Introduction

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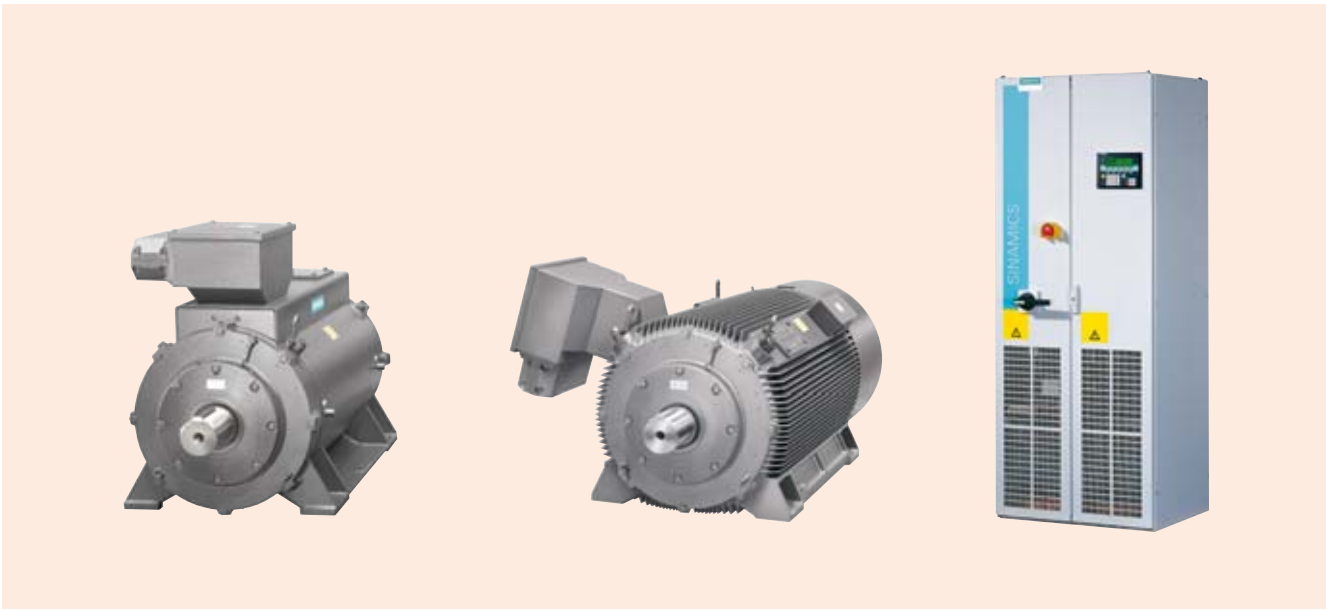
Overview

High-torque motors with SINAMICS frequency converters



HT-direct motors in combination with SINAMICS frequency converters form a variable-speed drive system for

- High torques
- Low speeds
- Low-maintenance operation

With

- Small space requirements
- High availability

With

- High efficiency
- Rugged design
- Low noise level

The HT-direct motors are a product range of extremely compact, low-voltage high-torque motors. In combination with a SINAMICS frequency converter, the HT-direct motor forms a perfectly matched drive system.

- Motor shaft heights of 400, 450 and 500 mm
- Motor torque range 5 – 40 kNm
- Motor rated voltage 400, 460 or 690 V
- Motor rated speed 200 to 800 rpm
- Type of construction of the motor IMB3
- Degree of protection of the motor IP55
- Motor cooling: Water-jacket cooled or forced ventilation
- Low-voltage converter with input voltages: 400 and 690 V/50 Hz, 460 V/60 Hz

SINAMICS frequency converters are designed for use in variable-speed drives in mechanical and plant engineering applications. They offer a low-cost drive solution which can be flexibly tailored from a wide spectrum of components and options to meet the requirements of individual customers.

