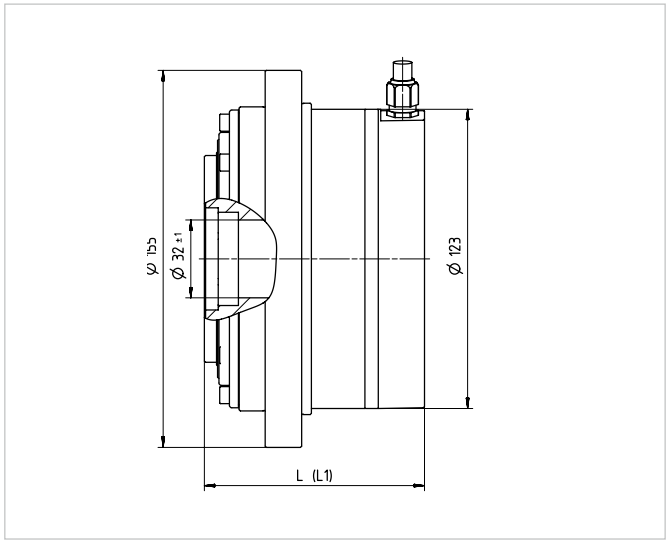



Table 34.3

| | Symbol [Unit] | FHA-17C | FHA-25C |
|---|---|---|---|
| Motor feedback system | | D250/US250 | D250/US250 |
| Length (without brake) | L [mm] | 78 ± 1 | 90.5 ± 1 |
| Length (with brake) | L1 [mm] | 93.5 ± 1 | 100 ± 1 |
| Cable length | L [mm] | 1.0 ... 1.2 | 1.0 ... 1.2 |

Illustration 34.4 FHA-32C-D250/US250 [mm]

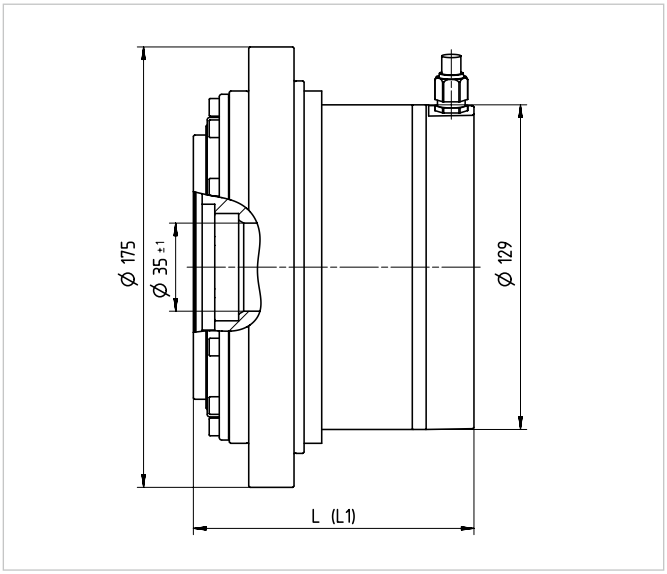



Illustration 34.5 FHA-40C-D250/US250 [mm]

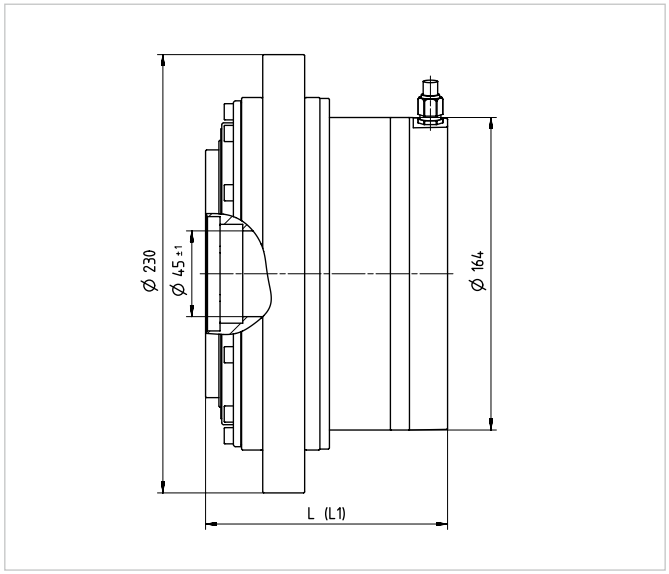



Table 34.6

| | Symbol [Unit] | FHA-32C | FHA-40C |
|---|---|---|---|
| Motor feedback system | | D250/US250 | C1024 |
| Length (without brake) | L [mm] | 111.5 ± 1 | 127 ± 1 |
| Length (with brake) | L1 [mm] | 132 ± 1 | 148 ± 1 |
| Cable length | L [mm] | 1.0 ... 1.2 | 1.0 ... 1.2 |

## 3.3.4 Accuracy

Table 35.1

| | Symbol [Unit] | FHA-17C | | FHA-25C | | FHA-32C | | FHA-40C | |
|---|---|---|---|---|---|---|---|---|---|
| Ratio | i [ ] | 50 | >50 | 50 | >50 | 50 | >50 | 50 | >50 |
| Transmission accuracy | [arcmin] | < 1 | <0.7 | < 0.7 | <0.5 | < 0.7 | <0.5 | < 0.7 | <0.5 |
| Repeatability | [arcmin] | < ± 0.1 | | < ± 0.1 | | < ± 0.1 | | < ± 0.1 | |
| Hysteresis loss | [arcmin] | < 2 | | < 2 | | < 2 | | < 2 | |
| Lost Motion | [arcmin] | < 1 | | < 1 | | < 1 | | < 1 | |

## 3.3.5 Torsional Stiffness

Table 35.2

| | Symbol [Unit] | FHA-17C | | FHA-25C | | FHA-32C | | FHA-40C | |
|---|---|---|---|---|---|---|---|---|---|
| T1 | [Nm] | 7 | | 29 | | 54 | | 108 | |
| T2 | [Nm] | 25 | | 108 | | 196 | | 382 | |
| Ratio | i [ ] | 50 | >50 | 50 | >50 | 50 | >50 | 50 | >50 |
| $K_3$ | [x10³ Nm/rad] | 20 | 25 | 84 | 110 | 150 | 200 | 300 | 370 |
| $K_2$ | [x10³ Nm/rad] | 13 | 17 | 61 | 77 | 110 | 140 | 210 | 290 |
| $K_1$ | [x10³ Nm/rad] | 11 | 13 | 47 | 61 | 88 | 110 | 170 | 210 |

## 3.3.6 Output Bearing

FHA 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 servo actuators are greatly simplified.

## Technical Data

Table 36.1

| | Symbol [Unit] | FHA-17C | FHA-25C | FHA-32C | FHA-40C |
|---|---|---|---|---|---|
| Bearing type [1] | | C | C | C | C |
| Pitch circle diameter | $d_p$ [mm] | 77.0 | 96.0 | 112.2 | 148.8 |
| Offset | R [mm] | 17.0 | 18.0 | 18.5 | 27.0 |
| Dynamic load rating | C [N] | 10800 | 18000 | 24100 | 44900 |
| Stating load rating | $C_0$ [N] | 18700 | 33300 | 44300 | 88900 |
| Dynamic tilting moment [2] | $M_{dyn\,(max)}$ [Nm] | 188 | 370 | 530 | 690 |
| Static tilting moment [3] | $M_{0\,(max)}$ [Nm] | 480 | 1066 | 1657 | 4409 |
| Tilting moment stiffness [5] | $K_B$ [Nm/arcmin] | 64 | 142 | 230 | 407 |
| Dynamic axial load [4] | $F_{A\,dyn\,(max)}$ [N] | 4180 | 6967 | 9328 | 17379 |
| Dynamic radial load [4] | $F_{R\,dyn\,(max)}$ [N] | 2801 | 4668 | 6250 | 11644 |

[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 $L_{10}$ = 15000h

[3][4] These data are only valid if the following conditions are fulfilled:

