TECHNICAL SPECIFICATION

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Rotating electrical machines –

Part 25: Guide for the design and performance of cage induction motors specifically designed for converter supply

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

Part 25: Guide for the design and performance of cage induction motors specifically designed for converter supply

FOREWORD

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- The subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 60034-25, which is a technical specification, has been prepared by IEC technical committee 2: Rotating machinery.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
2/1271/DTR	2/1288/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual edition of this Technical Specification may be issued at a later date.

INTRODUCTION

This introduction is intended to explain the aim of this part of IEC 60034.

Motor categories

There are 2 categories of cage induction motors, which can be applied in variable speed electric drive systems.

- Standard cage induction motors, designed for general purpose application. The design and performance of these motors are optimized for operation on a fixed-frequency sinusoidal supply. Nevertheless they are generally also appropriate for use in variable speed drive systems.

  Guidance on this field of application is given in IEC 60034-17.

- Cage induction motors specifically designed for converter operation. The design and construction of such motors may be based on standard motors with standardized frame sizes and dimensions, but with modifications for converter operation.

  This category is covered by this part of IEC 60034, and it is recommended that the motor be marked with a reference to this part of IEC 60034.

Motors for converter supplies greater than 1 000 V, or for converters other than voltage source, will be considered in later editions of this part of IEC 60034.

Incorporation of the motor into the power drive system

Figure 1 illustrates the Power Drive System (PDS). A PDS consists of a motor and a Complete Drive Module (CDM). It does not include the equipment driven by the motor. The CDM consists of a Basic Drive Module (BDM) and its possible extensions such as the feeding section or some auxiliaries (for example ventilation). The BDM contains converter, control and self-protection functions. The rating and performance of the complete PDS is covered in general by IEC 61800-2.

NOTE Figure 1 of IEC 61800-2 provides further details of the structure of a PDS.

The motor itself and additional specific requirements for its proper incorporation into the PDS are covered by the IEC 60034 series.

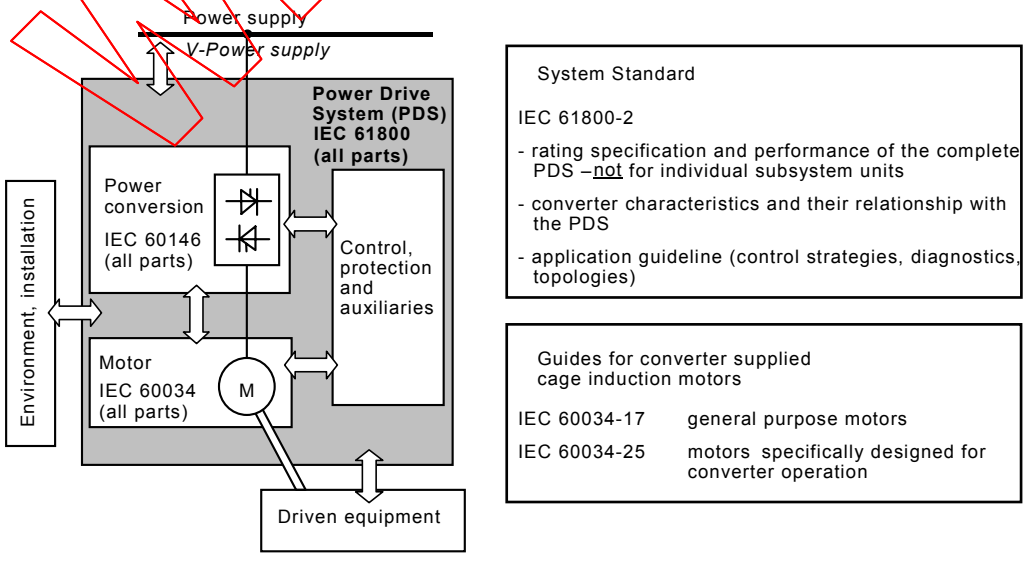


Figure 1 – Component parts of a PDS

ROTATING ELECTRICAL MACHINES –

Part 25: Guide for the design and performance of cage induction motors specifically designed for converter supply

1 Scope

This part of IEC 60034 describes the design features and performance characteristics of polyphase cage induction motors specifically designed for use on voltage source converter supplies up to 1 000 V. It also specifies the interface parameters and interactions between the motor and the converter including installation guidance as part of a power drive system.

