SIMODRIVE

AC Main Spindle Drives
with 1PH6 AC Motors and
SIMODRIVE 650 Transistor PWM Converters

Description

Edition February 1990

[illegible] Siemens 5800 Office System.

[illegible]

Contents

Catalogs

- SIEMENS SIMODRIVE DA 42.1 . 1990 — Servomotors
- SIEMENS SIMODRIVE DA 42.2 . 1990 — Compact 610 converter
- SIEMENS SIMODRIVE DA 42.3 . 1990 — Modular 611 converter
- SIEMENS SIMODRIVE DA 41.1 . 1990 — Main spindle drive

Technical Descriptions

- SIEMENS SIMODRIVE Accessories — Accessories
- SIEMENS SIMODRIVE SIMODRIVE 610 — SIMODRIVE 610
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Option Descriptions

- SIEMENS SIMODRIVE Ramp function — Ramp function generator
- SIEMENS SIMODRIVE Meas. system — Abs. value meas. system.
- SIEMENS SIMODRIVE 6RA29 — 6RA29 infeed/ regen.feedback unit

Operating instructions

0 Preliminary information

The following is a part of the SIMODRIVE documentation. The documents are available individually. The complete list of documentation for all brochures, catalogs, overviews, short descriptions, operating instructions and technical descriptions can be obtained from your local Siemens office with Order No., source and price.

Please note that the color coding of the connecting cables can change. Always check the signal leads before inserting plug connectors.

Important information throughout the text is highlighted in this form.

Reference to an ordering data supplement

1 AC main spindle drives

1.1 Application

The SIMODRIVE® AC main spindle drives for machine tools, described here, consist of a matched combination of 1PH6 AC squirrel-cage induction motors and SIMODRIVE 650 transistor PWM converters.

SIMODRIVE main spindle drives combine the advantages of induction motors - rugged and low-maintenance - with state-of-the-art microprocessor technology. Using the TRANSVEKTOR closed-loop control developed by Siemens, it has become possible to control asynchronous induction motors with a control quality comparable to that of DC drives. Digital technology allows extremely short startup times by presetting the main spindle drive, as well as a comprehensive measuring and diagnostics system. With these characteristics, SIMODRIVE AC main spindle drives fulfill all requirements demanded of a drive concept for machine tools in modern production facilities:

- *Fast startup*
- *High degree of operator friendliness and simple diagnostics*
- *High operational reliability*
- *Very low maintenance*
- *Simple reproducibility of set values, e.g. during servicing*
- *Large speed range at constant power*
- *Reduces number of mechanical gear stages*

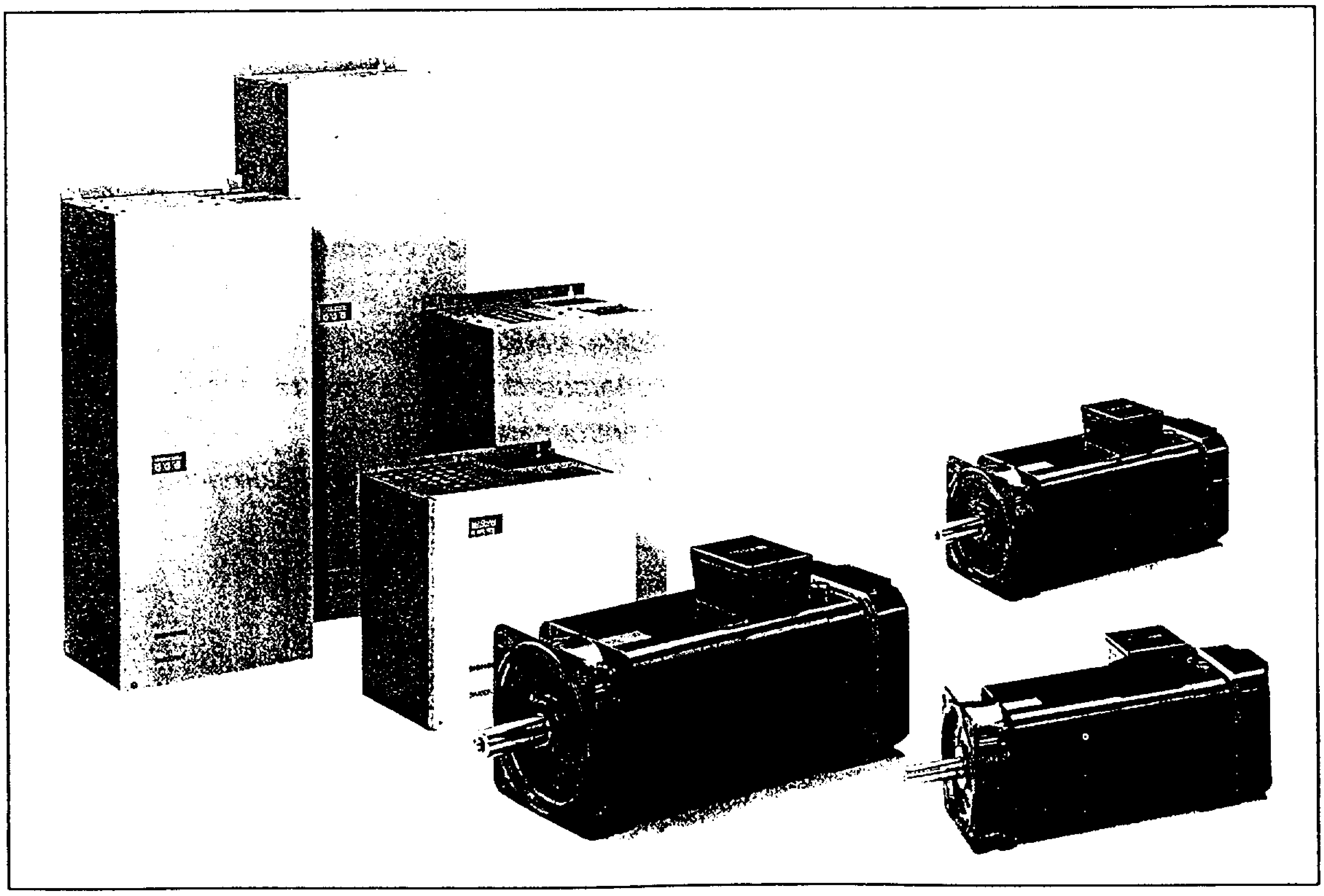


Fig. 1.1 1PH6 AC motors and SIMODRIVE 650 transistor PWM converter

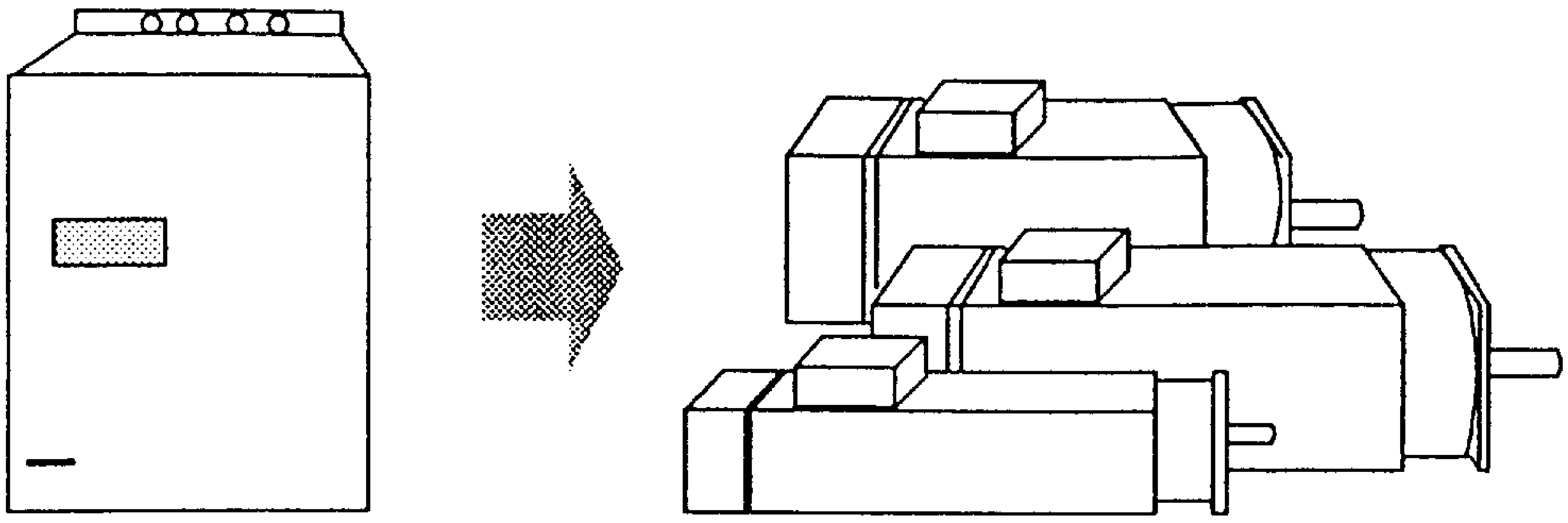
Important AC motor characteristics:

- *Rugged and low maintenance four-pole squirrel-cage induction motors*
- *Short torque rise time*
- *Short speed rise time*
- *Low moment of inertia*
- *Full motor torque, even continuously available at standstill*
- *Good smooth running characteristics even at the lowest speeds*
- *Shaft bearings suitable for machine tool applications*
- *No speed-dependent power limiting as a result of commutation*
- *Constant power range 1:4 to 1:16*
- *Speed control range > 1:1000, with "C axis" option >1:500 000*
- *Speeds down to 0 for C axis operation and positioning*
- *Short design length*
- *Short distance between bearings providing high vibrational stability*
- *High degree of protection : IP 54*
- *Externally cooled from the drive end to non-drive end*
- *Position and speed are brushlessly sensed*
- *Motor temperature monitoring*
- *Wide spectrum providing harmonized power steps*
- *Options:*
  - *Holding brake*
  - *Gearboxes*
  - *Space heaters*
- *IP 55 degree of protection*

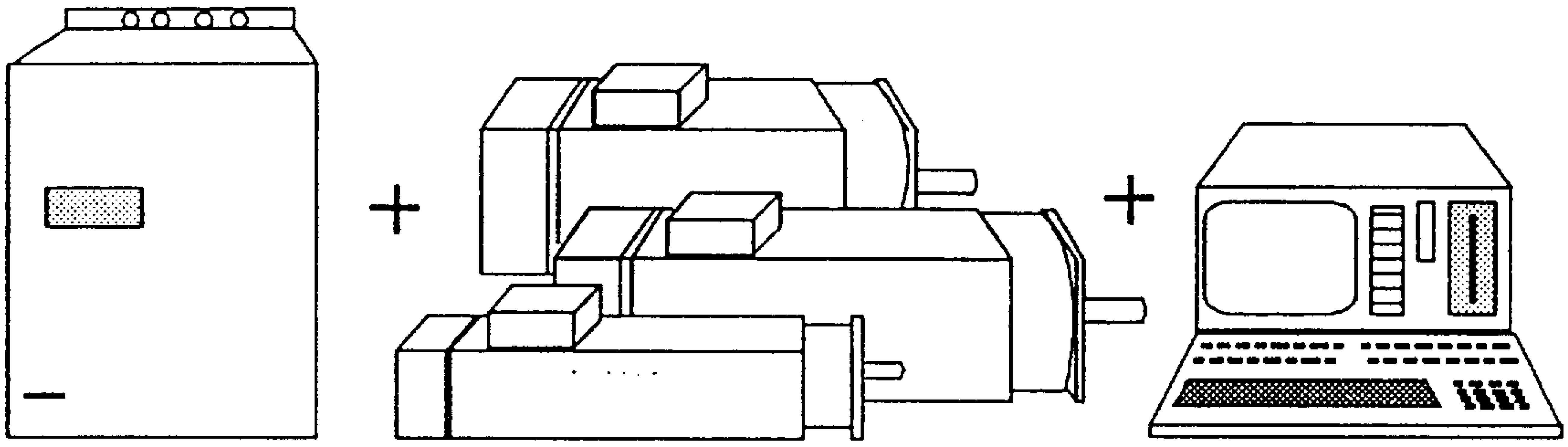
Important characteristics of transistor PWM converters:

- *Can be directly connected to the supply without transformer, commutating reactors, and in-rush current limiting*
- *Regenerative feedback into the line supply during braking*
- *Digital multiprocessor concept for speed and torque closed-loop control*
- *High long-time accuracy of the closed-loop control parameters*
- *Load and control characteristics similar to a DC motor as a result of field-orientated closed-loop control*
- *Simple and fast digital parameter input*
- *Operating and fault message display*
- *High degree of safety using monitoring circuits*
- *Microprocessor based diagnostics*
- *Options:*
  - *Spindle positioning*
  - *Main drive as C axis*

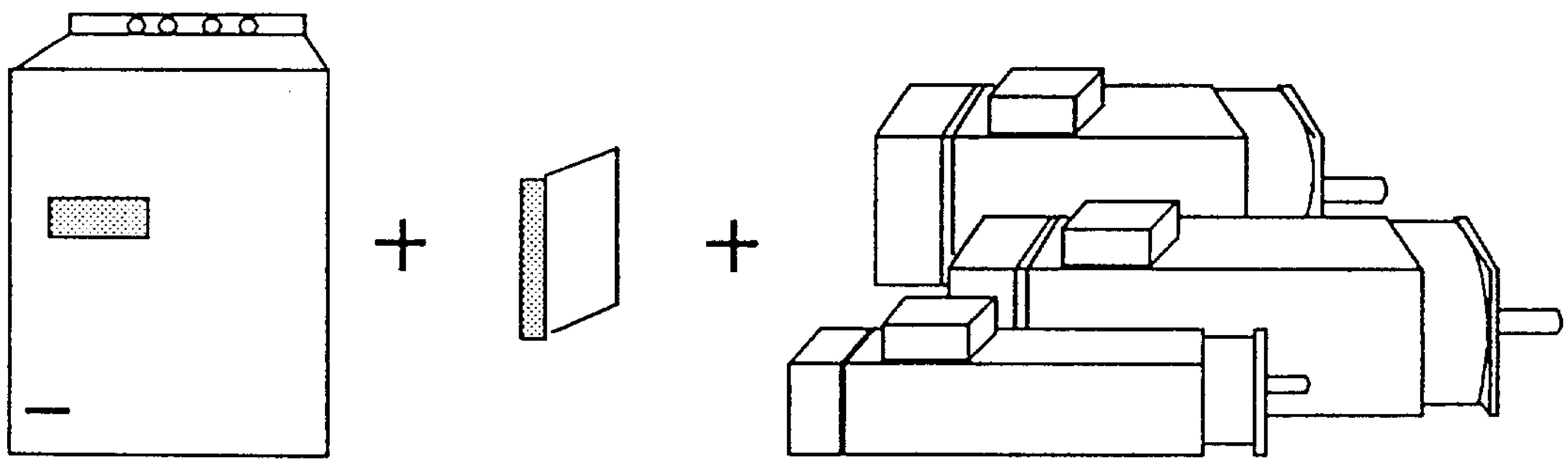
SIMODRIVE 650 PWM converter and 1 PH6 motors with ratings from 3 to 75 kW at speeds from 500 to 2000 RPM.



SIMODRIVE 650 PWM converter and 1 PH6 motors for startup and diagnostics with PG 675/ PG 685/ PG 635:



SIMODRIVE 650 PWM converter, A74 spindle positioning option (without NC) or A75 feed control for C-axis operation and spindle positioning option (without NC):



SIMODRIVE 650 PWM converter, A73 C-axis operation option and 1 PH6 motor with high-resolution tachometer (option H29):

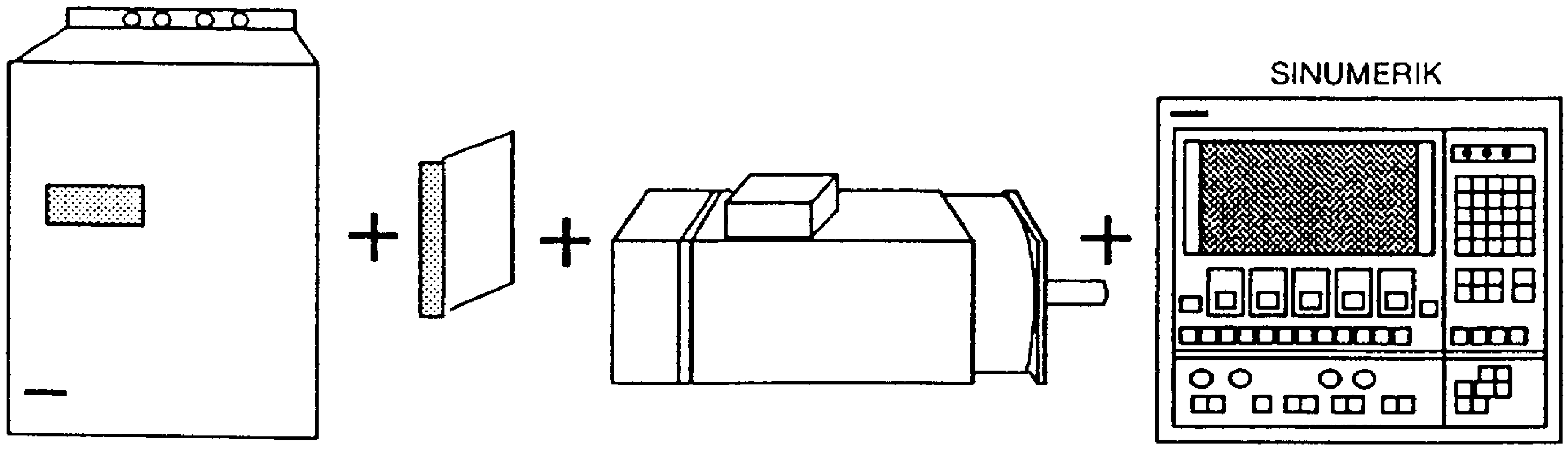


Fig 1.2 Applications of the SIMODRIVE 650 transistor PWM converter

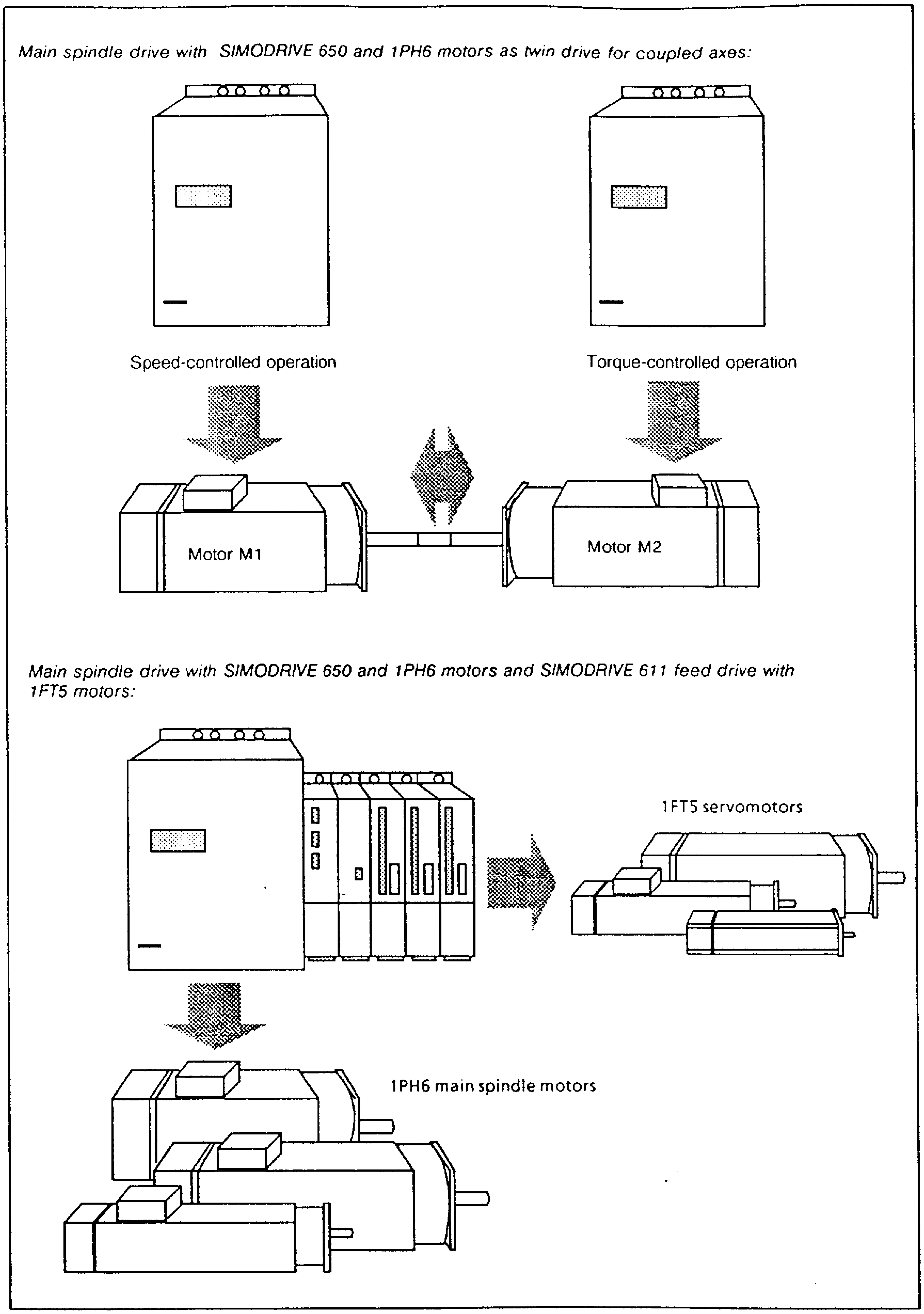


Fig. 1.2a Applications of the SIMODRIVE 650 transistor PWM converter

1.2 Mode of operation

With the SIMODRIVE AC main spindle drives, a new closed-loop control concept has been introduced into the machine tool sector, which is based on the principle of the field-orientated closed-loop control. Two microprocessors digitally represent the current and speed closed-loop circuits, and calculate the field. The open-loop and closed-loop control of the AC main spindle drive consists of a closed-loop speed controller with ramp-function generator and stored field weakening characteristic, as well as a secondary closed-loop torque control circuit and control system for the inverter and sequence control.

While AC drives used up until now always represented a non-linear controlled system, here, for the first time, there is a linear relationship, where the induction motor behaves similar to a DC motor and where the armature current (with constant excitation) is proportional to the torque.

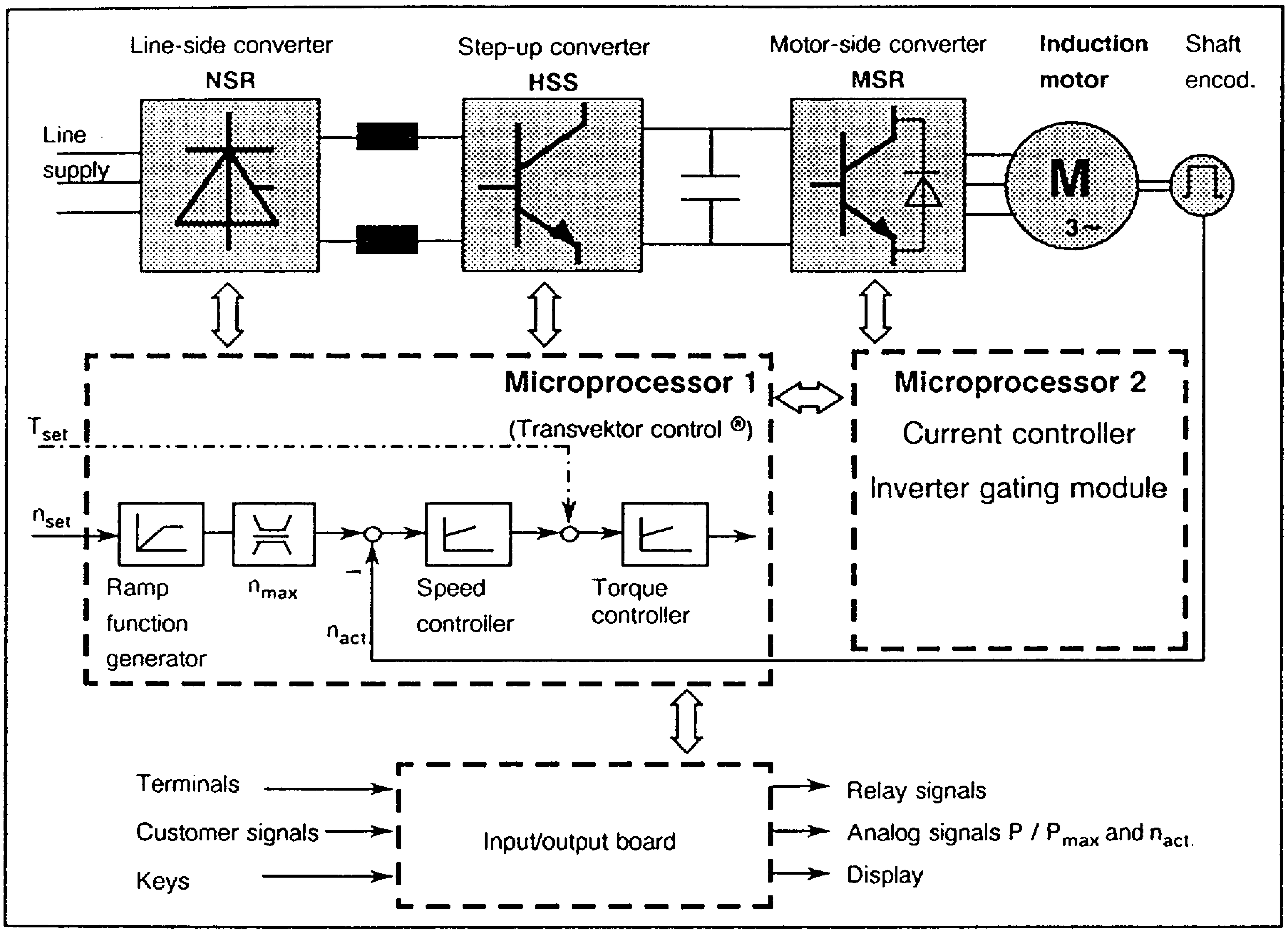


Fig. 1.3 Block diagram of the SIMODRIVE AC main spindle drive

It is possible to rapidly change the stator voltage and frequency of the AC motor using the transistor converter. Further, the magnetic flux and torque are decoupled.

The decoupling of these two motor variables is simulated in a microprocessor computer model. The reference variables for the motor supply, frequency, phase position and amplitude are generated using this computer model in order to provide each required torque and magnetic field, taking into account the torque and field limits. The resulting stator current vector is divided into a rotor flux and torque generating current components to the rotor flux. Field-orientated operation is provided if the current components generating the motor flux remain constant and the current components generating the torque are built up vertically to the rotor flux corresponding to the required torque.

This method of generating the current vector orientated to the flux vector position (field orientation) allows the torque and flux to be separately controlled and provides a closed-loop control quality similar to that for DC drives.

Two microprocessors are used in order to be able to execute arithmetic operations sufficiently fast for this closed-loop control concept. The current and speed controller circuits and the open-loop control are digital.

Digital technology provides a high degree of user friendliness and a high level of reproducibility of the setting variables. The parameters required for the closed-loop control are stored in a non-volatile EEPROM, which can also be used in other PWM converters.

1.3 Complete standard drives

The standard drives available are listed in Table 1.1. A suitable PWM converter is allocated to each AC motor depending on the required overload capacity. The available overload capacity refers to S6 or S3 operation with a duration of 10 minutes.

Contrary to DC technology, there is no linear relationship between current and torque of AC motors as a result of the magnetization current. Thus, the currents necessary for the required overload capacity of a specific AC motor are already taken into account for the required PWM converter in Table 1.1.

The PWM converter thermal time constant is significantly lower than that of AC motors. The converters are thermally dimensioned for continuous operation. Further, the 6SC6512 and 6SC6520 units have an overload capability. These characteristics are taken into account in the table below. The on-period in S6 or S3 operation should be taken from the motor data sheets.

AC motor	Motor rating [kW]	Rated speed [RPM]	Max. speed [RPM]	PWM converter for n x overload capacity 1.0	1.2	1.4	1.6
1PH6101-4CF4	3.7	1500	9000	6SC6502	6SC6502	6SC6502	6SC6502
1PH6101-4CG4	4.7	2000		6SC6502	6SC6502	6SC6502	6SC6503
1PH6103-4CF4	5.5	1500		6SC6502	6SC6502	6SC6503	6SC6503
1PH6103-4CG4	7.0	2000		6SC6502	6SC6503	6SC6503	6SC6503
1PH6105-4CF4	7.5	1500		6SC6503	6SC6503	6SC6503	6SC6504
1PH6105-4CG4	9.5	2000		6SC6503	6SC6503	6SC6504	6SC6504
1PH6107-4CC4	5.0	750		6SC6503	6SC6503	6SC6504	6SC6504
1PH6107-4CF4	9.0	1500		6SC6503	6SC6503	6SC6504	6SC6504
1PH6107-4CG4	11.5	2000		6SC6503	6SC6504	6SC6504	6SC6506
1PH6131-4CF4	9	1500	8000	6SC6503	6SC6504	6SC6504	6SC6504
1PH6131-4CG4	12	2000		6SC6504	6SC6504	6SC6504	6SC6506
1PH6133-4CB4	4.25	500		6SC6503	6SC6503	6SC6504	6SC6504
1PH6133-4CF0	11	1500		6SC6503	6SC6504	6SC6504	6SC6504
1PH6133-4CF4	11	1500		6SC6504	6SC6504	6SC6506	6SC6506
1PH6133-4CG4	14.5	2000		6SC6504	6SC6506	6SC6506	6SC6506
1PH6135-4CF0	15	1500		6SC6504	6SC6506	6SC6506	6SC6506
1PH6135-4CF4	15	1500		6SC6506	6SC6506	6SC6506	6SC6506
1PH6135-4CG4	20	2000		6SC6506	6SC6506	6SC6508	6SC6508
1PH6137-4CB4	7.5	500		6SC6506	6SC6506	6SC6506	6SC6508
1PH6137-4CF4	18.5	1500		6SC6506	6SC6506	6SC6508	6SC6508
1PH6137-4CG4	24	2000		6SC6506	6SC6508	6SC6508	6SC6508
1PH6138-4CF0	22	1500		6SC6506	6SC6506	6SC6508	6SC6508
1PH6138-4CF4	22	1500		6SC6508	6SC6508	6SC6508	6SC6512
1PH6138-4CG4	28	2000		6SC6508	6SC6508	6SC6512	6SC6512
1PH6161-4CF0	22	1500	6500 (8000)	6SC6506	6SC6508	6SC6508	6SC6508
1PH6161-4CF4	22	1500		6SC6508	6SC6508	6SC6508	6SC6512
1PH6161-4CG4	28	2000		6SC6508	6SC6508	6SC6512	6SC6512
1PH6163-4CB4	11.5	500		6SC6508	6SC6508	6SC6512	6SC6512
1PH6163-4CF0	30	1500		6SC6508	6SC6512	6SC6512	6SC6512
1PH6163-4CF4	30	1500		6SC6512	6SC6512	6SC6512	6SC6512
1PH6163-4CG4	38	2000		6SC6512	6SC6512	6SC6512	6SC6512
1PH6167-4CB4	14.5	500		6SC6508	6SC6512	6SC6512	6SC6512
1PH6167-4CF0	37	1500		6SC6508	6SC6512	6SC6512	6SC6512
1PH6167-4CF4	37	1500		6SC6512	6SC6512	6SC6512	6SC6512
1PH6167-4CG4	45	2000		6SC6512	6SC6512	6SC6512	6SC6512
1PH6186-4CE4	42	1250	5000 (7000)	6SC6508	6SC6512	6SC6512	6SC6512
1PH6186-4CF4	50	1500		6SC6512	6SC6512	6SC6512	6SC6512
1PH6206-4CE4	63	1250		6SC6512	6SC6512	6SC6520	6SC6520
1PH6206-4CF4	76	1500		6SC6520	6SC6520	6SC6520	6SC6520

Table 1.1 Standard drives available

2 AC motors

2.1 Applications

1PH6 AC motors are squirrel-cage induction motors, which have been especially developed for operation with SIMODRIVE 650 transistor PWM converters. Motor losses and noise have been significantly reduced, and the smooth running characteristics enhanced as a result of this matched system. Maximum speeds of up to 9000 RPM can be attained as a result of the compact mechanical design.

1PH6 AC motors are available with ratings from 3 kW to 75 kW at rated speeds between 500 and 2000 RPM.

The motor is available in two standard ranges with a constant power range between 1:5 and 1:6 at rated speeds of 1500 or 2000 RPM as well as a "wide range" series. This series covers a constant power range from 1:12 or 1:16 at rated speeds from 750 or 500 RPM and above. Thus, gear stages or complete gearboxes can be dispensed with and the drive train stiffness significantly increased.

2.2 Design

1PH6 AC motors have flanges and shafts which are compatible to 1G□5 DC motors having the same shaft height. The basic motor design consists of:

- *Active motor component*
- *NTC thermistor for motor temperature sensing*
- *Encoder system for sensing motor speed and rotor position*

Standard scope of supply of the 1PH6 range

AC squirrel-cage induction motor

- IM B3 type of construction (foot mounting)
- IP 54 degree of protection
- Insulating class F
- Vibrational severity R
- Terminal box with outlet to the right (without PG gland)
- 2 NTC thermistors in the stator winding
- Incorporated ROD 323 shaft encoder with 1024 pulses/revolution
- Anthracite grey paint finish with turquoise ring

The AC motors are forced-ventilated. The fans are mounted axially on the non-drive end. In order to discharge the dissipated motor heat away from the machine tool the air flows from the drive end to the non-drive end. For 1PH6 motors (shaft heights 100-160), the air is discharged radially towards the bottom, and the fan can be rotated through 4 x 90°. For motors with shaft heights 180 and 200, the radial air discharge can be either to the right or left.

Torque can be increased by using speed changing with a mounted gearbox.

1PH6 AC motors are equipped as standard with double bearings on the drive end to accept higher cantilever forces. The permissible cantilever loading can be taken from the diagrams in the Appendix.

If vibrational severity SR is required for 1PH6 motors (shaft heights 100-160), deep-groove ball bearings must be used on the drive end, which have a lower cantilever force loading capability. With vibration severity S, the motors are equipped with single bearings; double-bearing design is possible.

We recommend only single-bearing design for operation without cantilever loading (coupling, direct drive with gearbox).

1PH6 AC motors (shaft heights 180 + 200) are also available in IM B3 design with strengthened bearings for accepting increased cantilever forces. The maximum speed is reduced with this design.

A two-stage gearbox for extending the constant power range as well as a holding brake are available as option for mounting to the drive-side bearing end shield of the motors.

2.2.1 NTC thermistor

Two NTC thermistors are incorporated in the motor stator winding to sense motor temperature. The signals are evaluated in the PWM converter whose closed-loop controller takes into account the temperature characteristic of the motor resistors.

An external tripping unit is not required. The NTC thermistor function is monitored. A corresponding message is output on the PWM converter if a fault condition occurs.

With increasing motor temperature, a "motor overtemperature prewarning" relay signal is output. If this prewarning is not observed, the PWM converter shuts down when the motor limit temperature is exceeded, and issues a corresponding fault message.

The second NTC thermistor is a reserve sensor and can be selected by changing over the connections in the motor terminal box.

2.2.2 ROD 323 shaft encoder

A shaft encoder is mounted at the non-drive bearing end shield of the motor in order to sense speed and rotor position. The shaft encoder resolution is 1024 pulses per motor revolution as standard. The shaft encoder signals can be taken from the PWM converter for external applications. (e.g. transfer to a higher-level position control system).
When using the C-axis option (also refer to Section 3.4, Pages. 3-2), this shaft encoder is replaced by a double encoder system with an additional high-resolution track.

2.3 Mode of operation

The constant power range of 1PH6 AC motors is essentially from the rated speed n_N up to maximum speed n_{max} (5000 RPM, 6500 RPM, 7000 RPM, 8000 RPM or 9000 RPM) [1].
Constant torque T_n is available from standstill up to rated speed.

At higher speeds, i.e. in the constant power range, the maximum available torque T_{max} at a specific speed n is given, in a first approximation, by the formula:

$$T_{max}\,[\mathrm{Nm}] = 9{,}6\,\frac{P_{max}\,[\mathrm{W}]}{n\,[\mathrm{RPM}]}$$

AC motors have a large overload capacity in the constant torque and constant power ranges. With some AC motors, the overload capacity is reduced in the vicinity of the maximum speed. Specific information should be taken from the motor characteristics in Section 6.

The motor field remains constant in the basic speed range up to the motor rated speed. This is followed by a further constant power range, which is characterized by various gradients as a result of the field weakening.

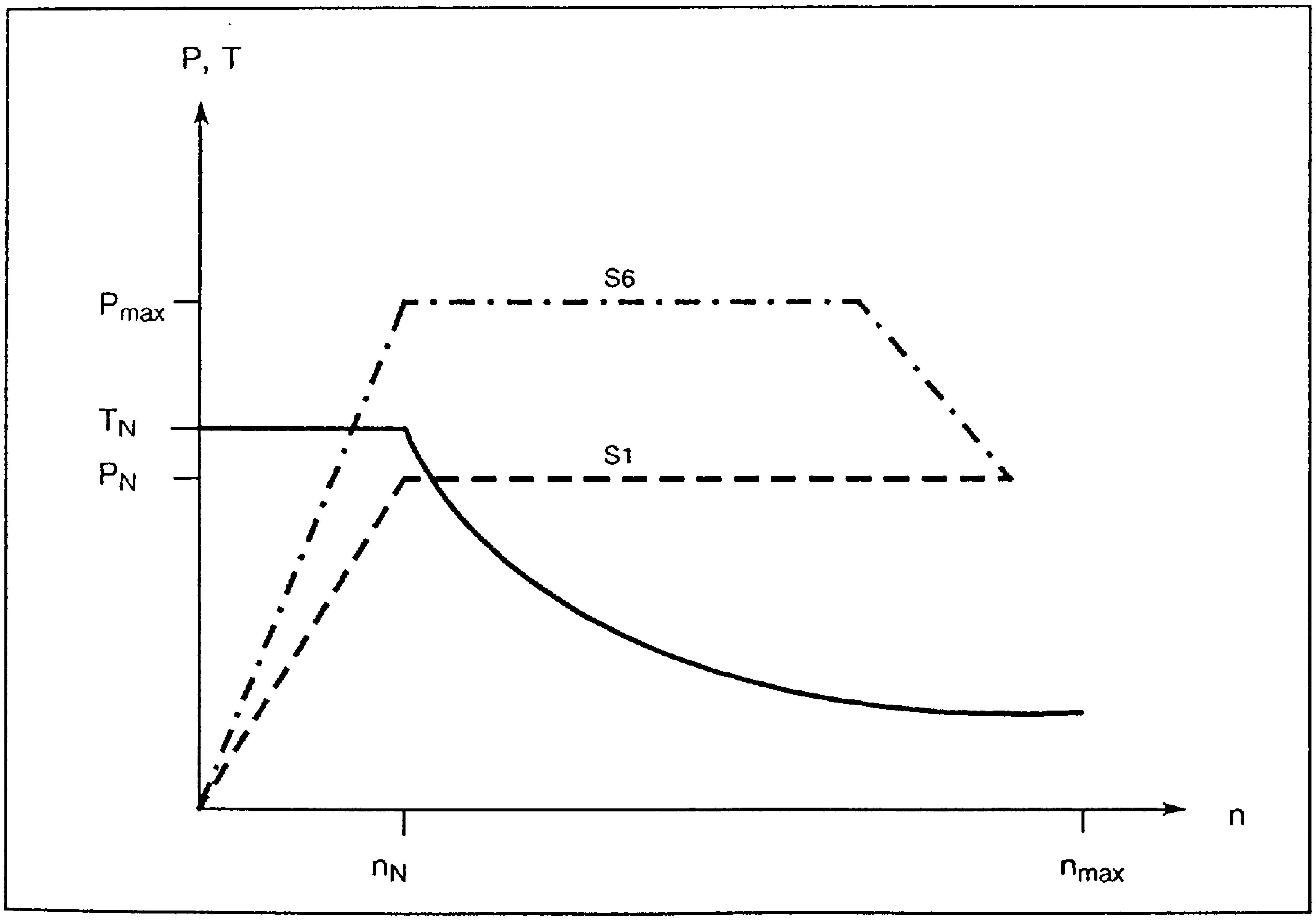


Fig. 2.1 Power P and torque T as a function of speed n

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1) Refer to the motor characteristics in the Appendix, Section 6, for deviations

2.4 Technical data

Motor voltage	Maximum: 3-ph, 430 V AC
Motor frequency	Maximum: 300 Hz
Motor noise (acc. to DIN 45635, 3dB tolerance)	up to/incl. shaft height 132: max. 70 dB(A) shaft height 160: max. 72 dB(A) shaft heights 180 and above: max. 75 dB(A)
Speed control range	>1 : 1000; with option A73 >1 : 500 000
Constant power range	≥ 1: 4 to 1:16
Insulation	Insulation class F acc. to DIN VDE 0530 for a winding temperature rise of ΔT = 105 K with a cooling medium temperature of + 40° C
Design	IM B3; IM B35; IM V15 or IM V36
Degree of protection	DIN 40050-IP54; Option: IP55
Ambient temperature	Maximum: + 40°C (otherwise derating necessary)
External fan	1PH610□: 3ph, 380VAC, 50/60 Hz 0.17 A; I_{max} = 0.39 A 1PH613□: 3ph, 380VAC, 50/60 Hz 0.26 A; I_{max} = 0.34 A 1PH616□: 3ph, 380VAC, 50/60 Hz 0.7 A; I_{max} = 0.8 A 1PH618□: 3ph, 380VAC, 50/60 Hz 0.7 A; I_{max} = 0.8 A 1PH620□: 3ph, 380VAC, 50/60 Hz 0.7 A; I_{max} = 0.8 A
Air flow direction	From the drive end to the non-drive end (standard) Available from the non-drive end to drive end as option. For 1PH6 (shaft heights 100-160) by using a 2CW6 fan unit from the 1GL5 series (motor is longer, dimension sheet on request). For 1PH6 (shaft heights 180 + 200) on request
Space heaters	Option
Terminal boxes	For 1PH6 (shaft heights 100-160), can be rotated through 4 x 90°, top mounting (either left or right). For 1PH6 (shaft heights 180-200) can be rotated (refer to the dimension sheets in the Appendix)
Flange design	Acc. to DIN 42955, tolerance M (option: tolerance R) (motors, frame size 100, can also be supplied with flange dimension b_1 = 230 mm and 38 mm shaft diameter).
Vibrational severity	R (option: S, SR) refer to the diagrams in the Appendix
Permissible cantilever forces	At the shaft, refer to the diagrams in the Appendix
Mounting possibility	2LG4 ZF gearbox Fail-safe holding brake on the drive-end bearing end shield

Table 2.1 Technical data of 1PH6 AC motors

Rating P_N [kW]	Rated speed n_N [RPM]	AC motor Order No.	Rated torque T_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
100 mm shaft height								
3.7 4.7	1500 2000	**1PH6 101-4CF4** **-4CG4**	24 22	13 13.9	20	9000	0.011	42
5.5 7.0	1500 2000	**1PH6 103-4CF4** **-4CG4**	35 33	18 20	20	9000	0.017	52
7.5 9.5	1500 2000	**1PH6 105-4CF4** **-4CG4**	48 45	23 26	20	9000	0.024	67
5.0 9.0 11.5	750 1500 2000	**1PH6 107-4CC4** **-4CF4** **-4CG4**	64 57 55	22.8 27.4 30	20	9000	0.031	80
132 mm shaft height								
9.0 12.0	1500 2000	**1PH6 131-4CF4** **-4CG4**	57 57	28 33	30	8000	0.038	78
4.25 11.0 11.0 14.5	500 1500 1500 2000	**1PH6 133-4CB4** **-4CF0** **-4CF4** **-4CG4**	81 70 70 69	26 28 32 39	30	8000	0.046	90
15.0 15.0 20.0	1500 1500 2000	**1PH6 135-4CF0** **-4CF4** **-4CG4**	95 95 95	36 43 52	30	8000	0.071	112
7.5 18.5 24.0	500 1500 2000	**1PH6 137-4CB4** **-4CF4** **-4CG4**	143 118 115	44 52 59	30	8000	0.085	130
22.0 22.0 28.0	1500 1500 2000	**1PH6 138-4CF0** **-4CF4** **-4CG4**	140 140 134	52 63 68	30	8000	0.104	150

Table 2.1 Technical data of 1PH6 AC motors

[illegible]	Rated speed n_N [RPM]	AC motor Order No.	Rated torque T_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm^2]	Weight m [kg]
[illegible] mm shaft height								
[illegible]	1500	**1PH6 161-4CF0**	140	55	35	6500 (8000)*)	0.131	140
[illegible]	1500	**-4CF4**	140	63				
[illegible]	2000	**-4CG4**	134	70				
[illegible]	500	**1PH6 163-4CB4**	220	67	35	6500 (8000)*)	0.17	175
[illegible]	1500	**-4CF0**	191	75				
[illegible]	1500	**-4CF4**	191	88				
[illegible]	2000	**-4CG4**	181	90				
[illegible]	500	**1PH6 167-4CB4**	277	80	35	6500 (8000)*)	0.206	210
[illegible]	1500	**-4CF0**	236	82				
[illegible]	1500	**-4CF4**	236	98				
[illegible]	2000	**-4CG4**	215	93				
[illegible] mm shaft height								
[illegible]	1250	**1PH6 186-4CE4**	320	84	40	5000 (7000)*)	0.310	350
[illegible]	1500	**-4CF4**	318	100				
[illegible] mm shaft height								
[illegible]	1250	**1PH6206-4CE4**	481	122	40	5000 (7000)*)	0.610	470
[illegible]	1500	**-4CF4**	484	154				

[illegible] Technical data of 1PH6 AC motors, continued

[illegible]

2.5 Type designation

The type designation (which is also the Order No.) consists of a combination of digits and letters. It is subdivided into 3 blocks which are connected by two hyphens.

The first block comprises 7 positions and identifies the motor type. The second block contains codes for additional design features. The third block is provided for additional information.

Configuration of the AC motor Order No. :

1 P H 6 1 3 1 – 4 C F 4 6 – Z

- 1PH6 – AC induction motor for main spindle drives
- 131 – Size
- 4 – No. of poles
- C – Free
- F – Rated speed
  - B = 500 RPM
  - C = 750 RPM
  - E = 1250 RPM
  - F = 1500 RPM
  - G = 2000 RPM
- 4 – Overload capacity
- 6 – Type of construction
  - 0 = IM B3
  - 6 = IM B35
  - 9 = IM V15, IM V36
- Z – Additional information specify with code or plain text (refer to Catalog DA 41.1)

Additional information for standard design and options

Plain text information	Code
IP 54 degree of protection and additional protection against penetration of electrically conductive dust	L35
IP 55 degree of protection (cannot be combined with K64) 1)	K49
Terminal box location (when viewing drive end)	
on the righthand side	K09
on the lefthand side	K10
top, shifted to the right 2)	K29
Bearing design at the drive end	
for gearbox mounting (locating bearing and radial shaft seal) 1)	K18
for increased radial forces (strengthened roller bearing) 2)	K20
for increased maximum speeds	
for reduced cantilever forces (spindle bearing) 3)	L37
Shaft drive end, special cylindrical shaft end	Y55 4)
Diameter greater than standard	Y56 4)
Vibrational severity	
Grade S (for double-bearing design) 1) 12)	K05
Grade S (for single-bearing design) 5) 12)	K02
Grade SR (for single-bearing design with option K18) 1) 12)	K03
Concentricity, tolerance R (reduced acc. to DIN 42-955R) 6)	K04
Cooling (airflow from the non-drive end to drive end)	K64
Installation altitude > 1000 m / cooling medium temperature > + 40°C	Y50 7)
Paint finish	
None, however with primer	K24
Special paint finish for the tropics, RAL 7030	K26
Standard paint finish in colors other than RAL 7030	Y53 8)
Special paint finish for tropics in colors other than RAL 7030	Y54 9)
Rating plate in a foreign language	Y80 11)
High-resolution shaft encoder for C-axis operation	H29
ZF gearbox mounting (i = 1:4) on motors, IM B35 type of contruction	
Gearbox with small output housing 1)	H34
Gearbox with large output housing 10)	H31
ZF gearbox mounting (i = 1:4) on motors, IM V15 type of construction	
Gearbox with small output housing 1)	H38
Gearbox with large output housing 10)	H36
Motor prepared for mounting a ZF gearbox (also includes the radial shaft seal)	G97

Plain text information	Code
Motor prepared for mounting a holding brake	G95
Holding brake mounted 1)	G46
Space heater, 220 V AC supply Space heater, 110 V AC supply	K45 K46
Design "B" drive shaft end (without key)	K42
Special paint finish (for the tropics)	L53

1) only for 1PH6 main spindle motors (shaft heights 100, 130 and 160), for single-bearing design
2) only for 1PH6 main spindle motors (shaft heights 180 and 200)
3) only for 1PH6 main spindle motors (shaft heights 160, 180 and 200)
4) additionally specify in plain text: non-standard cylindrical shaft end with diameter (mm) and length (mm)
5) only for 1PH6 main spindle motors (shaft heights 100, 130 and 160) with option K18
6) only shaft reworking
7) specify in plain text: Installation altitude (m above sea level) and/or cooling medium temperature (°C)
8) specify in plain text: Standard paint finish in RAL ...
9) specify in plain text: Special paint finish in RAL ...
10) only for 1PH6 main spindle motors (shaft heights 130 and 160)
11) specify in plain text: Language required
12) options K02, K03, K05 automatically include option K04

3 Transistor PWM converter

3.1 Application

SIMODRIVE 650 transistor PWM converters have been developed to supply 1PH6 AC main spindle motors with a controlled 600 V DC link voltage and fully regenerative braking. They control the drive power and speed in 4-quadrant operation. Seven converters are available with ratings between 15 and 150 kVA.

The transistor PWM converters are mounted in an enclosure, together with the incoming fuses, and can be connected directly to a 3-phase 380 V AC 50/60 Hz supply. Transformers, commutating reactors, and inrush limiters are not required. Monitoring electronics ensure short-circuit-, overload-, and ground fault protection for the converter. The TRANSVEKTOR closed-loop control concept guarantees high control performance such as is required for C-axis operation.

All 1PH6 motor data, required for the field calculation, is deposited in a memory in the converter. During startup, the microprocessor automatically provides the complete motor data. Customer-specific closed-loop control parameters can be entered or changed on a display and operator control unit. During operation, operational statuses and faults are indicated on the 6-digit display of the display and operator control unit.

All parameters and fault messages can be displayed in plain text on the programming unit screen with the "interface for connecting PG 685 / 675 programming units" option. A data set can be stored on floppy disk, and can be used for other standard machines.

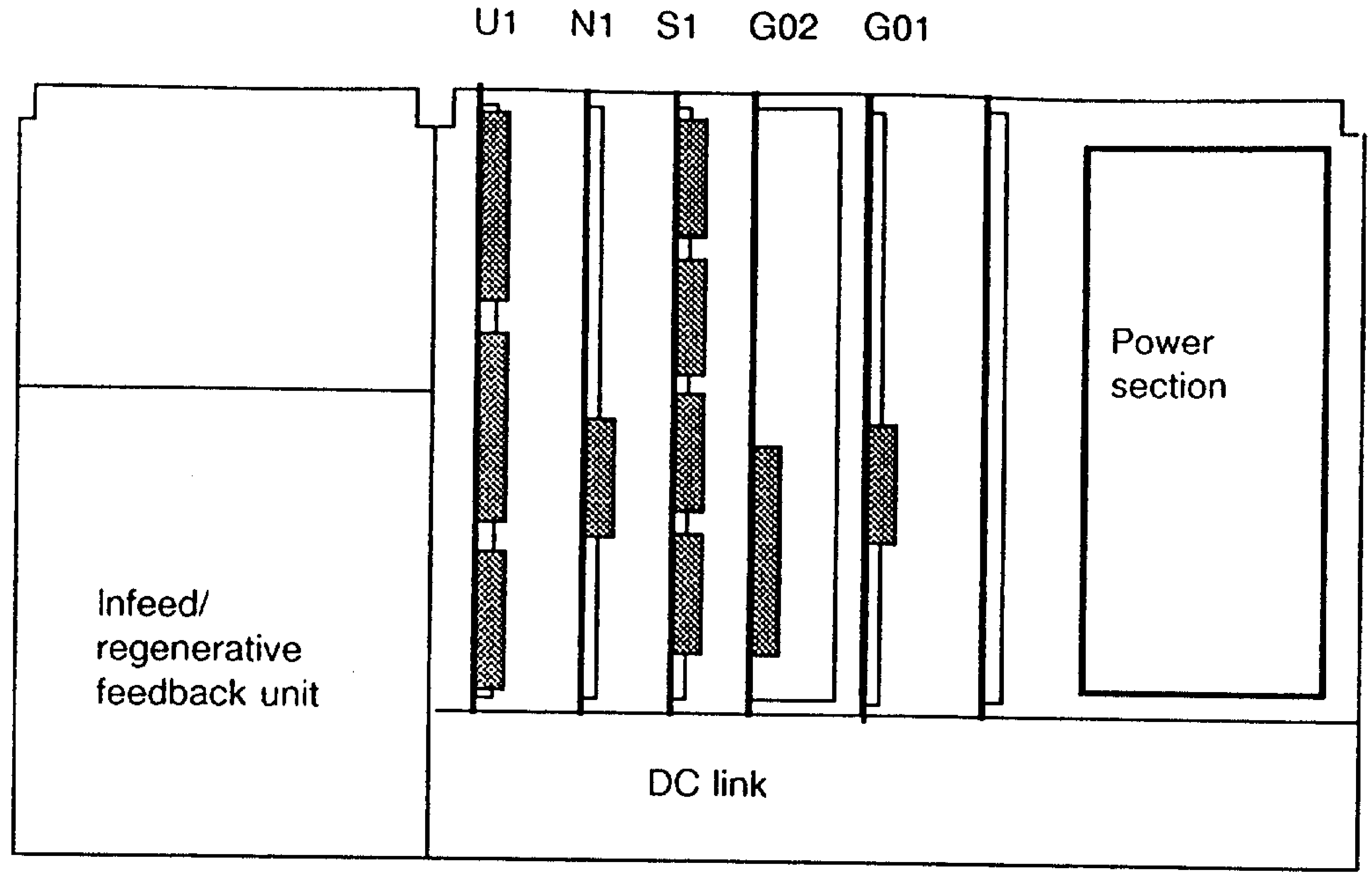
3.2 Design

The power section consists of:

- *a line-side converter with regenerative feedback into the supply*
- *a DC voltage link, and*
- *a transistor PWM converter which generates a variable-voltage and variable-frequency AC system*

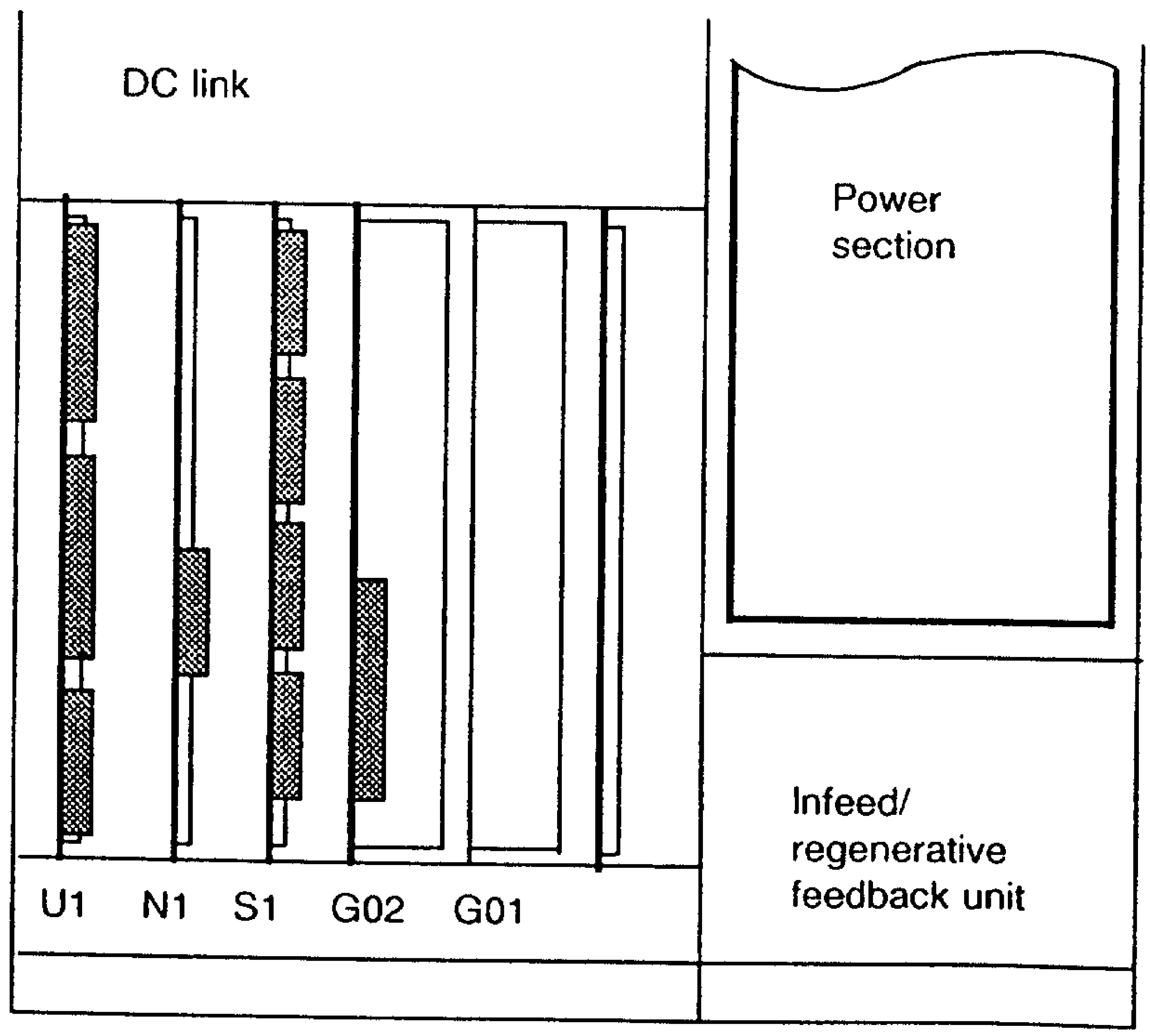
The electronics is supplied from the DC link, thus providing ride-through capability during brief supply voltage failures.

The necessary line-side fuses are incorporated in the pulse converter. Fuses are not blown on supply voltage failure when the unit is in the regenerative mode.



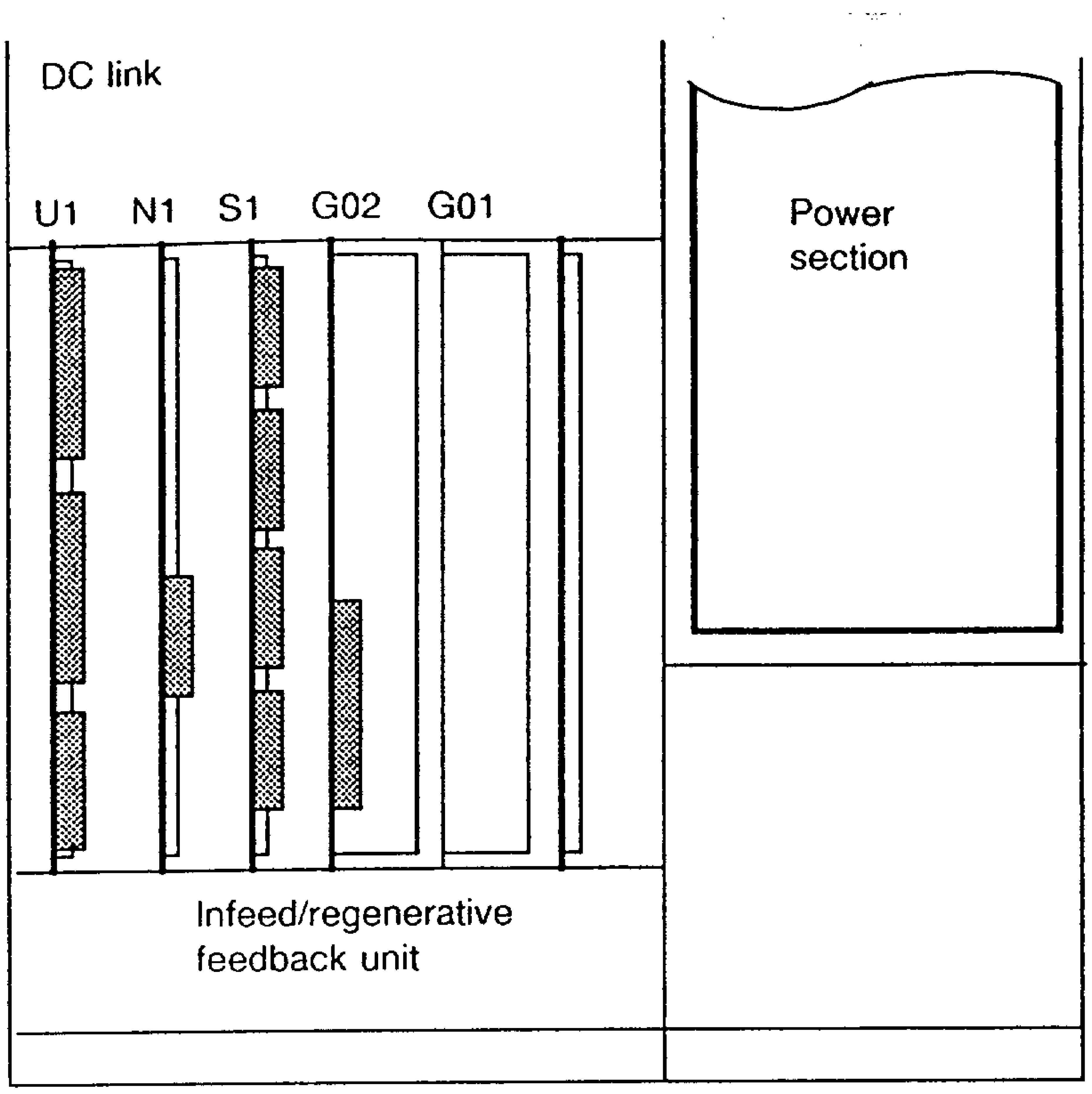
U1 = Input/output board
N1 = Closed-loop control board
S1 = "Spindle positioning" and "C-axis" option
G02 = Central board
G01 = Power supply

Fig. 3.1 Design of the 6SC6502 and 6SC6503 transistor PWM converters



U1 = Input/output board
N1 = Closed-loop control board
S1 = "Spindle positioning" and "C-axis" option
G02 = Central board
G01 = Power supply

Fig. 3.2 Design of the 6SC6504, 6SC6506 and 6SC6508 transistor PWM converters



U1 = Input/output board
N1 = Closed-loop control board
S1 = "Spindle positioning" and "C-axis" option
G02 = Central board
G01 = Power supply

Fig. 3.3 Design of the 6SC6512 and 6SC6520 transistor PWM converters

3.3 Mode of operation

3.3.1 Power section

The DC link is supplied from a 6-pulse thyristor bridge circuit which operates in both the rectifier and inverter modes. In the rectifier mode, the thyristors behave like diodes. The gating control uses gating transformers. The closed-loop controller realizes the actual pulse generation and the input/output board and gating board, further processing and amplification.

In order to permit regenerative operation with 6 thyristors, the DC link is reversed through the step-up converter, and the thyristors are controlled through the closed-loop control board per software, so that they operate in the inverter mode.

The motor-side converter consists of 6 transistors with integrated anti-parallel free-wheeling diodes. A pulse width modulated voltage of 0 to 430 volts is generated by controlling the transistors.

3.3.2 Closed-loop control

The N1 central closed-loop control board is used for the complete converter open-loop control, i.e. it generates the gating pulses for the line-side converter, calculates the control variables for the TRANSVEKTOR closed-loop control and provides the inverter modulation. All input signals are conditioned as frequencies, and all output signals as logic signals. The necessary software is stored in five EPROMs. The settings can be transferred unchanged if a PC board has to be replaced.

The gating and closed-loop control electronics has two microprocessors, which represent the digital current and speed control loops, and calculate the field. The closed-loop control structure is a speed control loop with ramp-function generator and secondary torque control loop. It is possible to directly input the torque setpoint, bypassing the speed controller.

The "orientated spindle stop" with higher-level closed-loop position control in a numerical control (NC function M19) can attain an accuracy of $\pm$ 0.5° as a result of the extremely accurate closed-loop control concept. Shaft encoders, mounted as standard in the motors, can be used. The position can be maintained, controlled, i.e. load torques are possible but still maintaining the required position.

Operational and fault messages are indicated on the 6-digit display.

3.4 Options

The "C-axis" and "spindle positioning" functions are either individually or collectively located on a board. Slots S1 in the converter is prepared for all boards.

- C-axis board with sinusoidal-cosinusoidal encoder — **Option A73**
  - 6SC6500-0BB01
  - 6SC6500-0BB81 (with connecting accessories)

- Spindle positioning board — **Option A74**
  - 6SC6500-0BC01
  - 6SC6500-0BC81 (with connecting accessories)

- C axis and spindle positioning board — **Option A75**
  - 6SC6500-0BA01
  - 6SC6500-0BA81 (with connecting accessories)

- Interface for connecting a PG635/675/685 programming unit — **(Retrofit set)**
  - 6SC6500-0SB81

The boards can be used to upgrade all SIMODRIVE 650 PWM converters delivered after 1.87. The boards require software version 03.88 and higher.

3.4.1 "Spindle positioning" board

"Spindle positioning" is the fastest possible spindle approach to a specific position (e.g. for tool changing) **without** higher-level closed-loop position control in a numerical control.

The spindle can be run into a specified position, without overshoot, using an external command, using the "spindle positioning" board.