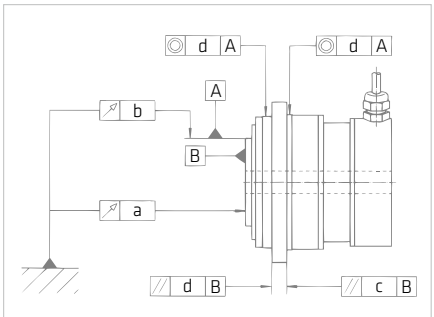
for $M_0$: $F_a$=0 N; $F_r$=0 N

$F_a$: M=0 Nm; $F_r$=0 N

$F_r$: M=0 Nm; $F_a$=0 N

[5] Average value

Illustration 36.2




## Tolerances

Table 36.3

| | Symbol [Unit] | FHA-17C | FHA-25C | FHA-32C | FHA-40C |
|---|---|---|---|---|---|
| a | [mm] | 0.010 | 0.012 | 0.012 | 0.014 |
| b | [mm] | 0.010 | 0.012 | 0.012 | 0.014 |
| c | [mm] | 0.040 | 0.050 | 0.050 | 0.060 |
| d | [mm] | 0.040 | 0.050 | 0.050 | 0.060 |

# 3.3.7 Motor Feedback Systems

## Design and Operation

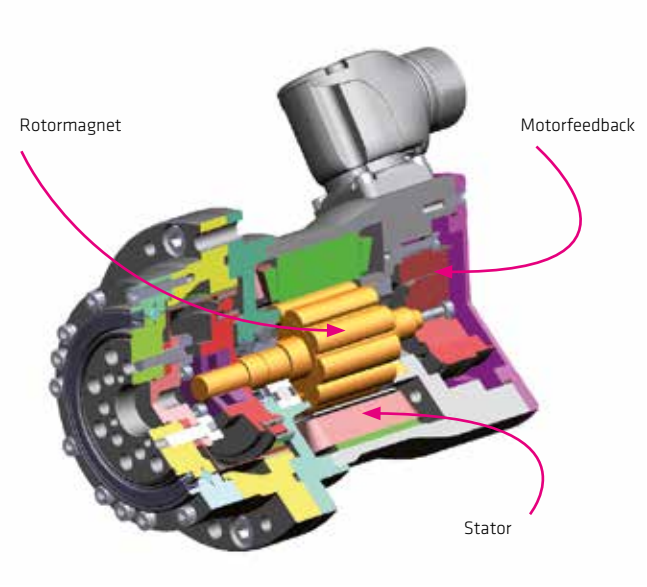
For accurate position setting, the servo motor and its control device are fitted with a measuring device (feedback), which determines the current position (e.g. the angle of rotation set for a starting position) of the motor.

This measurement is effected via a rotary 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 suing 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 FHA-C Series Actuators can be fitted with absolute measurement encoders directly to the actuator output (Option EC).

# C1024

## Incremental motor feedback with SIN / COS signals reference and commutation signals

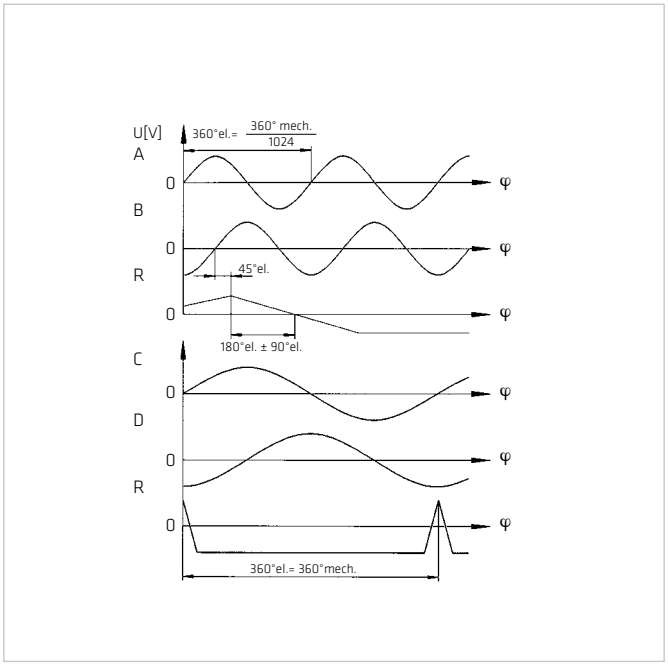
Table 38.1

| Ordering code | Symbol [Unit] | C1024 | | | | | |
|---|---|---|---|---|---|---|---|
| Manufacturer's designation | | CCK | | | | | |
| Power supply [1] | $U_b$ [VDC] | 5 ± 10% | | | | | |
| Current consumption [1] | I [mA] | 150 | | | | | |
| Incremental signals | $u_{pp}$ [$V_{ss}$] | 1 +20% / -25% | | | | | |
| Signal form | | sinusoidal | | | | | |
| Number of pulses | $n_1$ [A / B] | 1024 | | | | | |
| Commutation signals | $u_{pp}$ [$V_{ss}$] | 1 | | | | | |
| Signal form | | sinusoidal | | | | | |
| Number of pulses | $n_2$ [C / D] | 1 | | | | | |
| Reference signal | $n_3$ [R] | 1 | | | | | |
| Accuracy [1] | [arcsec] | ±12 | | | | | |
| Incremental resolution (motor side) [2] | inc [ ] | 262144 | | | | | |
| Resolution (output side) [2] | | Gear Ratio | | | | | |
| | i [ ] | 30 | 50 | 80 | 100 | 120 | 160 |
| | [arcsec] | 0.16 | 0.10 | 0.06 | 0.05 | 0.04 | 0.03 |

[1] Source: Manufacturer
[2] For interpolation with 8 bit

## Signal wave form

Illustration 38.2




Valid for direction of rotation
- CW at the motor shaft (when viewed from the front face of the motor)
- CCW at the output flange

# M512P

## Multi-turn absolute motor feedback system with incremental SIN / COS signals and EnDat® data interface

Table 39.1

| Ordering code | Symbol [Unit] | M512P | | | | | |
|---|---|---|---|---|---|---|---|
| Manufacturer's designation | | EQN 1125 | | | | | |
| Protocol | | EnDat 2.2 | | | | | |
| Power supply [1] | $U_b$ [VDC] | 3.6 ... 14 | | | | | |
| Current consumption (typically @ 5 VDC, without load) [1] | I [mA] | 105 | | | | | |
| Incremental signals | $u_{pp}$ [$V_{ss}$] | 0.8 ... 1.2 | | | | | |
| Signal form | | sinusoidal | | | | | |
| Number of pulses | $n_1$ [SIN / COS] | 512 | | | | | |
| Absolute position / revolution (motor side) [3] | | 8192 | | | | | |
| Number of revolutions | | 4096 | | | | | |
| Accuracy [1] | [arcsec] | ± 60 | | | | | |
| Resolution of the absolute value (output side) | | Gear ratio | | | | | |
| | i [ ] | 30 | 50 | 80 | 100 | 120 | 160 |
| | [arcsec] | 5.3 | 3.2 | 2.0 | 1.6 | 1.4 | 1.0 |
| Number of revolutions (at outputside) | | 136 | 81 | 51 | 40 | 34 | 25 |
| Incremental resolution (motor side) [2] | inc [ ] | 131072 | | | | | |
| Resolution (output side) [2] | | Gear ratio | | | | | |
| | i [ ] | 30 | 50 | 80 | 100 | 120 | 160 |
| | [arcsec] | 0.33 | 0.20 | 0.12 | 0.10 | 0.08 | 0.06 |

[1] Source: Manufacturer
[2] for interpolation with 8 bit
[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