NOTE 1 For motors operating in potentially explosive atmospheres, additional requirements as described in the IEC 60079 series apply.

NOTE 2 This technical report is not primarily concerned with safety. However, some of its recommendations may have implications for safety, which should be considered as necessary.

NOTE 3 Where a converter manufacturer provides specific installation recommendations, they should take precedence over the recommendations of this technical report.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-2:1972, *Rotating electrical machines – Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)*
Amendment 1 (1995)
Amendment 2 (1996)

IEC 60034-6, *Rotating electrical machines – Part 6: Methods of cooling (IC Code)*

IEC 60034-9, *Rotating electrical machines – Part 9: Noise limits*

IEC 60034-14, *Rotating electrical machines – Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher – Measurement, evaluation and limits of vibration severity*

IEC 60034-17, *Rotating electrical machines – Part 17: Cage induction motors when fed from converters – Application guide*

IEC 61800-2, *Adjustable speed electrical power drive systems – Part 2: General requirements – Rating specifications for low voltage adjustable frequency a.c. power drive systems*

IEC 61800-3, *Adjustable speed electrical power drive systems – Part 3: EMC product standard including specific test methods*

IEC 61800-5-1, *Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy*

3 Terms and definitions

For the purposes of this part of IEC 60034, the following terms and definitions apply.

3.1
bonding
electrical connection of metallic parts of an installation together and to ground (earth)

NOTE For the purposes of this part of IEC 60034, this definition combines elements of IEV 195-01-10 (equipotential bonding) and IEV 195-01-16 (functional equipotential bonding).

3.2
converter
operating unit for electronic power conversion, changing one or more electrical characteristics and comprising one or more electronic switching devices and associated components, such as transformers, filters, commutation aids, controls, protections and auxiliaries, if any

[IEC 61800-2, 2.2.1]

NOTE This definition is taken from IEC 61800-2, and for the purposes of this part of IEC 60034 embraces the terms Complete Drive Module (CDM) and Basic Drive Module (BDM) as used in the IEC 61800 series.

3.3
EMC (electromagnetic compatibility)
ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[IEV 161-01-07]

3.4
field weakening
motor operating mode where motor flux is less than the flux corresponding to the motor rating

3.5
peak rise time
time interval between the 10 % and 90 % points of the zero to peak voltage (see Figure 14)

3.6
Power Drive System
PDS
system consisting of power equipment (composed of converter section, AC motor and other equipment such as, but not limited to, the feeding section), and control equipment (composed of switching control – on/off for example –, voltage, frequency, or current control, firing system, protection, status monitoring, communication, tests, diagnostics, process interface/ port, etc.)

3.7
protective earthing
PE
earthing a point or points in a system or in an installation or in equipment for the purposes of electrical safety

[IEV 195-01-11]

3.8
skip band
small band of operating frequencies where steady-state operation of the PDS is inhibited

3.9
surface transfer impedance
quotient of the voltage induced in the centre conductor of a coaxial line per unit length by the current on the external surface of the coaxial line

[IEV 161-04-15]

4 System characteristics

4.1 General

Although the steps in specifying motor and converter features are similar for any application, the final selections are greatly influenced by the type of application. In this Clause, these steps are described and the effects of various application load types are discussed.

4.2 System information

Complete application information, that considers the driven load, motor, converter, and utility power supply, is the best way to achieve the required performance of the motor in the system. In general this information should include:

- The power or torque requirements at various speeds.
- The desired speed range of the load and motor.
- The acceleration and deceleration rate requirements of the process being controlled.
- Starting requirements including the frequency of starts and a description of the load (the inertia reflected at the motor, load torque during starting).
- Whether the application is a continuous process or a duty cycle of starts, stops, and speed changes.
- A general description of the type of application including the environment in which the drive system components will operate.
- A description of additional functionality that may not be met with the motor and converter only (for example: motor temperature monitoring, ability to bypass the converter if necessary, special sequencing circuits or speed reference signals to control the drive system).
- A description of the available electrical supply power and wiring. The final configuration may be affected by the requirements of the system selected.