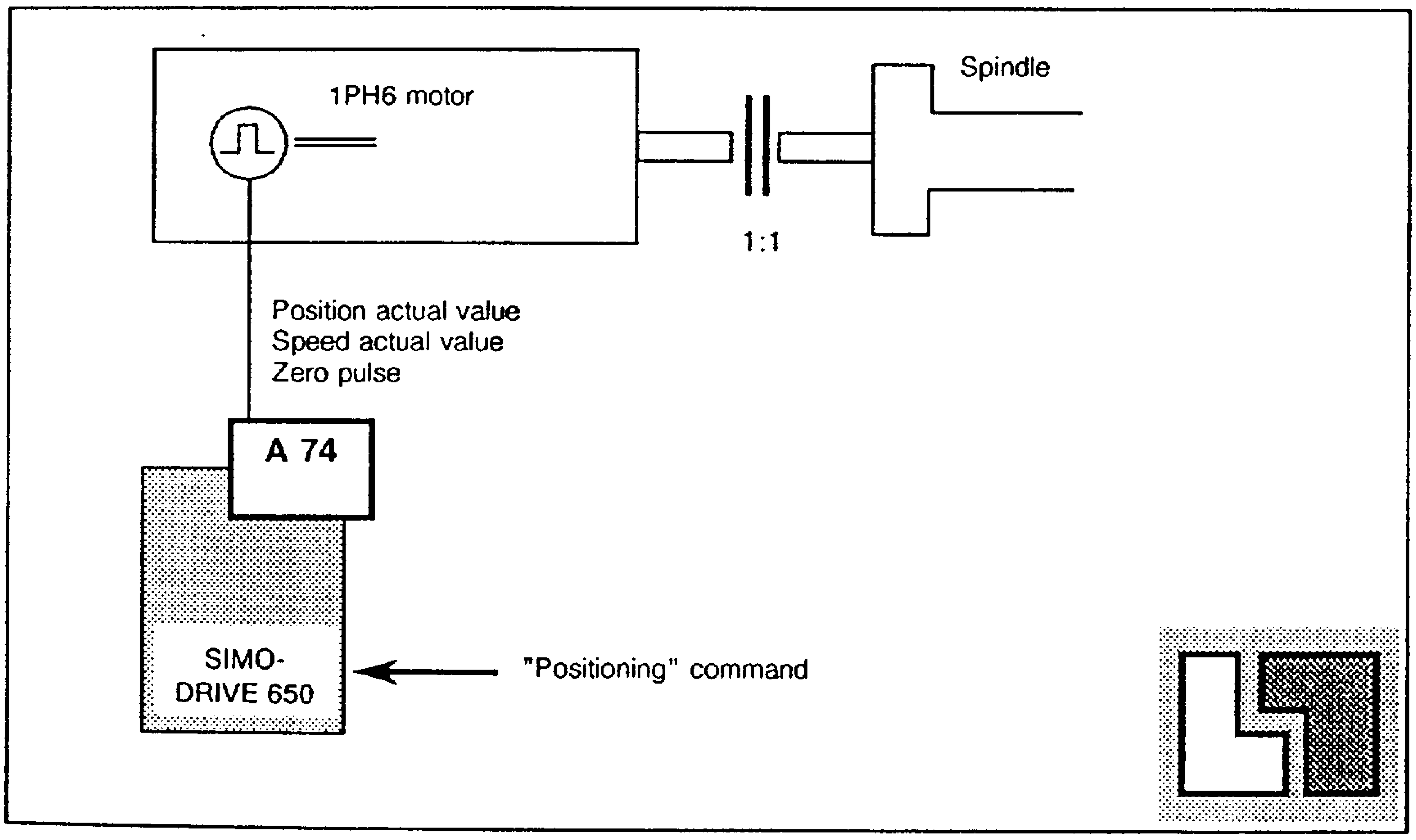
The position actual value can be sensed

- with the shaft encoder mounted in the motor (±0.1 ° accuracy referred to the motor shaft). The encoder zero mark, or with transmission systems between the motor and spindle, an external zero mark (e.g. BERO® proximity switch), can be used on the spindle for absolute position sensing.
- with an additional shaft encoder which is mounted on the spindle, whereby the zero mark is provided either from the shaft encoder or from an external BERO proximity switch.

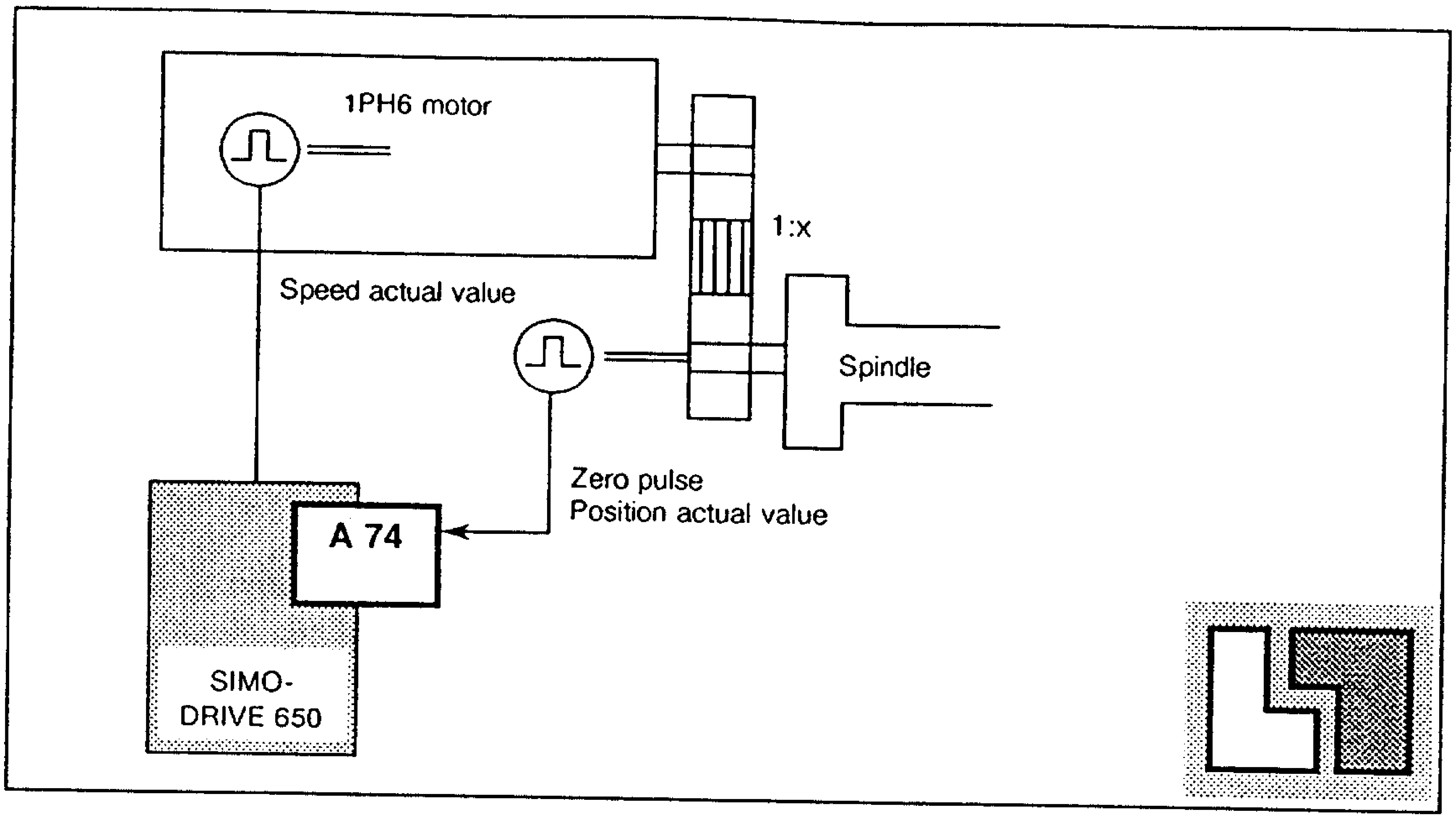
Orientated spindle stop in conjunction with a numerical control (NC function M19) is included in the basic version and requires no additional board.

Possibilities of spindle position sensing:

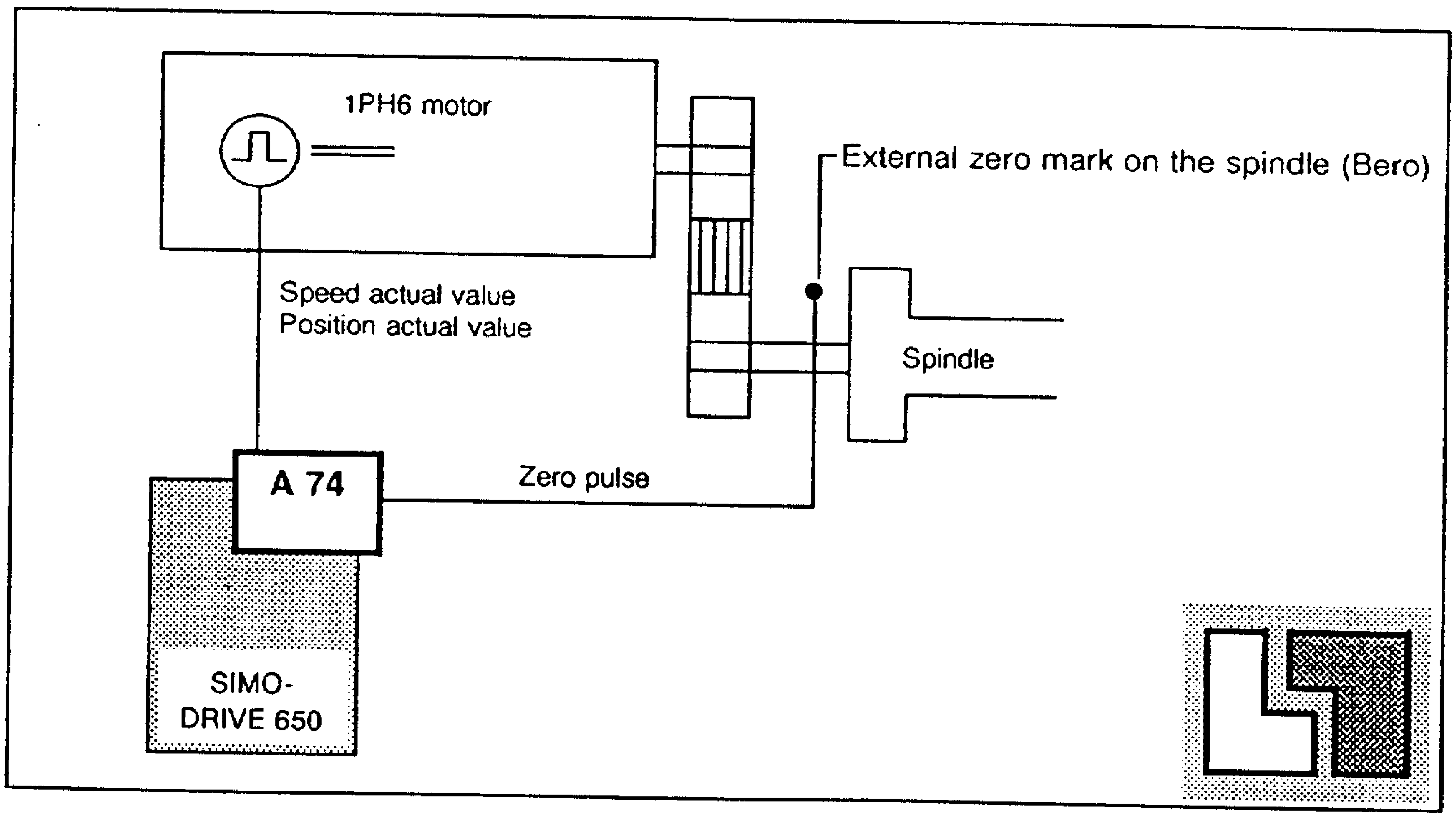
- Spindle positioning using the mounted ROD 323 motor shaft encoder without gearbox (direct coupling)



- Positioning the spindle with external spindle encoder (maximum 32767 pulses per revolution). The zero mark can either be supplied from an external spindle encoder or from a BERO proximity switch. (slip compensation with second encoder)



- Positioning the spindle with the mounted ROD 323 motor shaft encoder with gearbox (belt drives can only be used with additional encoder) and external zero mark on the spindle, e.g. BERO



Fixed angular positions can be input as well as repeatable angular steps. The entry is realized either

- externally through a 16-bit parallel interface (24 V) in hexadecimal code (e.g. by a 4-decade thumbwheel switch) or
- internally, using standard parameter input (five various positions are possible: One position for each of the four gear stages and a position independent of this.)

The positioning sequence is executed in several phases:

- *Braking the drive*
  Starting from any speed, the drive brakes down to the search speed according to the characteristic provided by the ramp-function generator. The speed setpoint required is input from the positioning control, and any speed setpoint at terminal 56 is suppressed. The search speed is the highest speed with which the drive can be braked at the target position in one revolution without overshoot.
- *Position sensing*
  The closed-loop position controller is switched-in after the search speed has been reached. The speed setpoint in this case comes directly from the closed-loop position controller. A search speed is input until the target position has been identified.
- *Travel to final position*
  The actual positioning sequence starts during the final revolution. This ensures that the approach sequence is always the same. The last revolution is subdivided into three phases:
  - Braking characteristic
  - Gradient 1
  - Gradient 2

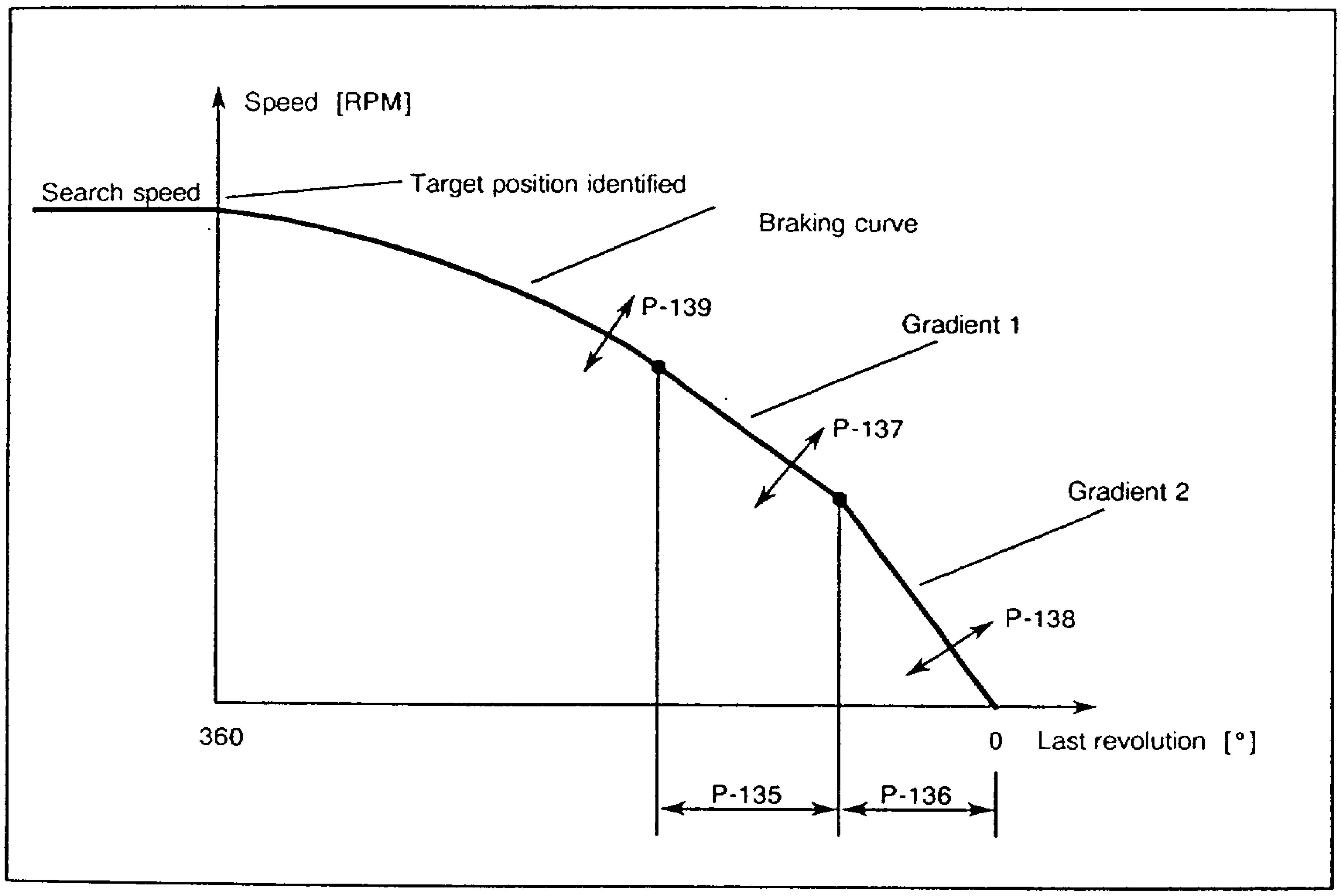


Fig. 3.4 Positioning sequence

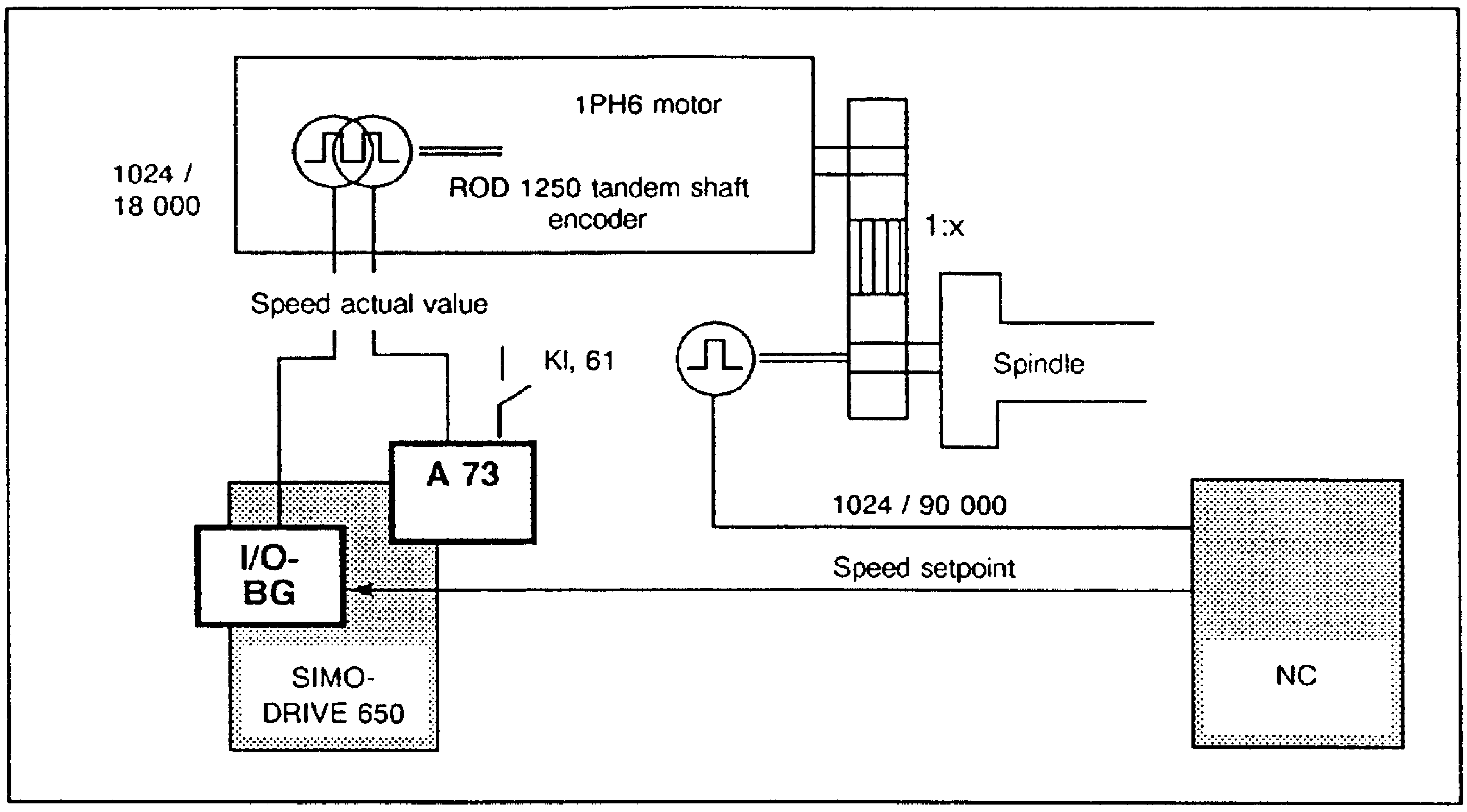
The application points and the gradients of the three phases can be set, the approach characteristic can thus be adapted to the various requirements with parameters P-135 to P-139.

The target position is monitored, and after having been reached, two relay signals are output, with different adjustable tolerance thresholds.

3.4.2 "C-axis" board

In the "C-axis" mode, the main spindle drive attains feed drive quality. This function is, for instance, necessary for machining with one chucking.

The speed range in the "C-axis" mode is 0.01 RPM up to 25% of the rated speed. High resolution speed actual value sensing must be provided on the motor shaft (motor option H29) in order to fulfill these high requirements.



The ROD323 shaft encoder, mounted as standard, with a resolution of 1024 pulses per revolution is in this case no longer sufficient. A special double-track encoder, type ROD1250, is used. This encoder has a square-wave track with 1024 pulses per revolution and a track with 18000 sinusoidal-cosinusoidal impulses per revolution, which are subdivided into a further 256 individual steps. This provides a resolution of 4.600.000 steps per revolution and one step corresponds to a mechanical angle of approx. 0.0001°.

The square-wave track is evaluated, in the normal mode, on the input/output board. The high-resolution encoder track is evaluated on the option board. The square-wave track signals are available on the I/O board for customer use.

The high-resolution encoder track is only evaluated below a changeover speed, which can be set with parameter P-108. The P-gain and integral action time are also changed over when changing from one to the other encoder track. This changeover occurs automatically without restricting operation.

3.4.3 "PG coupling" board

A SIMODRIVE 650 converter can be started up in a user-friendly fashion using a PG635/675/685 programming unit, using this board.

This option includes the interface board for connecting a SIMODRIVE 650 unit, and a program floppy disk for the programming unit.
For startup, the interface board is inserted at the plug connector X131 available as standard on the closed-loop control board N1. After startup, the interface board is withdrawn and can be used for other startups. The connection between the programming unit ("print" socket) and the interface board is established using a cable, type 6FC9344-1A (refer to Section 4), which is used as standard for establishing the connection between SINUMERIK and a programming unit or SIMATIC and a programming unit. A 9600 baud transmission rate is recommended to speed up the transmission.

The SIMODRIVE 650 converter startup program is subdivided into "process parameter" and "transfer data" blocks.

The converter parameter set is represented, menu prompted, in the "process parameter" block. The enable signals can either be realized in a file, or directly transferred on-line to the converter, so that their effect at the converter can be checked. In this operating mode, converter fault messages are also displayed in plain text on the programming unit screen. Further, it is possible to simultaneously display all operating messages and data of the converter (P-00-P11) on a program screen mask. In addition, the user can generate his own masks for startup purposes.

It is possible to store an optimized data set on a floppy disk or on a hard disk, or this data set can be directly transferred to the EEPROM of the converter for transcribing, in the "transfer data" block. This capability is especially useful and saves time when starting up standard machines.

3.4.4 External heat dissipation option

With this design (option E45), for units 6SC6504, 6SC6506, 6SC6508, 6SC6512 and 6SC6520, the cooling air circuit for the power section is separated from the interior of the machine tool cubicle. In this case, the power section heat dissipation must not be taken into account when dimensioning the cubicle cooling. The incorporated standard filter mat extracts particles having a diameter exceeding 5 µm.

The E45 option includes the complete set and cubicle fan, hose connections, outlet filter, and connecting flange.
Only 6SC6508 to 6SC6520 converters can be retroffited with the "external heat dissipation" option.
The total duct length cannot be greater than 1.5 m in order to ensure the necessary air-flow rate.

The connecting flanges themselves should be ordered with option E55.

3.5 Operation

The SIMODRIVE 650 digital transistor PWM converter can be easily started up and adjusted using the incorporated six-digit display and a simple keyboard. In normal operation, the display indicates the operating conditions. When a fault condition occurs, the fault is indicated which caused the shutdown.

The parameters are preset in the factory but can however be changed as required.

The drive parameters are set using two keys, which increase or decrease the value indicated in the display. The longer a key is pressed, the faster the displayed value is changed. The display mode is changed with the P key (operational display/number of the operational display or display of the parameter value/parameter number).

The parameters can be changed in steps of at least one part per thousand. The parameter is entered in a physical dimension, percentage or in hexadecimal format.

Customer-specific parameters for standard series-production machines can be completely entered in a programmed EEPROM. The motor data, necessary for the field calculation is retrieved from a stored file (EPROM) by entering a motor identification code.

Startup can be executed, menu prompted, with a programming unit. Once the settings have been optimized, the data set can be stored in the programming unit, and when starting up identical machine tools, can be completely transferred to the converter.

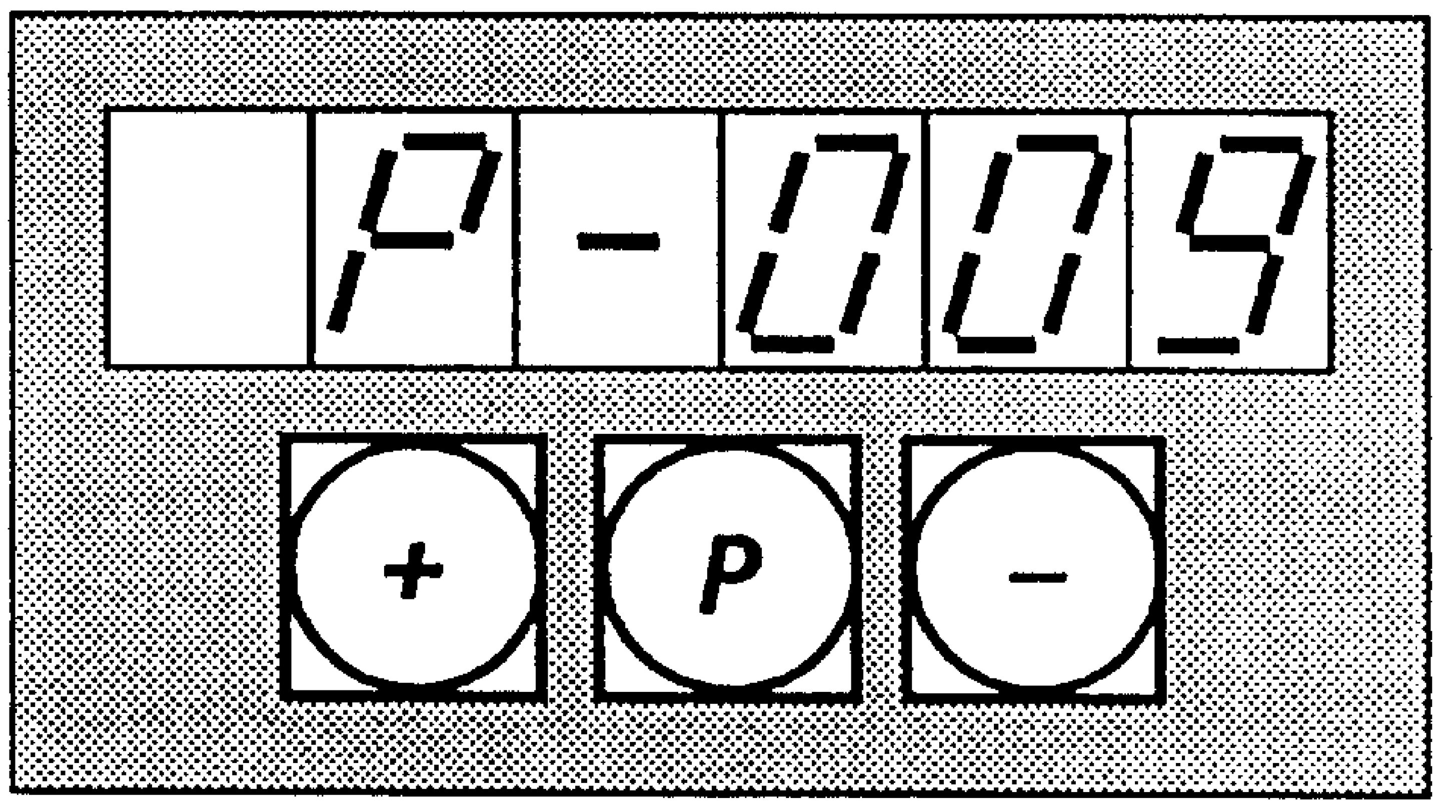


Fig. 3.5 Display and operator control elements

The most important operational and parameter displays are:

Operating displays:

P – 00	Enable status and torque direction with gear stage
P – 01	Speed setpoint
P – 02	Speed actual value
P – 03	Torque setpoint
P – 05	PWM converter output frequency
P – 06	DC link voltage
P – 07	DC link current
P – 08	DC link rating (not identical to P / P_{max})
P – 09	Line supply frequency
P – 10	Motor stator temperature
P – 11	Status of the binary inputs

Parameter displays:

P – 12	Normalization, speed actual value output
P – 13	Normalization, output P / P_{max}
P – 14, P–15	Setting value, speed setpoint
P – 16, P–18	Setting value, ramp-function generator
P – 21 to P29	Setting value, speed monitoring
P – 21	Response value, message n_{min}
P – 22	Reponse value n_{min} internal
P – 23	Response value, message n_x
P – 27	Response threshold, message $n_{set} = n_{act}$
P – 29	Maximum speed
P – 31 to 38	P- and I-components of the speed controller for 4 gear stages
P – 39 to 46	Torque limit value (absolute value and selectable for 4 gear stages)
P – 47	Response value, signal T_x
P – 51	Overwrite RAM enable
P – 52	Store RAM contents in the EEPROM
P – 65	Line resistance
P – 66 to 69	Measuring socket assignment
P – 95	Pulse converter adaption
P – 96	AC motor adaption
P – 98	Number of pulse tachometer pulses per revolution
P – 99	Software version

3.6 PWM converter - Interfaces

3.6.1 Inputs

- **Analog signals:**
  - Speed setpoint $n_{set\,1}$ (0 V to ± 10 V)
  - Speed setpoint $n_{set\,2}$ (0 V to ± 10 V)
  - Torque setpoint

- **Binary signals:**
  (can be driven, floating, with internal or external voltage)

  - Direct pulse suppression **(terminal 63)**
    (If this terminal is de-energized with the drive running, the motor idles down to standstill. This terminal directly influences the line- and motor-side converters.)
  - Closed-loop control enable **(terminal 64)**
    (If this terminal is de-energized, the drive brakes down to standstill with the selected ramp-down time. The motor is switched-off (no-voltage condition) when the speed is zero. At switch-on, the time constant for the re-magnitization must be taken into account.)
  - Ramp-function generator - Fast stop **(terminal 81)**
    (If this terminal is de-energized, the drive is braked down to standstill with the maximum torque. The motor remains magnetized at standstill.)
  - Limiting torque - Reduction **(terminal 111)**
    (When the terminal is energized, the maximum motor torque is reduced to a set value, dependent on reaching a selectable speed limit.)
  - Oscillating setpoint for gear change **(terminal 60)**
    (When this terminal is energized, an internal drive oscillation is generated, which has a variable frequency and amplitude, in order to facilitate gear change. Setpoints, if available, are suppressed.)
  - Set ramp-function generator to zero **(terminal 62)**
    (Ramp-function generator disabled)
  - Selection of four speed controller settings and limiting torques for various gear stages
  - Closed-loop torque control **(terminal 158)**
    (The torque setpoint of the "master" drive can be fed to the "slave" drive, for example for a twin drive. In this case, the "master" drive is speed controlled, and the "slave" drive is torque controlled in a open-loop fashion.)
  - Reset
    Remote acknowledgement of fault messages

Note : Use of the controller enable (terminal 64) and ramp-function generator - fast stop (terminal 81) signals:

When terminal 64 (closed-loop controller enable) is used to stop the drive, the motor is switched to a no-voltage condition when standstill is reached. This also means that the motor magnetic field decays. If at restart, a speed setpoint is input together with closed-loop controller enable, then the motor can only provide its full torque after approx. 400 ms, because the motor magnetic field must first be built up in this time.
For time-critical applications, such as e.g. automatic tool change, it is recommended that terminal 81 is used to brake the drive to a standstill (ramp-function generator - fast stop). After the motor has come to a stop, the digital speed setpoint zero is input. Terminal 111 should be simultaneously energized if the motor shaft should yield to an external torque. The drive starts instantaneously, and can accelerate with the maximum torque if terminal 81 is energized when the motor is started.

3.6.2 Outputs

- Analog signals:
  - n_{act}
  - P / P_{max} (e.g. for displaying the output power)
  - T_{set}

- Relay signals (floating):
  When configuring external adaptive controls it should be ensured that when faults occur the relays drop out.
  - Signal Ready with group fault signal
  - Signal $n < n_{min}$
  - Signal $n < n_x$
  - Signal $n_{set} = n_{act.}$
  - Signal $T < T_x$
  - Signal Motor overtemperature prewarning

- Shaft encoder signals:

  The shaft encoder signals are available on the input/output board for external use. This output is fed to the PWM converter through a driver stage and is thus decoupled from the actual function.
  An adaptor cable is available for this connection.

- Display messages (alternative):

  - Operating displays:
    - PWM converter ready
    - Closed-loop control enable
    - Torque direction
    - Gear stage
    - Status of the digital inputs
    - Status of the digital outputs
  - Measured values:
    - T_{set}
    - n_{set}
    - n_{act}
    - DC link voltage
    - DC link current
    - DC link power
    - P / P_{max} in %
    - T / T_{max} in %
    - Output frequency
    - Motor temperature
    - Line frequency

- **Display messages:**

  - Fault messages:
    (several simultaneous faults can be called up one after another)
    - Supply monitoring:
      Frequency
      Phase failure
      Incorrect phase sequence
    - Supply undervoltage
    - DC link overcurrent
    - Inverter overcurrent
    - Overload
    - Closed-loop control deviation too great (rotor locking protection)
    - DC link overvoltage
    - DC link undervoltage
    - DC link is not charged (switch-on sequence)
    - Actual value missing:
      Encoder
      Voltage
      Current
      NTC thermistor
    - Defective transistor in the inverter or step-up converter
    - Converter overtemperature
    - Motor overtemperature

3.7 Startup

3.7.1 Display and operator control elements

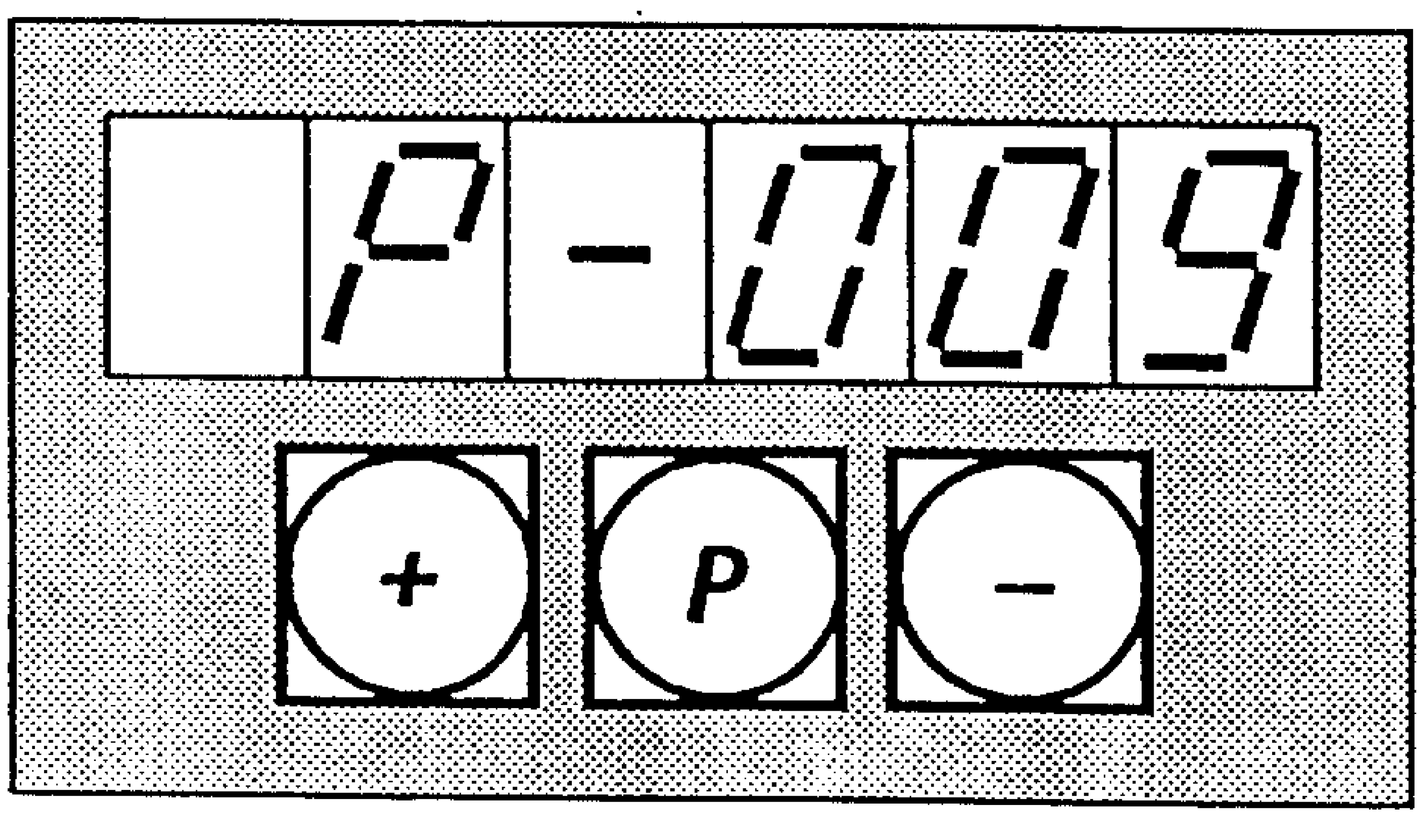


Fig. 3.4 Display and operator control elements

The parameter numbers and the setting values are indicated on the six-digit 7-segment display. The values are either indicated in decimal or hexadecimal format.

If the setting values are to be displayed in decimal, the preliminary zeros are suppressed.

When the setting values are displayed in hexadecimal, the letter "*H*" is inserted at the last display position, and the leading zeros are <u>not</u> suppressed. A point is inserted at the last position when the parameter number is displayed in hexadecimal.

The operator control elements are the " + " key, "P" key (parameter key) and the "–" key.

The values are changed by +1 or -1 at the last position by briefly depressing the " + " or "–" key. The longer the key is depressed, the quicker the value changes. If the "P" key is simultaneously depressed, then the value changes with 16 × speed.

The keys have a different function in the operator control mode as in the fault mode.

Key	Operator control mode function	Fault mode function
" + " key	Increase parameter number or parameter value	Switch to the next fault message
"–" key	Decrease parameter number or parameter value	Brief changeover (for approx.1 min.) into the operator control mode
"P" key	Changeover parameter number to parameter value or changeover parameter value to parameter number	Fault acknowledgement with controller inhibit available
" + "-key and "P"-key	Fast change of the parameter value to more positive values	none
"–"-key and "P"-key	Fast change of the parameter value to more negative values	none

3.7.2 Operating display

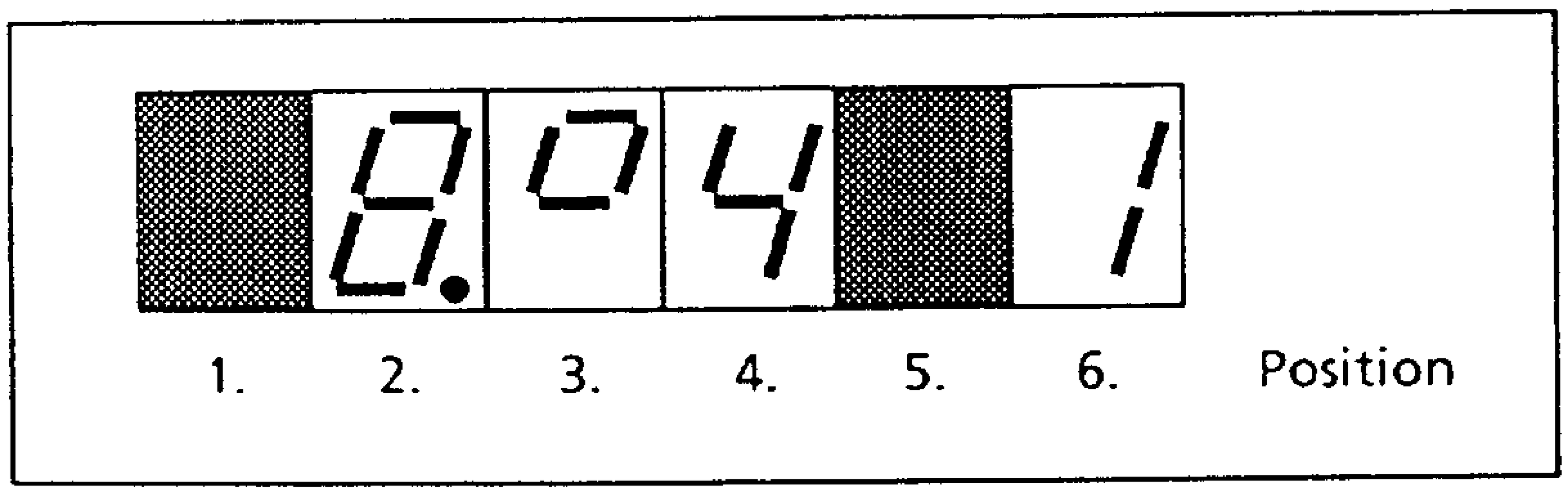


Fig. 3.5 Example of an operating display

The first and fifth position in the operating display are not controlled, and remain dark.

- **Significance of the second position**

The relay statuses are displayed at the second display position after the DC link has been charged. The individual display segments are controlled if the applicable relay signal is active, i.e. the relay has pulled in. The relays drop out when fault conditions occur (fault signals).

The individual display segments are assigned to the relay functions as follows:

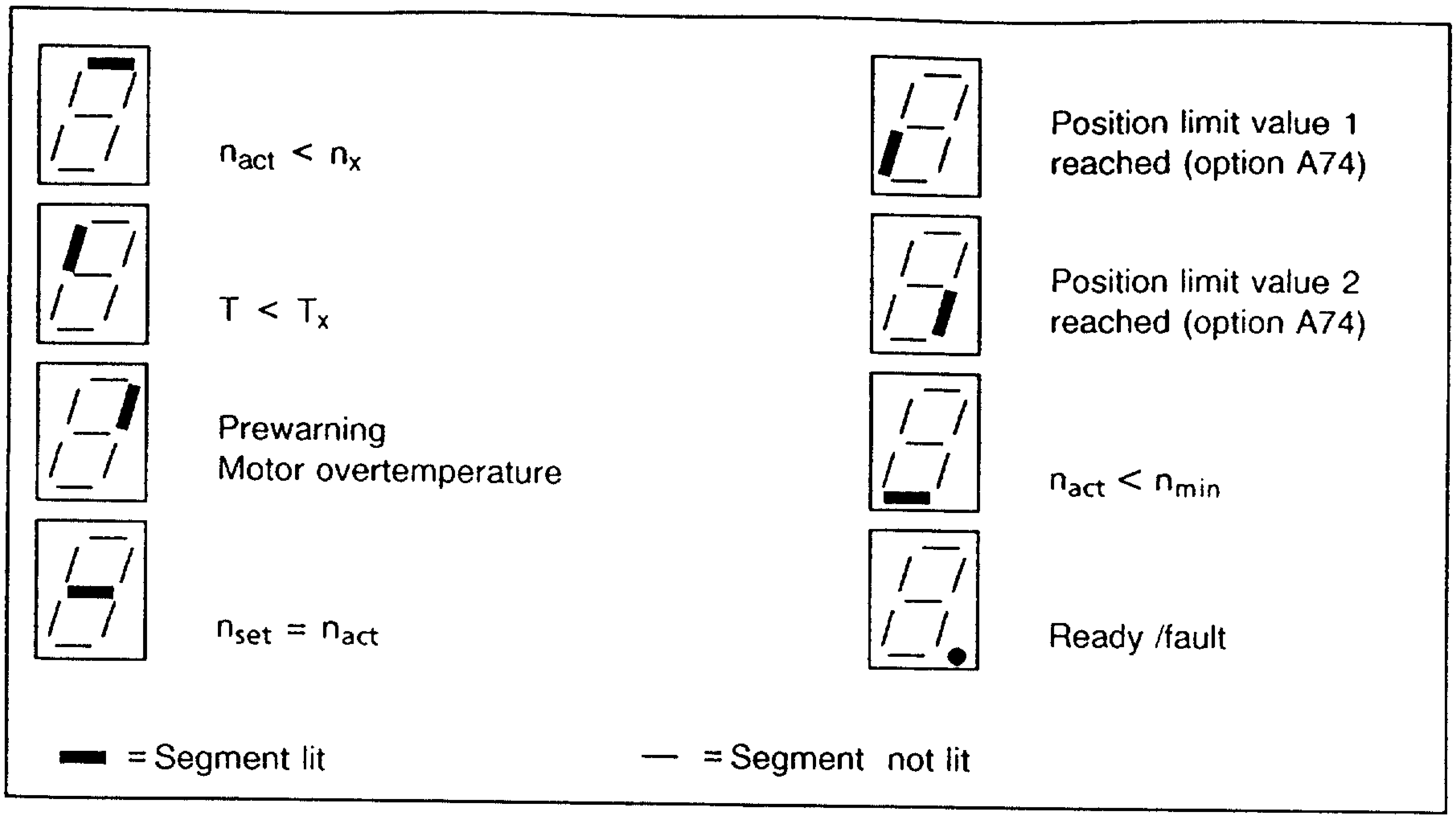
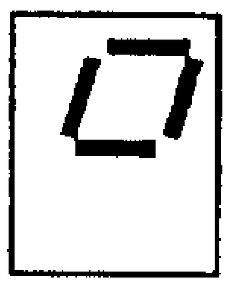
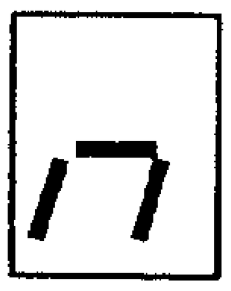
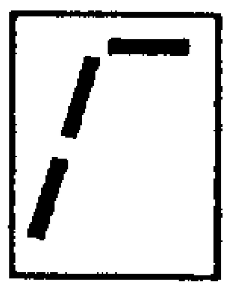
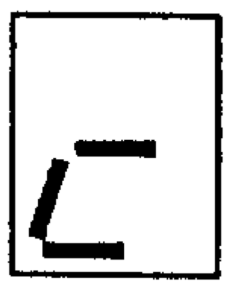
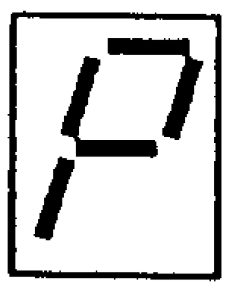
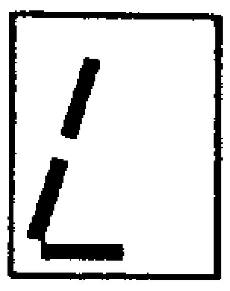


Fig. 3.6 Displays at the second display position

- **Significance of the third position**

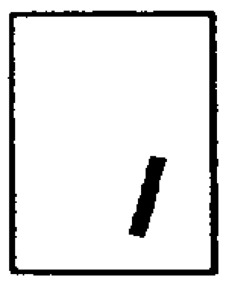
	The PWM converter is in the wait state. The progression condition is displayed at the next position (fourth position).
	All enable signals are available. Closed-loop speed control is preselected.
	All enable signals are available. Open-loop torque control is preselected.
	All enable signals are available. "C-axis" operating mode is selected (option).
	All enable signals are available. "Positioning" operating mode is selected (option).
	All enable signals are available. "NC function M19" operating mode is selected

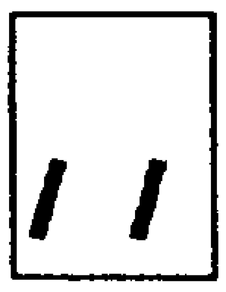
- **Significance of the fourth position**

The progression conditions are displayed at the fourth position of the display before the motor starts.

5	Line-side gating unit enable
4	Charge DC link
3	Pulse enable (inverter)
2	Closed-loop control enable (inverter)
1	Ramp-function generator enable

As soon as the progression conditions are fulfilled, the fourth position indicates the torque direction demanded by the closed-loop control.


Motor operation


Generator operation

- **Significance of the sixth position**

The sixth position of the display indicates the preselected gear stage.

1	No gear stage available or selected
2	Gear stage 2 selected
3	Gear stage 3 selected
4	Gear stage 4 selected

3.7.3 Measured value displays

The following measured value displays are assigned to parameters (P-01) to (P-10) :

Parameter	Significance	Unit	Format
(P-01)	Speed setpoint	%	0 to 100.0
(P-02)	Speed actual value	RPM	0 to 16000
(P-03)	Torque setpoint (converter related)	%	0 to 100.0
(P-04)	P/P_{max} PWM converter [1)]	%	0 to 100.0
(P-05)	Motor frequency	Hz	0 to 300.0
(P-06)	DC link voltage	V	0 to 999
(P-07)	DC link current	A	0 to 300
(P-08)	DC link power	kW	0 to 160.0
(P-09)	Supply voltage frequency	Hz	0 to 100.0
(P-10)	Stator temperature	°C	-10 to + 150

1) T/T_{max} is valid up to rated speed n_N; P/P_{max} is valid above n_N

3.7.4 Assignment and normalization of the D/A converter (measuring sockets)

Measuring sockets are available on the closed-loop control board for diagnostics. The measuring sockets are driven by D/A converters. The assignment of the D/A converters can be freely selected per parameter. Please take the address assignment from the list of variables.
The assignment of the measuring socket I_D to the analog converted current setpoint of the DC link is fixed, and cannot be changed.

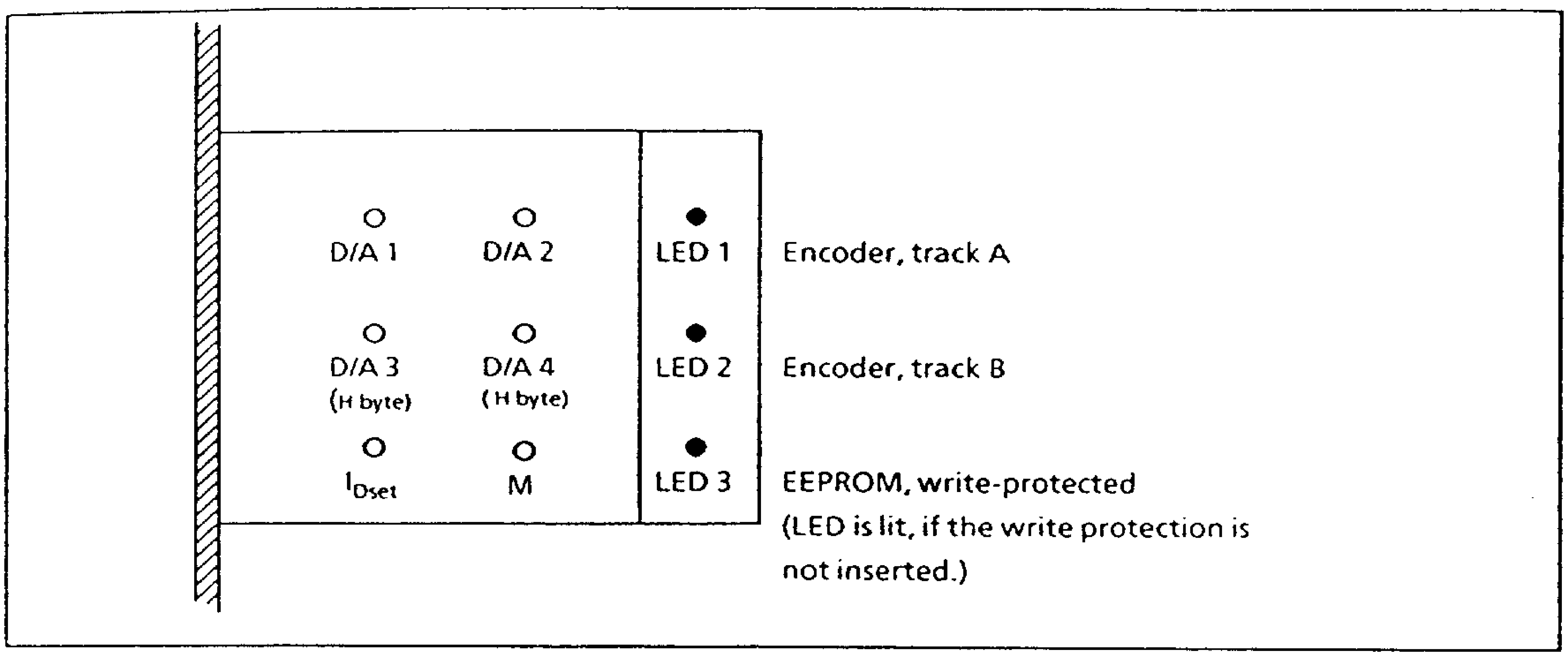


Fig. 3.11 Assignment of the measuring sockets and LEDs on the N1 closed-loop control board N1

Parameter	Significance	Unit	Format
P-66	D/A converter 1 assignment (RAM address: $0272_{Hex} = n_{act}$)	Hex	0000H.
P-67	D/A converter 1 normalization (shift to the left)	Hex	0000H.
P-68	D/A converter 2 assignment (RAM address: $0274_{Hex} = P/P_{max}$)	Hex	0000H.
P-69	D/A converter 2 normalization (shift to the left)	Hex	0000H.
P-76	D/A converter 3 assignment (14 bit select output)	Hex	0000H.
P-77	D/A converter 3 normalization (shift to the left)	Hex	0000H.
P-78	D/A converter 1 offset	Hex	0000H.
P-79	D/A converter 2 offset	Hex	0000H.
P-80	D/A converter 3 offset	Hex	0000H.

The normalization is realized by shifting the selected data values to the left. Data values can be shifted a maximum of 15 x to the left (setting the parameter in hexadecimal format $000F_{Hex}$).

The D/A converters have an 8-bit resolution. The most significant byte of a word is evaluated. If $0007F_{Hex}$ is available at the D/A converter + 10 V analog is output, and for 0080_{Hex}, −10 V.

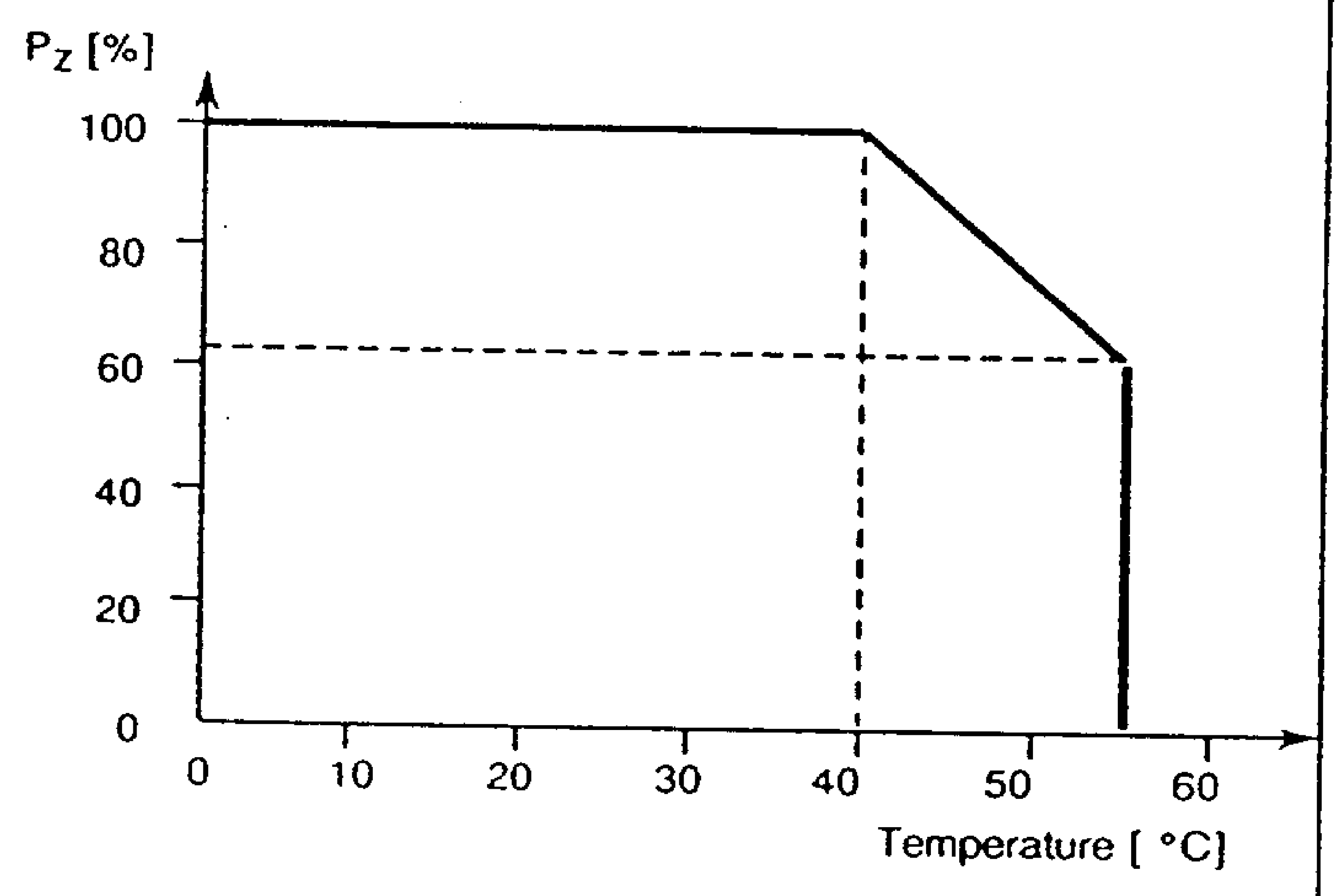
A 14-bit resolution is attained at terminals 18 and 78 by connecting D/A converter 3 and D/A converter 4 in parallel.

The analog outputs of the input/output boards are connected in parallel with those of the CPU (D/A converter 1 to D/A converter 4). Please ensure that in the operating state, the addresses of those variables which are stored in P-66, P-68 and P-76 are those which are to be indicated on external instruments.

1) preset in the factory

3.8 Technical data

Supply voltage	3 phase 400V AC (-15% / + 10%)
Supply frequency	45-63 Hz
Output voltage	3 phase 0 to 430 V AC
Output frequency	0 to 300 Hz
Efficiency	approx. 97%
DC link voltage	575 V DC
Clock frequency	variable, up to 1.8 kHz
Permissible ambient temperature	
in operation	0°C to 40°C (up to 55°C if derated)
during transport and storage	-30°C to 70°C

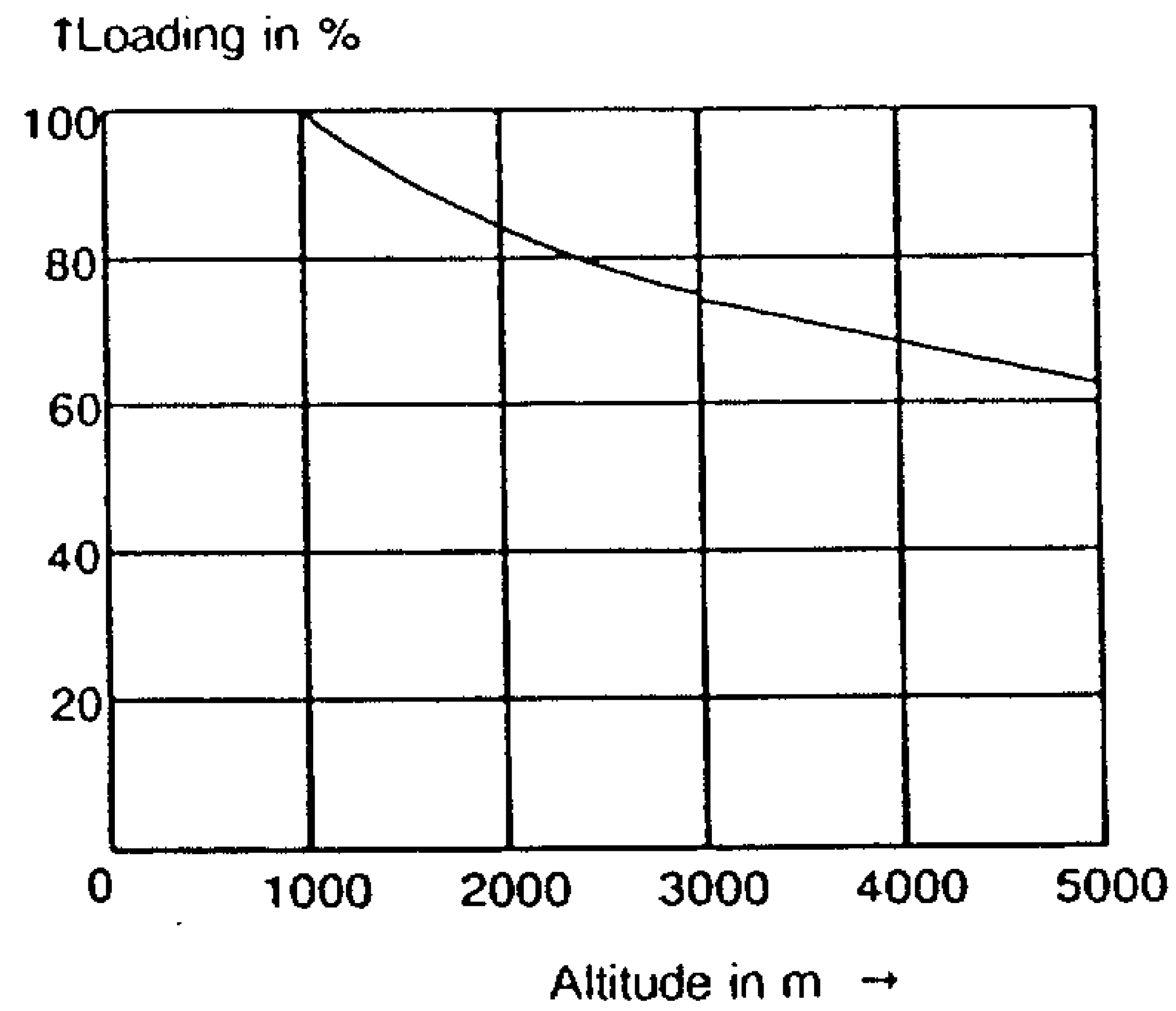


Derating for increased ambient temperature

Insulation	Group C according to DIN VDE 0110/11.72 380 V
High voltage test	Units are tested according to VDE 0160/5.88
Degree of protection	IP 00 according to DIN 40050 and IEC 144
Permissible humidity rating	Class F according to DIN 40040 Average annual relative humidity ≤ 75 % 30 days annually, continuous 95 % occasionally on the other days 85 %
Cooling type	External

Installation altitude

The specified values for the rated and limiting DC current refer to installation altitudes up to 1000 m above sea level. The rated DC currents should be reduced according to the diagram below for site altitudes exceeding 1000 m.



PWM converter Order No. 6SC65	Line-side current at rated voltage [A]	Line-side current at undervoltage condition [A]	Rated o/p current [A]	Rated app. power [kVA]	Cont. infeed power [kW]	Cont. regenerative power [kW]	Max. power loss [W]	Incoming fuse (incorporated) [A]	Weight approx. [kg]
02-4AA□□	18	22.5	20	15	18.5	14	400	45	40
03-4AA□□	30	33.5	30	22.5	18.5	14	450	45	40
04-4AA□□	36	41	40	30	28	22	750	45	55
06-4AA□□	54	62	60	45	33	27	1100	80	55
08-4AA□□	72	82	85	60	56	45	1500	2 x 45	70
12-4AA□□	108	124	120 1)	90	87	70	2300	160	120
20-4AA□□	180	205	200 2)	150	120	100	3300	250	220

Table 3.2 Technical data of the PWM converter

1) S6-60% (10min cycle) 140A, S6-40% 150A
2) S6-60% 220A

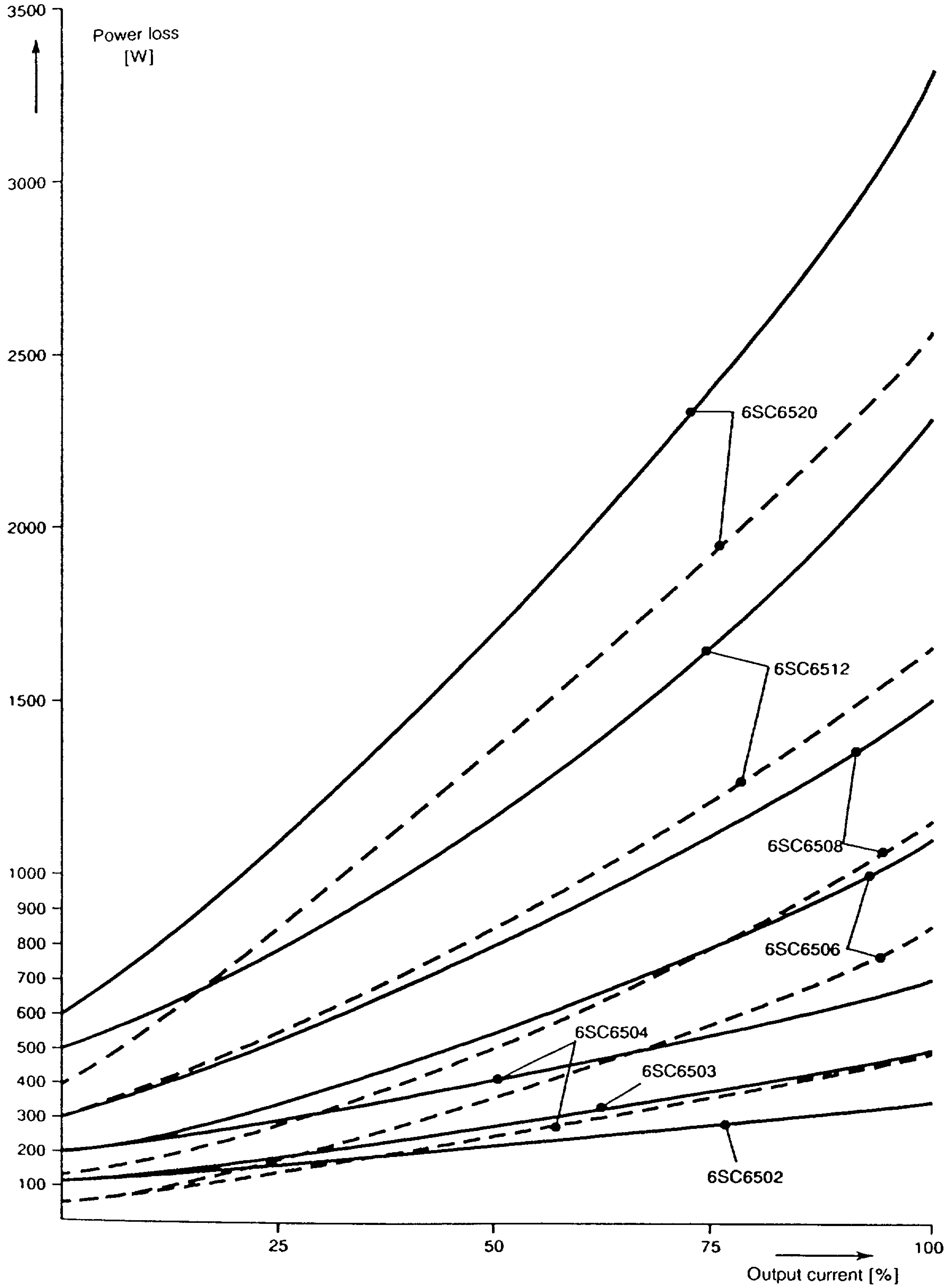


Fig 3.14 —— *Maximum power loss at rated voltage as a function of the output current*

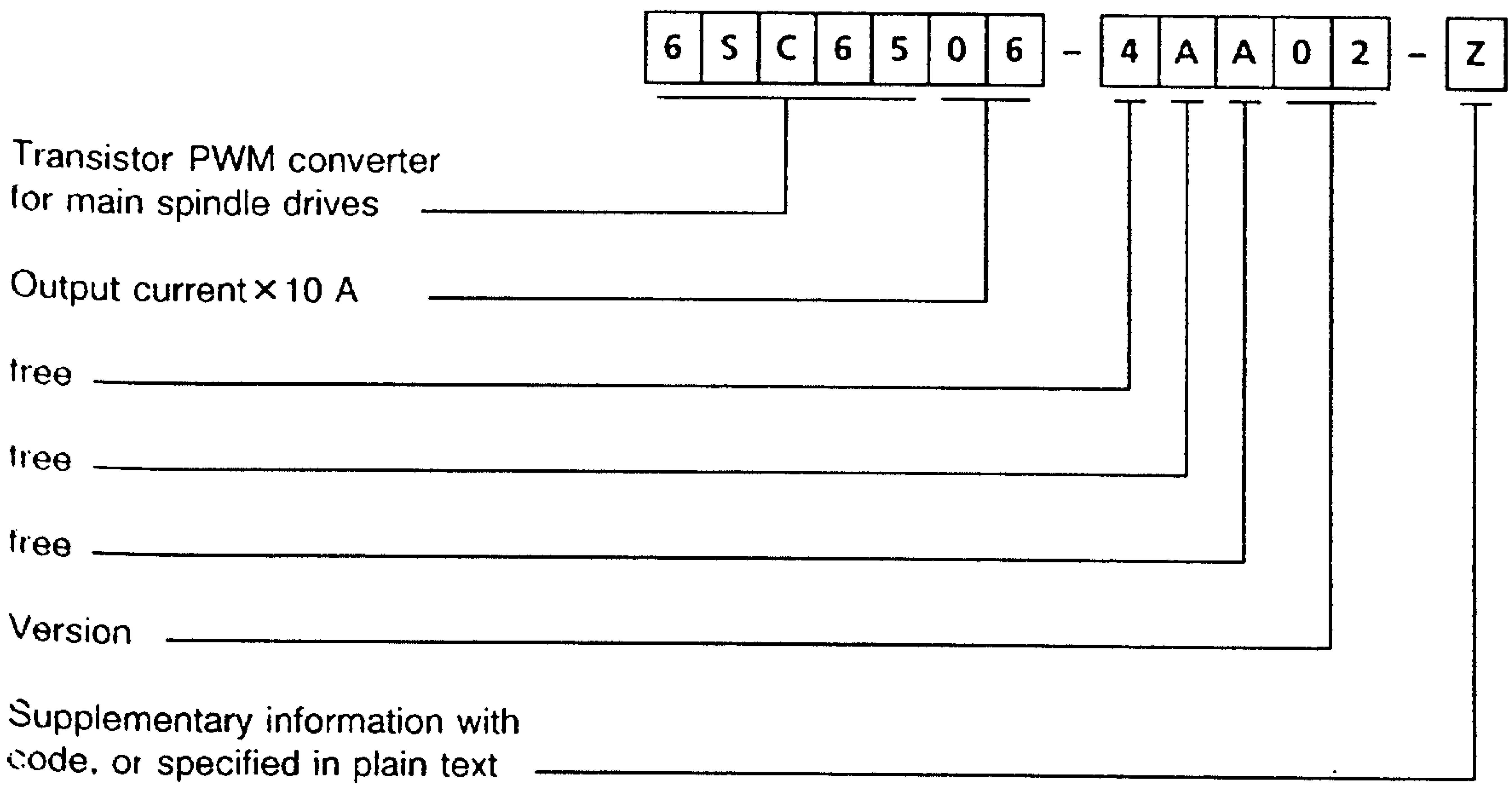
- - - *Power loss dissipated with option E 45 external heat dissipation (the difference between the dotted and continuous lines corresponds to the heat which is not dissipated)*

3.9 Type designation

The type designation (which is also the Order No.) consists of a combination of digits and letters. It is subdivided into 3 blocks, which are connected by two hyphens.

