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Second edition
2007-03

Rotating electrical machines –

Part 25: Guidance for the design and performance of a.c. motors specifically designed for converter supply

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ROTATING ELECTRICAL MACHINES –

Part 25: Guidance for the design and performance of a.c. motors specifically designed for converter supply

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- 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.

This second edition cancels and replaces the first edition published in 2004.

This second edition contains the following significant technical changes with respect to the previous edition:

a) replacement of the original introduction by a shorter introduction;
b) extension of the scope to include all converter-fed motors, not just LV-induction motors;
c) minor changes throughout Clauses 4 to 9;
d) addition of subclauses 4.3.4, 4.3.5, 5.4, 6.2.1, 8.6.3, 8.7 and 8.8, and Figure 7;
e) inclusion of subclauses 4.4 and 4.5 in Annex A;
f) expansion of original Annex A which becomes Annex B;
g) re-drafting of Clause 5;
h) upgrading of 6.1.4 to 6.3;
i) removal of noise limits from normative text;
j) addition of reference to IEC 60034-9;
k) addition of Annex C.

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

Enquiry draft	Report on voting
2/1406/DTS	2/1420A/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 the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this technical specification may be issued at a later date.

INTRODUCTION

The performance characteristics and operating data for *converter*-fed motors are influenced by the complete drive system, comprising supply system, *converter*, cabling, motor, mechanical shafting and control equipment. Each of these components exists in numerous technical variants. Any values quoted in this technical specification are thus indicative only.

In view of the complex technical interrelations within the system and the variety of operating conditions, it is beyond the scope and object of this technical specification to specify numerical or limiting values for all the quantities which are of importance for the design of the drive system.

To an increasing extent, it is practice that drive systems consist of components produced by different manufacturers. The object of this technical specification is to explain, as far as possible, the influence of these components on the design of the motor and its performance characteristics.

This technical specification deals with a.c. motors which are specifically designed for *converter* supply. *Converter*-fed motors within the scope of IEC 60034-12, which are designed originally for mains supply, are covered by IEC 60034-17.

Clauses 5 to 9 of this technical specification consider mainly the requirements for low voltage induction motors fed from voltage-source *converters* (U-*converters)*. Clauses 10 to 16 provide additional information for other configurations.

ROTATING ELECTRICAL MACHINES –

Part 25: Guidance for the design and performance of a.c. motors specifically designed for converter supply

1 Scope

This part of IEC 60034 describes the design features and performance characteristics of a.c. motors specifically designed for use on *converter* supplies. It also specifies the interface parameters and interactions between the motor and the *converter* including installation guidance as part of a *power drive system*.

The general requirements of relevant parts of the IEC 60034 series of standards also apply to motors within the scope of this technical specification.

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

NOTE 2 This technical specification 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 specification.

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, *Rotating electrical machines – Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests (excluding machines for traction vehicles)*

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 60034-17:2006, *Rotating electrical machines – Part 17: Cage induction motors when fed from converters – Application guide*

IEC 61000-5-1, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 1: General considerations – Basic EMC publication*

IEC 61000-5-2, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*

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*

IEC 61800-5-2, *Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*[1]

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Table 1 provides an alphabetical cross-reference of terms.

Table 1 – Alphabetical list of terms

Term	Term number	Term	Term number	Term	Term number
bearing voltage ratio (BVR)	3.1	electromagnetic compatibility (EMC)	3.5	protective earthing	3.9
bonding	3.2	field weakening	3.6	skip band	3.10
common mode voltage (current)	3.3	peak rise time	3.7	surface transfer impedance	3.11
converter	3.4	power drive system (PDS)	3.8		

NOTE Throughout this technical specification, references to the following definitions are identified by italic script.

3.1
bearing voltage ratio
BVR
ratio of the capacitively coupled bearing voltage to the *common mode voltage*

3.2
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).

3.3
common mode voltage (current)
arithmetic mean of the phase voltages (currents) to earth

3.4
converter
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, modified]

NOTE This definition is taken from IEC 61800-2 and, for the purposes of this technical specification, embraces the terms complete drive module (CDM) and basic drive module (BDM) as used in the IEC 61800 series.

[1] To be published.

3.5
electromagnetic compatibility
EMC
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]

3.6
field weakening
motor operating mode where motor flux is less than the flux corresponding to the motor rating

3.7
peak rise time
time interval between the 10 % and 90 % points of the zero-to-peak voltage (see Figure 11)

3.8
power drive system
PDS
system consisting of power equipment (composed of *converter* section, a.c. 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.)

3.9
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, modified]

3.10
skip band
small band of operating frequencies where steady-state operation of the *PDS* is inhibited

3.11
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 entire 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);
- the duty cycle of the application (a continuous process or a combination of starts, stops, and speed changes; see 3.1 of IEC 60034-1);
- a general description of the type of application including the environment in which the *PDS* 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 *PDS*);
- 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 motors, the significant influencing factors and their consequences are shown in Figure 1, Figure 2 and Figure 3. Depending on the performance requirements of the *PDS*, different motor designs are possible for an adaptation of the individual limiting values.

NOTE Figure 1 to Figure 3 do not show the possible *skip bands* (see 4.3.7).

4.3.2 Torque/speed capability

Figure 1 shows the torque/speed capability of *converter*-fed 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 $1/n$. For induction motors, 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). For synchronous motors, the extended range does not apply. The maximum usable speed n_{max} is limited not only by the reduction of torque due to *field weakening* at speeds above n_0, but also by the mechanical strength and stability of the rotor, by the speed capability of the bearing system, and by other mechanical parameters.

At low frequency, the available torque may be reduced in self-cooled motors to avoid the possibility of overheating.

In some applications, it may be possible to apply a short-time torque boost for starting.