# M128P

## Multi-turn absolute motor feedback system with incremental SIN / COS signals and HIPERFACE® interface

Tabelle 40.1

| Ordering code | Symbol [Unit] | M128P | | |
|---|---|---|---|---|
| Manufacturer's designation | | SKM36 | | |
| Type identifier [1] | | 37h | | |
| Protocol | | HPERFACE® | | |
| Power supply [1] | $U_b$ [VDC] | 7 ... 12 | | |
| Current consumption (typically @ 5 VDC, without load) [1] | I [mA] | 60 | | |
| Incremental signals | $u_{pp}$ [$V_{ss}$] | 0.8 ... 1.1 | | |
| Signal form | | sinusoidal | | |
| Number of pulses | $n_1$ [SIN / COS] | 128 | | |
| Absolute position / revolution (motor side) [3] | | 4096 | | |
| Number of revolutions | | 4096 | | |
| free EEPROM | [Bytes] | 1792 | | |
| Accuracy [1] | [arcsec] | ± 80 | | |
| Resolution of the absolute value (output side) | | Gear ratio FHA-C | | |
| | i [ ] | 50 | 100 | 160 |
| | [arcsec] | 6.4 | 3.2 | 2.0 |
| Number of revolutions (at outputside) | | 81 | 40 | 25 |
| Incremental resolution (motor side) [2] | inc [ ] | 32768 | | |
| Resolution (output side) [2] | | Gear ratio | | |
| | i [ ] | 50 | 100 | 160 |
| | [arcsec] | 0.79 | 0.40 | 0.25 |

[1] Source: Manufacturer
[2] for interpolation with 8 bit
[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

# D250

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

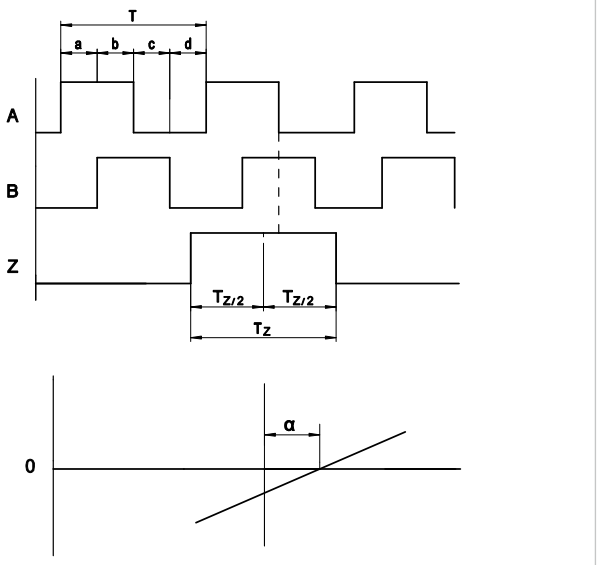
Tabelle 41.1

| Ordering code | Symbol [Unit] | D250 | | |
|---|---|---|---|---|
| Manufacturer's designation | | – | | |
| Power supply [1] | $U_b$ [VDC] | 5 ± 5% | | |
| Current consumption (typically @ 5 VDC, without load) [1] | I [mA] | 250 | | |
| Incremental signals | | RS422 | | |
| Signal form | | square wave | | |
| Number of pulses | $n_1$ [SIN / COS] | 2500 | | |
| Commutation signals | | RS422 | | |
| Signal form | | square wave | | |
| Number of pulses | n [U, V, W] | 6 | | |
| Reference signal | $n_3$ [Z] | 1 | | |
| Accuracy [1] | [arcsec] | – | | |
| Incremental resolution (motor side) [2] | inc [ ] | 10000 | | |
| Resolution (output side) [2] | | Gear ratio | | |
| | i [ ] | 30 | 50 | 100 |
| | [arcsec] | 4.4 | 2.6 | 1.3 |

[1] Source: Manufacturer
[2] for quadcounting

## Signal wave form

Illustration 41.2

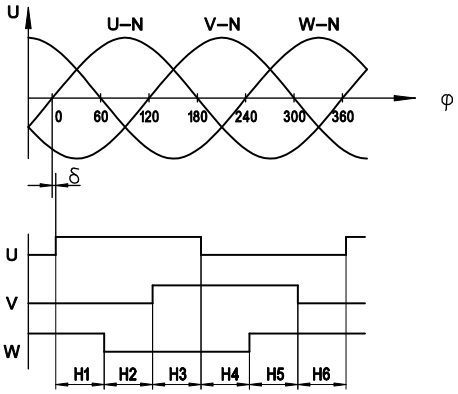



T= 360°/2500
a,b,c,d = 0,25T ±0,1T
Tz = 0,5T ... 1,5T
HN = 10° ±3°
α = δ ≤ ±2°

Valid for direction of rotation
- for rotation in counter clockwise direction, looking at the output flange

## Commutation

Illustration 41.3



# US250

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

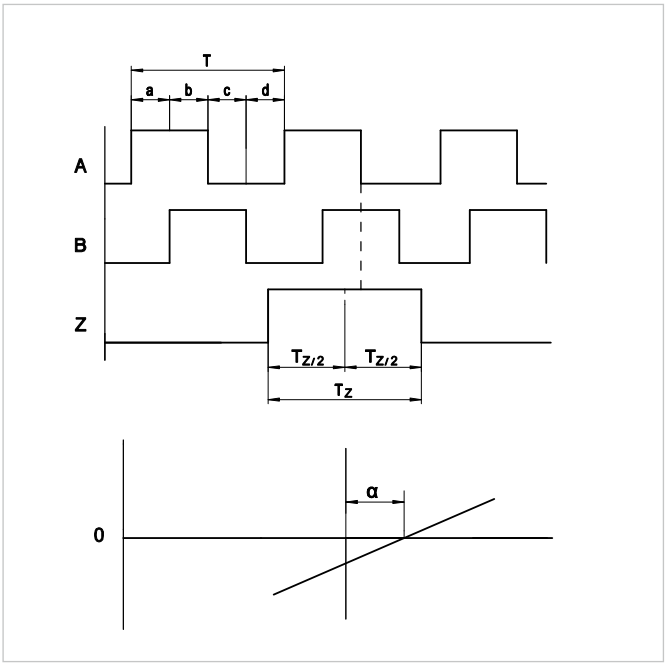
Tabelle 42.1

| Ordering code | Symbol [Unit] | US250 | | |
|---|---|---|---|---|
| Manufacturer's designation | | – | | |
| Power supply [1] | $U_b$ [VDC] | 5 ± 5% | | |
| Current consumption (typically @ 5 VDC, without load) [1] | I [mA] | 250 | | |
| Incremental signals | | RS422 | | |
| Signal form | | square wave | | |
| Number of pulses | $n_1$ [SIN / COS] | 2500 | | |
| Commutation signals | | RS422 | | |
| Signal form | | square wave | | |
| Number of pulses | n [U, V, W] | 6 | | |
| Reference signal | $n_3$ [Z] | 1 | | |
| Accuracy [1] | [arcsec] | – | | |
| Incremental resolution (motor side) [2] | inc [ ] | 10000 | | |
| Resolution (output side) [2] | | Gear ratio FHA-C | | |
| | i [ ] | 30 | 50 | 100 |
| | [arcsec] | 4.4 | 2.6 | 1.3 |

[1] Source: Manufacturer
[2] for quadcounting

## Signal wave form

Illustration 42.2

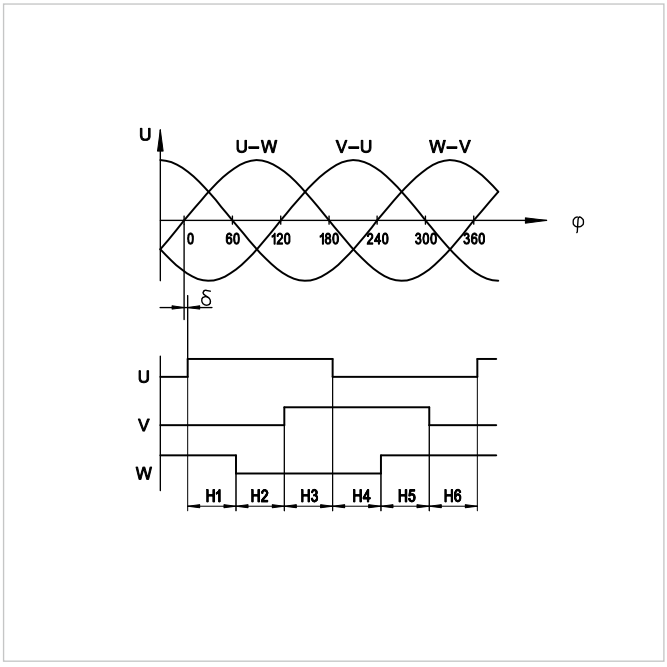



T= 360°/2500
a,b,c,d = 0,25T ±0,1T
Tz = 0,5T ... 1,5T
HN = 10° ±3°
α = δ ≤ ±2°

Valid for direction of rotation
- for rotation in counter clockwise direction, looking at the output flange

## Commutation

Illustration 42.3



## 3.3.8 Temperature Sensors

For motor protection at speeds greater than zero, temperature sensors are integrated in the motor windings. For applications with high load where the speed is zero, additional protection (eg $I^2t$ monitoring) is recommended. When using the KTY 84-130 the values given in the table can be parametrized in the servo controller or an external evaluation unit.