The first block comprises 7 positions, and identifies the PWM converter type. The second block contains codes for additional design features. The third block is provided for additional information.

Configuration of the PWM converter Order No.:



Codes:
A73 = "C axis" option
A74 = "Spindle positioning" option without numerical control
A75 = "Spindle positioning and C axis" option
E45 = "External heat dissipation" option
E55 = Option for connecting flange for external heat dissipation

Ordering example:

Transistor PWM converter	6SC6506-4AA02
Special design	-Z
"C axis" code	A73
E45	

Complete Order No.: **6SC6506-4AA02-Z A73**

4 Installation instructions

4.1 Installation

WARNING

Hazardous voltages are used in the operation of this equipment, and will cause severe personal injury or loss of life and property damage if the equipment is not handled in the correct fashion. Please observe the warnings in the following text and on the equipment itself.

- Only qualified personnel familiar with this equipment should service, repair or troubleshoot the equipment.
- Before carrying out any work the equipment should be isolated from the supply and grounded.
- Only spare parts authorized by the manufacturer should be used.
- The specified maintenance intervals and work as well as the repair and replacement procedures must be strictly adhered to.

4.1.1 AC motors

Use all of the lifting eyelets during transport.

- The 1PH6 motor are dynamically balanced. High-speed motors (option L37) are always balanced with half key. Other motors are, at the present, time balanced with full key. It can be assumed that this will change to half key balancing as a result of a change in the balancing specifications for electrical machines (DIN ISO 8821). Motors, balanced with half key, are designated with an "H" on the shaft end face.
- When mounting drive elements the suitable equipment should always be used together with the thread on the shaft.
- It is not permissible to use a hammer, as this will damage the shaft encoder.
- Precise alignment and good balancing of the mounted drive elements are prerequisites for good smooth running, free of vibration. Especially for high-speed motors, it should be ensured that the flange mounting is stiff in order to position the resonant frequency of the mounted unit as high as possible and thus above the maximum rotational frequency.

- The AC motors must be located so that the cooling air intake and discharge are not restricted. The discharged air must not be drawn in again.

- The covers for the foot mounting screw holes should be relocated after the motor has been mounted.

4.1.2 PWM converter

- The PWM converters are suitable for installation in enclosed electrical rooms (DIN VDE 0558 Part 1a, Sections 5.4.3.2.1 and 5.4.3.2.2). In the operating condition, protection is thus provided against direct contact.

- The mounting dimensions and positions of the mounting points should be taken from the dimension drawings.

- The PWM converters are designed for vertical mounting in cubicles or machine frames. The incoming connections and motor feeder connections should be mounted below.

- It should be ensured that the air intake and discharge are unrestricted. A space of 100 mm must be maintained above and below the PWM converter. The PWM converters must be mounted so that they are protected from deposits of conductive dust.

4.2 Connecting up

> ***The equipment must always be switched off and be in the no-voltage condition before carring out any work.***

4.2.1 AC motors

> ***Before starting any work on the AC motor ensure that it is switched-off and is interlocked so that it cannot be switched on again !***

- AC motors can only be operated with the assigned PWM converter.

- Observe the rating plate data and the circuit diagram in the terminal box.

- The terminal box upper section with connecting board can be rotated through 90°. When connecting to the terminal board, the feeder cables should be dimensioned according to the rated current and the correct cable lug size selected for the terminal bolt dimensions.

- Twisted, or a three-core cable with additional ground conductor should be used for the motor feeder. Only enough insulation should be removed from the conductor ends so that the remaining insulation reaches up to the cable lug or terminal.

- The connecting cables should be arranged in the terminal box so that the equipment grounding conductor is somewhat longer, and that the core insulation is not damaged. It should be ensured that the connecting cables are strain relieved.

- Please ensure that the minimum air clearances are maintained:
  Connecting voltages up to 500 V: Minimum air gap 4.5 mm.

- After connecting up it should be checked that
  - the inside of the terminal box is clean and has no conductor remnants in it,
  - all terminal screws are tight,
  - the minimum air gaps are available,
  - the cable glands are reliably sealed,
  - all unused entries are closed and the plug elements are tightly screwed in and
  - all sealing surfaces are secure.

- The cooling air ducts through which the ambient air flows should be cleaned regularly, at intervals depending on the degree of local pollution, e.g. using dry, oil-free compressed air. The inside of surface-cooled motors should be cleaned at the normal routine maintenance intervals.

4.2.2 PWM converter

- Connect-up the PWM converter as recommended (Fig. 4.5).

> ***The converter can only be supplied from a grounded supply network. Ensure that the correct phase sequence for a clockwise rotating field supply is available and the connection between the PWM converter and the AC motor.***

- The ground conductors of the supply and motor feeder must be attached to the grounding rail (grounding bolts) of the PWM converter. If the motor housing is not well grounded, capacitive equalization currents can flow and thus cause faults in the electronic components.

- The PWM converter cover must be screwed into place for operation in order to ensure a good ground connection.

- If SIMODRIVE 611 feed drives are to be fed from the DC link of a SIMODRIVE 650 converter, then during the design phase, the maximum infeed/regenerative feedback power of the SIMODRIVE 650 should be taken into account. The data can be taken from Table 3.2, Section 3.8, Technical data. The calculation of the necessary infeed/regenerative feedback power from feed drives can be taken from the Technical description for SIMODRIVE 611, (Order No. 6ZB5 420-0AG01-0BA1), Section 3.4.4 DC link design. See also Information AUT 221-11-014--drive combination consisting of main spindle and feed drives SIMODRIVE 611 and SIMODRIVE 650.

- The PWM converters are completely protected with the incorporated fuses. The fuses indicated in the recommended connection diagram (Fig. 4.3) are cable fuses according to DIN VDE 0100.
- The setpoint and actual value cables are screened, and routed separately from the power cables. The control lines for the closed-loop controller enable signals and power supply should be separated from the contactor control cables.
- The shaft encoder cable screen and the common AC motor and PWM converter potential should be correctly connected to the screen rail of the PWM converter (for 6SC6504-20) or at connecting bolt X131 of the G01 power supply board (for 6SC6502-03).
- A contactor can be connected between the AC motor and the PWM converter to electrically isolate the motor from the supply voltage for safety reasons. This contactor must be located between the motor and converter as energy is still in the DC link, even after "power off".

Under no circumstances must the contactor be switched under load as the arc could destroy the power transistors.

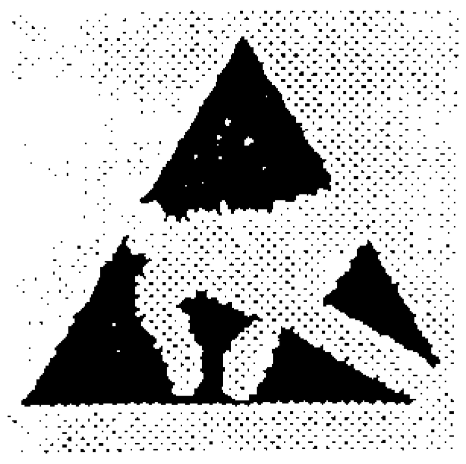
- The control should be interlocked to ensure that this contactor can only be switched at pulse inhibit (terminal 63 not energized). Further, terminal 63 should be interlocked with an auxiliary contact of the contactor.
- A contactor should be used with a delayed dropout time so that even at power failure, the PWM converter buffer time can be overridden. The contactor must override the maximum reaction time of terminal 63 (pulse enable) of 40 ms. This can be easily realized using a contactor with a DC coil (3TB4.17-0B) by connecting a free-wheeling diode (3TX6406-0H) across the contactor coil.
- If a contactor is switched in directly in front of the line-side converter, then it should be ensured that this contactor can only be switched at converter pulse inhibit (terminal 63). A minimum delay time of 40 ms must be maintained between pulse inhibit and contactor switching. If this is not ensured, fuses could blow or thyristors could be damaged.
- Fuses are not blown when power failures occur during operation as a result of line reactance.
- Also refer to the terminal diagram

Observe the discharge time (approx. 4 minutes) for the DC link capacitors!

The PWM converter is maintenance free, when the information specified in the installation section is observed.

- If dust and dirt start to collect in the PWM converter we recommend that it be cleaned using dry, oil-free compressed air in order to prevent voltage arcs and reduced cooling.

Board handling



Board/components, which have this warning symbol (yellow hand with a diagonal line through it on a black triangle) can be damaged if they are electrostatically charged.

Thus, the following instructions should be adhered to:

- Basically, electronic boards must only be touched if absolutely necessary as a result of the work to be undertaken.
- Your body should be discharged before coming into contact with electronic boards. This is most easily realized by touching a conductive grounded object directly beforehand (e.g. unpainted cubicle components, protective gound contact in electrical sockets).
- Boards must not come into contact with highly insulating materials (e.g. plastic foils, insulated desktops, clothing articles from man-made fibers).
- Boards must only be deposited on conductive surfaces.
- Boards must only be inserted or withdrawn in the no-voltage condition
- Signal voltages must only be applied with the supply voltage on.
- Boards and components should always be stored or transported in conductive packing materials (e.g. metalized plastic boxes, metal boxes).
- If packages are not conductive, the boards must be covered in a conductive material beforehand. Conductive foam rubber or household aluminum foil.

Connecting terminals for PWM converters 6SC6502 and 6SC6503

Terminals: Number	Terminals: Location	Function	Type	Typical voltage	Maximum connected cross-section
Power section					
U1,V1,W1	Support a	Supply connection	I	3ph 380V AC 50/60 Hz	M6 connection
PE1		Equip. ground. conductor	I	0 V	
U2,V2,W2	A1	Motor connection	O	3ph 430V AC, 300 Hz	6 mm²
PE2		Motor ground conductor	O	0 V	
PE	G01-X131 m	Encoder. cable screen		0 V	M6 connection
Analog electronic signals					
56	U1-X111.1 c	Speed setpoint 1 (+)	I	+10 V DC	1.5 mm²
14	U1-X111.2 c	Speed setpoint 1 (−)	I	−10 V DC	1.5 mm²
24	U1-X111.4 c	Speed setpoint 2 (+)	I	+10 V DC	1.5 mm²
8	U1-X111.5 c	Speed setpoint 2 (−)	I	−10 V DC	1.5 mm²
75	U1-X111.7 c	Speed actual value	O	0 V to ± 10 V DC; 5 mA	1.5 mm²
76	U1-X111.8 c	Speed actual value	RV	0 V to ± 10 V DC; 5 mA	1.5 mm²
16	U1-X111.9 c	P / P_{max}	O	0 V	1.5 mm²
77	U1-X111.10 c	P / P_{max}	RV	0 V to ± 10 V DC; 5 mA	1.5 mm²
18	U1-X111.11 c	Select output (14 bit)	O	0 V	1.5 mm²
78	U1-X111.12 c	Select output (14 bit)	RV	+10 V DC; 10 mA	1.5 mm²
47	U1-X111.13 c	P 10 } Reference voltage for	O	0 V	1.5 mm²
69	U1-X111.14 c	M } speed setpoint input	O	−10 V DC; 10 mA	1.5 mm²
46	U1-X111.15 c	N10 }	O		1.5 mm²
Digital electronic signals					
9	U1-X121 d	P24 - external (aux. voltage)	O	+24 V DC 150 mA	1.5 mm²
19	U1-X121 d	RV for 24 V DC + enable signals	O/I	0 V	1.5 mm²
63	U1-X121 d	Pulse enable	I	DC +12 V to +30 V	1.5 mm²
64	U1-X121 d	Closed-loop controller enable	I	DC +12 V to +30 V	1.5 mm²
81	U1-X121 d	Ramp-function gen. - fast stop	I	DC +12 V to +30 V	1.5 mm²
62	U1-X121 d	Set ramp-function gen. to zero	I	DC +12 V to +30 V	1.5 mm²
111	U1-X121 d	Torque limiting	I	DC +12 V to +30 V	1.5 mm²
60	U1-X121 d	Oscillation	I	DC +12 V to +30 V	1.5 mm²
117	U1-X121 d	Gear stage 2	I	DC +12 V to +30 V	1.5 mm²
118	U1-X121 d	Gear stage 3	I	DC +12 V to +30 V	1.5 mm²
119	U1-X121 d	Gear stage 4	I	DC +12 V to +30 V	1.5 mm²
158	U1-X121 d	Torque control (open-loop)	I	DC +12 V to +30 V	1.5 mm²
R	U1-X121 d	Remote acknowledgement	I	DC +12 V to +30 V	1.5 mm²
Encoders					
Plug con.	U1-X131 g	Encoder input, motor temp.	I	+5 V 1.8 kΩ - 100 kΩ	screened cable
Plug con.	U1-X231 g	Encoder signals (buffered)	O	+5 V > 150-Ω load	ribbon cable
Relay contacts					
72	G0.2-X131 e		NO	1 60 V AC 5 A	1.5 mm²
73.2	G0.2-X131 e	Ready	I	1 60 V AC 5 A	1.5 mm²
73.1	G0.2-X131 e	Fault	I	1 60 V AC 5 A	1.5 mm²
74	G0.2-X131 e		NC	1 60 V AC 5 A	1.5 mm²
115	G0.2-X131 e		NO	1 60 V AC 5 A	1.5 mm²
114	G0.2-X131 e	$n < n_{min}$	I	1 60 V AC 5 A	1.5 mm²
116	G0.2-X131 e		NC	1 60 V AC 5 A	1.5 mm²
127	G0.2-X131 e		NO	1 60 V AC 5 A	1.5 mm²
126	G0.2-X131 e	$n_{set} = n_{act}$	I	1 60 V AC 5 A	1.5 mm²
128	G0.2-X131 e		NC	1 60 V AC 5 A	1.5 mm²
109	G0.2-X141 e		NO	1 60 V AC 5 A	1.5 mm²
108	G0.2-X141 e	$T < T_x$	I	1 60 V AC 5 A	1.5 mm²
110	G0.2-X141 e		NC	1 60 V AC 5 A	1.5 mm²
215	G0.2-X141 e		NO	1 60 V AC 5 A	1.5 mm²
214	G0.2-X141 e	$n < n_x$	I	1 60 V AC 5 A	1.5 mm²
216	G0.2-X141 e		NC	1 60 V AC 5 A	1.5 mm²
209	G0.2-X141 e		NO	1 60 V AC 5 A	1.5 mm²
208	G0.2-X141 e	Motor overtemperature	I	1 60 V AC 5 A	1.5 mm²
210	G0.2-X141 e	prewarning	NC	1 60 V AC 5 A	1.5 mm²

Connecting terminals for PWM converters 6SC6502 and 6SC6503 (continued)

Terminals		Function	Type	Typical voltage	Maximum connected cross-section
Number	Location				
Option board					
501	S1-X111 h	Position reached 1	NO	160 V AC 5 A	1.5 mm²
503	S1-X111 h		I	160 V AC 5 A	1.5 mm²
502	S1-X111 h		NC	160 V AC 5 A	1.5 mm²
541	S1-X111 h	Position reached 2	NO	160 V AC 5 A	1.5 mm²
543	S1-X111 h		I	160 V AC 5 A	1.5 mm²
542	S1-X111 h		NC	160 V AC 5 A	1.5 mm²
		M24 external	O/I	0 V	1.5 mm²
512	S1-X112 i	Positioning ON	I	+12 V to +30 V DC	1.5 mm²
516	S1-X112 i	1st / 2nd position	I	+12 V to +30 V DC	1.5 mm²
513	S1-X112 i	Incremental positioning	I	+12 V to +30 V DC	1.5 mm²
517	S1-X112 i	External/internal pos. setpoint	I	+12 V to +30 V DC	1.5 mm²
61	S1-X112 i	C-axis operation ON	I	+12 V to +30 V DC	1.5 mm²
518	S1-X112 i	Accept external pos. setpoint	I	+12 V to +30 V DC	1.5 mm²
518	S1-X112 i	External zero mark	I	+12 V to +30 V DC	1.5 mm²
Plug con.	S1-X113 j	External pos. setpoint	I	High: +12 to +30 V DC	screened cable
Plug con.	S1-X113 j	Transmitter output for NC	O	+5 V >150 Ω load	screened cable
Plug con.	S1-X114 k	Encoder input (rectangular)	I	+5 V 1.8 kΩ - 100 kΩ	screened cable
Plug con.	S1-X114 k	Encoder input (sinusoidal)	I	µA	screened cable
Plug con.	N1-X131 l	Digital interface to PG	I/O		interface block

I = Input
O = Output
NC = Normally closed
NO = Normally open contact
RV = Reference voltage for analog outputs (D/A converter)

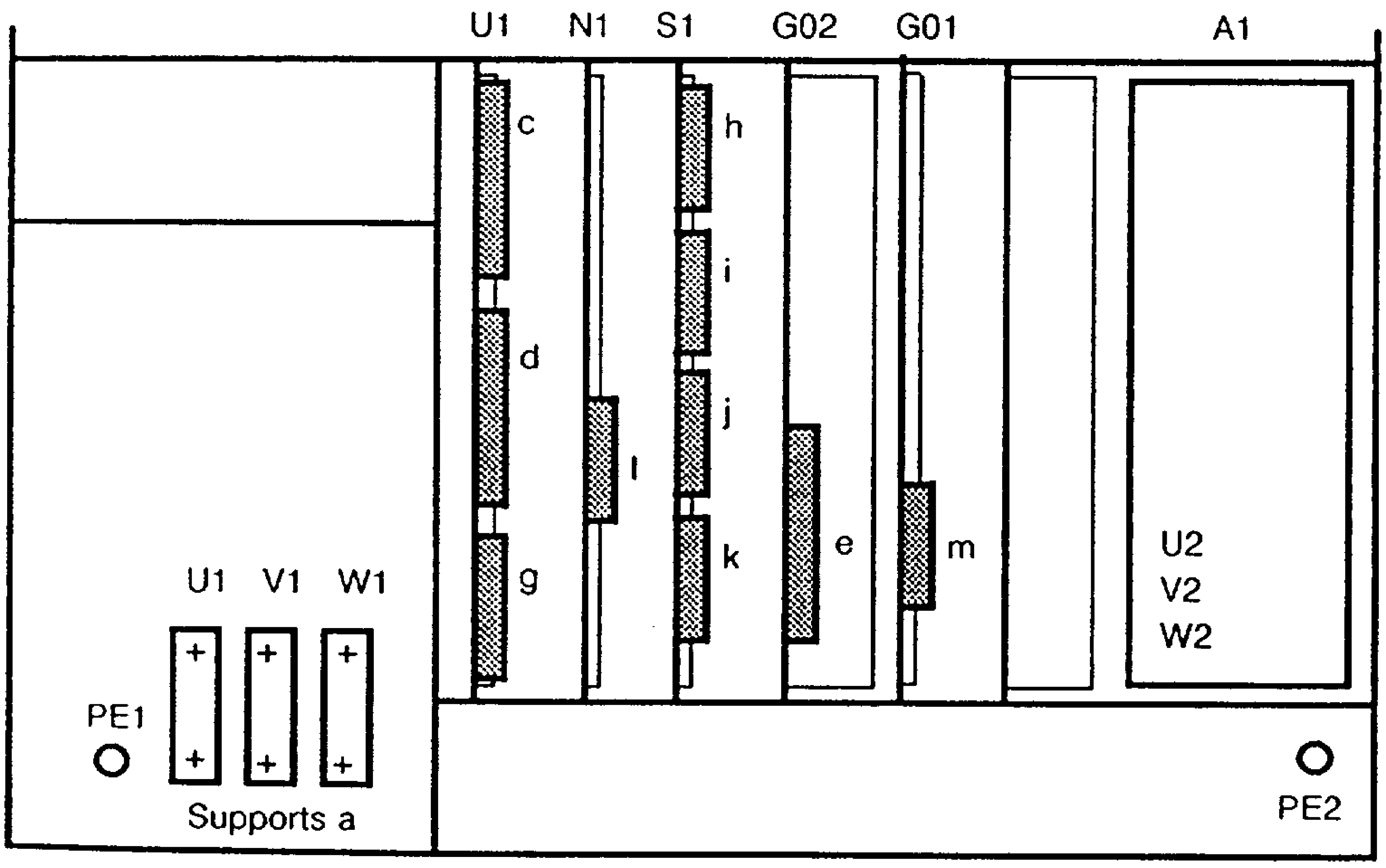


Fig. 4.1 Terminal locations for PWM converters 6SC6502 and 6SC6503

U1 = Input/output board
N1 = Closed-loop control board
S1 = "Spindle positioning" and "C-axis" option
G02 = Central board
G01 = Power supply 1
c = X111; d = X121; e = X131 and X141;
g = X231 and X131; h = X111; i = X112;
j = X113; k = 114; l = X131
m = X131

Terminals for PWM converters 6SC6504, 6SC6506, 6SC6508, 6SC6512, 6SC6520

Terminals		Function	Type	Typical voltage	Maximum connected cross-section
Number	Location				
Power section					
U1,V1,W1	Support a	Supply connection	I	3 P. 380 V AC 50 /60 Hz	M6 connection
PE		Equip. ground. conductor	I	0 V	
U2,V2,W2	Support b	Motor connection	O	3 Ph. 430 V AC 300 Hz	M6 connection *)
PE		Motor equip. ground. cond.	O	0 V	
X600	Terminals n	DC link tap	O	600V DC	
Analog electronic signals					
56	U1-X111.1 c	Speed setpoint 1 (+)	I	+10 V DC	1.5 mm²
14	U1-X111.2 c	Speed setpoint 1 (−)	I	−10 V DC	1.5 mm²
24	U1-X111.4 c	Speed setpoint 2 (+)	I	+10 V DC	1.5 mm²
8	U1-X111.5 c	Speed setpoint 2 (−)	I	−10 V DC	1.5 mm²
75	U1-X111.7 c	Speed actual value	O	0 V to ± 10 V DC; 5 mA	1.5 mm²
76	U1-X111.8 c	Speed actual value	RV	0 V	1.5 mm²
16	U1-X111.9 c	P / P_{max}	O	0 V to ± 10 V DC; 5 mA	1.5 mm²
77	U1-X111.10 c	P / P_{max}	RV	0 V	1.5 mm²
18	U1-X111.11 c	Select output (14 bit)	O	0 V to ± 10 V DC; 5 mA	1.5 mm²
78	U1-X111.12 c	Select output (14 bit)	RV	0 V	1.5 mm²
47	U1-X111.13 c	P 10 } Reference voltage for	O	+10 V DC; 10 mA	1.5 mm²
69	U1-X111.14 c	M } speed setpoint input	O	0 V	1.5 mm²
46	U1-X111.15 c	N10 }	O	−10 V DC; 10 mA	1.5 mm²
Digital electronic signals					
9	U1-X121 d	P24 - external (Aux. voltage)	O	+24 V DC 150 mA	1.5 mm²
19	U1-X121 d	RV for 24 V DC + enable signals	O/I	0 V	1.5 mm²
63	U1-X121 d	Pulse enable	I	+12 V to +30 V DC	1.5 mm²
64	U1-X121 d	Closed-loop controller enable	I	+12 V to +30 V DC	1.5 mm²
81	U1-X121 d	Ramp-function gen. fast stop	I	+12 V to +30 V DC	1.5 mm²
62	U1-X121 d	Set ramp-function gen. to zero	I	+12 V to +30 V DC	1.5 mm²
111	U1-X121 d	Torque limiting	I	+12 V to +30 V DC	1.5 mm²
60	U1-X121 d	Oscillation	I	+12 V to +30 V DC	1.5 mm²
117	U1-X121 d	Gear stage 2	I	+12 V to +30 V DC	1.5 mm²
118	U1-X121 d	Gear stage 3	I	+12 V to +30 V DC	1.5 mm²
119	U1-X121 d	Gear stage 4	I	+12 V to +30 V DC	1.5 mm²
158	U1-X121 d	Torque control	I	+12 V to +30 V DC	1.5 mm²
R	U1-X121 d	Remote acknowledgement	I	+12 V to +30 V DC	1.5 mm²
Encoder					
Plug con.	U1-X131 g	Encoder input, motor temp.	I	+5 V 1.8 kΩ - 100 kΩ	screened cable
Plug con.	U1-X231 g	Encoder signals (buffered)	O	+5 V > 150 Ω load	ripple cable
Relay contacts					
72	G02-X131 e	Ready	NO	1 ph. 60 V AC 5 A	1.5 mm²
73.2	G02-X131 e	Fault	I	1 ph. 60 V AC 5 A	1.5 mm²
73.1	G02-X131 e		I	1 ph. 60 V AC 5 A	1.5 mm²
74	G02-X131 e		NC	1 ph. 60 V AC 5 A	1.5 mm²
115	G02-X131 e	$n < n_{min}$	NO	1 ph. 60 V AC 5 A	1.5 mm²
114	G02-X131 e		I	1 ph. 60 V AC 5 A	1.5 mm²
116	G02-X131 e		NC	1 ph. 60 V AC 5 A	1.5 mm²
127	G02-X131 e	$n_{set} = n_{act}$	NO	1 ph. 60 V AC 5 A	1.5 mm²
126	G02-X131 e		I	1 ph. 60 V AC 5 A	1.5 mm²
128	G02-X131 e		NC	1 ph. 60 V AC 5 A	1.5 mm²
109	G02-X141 e		NO	1 ph. 60 V AC 5 A	1.5 mm²
108	G02-X141 e	$T < T_x$	I	1 ph. 60 V AC 5 A	1.5 mm²
110	G02-X141 e		NC	1 ph. 60 V AC 5 A	1.5 mm²
215	G02-X141 e		NO	1 ph. 60 V AC 5 A	1.5 mm²
214	G02-X141 e	$n < n_x$	I	1 ph. 60 V AC 5 A	1.5 mm²
216	G02-X141 e		NC	1 ph. 60 V AC 5 A	1.5 mm²
209	G02-X141 e		NO	1 ph. 60 V AC 5 A	1.5 mm²
208	G02-X141 e	Motor overtemp. prewarning	I	1 ph. 60 V AC 5 A	1.5 mm²
210	G02-X141 e		NC	1 ph. 60 V AC 5 A	1.5 mm²

Connecting terminals for PWM converters 6SC6504, 6SC6506, 6SC6508, 6SC6512, 6SC6520 (continued)

Terminals Number	Terminals Location	Function	Type	Typical voltage	Maximum connected cross-section
Option board					
501	S1-X111 h	Position 1 reached	O	1 ph. 60 V AC 5 A	1.5 mm²
503	S1-X111 h		I	1 ph. 60 V AC 5 A	1.5 mm²
502	S1-X111 h		NC	1 ph. 60 V AC 5 A	1.5 mm²
541	S1-X111 h	Position 2 reached	O	1 ph. 60 V AC 5 A	1.5 mm²
543	S1-X111 h		I	1 ph. 60 V AC 5 A	1.5 mm²
542	S1-X111 h		NC	1 ph. 60 V AC 5 A	1.5 mm²
		M24 external	O/I	0 V	1.5 mm²
512	S1-X112 i	Positioning ON	I	DC +12 V to +30 V	1.5 mm²
516	S1-X112 i	1st / 2nd position	I	DC +12 V to +30 V	1.5 mm²
513	S1-X112 i	Incremental positioning	I	DC +12 V to +30 V	1.5 mm²
517	S1-X112 i	External/internal pos. setpoints	I	DC +12 V to +30 V	1.5 mm²
61	S1-X112 i	C-axis operation ON	I	DC +12 V to +30 V	1.5 mm²
518	S1-X112 i	Accept external pos. setpoints	I	DC +12 V to +30 V	1.5 mm²
518	S1-X112 i	External zero mark	I	DC +12 V to +30 V	1.5 mm²
Plug con.	S1-X113 j	External pos. setpoint	I	High: DC + 12 to + 30 V	Screened cable
Plug con.	S1-X113 j	Encoder output for NC	O	+5 V >150 Ω load	Screened cable
Plug con.	S1-X114 k	Encoder input (rectangular)	I	+5 V 1.8 kΩ - 100 kΩ	Screened cable
Plug con.	S1-X114 k	Encoder input (sinusoidal)	I	µA	Screened cable
Plug con.	N1-X131 l	Digital interface to PG	I/O		Interface block

I = Input
O = Output
NC = Normally closed
NO = NO contact
RV = Reference voltage for analog putput (D/A converter)
**) For 6SC6508 and 6SC6512, M8 connection*

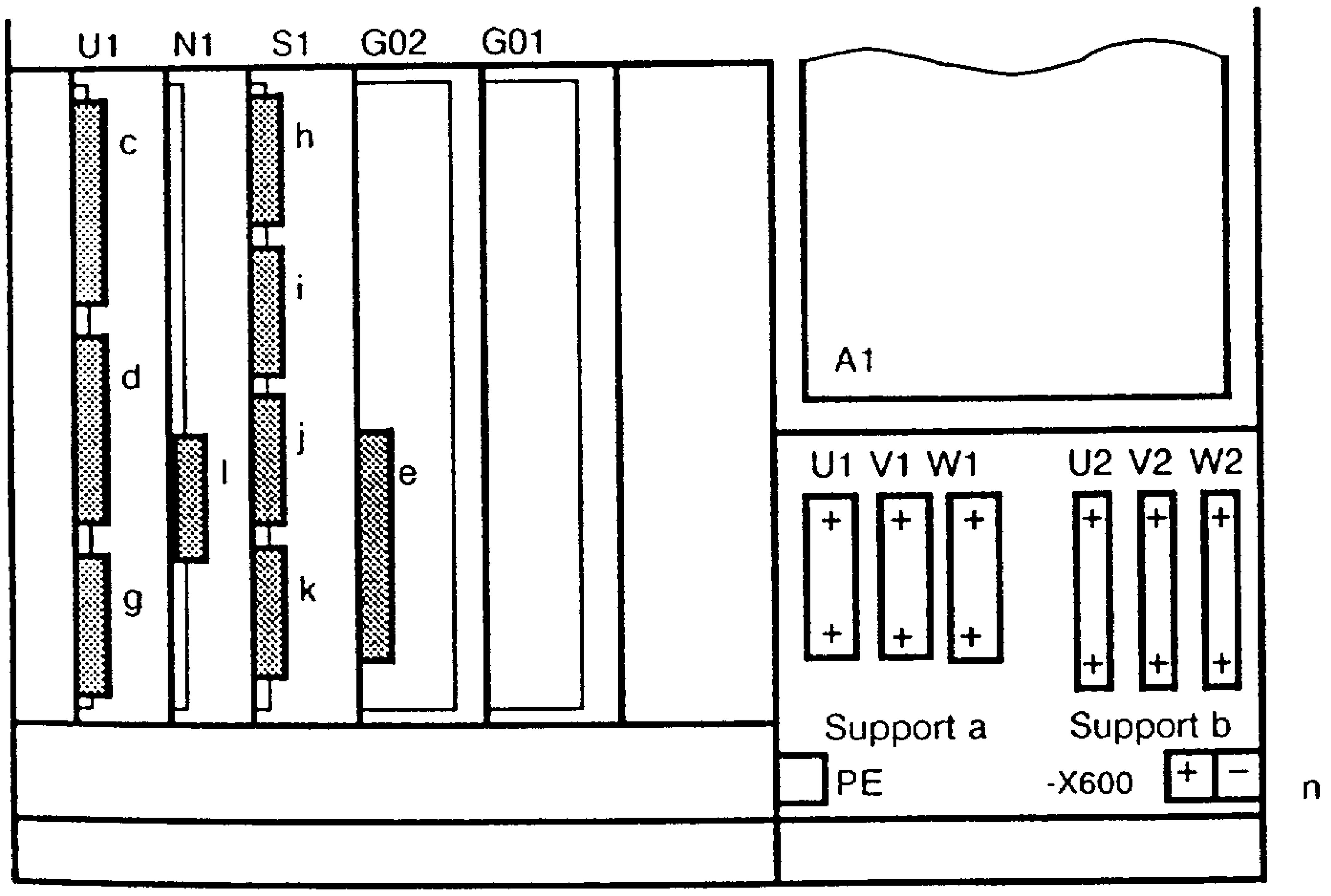


Fig. 4.3 Location of plug connectors, for 6SC6504, 6SC6506 and 6SC6508 transistor PWM converters

U1 = Input/output board
N1 = Closed-loop control board
S1 = "Spindle positioning" and "C axis" option
G02 = Central board
G01 = Power supply 1
c = X111; d = X121; e = X131 and X141;
g = X231 and X131; h = X111; i = X112; j = X113;
k = 114 l = X131 n = X600

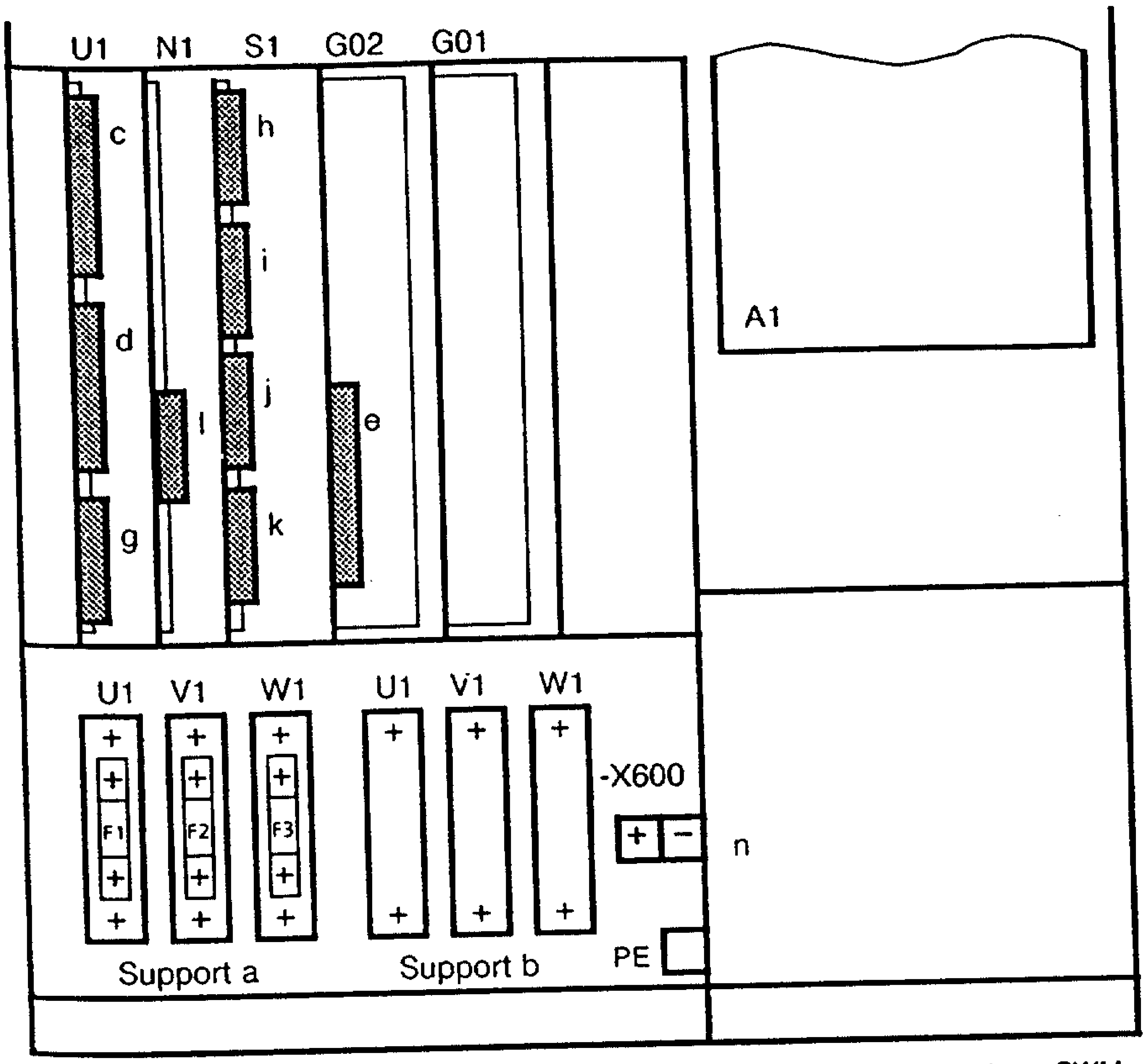


Fig. 4.4 Location of plug connectors, for 6SC6512 and 6SC6520 transistor PWM converters

U1 = Input/output board
N1 = Closed-loop control board
S1 = "Spindle positioning" and "C axis" option
G02 = Central board
G01 = Power supply 1

c = X111; d = X121; e = X131 and X141;
g = X231 and X131; h = X111; i = X112; j = X113;
k = 114 l = X131 n = X600

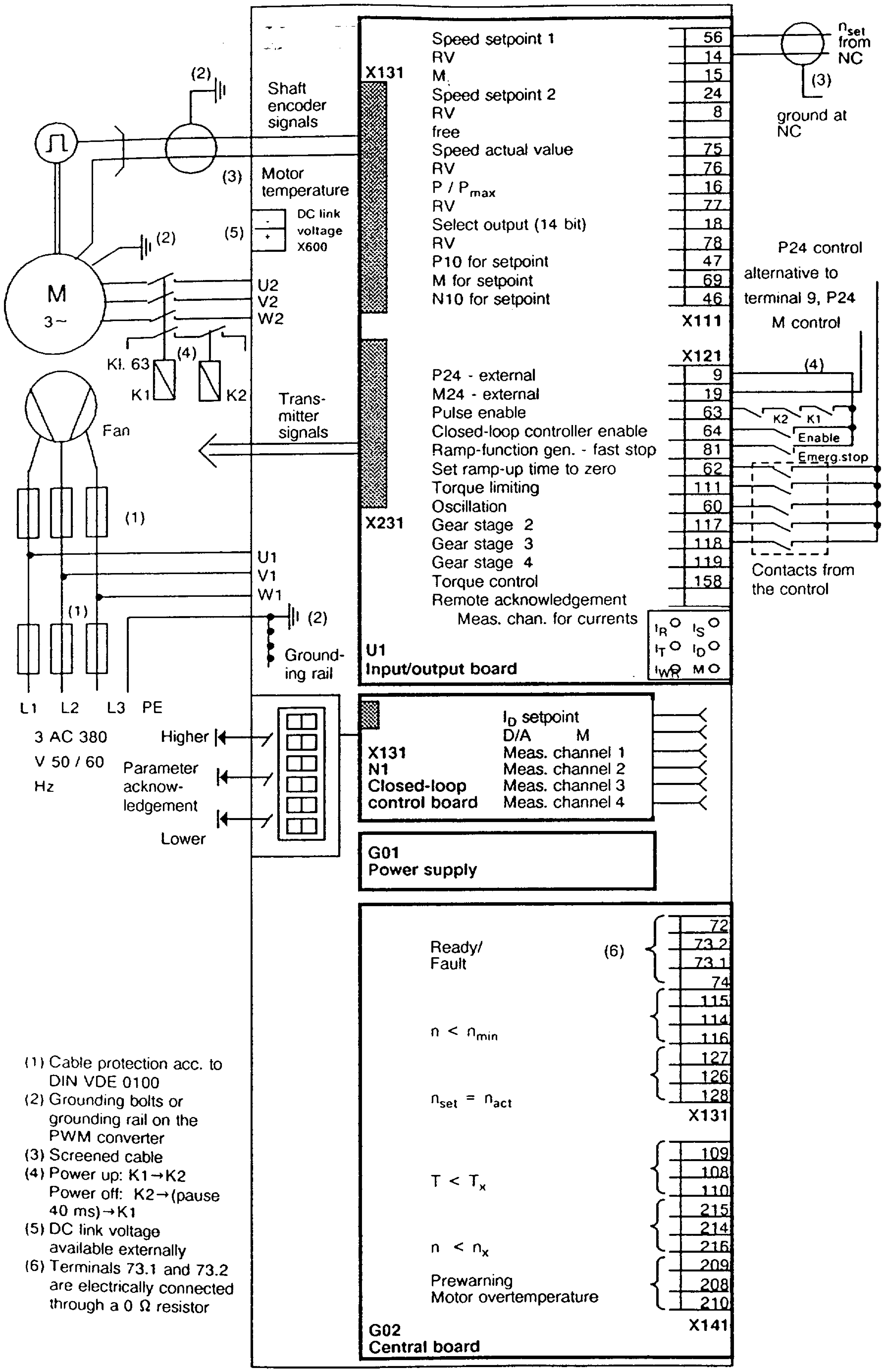


Fig. 4.5 Connecting up the SIMODRIVE 650 transistor PWM converter

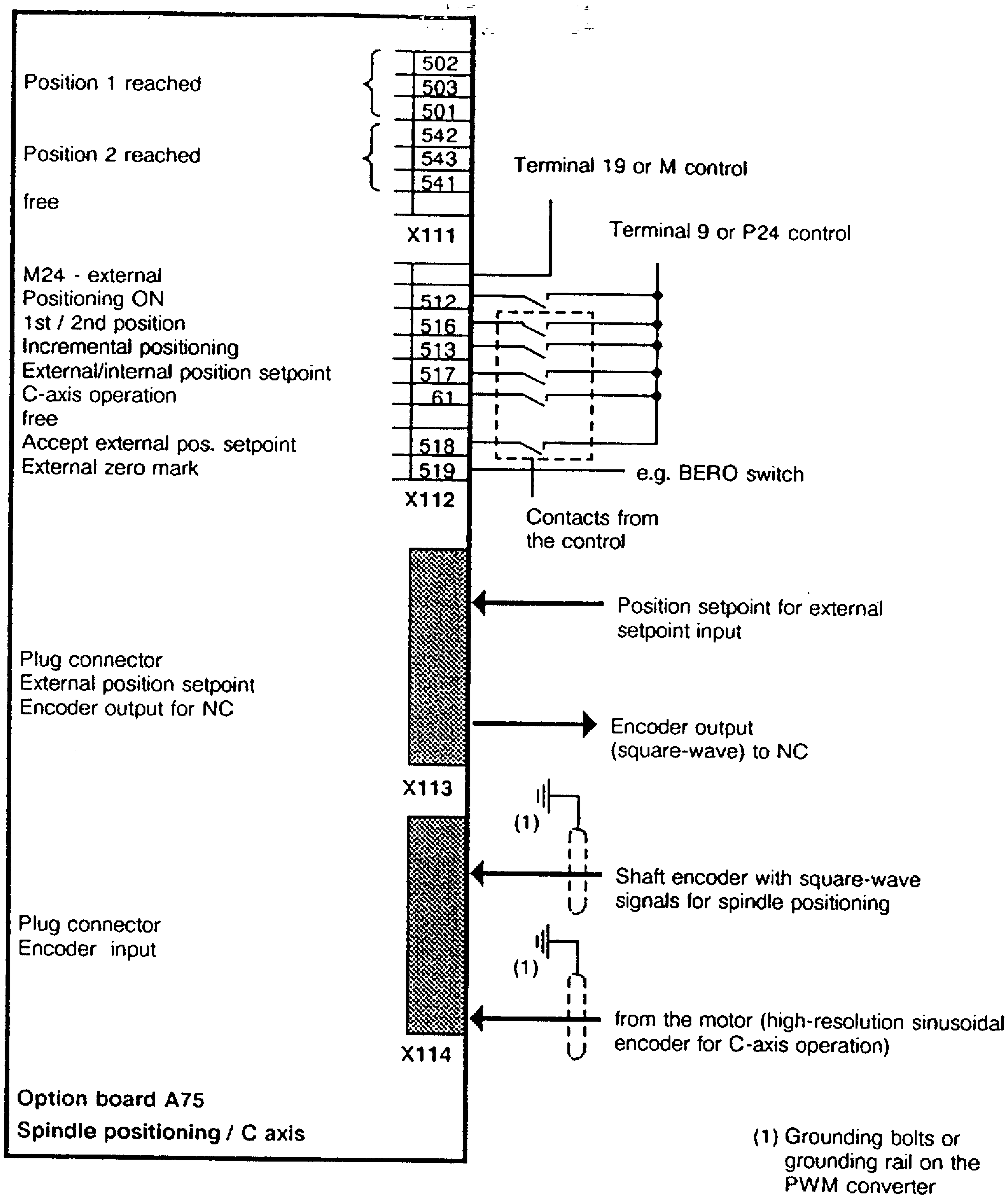


Fig. 4.6 Connecting option board S1

4.3 Interfaces

4.3.1 Relay signals

When designing external matching controls please note that the relays drop out when faults occur.

Board plug con. pin	Terminal No.	Contact	Explanations
Relay $n_{act} < n_x$			
G1 X141.6 X141.5 X141.4	216 214 215	NC I NO	Relay drops out if $n_{act} > n_x$. Can be set with parameters P23 to P26 (dependent on the gear stage).
Relay prewarning motor overtemperature (motor)			
G1 X141.9 X141.8 X141.7	210 208 209	NC I NO	The relay drops out when the motor overtemperature is reached. If this prewarning is not observed, and the temperature continues to increase, the converter is shutdown after approx. 4 min. with a fault signal.
Relay $T < T_x$			
G1 X141.1 X141.2 X141.3	109 108 110	NO I NC	The relay drops out for $T > T_x$. The setting via P-47 refers to the actual torque limiting, and is masked out for n_{set} change
Relay $n_{set} = n_{act}$			
G1 X131.8 X131.9 X131.10	127 126 128	NO I NC	The relay pulls in for $n_{set} = n_{act}$ taking into account the tolerance band set with parameter P-27. Speed fluctuations as a result of load changes do not cause the relay to switch.
Ready / fault relay			
G1 X131.4 X131.3 X131.2 X131.1	74 73.1 73.2 72	NC I I NO	Preselectable with parameter P-53.
Relay $n < n_{min}$			
G1 X131.7 X131.6 X131.5	116 114 115	NC I NO	The relay pulls in for $n < n_{min}$. Can be set with parameter P-21

4.3.2 Digital signals

Board plug con. Pin	Terminal No.	Function	Explanations
Input / output boards			
U1 X121.1 X121.2	9 19	P24 external M24 external	The auxiliary voltage is generated from the DC link voltage, and is thus only available after the DC link has charged up.
X121.3	63	Pulse enabling	If terminal 63 is disconnected from P24, the pulses are inhibited and the drive idles down to standstill.
X121.4	64	Closed-loop controller enable	If P24 is fed to terminal 64, the pulses for the power transistors and the closed-loop speed control are enabled. In the first starting phase (approx. 400 ms), the magnetic field must be built-up in the motor. The motor cannot provide its full torque until rated flux has been built up in this first phase. Thus, we recommend for time-critical applications (e.g. automatic tool changing), that the motor is stopped using terminal 81. If P24 is removed, the drive brakes corresponding to the ramp-down characteristics; when n_{min} is reached, the speed controller and pulses are internally inhibited.
X121.5	81	Ramp-function generator - fast stop	n_{set} is instantaneously set to zero if P24 is removed from terminal 81. The motor brakes along the torque limiting characteristic. The speed setpoint is held digitally at zero. The motor remains magnetized and can thus instantaneously run-up with its full torque after terminal 81 has been energized.
X121.6	62	Set ramp-up time to zero	The ramp-function generator is bypassed if P24 is connected to terminal 62.
X121.7	111	Torque limiting	Additional torque limiting is activated by connecting terminal 111.
X121.8	60	Oscillating	Oscillating setpoint is injected for gear change
X121.9 X121.10 X121.11	117 118 119[1)]	Gear stage 2 Gear stage 3 Gear stage 4	For example, the control parameters are changed over through terminals 117, 118 and 119
X121.12	158[1)]	Torque control	When terminal 158 is connected, torque control (open-loop) is selected instead of speed closed-loop control.
X121.13	R[1)]	Remote acknowledgement	Fault signal acknowledgement

1) Parameter function can be selected.

Board plug con. pin	Terminal No.	Function	Explanations
Option board			**(only for 6SC6500-0BA01 and 6SC6500-0BC01!)**
S1 X111.1 X111.2 X111.3	502 503 501	NO Position 1 I reached NC	The relay pulls in if the position setpoint is reached. The bandwidth can be selected with parameter P-144.
X111.4 X111.5 X111.6	542 543 541	NO Position 2 I reached NC	The relay pulls in if the position setpoint is reached. The bandwidth can be selected with parameter P-145.
Option board			**(X112.1 to 9 only for 6SC6500-0BA01!) (X112.1 and .6 only for 6SC6500 0BB01!) (X112.1 to 5, .8 and .9 only for 6SC6500-0BC01!)**
S1 X112.1		M24 external	Must be connected to terminal 19 or M control, depending on the P24 source
X112.2	512	Positioning ON	The drive travels to the set position. H ≙ positioning on.
X112.3	516	1st/2nd position	Select first and second position. H ≙ 2nd position
X112.4	513	Incremental positioning	When 24 V is connected, the setpoint input in P-127 is added to the current position and the drive approaches this new position. Condition: Relay 2 signals that the position has been reached
X112.5	517	External/internal positioning setpoint	L = External position setpoint (X112) H ≙ Internal position setpoint (P-121 to P-127)
X112.6	61	C-axis operation	H ≙ C-axis operation ON
X112.7		free	
X112.8	518	Accept external position setpoint	H ≙ Accept position setpoint. The position setpoint is accepted at the change from L to H, and is executed at the next position command.
X112.9	519	External zero mark	Zero is recognized at the change from L to H.

Board plug con. pin	Terminal No.	Function	Explanations
Option board			**(S1 X113.1 up to 16 not for 6SC6500-0BB01!)**
S1 X113.1		Bit 0	External position setpoint
X113.2		Bit 1	
X113.3		Bit 2	
X113.4		Bit 3	
X113.5		Bit 4	
X113.6		Bit 5	
X113.7		Bit 6	
X113.8		Bit 7	
X113.9		Bit 8	
X113.10		Bit 9	
X113.11		Bit 10	
X113.12		Bit 11	
X113.13		Bit 12	
X113.14		Bit 13	
X113.15		Bit 14	
X113.16		Bit 15	
X113.17		free	
X113.18		A	Encoder output for NC
X113.19		A, inverted	
X113.20		0	
X113.21		B	
X113.22		B, inverted	
X113.23		0, inverted	
X113.24		P6	
X113.25		M6	
Option board			**(S1 X114.1 up to .6 not for 6SC6500-0BB01!)** **(S1 X114.9 up to . 15 not for 6SC6500-0BC01!)**
S1 X114.1		M6	Encoder power supply
X114.2		P6	
X114.3		Zero, inverted	Square-wave generator input
X114.4		B, inverted	
X114.5		B	
X114.6		Zero	
X114.7		A, inverted	
X114.8		A	
X114.9		Inner screen	High-resolution sinusoidal-cosinusoidal generator input
X114.10		Zero	
X114.11		cosin., inverted	
X114.12		Cosinusoidal	
X114.13		Zero, inverted	
X114.14		Sinus., inverted	
X114.15		Sinusoidal	

4.4 Cable connections

The only cables required between the AC motor and the PWM converter are the shaft encoder cable and the power cables (individual conductors or cables, including ground conductor).

A 16-core screened cable with twisted pairs must be used for connecting the shaft encoder to the PWM converter. The NTC thermistor signals are also transmitted through this cable (Fig. 4.6). The shaft encoder cable can have a maximum length of 50 m.

The shaft encoder cable screening must be correctly connected to the PWM converter (refer to Section 4.2.2 and Pages 4-18). In order to prevent ground loops, the shaft encoder cable screen must be connected to pin H of the motor-side connector and the screen must not be connected to the housing of the motor connector.

The PWM converter connectors are part of the scope of the supply of the PWM converter.

With the "C-axis" option, cable 6FC9348-0B must be used to transmit the signals from the high-resolution encoder. Fault-free signal transmission, and thus drive reliability, can only be guaranteed when this 6FC9348-0B cable is used.

The signals from the motor shaft encoder can also be transmitted directly from the converter through the 6FC9 348-5XB adaptor cable for a higher-level closed-loop position control, with the corresponding option.

Accessories	Order No.	Length
Shaft encoder cable 8 x 2 x 0.18 mm^2 screened, with twisted pairs, without plug connector	6FC9343-0AA	(Available by the meter)
Shaft encoder cable 8 x 2 x 0.18 mm^2 screened, with drill pairs, with plug connector	6FC9348-0A B to G 1)	5 to 50 m
Adaptor cable for connecting to the SINUMERIK measuring circuit cable	6FC9348-5XB	0.65 m
Shaft encoder cable for high-resolution encoder	6FC9348-0B B to F 1)	5 to 25 m
15-pin subminiature socket connector for connecting to the PWM converter,	6FC9348-7AA	-
17-pin socket connector for connecting to the AC motor,	6FC9341-1AC	-
Round plug connector for connecting to the SINUMERIK measuring circuit cable	6FC9341-1FC	-
Connecting cable between the programming unit and the interface block	6FC9344-1A	10 to 30 m

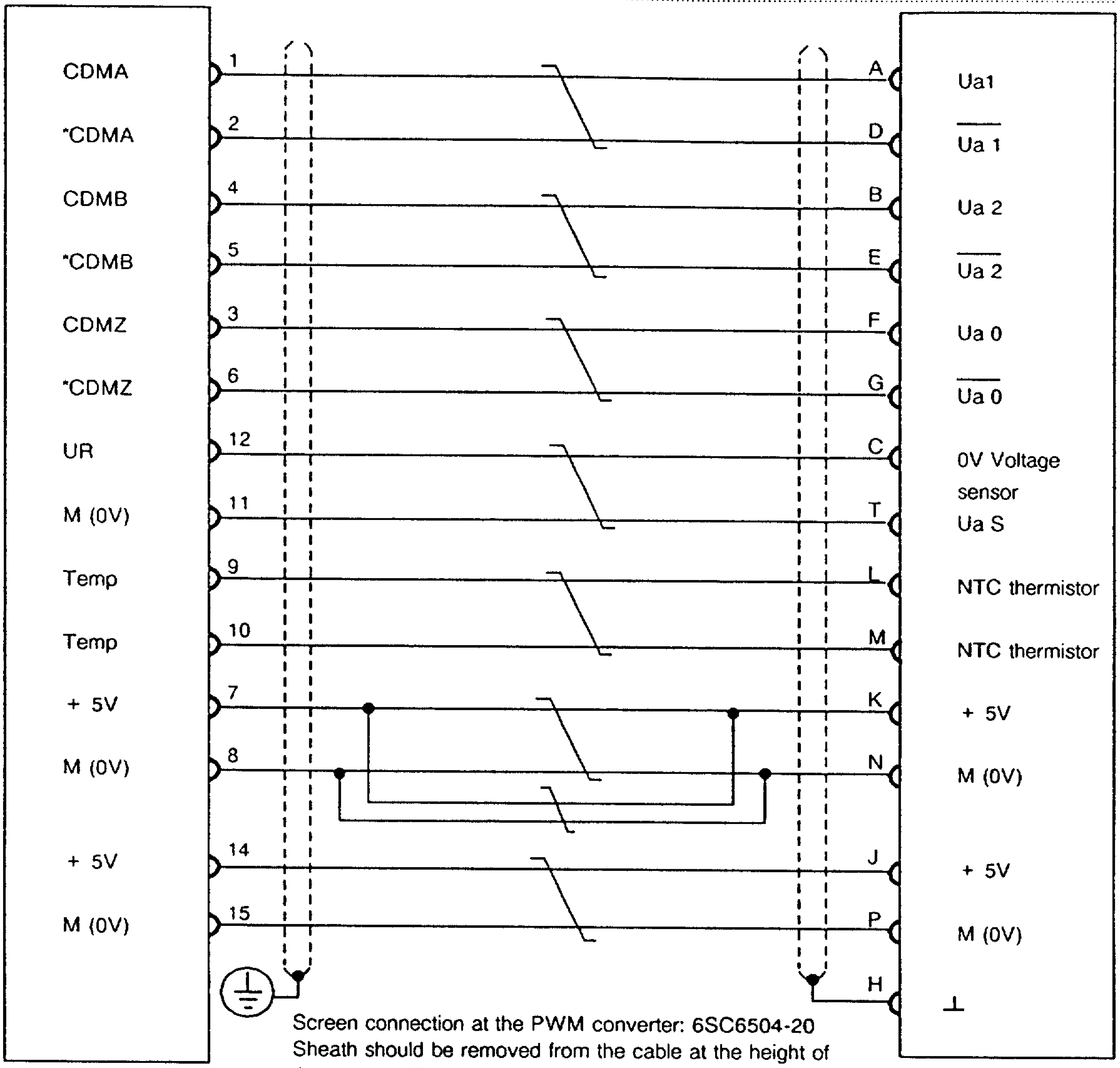
Table 4.3 Accessories

*1) Cable lengths B = 5 m C = 10 m D = 15 m E = 18 m
H = 20 m F = 25 m J = 30 m G = 50 m*

Cable name: Shaft encoder cable
Order No.: **6FC9 348-0A☐**

SIMODRIVE: 650
Board location: U1, Input/output board
Board connector: X131

AC motor
6FC9 341-1AC

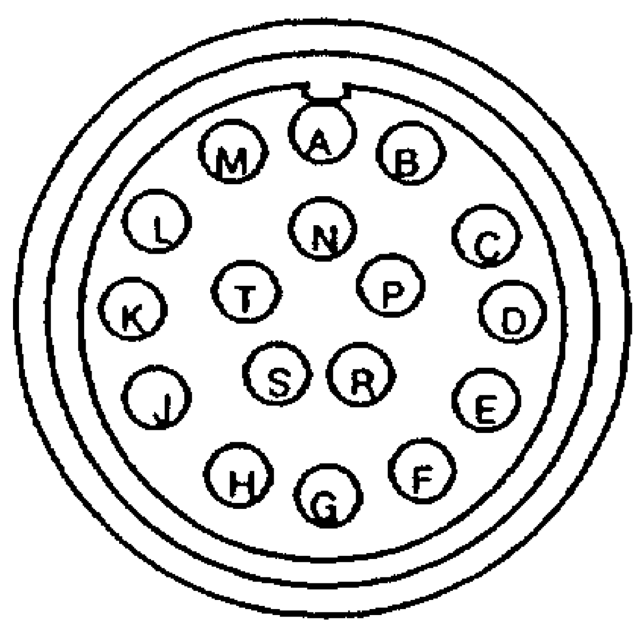


Screen connection at the PWM converter: 6SC6504-20
Sheath should be removed from the cable at the height of the screen rail, and the screen should be electrically connected to the screen rail (simultaneous strain relief).
6SC6502/30: Route screen to X131 of the G01 board

PWM converter
Connector X131

Connector
17-pin, socket
ITT Cannon
CA 08-20-295
Connecting side

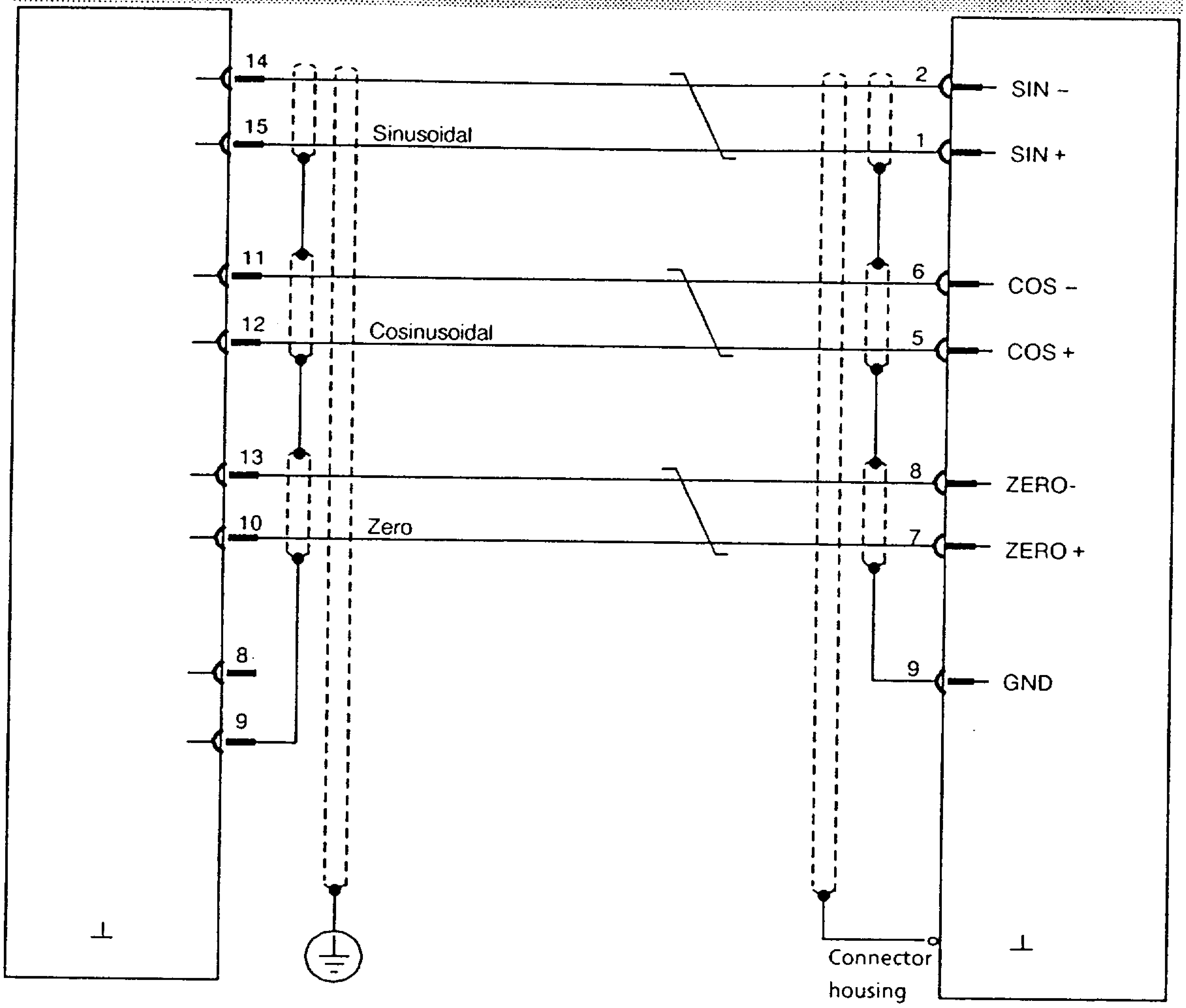
6 FC9 341 - 1AC



Cable No.: Shaft encoder cable for high-resolution encoder
Order No.: **6FC9 348-0B□**

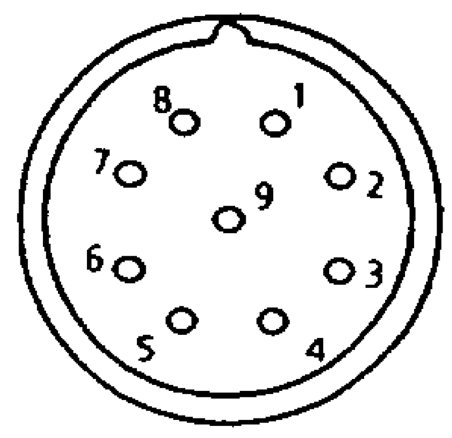
SIMODRIVE: 650
Board location: U1, input/output board
Board connector: X114

AC motor
6FC9 341-7AU



PWM converter
Connector X114
6FC9348-7AK

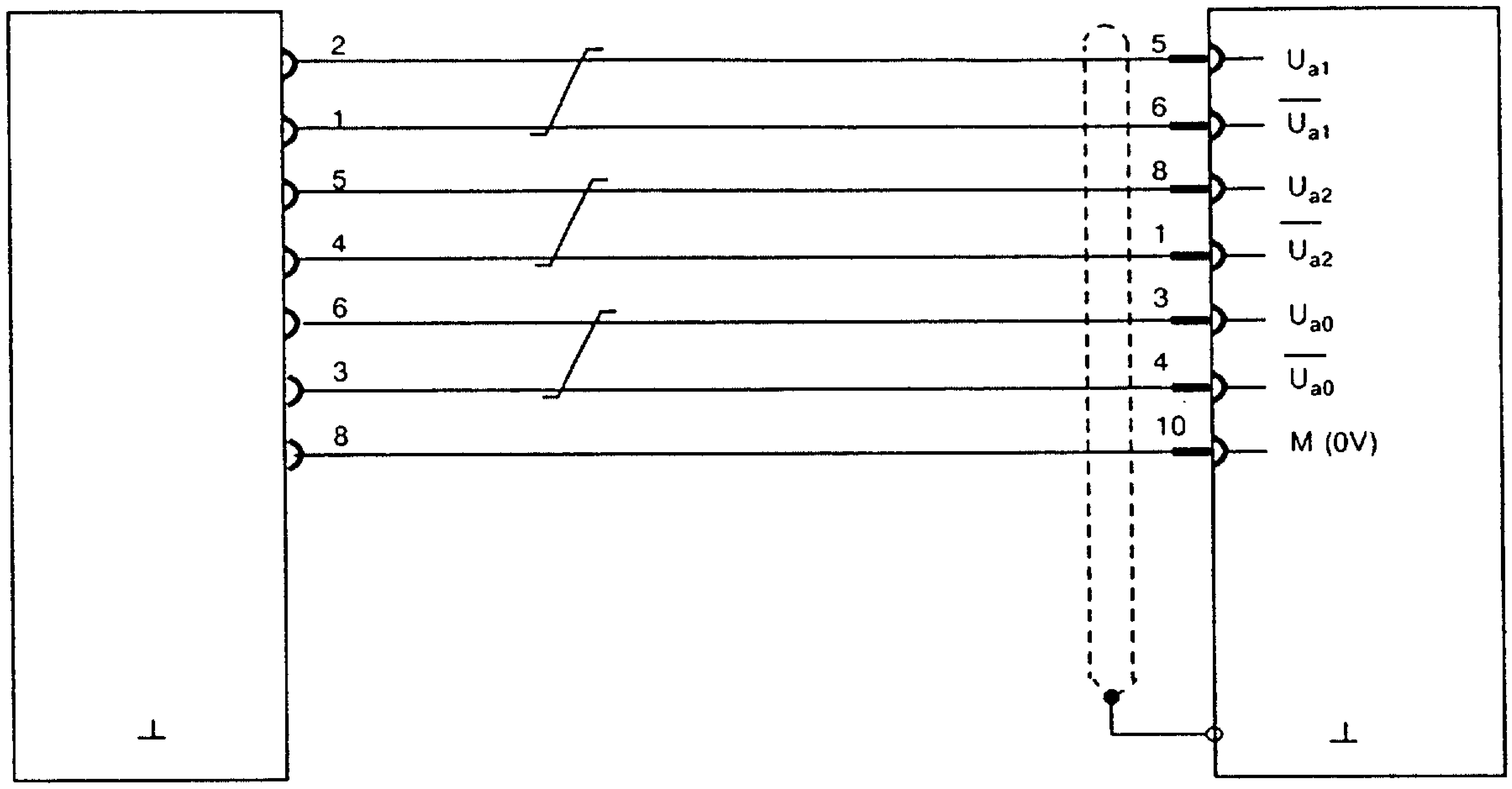
Connector
9-pin socket
SIEMENS
8 mm cable diameter
Connecting side



6 FC9 341 - 1AU

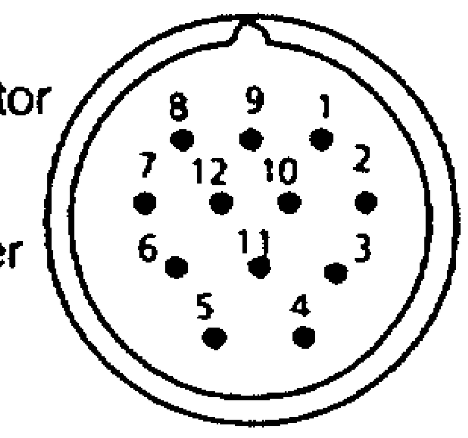
Cable name: Adaptor cable for connecting to the SINUMERIK measuring circuit cable
Order No. : **6FC9 348-5XB**

SIMODRIVE : 650 **SINUMERIK**
Board location : U1
Board pug connector : X321



10-pin ribbon cable flat connector,
according to DIN 41651
Plug connector X231 (6FC9 348-7AH)

Connector
12-pin, plug connector
SIEMENS
6 mm cable diameter
Connecting side
6 FC9 341 - 1FQ

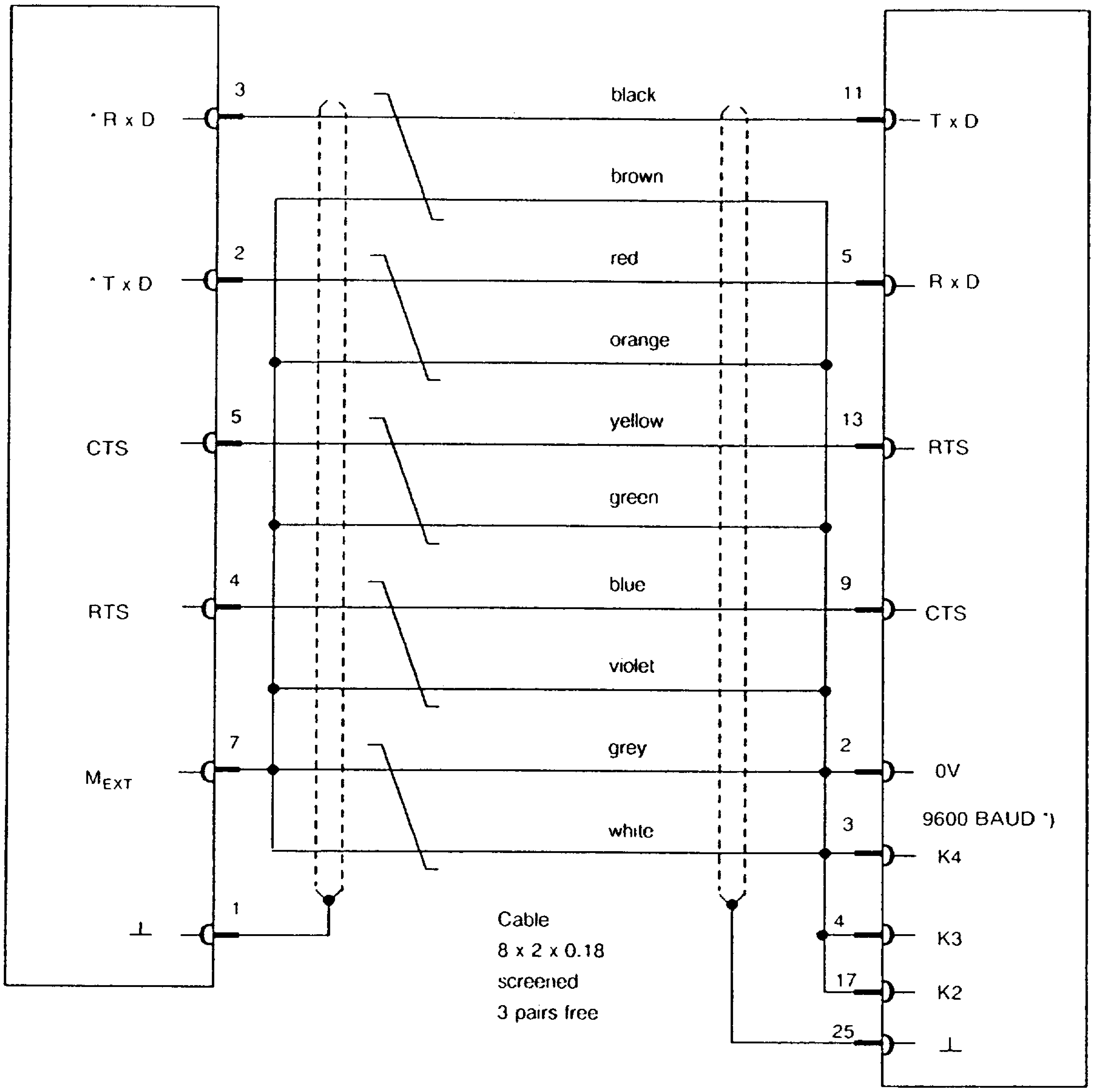


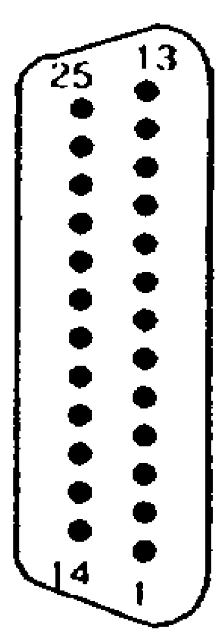
An adaptor cable can be used for connecting to the SINUMERIK measuring circuit cable if the shaft encoder output (connector X231 on input/output board U1) is used.