4.3 Torque/speed considerations

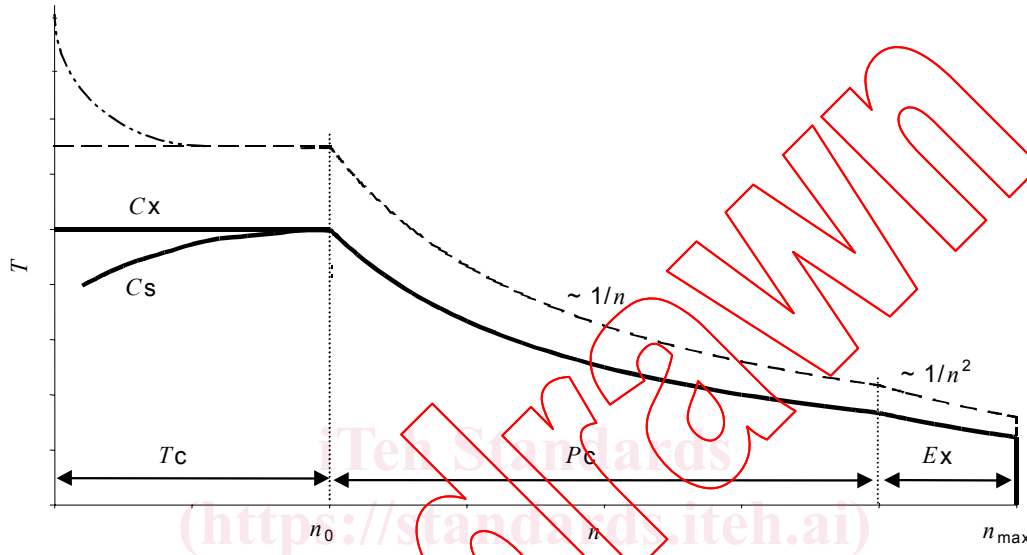
4.3.1 General

The typical torque/speed characteristics of converter-fed cage induction motors, the significant influencing factors and their consequences are shown in Figure 2, Figure 3 and Figure 4. Depending on the performance requirements of the power drive systems, different motor designs are possible for an adaptation of the individual limiting values.

NOTE Figure 2 to Figure 4 do not show the possible skip bands (see 4.3.5).

4.3.2 Torque/speed capability

Figure 2 shows the torque/speed capability of converter-fed cage induction motors. The maximum available torque is limited by the rating of the motor and by the current limitation of the converter. Above the field-weakening frequency f_0 and speed n_0 the motor can operate with constant power with a torque proportional to $1/n$. If the minimum breakdown torque (which is proportional to $1/n^2$) is reached, the power has to be further reduced proportional to $1/n$, resulting in torque proportional to $1/n^2$ (extended range). The maximum speed n_{max} is limited by the mechanical strength and stability of the rotor, by the speed capability of the bearing system, and by other mechanical parameters.



Key

——— continuous operation — *T*c – constant torque range — *C*x – separate cooling

-------- short-time operation — *P*c – constant power range — *C*s – self-cooling

—·—·— starting boost — *E*x – extended range

Figure 2 – Torque/speed capability

Figure 3 shows the corresponding converter output current (*I*) capability.