Table 43.1 FHA-C-L-C1024/M512P/M128P

| Sensor type | Parameter | $T_{Nat}$ [°C] |
|---|---|---|
| PTC | Rated operating temperature | 145 |

PTC thermistors, because of their very high positive temperature coefficient at nominal operating temperature ($T_{Nat}$), are ideally suited for motor winding protection.

Due to their principle, the PTC sensors should only be used to monitor the winding temperature.

Illustration 43.2 Diagram PTC

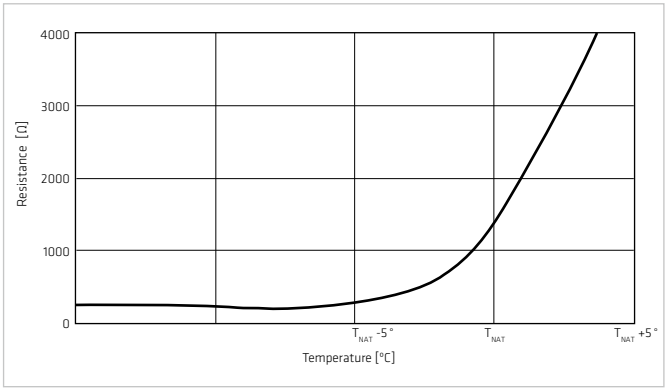



Table 43.3

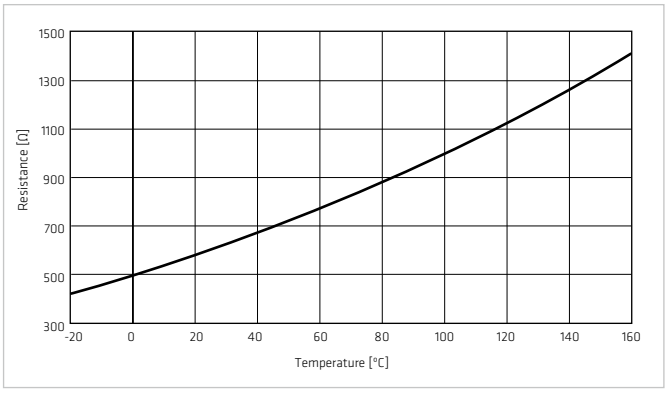
| Sensor type | Parameter | Symbol [Unit] | Warning | Shutdown |
|---|---|---|---|---|
| KTY 84-130 | Temperature | T [°C] | 80 | 90 |
| | Resistance | R [Ω] | 882 ± 3% | 940 ± 3% |

The KTY sensor is used for temperature measurement and monitoring the motor winding.

Because the KTY sensor provides an analogue temperature measurement, it is also possible to protect the actuator grease from temperature overload.

Temperature sensors used in the FHA-C-H Actuator Series meet the requirements for safe separation according to EN50178.

Illustration 43.4 Diagram KTY 84-130




ADVICE

**The FHA-xxC with motor feedback system D250 and US250 are without temperature sensor.**

## 3.3.9 Electrical Connections

### FHA-xxC-xx-H-C1024 / H-M512P

Table 44.1

| | |
|---|---|
| Motor connector | 6 / M23 x 1 |
| Cable plug | 6 / M23 x 1 / Mat.-no. 301193 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 44.2

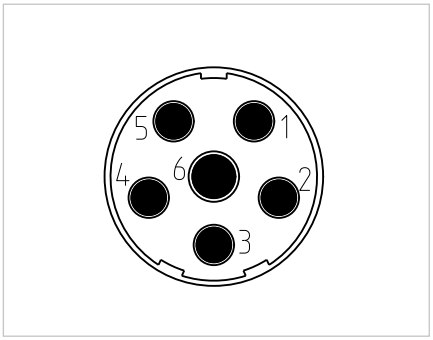



Table 44.3

| Connector pin | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Motor phase | U | V | PE | BR+ | BR- | W |

Table 44.4

| | |
|---|---|
| Encoder connector | 17 / M23 x 1 |
| Cable plug | 17 / M23 x 1 / Mat.-no. 270199 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 44.5

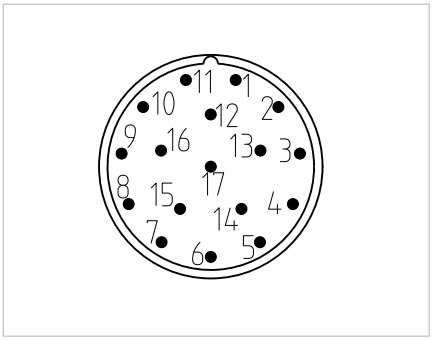



Table 44.6

| **Connector pin** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C 1024 Signal | A+ | A- | R+ | D- | C+ | C- | GND | Temp+ KTY | Temp- KTY | Up | B+ | B- | R- | D+ | GND Sensor | Up Sensor | Inner shield |
| M512P Signal | A+ | A- | Data+ | n.c. | Clock+ | n.c. | GND | Temp+ KTY | Temp- KTY | Up | B+ | B- | Data- | Clock- | GND Sensor | Up Sensor | Inner shield |

## Connecting cables SINAMICS S120 with SMC modul

Table 45.1

| **Power Connection** | |
|---|---|
| FHA-C without Brake | 6FX8002-5CA01-1xx0 |
| FHA-C with Brake | 6FX8002-5DA01-1xx0 |
| **Motor feedback** | |
| H-C1024 | 6FX8002-2CA31-1xx0 |
| H-M512P | 6FX8002-2EQ10-1xx0 |

## Connecting cables with flying leads

Table 45.2

| **Version** | **Mat.-no.** | **Length [m]** |
|---|---|---|
| FHA-xxC-H-C1024 | 308853<br>308854<br>308855<br>308856<br>308857 | 5<br>10<br>15<br>20<br>25 |
| FHA-xxC-H-M512P | 308858<br>308859<br>308860<br>308861<br>308862 | 5<br>10<br>15<br>20<br>25 |

## Connecting cables for the connection to YukonDrive®

Table 45.5

| **Version** | **Mat.-no.** | **Length [m]** |
|---|---|---|
| FHA-xxC-H-M512 | 314260<br>314261<br>314262 | 3<br>5<br>10 |

Table 46.1

| | |
|---|---|
| Motor connector | 8 / M23 x 1 |
| Cable plug | 8 / M23 x 1 / Mat.-no. 303549 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 46.2

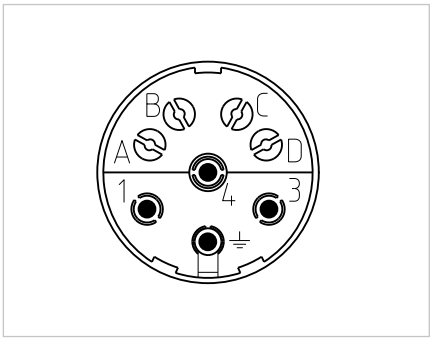



Table 46.3

| Connector pin | 1 | 2 | 3 | 4 | A | B | C | D |
|---|---|---|---|---|---|---|---|---|
| Motor phase | U | PE | W | V | BR+ | BR- | Temp+ PTC | Temp- PTC |

Table 46.4

| | |
|---|---|
| Encoder connector | 17 / M23 x 1 |
| Cable plug | 17 / M23 x 1 / Mat.-no. 270199 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 46.5