Cable name: Data line PG 675/PG 685/PG 635 (SINUMERIK-PG IN)
Order No. : 6FC9 344-1A.

SIMODRIVE 650
Board location : Interface block
Board connector :

PG 675/685
Plug connector
Printer (V.24)



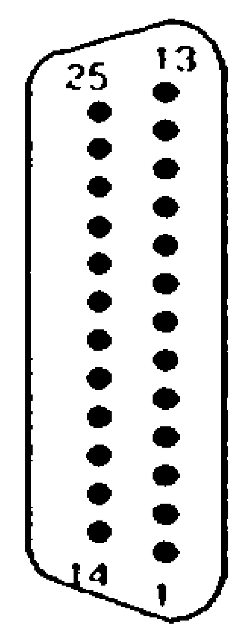


Connector
Position 1 below
D - Sub
25-pin plug connector
Connecting side
Housing with shift lock

6FC 9 341 - 2AA
Designation: NC

*) 9600 baud transmision rate is selected by connecting K1, K2, K3 and ground (0V) at the PG connector.

Connector
Position 1 below
D - sub
25-pin plug connector
Connecting side
Connector housing
6FC 9 341 - 1ES
Designation: PG D



[illegible] Siemens 5800 Office System.

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5 Change gearboxes for AC motors

5.1 Application

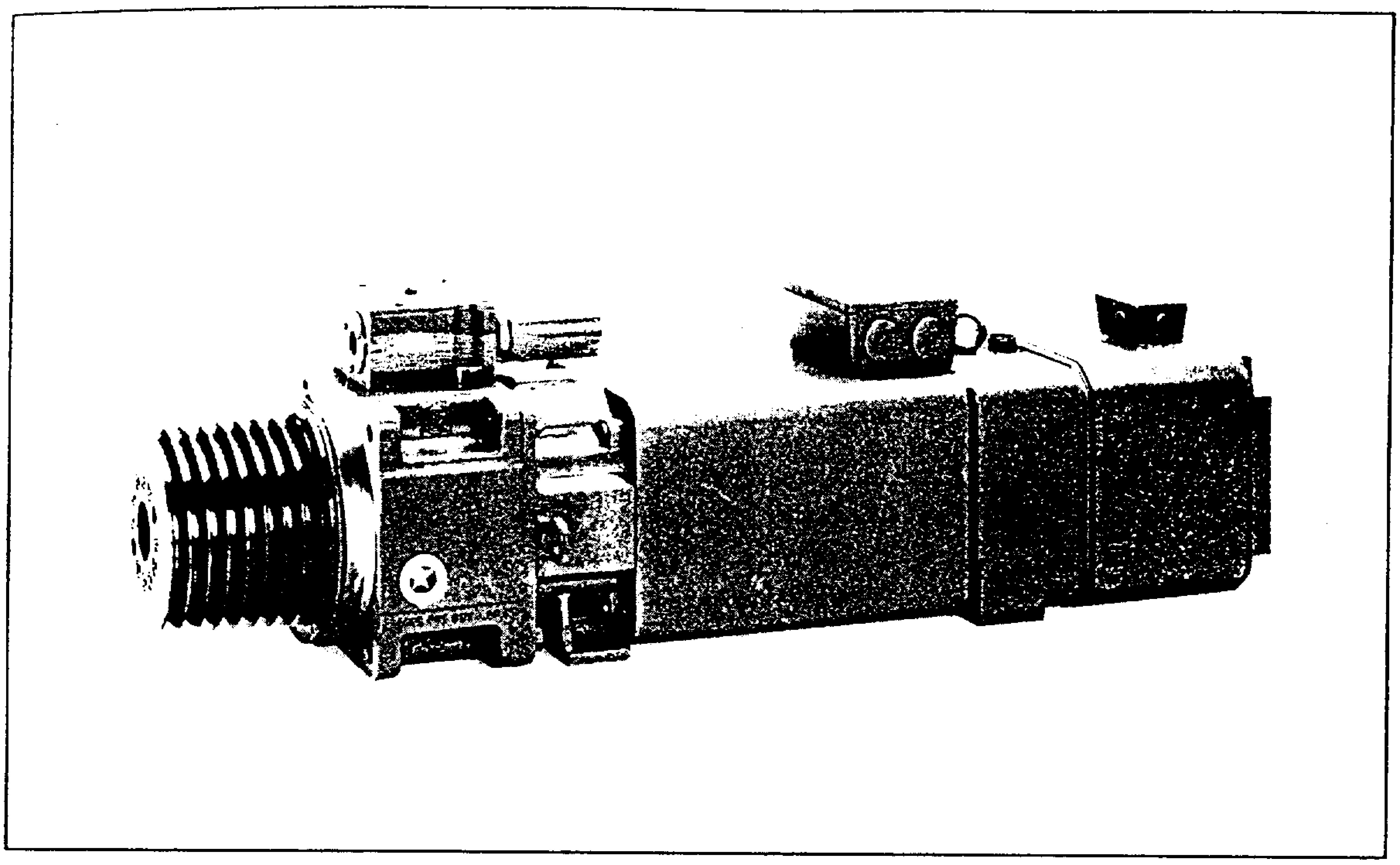


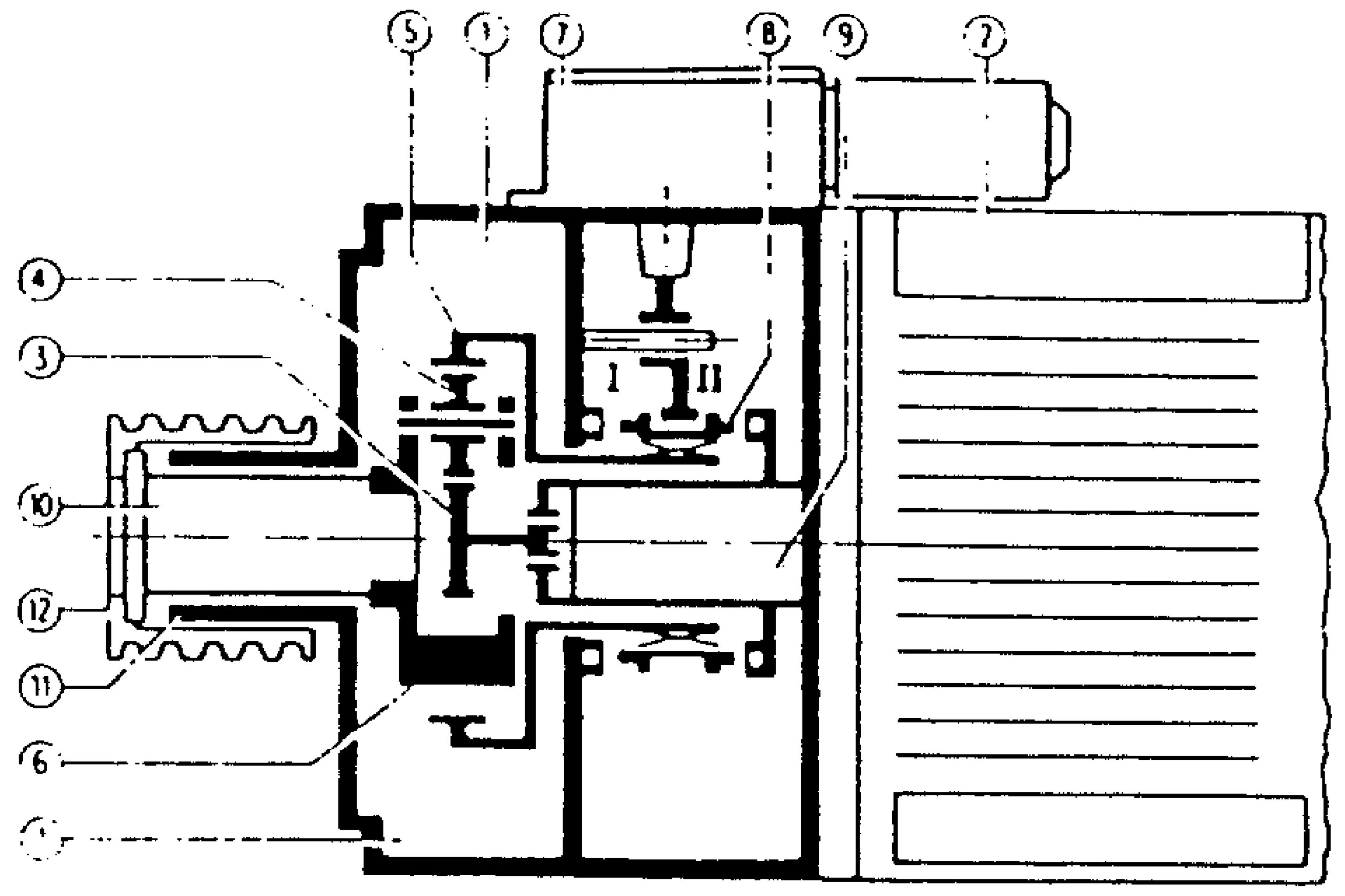
Fig. 5.1 AC motor (15 kW) with ZF gearbox as compact drive unit

A wide speed range at constant drive power is obtained with the gearbox mounted on the AC motor.

The following advantages are provided by locating the gearbox outside the machine tool spindle box, :

- *gearbox oscillations are not transmitted to the main spindle, and thus the machining quality is not diminished*
- *Good adaption to the machine tool*
- *No noise and no temperature drift as a result of the gearbox in the spindle box*
- *Separate lubrication system for the main spindle and the gearbox*
- *High gearbox efficiency (over 95 %)*
- *Only one belt drive necessary*
- *The drive unit (motor and gearbox) has IMB35 type of construction, and can thus be mounted in B3/B5 and IMV1*
- *The drive power can be transmitted through a gear wheel or a flexible coupling from the gearbox output, instead of through belts.*

5.2 Design



1 Gearbox housing
2 Siemens AC motor
3 Sun wheel
4 Planetary wheel
5 Annular wheel
6 Flange
7 Gear change unit
8 Sliding sleeve
9 Motor shaft
10 Gearbox output shaft
11 Output housing
12 Pulley

Fig 5.2 Gearbox design

The change gears are planetary gears. The unit is relatively compact as, with this gear system, the power from the central sun wheel is distributed over several planetary wheels. The gear shifting unit, an axially shifted, toothed sliding sleeve, is form-locking.

The following is valid for the change gear:

Gear position I : $i_1 = 4$ Gear position II: $i_2 = 1$

Both gear positions are electrically monitored by limit switches S1 and S2. The gearboxes are suitable for both directions of rotation.

The gearboxes are directly flanged to the drive end of AC motors, IM B35 type of construction, which are prepared for gearbox mounting. IM V1 type of construction is also available.

The compact drive unit can be centered using diameter a_{12}. The gearbox output is coaxial with the motor shaft.

The gearboxes have, as standard, a play of 30 to 40 minutes at the output, whereby the gear position has almost no effect on the play. Special-design change gears have a maximum play of 25 minutes.

- **Belt pulley**

  The belt pulley is designed as cup wheel. The gearbox output shaft has a flange for external centering and threaded holes for mounting the belt pulley. This ensures easy mounting and removal of the pulley.

  The complete drive should be designed as stiff as possible using large belt cross-sections. Depending on the particular application and power, then for instance, the SPB belt profile, according to DIN 2211, Sheet .1, has a positive effect on the smoothness of the complete drive.

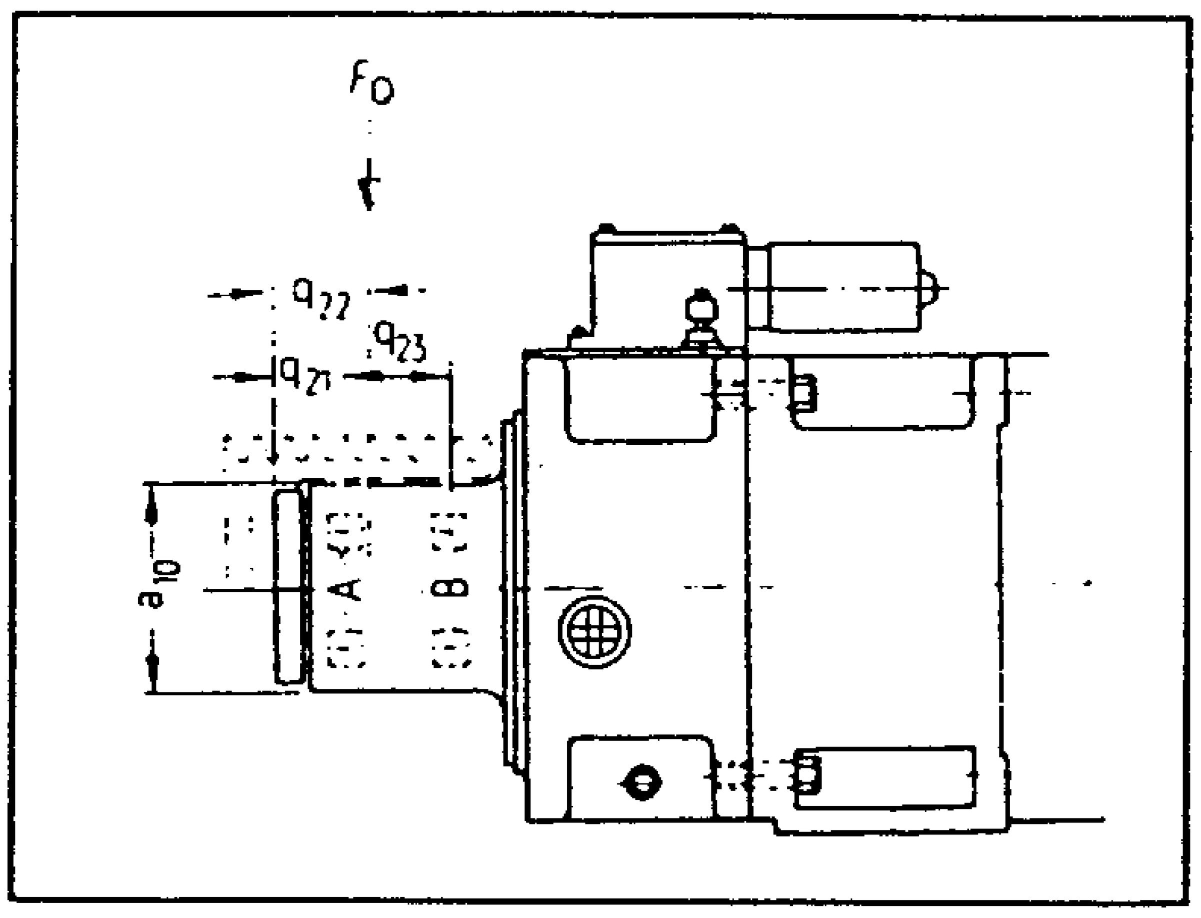
- **Gearbox output housing**

  Change gears for mounting on AC motors, size 100, have an output housing with diameter $a_{10} = 82$ mm.

  For change gears for AC motors, sizes 132 and 160, there are two different output housings with diameters $a_{10} = 116$ mm or $a_{10} = 140$ mm.

- **Bearing assignment for permissible cantilever forces F_Q**

  The following roller bearings are installed in the gear output shafts of the change gear:



Output housing size (Dimension a_{10}) [mm]	Bearing for change gear with $i_1 = 4$ in Position A	Position B
82	RNU 2206 EC	NUP 206 EC
116	RNU 308 E	NUP 209 E
140	RNU 309 E	NUP 211 E

Fig. 5.3 Bearing positions A and B

With this information, the service life of the gearbox output shaft bearing can be determined by the user himself by selecting location, diameter and speed of the belt pulley.

The line of action of cantilever force F_Q (belt tension) under operating conditions, must lie in the vicinity of q_{23}. This assumption is also made when designing the bearings.

- **Holding brake**

The change gearboxes can also be equipped with a holding brake (single-disk brake) for holding the gearbox output shaft, and thus the main spindle stationery. This electromagnetic single-disk brake is a magnetically operated brake. The solonoid core is incorporated into the gear output drive housing. The holding brake cannot be retrofitted.

Drive with motors of size	Holding torques of the brakes under dry conditions
100	40 Nm
132	90 Nm
160	90 Nm

The holding brake armature disk must be mounted on the front of the belt pulley. The air gap (dimension q_{44}) should be set between 0.4 to 1.0 mm depending on the size.

The holding brake is connected to 24 V DC; the polarity of the plug-in contacts is irrelevant.

The holding brake must be released (no current) during gear changing and when the motor is running, and can only be operated when the motor is stationary.

5.3 Gear changing

During gear changing the motor must change direction approximately 5 times per second. However, the gears mesh mostly at the first rotation change, so that the shift time is approximately 300 to 400 ms. Terminal 60 ("oscillation") is provided on the transistorized PWM converter in order to attain the necessary oscillation.

The mechanical gear change is realized using a gear change unit on the gearbox. The gear change unit is operated from a DC motor, which requires a separate power supply (24 V DC).

Gear changing must be monitored using a time relay, which reverses the change after 2 s, if the change command was not able to be executed. A 10 s time limit should be provided for approximately 4 to 5 further attempts.

Gear change without oscillation at low speed (creep speed) or at standstill should be prevented as it does not permit perfect gear changing.

The motor can only be started 200 ms after the gear change operation has been completed.

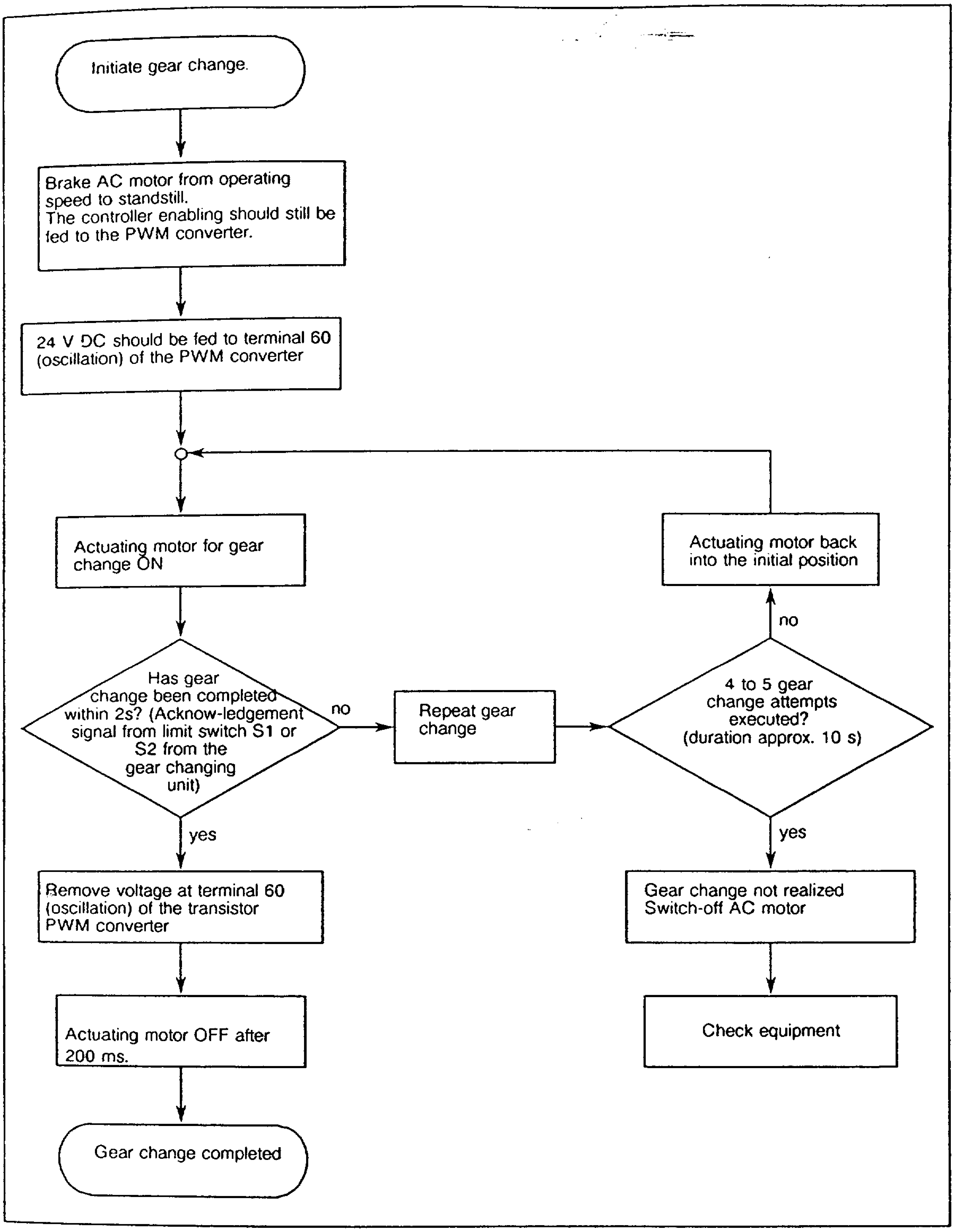


Fig. 5.4 Gear change sequence

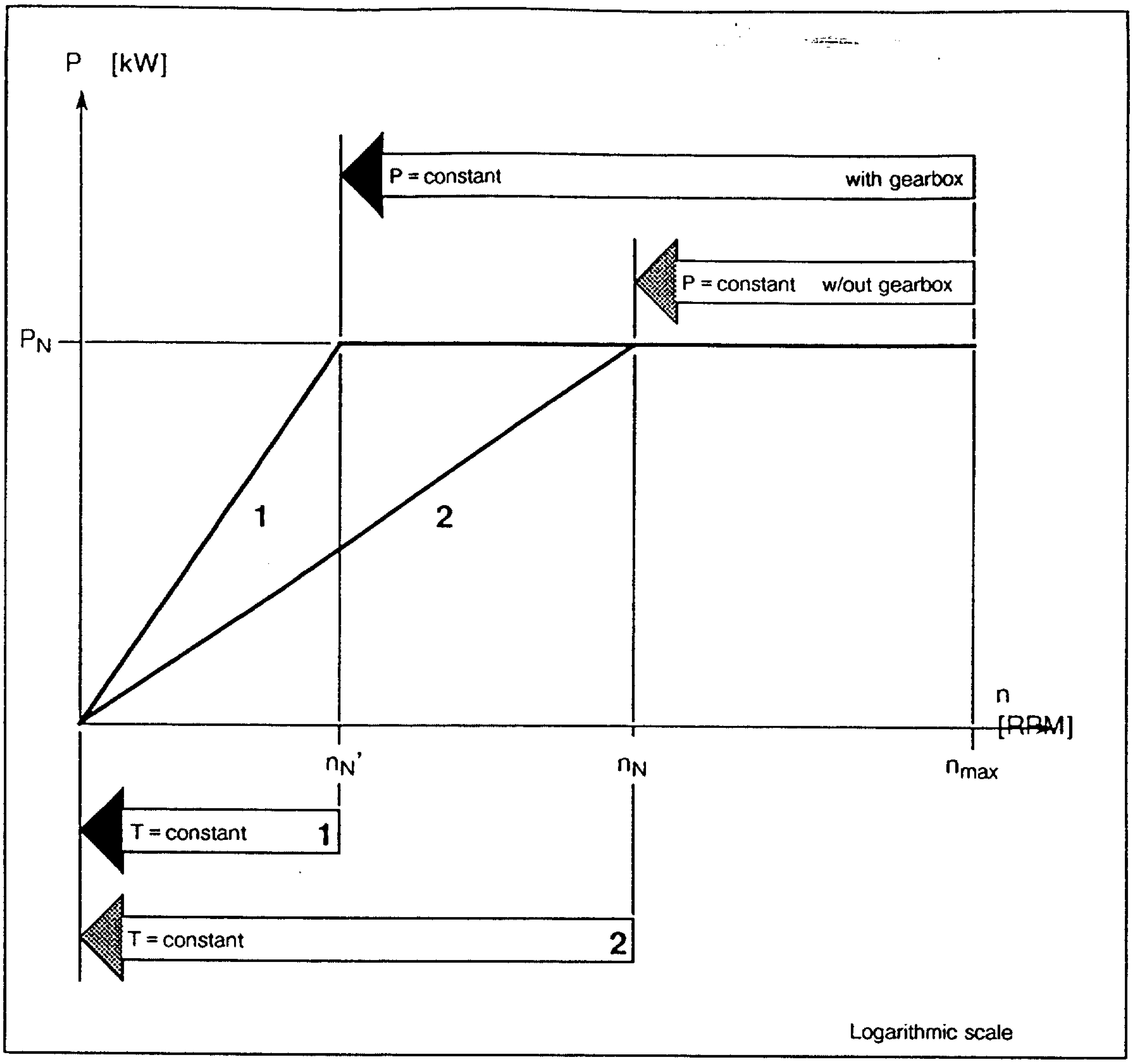


Fig. 5.5 Speed-power characteristic when using a two-stage gearbox for extending the constant power speed range for main spindle drive AC motors

n_N	Rated speed
n_N'	Rated speed with two-stage gearbox
n_{max}	Maximum permissible speed
P_N	Rated power and also constant power of the AC motors in the speed range from n_N to n_{max} bzw. n_N' to n_N
T	Torque

Example:

AC motor without gearbox: A constant power control range exceeding 1:4 is possible with P = constant from n_N = 1500 RPM to n_{max} = 6300 RPM.

Same AC motor with gearbox: A constant power control range greater than 1:16 is possible for gear stage $i_1 = 4$.
(n_N' = 375 RPM to n_{max} = 6300 RPM)

5.4 Lubrication

The gearboxes have splash lubrication. The oil level can be checked using sight glasses on both sides of the gearbox. Lubricating oil must be filled to the center of the sight glass when the drive is in the horizontal and vertical position.
An angular oil level indicator must be mounted if the gearbox is mounted at an angle. The required oil level should be marked on this. Oil drain screws should be located on both sides.

HLP oils, with viscosity classification ISO-VG 68 (lower viscosity limit), with good aging characteristics and additives to increase the corrosion and wear protection should be used for lubrication

When the gearbox is flange mounted to the motor, some of the heat generated in the gearbox, is transferred to the motor housing. Depending on the machine mechanical design, a machine housing temperature rise can affect the machining accuracy. In these cases, we recommend forced oil lubrication system whose effectivity can be improved by oil cooling.

With the forced oil lubrication, a flow of approx. 1 l/min. should be injected through the oil drain hole. A pressure of 0.5 bar to 2 bar is obtained, depending on the oil viscosity. The oil can be fed through the holes for the oil sight glasses with a sufficiently high drain cross-section.

A forced oil lubrication system should be provided for vertical mounting, so that heat can be dissipated from the gearbox.

Special oil circulating conduits, in some cases dependent on the mounting, can be provided on request.

The measures necessary to dissipate the heat can be most accurately determined with a test run on the machine, as the heat generated in the gearbox is dependent on the speed and the operating time.

Gearbox for motor sizes	Necessary oil quantity in the gearbox	
	horizontal	vertical
Shaft height 100	0.8 Liter	0.5 Liter
Shaft height 132	2.0 Liter	1.0 Liter
Shaft height 160	3.5 Liter	1.5 Liter

5.5 Technical data

Gearbox with $i_1 = 4$	Weight of two-stage gearbox with output housing		
	$a_{10} = 82$ mm approx. [kg]	$a_{10} = 116$ mm approx. [kg]	$a_{10} = 140$ mm approx. [kg]
w/out holding brake	28	52	55
with holding brake	29	54	57

5.6 Circuit diagram

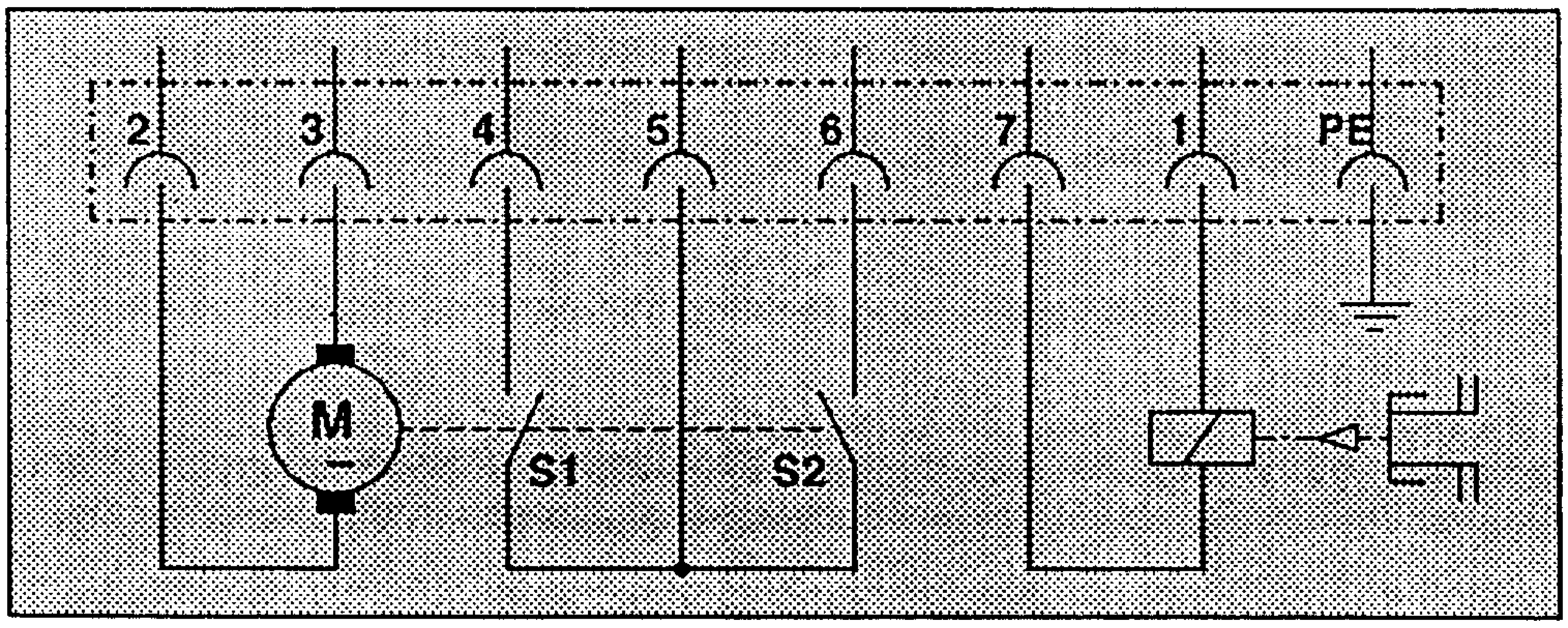


Fig. 5.6 Circuit diagram for gear change circuit

Connected through Harting 7-pin + PE plug connector, Type HAN 7D (connector is part of the scope of supply).

Plug connector contact No.	No. and designation	In-put	Out-put	Voltage	Current
2 and 3	1 actuating motor	o	–	24 V DC	$I_{max} = 5$ A (in-rush current)
4 to 6	2 limit switches	o	o	24 V DC $U_{max} = 42$ V DC	$I_{max} = 5$ A
1 and 7 (optional)	1 holding brake (open-circuit actuated)	o	–	24 V DC	$I \approx 2$ A

Control sequence for gear change	Connector contact No.			
	2	3	4/5 (S1)	5/6 (S2)
for change from stage i_2 to i_1				
a Initial position (f) b Actuating motor runs c Mechanical change runs to end stop*)	+24 V DC	0 V	0 0 L	L 0 0
for change from stage i_1 to i_2				
d Initial position (c) e Actuating motor runs f Mechanical change runs to end stop (a)*)	0 V	+24 V DC	L 0 0	0 0 L

*) A limit switch (S1 or S2) issues a signal to the control to switch-off the actuating motor after the change operation
L Contact closed
0 Contact open

5.7 Dimension sheet

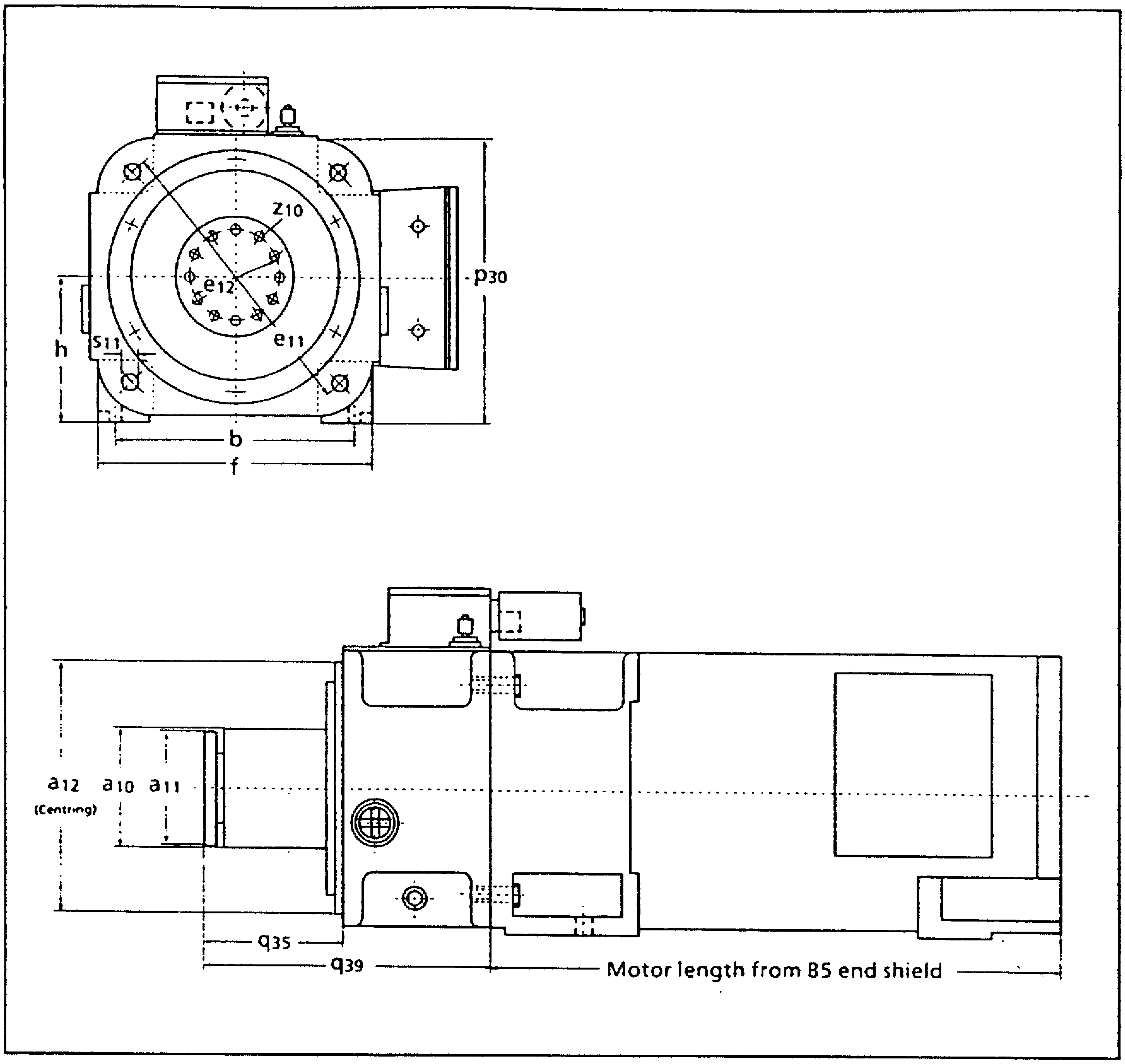


Fig. 5.7 AC motor with gearbox

AC motor, size	Output housing Size	Dimensions in mm a_{10}	a_{11} k6	a_{12} g6	b	e_{11} ±0.2	e_{12} ±0.2	f	h	p_{30}	q_{35}	q_{39}	s_{11}	z_{10}	Threaded holes Number
100	**82**	82	85	190	160	215	65	197	100	202	126	257	14	M8	8×45°
132	**116** **140**	116 140	118 130	250	216	300	100	258	132	264	171	321	18	M12	12×30°
160	**116** **140**	116 140	118 130	250	254	350	100	314	160	321	171	321	18	M12	12×30°

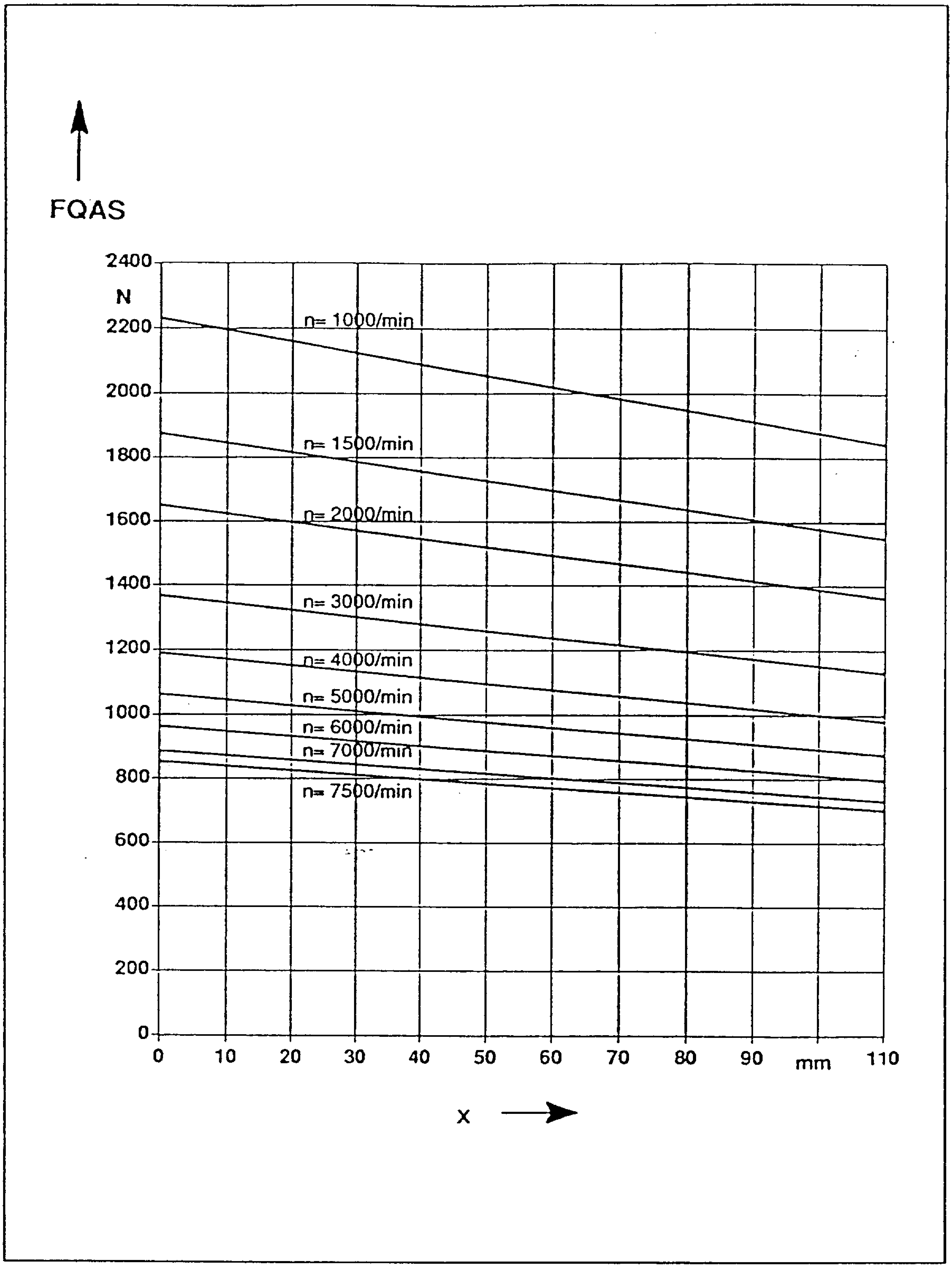


Fig. 6.44 Cantilever force chart for 1PH6 13□-4 AC motors, with single-bearing design

Fig. 6.45 Cantilever force chart 1PH6 13□-4 AC motors, with spindle bearing

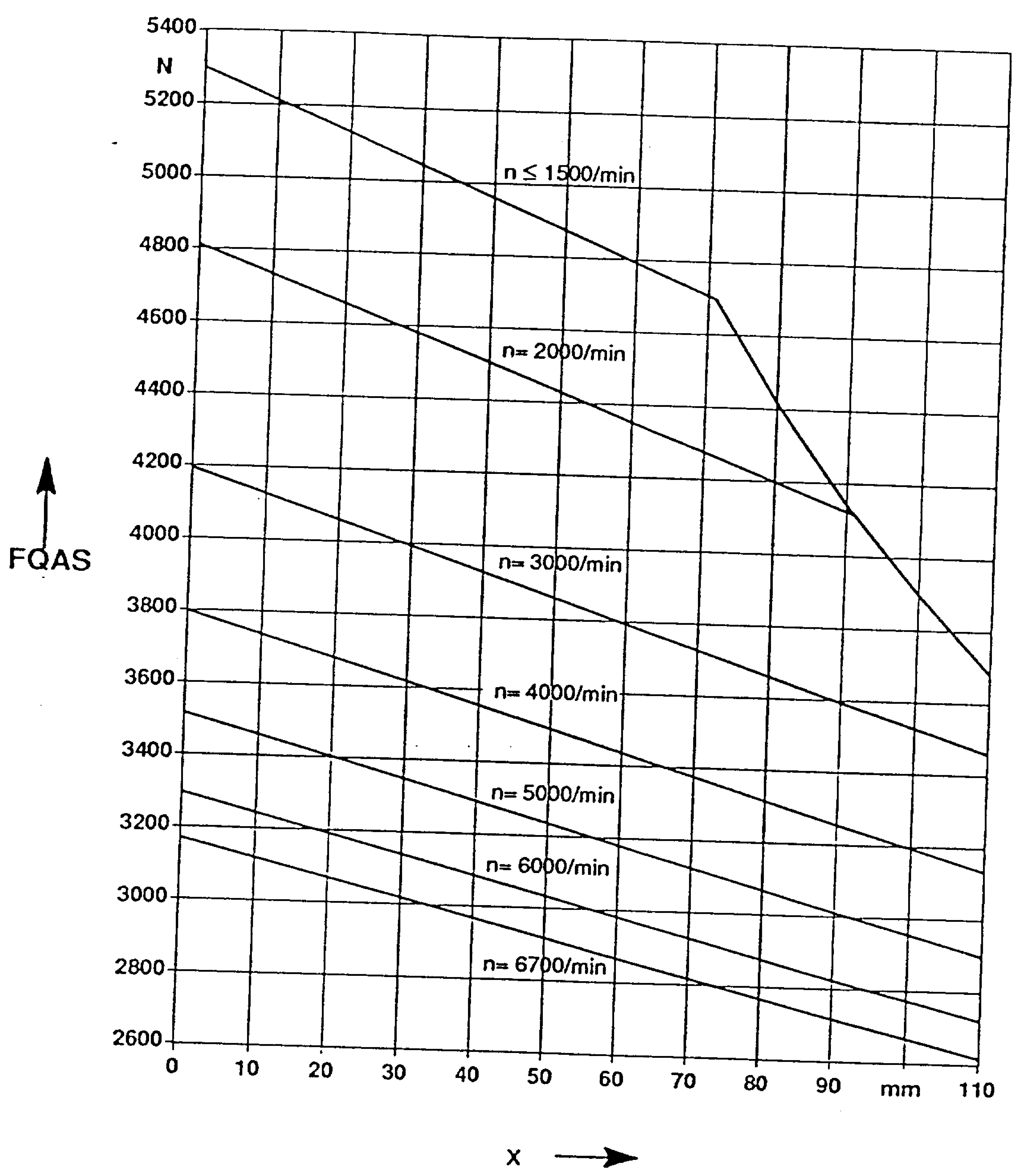


Fig. 6.46 Cantilever force chart for 1PH613□-4 AC motors, with double-bearing design

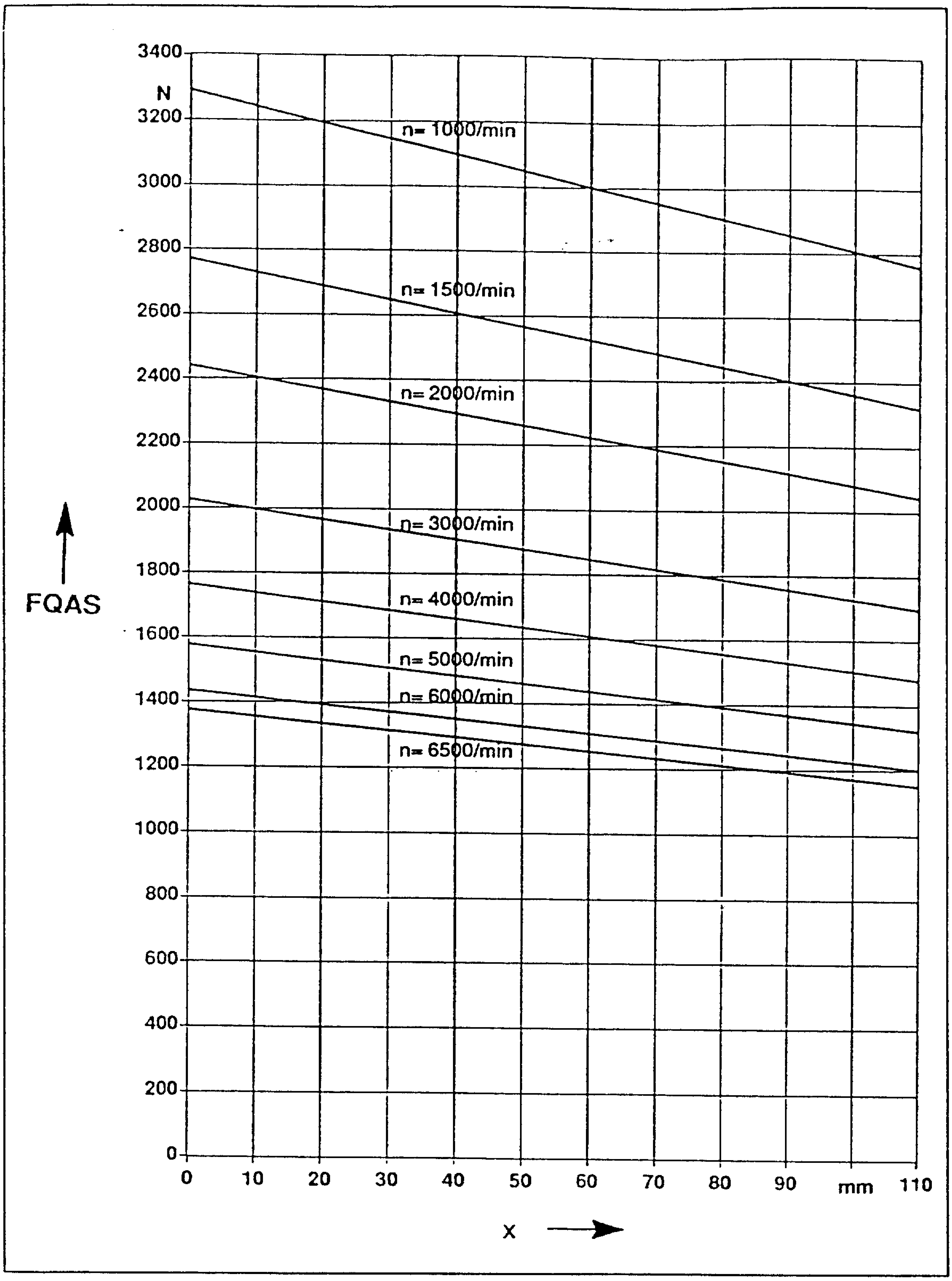


Fig. 6.47 Cantilever force chart for 1PH616□-4 AC motors, with single-bearing design

Fig. 6.48 Cantilever force chart for 1PH6 16□-4 AC motors, with spindle bearing

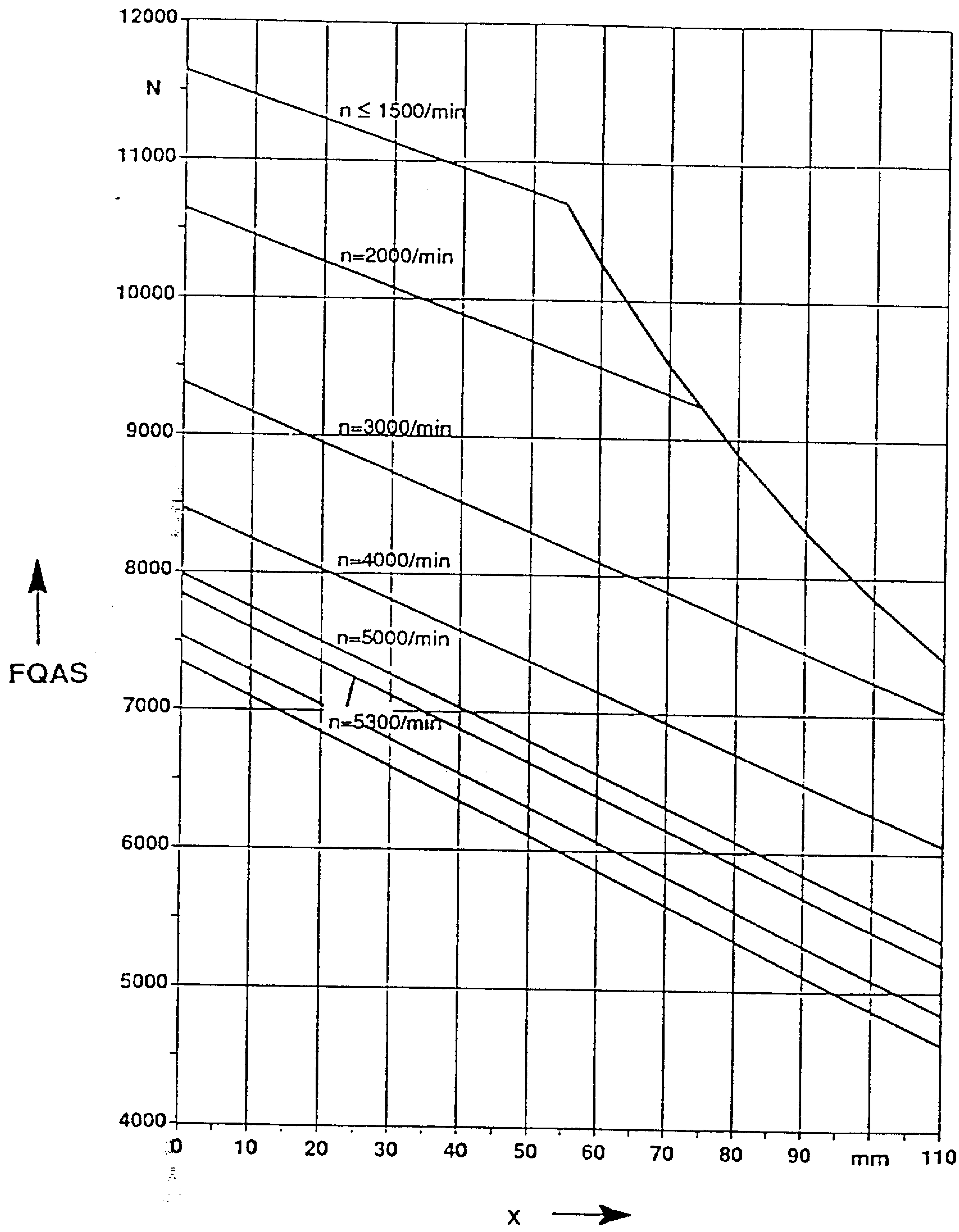


Fig. 6.49 Cantilever force chart for 1PH6 16□-4 AC motors, with double-bearing design

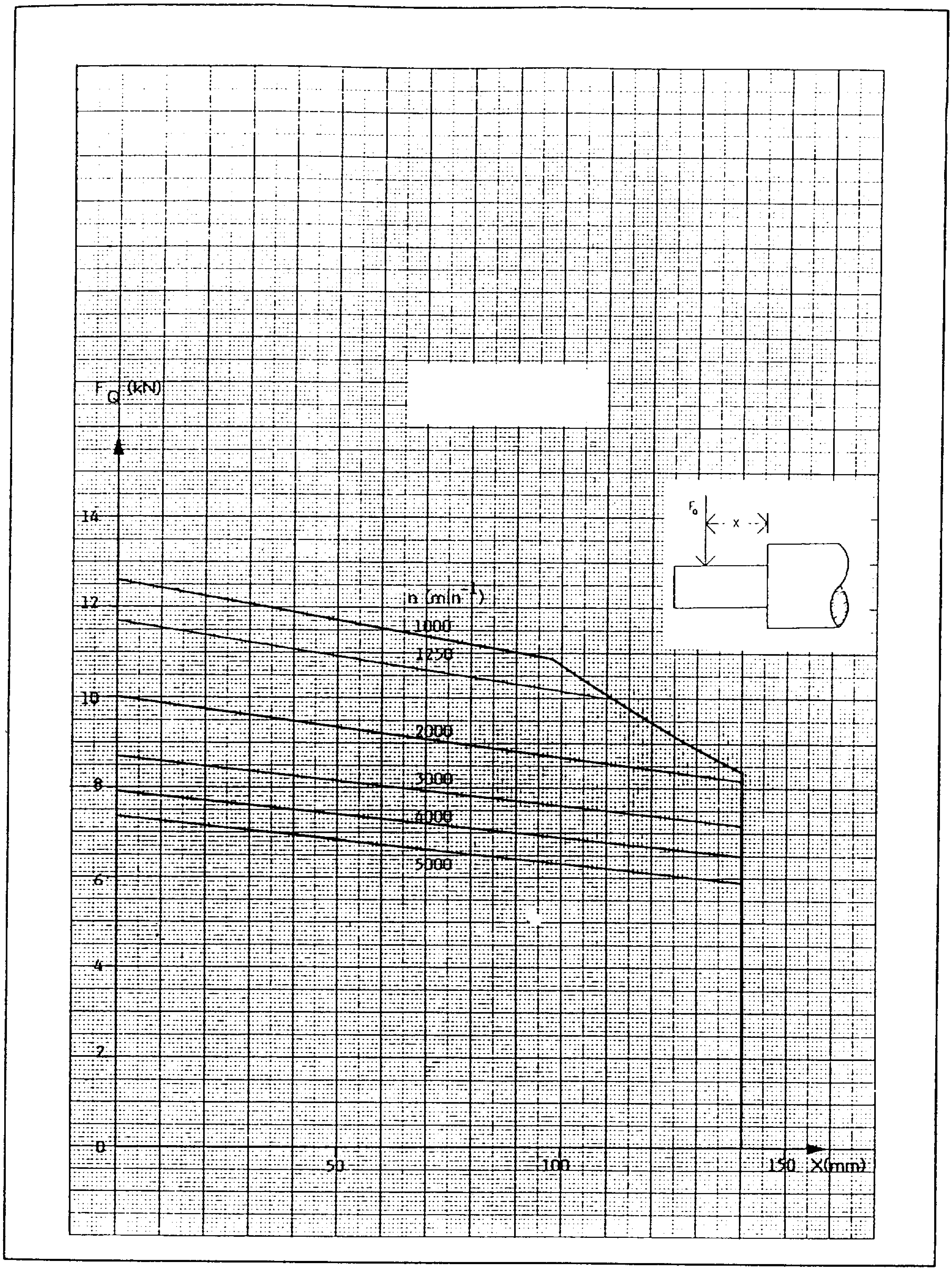


Fig. 6.50 Cantilever force chart for 1PH6 186-4 AC motors, with single-bearing design

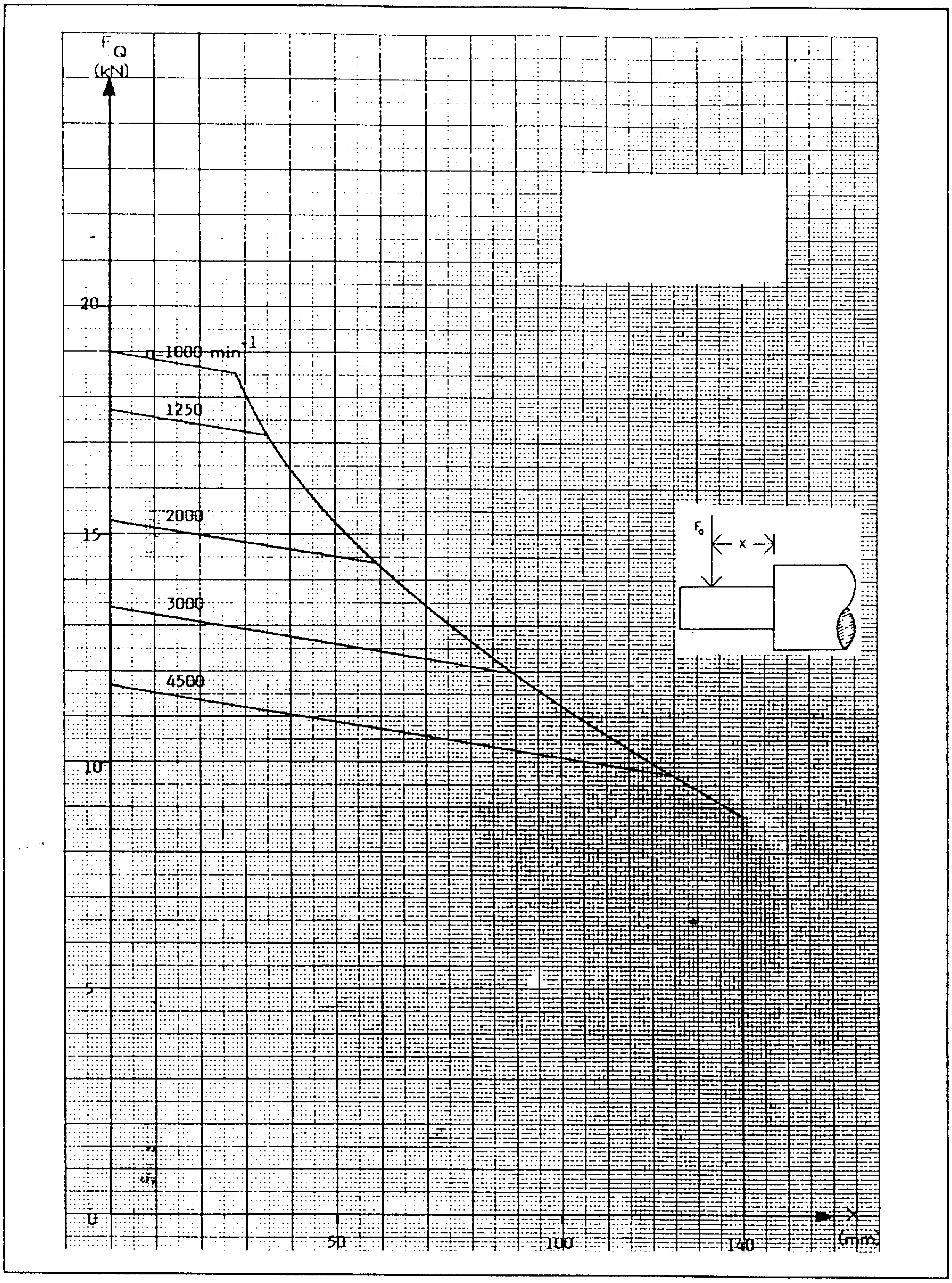


Fig. 6.51 Cantilever force chart for 1PH6 186-4 AC motors, with reinforced bearing