HT-direct motors can be operated with converters of the SINAMICS S120/S150 and G130/G150 types. Closed-loop control software for permanent-magnet synchronous motors has also been developed.

SINAMICS S converters are used in the implementation of demanding drive-system tasks and satisfy stringent requirements on

- Dynamics and accuracy
- Integration of extensive technological functions in the drive control system.

SINAMICS G converters are designed for standard applications. These applications have less stringent requirements regarding the dynamics and accuracy of the motor speed.

For a detailed description of the SINAMICS product series, see the following catalogs:

Siemens converter series	Catalog short code	Catalog Order No.
SINAMICS G130 (chassis units)	D 11	E86060-K5511-A101-A3
SINAMICS G150 (cabinet units)		
SINAMICS S120 (chassis and booksize units)	D 21.1	E86060-K5521-A111-A2
SINAMICS S150 (cabinet units)	D 21.3	E86060-K5521-A131-A1
SINAMICS S120 (cabinet modules)	D 21.3 CM	–

Benefits

The benefits of the HT-direct motors:

- With slow-running drives, the efficiency of the HT-direct motors is approximately 2 to 3% higher than for similar drive concepts. For a 1000 kW motor, this results in a saving of 33 kW, which is an annual saving of approximately 15000 € for an operating time of 8 hours per day.
- The multi-pole drive design ensures that the space requirement and mass of the motors are lower than for similar induction machines. The slow-running motors of the HT-direct series obviate the need for a gearbox in many cases (reduction in engineering, assembly and maintenance outlay, lower investment and lower operating costs).
- Efficient, optimally matched drive system, SINAMICS converter and HT-direct motor for operation without encoders.
- Thanks to their long service life (nominal bearing lifetime > 60000 hours), HT-direct motors are maintenance-low and have a high availability especially for applications in which a gearbox can be omitted.
- Environmentally friendly system (where applicable, no disposal of gearbox oil is necessary; energy-saving drive system).

Application

Permanent-magnet synchronous motors are used in combination with converters as slow-running direct drives, e.g. for paper machines, in the steel and plastics industries and in shipbuilding.

Order No. code

High-torque motors with permanent-magnet technology

Position	1	2	3	4	5	6	7		8	9	10	11	12		13	14	15	16
	1	F	W	4	■	■	■	–	■	H	■	■	0	–	1	A	A	■	–	Z

Positions 1 to 3 (digit, character, character)	Type
Position 4 (digit)	Type series
Positions 5 to 7 (digits)	Frame size
Position 8 (digit)	Cooling method
Position 9 (character)	Number of poles
Position 10 (character)	Rated speed
Position 11 (digit)	Voltage
Position 12 (digit)	Type of construction
Position 13 (digit)	Rotor design
Position 14 (character)	(Not used at this time)
Position 15 (character)	Shaft version
Position 16 (digit)	Bearing design
Special versions	Please specify additional order code and any plain text

Ordering example

HT-direct motor, water-cooled

400 rpm; 40 kNm; 1676 kW; 690 V$\curlyvee$ →
Frame size 508

Temperature class 155 (F)
Used acc. to 155 (F)
IP55 degree of protection
IM B3 type of construction
Standard bearing design

Order No.	1 F W 4 5 0 8 – 1 ■ ■ ■ ■ – ■ A ■ ■
Number of poles	– H
Rated speed	– C
Voltage	– 7
Type of construction	– 0
Rotor design	– 1
(Spare position)	– A
Shaft version	– A
Bearing design	– 0
Specify when ordering:	1 F W 4 5 0 8 – 1 H C 7 0 – 1 A A 0

Protection strategy

Reverse power

Due to the permanent magnets in the rotor, magnetic flux is continuously present in the motor and for each revolution of the rotor, a voltage is generated at the motor terminals, even when the feeding converter is switched off and disconnected from the supply system.