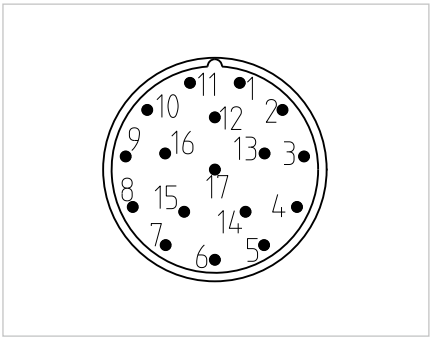



Table 46.6

| **Connector pin** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1024 Signal | A+ | A- | R+ | D- | C+ | C- | GND | – | – | Up | B+ | B- | R- | D+ | GND Sensor | Up Sensor | Inner Schirm |
| M512 Signal | A+ | A- | Data+ | n.c. | Clock+ | n.c. | GND | – | – | Up | B++ | B- | Data- | Clock- | GND Sensor | Up Sensor | Inner Schirm |

Table 47.1

| | |
|---|---|
| Motor connector | 6 / M23 x 1 |
| Cable plug | 6 / M23 x 1 / Mat.-no. 301193 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 47.2

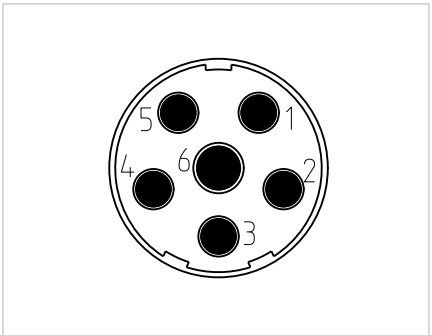



Table 47.3

| Connector pin | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Motor phase | U | V | PE | BR+ | BR- | W |

Table 47.4

| | |
|---|---|
| Encoder connector | 12 / M23 x 1 |
| Cable plug | 12 / M23 x 1 / Mat.-no. 305068 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 47.5

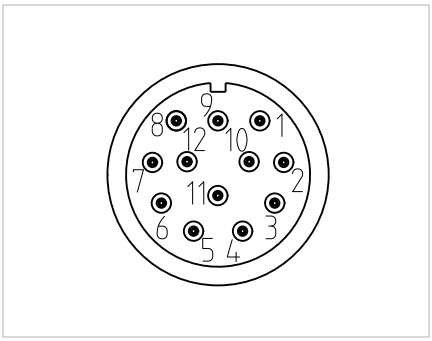



Table 47.6

| **Connector pin** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M128P Signal | Us | GND | SIN | REFSIN | Data+ | Data- | COS | REFCOS | Temp+ KTY | Temp- KTY | – | – |

Table 48.1

| | |
|---|---|
| Motor connector | 8 / M23 x 1 |
| Cable plug | 8 / M23 x 1 / Mat.-no. 303549 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 48.2

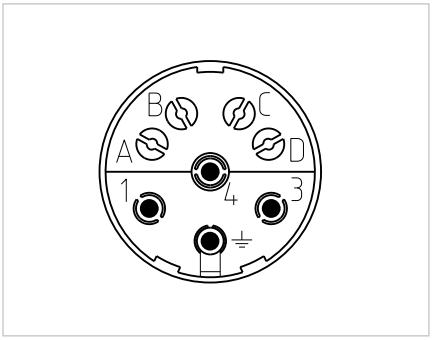



Table 48.3

| Connector pin | 1 | 2 | 3 | 4 | A | B | C | D |
|---|---|---|---|---|---|---|---|---|
| Motor phase | U | PE | W | V | BR+ | BR- | Temp+ PTC | Temp- PTC |

Table 48.4

| | |
|---|---|
| Encoder connector | 12 / M23 x 1 |
| Cable plug | 12 / M23 x 1 / Mat.-no. 305068 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 48.5

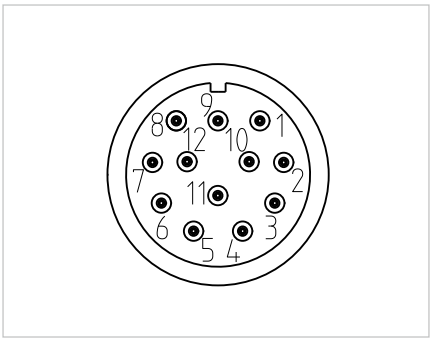



Table 48.6

| **Connector pin** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Signal | Us | GND | SIN | REFSIN | Data+ | Data- | COS | REFCOS | – | – | – | – |

## Connecting cables for the connection to YukonDrive®

Table 48.5

| **Version** | **Mat.-no.** | **Length [m]** |
|---|---|---|
| FHA-xxC-L-M128P | 1004153<br>1004154<br>1004155 | 3<br>5<br>10 |

Table 49.1

| Motor connector | U | V | W | PE | Brake | Brake | Shield |
|---|---|---|---|---|---|---|---|
| Color | red | white | black | green yellow | blue | yellow | |
| Cross section [mm²] | AWG 20 (FHA-17C/FHA-25C)<br>AWG 18 (FHA-32C/FHA-40C) | | | | | | |

Table 49.3

| D250/US250 Signal | A+ | A- | B+ | B- | Z+ | Z- | U+ | U- | V+ | V- | W+ | W- | GND | Up | Shield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Color | green | green white | grey | grey white | yellow | yellow white | brown | brown white | blue | blue white | orange | orange white | black | red | |
| Cross section [mm²] | AWG 24 | | | | | | | | | | | | AWG 22 | | |

**Connecting cables for the connection to YukonDrive®**

Table 49.3

| Version | Mat.-no. | Length [m] |
|---|---|---|
| FHA-C-D250 | 1029602<br>1037598<br>1020056 | 2<br>10<br>25 |

ADVICE

**The cable set does not include the mating connectors for the actuator.**

# 3.3.10 Options

## Position measuring system option EC

The FHA-C Hollow Shaft Servo Actuators Series are ideally suited for equipping with a single turn absolute measuring system that can be connected directly to the actuator output.

The ECN113 single turn absolute encoder is connected to the actuator flange by means of a torsionally stiff hollow shaft.

Table 50.1

| **Ordering code** | **Symbol [Unit]** | **EC** | | | | | |
|---|---|---|---|---|---|---|---|
| Manufacturer's designation | | ECN 113 | | | | | |
| Protocol | | EnDat 2.2 | | | | | |
| Power supply [1] | $U_b$ [VDC] | 5 ± 5% | | | | | |
| Current consumption [1] | I [mA] | 180 | | | | | |
| Incremental signals | $u_{pp}$ [$V_{ss}$] | 1 | | | | | |
| Signal form | | sinusoidal | | | | | |
| Number of pulses | $n_1$ [SIN / COS] | 2048 | | | | | |
| Absolute position / revolution (motor side) [3] | | 8192 | | | | | |
| Accuracy [1] | [arcsec] | ±20 | | | | | |
| Resolution of the absolute value (output side) | phi [arcsec] | 158 | | | | | |
| Resolution (output side) [2] | phi [arcsec] | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |

[1] Source: Manufacturer
[2] for interpolation with 8 bit
[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

The encoder system is connected using a standard signal connector.
The evaluation of the compatibility of the measurement system must be checked prior to commissioning. The measuring system contains electrostatically sensitive components, please observe the ESD measures.