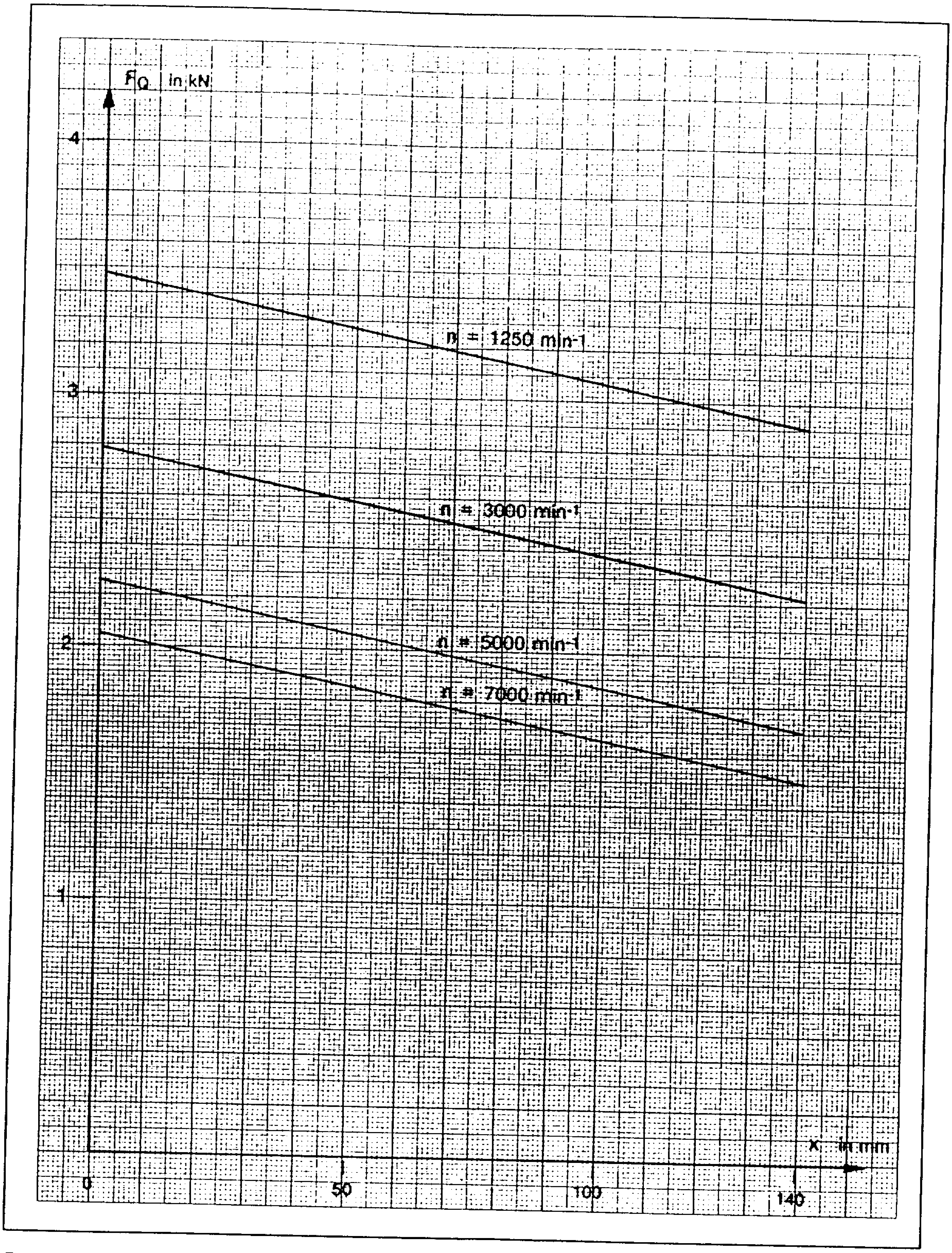


Fig. 6.52 Cantilever force chart for 1PH6 186-4 AC motors, for high speed motors with option L 37

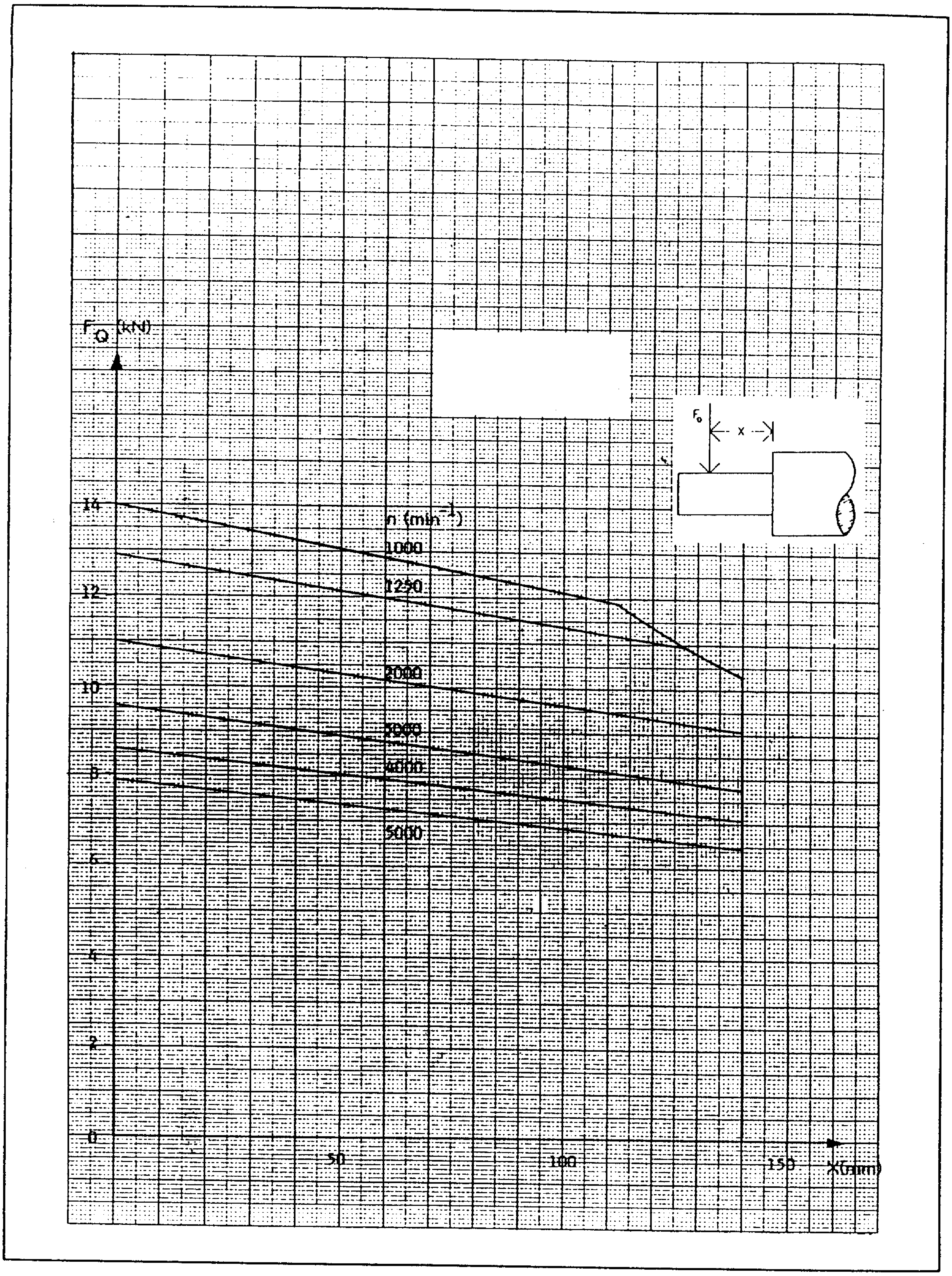


Fig. 6.53 Cantilever force chart for 1PH6 206-4 AC motors, with single-bearing design

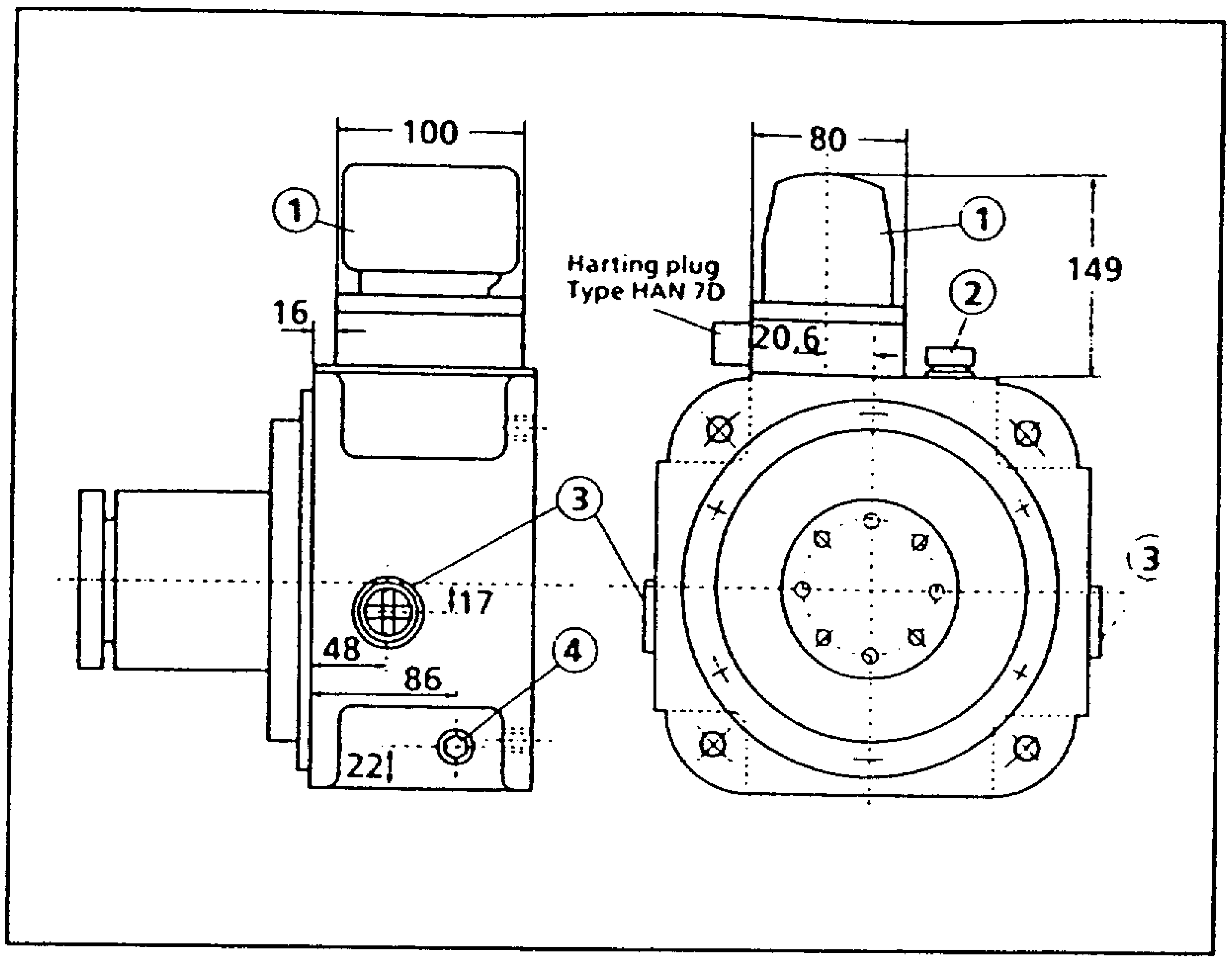


Fig. 5.8 Gearbox with gear change unit for size 100

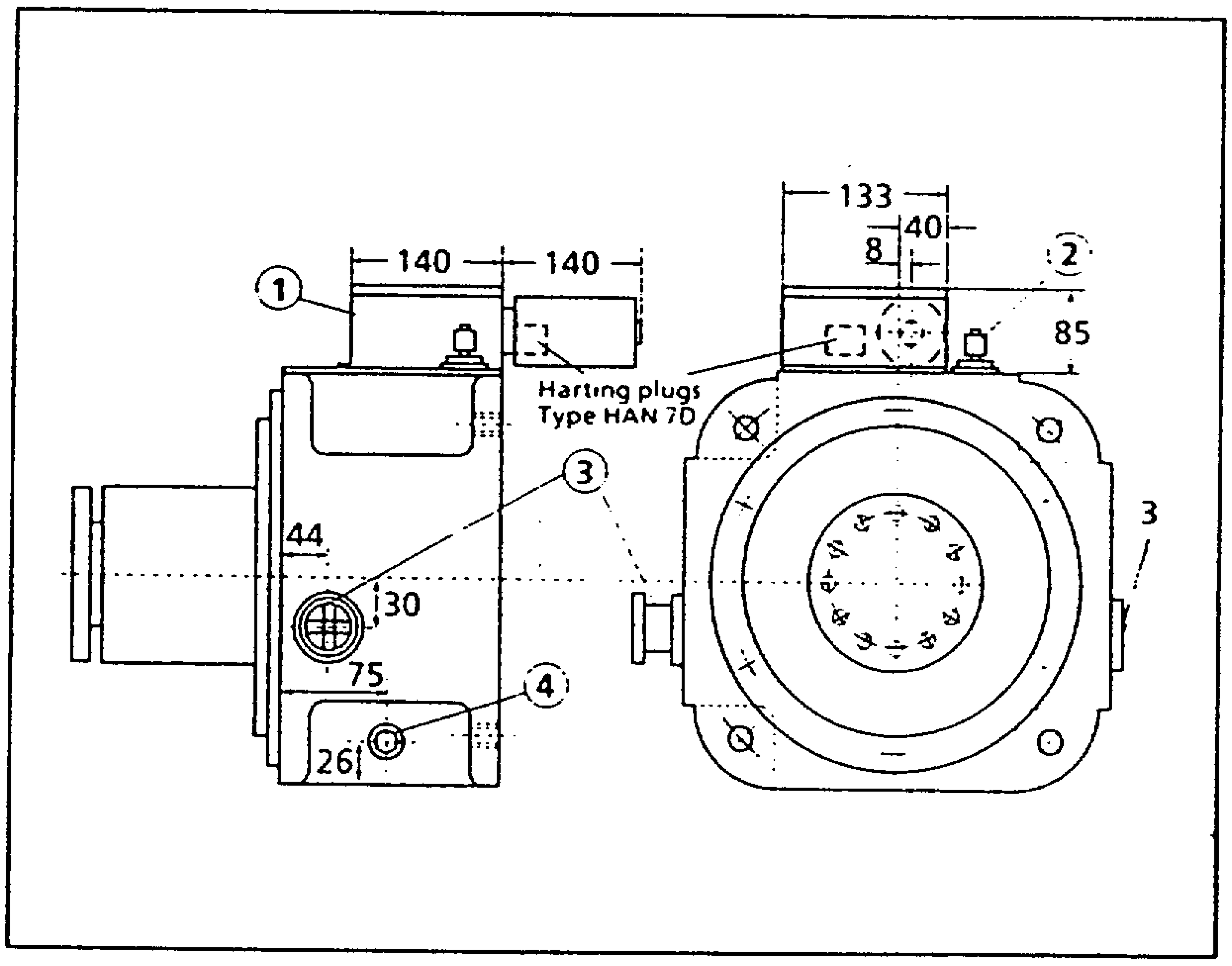


Fig. 5.9 Gearbox with gear change unit for sizes 132 and 160

① Gear change unit

② Oil filling screw with bleed valve, M22 × 1.5

③ Two oil level sight glasses (left and right) in M42 × 1.5 threaded hole, or for closed-loop oil lubrication, an oil level sight glass (left or right) and a M42x1.5 hole for oil return (right or left)

④ Two oil drain screws in M22x1.5 threaded hole (left and right) for horizontal mounting, or a threaded hole (right or left) as oil feed for closed-loop oil lubrication

6 Appendix

6.1 Power - speed characteristics

Note: Dotted lines ----- are indicated in the power - speed characteristics. These lines indicate the power limit of the PWM converter for the specified AC motor. The converter type is specified.

The speeds designated with * are optional.

Power ratings for duty types S1 and S6:

All power specifications for AC main spindle drive motors are for continuous operation, corresponding to duty type S1 according to VDE 0530, Part 1, Section 4.1.
However, duty type S1 (continuous operation) is not valid for many applications, e.g. for high, unspecified loading requirements as a function of time. In this case, an equivalent loading sequence can be specified, which represents at least the same loading as the actual motor loading .

The following duty types can be considered to be valid for most applications met in practice:

- S6 duty types- Continuous duty with intermittent loading

Both duty types are defined in VDE 0530, Part 1, Section 4.
VDE 0530, Part 1, Section 6.1 specifies a max. cycle duration of 10 min., if no other conditions are specified. 25%, 40% and 60% are recommended as relative switch-on duration.

AC main spindle drive motors must be continually ventilated in operation independent of the duty type.

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
3.7	1500	24	13	20	9000	0.011	42

1PH6 101-4CF4

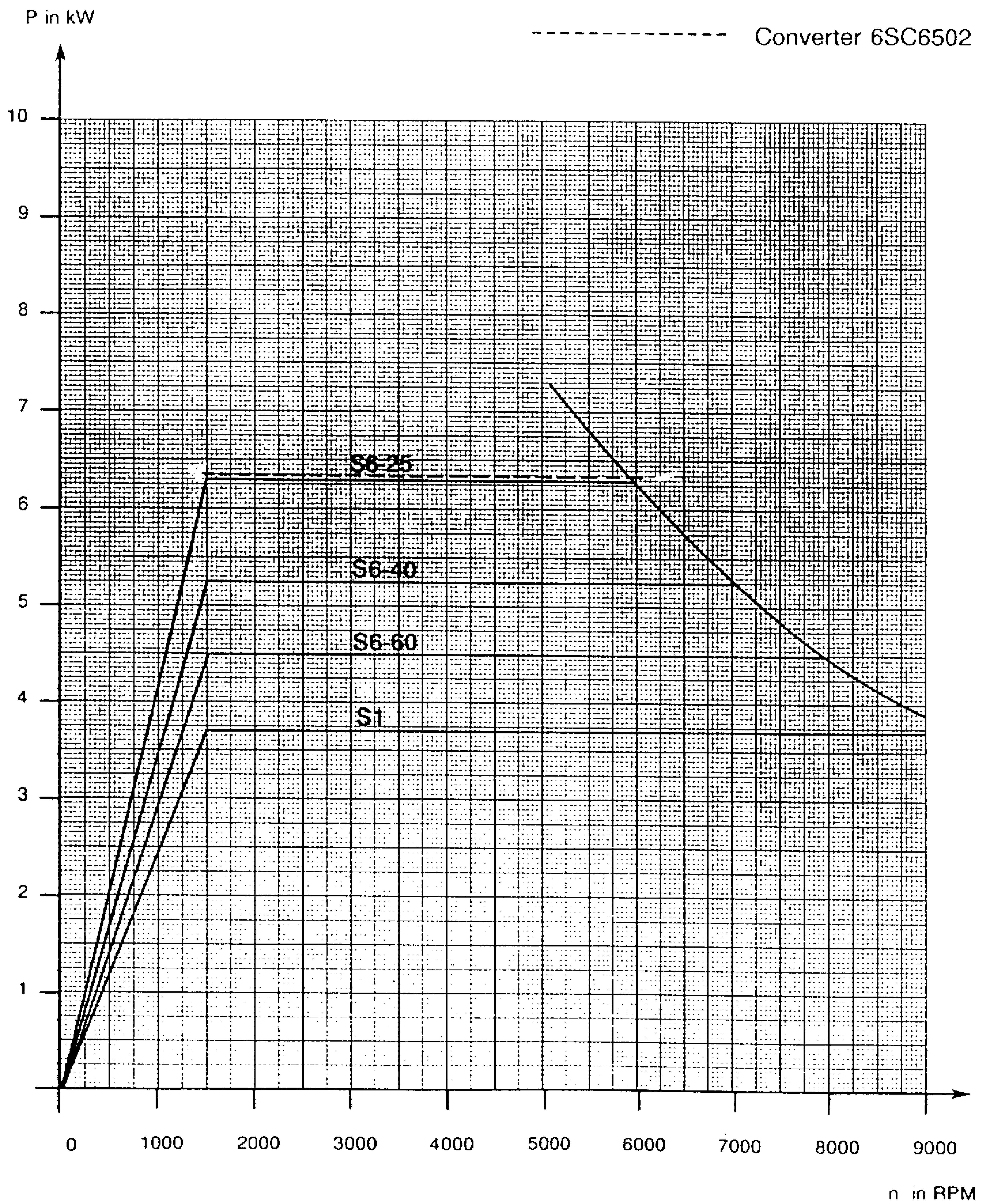


Fig. 6.1 Power - speed characteristic for the 1PH6 101-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
4.7	2000	22	13.9	20	9000	0.011	42

1PH6 101-4CG4

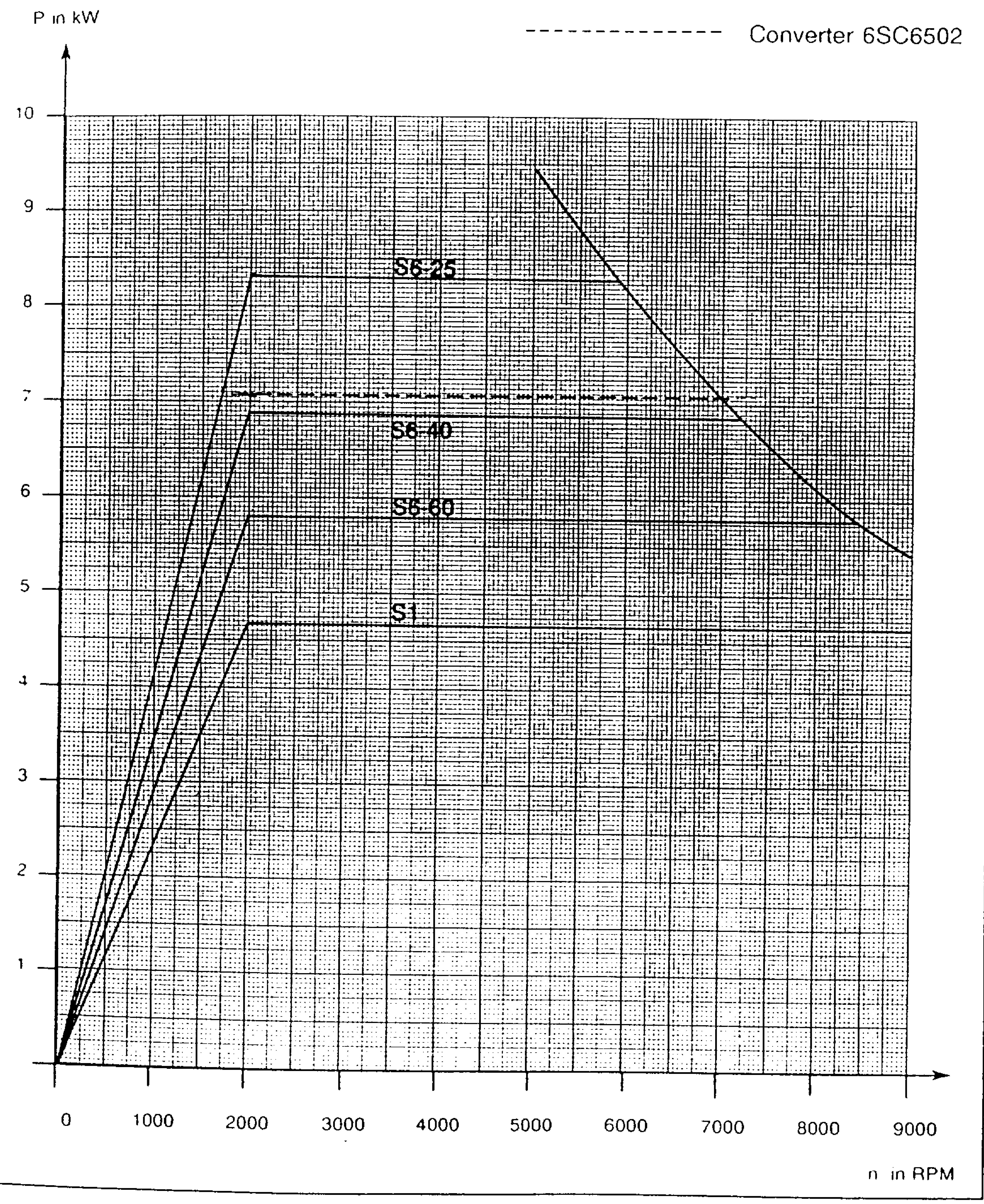


Fig. 6.2 Power - speed characteristic for the 1PH6 101-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm^2]	Weight m [kg]
5.5	1500	35	18	20	9000	0.017	52

1PH6 103-4CF4

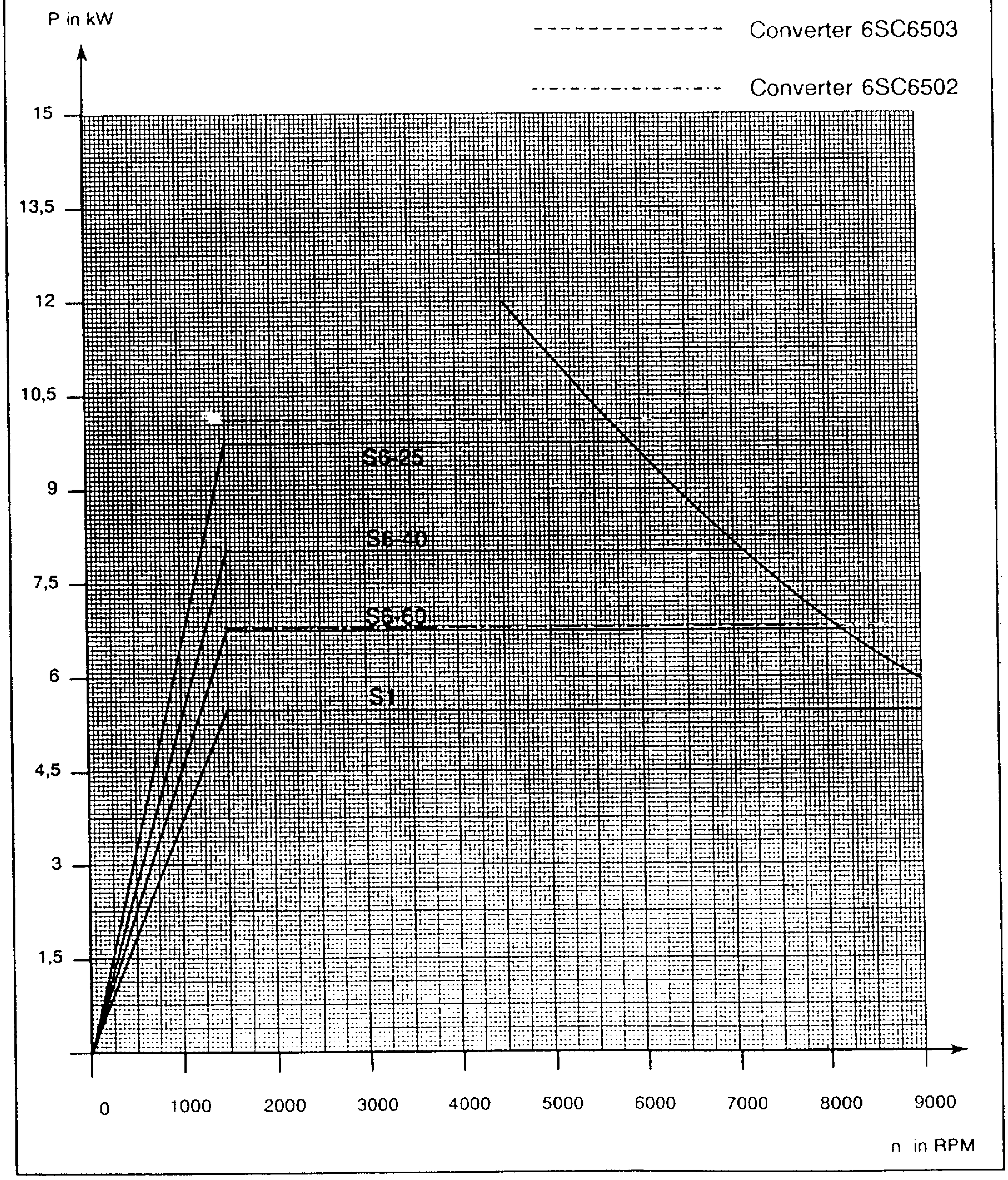


Fig 6.3 Power - speed characteristic for the 1PH6 103-4CF4 AC motor

Rated current P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
7.0	2000	33	20	20	9000	0.017	52

1PH6 103-4CG4

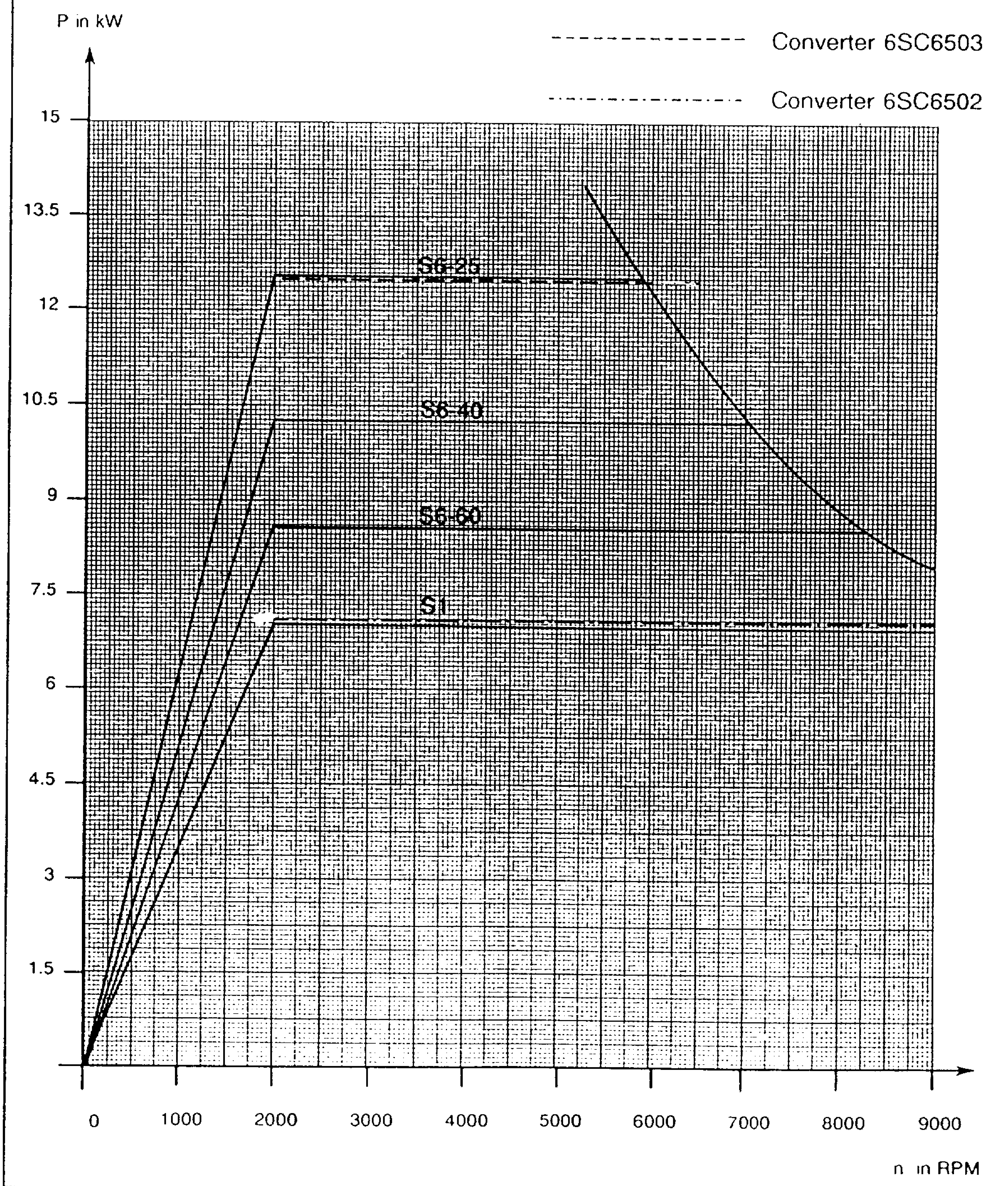


Fig. 6.3 Power - speed characteristic for the 1PH6 103-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
7.5	1500	48	23	20	9000	0.024	67

1PH6 105-4CF4

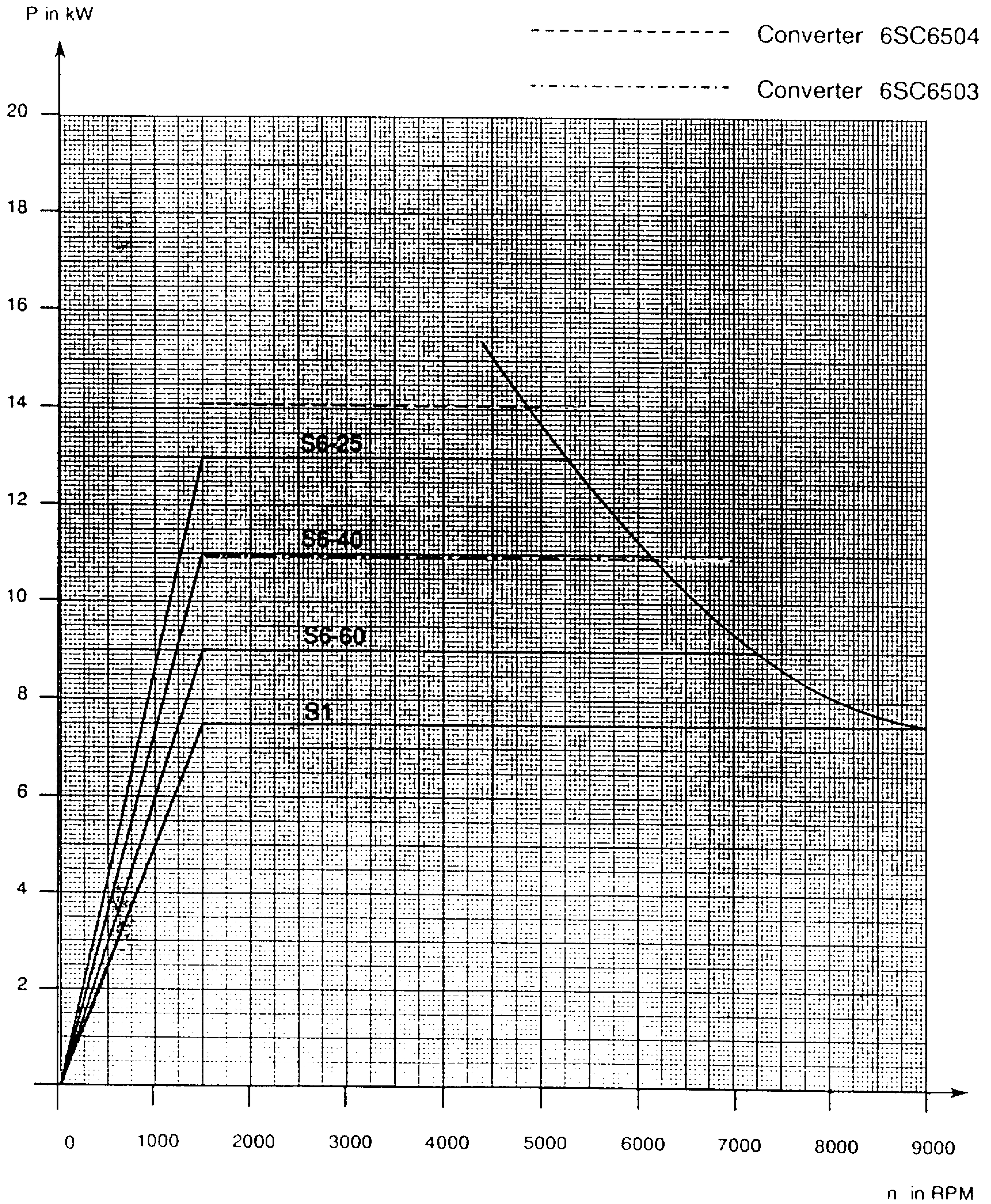


Fig. 6.5 Power - speed characteristic for the 1PH6 105-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
9.5	2000	45	26	20	9000	0.024	67

1PH6 105-4CG4

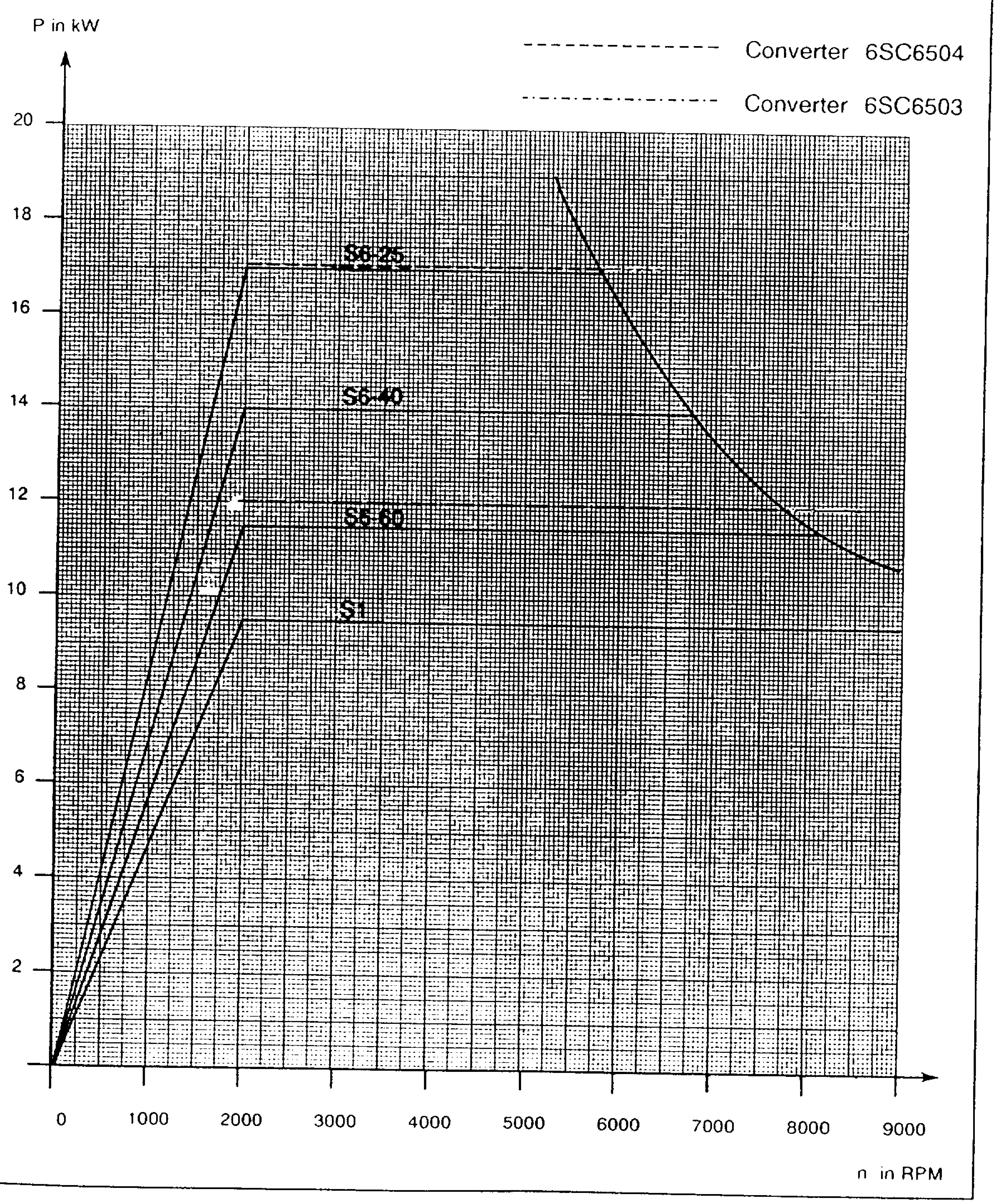


Fig. 6.6 Power - speed characteristic for the 1PH6 105-4CFG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
5.0	750	64	22.8	20	9000	0.031	80

1PH6 107-4CC4

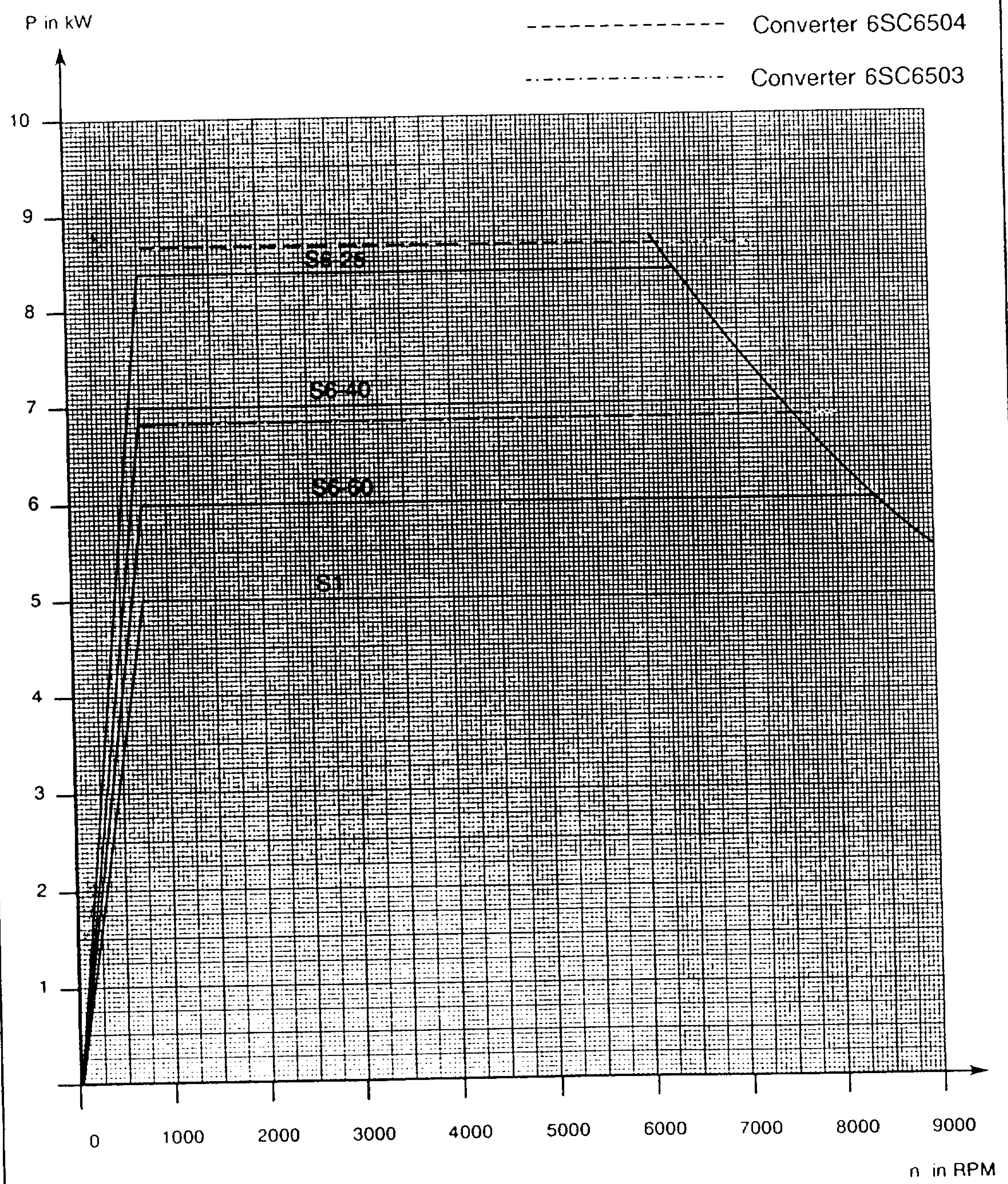


Fig. 6.7 Power - speed characteristic for the 1PH6 107-4CC4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
9.0	1500	57	27.4	20	9000	0.031	80

1PH6 107-4CF4

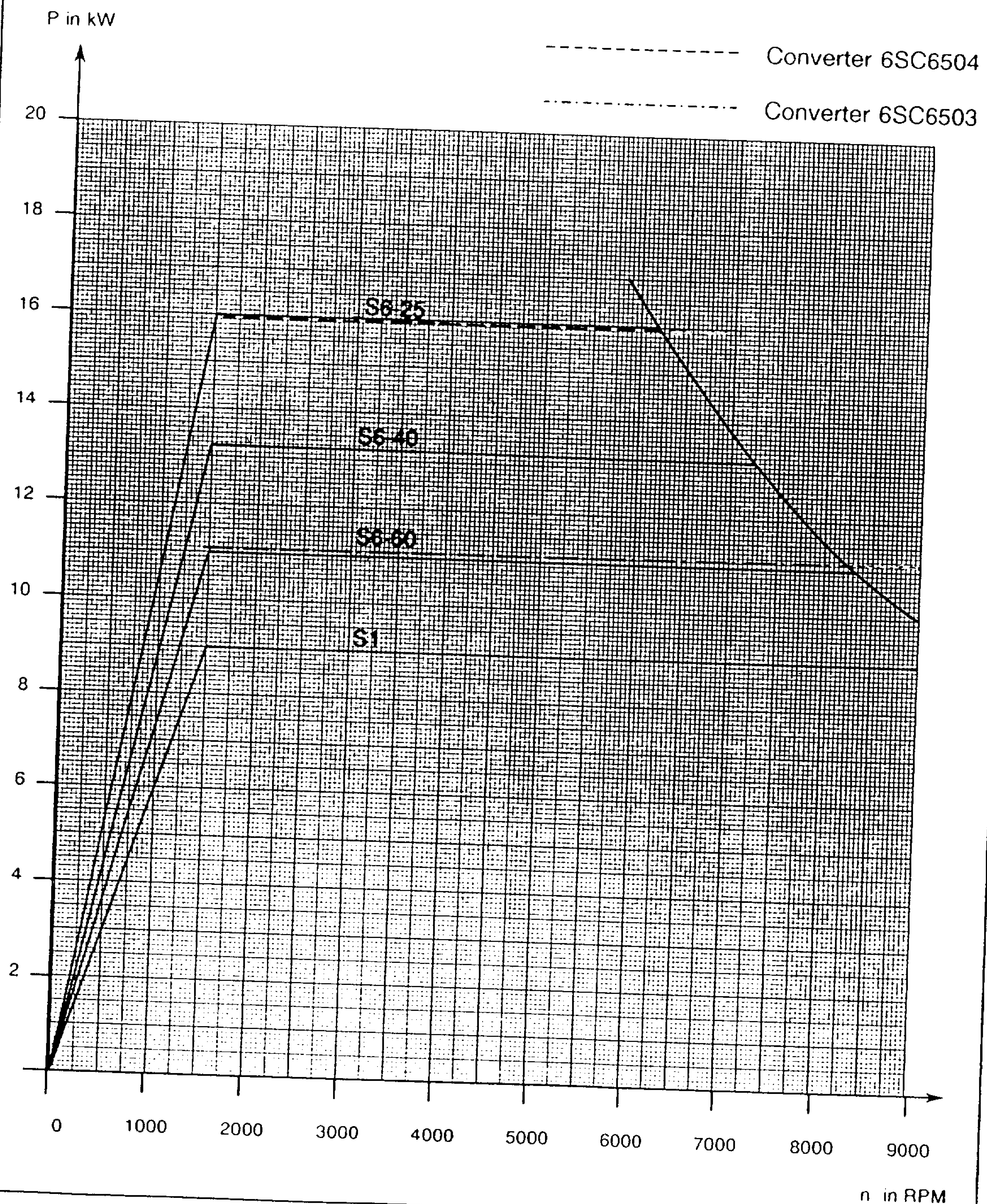


Fig. 6.8 Power - speed characteristic for the 1PH6 107-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
11.5	2000	55	30	20	9000	0.031	80

1PH6 107-4CG4

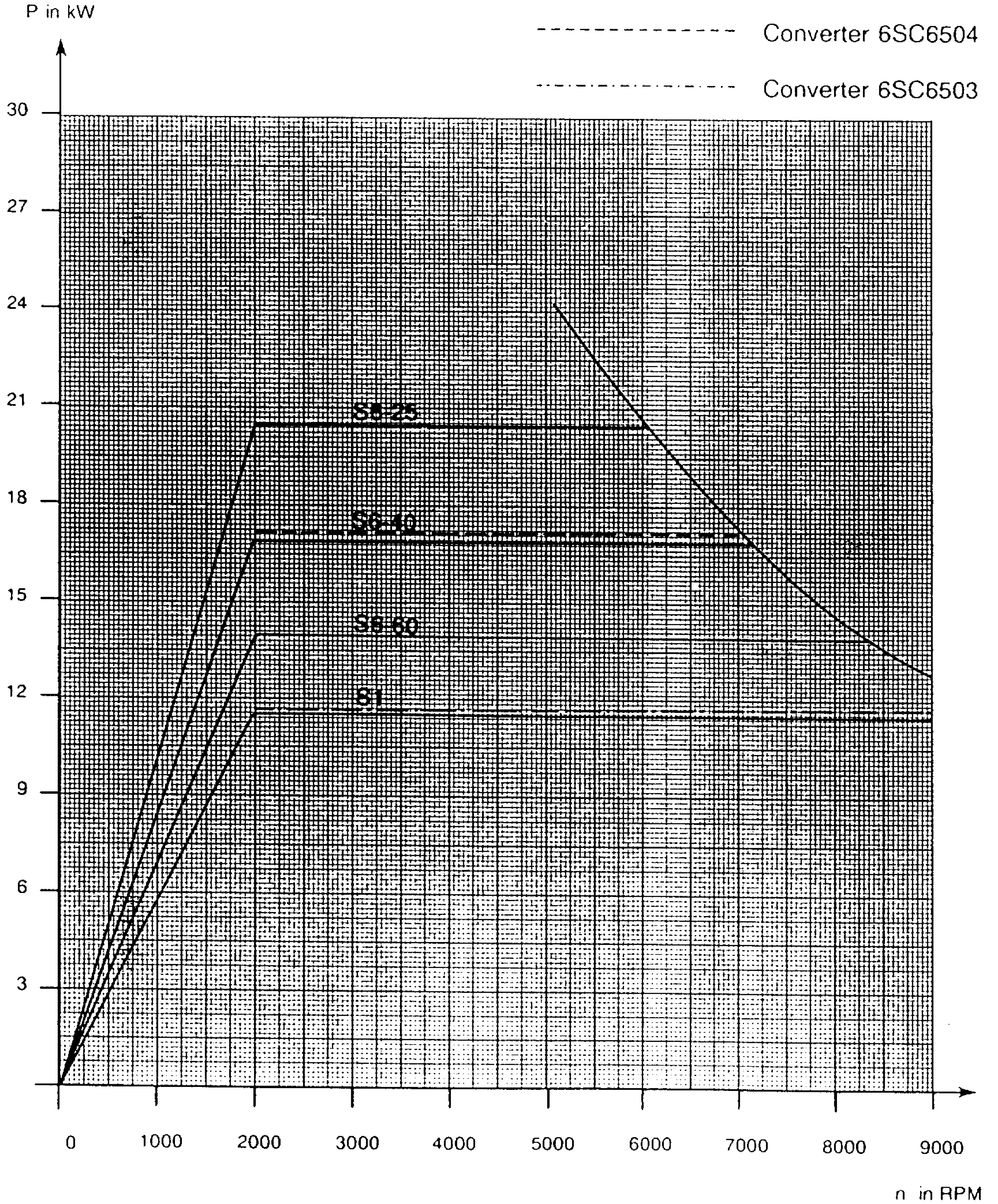


Fig. 6.9 Power - speed characteristic for the 1PH6 107-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
9.0	1500	57	28	30	8000	0.038	78

1PH6 131-4CF4

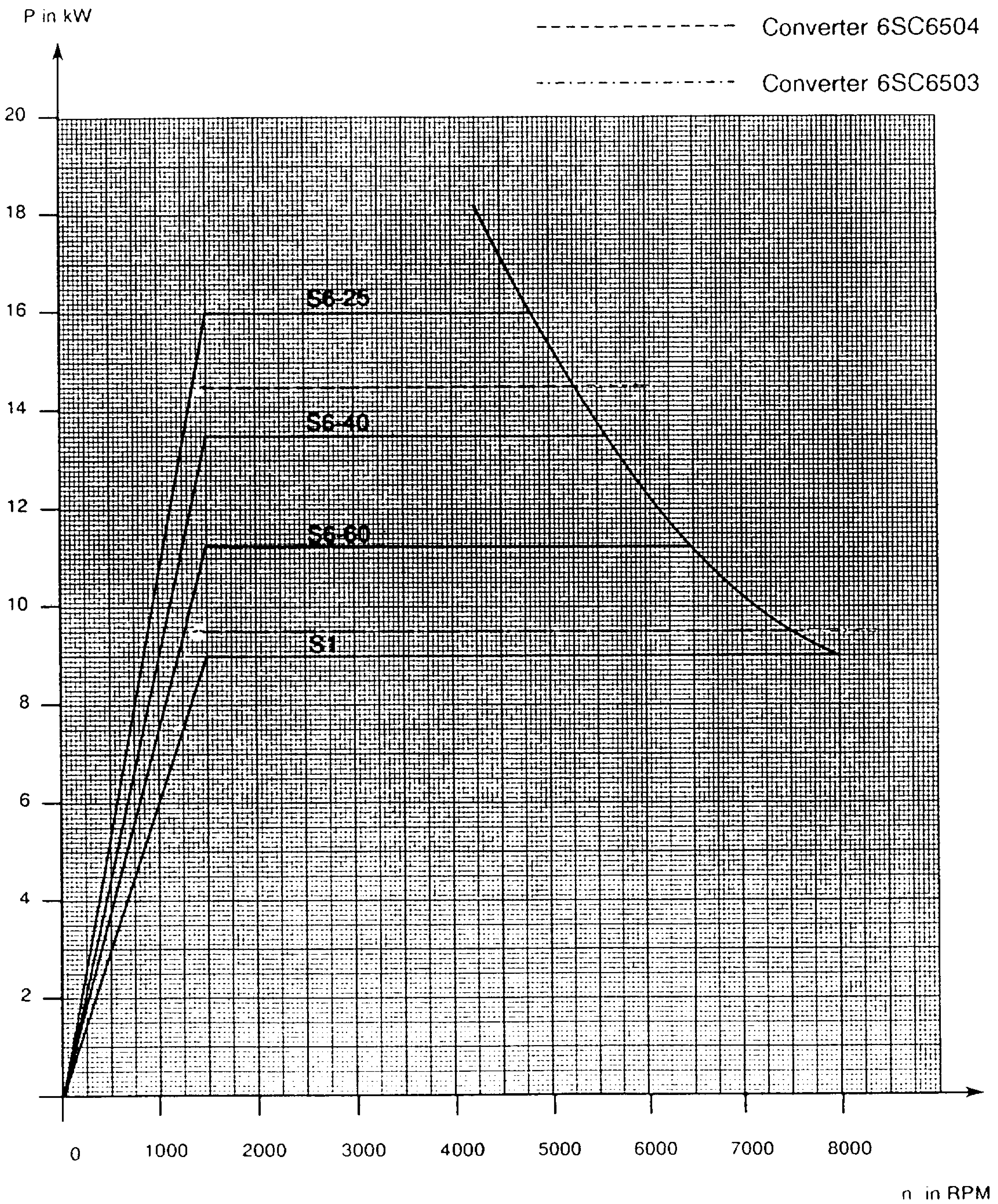


Fig. 6.10 Power - speed characteristic for the 1PH6 131-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
12.0	2000	57	33	30	8000	0.038	78

1PH6 131-4CG4

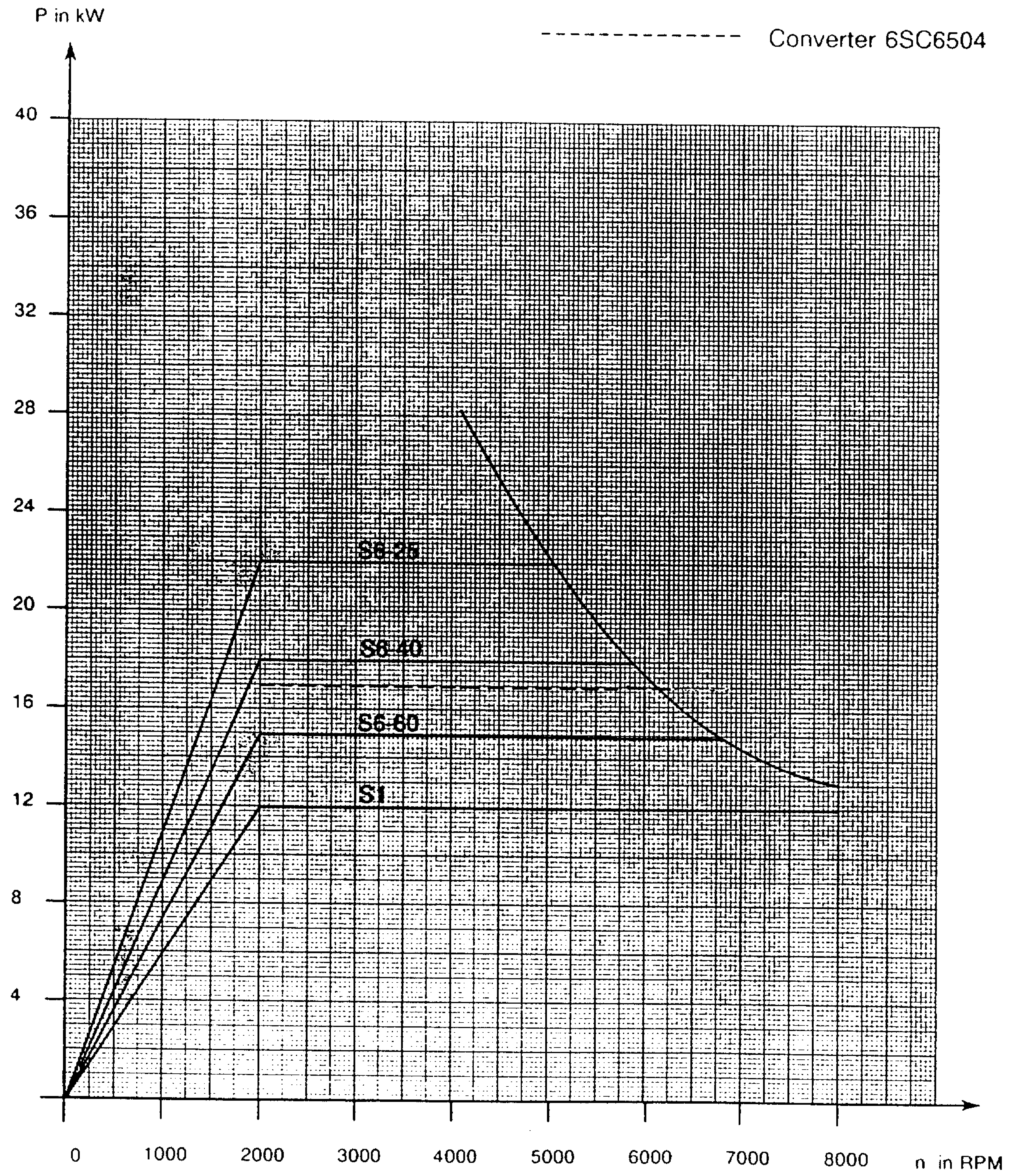


Fig. 6.11 Power - speed characteristic for the 1PH6 131-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
4.25	500	81	26	30	8000	0.046	90

1PH6 133-4CB4

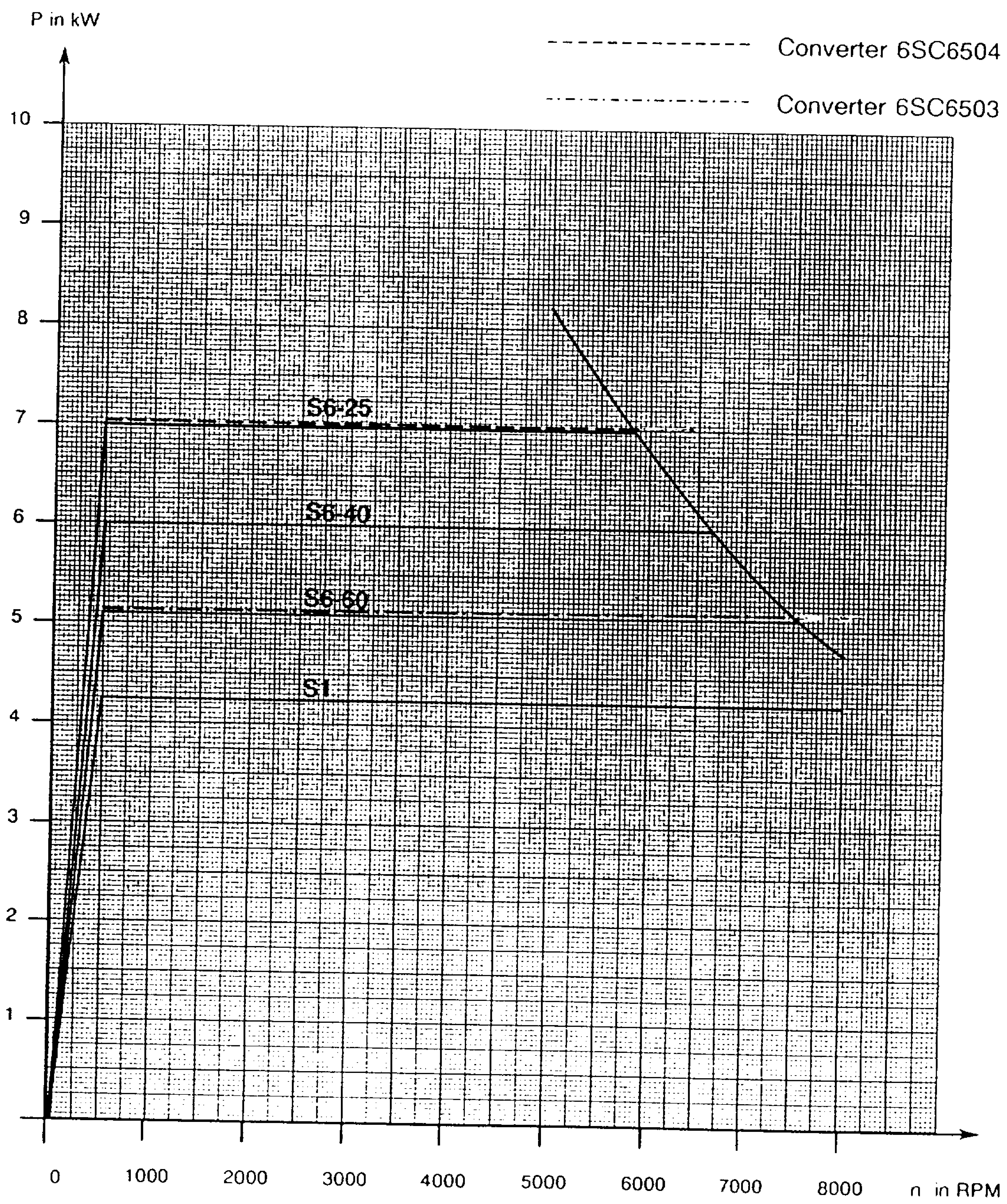


Fig. 6.12 Power - speed characteristic for the 1PH6 133-4CB4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm^2]	Weight m [kg]
11.0	1500	70	28	30	8000	0.046	90

1PH6 133-4CF0

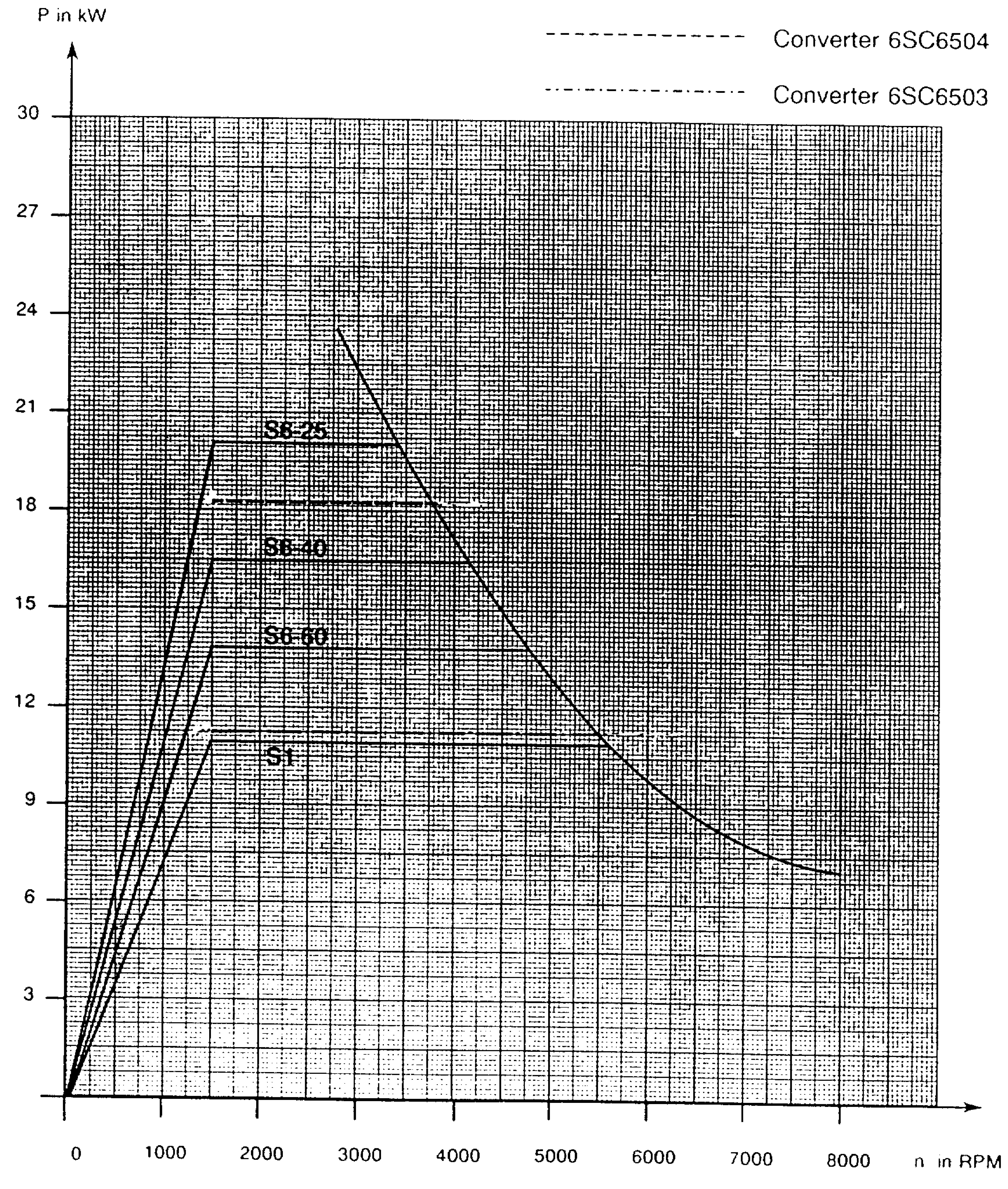


Fig. 6.13 Power - speed characteristic for the 1PH6 133-4CF0 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
11.0	1500	70	32	30	8000	0.046	90