Power from feeding converter

Also, when the rotor is at a standstill, voltage can still be present at the motor terminals if the feeding converter has not yet been switched off or the DC link circuit of the converter is not yet discharged.

Notes on safety, application and design

If work is to be performed on the drive system (converter and/or motor), the following safety measures must be implemented:

- The converter must be isolated from the supply system by a switch (isolating switch or circuit-breaker).
- Prevent any rotary motion of the motor.
- A separate protective device must be used for plants, in which the rotor can be accelerated by an active load, for example a circuit breaker must be used.
- The field weakening range is limited to 120%. In case of an active load (rotor can be accelerated by the plant) the DC link must be protected against overspeed/overvoltage.

Safety precautions when working on		**Maintenance or repair on the motor and/or the converter after commissioning of the drive system may only be carried out under the following preconditions.**
Motor terminal box	Important! Only permissible when the rotor is at a standstill!	Before opening the motor terminal box it must be ensured that • the rotor is at a standstill, • the converter is disconnected from the supply and • the DC link of the converter is discharged.
Converter	On rotor standstill.	Before opening the converter it must be ensured that • the converter is disconnected from the supply, • the DC link of the converter is discharged and • the rotor is at a standstill.
	With a rotating rotor that is coupled depending on the plant.	Before opening the converter it must be ensured that • the converter is disconnected from the supply, • the DC link of the converter is discharged and • that the (coupled) motor is electrically isolated from the converter by means of a suitable switch (for SINAMICS S120 Cabinet Modules a corresponding circuit-breaker on the output side can be ordered with the converter opion **L34**).

Converter-fed operation

Converters

SINAMICS S converters

The **SINAMICS S120 and S150 converters** allow regenerative feedback into the supply system. The motor can be operated, if required, with a rotor position encoder.

SINAMICS G converters

The **SINAMICS G130 and G150 converters** do not allow regenerative feedback into the supply system. These converters also do not support the use of a rotor position encoder. The motor can only be operated without encoder.

All converters must be operated at a pulse frequency of ≥ 2.5 kHz due to the eddy-current losses that arise in the magnets.

Encoderless speed control

Encoderless speed and torque control has been developed for the HT-direct motors.

The motors can be started up from a standstill without encoders. After a few revolutions, the converter can calculate the speed and position of the rotor from the voltage induced by the magnets in the motor winding. Motor operation down to standstill is possible. For highly dynamic torque control, an encoder is required at low speeds. For connection to a rotating machine (capture) in encoderless operation, a voltage measuring module is required. This module is offered as an option (K 51) for the converter and can be used instead of an encoder module.

Synchronized operation of multiple drives

The accuracy for speed or frequency for synchronized operation of several drives is 0.01% related to the maximum speed or frequency over a period of one second. A SINAMICS converter is required for each motor.

Approach

Start-up from standstill with full rated torque is possible for encoderless motors as well as for motors with speed encoders.

Creep operation

Water-jacket-cooled and forced-ventilated motors can be operated for 3 hours with 1/100 of the rated speed. At this operating point, the converter is only permitted to be operated at 50% of the rated current. A speed encoder is required for torque-controlled operation in this range.

In creep mode, if the torque is more than the applicable torque at 50% of rated current, a converter with a higher rating must be selected.

Operation in the field weakening range

The field weakening range for the HT-direct motors is limited to 20% of the rated speed. The magnets in the rotor do not allow conventional field weakening, so field weakening can only be achieved by the injection of a phase-displaced current by the converter. In the case of high field-weakening speeds, this would require an increase in converter frame size. The limited field-weakening range also ensures that the DC-link voltage of the converter does not exceed the maximum permissible value in case of pulse blocking due to the induced voltage of the motor.

Overload capability

The overload capability of the motor converter system is determined by the design of the converter and motor (see SINAMICS catalogs). The motor and converter can be temporarily overloaded by up to 50%. The basic load current of the converter that is available is reduced by overload requirements which may require selection of a larger converter. For higher overloads and more complex duty cycles, please submit an enquiry.