Table 50.2

| | |
|---|---|
| Encoder connector | 17 / M23 x 1 |
| Cable plug | 17 / M23 x 1 / Mat.-no. 270199 |
| External diameter | ca. 26 mm |
| Length | ca. 60 mm |

Illustration 50.3

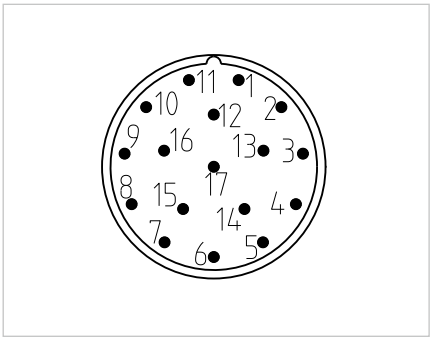



Table 50.4

| **Connector pin** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Signal | Up Sensor | n.c | n.c | GND Sensor | n.c. | n.c | Up | CLOCK+ | CLOCK- | GND | Inner shield | B+ | B- | DATA+ | A+ | A- | DATA- |
| Connecting Cables | | | | | | | | | | | | | | | | | |
| SIMODRIVE | 6FX8002-2AD00-1xx0 | | | | | | | | | | | | | | | | |
| SINAMICS S120 (SMC20) | 6FX8002-2CH00-1xx0 | | | | | | | | | | | | | | | | |
| YukonDrive® | Art.-Nr. 1010747 (3m; other length on request) | | | | | | | | | | | | | | | | |

# 4. Actuator Selection Procedure

## 4.1. Selection Procedure and Calculation Example

### Flowchart for actuator selection

Equation 51.1

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

Equation 51.2

$$T_2 = T_L$$

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

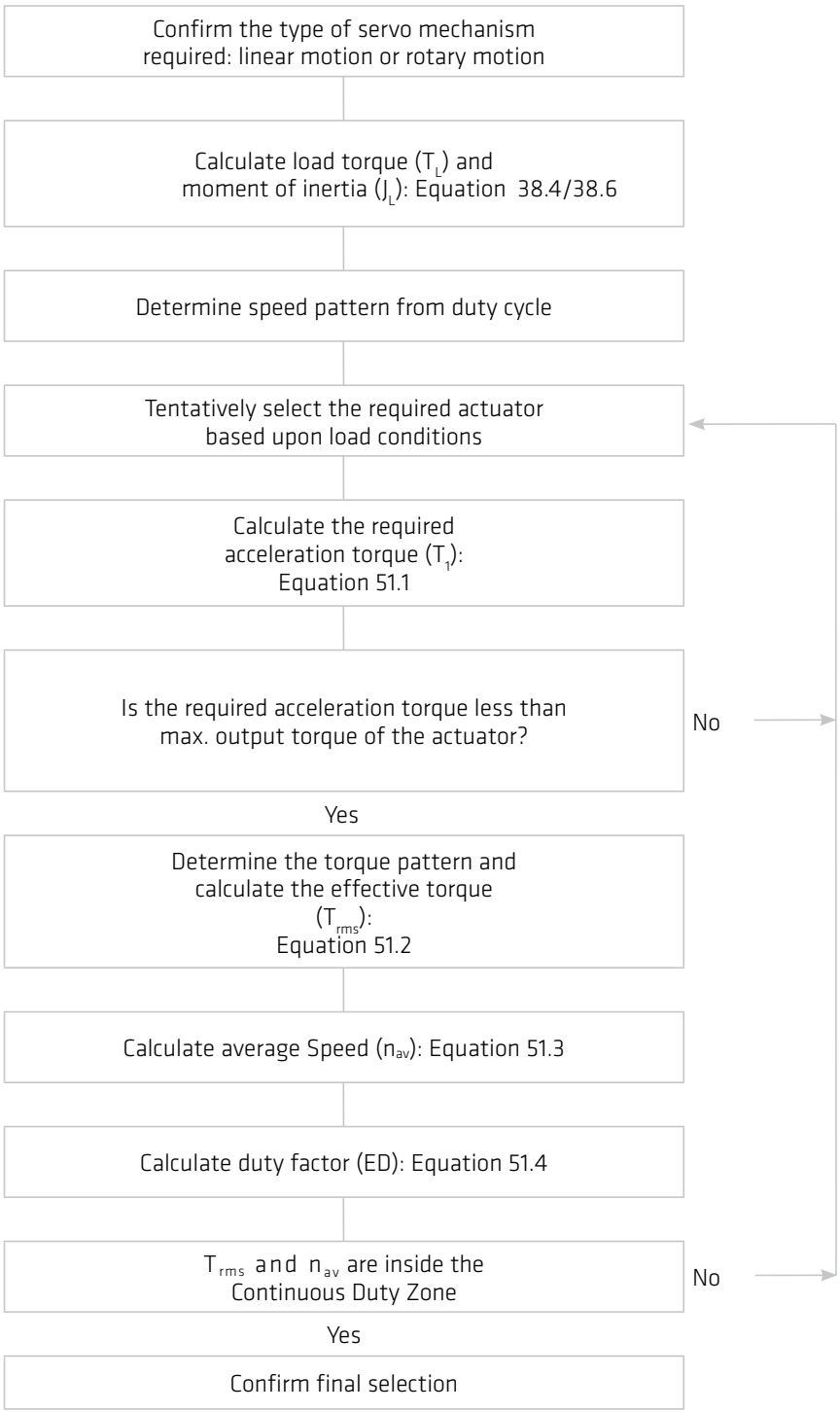
$$T_{rms} = \sqrt{\frac{T_1^2 \cdot t_1 + T_2^2 \cdot t_2 + T_3^2 \cdot t_3}{t_1 + t_2 + t_3 + t_p}}$$

Equation 51.3

$$n_{av} = \frac{\frac{|n_2|}{2} \cdot t_1 + |n_2| \cdot t_2 + \frac{|n_2|}{2} \cdot t_3}{t_1 + t_2 + t_3 + t_p}$$

Equation 51.4

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



## Pre selection conditions

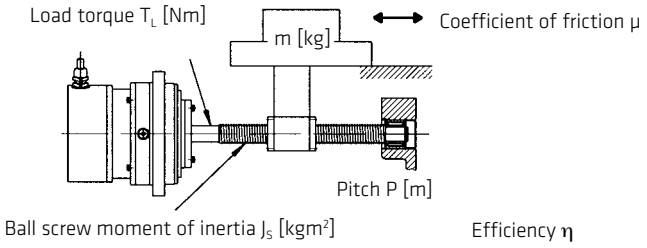
Table 52.1

| Load | Confirmation | Catalogue value | Unit |
|---|---|---|---|
| Load max. rotation speed ($n_2$) | ≤ $n_{max}$ | Max. output speed | [rpm] |
| Load moment of inertia ($J_L$) | ≤ $3J_{Out}$ [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 52.2



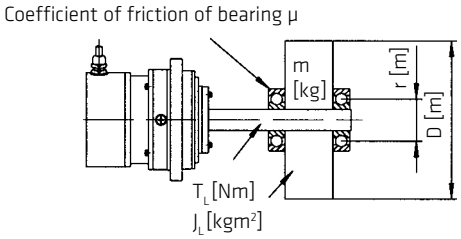

Equation 52.3

$$J_L = J_S + m \left(\frac{P}{2\pi}\right)^2 \text{ [kgm²]}$$

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

## Rotary motion

Illustration 52.4

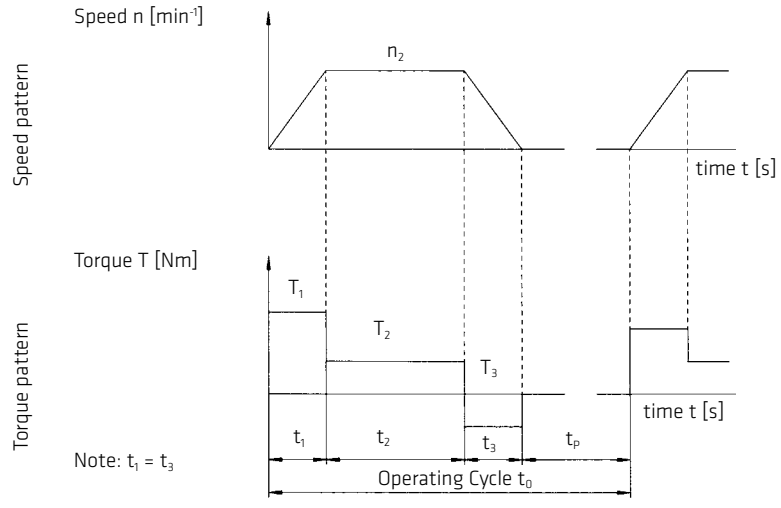



Equation 52.5

$$J_L = \frac{m}{8} \cdot D^2 \text{ [kgm²]}$$

$T_L = \mu \cdot m \cdot g \cdot r$ [Nm] g = 9.81 [m/s²]