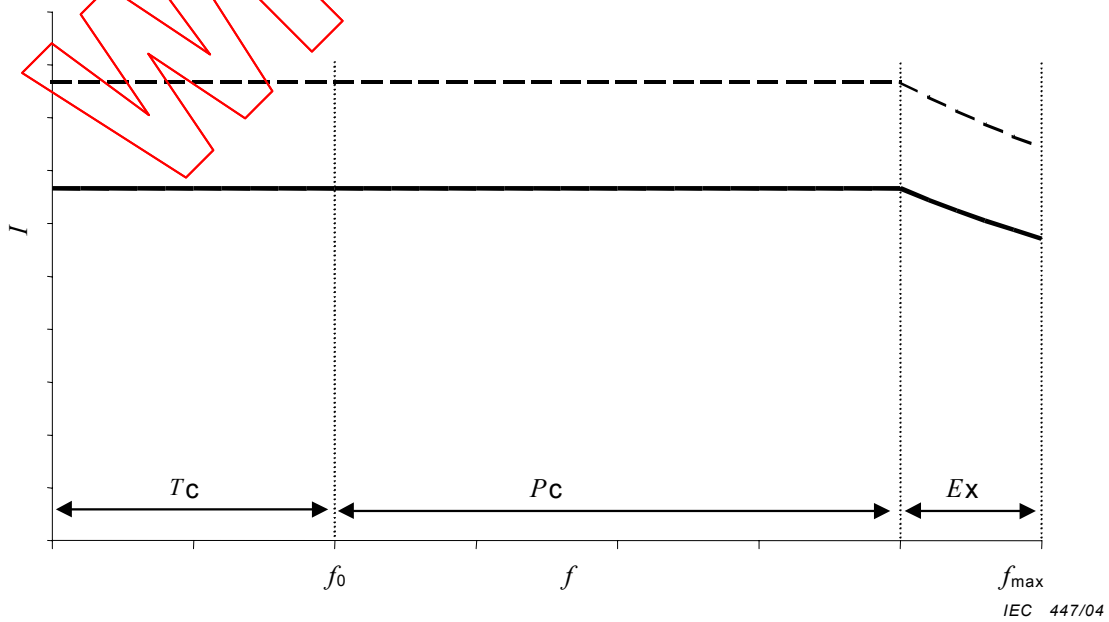
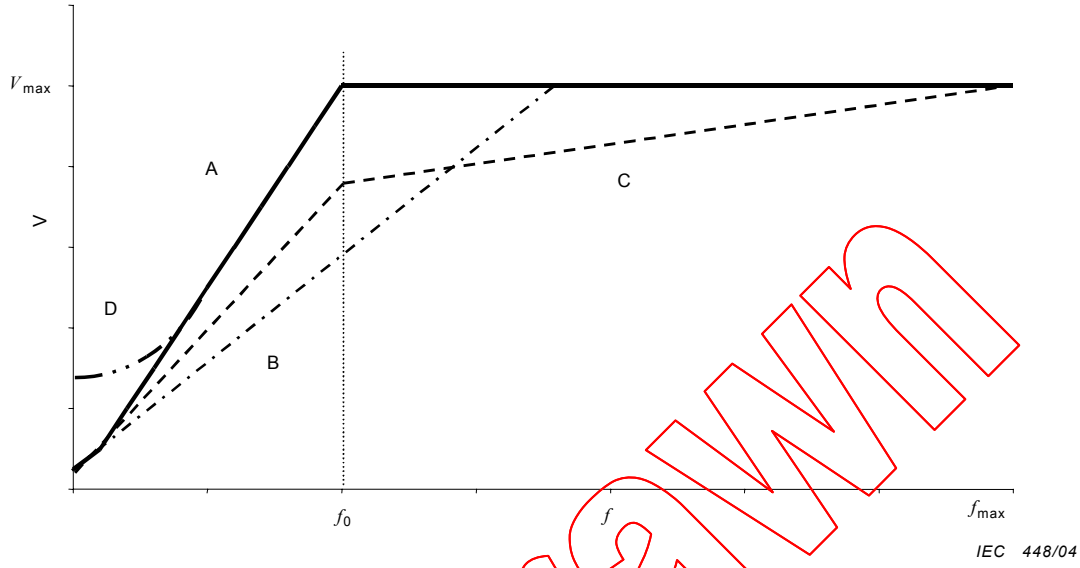


Figure 3 – Converter output current

4.3.3 Voltage/speed characteristics

The converter output voltage (V) can be varied with speed in several ways, as shown in Figure 4.



Key

A The voltage increases with speed, and the maximum converter output voltage V_{max} is achieved at the field-weakening frequency f_0.

B The voltage increases with speed, and the maximum converter output voltage V_{max} is achieved above f_0. This provides an extended speed range at constant flux (constant torque), but the available torque is reduced in this speed range.

C The voltage increases with speed up to f_0, and then increases at a lower rate, the maximum converter output voltage V_{max} being achieved at f_{max}. This avoids excessive torque reduction in the constant flux range.

D A voltage boost is applied at very low speeds to improve starting performance.

In all of these cases, the voltage-speed dependence may be linear or non-linear, according to the torque-speed requirements of the load.

Figure 4 – Converter output voltage

4.3.4 Limiting factors on torque/speed capability

The significant factors which influence the torque/speed capability are shown in Table 1.

Table 1 – Significant factors affecting torque/speed capability

Condition	Motor	Converter and motor
Breakaway	Maximum flux capability	Maximum current
Constant flux	Cooling (I^2R losses due to current variations)	Maximum current
Field weakening (reduced flux)	Maximum speed (mechanical strength and stability) Maximum torque (breakdown torque)	Maximum voltage
Dynamic response	Equivalent circuit parameters (determined by modelling)	Control capability