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भारतीय मानक
Indian Standard

Rotating Electrical Machines

Part 9 Noise Limits

(First Revision)

Rotating Electrical Machines

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ICS 29.260.20

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Rotating Machinery Sectional Committee, ETD 15

NATIONAL FOREWORD

This Indian Standard IS 12065 which is identical with IEC 60034-9 : 2021 'Rotating Electrical Machines — Part 9: Noise Limits' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on recommendationof the Rotating Machinery Sectional Committee, and approval of the Electrotechnical Division Council.

IS 12065 'Permissible Limits of Noise Levels for Rotating Electrical Machines' was first published in 1987 and subsequently second reprinted in 1997. This standard was later reaffirmed in 2004, then again in 2014 and latest was reaffirmed in 2019.

While reviewing this most latest version this standard, its first revision is undertaken to align with latest version of IEC 60034-9 : 2021 however with few adaptations which are detailed in subsequent clauses of this standard.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain terminology and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60034-1 Rotating electrical machines - Part 1: Rating and performance	IS 15999 Part 1: 2021 Rotating electrical machines – Part 1 Rating and performance	Identical with IEC 60034-1 : 2017
IEC 60034-5 Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification.	IS/IEC 60034: Part 5: 2000 (Reaffirmed 2018) : Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification.	Identical with IEC 60034-5 : 2020
IEC 60034-6 Rotating electrical machines; part 6: methods of cooling (IC code)	IS 6362: 1995 (Reaffirmed 2017) : Designation of Methods of cooling of rotating electrical machines	Identical with IEC 60034-6 : 1991

(*Continued on third cover*)

Indian Standard

ROTATING ELECTRICAL MACHINES

Part 9: Noise limits

1 Scope

This part of IEC 60034:

– specifies test methods for the determination of sound power level of rotating electrical machines;
– specifies maximum A-weighted sound power levels for factory acceptance testing of network-supplied, rotating electrical machines in accordance with IEC 60034-1, having methods of cooling according to IEC 60034-6 and degrees of protection according toIEC 60034-5, and having the following characteristics:
    - standard design, either AC or DC, without additional special electrical, mechanical, or acoustical modifications intended to reduce the sound power level
    - rated output from 1 kW (or kVA) up to and including 5 500 kW (or kVA)
    - rated speed not greater than 3750 min^{-1}

Excluded are noise limits for AC motors supplied by converters. For these conditions see Annex B for guidance.

The object of this document is to determine maximum A-weighted sound power levels, L_{WA} in decibels, dB, for airborne noise emitted by rotating electrical machines of standard design, as a function of power, speed and load, and to specify the method of measurement and the test conditions appropriate for the determination of the sound power level of the machines to provide a standardized evaluation of machine noise up to the maximum specified sound power levels. This document does not provide correction for the existence of tonal characteristics.

Sound pressure levels at a distance from the machine may be required in some applications, such as hearing protection programs. Information is provided on such a procedure in Clause 7 based on a standardized test environment.

NOTE 1 This document recognizes the economic reason for the availability of standard noise-level machines for use in non-critical areas or for use with supplementary means of noise attenuation.

NOTE 2 Where sound power levels lower than those specified in Table 1, Table 2 or Table 3 are required, these are agreed between the manufacturer and the purchaser, as special electrical, mechanical, or acoustical design may involve additional measures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

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

ISO 3741, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms*

ISO 3743-1, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 1: Comparison method for a hard-walled test room*

ISO 3743-2, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 2: Methods for special reverberation test rooms*

ISO 3744, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for anechoic rooms and hemi-anechoic rooms*

ISO 3746, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 3747, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering/survey methods for use in situ in a reverberant environment*

ISO 4871, *Acoustics – Declaration and verification of noise emission values of machinery and equipment*

ISO 9614-1, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*

ISO 9614-2, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
sound power level
L_W
ten times the logarithm to the base 10 of the ratio of the sound power radiated by the source under test to the reference sound power [W_0 = 1 pW (10^{-12} W)] expressed in decibels

3.2
sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure to the square of the reference sound pressure [P_0 = 20 µPa (2 × 10^{-5} Pa)] expressed in decibels

3.3
measurement surface index
L_S
ten times the logarithm to the base 10 of the ratio of the measurement surface S to the reference surface [S_0 = 1 m^2] expressed in decibels

3.4
maximum value
value that defines the upper limit without further tolerance

4 Methods of measurement

4.1 Sound pressure level measurements and calculation of sound power level produced by the machine shall be made in accordance with ISO 3744, unless one of the alternative methods specified in 4.3 or 4.4 below applies.