1PH6 133-4CF4

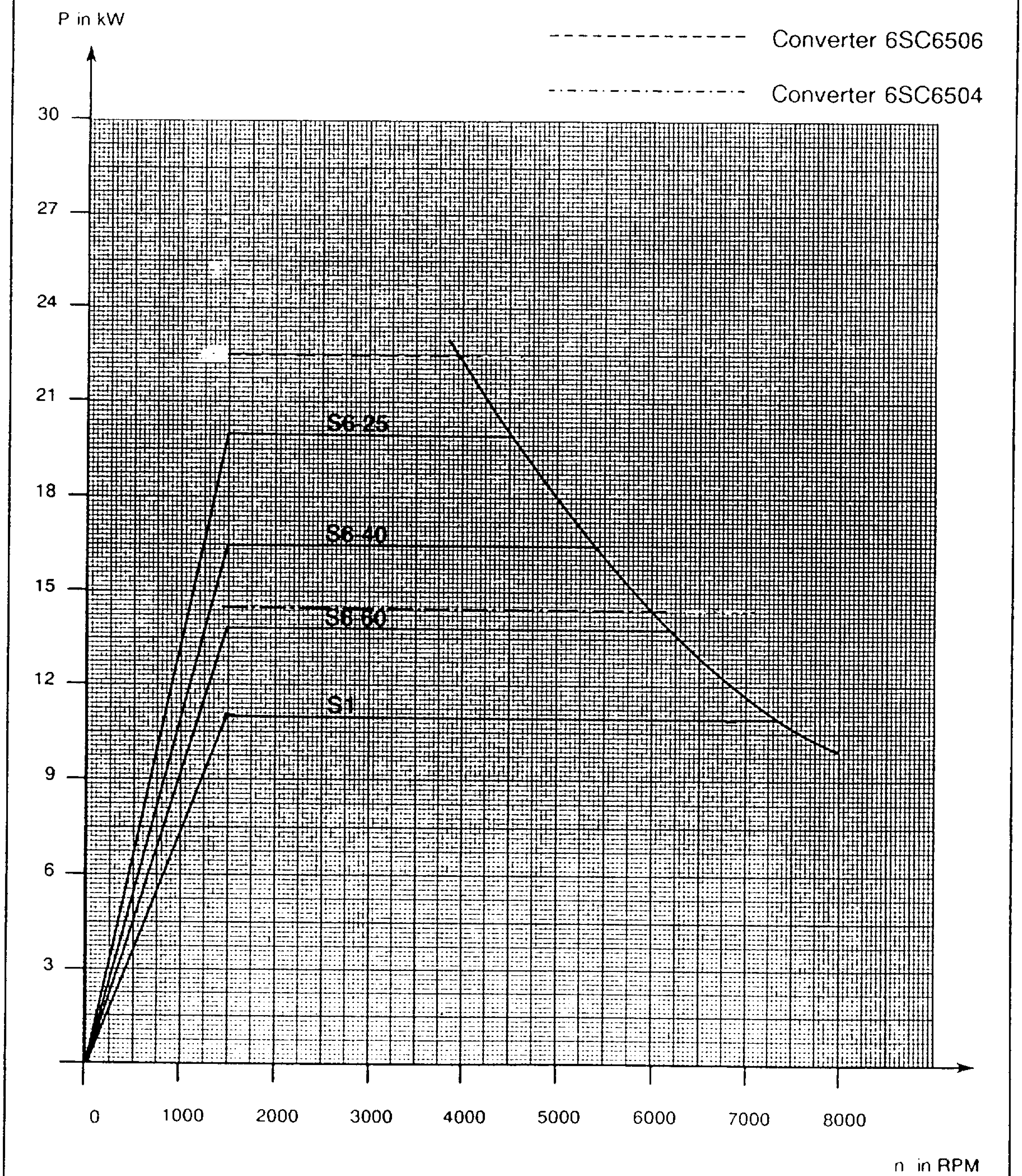


Fig. 6.14 Power - speed characteristic for the 1PH6 133-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
14.5	2000	69	39	30	8000	0.046	90

1PH6 133-4CG4

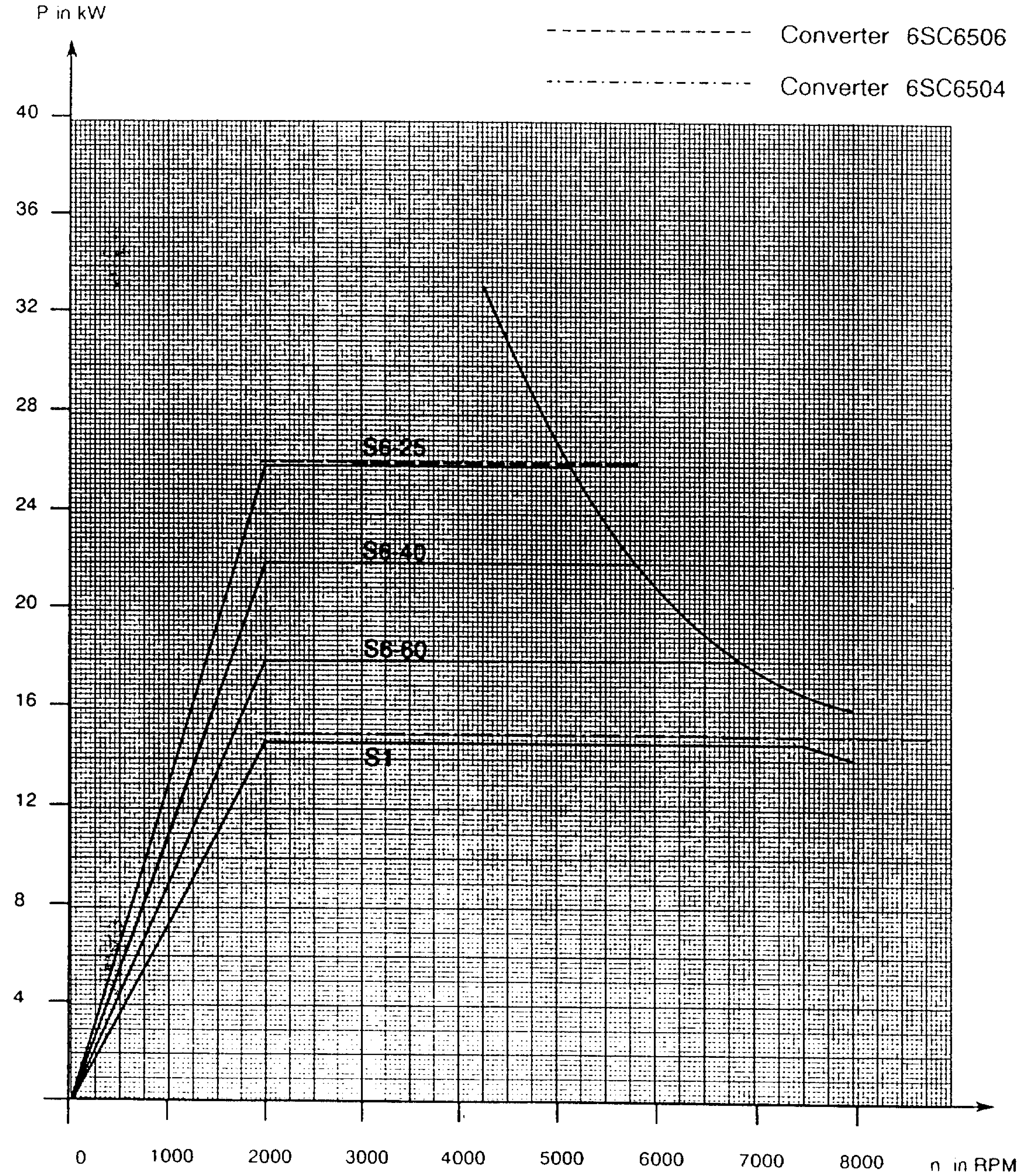


Fig. 6.15 Power - speed characteristic for the 1PH6 133-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
15.0	1500	95	36	30	8000	0.071	112

1PH6 135-4CF0

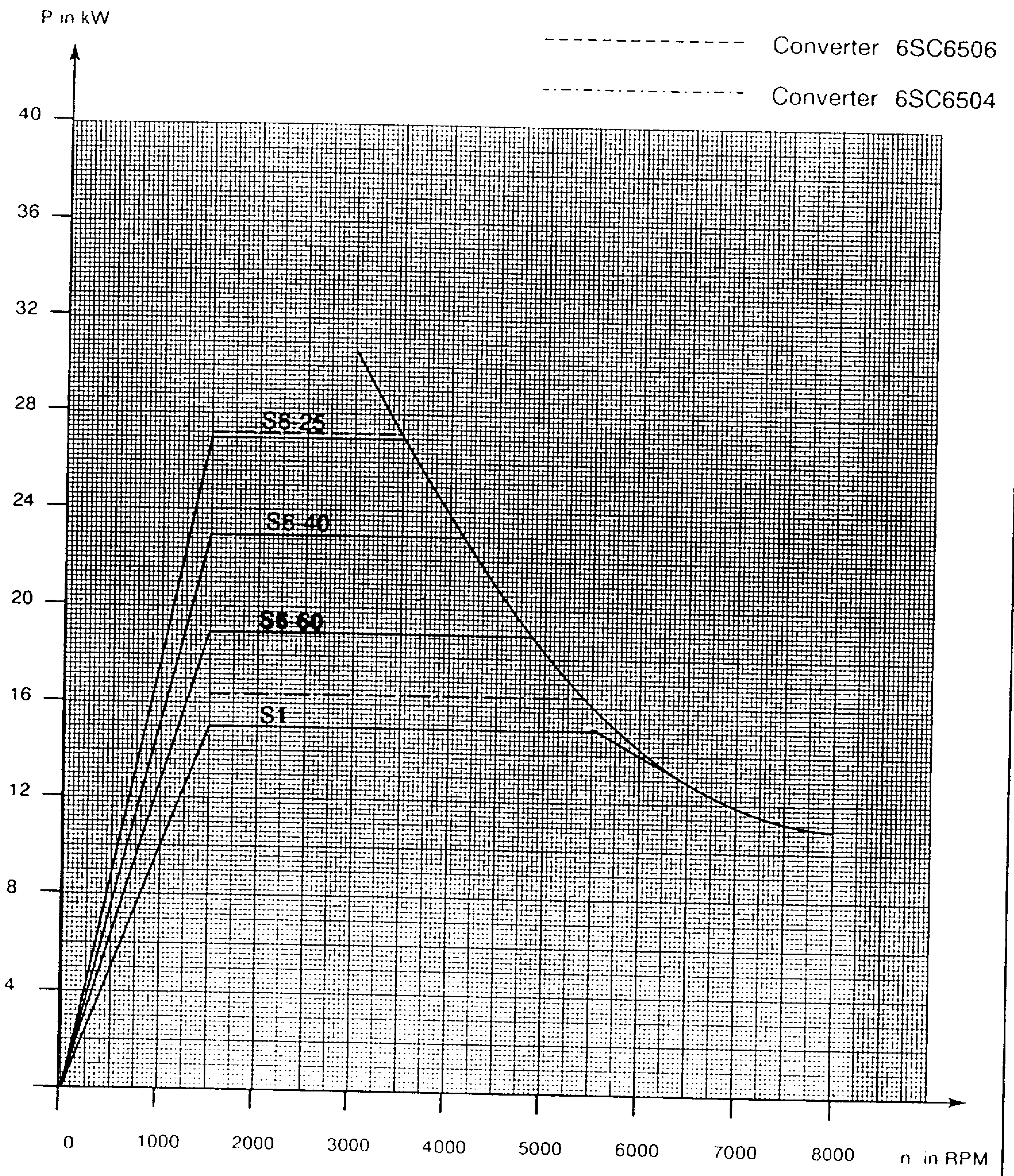


Fig. 6.16 Power - speed characteristic for the 1PH6 135-4CF0 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
15.0	1500	95	43	30	8000	0.071	112

1PH6 135-4CF4

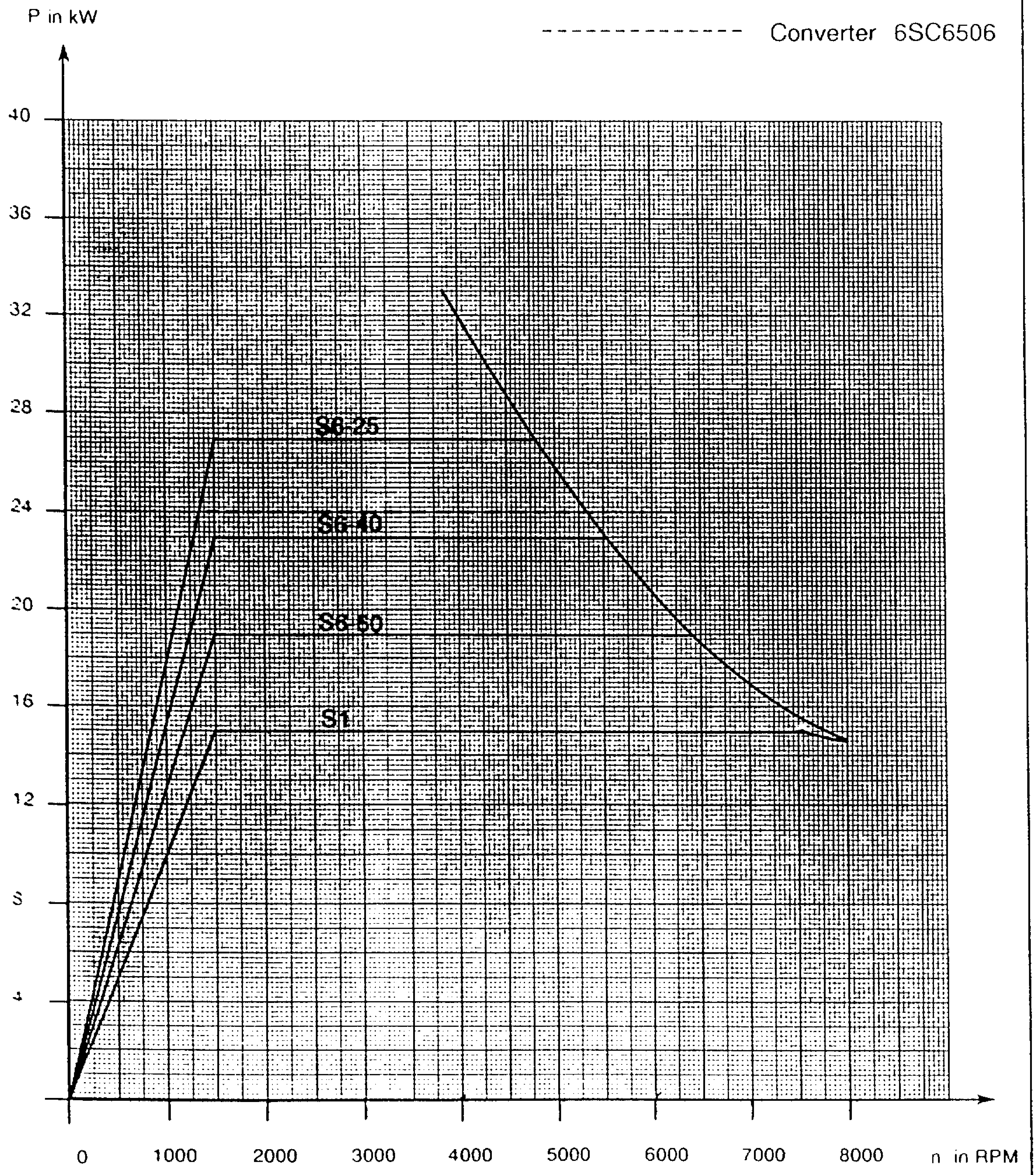


Fig. 6.17 *Power - speed characteristic for the 1PH6 135-4CF4 AC motor*

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
20.0	2000	95	52	30	8000	0.071	112

1PH6 135-4CG4

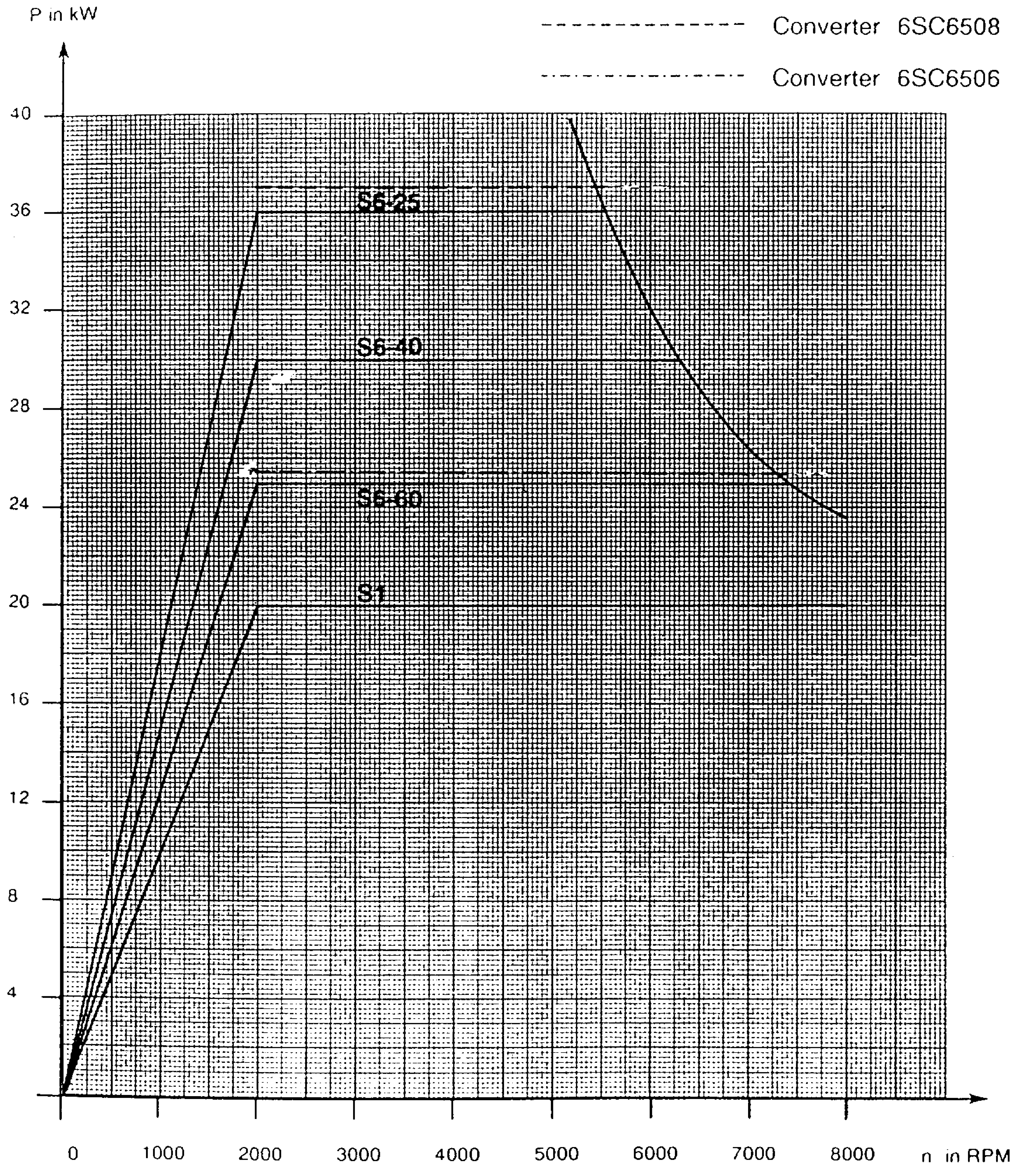


Fig. 6.18 Power - speed characteristic for the 1PH6 135-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
7.5	500	143	44	30	8000	0.085	130

1PH6 137-4CB4

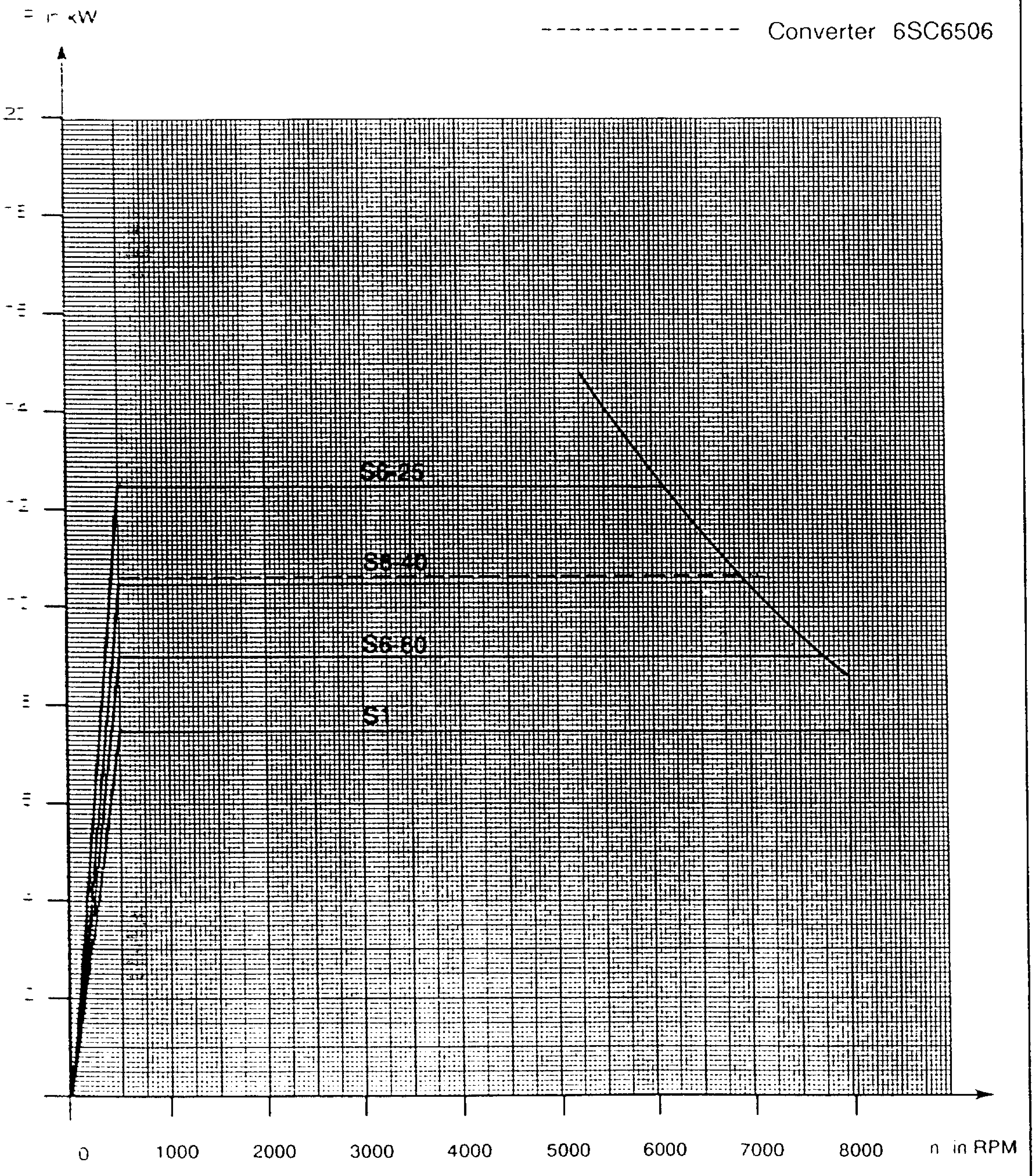


Fig. 5.19 *Power - speed characteristic for the 1PH6 137-4CB4 AC motor*

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
18.5	1500	118	52	30	8000	0.085	130

1PH6 137-4CF4

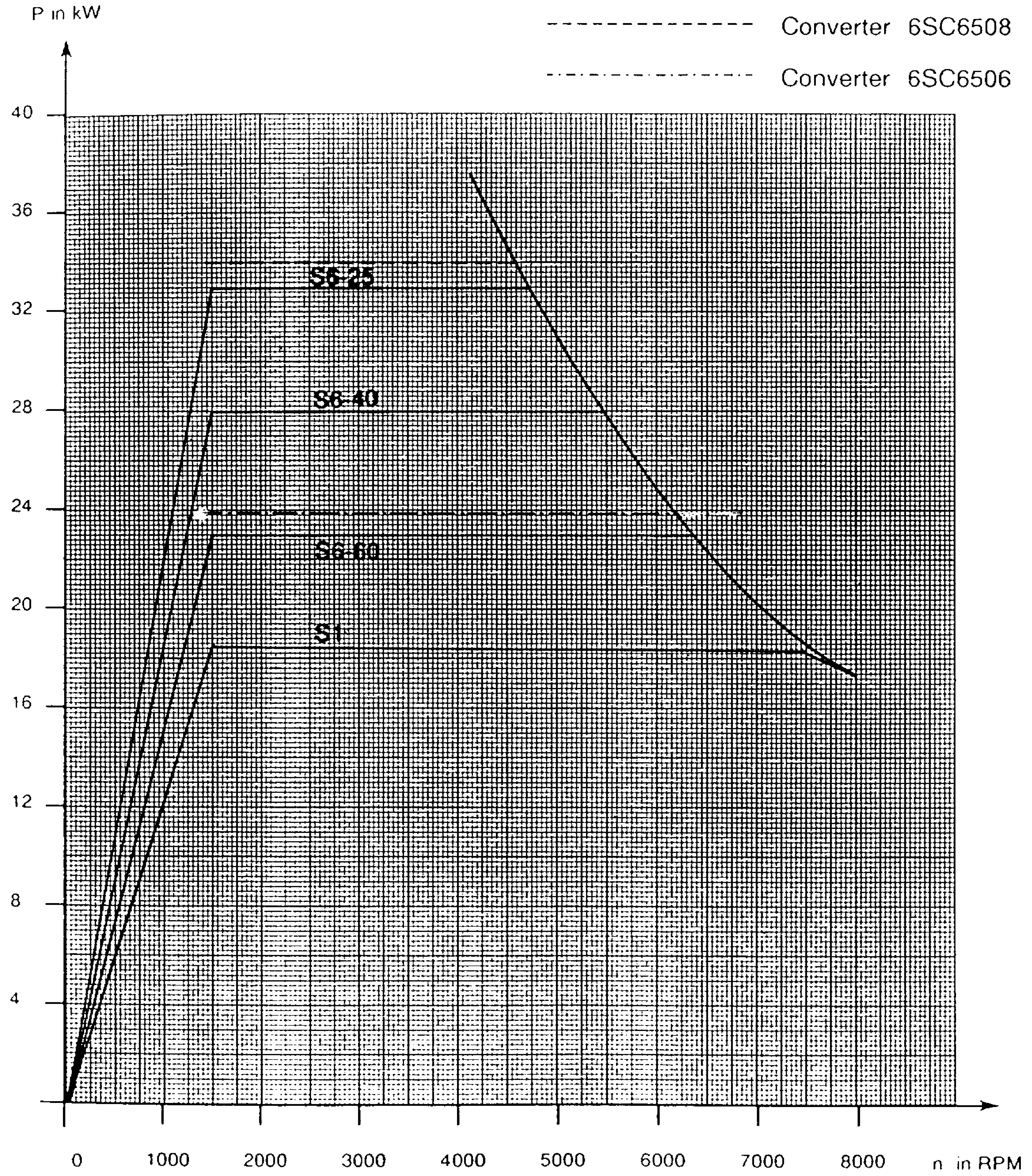


Fig. 6.20 Power - speed characteristic for the 1PH6 137-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
24.0	2000	115	59	30	8000	0.085	130

1PH6 137-4CG4

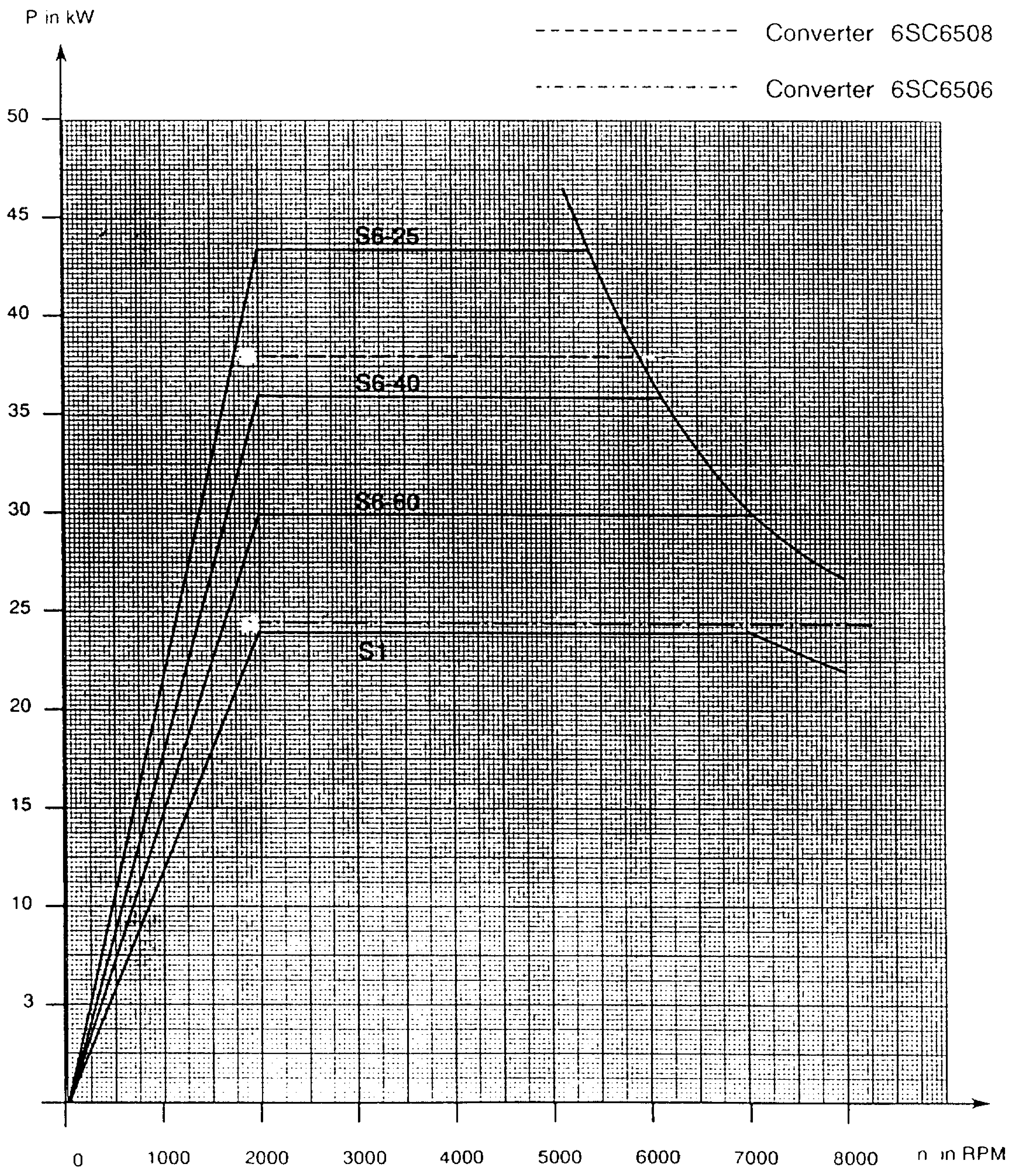


Fig. 6.21 Power - speed characteristic for the 1PH6 137-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
22.0	1500	140	52	30	8000	0.104	150

1PH6 138-4CF0

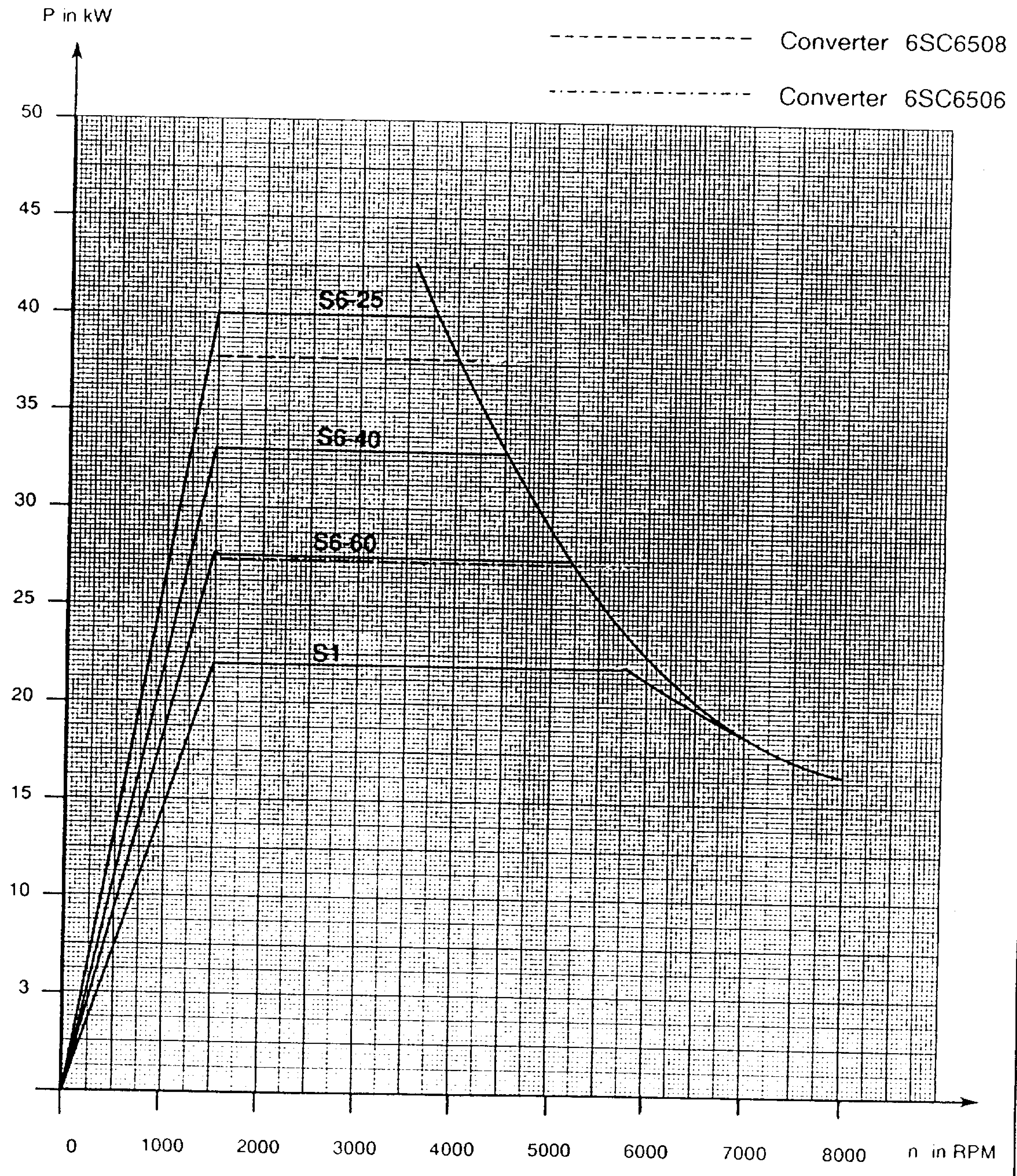


Fig. 6.22 Power - speed characteristic for the 1PH6 138-4CF0 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
22.0	1500	140	63	30	8000	0.104	150

1PH6 138-4CF4

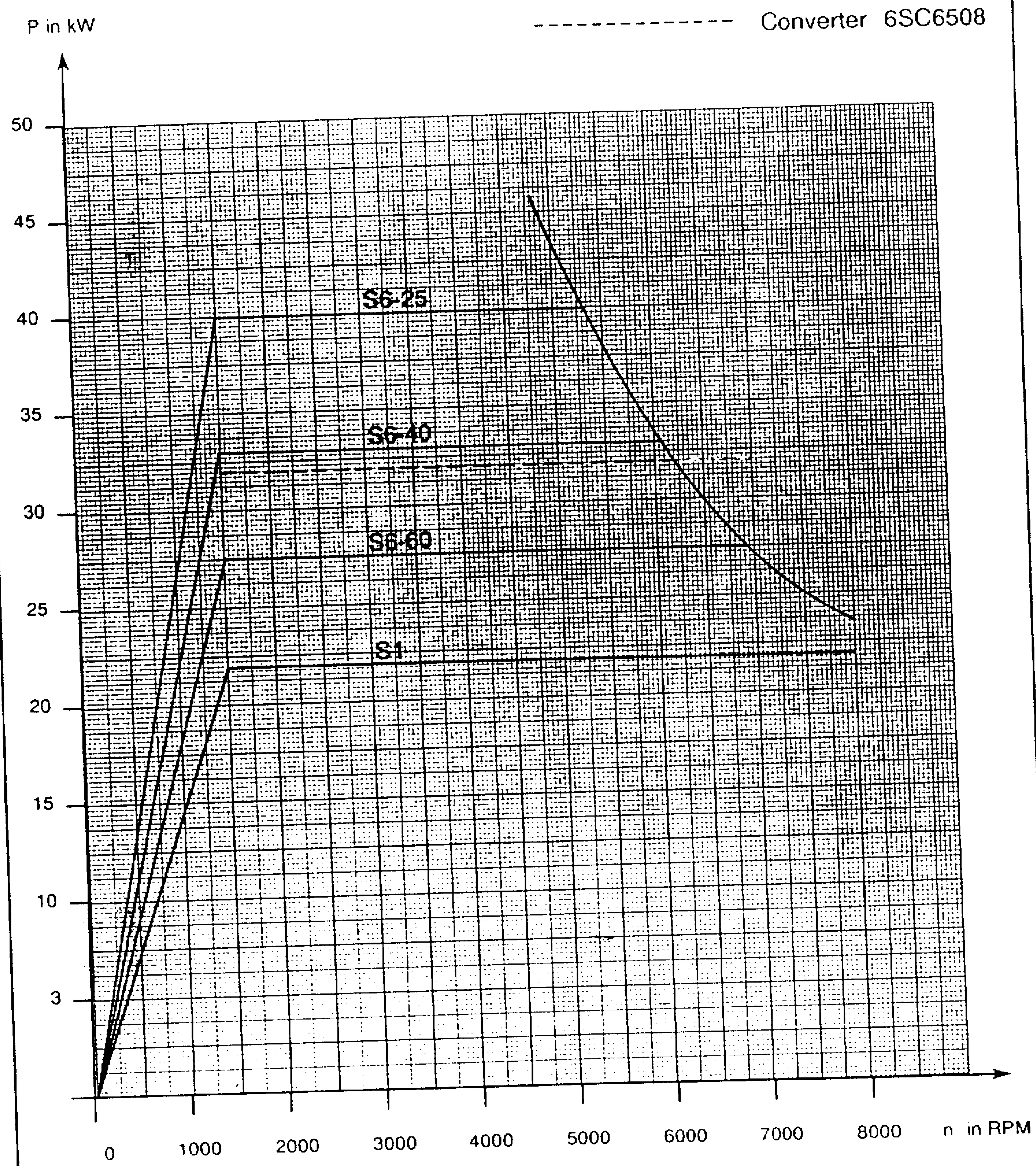


Fig. 6.23 Power - speed characteristic for the 1PH6 138-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
28.0	2000	134	68	30	8000	0.104	150

1PH6 138-4CG4

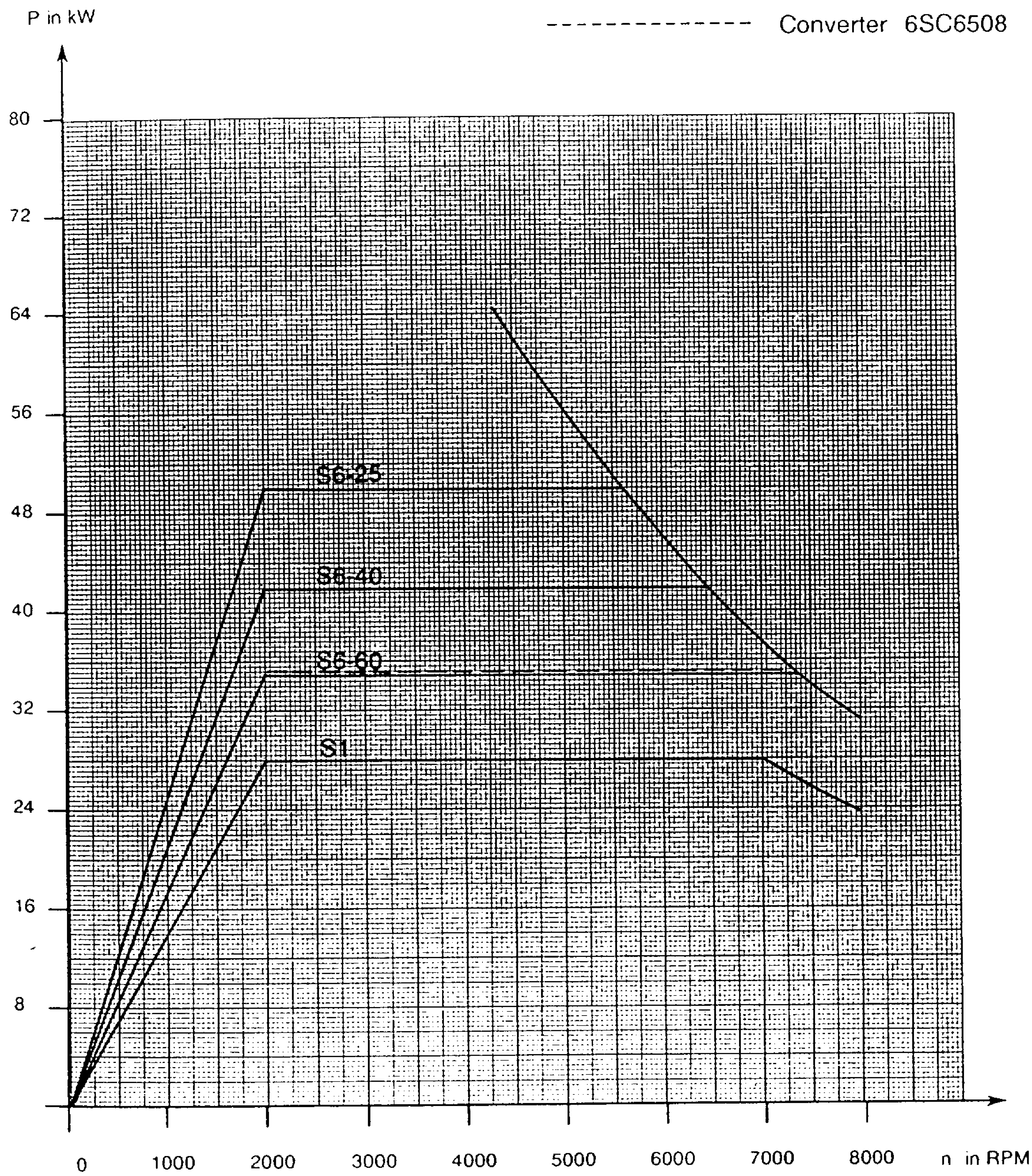


Fig. 6.24 Power - speed characteristic for the 1PH6 138-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
22.0	1500	140	55	35	6500 (8000)*	0.131	140

1PH6 161-4CF0

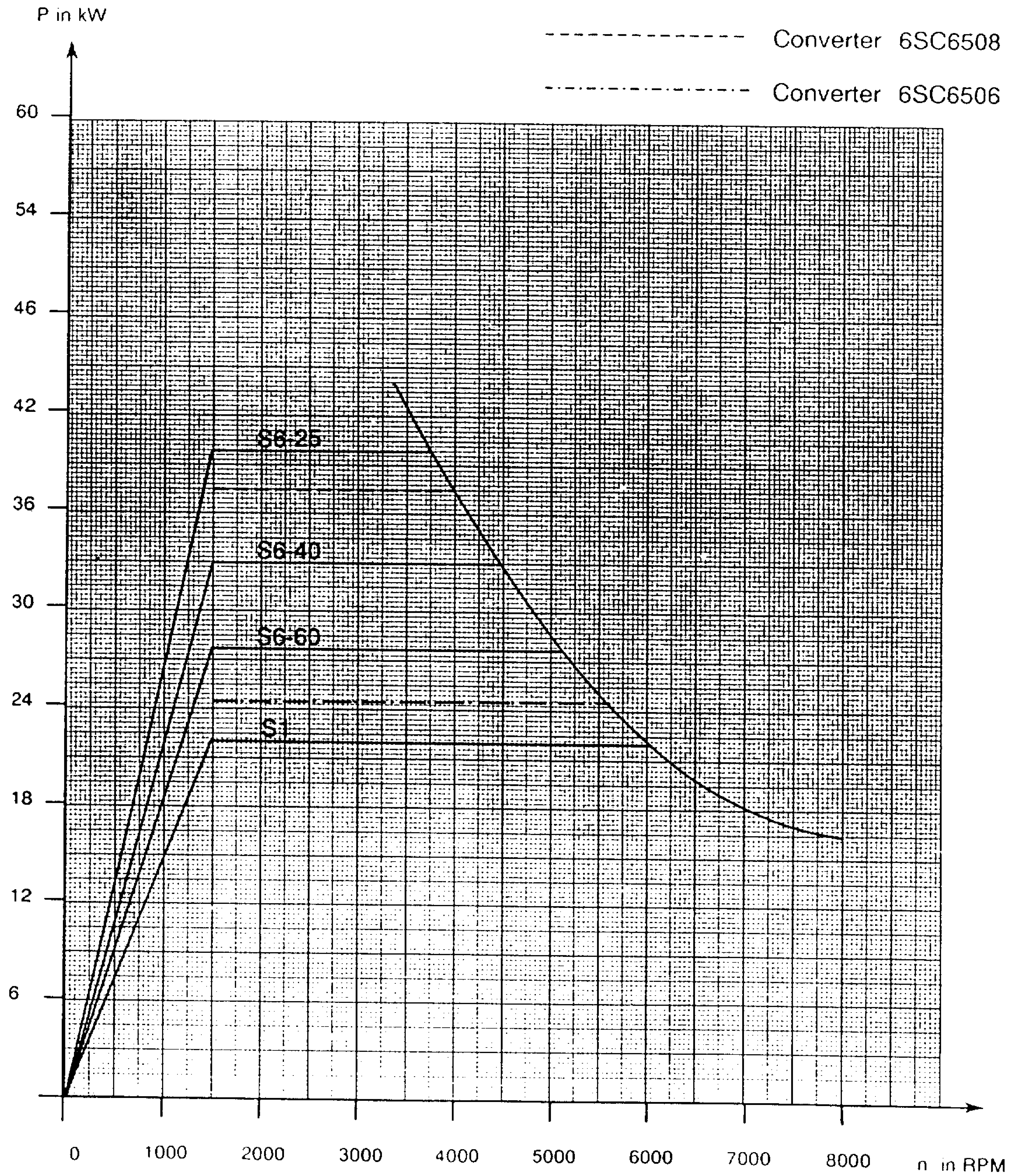


Fig. 6.25 Power - speed characteristic for the 1PH6 161-4CF0 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
22.0	1500	140	63	35	6500 (8000)*	0.131	140

1PH6 161-4CF4

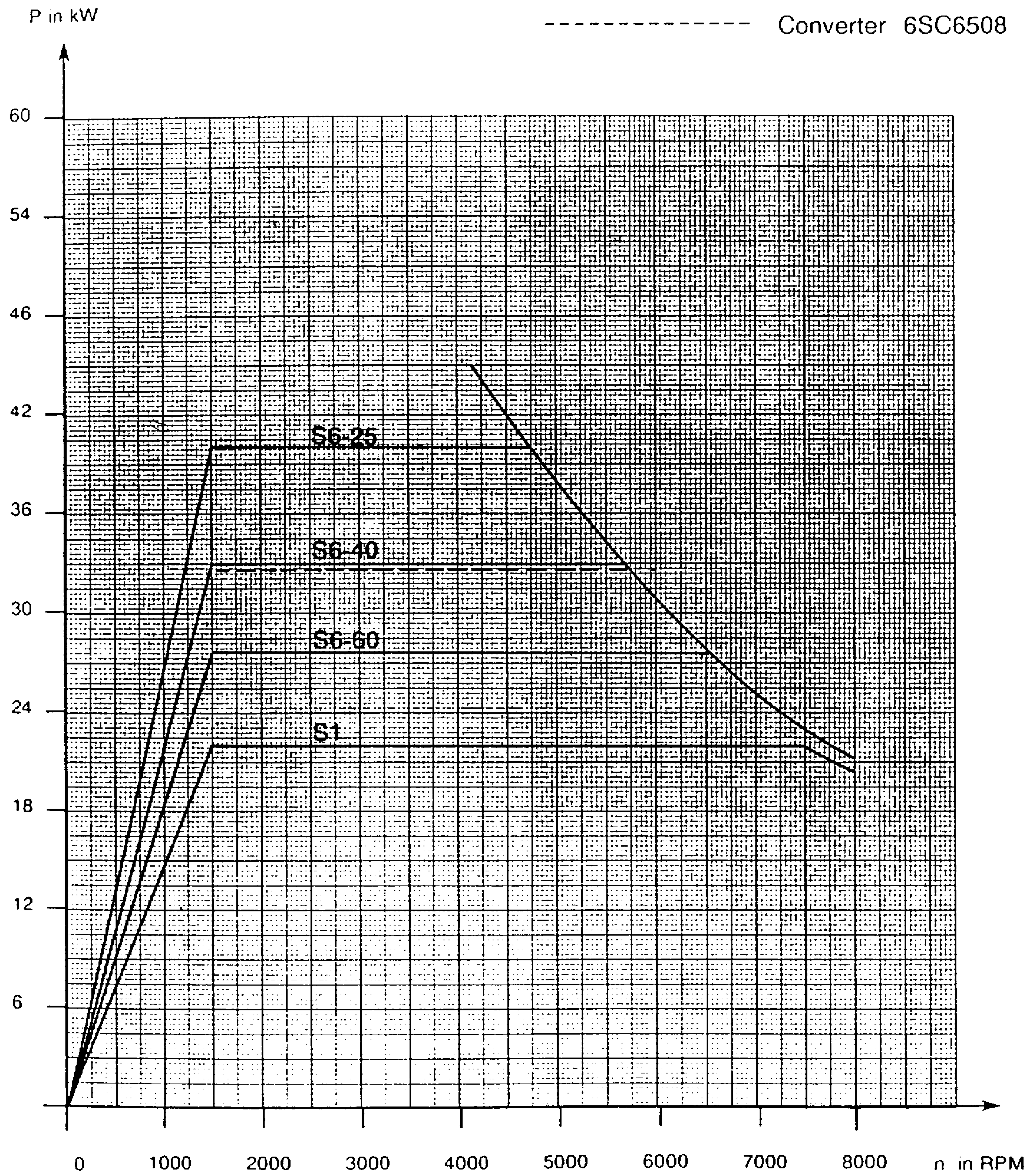


Fig. 6.26 Power - speed characteristic for the 1PH6 161-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
28.0	2000	134	70	35	6500 (8000)*	0.131	140

1PH6 161-4CG4

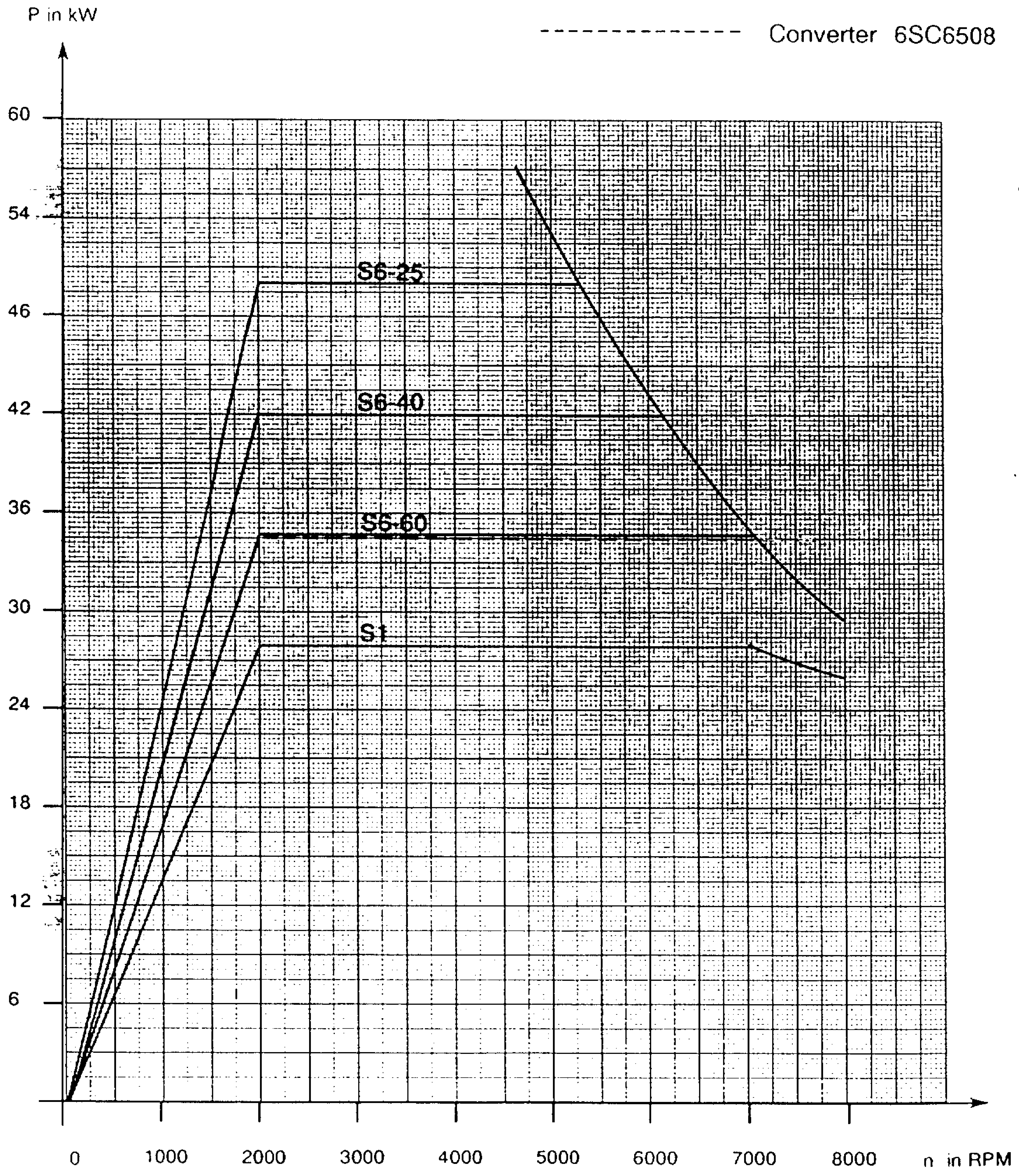


Fig. 6.27 Power - speed characteristic for the 1PH6 161-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
11.5	500	220	67	35	6500 (8000)*	0.17	175

1PH6 163-4CB4

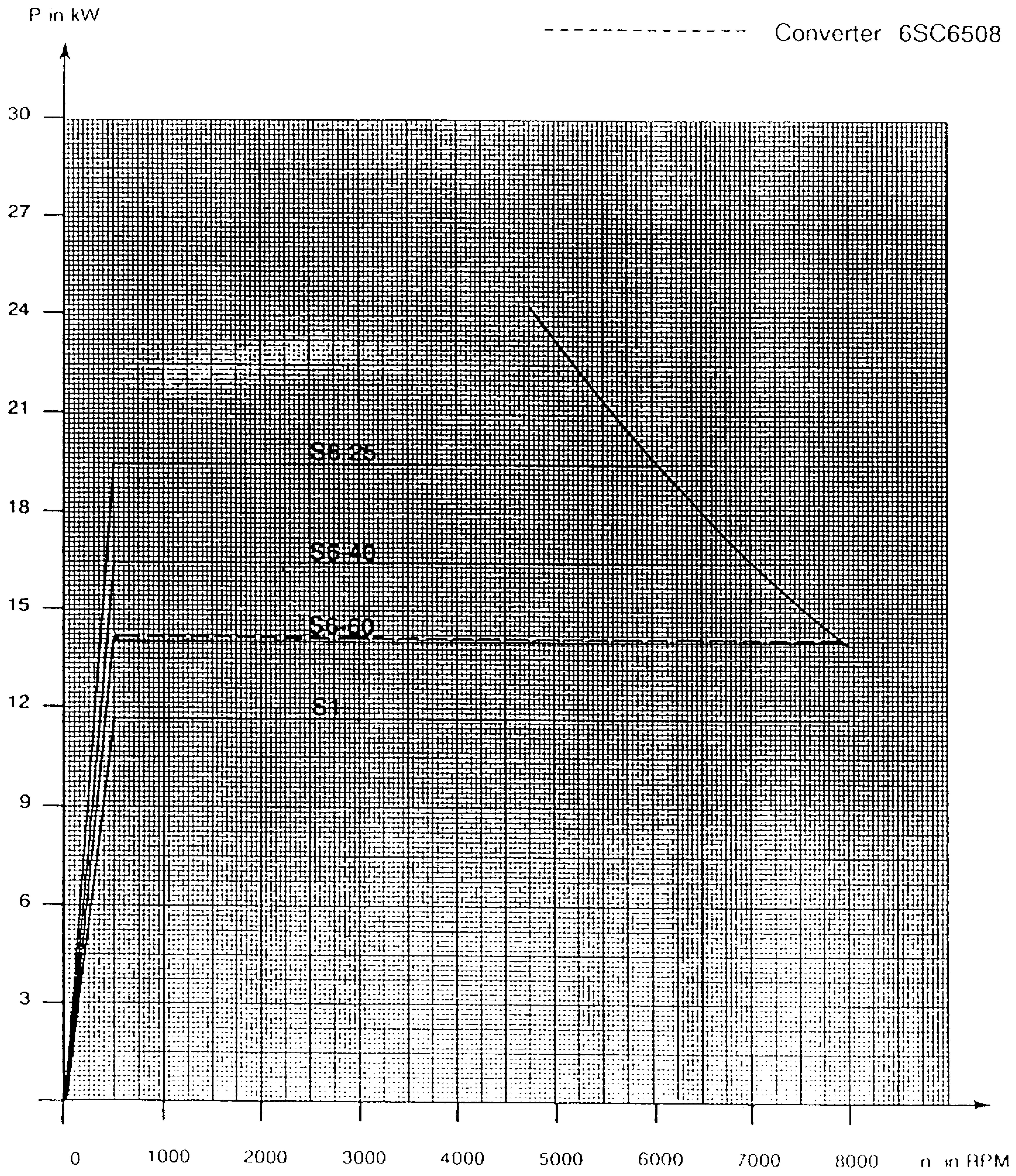


Fig. 6.28 Power - speed characteristic for the 1PH6 163-4CB4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
30.0	1500	191	75	35	6500 (8000)*	0.17	175

1PH6 163-4CF0

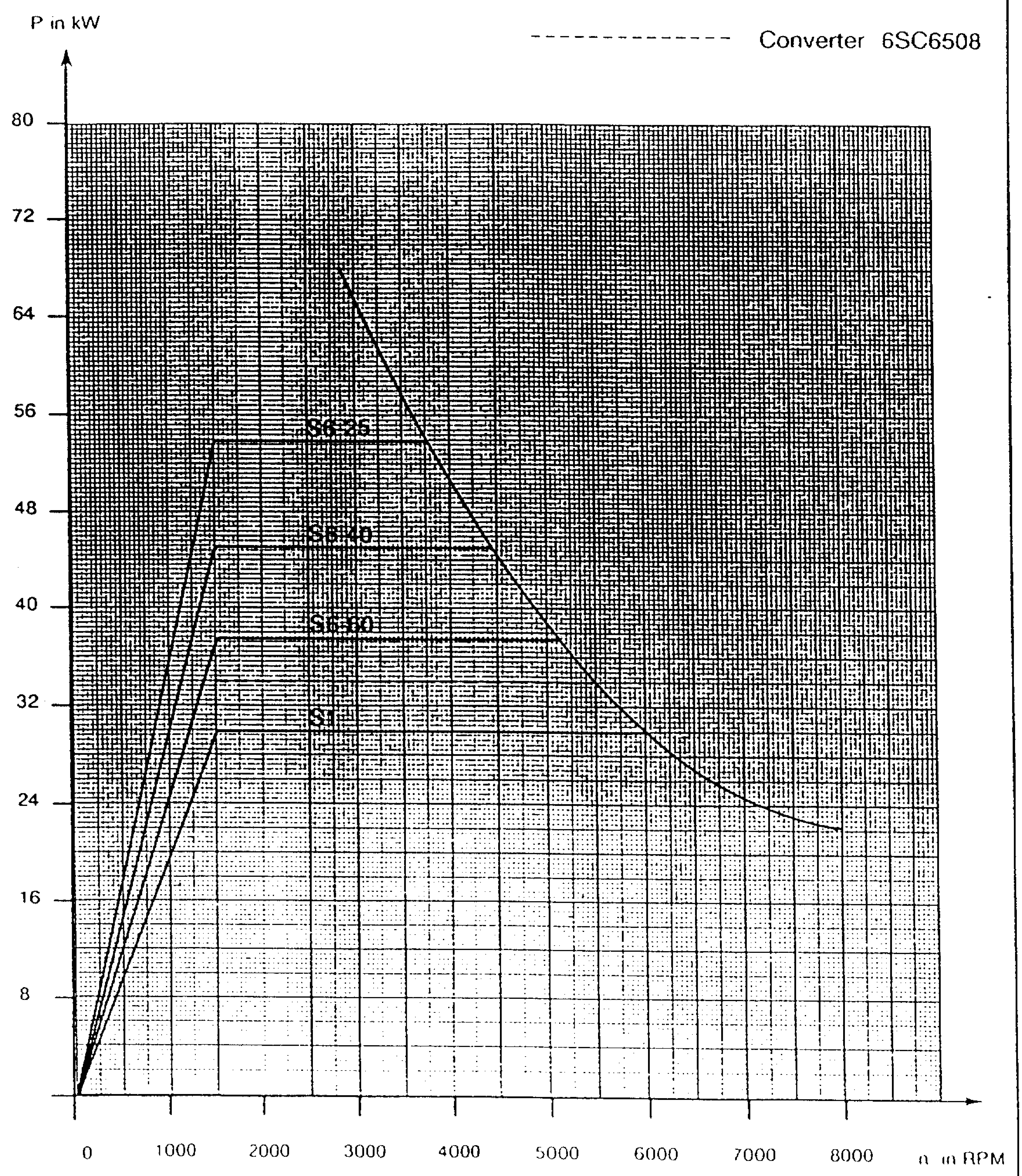


Fig. 6.29 Power - speed characteristic for the 1PH6 163-4CF0 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
30.0	1500	191	88	35	6500 (8000)*	0.17	175

1PH6 163-4CF4

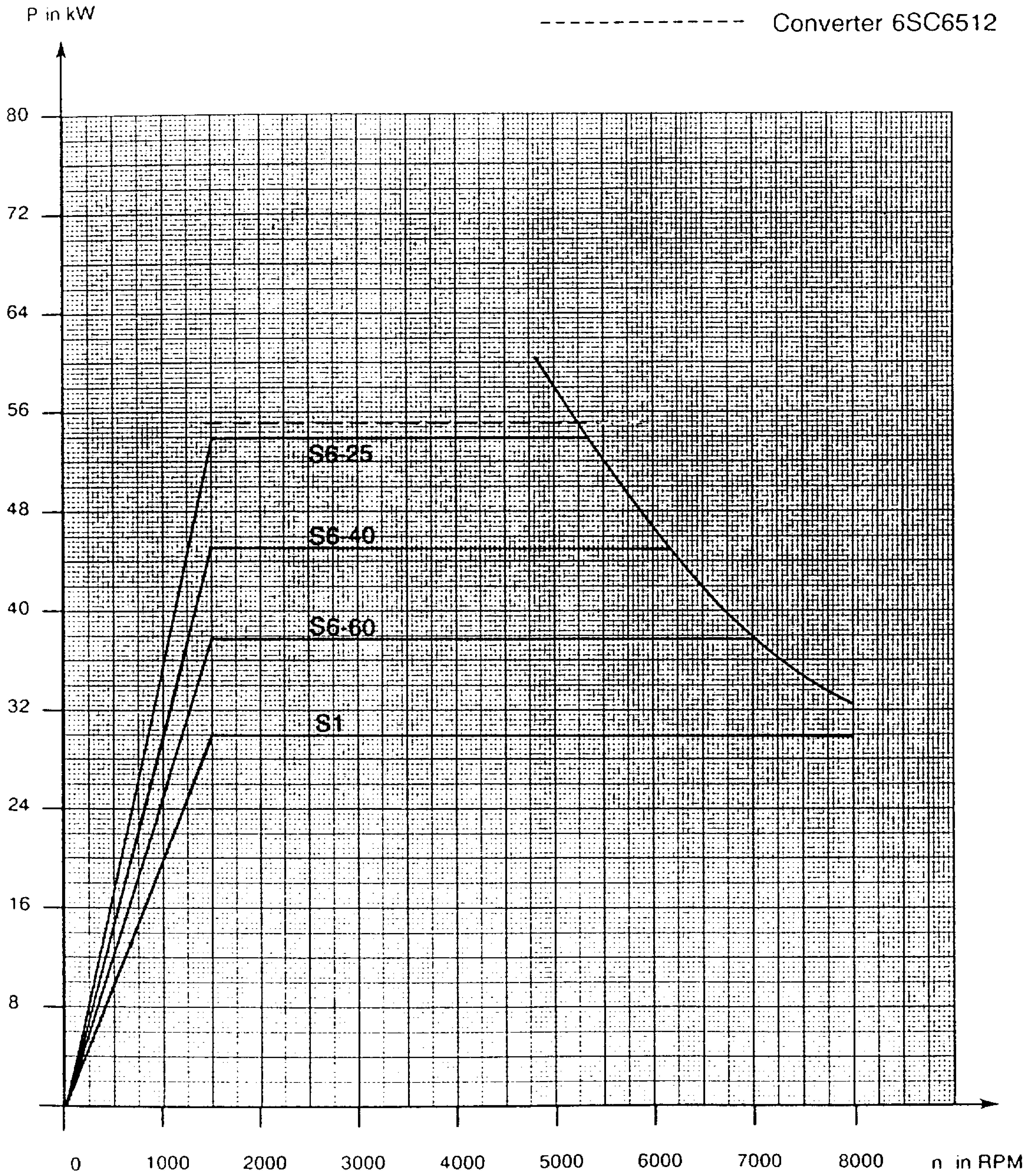


Fig. 6.30 Power - speed characteristic for the 1PH6 163-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
38.0	2000	181	90	35	6500 (8000)*	0.17	175