Cable lengths between the motor and converter

The maximum cable length for shielded motor connection cables is 300 m without any additional measures (see the section “Bearings and bearing currents”).

Duty type

The standard duty type is S1. For other duty types, please specify the duty cycle.

Use according to temperature class 130 (previously temperature class B) available on request.

General technical data

Bearings and bearing currents

When operating multiphase AC machines by a converter, an electrical bearing stress results from a capacitive induced voltage via the bearing lubricating film, depending on the principle being used. The physical cause of this is the common-mode voltage at the converter output: The sum of the three phase-to-neutral voltages is not zero at all times, unlike with direct on-line operation. The high-frequency, pulse-shaped common-mode voltage brings about a residual current, which closes back to the converter's DC link via the machine's internal capacitances, the machine housing and the earthing circuit. The machine's internal capacitances include the main insulation winding capacitance, the geometric capacitance between the rotor and stator, the lubricating film capacitance and the capacitance of any bearing insulation that may be present. The current level via the internal capacitances is proportional to the common-mode voltage regulation ($i(t) = C \cdot du/dt$).

In order to apply currents to the motor which are sinusoidal as far as possible (smooth running, oscillation torques, stray losses), a high pulse frequency is required for the converter's output voltage. The related (very steep) switching edges of the converter output voltage (and also, therefore, of the common-mode voltage) cause correspondingly high capacitive currents and voltages on the machine's internal capacitances.

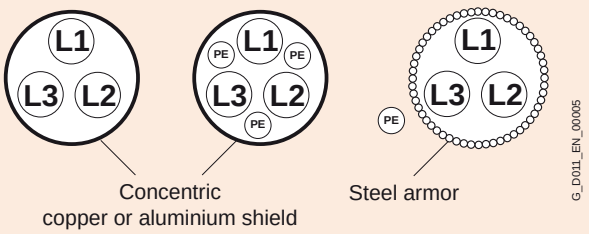
In the worst-case scenario, the capacitive voltage induced via the bearing can lead to random punctures of the bearing lubricating film, thus damaging the bearing/causing premature wear. The current pulses caused by the puncture in the lubricating film are referred to as EDM (Electrostatic Discharge Machining) currents, although this is not primarily a question of an electrostatic effect, but more of (partial) punctures of insulating material, i.e., of partial discharges.

This physical effect, which occurs in isolated cases, has mostly been observed in connection with larger motors.

EMC-compliant installation of the drive system is a basic prerequisite for preventing premature bearing damage via bearing currents.

The most important measures for reducing bearing currents:

- Use of cables with a symmetrical cable cross-section (see Figure below)

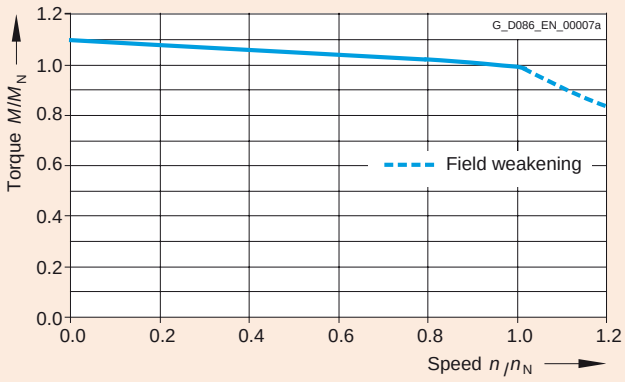


- Use of motor reactors (converter option L08)
- Preference given to a supply with insulated neutral point (IT system)
- Use of grounding cables with low impedance in a large frequency range (DC up to approximately 70 MHz): for example, plaited copper ribbon cables, HF litz wires
- Separate HF equipotential-bonding cable between motor housing and driven machine
- Separate HF equipotential-bonding cable between motor housing and converter PE busbar
- 360° HF contacting of the cable shield on the motor housing and the converter PE busbar. This can be achieved using EMC screwed glands on the motor end and EMC shield clips on the converter end, for example.
- Common-mode filters at the converter output
- The HT-direct motors are equipped with an electrically insulated bearing housing at NDE.