NOTE It is general practice to use the parallelepiped method for all shaft heights.

4.2 The maximum sound power levels specified in Table 1, Table 2 and Table 3 or adjusted by Table 4 relate to measurements made in accordance with 4.1.

4.3 When appropriate, one of the methods of precision or engineering grade accuracy, such as the methods of ISO 3741, ISO 3743-1, ISO 3743-2, ISO 3745, ISO 9614-1 or ISO 9614-2, may be used to determine sound power levels.

4.4 The simpler but less accurate method specified in ISO 3746 or ISO 3747 may be used, especially when the environmental conditions required by ISO 3744 cannot be satisfied (for example, for large machines).

However, to prove compliance with this document, unless a correction due to inaccuracy of the measurement has already been applied to the values determined by this method in accordancewith ISO 3746 or ISO 3747, the levels of Table 1, Table 2 and Table 3 shall be decreased by 2 dB.

4.5 If testing under rated load conditions, the methods of ISO 9614 are preferred. However, other methods are allowed when the load machine and auxiliary equipment are acoustically isolated or located outside the test environment.

5 Test conditions

5.1 Machine mounting

5.1.1 Precautions

Care should be taken to minimize the transmission and the radiation of structure-borne noise from all mounting elements including the foundation. This can be achieved by the resilient mounting for smaller machines; however, larger machines can usually only be tested under rigid mounting conditions.

Machines tested under load conditions shall be rigidly mounted.

5.1.2 Resilient mounting

The natural frequency of the support system and the machine under test shall be lower than a third of the frequency corresponding to the lowest rotational speed of the machine.

The effective mass of the resilient support shall be not greater than one-tenth of that of the machine under test.

5.1.3 Rigid mounting

The machines shall be rigidly mounted to a surface with dimensions adequate for the machinetype (for example by foot or flange fixed in accordance with the manufacturer's instructions). The machine shall not be subject to additional mounting stresses from incorrect shimming or fasteners.

5.2 Test operating conditions

The following test conditions shall apply:

a) The machine shall operate at rated voltage(s), rated frequency or rated speed(s) and with appropriate field current(s) (when applicable). These shall be measured with instruments of an accuracy of 1 % or better.
   - The standard load condition shall be no-load, except for series wound motors.
   - When required, the machine shall be operated at an agreed load condition.

b) Machines shall be tested in their operating position within their specified duty that generates the greatest noise.

c) For an AC motor, the waveform and the degree of unbalance of the supply system shall comply with the requirements of IEC 60034-1.

   NOTE Any increase of voltage (and current) waveform distortion and unbalance will result in an increase of noise.

d) A synchronous motor with adjustable excitation field shall be run with excitation to obtain unity power factor or for large machines tested as a generator.

e) A generator shall be either run as a motor or driven at rated speed with excitation to obtain the rated voltage on open circuit.

f) A machine suitable for more than one speed shall be evaluated over the operating speed range.

g) A motor intended to be reversible shall be operated in both directions unless no differencein sound power level is expected. A unidirectional motor shall be tested in its design direction.

