BS EN 62024-2:2009

BSI British Standards

High frequency inductive components — Electrical characteristics and measuring methods —

Part 2: Rated current of inductors for DC to DC converters

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British Standards

National foreword

This British Standard is the UK implementation of EN 62024-2:2009. It is identical to IEC 62024-2:2008.

The UK participation in its preparation was entrusted to Technical Committee EPL/51, Transformers, inductors, magnetic components and ferrite materials.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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EUROPEAN STANDARD

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English version

High frequency inductive components - Electrical characteristics and measuring methods - Part 2: Rated current of inductors for DC to DC converters
(IEC 62024-2:2008)

Composants inductifs à haute fréquence -
Caractéristiques électriques
et méthodes de mesure -
Partie 2: Courant assigné
des bobines d'induction
des convertisseurs continus-continus
(CEI 62024-2:2008)

Induktive Hochfrequenz-Bauelemente -
Elektrische Eigenschaften
und Messmethoden -
Teil 2: Bemessungsstrom
von Drosselspulen für DC/DC-Wandler
(IEC 62024-2:2008)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 62024-2:2009 E

Foreword

The text of document 51/937/FDIS, future edition 1 of IEC 62024-2, prepared by IEC TC 51, Magnetic components and ferrite materials, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62024-2 on 2008-12-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2009-09-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-12-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62024-2:2008 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60068-1	-[1]	Environmental testing - Part 1: General and guidance	EN 60068-1	1994[2]
IEC 62025-1	-[1]	High frequency inductive components - Non-electrical characteristics and measuring methods - Part 1: Fixed, surface mounted inductors for use in electronic and telecommunication equipment	EN 62025-1	2007[2]

[1] Undated reference.

[2] Valid edition at date of issue.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH FREQUENCY INDUCTIVE COMPONENTS – ELECTRICAL CHARACTERISTICS AND MEASURING METHODS –

Part 2: Rated current of inductors for DC to DC converters

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International Standard IEC 62024-2 has been prepared IEC technical committee 51: Magnetic components and ferrite materials.

The text of this standard is based on the following documents:

FDIS	Report on voting
51/937/FDIS	51/941/RVD

Full information on the voting for the approval of this standard 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.

A list of all parts of IEC 62024 series, under the general title *High frequency inductive components – Electrical characteristics and measuring methods*, can be found on the IEC website.

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

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

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

HIGH FREQUENCY INDUCTIVE COMPONENTS – ELECTRICAL CHARACTERISTICS AND MEASURING METHODS –

Part 2: Rated current of inductors for DC to DC converters

1 Scope

This part of IEC 62024 specifies the measuring methods of the rated direct current limits for small inductors.

Standardized measuring methods for the determination of ratings enable users to accurately compare the current ratings given in various manufacturers' data books.

This standard is applicable to leaded and surface mount inductors with dimensions according to IEC 62025-1 and generally with rated current less than 22 A, although inductors with rated current greater than 22 A are available that fall within the dimension restrictions of this standard (no larger than 12 mm × 12 mm footprint approximately). These inductors are typically used in DC to DC converters built on PCB, for electric and telecommunication equipment, and small size switching power supply units.

The measuring methods are defined by the saturation and temperature rise limitations induced solely by direct current.

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 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 62025-1, *High frequency inductive components – Non-electrical characteristics and measuring methods – Part 1: Fixed, surface mounted inductors for use in electronic and telecommunication equipment*

3 Terms and definitions

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

3.1
DC saturation limited current
allowable value of DC current for which the decrease of the inductance is within the specified value

3.2
temperature rise limited current
allowable value of DC current for which the self-generation heat of the inductor results in temperature rise within the specified value

4 Standard atmospheric conditions

4.1 Standard atmospheric conditions for testing

Standard atmospheric conditions for testing shall be as follows (see 5.3.1 of IEC 60068-1):

– temperature: 15 °C to 35 °C;
– relative humidity: 25 % to 75 %;
– air pressure: 86 kPa to 106 kPa.

In the event of dispute or where required, the measurements shall be repeated using the referee temperatures and such other conditions as given in 4.2.

4.2 Reference conditions

For reference purposes, one of the standard atmospheric conditions for referee tests taken from 5.2 of IEC 60068-1 shall be selected and shall be as follows:

– temperature: 20 °C ± 2 °C;
– relative humidity: 60 % to 70 %;
– air pressure: 86 kPa to 106 kPa.

5 Measuring method of DC saturation limited current

5.1 General

When alternating current in which DC current is superimposed is supplied to an inductor, the inductance of the inductor decreases according to the DC current value.

In a typical application, the saturation current results from the peak current of the superposition of AC on DC current. In this standard, the saturation current is measured as DC current offsetting a small signal AC current.

NOTE It is not practical to set a standard for AC saturation limited current, because there are an unlimited number of different ways to apply AC current in an application. Therefore, manufacturers and users have generally defined DC saturation limited current as a common point of reference. This standard does the same.