1PH6 163-4CG4

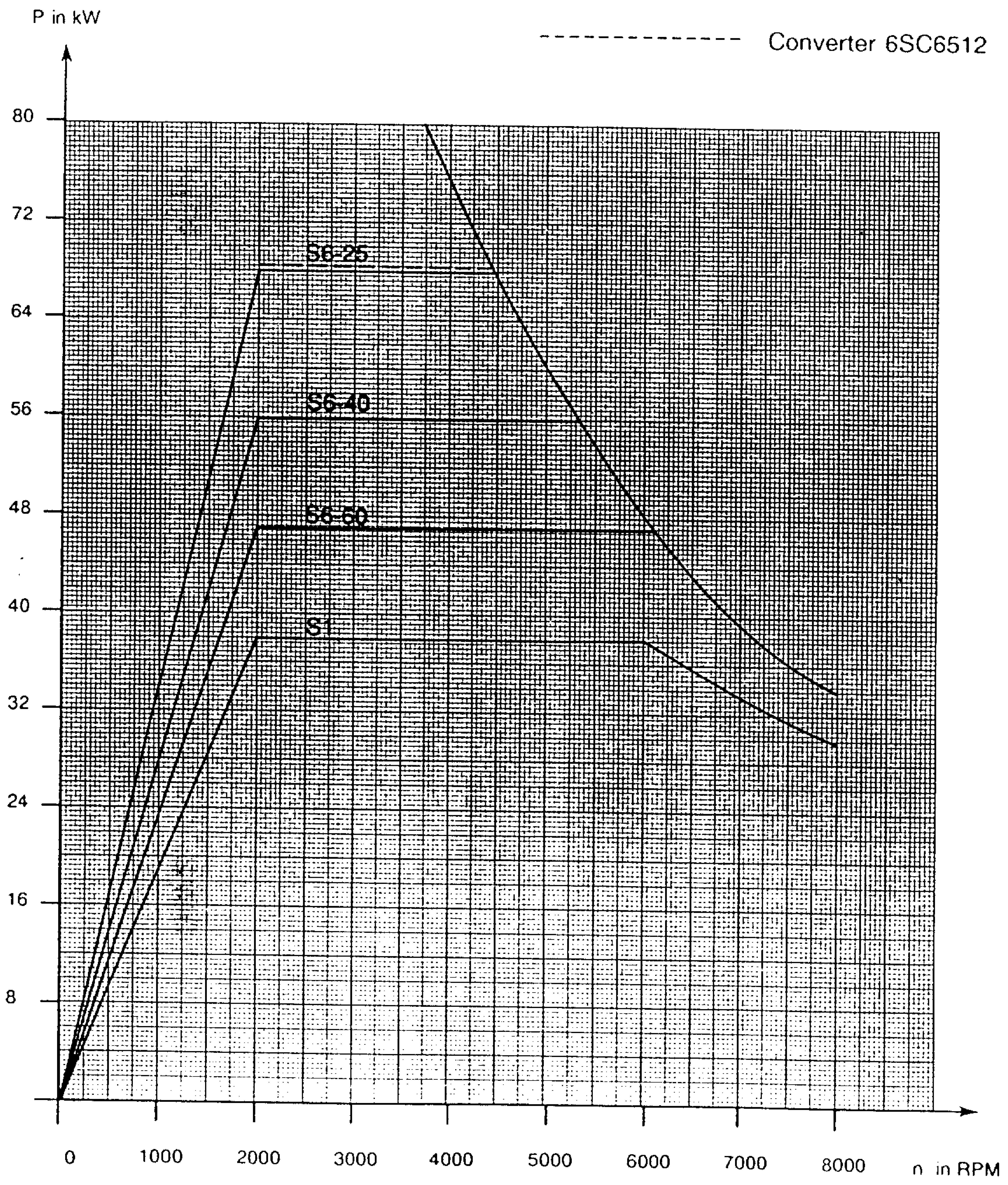


Fig. 6.31 Power - speed characteristic for the 1PH6 163-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
14.5	500	277	80	35	6500 (8000)*	0.206	210

1PH6 167-4CB4

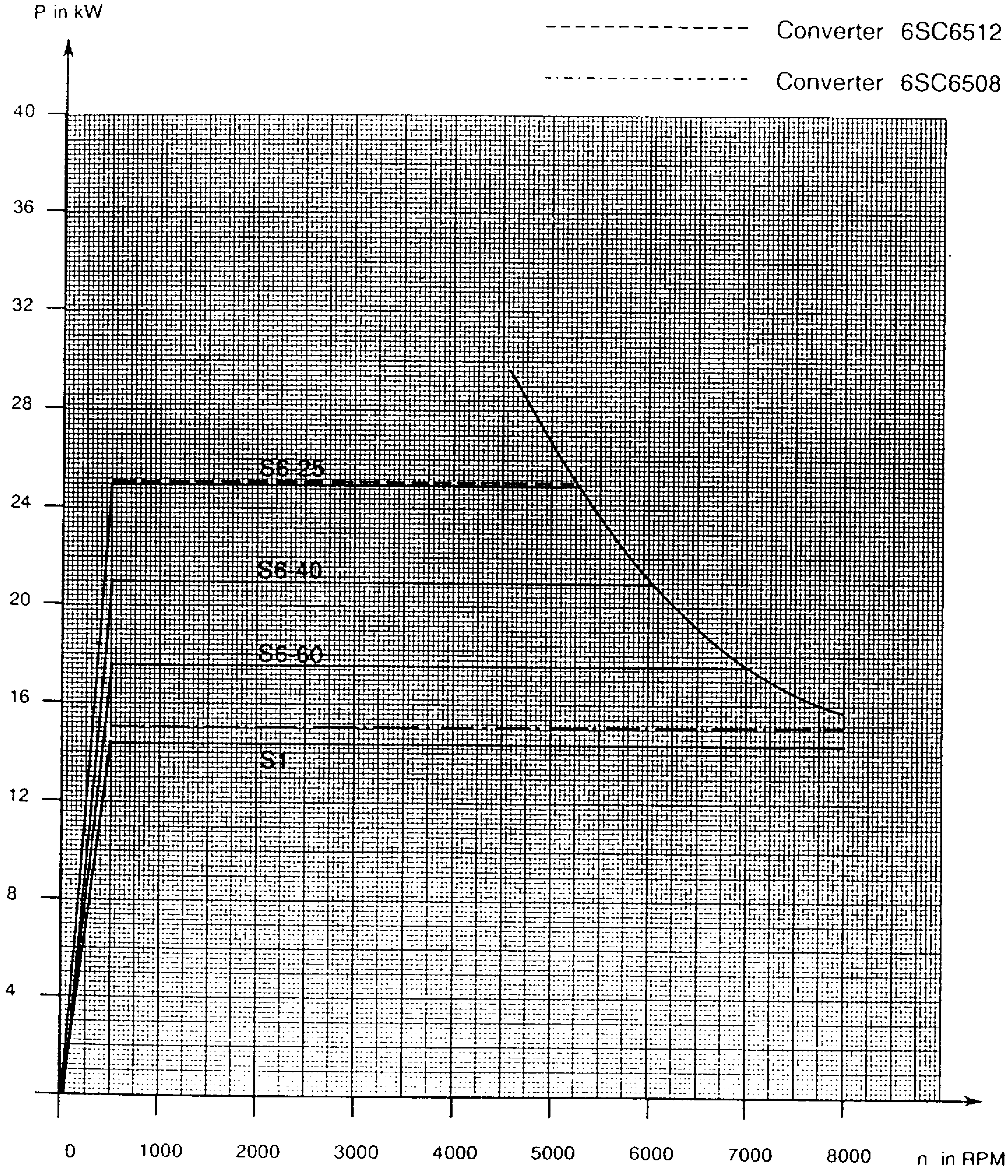


Fig. 6.32 Power - speed characteristic for the 1PH6 167-4CB4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
37.0	1500	236	82	35	6500 (8000)*	0.206	210

1PH6 167-4CF0

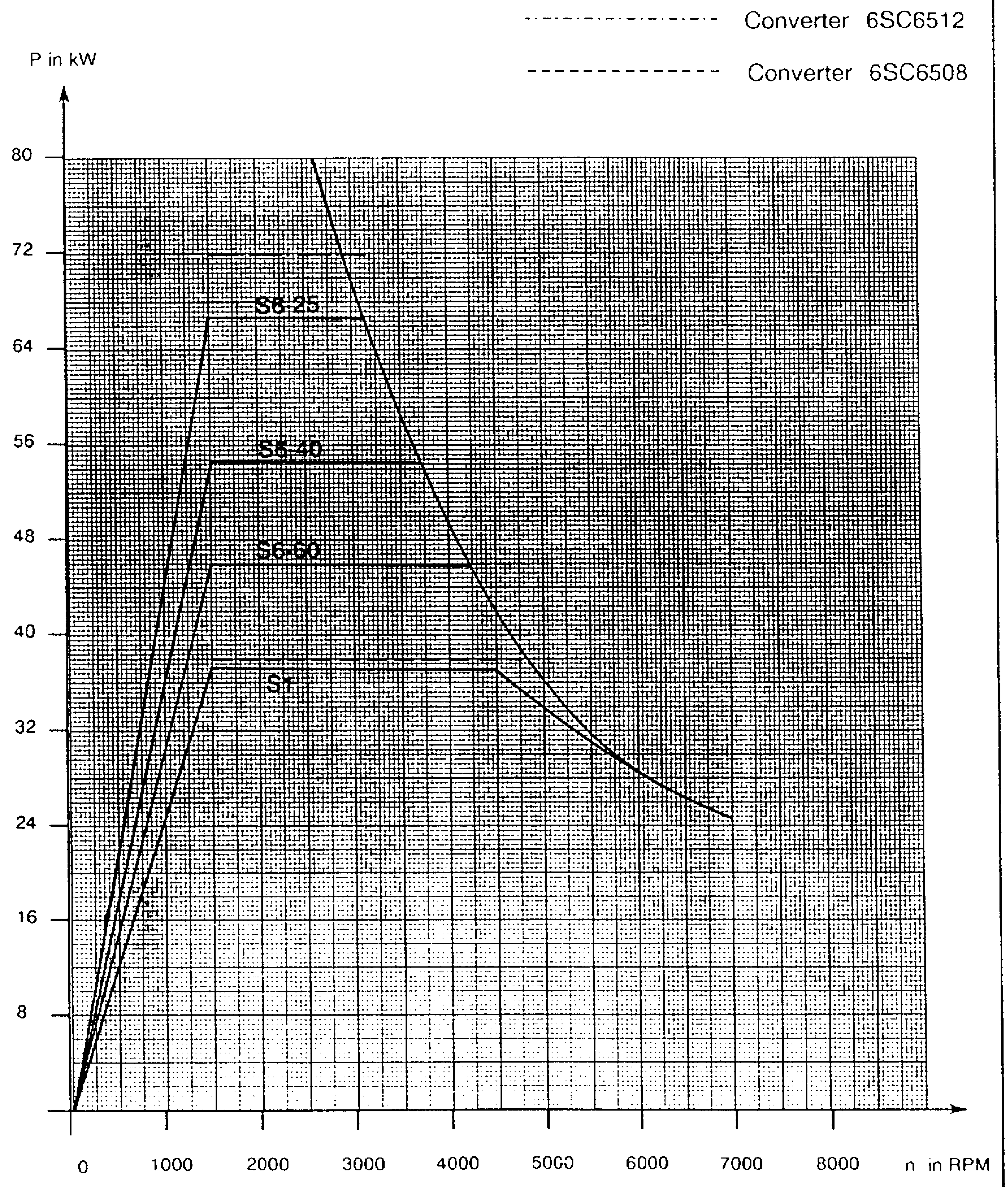


Fig. 6.33 Power - speed characteristic for the 1PH6 167-4CF0 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
37.0	1500	236	98	35	6500 (8000)*	0.206	210

1PH6 167-4CF4

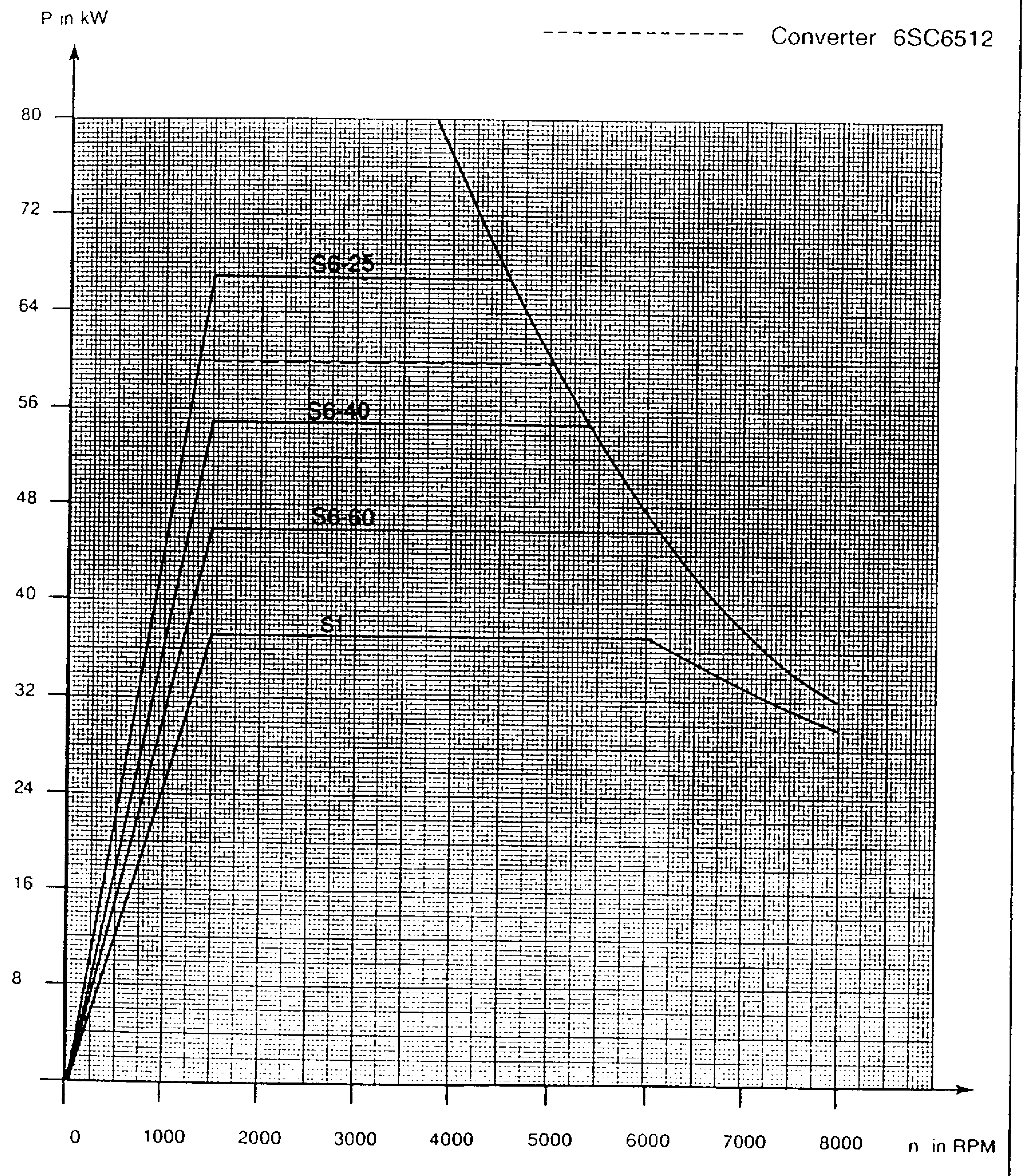


Fig. 6.34 Power - speed characteristic for the 1PH6 167-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm^2]	Weight m [kg]
45	2000	215	93	35	6500 (8000)*	0.206	210

1PH6 167-4CG4

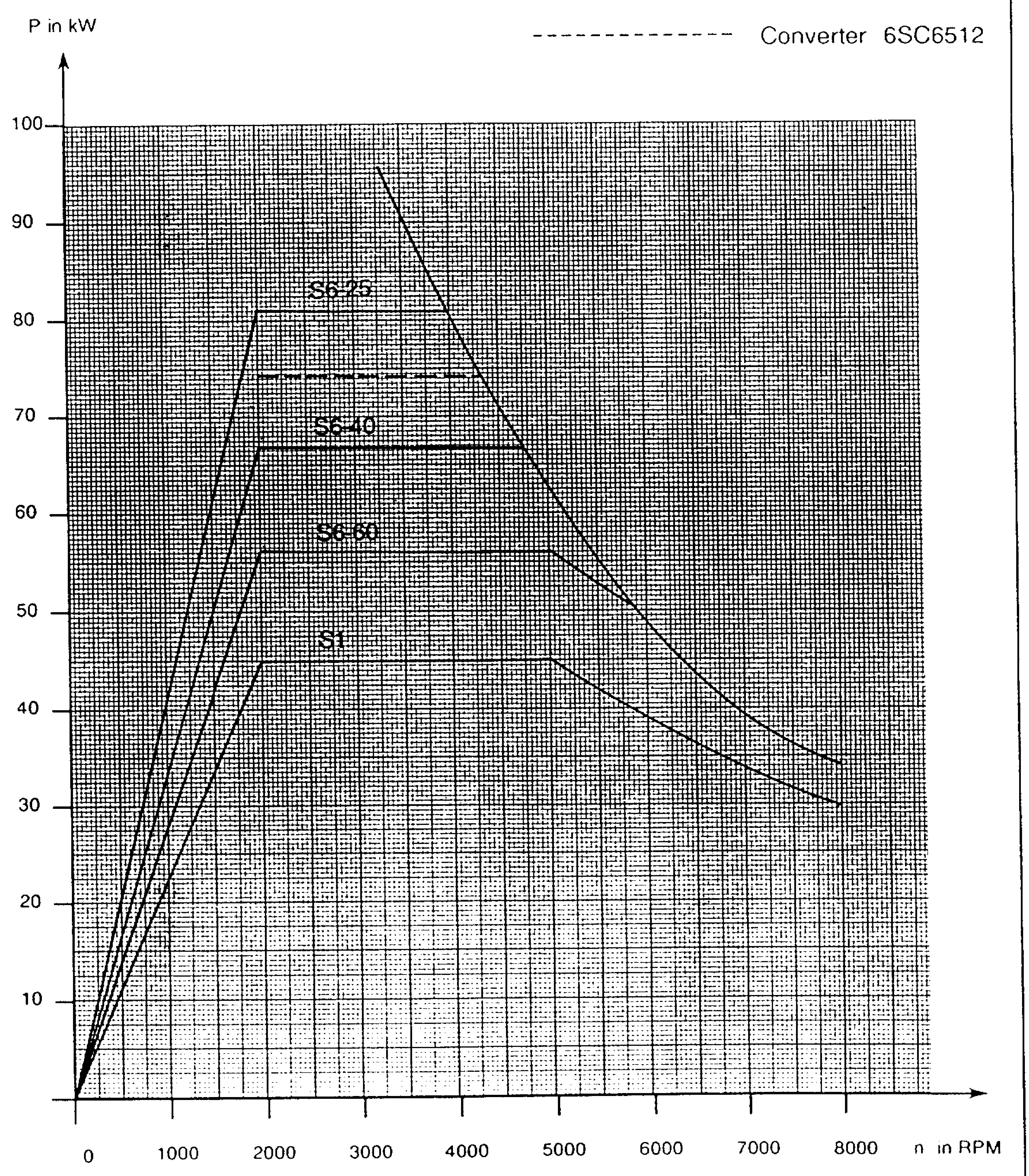


Fig. 6.35 Power - speed characteristic for the 1PH6 167-4CG4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
42.0	1250	320	84	40	5000 (7000)*	0.310	350

1PH6 186-4CE4

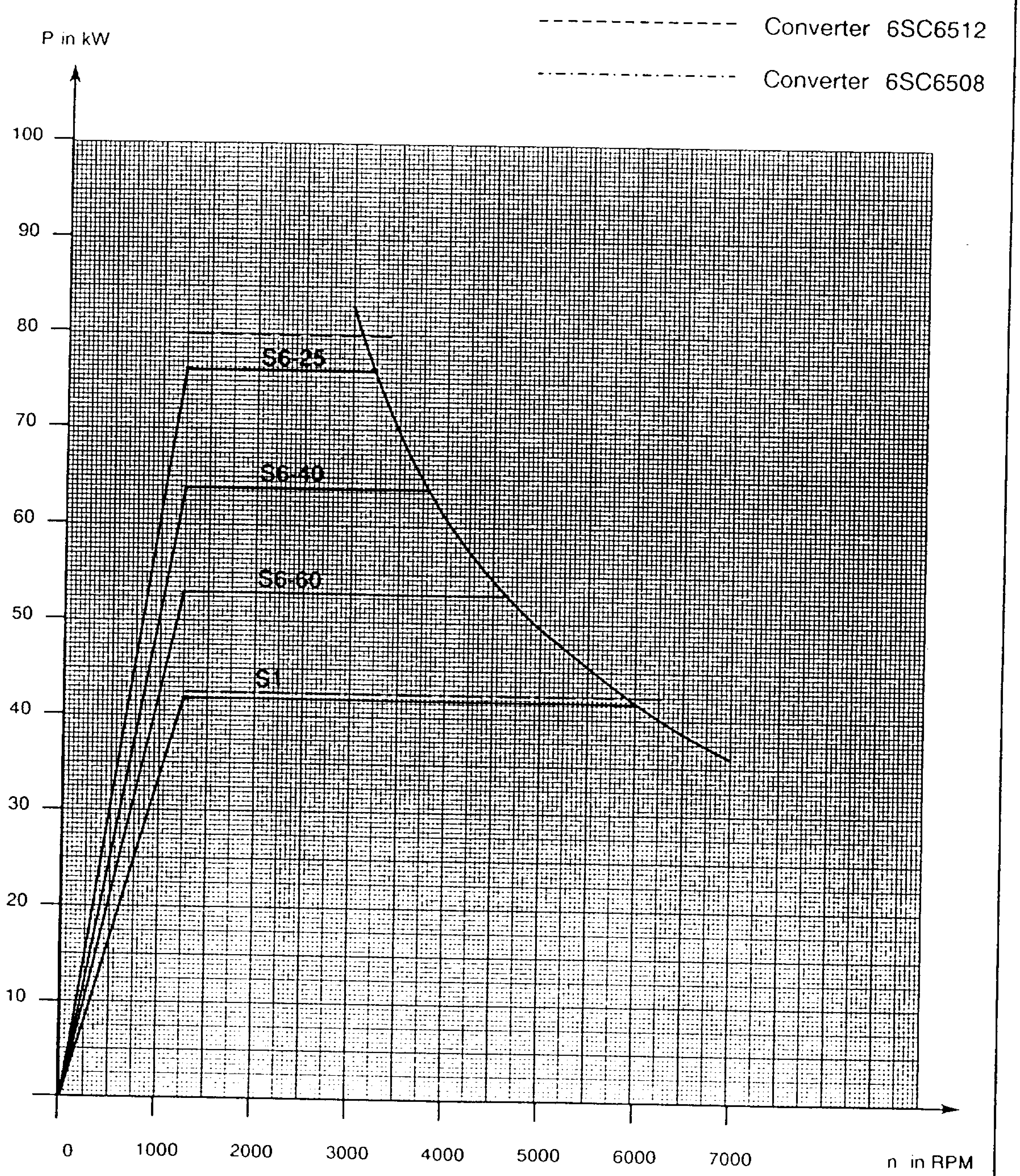


Fig. 6.36 Power - speed characteristic for the 1PH6 186-4CE4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
50.0	1500	318	100	40	5000 (7000)*	0.310	350

1PH6 186-4CF4

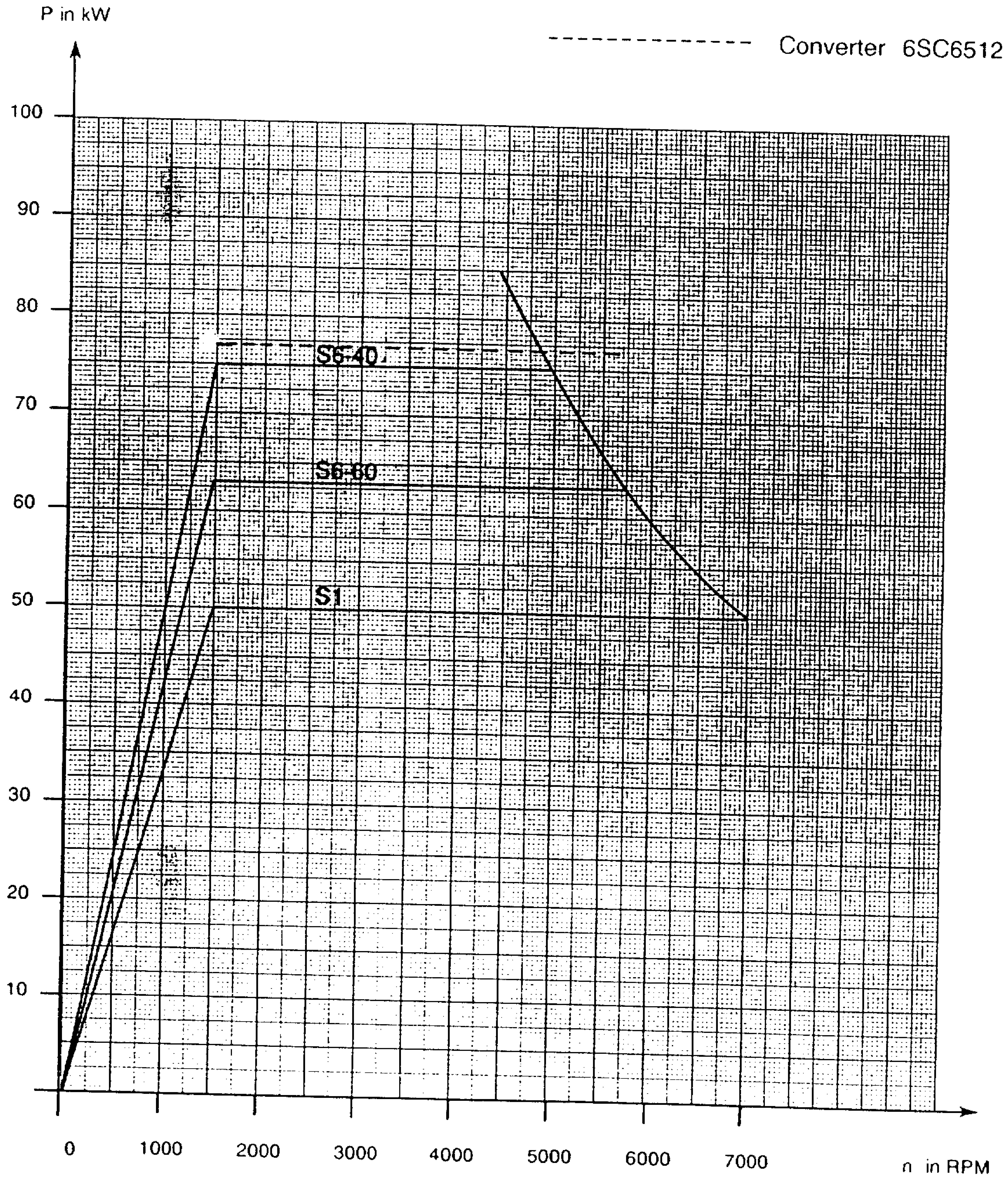


Fig. 6.37 Power-speed characteristic for the 1PH6 186-4CF4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
63.0	1250	481	122	40	5000 (7000)*	0.610	470

1PH6 206-4CE4

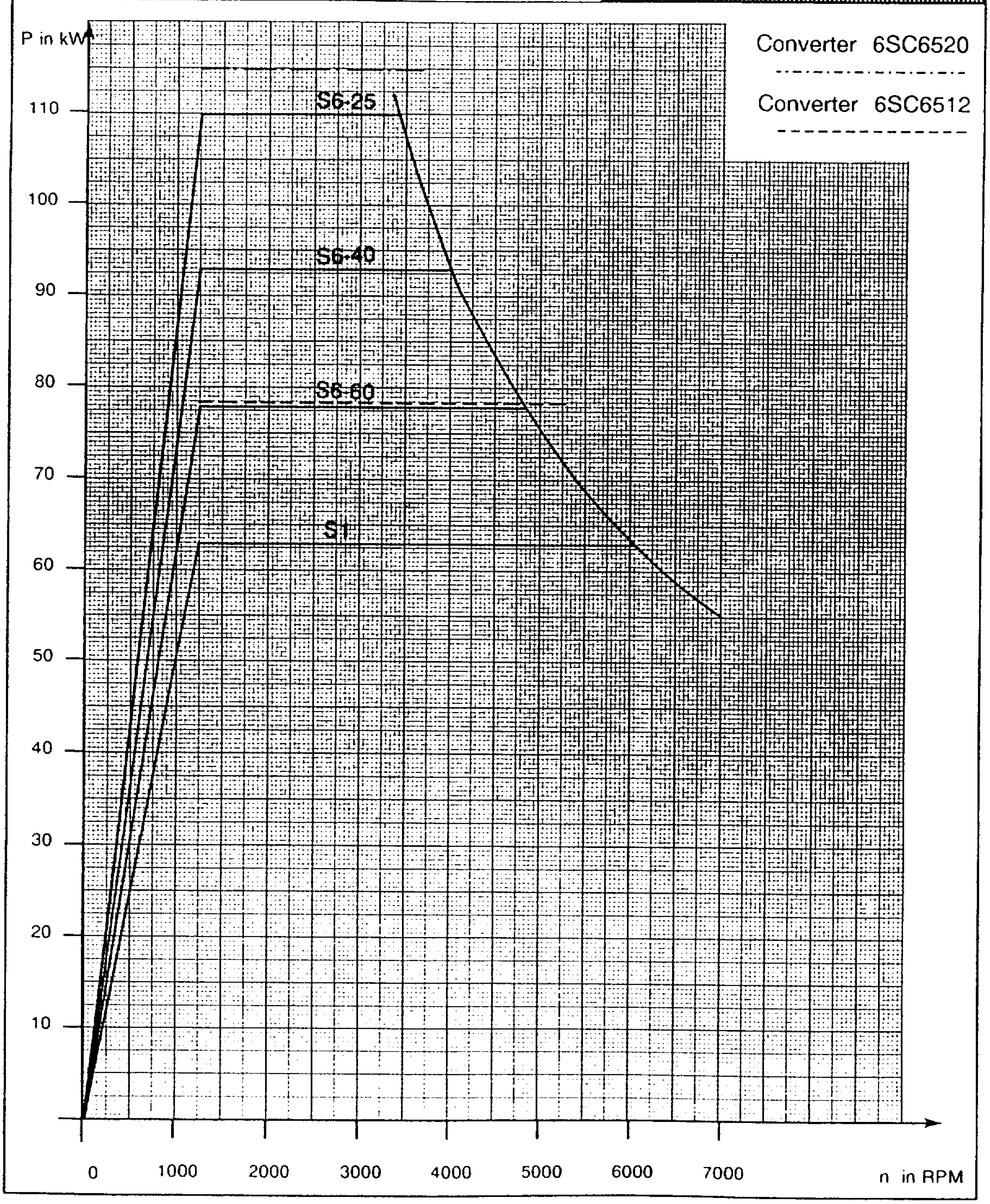


Fig. 6.38 Power - speed characteristic for the 1PH6 206-4CE4 AC motor

Rated power P_N [kW]	Rated speed n_N [RPM]	Rated torque M_N [Nm]	Rated current I_N [A]	Time constant (therm.) T_{th} [min]	Max. speed n_{max} [RPM]	Moment of inertia J [kgm²]	Weight m [kg]
76.0	1500	484	154	40	5000 (7000)*	0.610	470

1PH6 206-4CF4

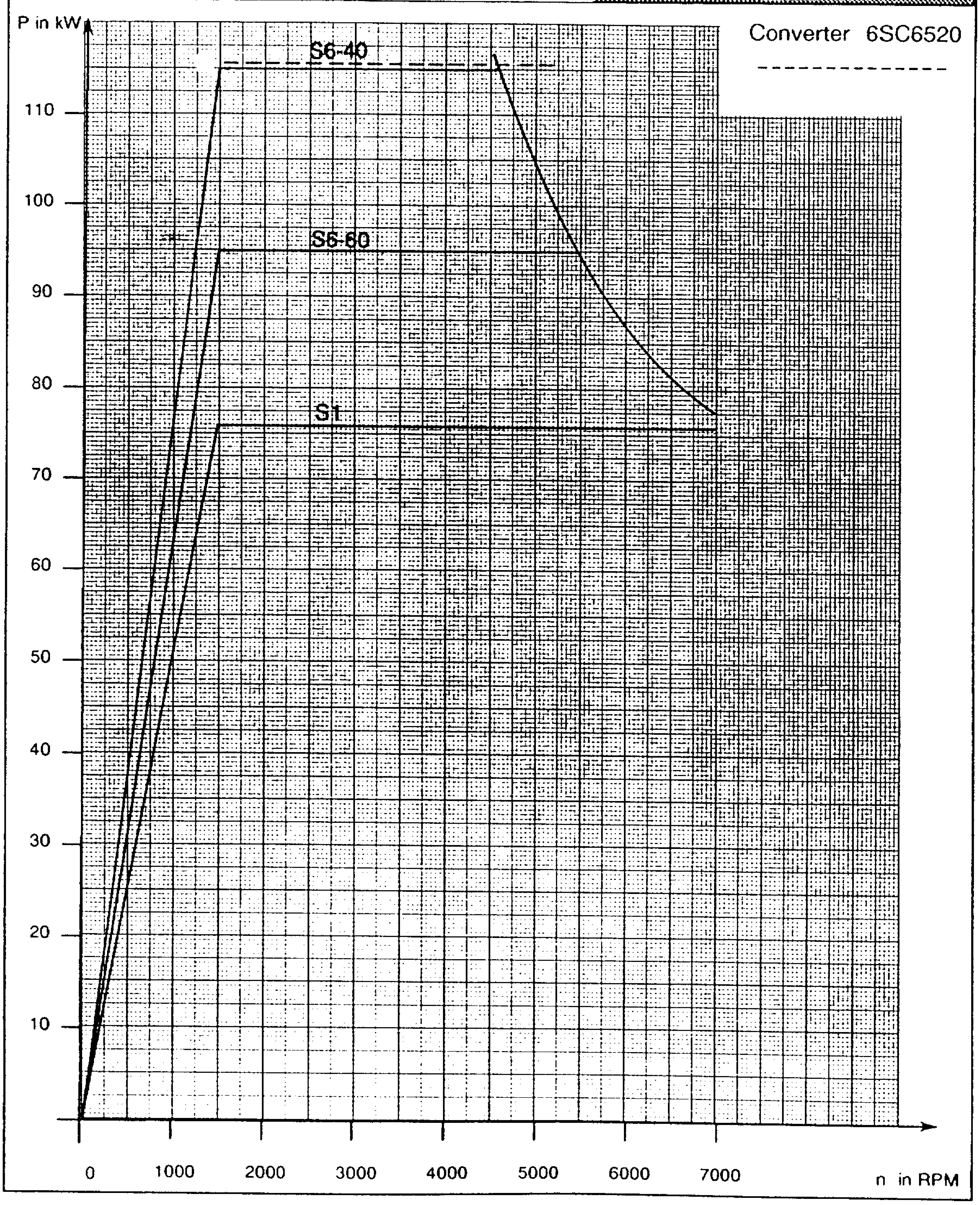


Fig. 6.39 Power - speed characteristic for the 1PH6 206-4CF4 AC motor

6.2 Cantilever force charts

Note: The cantilever force charts indicate the cantilever force F_Q at a distance x from the shaft shoulder for a nominal bearing service life of 20 000 h.

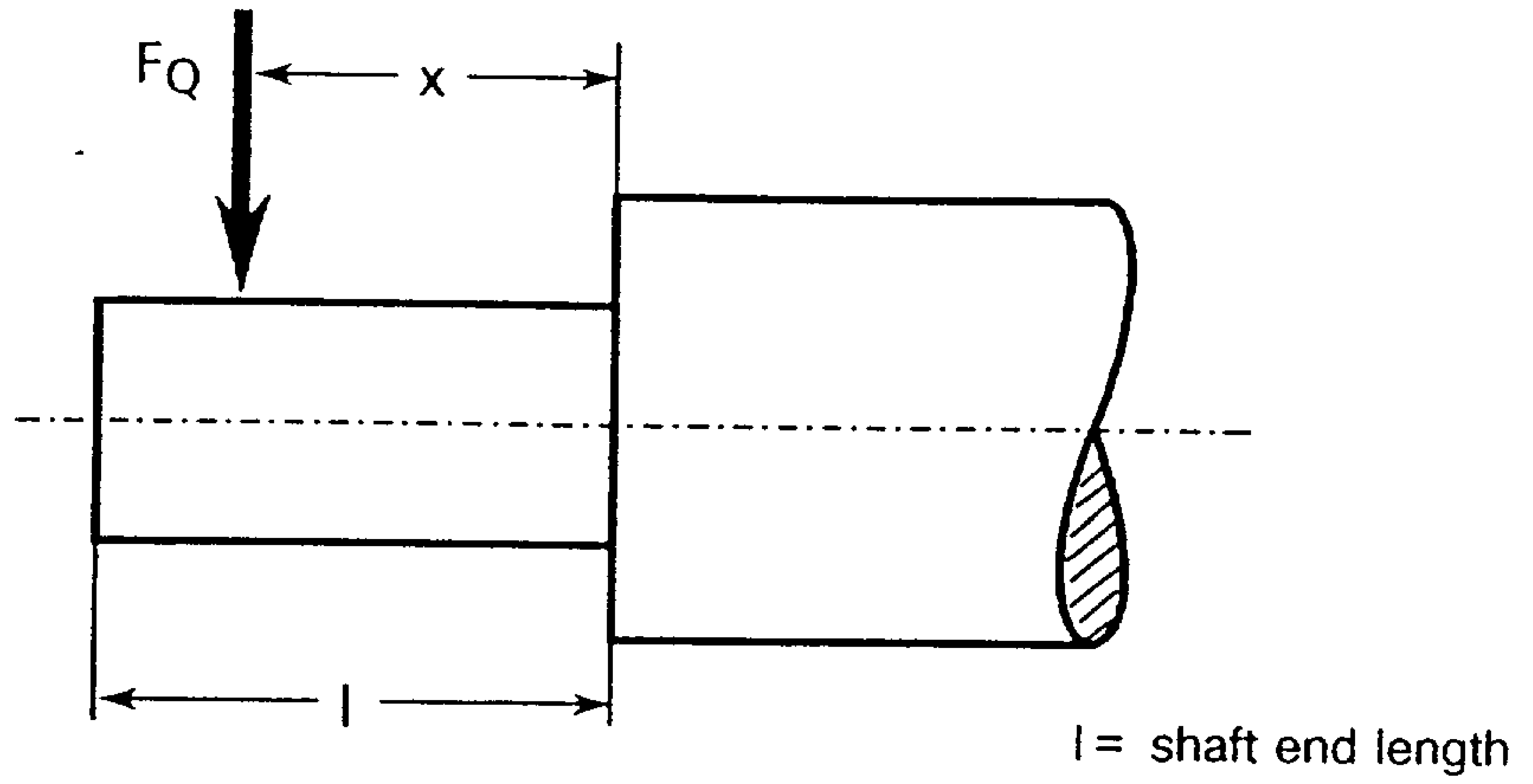


Fig. 6.40 Application point of cantilever forces at the motor shaft end

Total cantilever force

$$F_Q = c \times F_U$$

In this case, the initial tensioning force c is a value based on the experience of the belt manufacturer. It can be approximately obtained as follows:

- for standard flat belts with tensioning roll c = 2,
- for V belts c = 1.5 to 2.5
- for special plastic belts depending on the loading type and belt type c = 2.0 to 2.5.

The peripheral speed F_U is calculated using the following equation:

$$F_U = 2 \times 10^7 \times P / (n \times D) \quad \text{in N}$$

F_U Peripheral force in N
P Motor power (transmitted power in kW)
D Pulley wheel diameter in mm

When using power transmission elements which exert a cantilever force on the shaft end, it should be ensured that the limiting values specified in the cantilever force charts are not exceeded. The cantilever force charts are only valid for standard drive shaft ends; for non-standard drive shaft ends, each particular case is dimensioned according to the permissible cantilever forces.

Cantilever forces exceeding those given in the charts should be separately inquired.

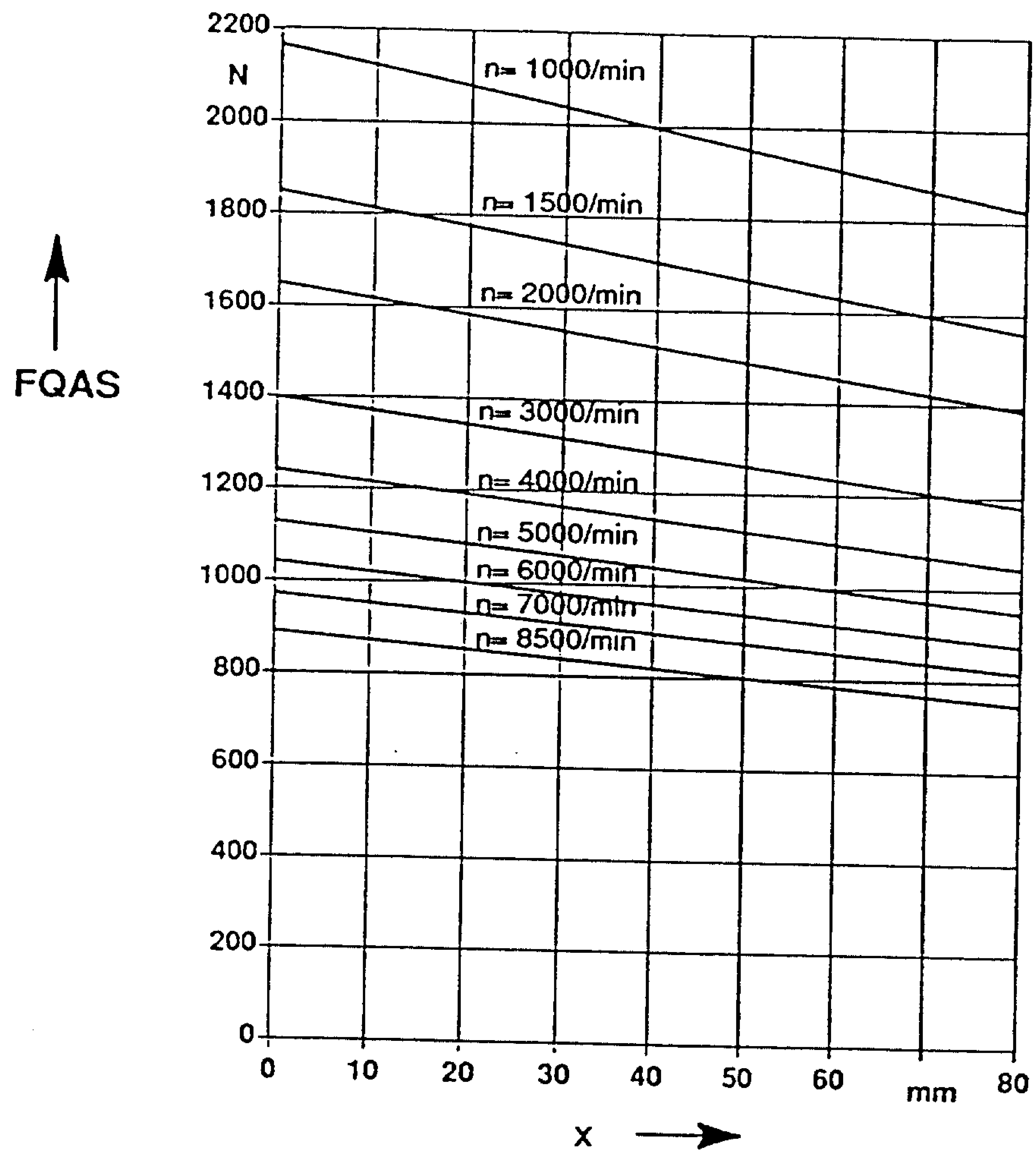


Fig. 6.41 Cantilever force chart for 1PH6 10□-4 AC motors, single-bearing design

Fig. 6.42 Cantilever force chart for 1PH6 10□-4 AC motors, with spindle bearing

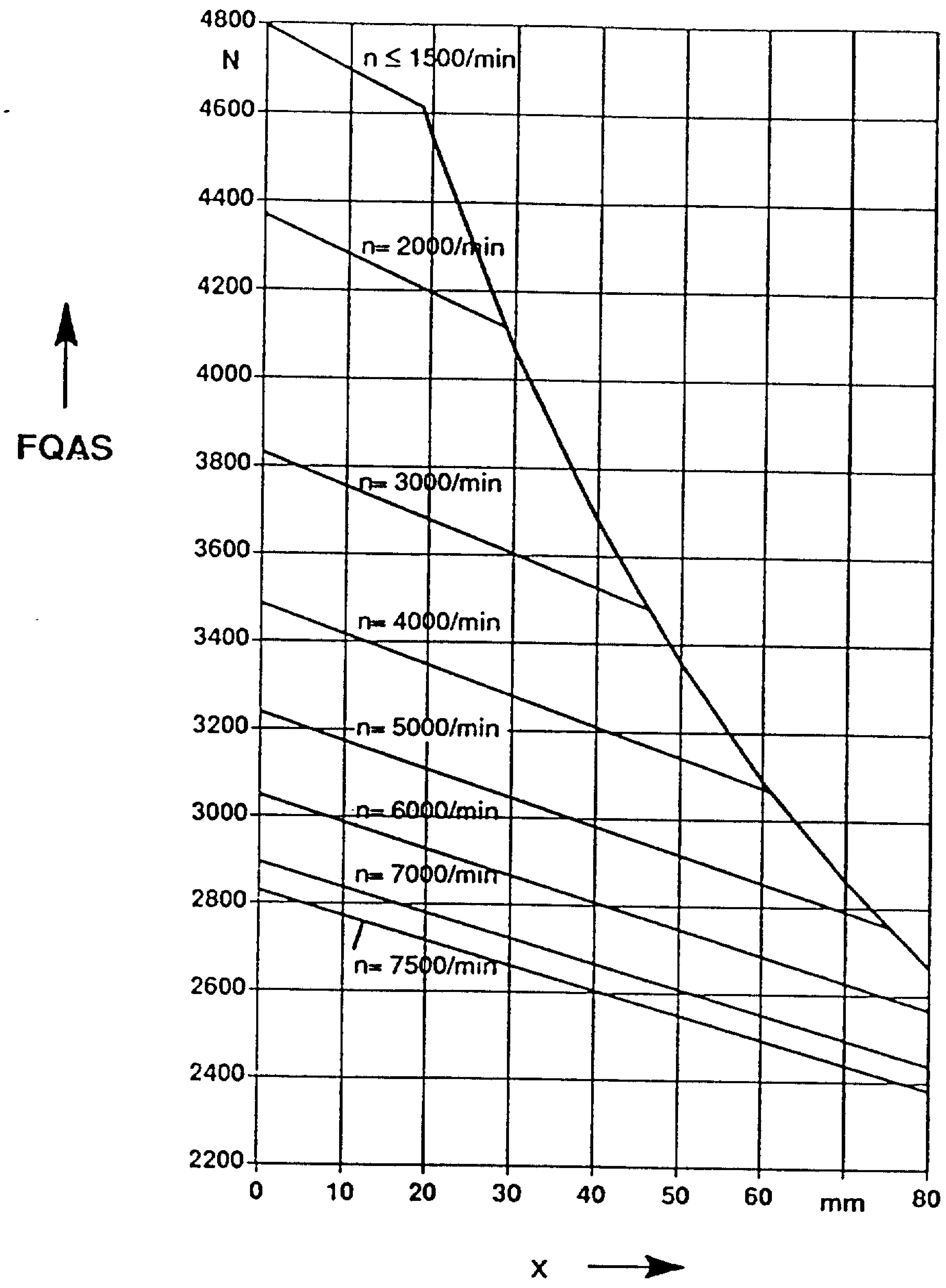


Fig. 6.43 Cantilever force chart for 1PH6 10□-4 AC motors, with double-bearing design

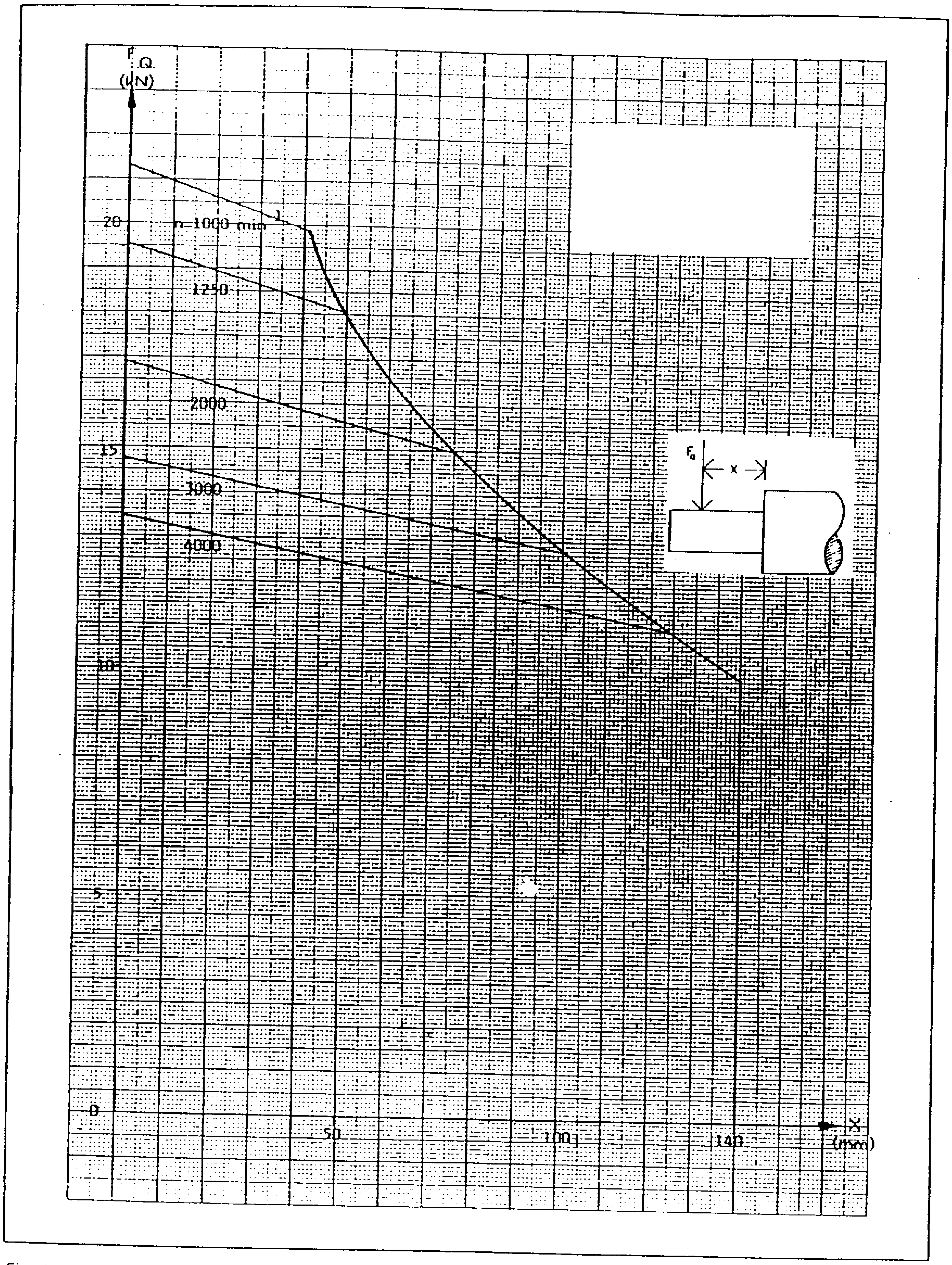


Fig. 6.54 Cantilever force chart for 1PH6 206-4 AC motors, with reinforced bearing

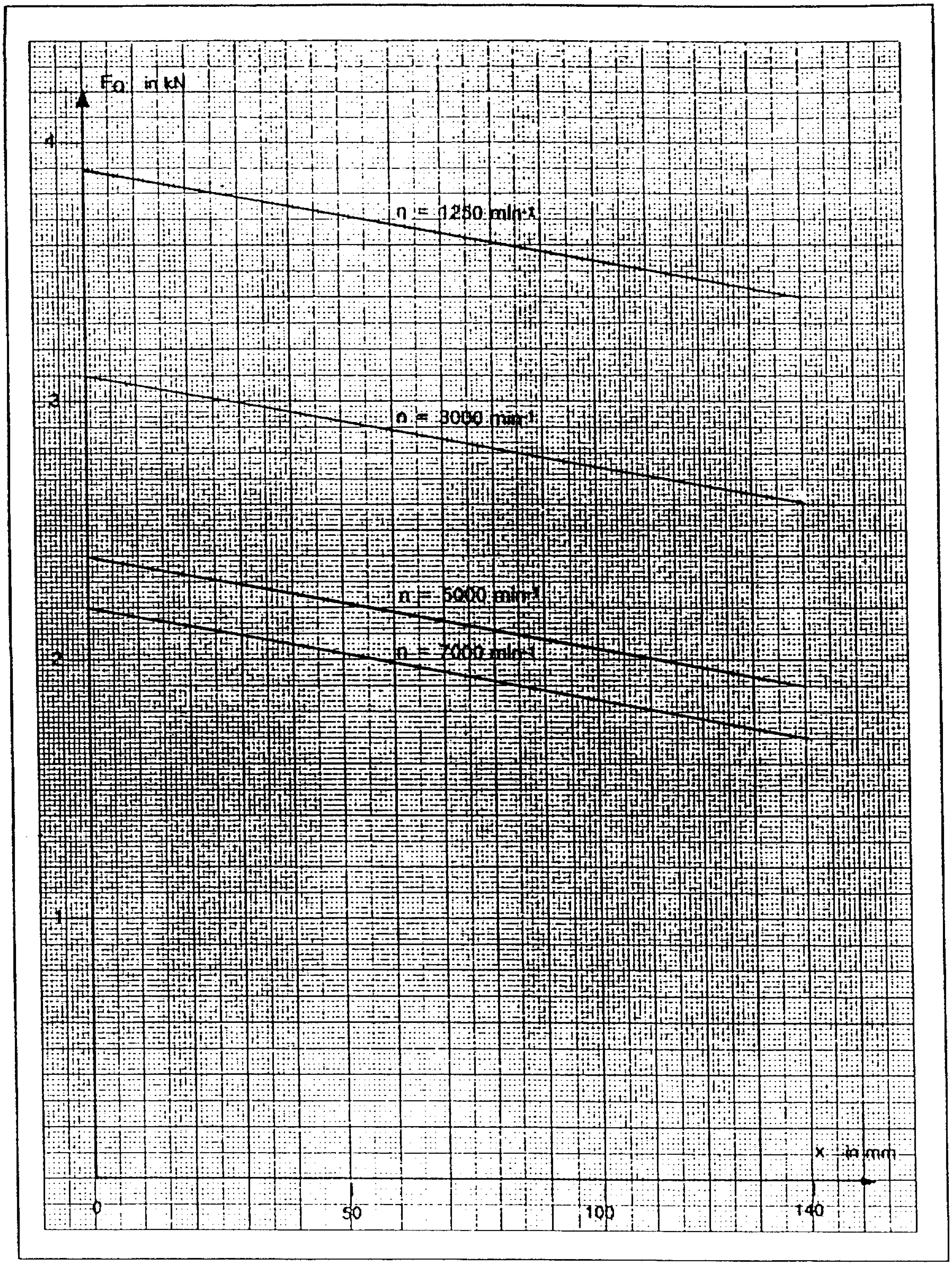


Fig. 6.55 Cantilever force chart for 1PH6 206-4 AC motors, for high-speed motors with option L37

6.3 Vibrational severity charts

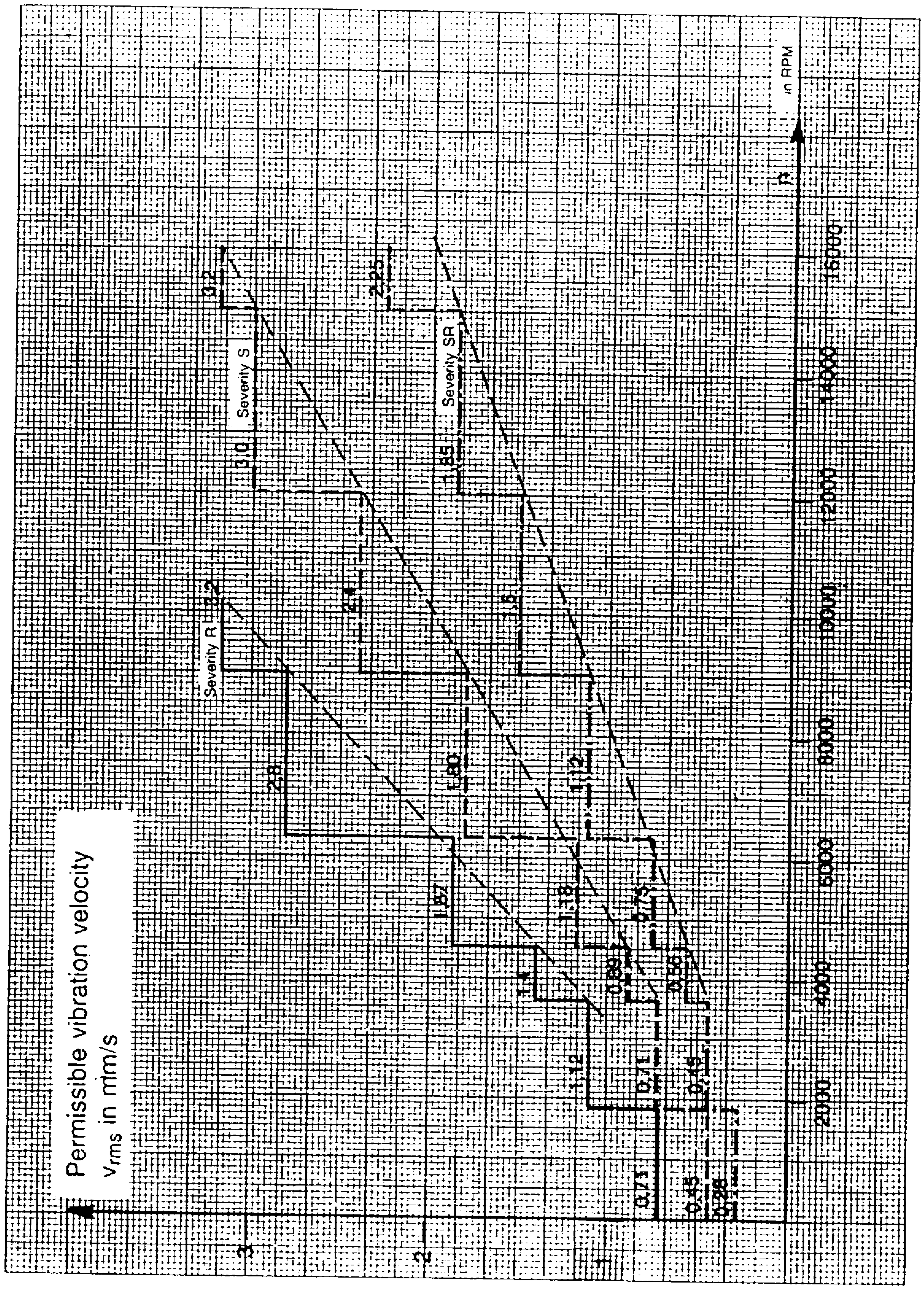


Fig. 6.56 Vibration severity limiting values, AC motors shaft height 100 mm to 132 mm

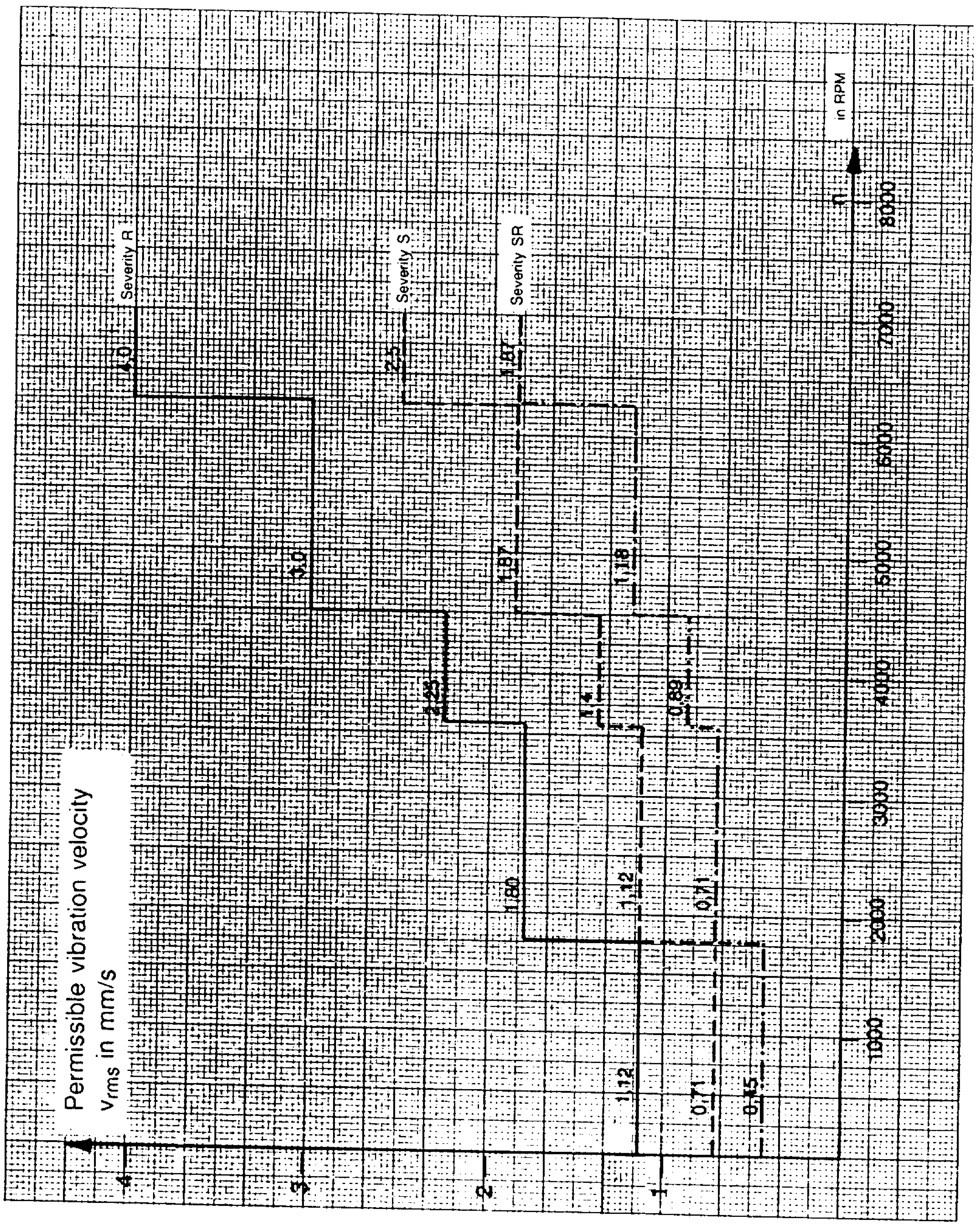
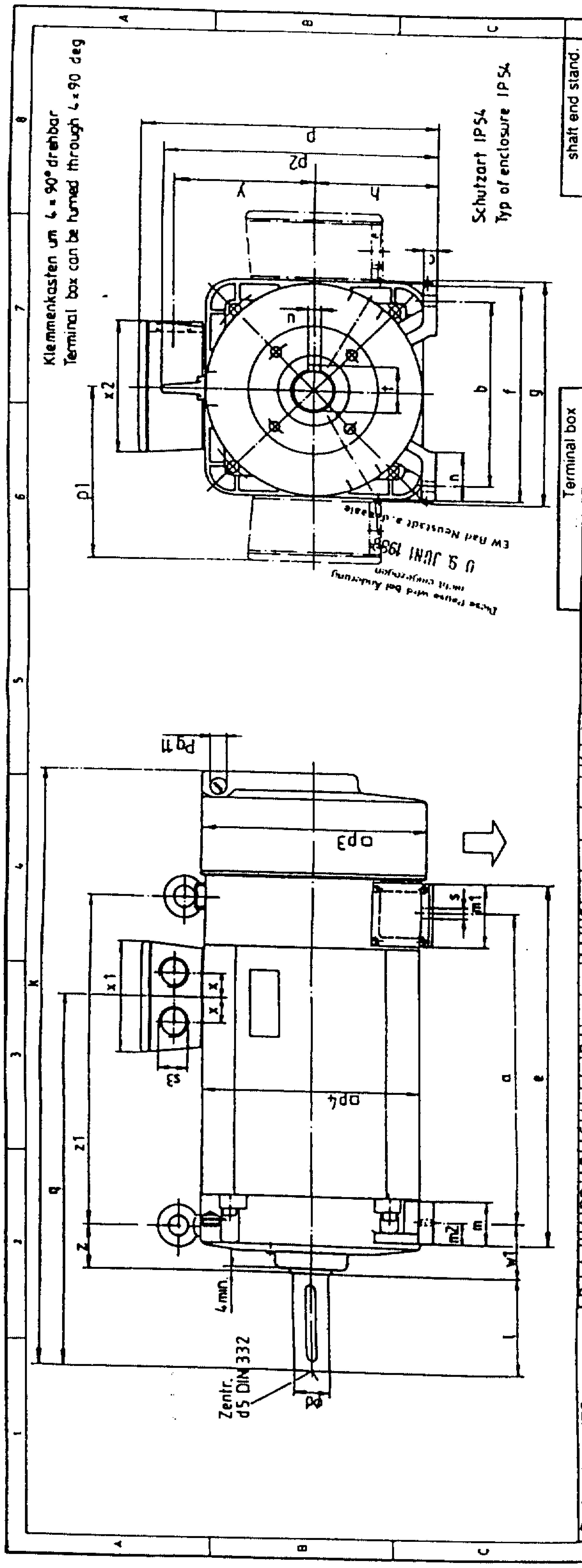


Fig. 6.57 Vibration severity limiting values, AC motors shaft height AH 160 mm to 200 mm

6.4 AC motor dimension sheets

Dim.	Permissible deviations		
a, b	up to 250 mm above 250 mm to 500 mm above 500 mm to 750 mm		± 0.75 mm ± 1.0 mm ± 1.5 mm
b_1	up to 230 mm above 230 mm	DIN 7160	j6 h6
d, d_1	up to 11 mm above 11 mm to 50 mm above 50 mm	DIN 7160	j6 k6 m6
e_1	up to 200 mm above 200 mm to 500 mm		± 0.25 mm ± 0.5 mm
h	above 50 mm to 250 mm above 250 mm to 500 mm	DIN 747	– 0.5 mm – 1.0 mm
i, i_1,i_2	up to 85 mm above 85 mm to 130 mm above 130 mm to 240 mm		± 0.75 mm ± 1.0 mm ± 1.5 mm
u, t, u_1, t_1	according to DIN 6885 Bl.1		