6 Sound power level limits

Where a machine is tested under the conditions specified in Clause 5, the sound power level of the machine shall not exceed the relevant value(s) specified as follows:

a) A machine, other than those specified in b), operating at no-load shall be as specified in Table 1.

b) A single-speed three-phase cage induction motor with cooling classification IC411, IC511, IC611, IC01, IC11, IC21, IC31, IC71 and IC81, at 50 Hz or 60 Hz, shaft heights from 90 upto and including 560, and with rated output not less than 1,0 kW and not exceeding 1 000 kW:
   - operating at no-load shall be as specified in Table 2
   - operating at rated load shall be the sum of the values established in Table 2 and Table 3
   - Grade A in Table 2 is the maximum level that a standard motor shall meet for 50Hz.

- Grade B in Table 2 is a reduced level for 50Hz motors that will meet the more stringentrequirements of the end-user.
- unless grade B is specifically requested, grade A is to be used as the default noise level for 50 Hz motors as per Table 2.

NOTE 1 The limits of Table 1, Table 2 recognize class 2 accuracy grade levels of measurement uncertainty and production variations.

NOTE 2 Sound power levels, under full-load condition, are normally higher than those at no-load. Generally, if ventilation noise is predominant the change may be small; but if the electromagnetic noise is predominant the change may be significant.

NOTE 3 The limits are irrespective of the direction of rotation. A machine with a unidirectional ventilator is generally less noisy than one with a bi-directional ventilator. This effect is more significant for high-speed machines, which may be designed for unidirectional operation only.

NOTE 4 For some machines, the limits in Table 1 may not apply for speeds below nominal speed. In such a case, or where the relationship between noise level and load is important, limits should be agreed between the manufacturer and the purchaser.

NOTE 5 For multispeed machines the values in the Table 1 apply.

7 Determination of sound pressure level

Sound pressure levels are not required as part of this document.

However, if requested by end user to provide pressure levels, for example in accordance with Annex A, it shall be per agreement between user and manufacturer. An A-weighted sound pressure level may be determined directly from the sound power level as follows:

$$L_{\mathrm{p}} = L_{\mathrm{W}} - L_{\mathrm{S}}$$

$$L_{\mathrm{S}} = 10 \log_{10} \left(\frac{S}{S_0} \right)$$

where:

L_{p} is the sound pressure level in a free field over a reflecting plane at 1 m distance from the machine;

L_{W} is the sound power level determined according to this document;

L_{S} is the measurement surface index;

S_0 is 1,0 m^2;

S is the area of the surface enveloping the machine at a distance of 1 m according to ISO 3744, 7.2.4. (Parallelepiped measurement surface).

NOTE 1 These sound pressure levels are for free field, over a reflecting plane. The sound pressure level for *in situ* conditions (that is, for hearing protection requirements) is different.

NOTE 2 For typical values of the measurement surface index used for conversions from sound power to sound pressure levels for machines in Table 2 and Table 3, see Annex A.

8 Declaration and verification of sound power values

A machine can be declared to comply with this document if, when tested under the conditions specified in Clause 5, the sound power level of the machine does not exceed the value specified in Clause 6.

The method selected and the type of measurement surface used shall be reported.

When requested sound power values determined according to this document can be reported according to the procedures of ISO 4871 using the dual-number presentation (determined sound power level *L* and uncertainty *K*).

Values for the uncertainty *K* are:

a) single machine

   1,5 dB (grade 1: laboratory)

   2,5 dB (grade 2: expertise)

   4,5 dB (grade 3: verification) (confidence 95 %).

b) set of machines of the same batch

   1,5 dB to 4,0 dB (grades 1 and 2)

   4,0 dB to 6,0 dB (grade 3).

Table 1 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load (excluding motors according to Table 2)
(Method of cooling, IC code, see IEC 60034-6,
Method of protection, IP code, see IEC 60034-5)