Illustration 52.6



## Example of actuator selection

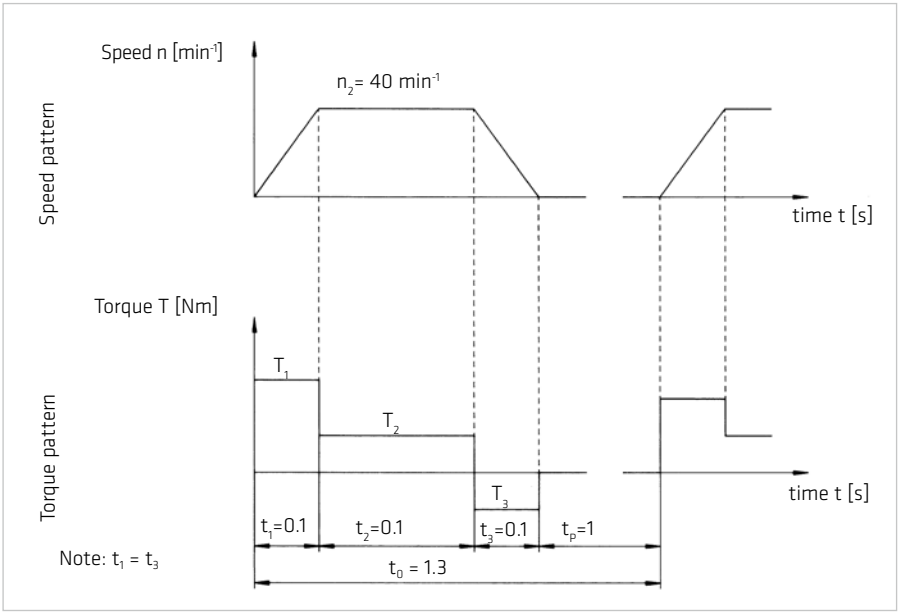
**Load Conditions**
Assume servo mechanism is used to cyclically position a mass with a horizontal axis of rotation.

Table 53.1

| | |
|---|---|
| Load rotation speed | $n_2$ = 40 [$min^{-1}$] |
| Load torque (e. g. friction) | $T_L$ = 5 [Nm] |
| Load inertia | $J_L$ = 1.3 [$kgm^2$] |
| **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 53.2




## Actuator data FHA-25C-50-L

Table 53.3

| | |
|---|---|
| Max. Torque | $T_{max}$ = 151 [Nm] |
| Max. output speed | $n_{max}$ = 90 [$min^{-1}$] |
| Moment of inertia | $J_{Out}$ = 0.86 [$kgm^2$] |

# Actuator selection

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

$n_2 = 40\ min^{-1} < n_{max} = 90\ min^{-1}$
$J_L = 1.3\ kgm^2 < 3J_{out} = 2.58\ kgm^2$

Calculate required acceleration torque ($T_1$)

$$T_1 = 5 + \frac{2\pi}{60} \cdot \frac{(1.3 + 0.86) \cdot 40}{0.1} = 95\ Nm$$

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

$T_1 = 95\ Nm < T_{max} = 151\ Nm$

No

Yes

Calculate effective torque ($T_{rms}$)

$T_1 = 95\ Nm$
$T_2 = T_L = 5\ Nm$
$T_3 = T_L - (T_1 - T_L) = -85\ Nm$

$$T_{rms} = \sqrt{\frac{95^2 \cdot 0.1 + 5^2 \cdot 0.1 + (-85)^2 \cdot 0.1}{1.3}} = 35\ Nm$$

Calculation of the average speed

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

$n_{av} = 6\ min^{-1}$

Calculation of the duty factor

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

$ED = 23\,\%$

$T_{rms} = 35\ Nm$
$n_{av} = 6\ min^{-1}$

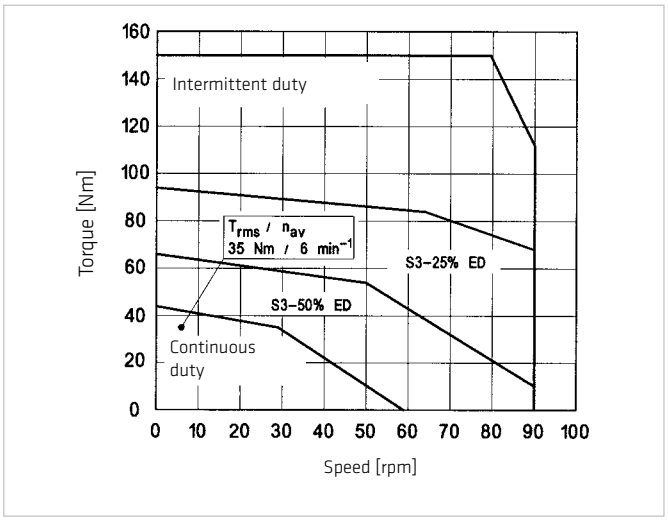
Check according to the performance characteristics

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

Confirm final selection

Illustration 54.1

FHA-25C-50L




$min^{-1} \triangleq rpm$

ED = 1 min.

ADVICE

**We will be pleased to make a gear calculation and selection on your behalf. Please contact our application engineers.**

## 4.2 Calculation of the Torsion Angle

Equation 55.1

$$T \leq T_1$$

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

Equation 55.2

$$T_1 < T \leq T_2$$

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

Equation 55.3

$$T > T_2$$

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

$\varphi$ = Angle [rad]
T = Torque [Nm]
K = Stiffness [Nm/rad]

**Example**

$T = 60$ Nm $\quad K_1 = 6.7 \cdot 10^4$ Nm/rad

$T_1 = 29$ Nm $\quad K_2 = 1.1 \cdot 10^5$ Nm/rad

$T_2 = 108$ Nm $\quad K_3 = 1.2 \cdot 10^5$ 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 55.4

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

# 4.3 Output Bearing

## 4.3.1 Lifetime calculation

### For oscillating motion

The operating life at oscillating motion can be calculated using equation 56.1.

Equation 56.1

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

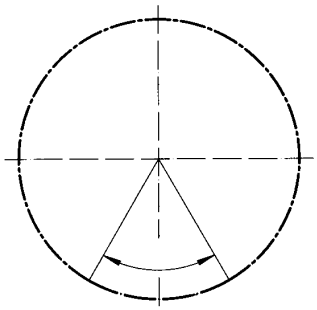
with:

| | | |
|---|---|---|
| $L_{OC}$ [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 |
| $\varphi$ [Degree] | = | Oscillating angle |
| $f_W$ | = | Operating factor (Table 57.3) |

* one oscillation means 2$\varphi$

Illustration 56.2

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 "Output Bearing Ratings" in the appropriate product chapter.

Table 56.3

| Bearing type | 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 56.3.

Equation 56.4

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

where:

| | | |
|---|---|---|
| $L_{10}$ [h] | = | Operating life |
| $n_{av}$ [$min^{-1}$] | = | Average output speed |
| C [N] | = | Dynamic load rating, see table "Output Bearing Ratings" |
| $P_C$ [N] | = | Dynamic equivalent load |
| $f_W$ | = | Operating factor |

**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 56.5

| 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 57.1

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

Equation 57.2

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

Equation 57.3

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

where:

| | | |
|---|---|---|
| $F_{rav}$ [N] | = | Radial force |
| $F_{aav}$ [N] | = | Axial force |
| $d_p$ [m] | = | Pitch circle |
| x | = | Radial load factor (Table 57.4) |
| y | = | Axial load factor (Table 57.4) |
| M | = | Tilting moment |

Table 57.4

| 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 57.5

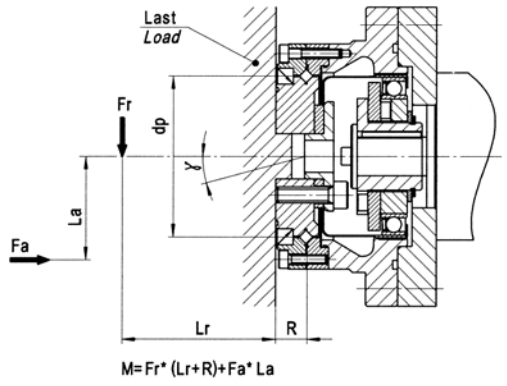
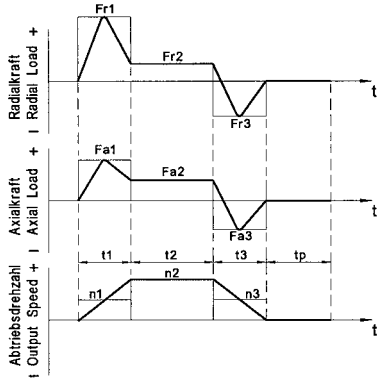