Table 6.1 Permissible deviations

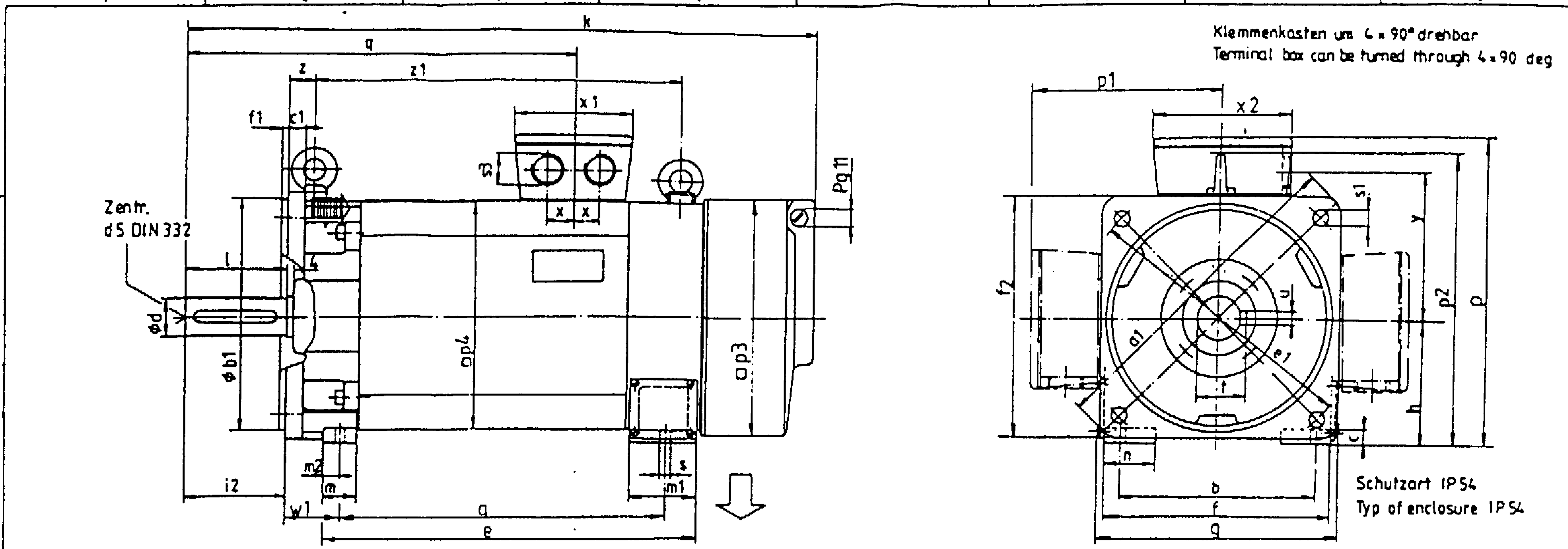


Designation to IEC			B	A	HA	BB	AB	AC	H	L	BA			AA	HC				K	C			HD	AD						D	E	GA	F	
AH frame	Typ typ	Kl-Kasten term-box	a	b	c	e	f	g	h	k	m	m1	m2	n	p2	p3	p4	q	s	w1	z	z1	p	p1	s3	x	x1	x2	y	d	l	t	u	d5
100	1PH6 101 103 105 107	gk 233	247 292 352 417	160	12	292 337 397 462	190	200	100	531 576 636 701	30	62	15	40	233	190	190	286 331 391 456	12	50	46	262 307 367 432	259	159	Pg 21	21	117	122	124	38	80	41	10	DRM 12
132	1PH6 131 133 135 137 138	gk 333	289 316 386 436 506	216	14	345 372 442 492 562	246	255	132	622 649 719 769 839	40	62	25	46	302	252	245	368 395 465 515 585	12	63	58	304 331 401 451 521	333	201	Pg 29	27	132	152	159	42	110	45	12	DRM 16
160	1PH6 161 163 167	gk 433	385 445 500	254	18	434 494 549	294	304	160	742 802 857	33	62	18	52	363	302	294	457 517 572	14	70	52	412 472 527	383	223	Pg 29	27	162	162	180	55	110	59	16	DRM 20

(Terminal box: p, p1, s3, x, x1, x2, y; shaft end stand.: d, l, t, u, d5)

Maße	Zulässige Abweichungen
a und b	[illegible]
d.	DIN 7160 [illegible]
h	[illegible]
l + w1 + l	[illegible]
u. l.	nach DIN 6885 Bl. 1

Fig. 6.58 Dimension sheet for 1PH6 101 to 167, AC motors, type of construction IM B3 (Dimensions in mm, not to scale)



Designation to IEC			B	A	HA	BB	AB	AC	H	Befestigungsflansch	P	N	LA	M	T			S	L	BA			AA	HD	AD	HC				K	C			shaft end stand. D	E	GA	F	
AH frame	Typ typ	Kl-Kasten term-box	a	b	c	e	f	g	h	Größe size	a1	b1	c1	e1	f1	f2	i2	s1	k	m	m1	m2	n	p	p1	p2	p3	p4	q	s	w1	z	z1	d	l	t	u	d5
100	1PH6 101	gk 233	247	160	10	289	190	200	100	A 250	250	180	12	215	4	196	80	14	531	30	62	12	40	259	159	233	190	190	291	12	50	24	284	38	80	41	10	DRM 12
	103		292			334													576										336				329					
	105		352			394													636										396				389					
	-107		417			459													701										461				454					
132	1PH6 131	gk 333	289	216	14	335	246	255	132	A 350	350	250	14	300	5	262	110	18	622	30	62	15	46	333	201	302	252	245	368	12	63	28	334	42	110	45	12	DRM 16
	133		316			362													649										395				361					
	135		386			432													719										465				431					
	137		436			482													769										515				481					
	138		506			552													839										585				551					
160	1PH6 161	gk 433	385	254	18	434	294	304	160	A 400	400	300	18	350	5	314	110	18	742	32	62	18	55	383	223	363	302	294	457	14	70	28	426	55	110	59	16	DRM 20
	163		445			494													802										517				486					
	167		500			549													857										572				541					

dimension Maße	admissible tolerance Zulässige Abweichungen
a und b	[illegible]
h	[illegible] DIN 7160
d	[illegible] DIN 7160
e1	[illegible]
k	[illegible] DIN 7167
i, w1, i2	[illegible]
u, t	nach DIN 6885 Bl.1

Terminal box					
Größe size	s3	x	x1	x2	y
gk 233	Pg 21	21	117	122	124
gk 333	Pg 29	27	132	152	159
gk 433	Pg 29	27	162	162	180

Fig. 6.59 Dimension sheet for 1PH6 101 to 167 AC motors, type of construction IM B35 (dimensions in mm, not to scale)

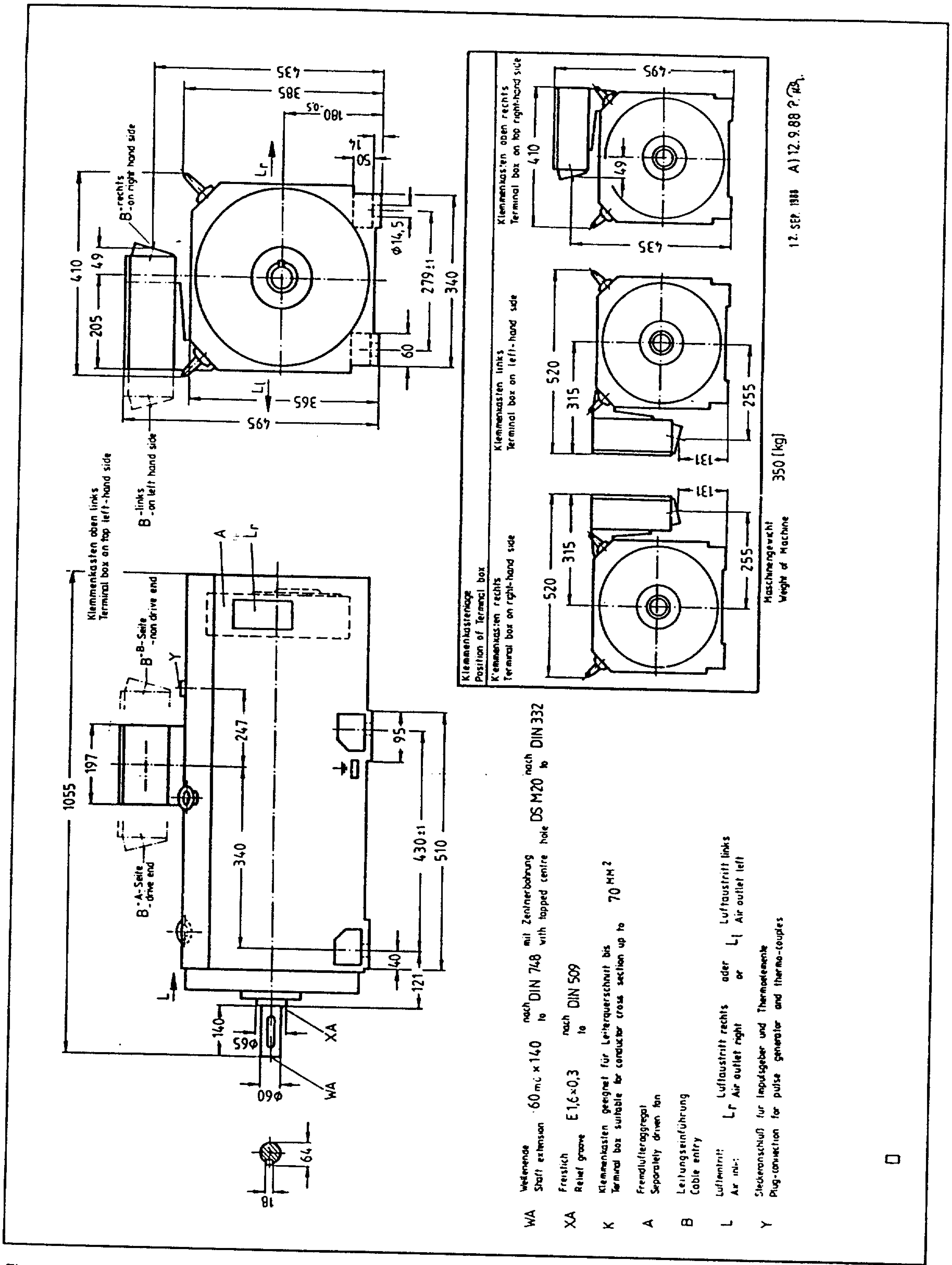
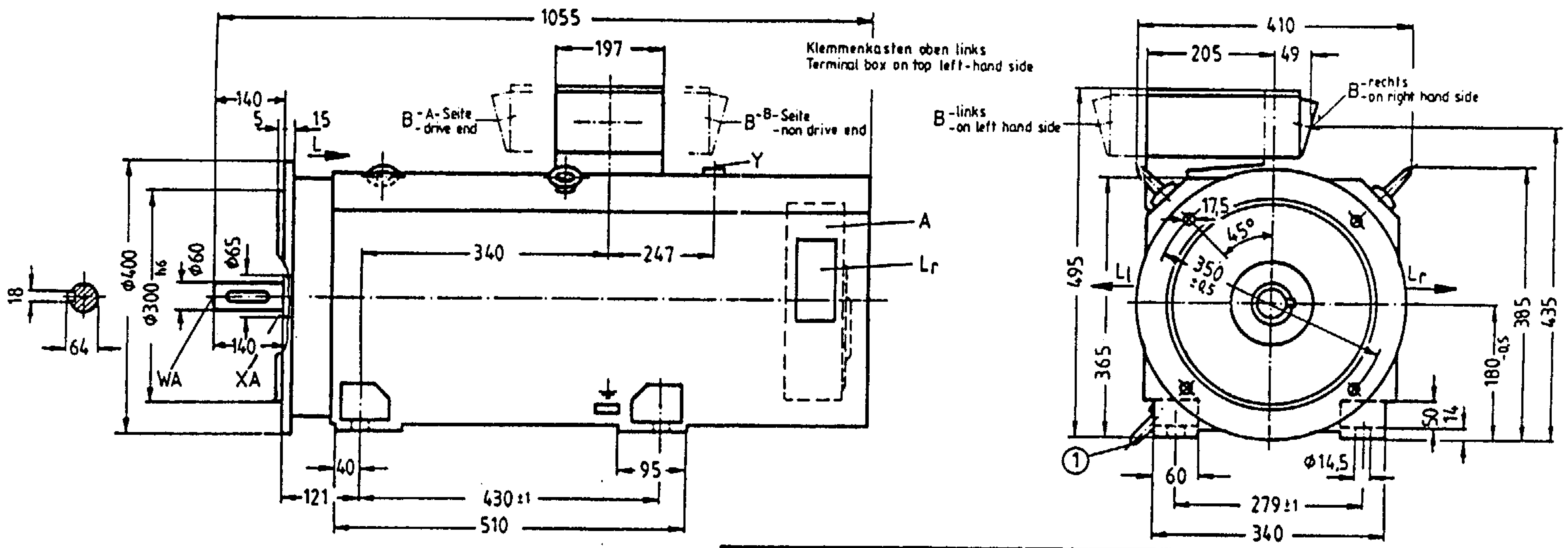
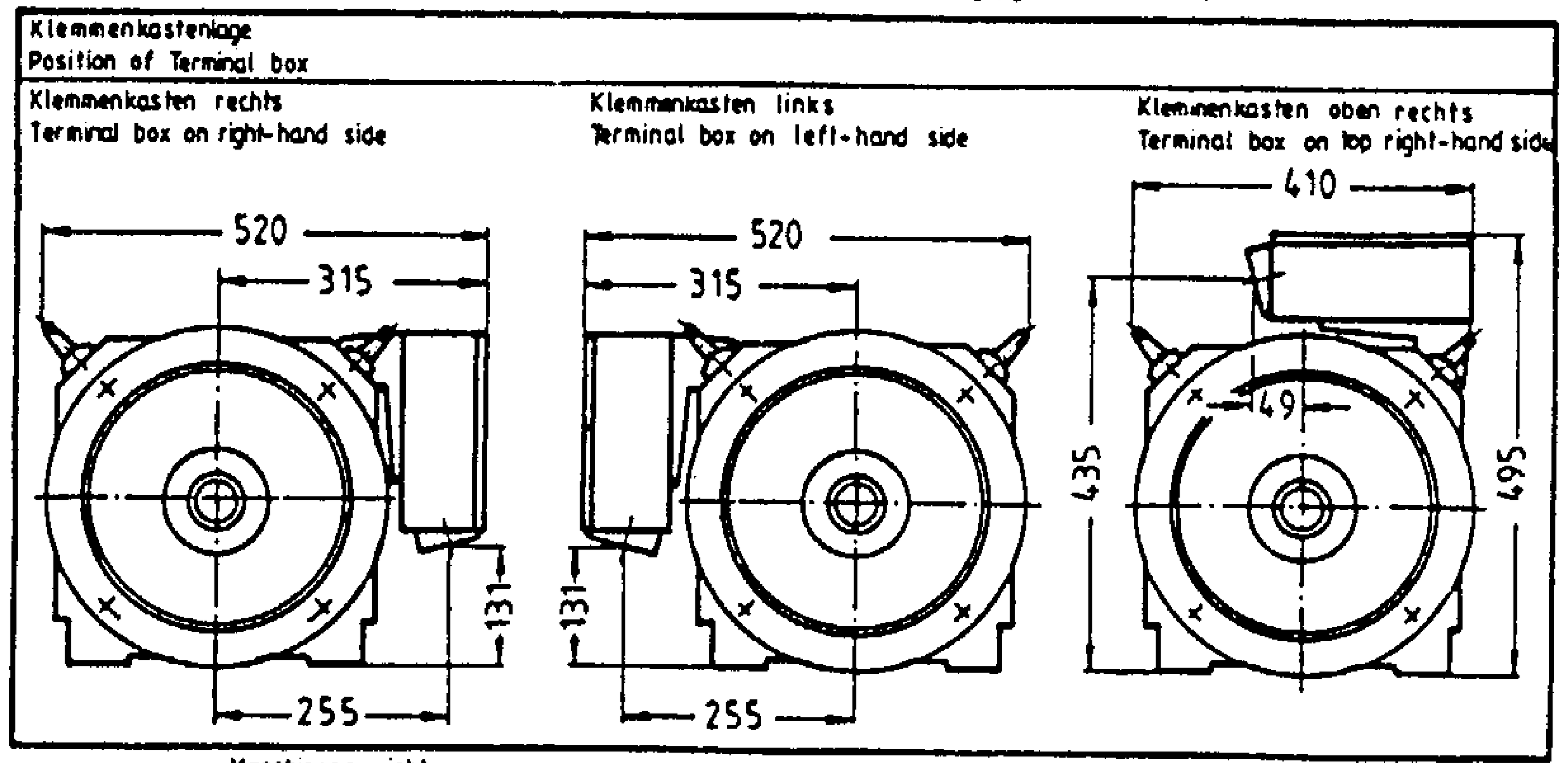


Fig. 6.60 Dimension sheet for 1PH6 186-4C AC motors, type of construction IM B3 (dimensions in mm, not toscale)





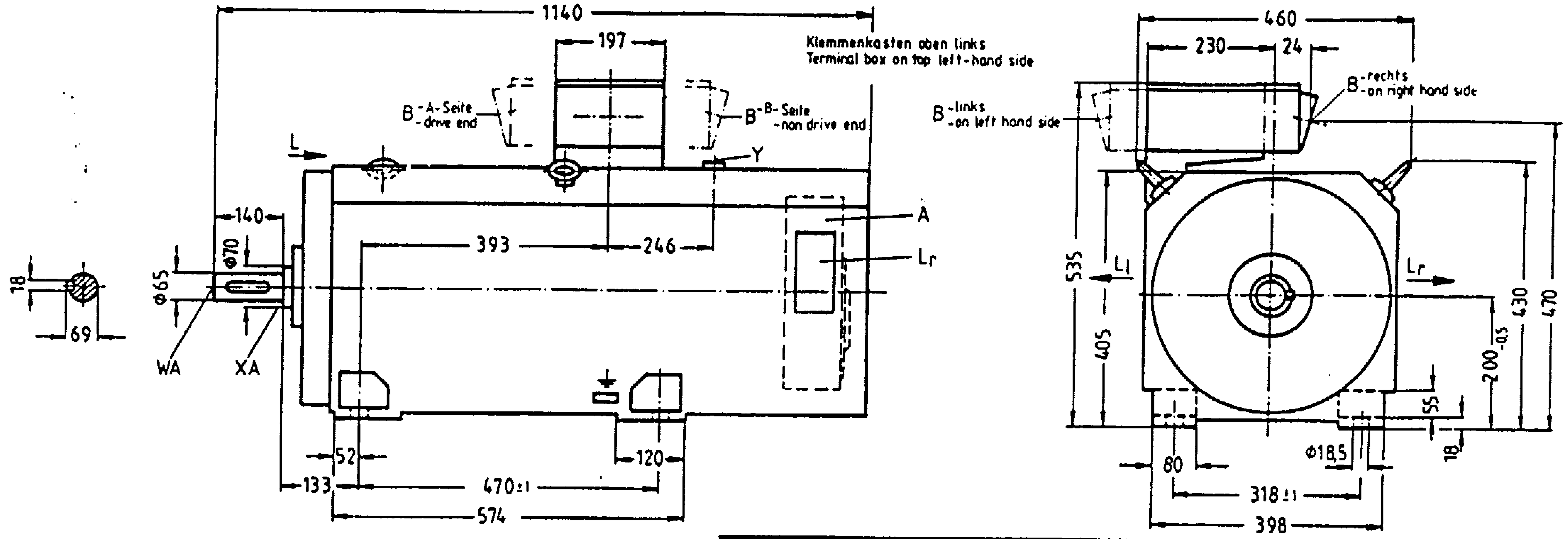
WA	Wellenende / Shaft extension	60 m6 × 140 nach / to DIN 748 mit Zentrierbohrung / with tapped centre hole DS M20 nach / to DIN 332
XA	Freistich / Relief groove	E 1,6×0,3 nach / to DIN 509
K	Klemmenkasten geeignet für Leiterquerschnitt bis / Terminal box suitable for conductor cross section up to	70 MM²
A	Fremdlüfteraggregat / Separately driven fan	
B	Leitungseinführung / Cable entry	
L	Lufteintritt / Air inlet	Lr Luftaustritt rechts / Air outlet right oder / or Ll Luftaustritt links / Air outlet left
Y	Steckeranschluß für Impulsgeber und Thermoelemente / Plug-connection for pulse generator and thermo-couples	

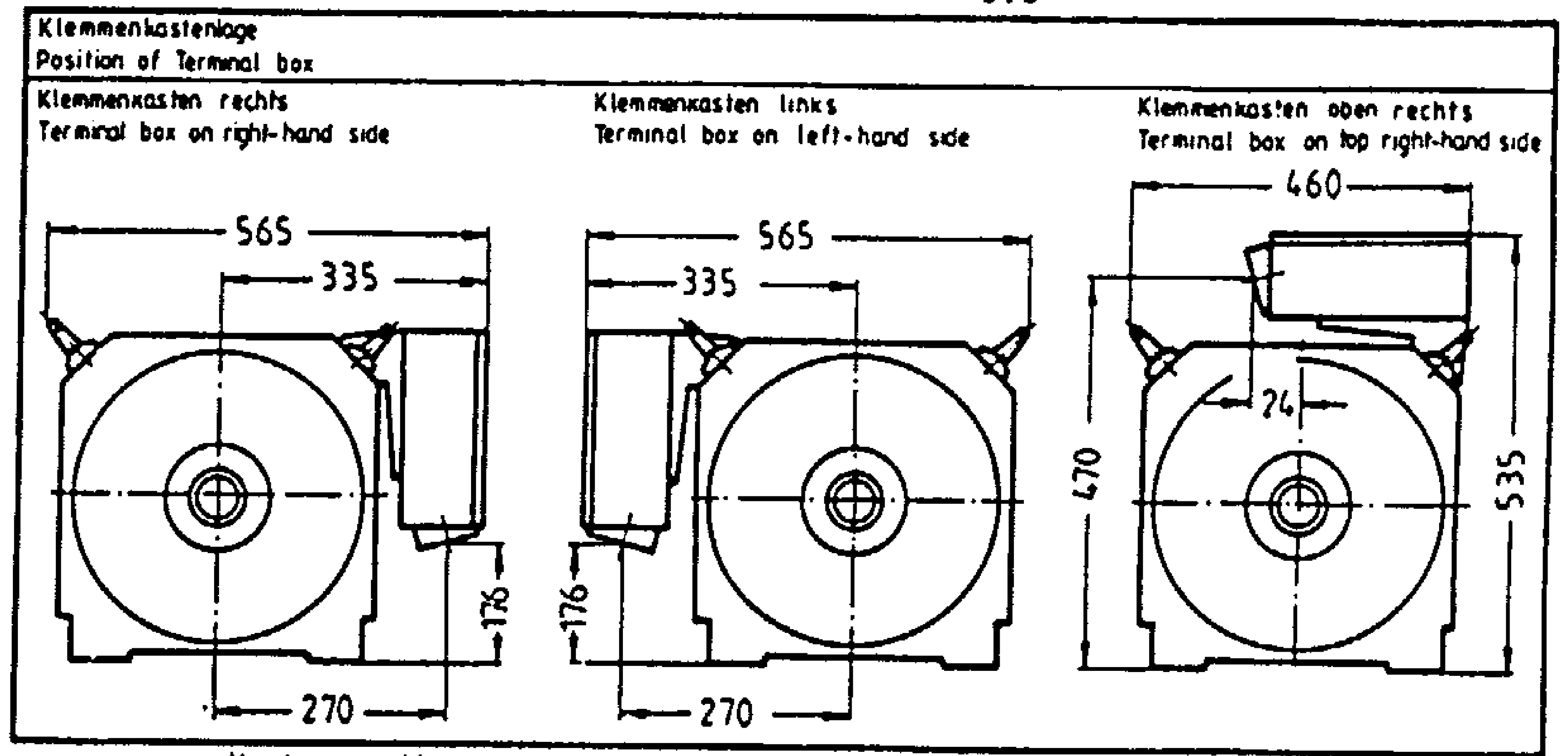
① Nur bei Bauform / Only for type of construction IM V15, IM V36

Maschinengewicht / Weight of Machine 350 [kg]

22. SEP. 88 B) 12.9.88 P.W.
A) 14.7.86 Werner

Fig. 6.61 Dimension sheet for 1PH6 186-4C AC motors, type of construction IM B35, IM V15 and IM V36 (dimensions in mm, not to scale)





WA	Wellenende / Shaft extension	65m6 × 140 nach/to DIN 748 mit Zentnerbohrung / with tapped centre hole DR M20 nach/to DIN 332
XA	Freistich / Relief groove	E 1,6×0,3 nach/to DIN 509
K	Klemmenkasten geeignet für Leiterquerschnitt bis / Terminal box suitable for conductor cross section up to	70 mm²
A	Fremdlufteraggregat / Separately driven fan	
B	Leitungseinführung / Cable entry	
L	Lufteintritt / Air inlet	Lr Luftaustritt rechts / Air outlet right oder/or Ll Luftaustritt links / Air outlet left
Y	Steckeranschluß für Impulsgeber und Thermoelemente / Plug-connection for pulse generator and thermo-couples	

Maschinengewicht / Weight of Machine 470 [kg]

B17.6.89 P.Rx.

Fig. 6.62 Dimension sheets for 1PH6 206-4C AC motors, type of construction IM B3 (dimensions in mm, not to scale)

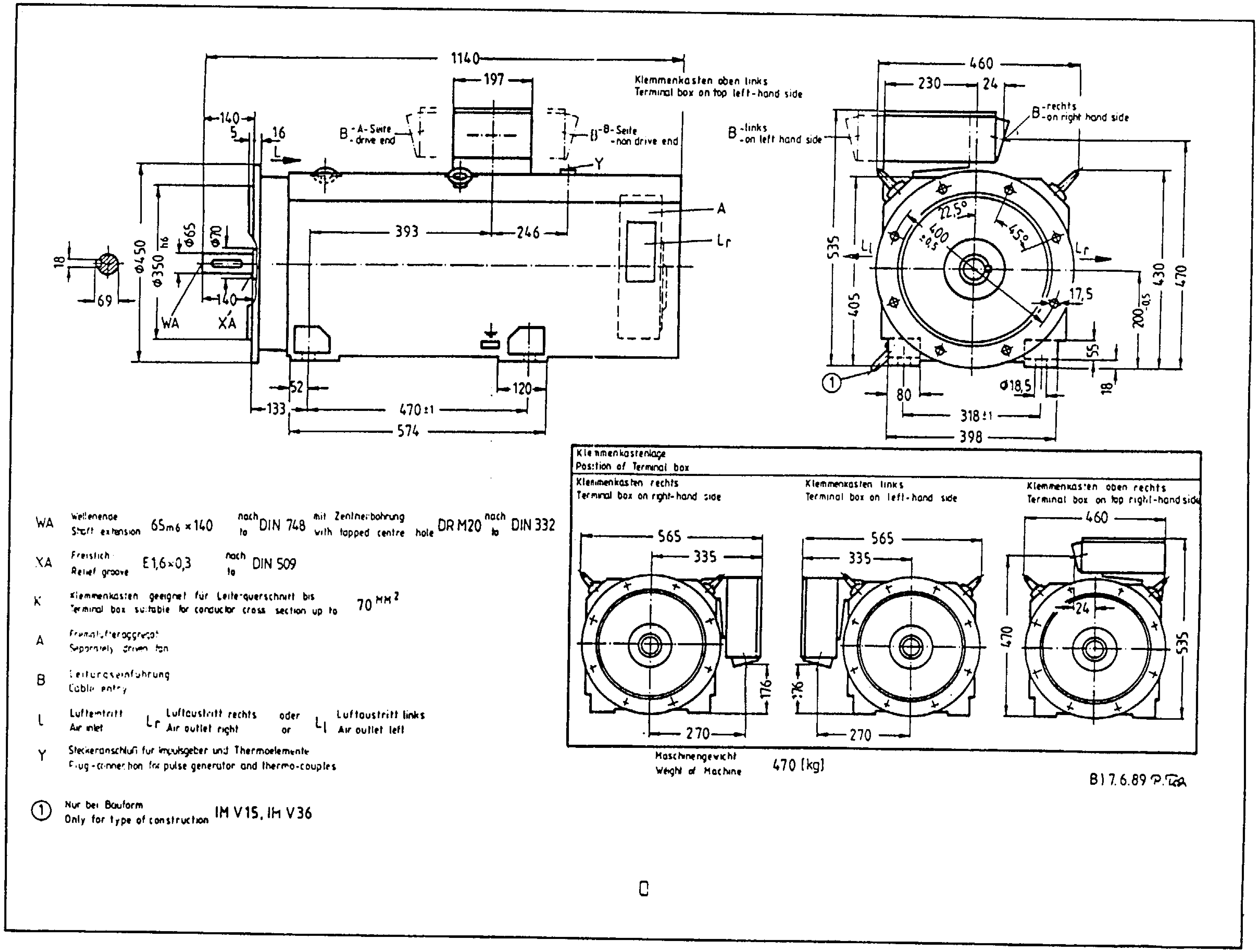


Fig. 6.63 Dimension sheet for 1PH6 206-4C AC motors, type of construction IM B35, IM V15 and IM V36 (dimensions in mm, not to scale)

6.5 PWM converter dimension sheets

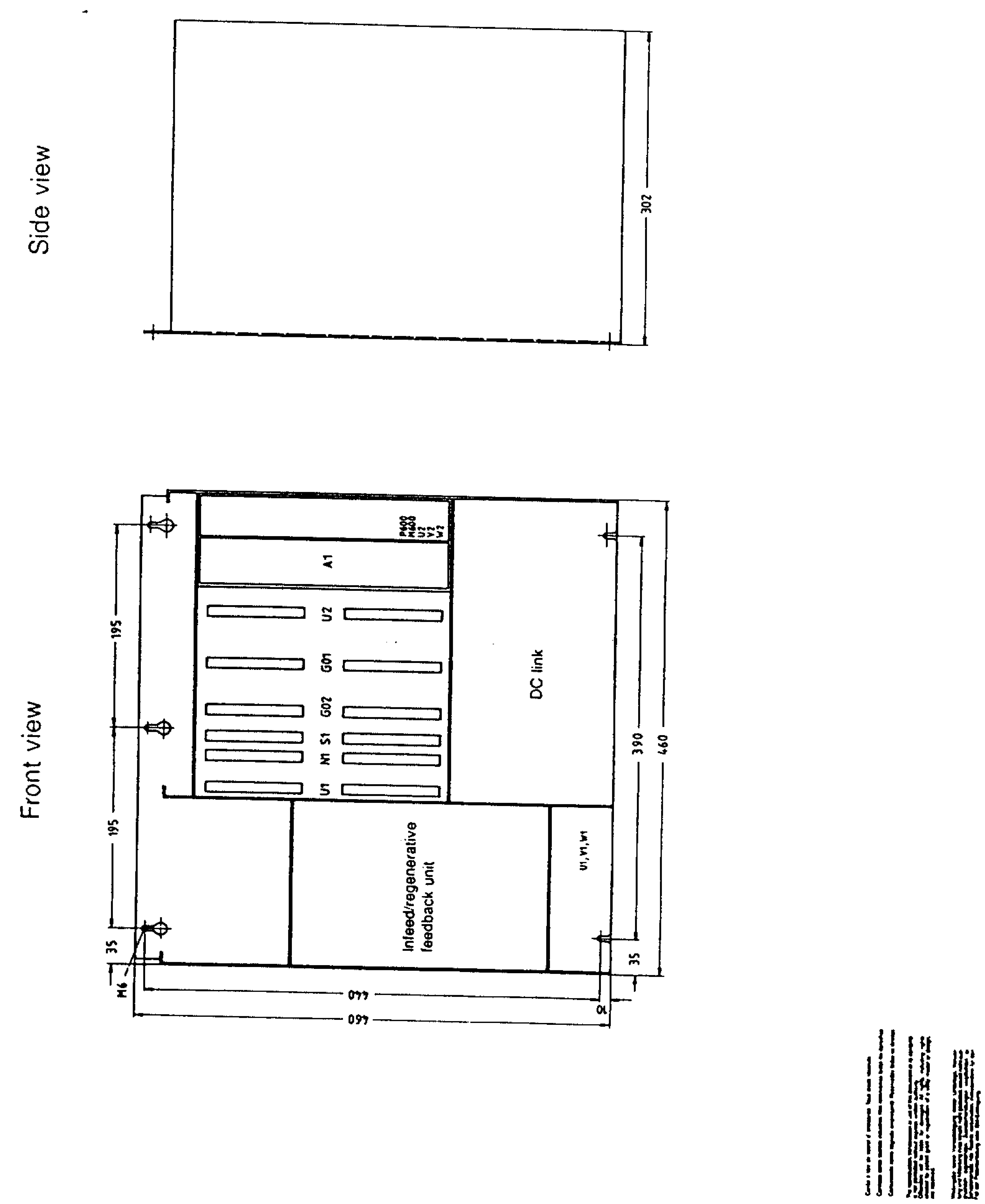


Fig. 6.64 Dimension sheet for PWM converters 6SC6502 and 6SC6503 (dimensions in mm, not to scale)

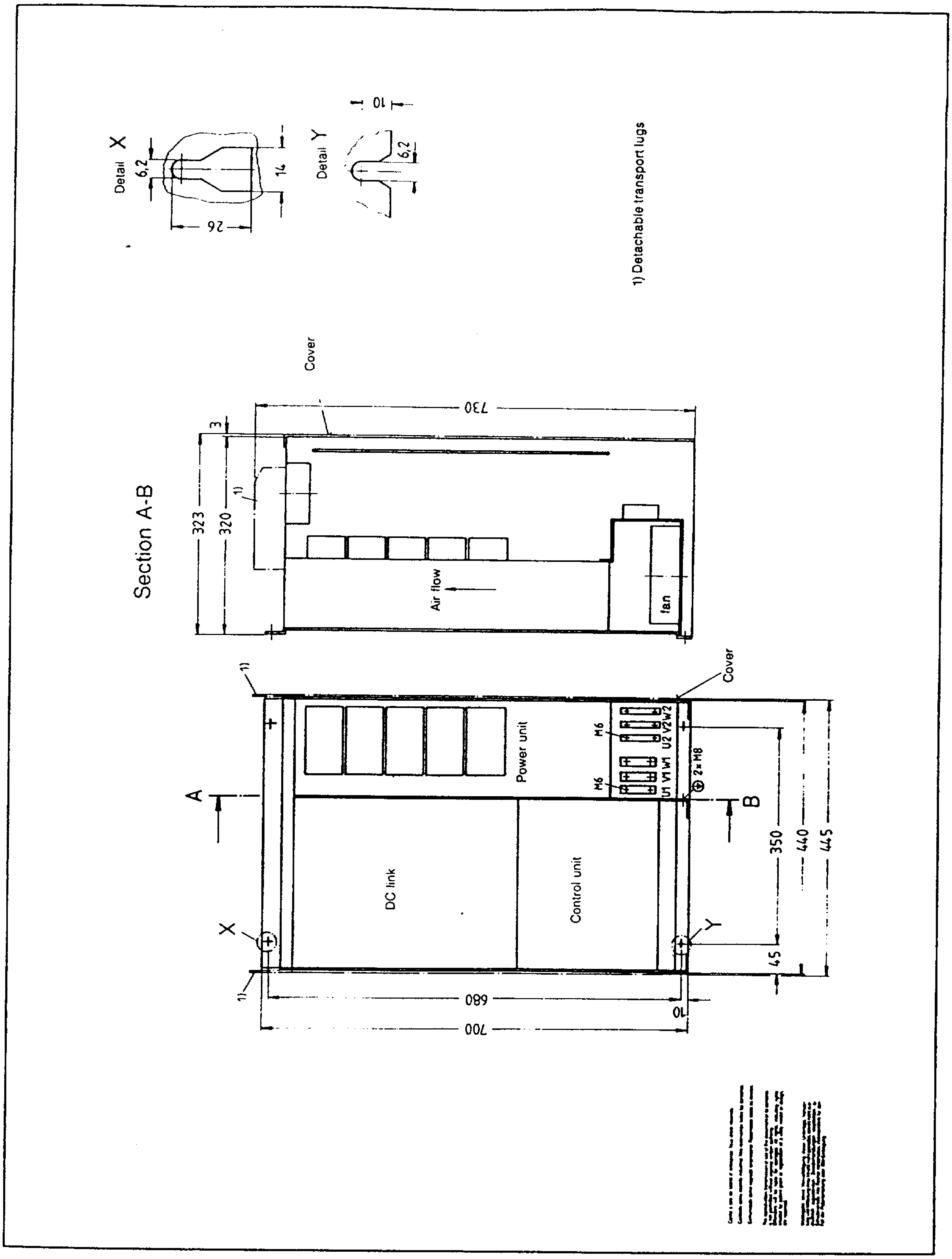


Fig. 6.65 Dimension sheet for PWM converters 6SC6504 and6SC6506 (dimensions in mm, not to scale)

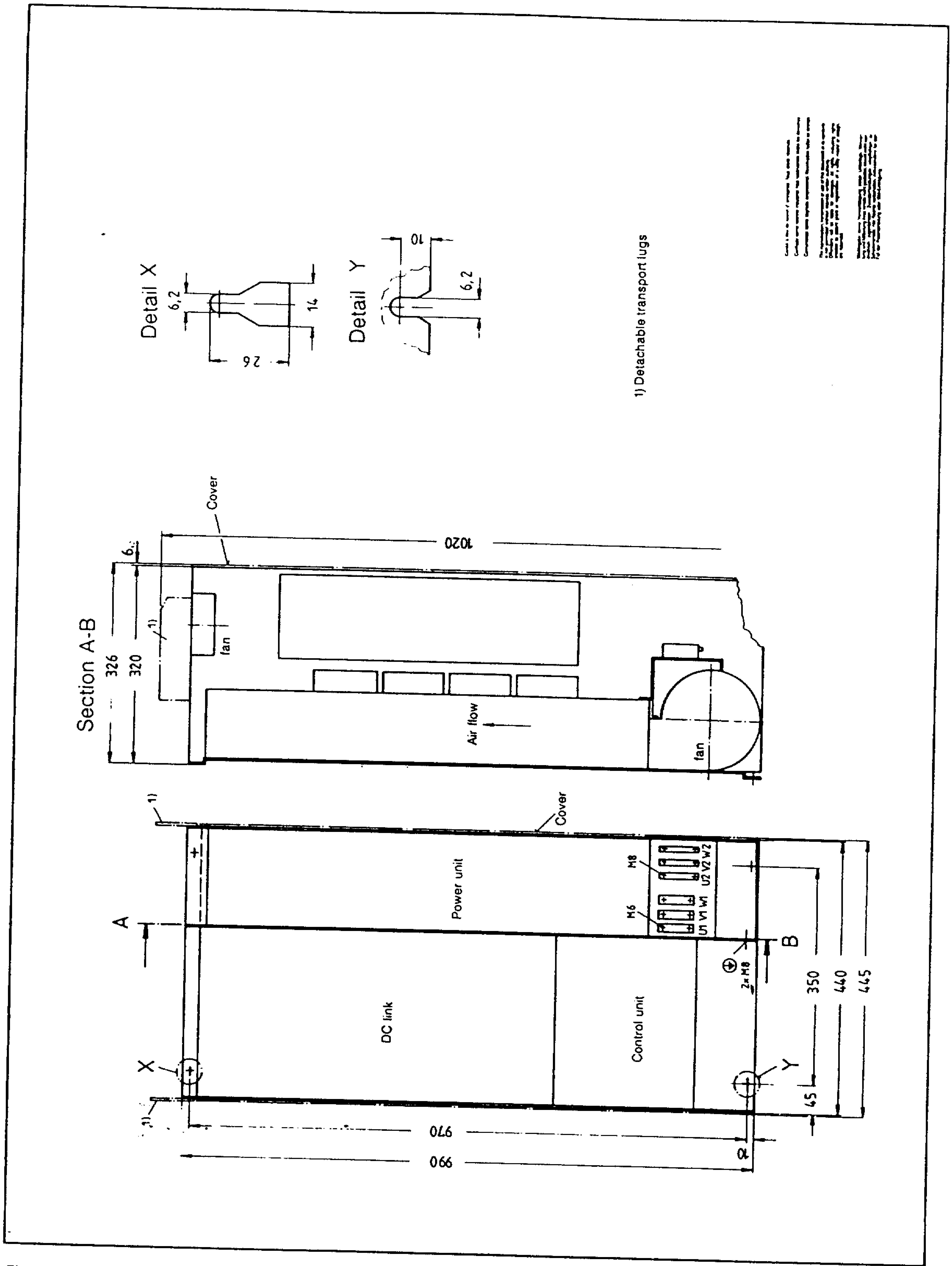


Fig. 6.66 Dimension sheet for PWM converters 6SC6508 (dimensions in mm, not to scale)

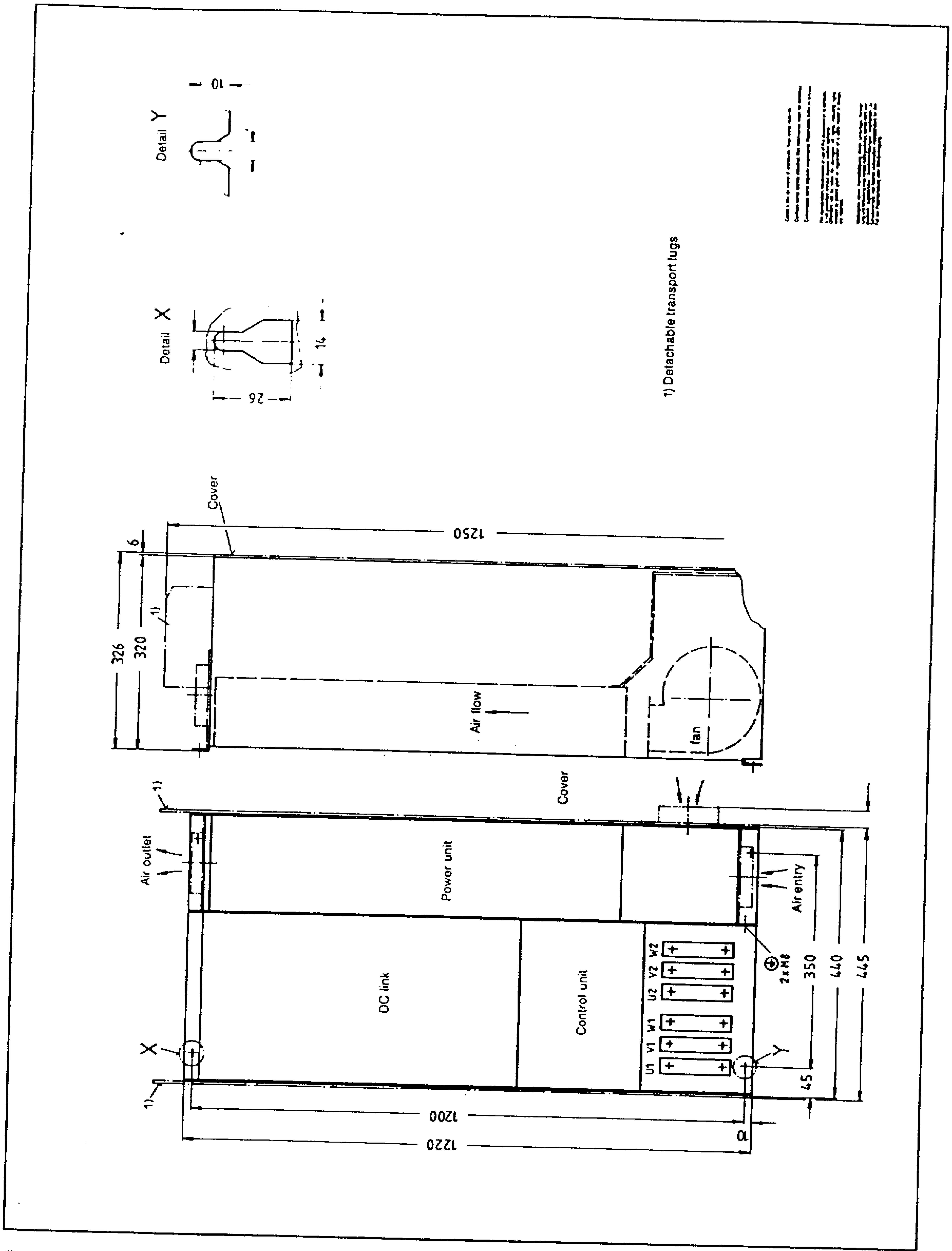


Fig. 6.67 *Dimension sheet for PWM converter 6SC6512 (dimensions in mm, not to scale)*

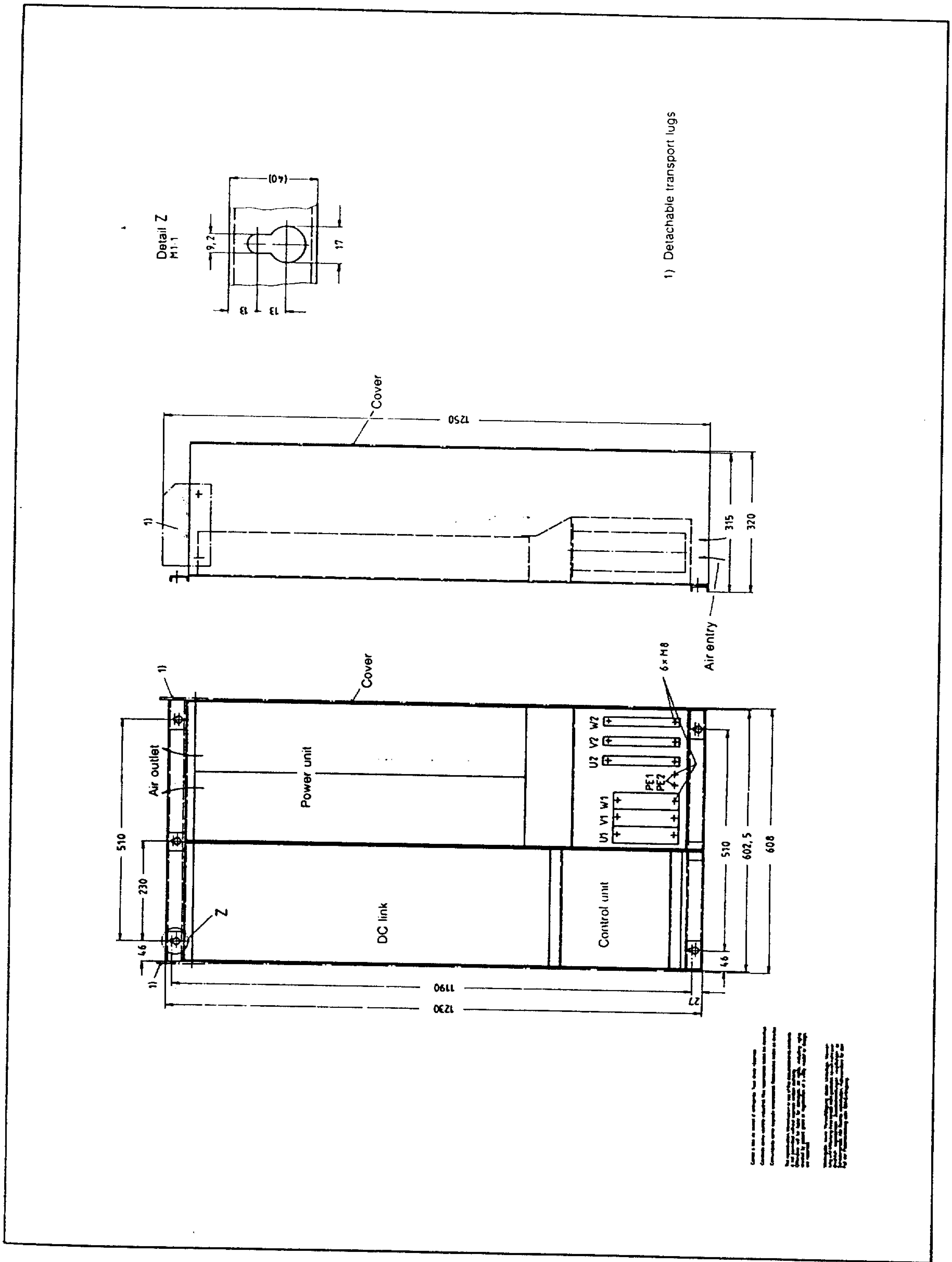


Fig. 6.68 *Dimension sheet for PWM converter 6SC6520 (dimensions in mm, not to scale)*

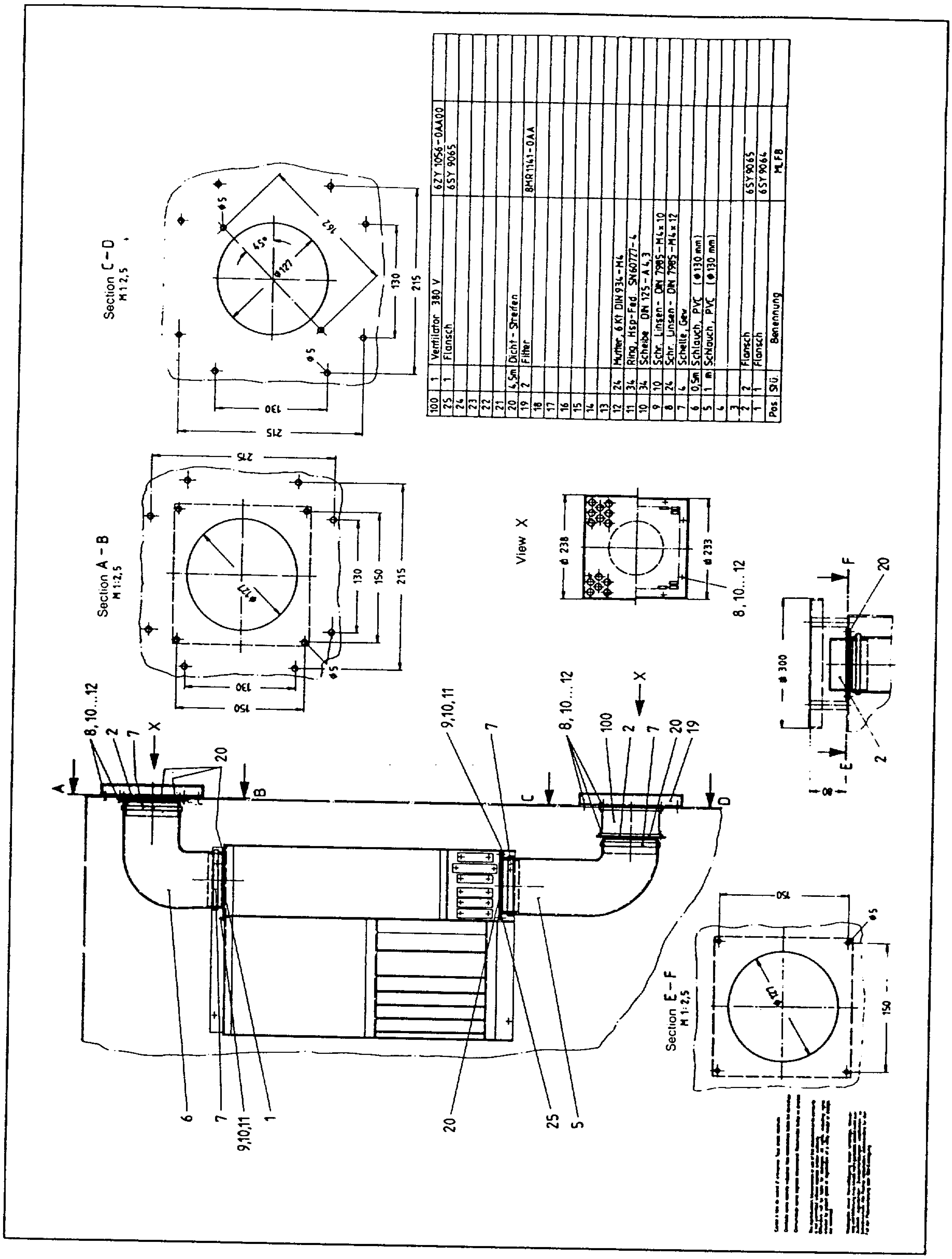


Fig. 6.69 Dimension sheet for external heat dissipation, option E45 (6SC6504, 6SC6506)

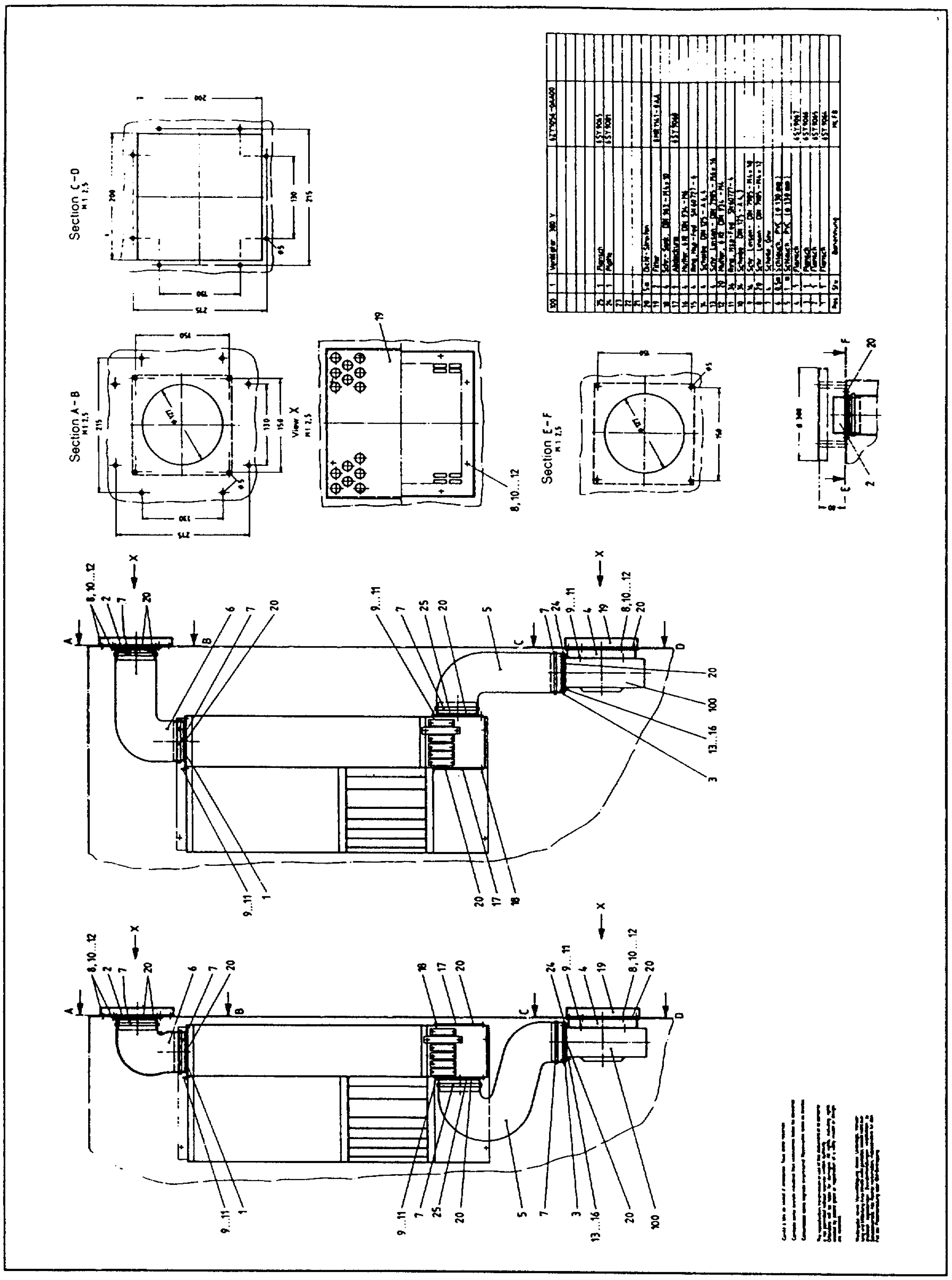


Fig. 6.70 Dimension sheet for external heat dissipation, option E45 (6SC6508)

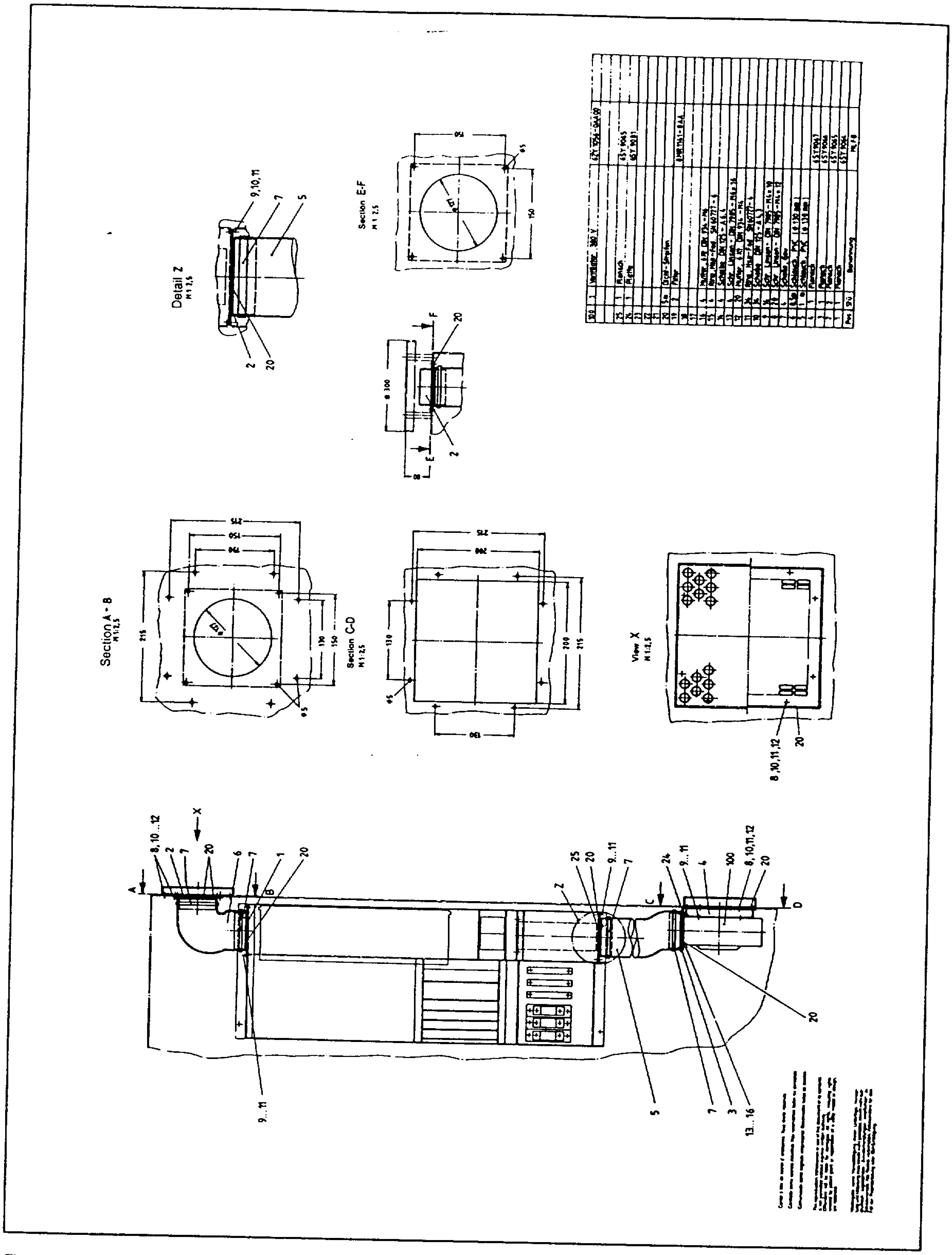


Fig. 6.71 *Dimension sheet for external heat dissipation, option E45 (6SC6512)*

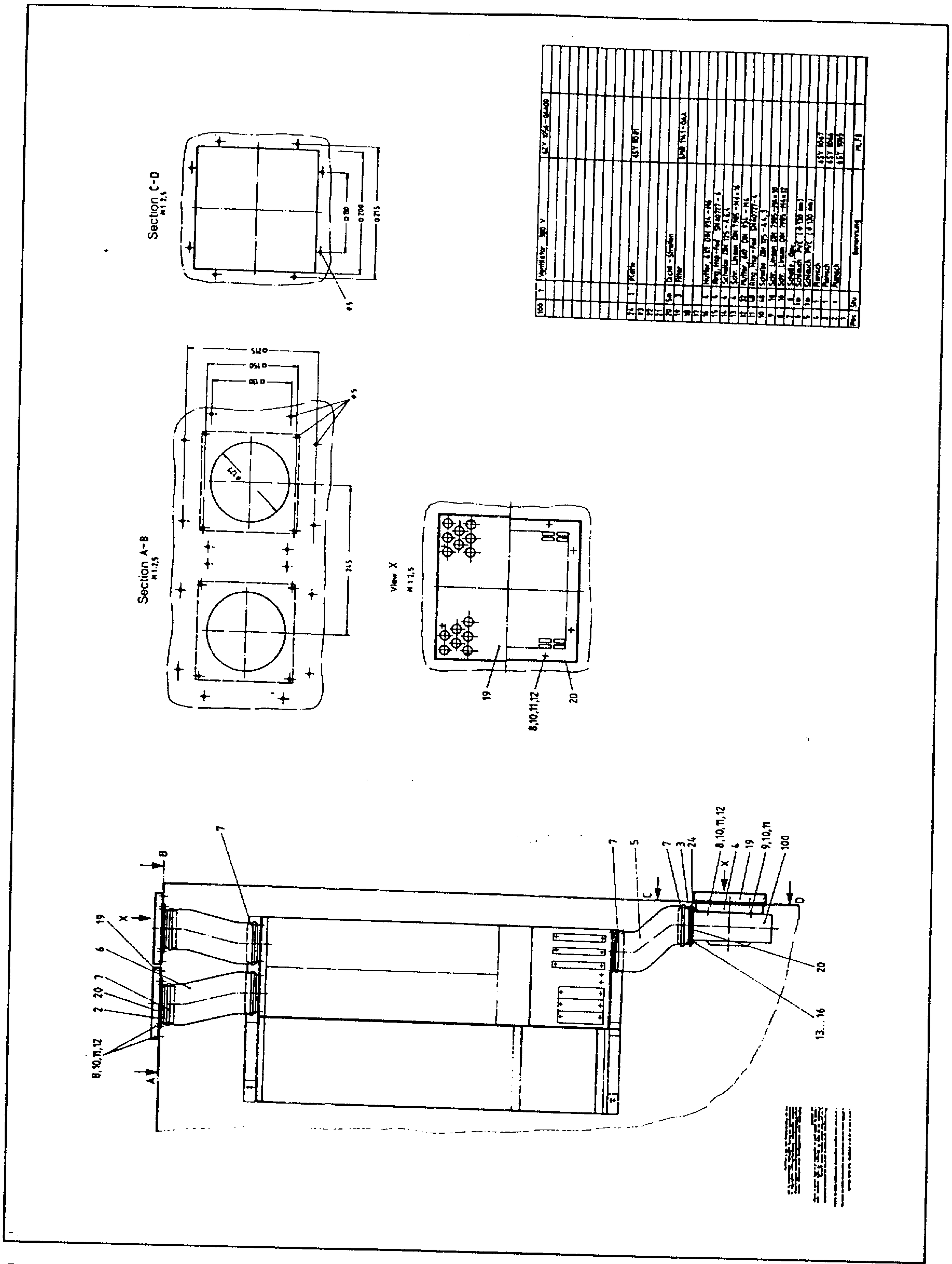


Fig. 6.72 Dimension sheet for external heat dissipation connecting flange, option E55 (6SC6504/ 06/ 12)

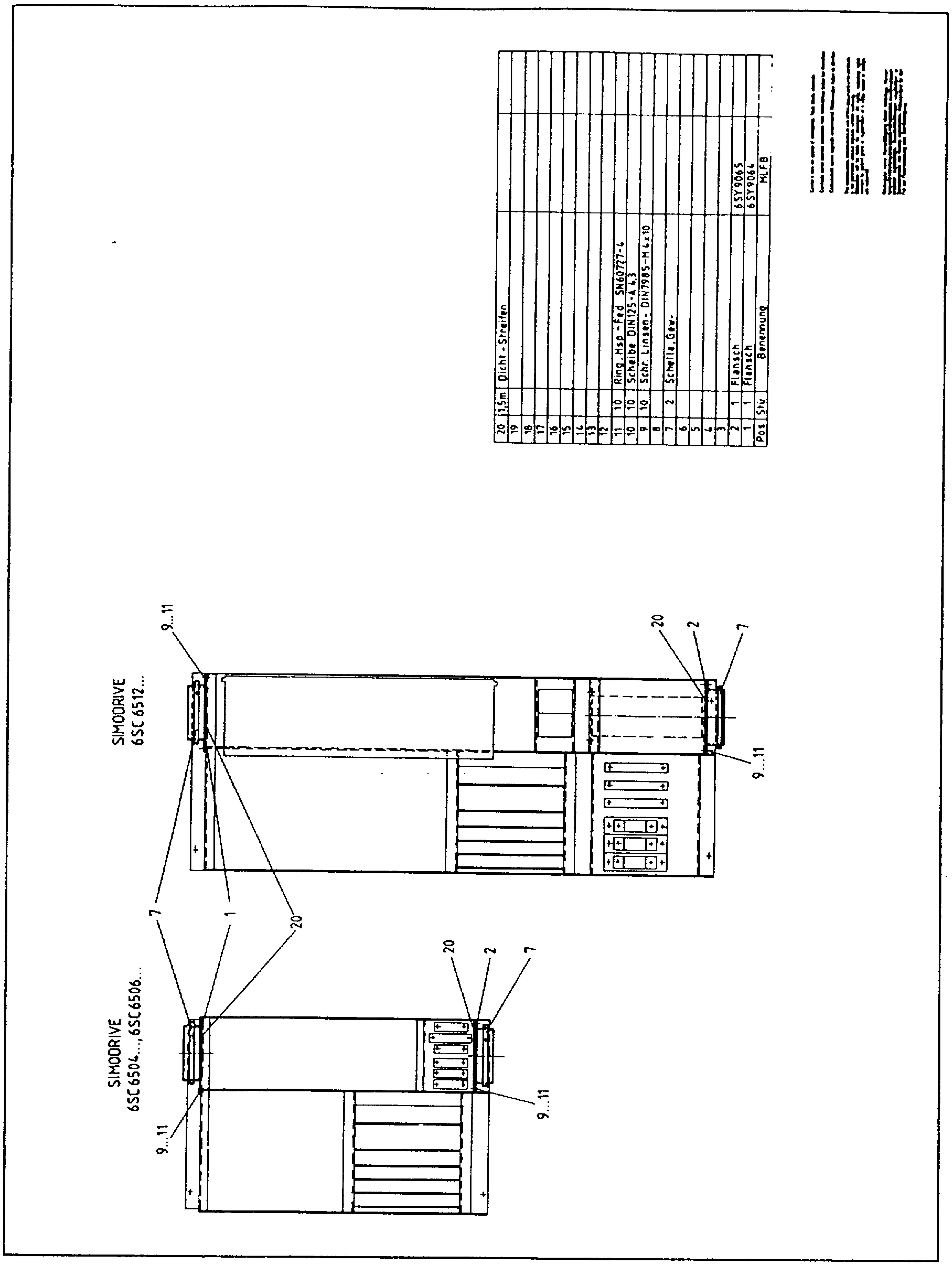


Fig. 6.73 Dimension sheet for external heat dissipation connecting flange, option E55 (6SC6508)

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