Rated speed n_N **min**$^{-1}$	$n_N \le 960$			$960 < n_N \le 1\ 320$			$1\ 320 < n_N \le 1\ 900$			$1\ 900 < n_N \le 2\ 360$			$2\ 360 < n_N \le 3\ 150$			$3\ 150 < n_N \le 3\ 750$		
Methods of cooling (simplified code)	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2
Rated output P_N kW (or kVA)																		
$1 \le P_N \le 1,1$	73	73	–	76	76	–	77	78	–	79	81	–	81	84	–	82	88	–
$1,1 < P_N \le 2,2$	74	74	–	78	78	–	81	82	–	83	85	–	85	88	–	86	91	–
$2,2 < P_N \le 5,5$	77	78	–	81	82	–	85	86	–	86	90	–	89	93	–	93	95	–
$5,5 < P_N \le 11$	81	82	–	85	85	–	88	90	–	90	93	–	93	97	–	97	98	–
$11 < P_N \le 22$	84	86	–	88	88	–	91	94	–	93	97	–	96	100	–	97	100	–
$22 < P_N \le 37$	87	90	–	91	91	–	94	98	–	96	100	–	99	102	–	101	102	–
$37 < P_N \le 55$	90	93	–	94	94	–	97	100	–	98	102	–	101	104	–	103	104	–
$55 < P_N \le 110$	93	96	–	97	98	–	100	103	–	101	104	–	103	106	–	105	106	–
$110 < P_N \le 220$	97	99	–	100	102	–	103	106	–	103	107	–	105	109	–	107	110	–
$220 < P_N \le 550$	99	102	98	103	105	100	106	108	102	106	109	102	107	111	102	110	113	105
$550 < P_N \le 1\ 100$	101	105	100	106	108	103	108	111	104	108	111	104	109	112	104	111	116	106
$1\ 100 < P_N \le 2\ 200$	103	107	102	108	110	105	109	113	105	109	113	105	110	113	105	112	118	107
$2\ 200 < P_N \le 5\ 500$	105	109	104	110	112	106	110	115	106	111	115	107	112	115	107	114	120	109

NOTE 1 Typical enclosure classification IP22 or IP23.

NOTE 2 Typical enclosure classification IP44 or IP55.

Table 2 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load, 50 Hz, sinusoidal supply (for single speed three-phase cage induction motors)

	IC411, IC511, IC611								IC01, IC11, IC21 IC31, IC71, IC81							
Shaft height, *H* in mm	2 pole		4 pole		6 pole		8 pole		2 pole		4 pole		6 pole		8 pole	
	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B
71	78	76	68	64	67	63	67	63	83	83	71	71	65	65	65	65
80	79	77	69	65	67	63	67	63	84	84	72	72	66	66	66	66
90	80	78	70	66	67	63	67	63	85	85	73	73	67	67	67	67
100	83	82	74	70	68	64	68	64	89	89	77	77	68	68	68	68
112	83	83	76	72	74	70	74	70	90	90	79	79	74	74	74	74
132	86	85	79	75	77	73	75	71	92	92	82	82	77	77	75	75
160	89	87	81	77	77	73	76	72	94	94	84	84	77	77	76	76
180	89	88	85	80	77	77	77	76	95	95	87	87	81	81	80	80
200	95	90	86	83	80	80	80	79	97	97	90	90	84	84	83	83
225	96	92	92	84	83	80	83	79	99	99	91	91	84	84	83	83
250	97	92	95	85	87	82	86	80	99	99	92	92	86	86	84	84
280	102	94	102	88	97	85	94	82	102	101	100	95	96	89	92	86
315	108	98	105	94	100	89	97	88	106	105	105	101	99	93	95	92
355	111	100	108	95	103	94	99	92	107	107	106	102	104	98	98	96
400	111	100	108	96	103	95	99	94	107	107	107	103	104	99	98	98
450	111	100	110	98	103	98	102	96	109	107	107	105	104	102	100	100
500	113	103	110	99	105	98	104	97	110	110	107	106	106	102	104	101
560	113	105	110	100	106	99	104	98	112	112	107	107	106	103	104	102

NOTE 1 The sound-power levels for 2 and 4 pole motors with shaft heights > 315 mm recognize a directional fan configuration. All other values are for bi-directional fans.