Thermal limit characteristic and field-weakening range

Due to the speed-independent cooling of the HT-direct motors, no torque reduction or only a relatively minor torque reduction (depending on their speed range) is required for operation at constant load torque and with wide speed ranges.

Guide values for the maximum load torques at various speeds can be obtained from the diagrams below:



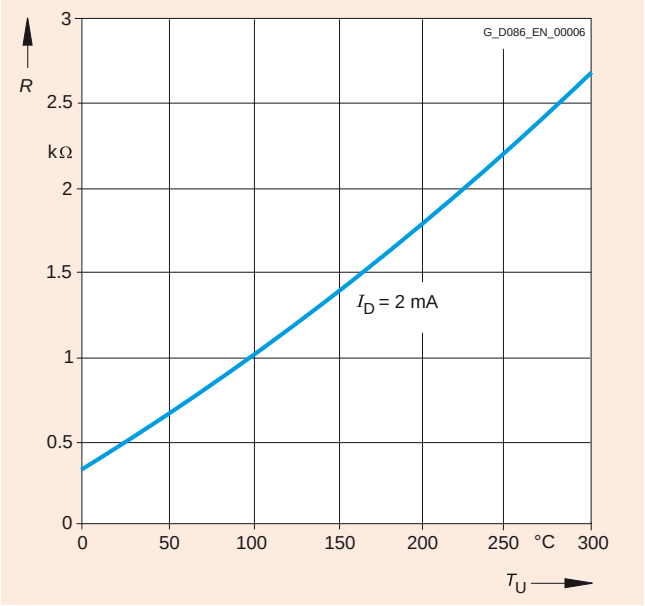
Motor protection

In addition to the current-dependent overload protection device located in the connecting leads, we recommend that you also monitor the temperature rise in the motor - and consequently the winding temperature - with the aid of the KTY 84-130 temperature sensors built into the stator winding as standard.

Winding temperature detection with KTY 84-130 temperature sensors (standard)

The KTY 84-130 sensor is a semiconductor sensor that changes its resistance depending on temperature in accordance with a defined, approximately linear characteristic. Two temperature sensors are built into the winding overhang as standard, whereby one sensor is used as a spare. The temperature is evaluated in the Siemens converter using the resistance of the temperature sensor. The required temperature for alarm and tripping can be set on the converter.

Two auxiliary terminals are provided for connection in the terminal box.



Optional winding temperature detection with PTC thermistors (thermistor motor protection)

Protection against thermal overloading of the motor is also provided by PTC thermistors installed in the winding overhang. When a limit temperature is reached (rated tripping temperature), the PTC thermistor undergoes a step change in resistance. This is evaluated by a tripping unit and can be used to open auxiliary circuits.

Two auxiliary terminals are provided in the terminal box for connecting three built-in temperature sensors for shutdown.

Optional winding temperature detection with PT100 resistance thermometers

PT100 resistance thermometers can also be installed in the winding overhang. An additional auxiliary terminal box is required for connection.

Changes in temperature are transferred to a display device in the form of changes in resistance. The indicator is not included in the scope of supply.

Bearing monitoring

Standard bearing vibration monitoring using SPM shock-pulse measurement

Measuring nipples for SPM shock-pulse measurement are screwed into the bearing housing at the drive end and non-drive end as standard.

Optional bearing temperature detection with PT100 resistance thermometers

As an option, bearing thermometers can be screwed into the bearing housings at the drive end and non-drive end. The wires are routed through an additional terminal box.

Changes in temperature are transferred to a display device in the form of changes in resistance. The indicator is not included in the scope of supply.