Illustration 57.6




**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 58.1:

Equation 58.1

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

with:

| | | |
|---|---|---|
| $\gamma$ [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.**

## 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 table 45.1.

Table 59.1

| | Symbol [Unit] | FHA-17C | FHA-25C | FHA-32C | FHA-40C |
|---|---|---|---|---|---|
| **Load assembly** | | | | | |
| Number of screws | | 6 | 8 | 16 | 8 |
| Screw size | | M5 | M6 | M6 | M10 |
| Screw quality | | 12.9 | 12.9 | 12.9 | 12.9 |
| Pitch circle diameter | [mm] | 60 | 74 | 95 | 112 |
| Screw tightening torque | [Nm] | 9.5 | 16.5 | 16.5 | 79 |
| **Housing assembly** | | | | | |
| Number of screws | | 6 | 8 | 12 | 8 |
| Screw size | | M5 | M6 | M6 | M10 |
| Screw quality | | 8.8 | 8.8 | 8.8 | 8.8 |
| Pitch circle diameter | [mm] | 118 | 142 | 162 | 208 |
| Screw tightening torque | [Nm] | 5.5 | 9.5 | 9.5 | 46 |

The data in the table are valid for completely cleaned and degreased surfaces (friction coefficient μ = 0.15).

## 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 nmax 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.

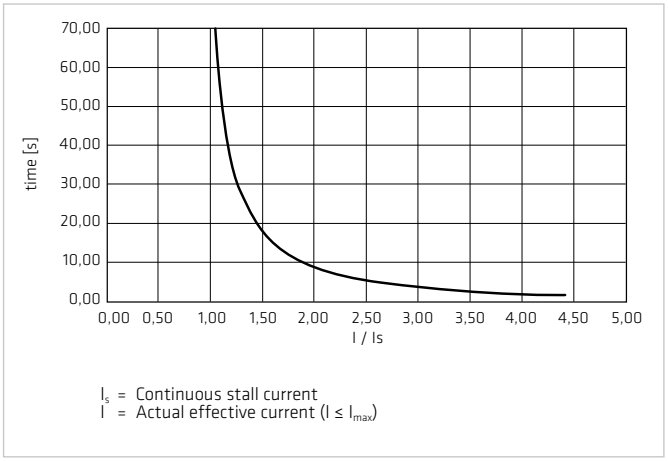
## 5.6 Overload Protection

Temperature sensors are integrated into the servo actuators and motors to protect them from.

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 only 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.

Illustration 61.1 Over load characteristic




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.

## 5.7 Protection against Corrosion and Penetration of Liquids and Debris

Table 62.1

| | FHA-C-L/H |
|---|---|
| Corrosion protection | IEC 68 2-11 |
| Salt spray test | Test time 4 h |

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.**

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

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 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 (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.

# 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.

# 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]

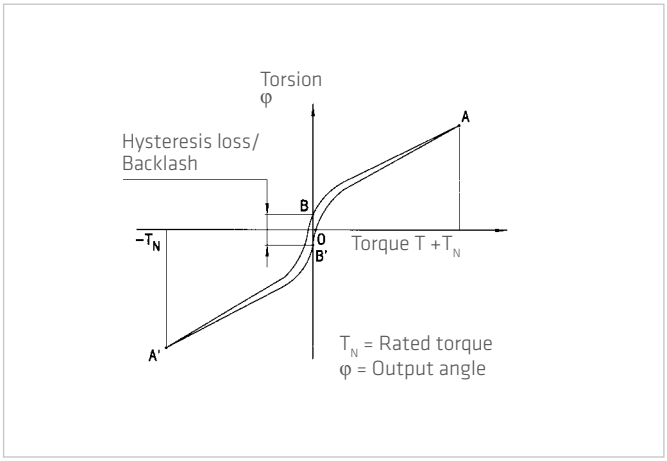
Maximum permissible average gear input speed for oil lubrication. The applications average input speed must be lower than the permitted average input speed of the gear.

### 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 $\tau_e$ [s]

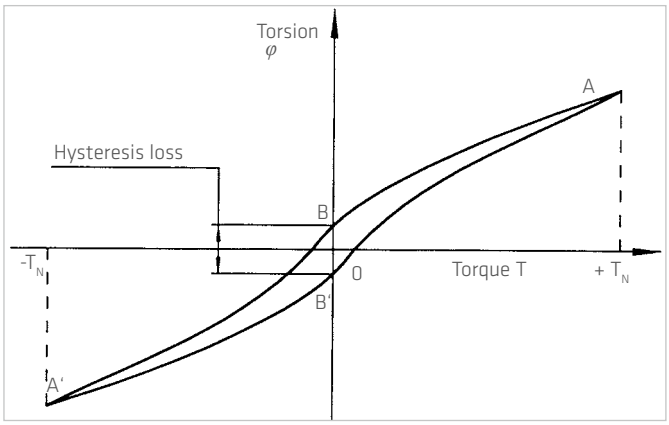
The electrical time constant is the time required for the current to reach 63 % of its final value.

## 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
$\varphi$ = Output rotation angle

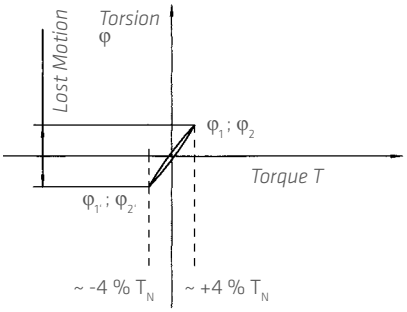
## Inductance (L-L) $L_{L-L}$ [mH]

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 $\tau_m$ [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 $U_N$ [$V_{rms}$]

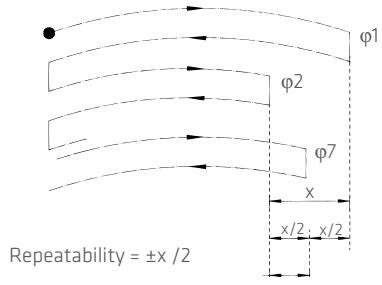
Supply voltage for operation with rated torque and rated speed.

## 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) $k_{Tout}$ [$Nm/A_{rms}$]

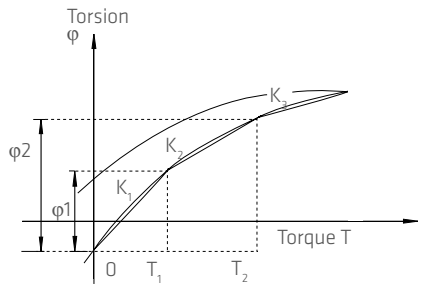
Quotient of stall torque and stall current, taking into account the transmission losses.

## 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 $> T_3$

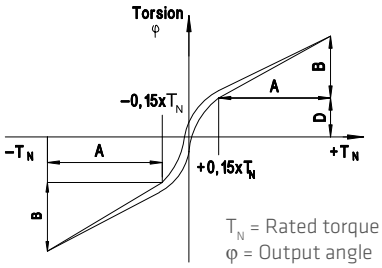
The values given for the torsional stiffness $K_1$, $K_2$ and $K_3$ are average values that have been determined during numerous tests. The limit torques $T_1$ and $T_2$ and an calculation example for the torsional angle can be found in chapter "torsional stiffness" and "calculation of the torsion angle"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

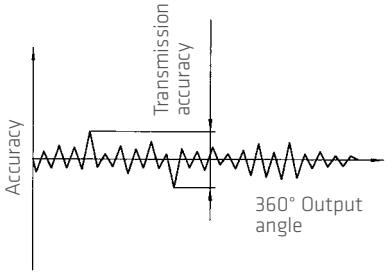
The amount of elastic rotation at the output for a given torque and blocked input shaft. The torsional rigidity of the Harmonic Planetary Gear describes the rotation of the gear above a reference torque of 15 % of the rated torque. In this area the torsional stiffness is almost linear.




$T_N$ = 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.

Deutschland
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

1018853 11/2019 V03