Note 2 Limits related to 60Hz operation to be referred from latest valid standard IEC 60034-9

Table 3 – Expected increase, over no-load condition, in A-weighted sound power levels, ΔL_{WA} in dB, for rated load condition (for motors according to Table 2)

Shaft height, *H* mm	2 pole	4 pole	6 pole	8 pole
71 ≤ *H* ≤ 160	2	5	7	8
180 ≤ *H* ≤ 200	2	4	6	7
225 ≤ *H* ≤ 280	2	3	6	7
H = 315	2	3	5	6
355 ≤ *H*	2	2	4	5

NOTE 1 This table gives the expected increase at rated load condition to be added to any declared no-load value.

NOTE 2 This table does not give guaranteed values. Values can be different for various machines and manufacturers.

Annex A
(informative)

Typical values for measurement surface index

Table A.1 – Typical values for measurement surface index for the conversion from sound power level to sound pressure level based on using parallelepiped measurement surface according to ISO 3744

$$L_S = 10 \log_{10} \left(\frac{S}{S_0} \right)$$

Shaft height, H mm	L_S dB
71	11
80	12
90	12
100	12
112	12
132	12
160	12
180	13
200	13
225	13
250	14
280	14
315	14
355	15
400	16
450	16
500	17
560	17
NOTE The values above are only for guidance and are not used for sound power level determination according to ISO 3744 or other relevant standards.	

Annex B
(informative)

Information on typical noise increments caused by converter supply

Noise emissions of electromagnetic origin at the converter supply can be considered as the superposition of:

- the noise generated by the voltages and currents of fundamental frequency, which is identical with the noise at sinusoidal supply of the same values, and
- an increment caused by voltages and currents at other frequencies.

Two features mainly influence this increment:

a) The frequency spectrum at the converter terminals

Three typical frequency spectra can be identified in Figure B.1, Figure B.2 and Figure B.3.

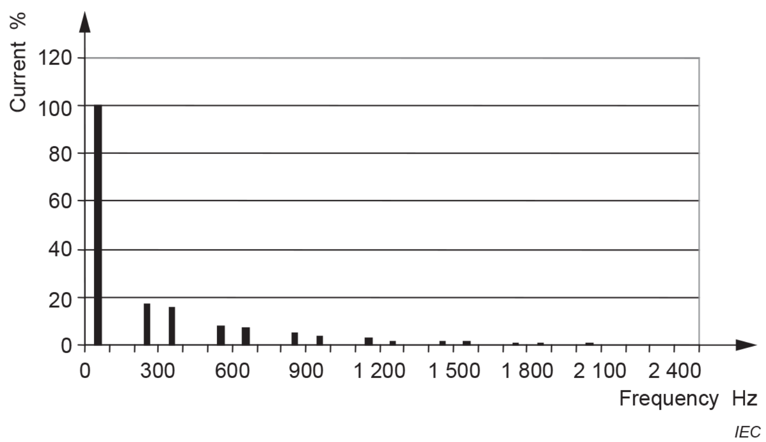

Figure B.1 – Frequency spectrum of the currents at the output terminals of a 6-pulse block-type current-source converter f_1 = 50 Hz

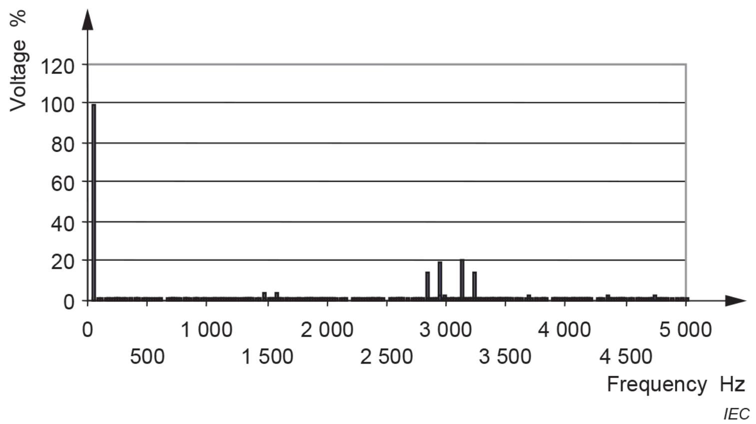

Figure B.2 – Frequency spectrum of the voltages at the terminals of a type A voltage-source converter (characterized by pronounced spikes close to the switching frequency and its multiples) f_1 = 50 Hz, f_s = 3 kHz

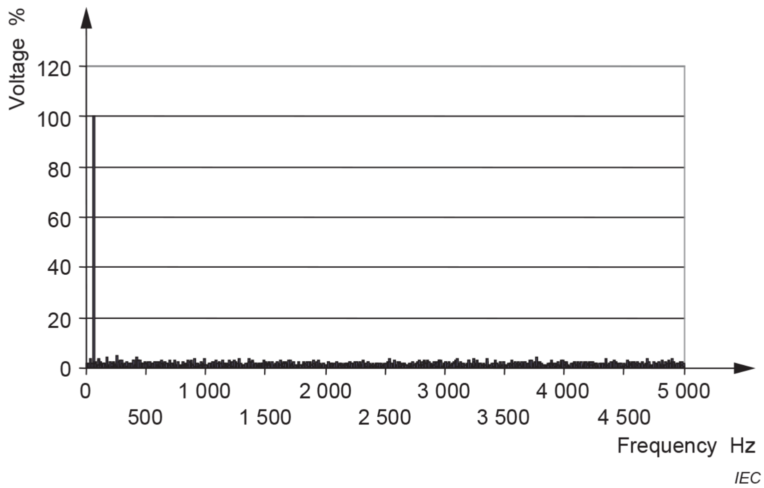

Figure B.3 – Frequency spectrum of the voltages of a type B voltage-source converter (characterized by a broad voltage spectrum without pronounced spikes) f_1 = 50 Hz, f_s average = 4,5 kHz

Specific considerations are necessary when the spectrum deviates significantly from a typical spectrum.

b) Typical values, historically based, for resonance frequencies of the motor for the modes of vibration caused by the harmonics

The relevant resonance frequencies of motors can be grouped according to Table B.1.

Table B.1 – Resonance frequencies of vibration mode r

Shaft height H	**Resonance frequencies of vibration mode r**			
	r = 0	r = 2	r = 4	r = 6
H ≤ 200 mm	> 4 000 Hz	> 600 Hz	> 4 000 Hz	> 5 000 Hz
H ≥ 280 mm	< 3 000 Hz	< 500 Hz	< 2 500 Hz	< 4 000 Hz

A magnetically excited tone is generated by the interaction of the fundamental fields of the number of pole pairs p of the fundamental frequency f_1 at the motor terminals and of one of the harmonic frequencies $n \times f_1$, as shown in the relevant frequency spectrum. The tones are of:

frequencies

$$f_r = f_1 \times (n \pm 1) = \begin{cases} (n+1) \times f_1 \\ (n-1) \times f_1 \end{cases}$$

vibration modes

$$r = p \pm p = \begin{cases} 2p \\ 0 \end{cases}$$

Usually combinations with $n \times f_1$, close to the switching frequency generate objectionable tones.

A reasonable increase of the audible noise is to be expected, if the frequency and the vibrationmode of a tone are close to the corresponding values of the resonant structure of the motor. In some cases, objectionable tones may be avoided by changes to the parameter assignment of the converter.

Table B.2 shows the typical increase of noise, at converter supply, when compared to the noise at sinusoidal supply, with the same fundamental values of voltage and frequency.

Table B.2 – Increments of A-weighted noise values

Kind of converter	Case	Expected increment
Block-type current-source converter	6-pulse or 12-pulse	1 dB to 5 dB The higher values relate to motors with low ventilation noise. Increment depends on load.
Type A voltage-source converter	High frequency voltages of high amplitudes excite resonances of the motor	Up to 15 dB Increment does not depend on load. Initial calculation possible by adequate software.
	High frequency voltages of high amplitudes do not excite resonances of the motor	1 dB to 5 dB Increment does not depend on load.
Type B voltage-source converter	Broad voltage spectrum without pronounced spikes	5 dB to 10 dB Increment does not depend on load.

Bibliography

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