5.2 Test conditions

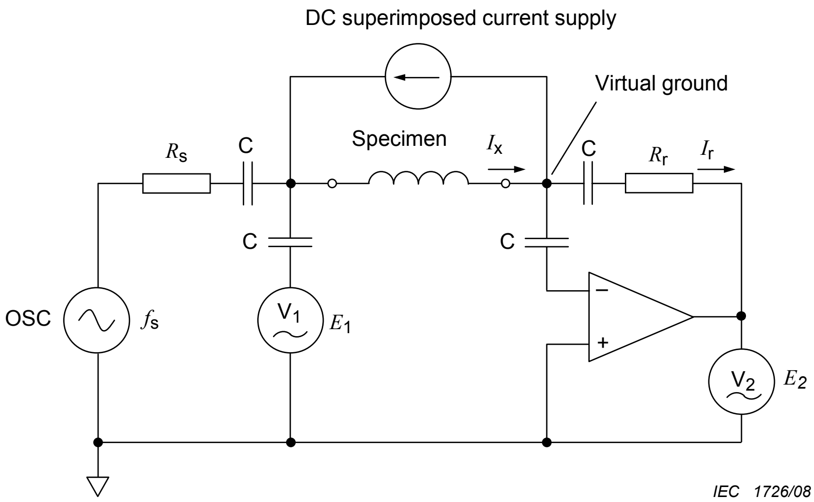
Unless otherwise specified in the detail specification, the test conditions shall be in accordance with Clause 4.

NOTE The variation of the value of DC saturation limited current, as a function of temperature, is dependent on the magnetic material and the structure of the magnetic core of the inductor. However, measurement of DC saturating currents at elevated temperatures is generally not practical for inspection purposes. Therefore, the measurement at room temperature as provided by this standard is generally applied for specification purposes. De-rating curves indicating variation of DC saturation limited current as a function of maximum operating temperature of the inductor can be generated. These curves can be used to correlate the DC saturation limited current at room temperature to the DC saturation limited current at typical operating temperatures. In some cases, it will become necessary for the manufacturer and user to agree on an additional specification at a high temperature such as 85 °C, 105 °C or 125 °C.

5.3 Measurement circuit and calculation

a) Measuring circuit

The measuring circuit is as shown in Figure 1.



Components

R_s	source resistor R = R_s
R_r	range resistor R = R_r
V_1	voltmeter $V_1 = E_1$
V_2	voltmeter $V_2 = E_2$
C	DC current blocking capacitor

Supplies

f_s	frequency of source
I_r	supplied current to range resistor
I_x	supplied current to specimen
	$I_x = I_r$

Figure 1 – Inductance measurement circuit under application of DC saturation condition

b) Calculation

Voltages E_1 and E_2 shall be measured when frequency f_s and voltage E_s of the signal generator are supplied in accordance with the detail specification, and an initial value of the inductance shall be calculated by the following formulas.

$$Z_x = \frac{E_1}{I_r} = \frac{-E_1}{E_2} R_r$$

$$Z_x = |Z_x| \cos\theta + j|Z_x| \sin\theta$$

$$Z_x = R_x + jX_x$$

$$L_x = \frac{X_x}{\omega} = \frac{X_x}{2\pi f_s}$$

where

R_x is the resistance of the specimen;

X_x is the reactance of the specimen;

Z_x is the impedance of the specimen;

L_x is the equivalent series inductance of the specimen;

E_1 is applied voltage to specimen;

E_2 is applied voltage to range resistor (= $I_r R_r$) (E_2 can be regarded as current);

θ is phase angle difference between E_1 and E_2.

5.4 Attachment jig of inductor

Attachment jig of specimen shall be specified in the detail specification.

5.5 Measuring method

a) Short compensation shall be done before measurement.

b) The specimen shall be connected to the circuit shown in Figure 1, by using the attachment jig specified in 5.4.

c) When the specimen is connected by soldering, it shall be left until it becomes cool enough.

d) Voltages E_1 and E_2 shall be measured when frequency f_s and voltage E_s of the signal generator are supplied in accordance with the detail specification, and an initial value of the inductance shall be calculated by the formulas of 5.3 b).

e) The value of the DC current that is superimposed on the specimen shall be modulated and the inductance value shall be measured.

f) The decrease from the initial value of the inductance shall be calculated. DC saturation limited current shall be determined by measuring the DC current when the decrease in inductance matches the specified value in the detail specification.

g) The decrease in inductance that is specified in the detail specification should be 10 % or 30 %.

NOTE 10 % is one of the design points typical for sharp-saturating inductors, and 30 % is one of the design points typical for soft-saturating inductors. See Annex A.

5.6 Quality conformance inspection

The DC current specified in the detail specification shall be supplied to a specimen in accordance with the methods specified in 5.3 to 5.5, and then inductance shall be measured. The decrease in inductance shall be within the specified value.

6 Measuring method of temperature rise limited current

6.1 General

When DC current is supplied to an inductor, the inductor generates heat by itself according to the supplied DC current value because of its DC current resistance.

NOTE 1 Temperature rise results from self-heating of the inductor. The sources of heating are DC copper losses, AC copper losses and AC core losses. This standard defines the temperature rise induced only by DC currents. In specific applications, it is necessary to consider AC copper losses and AC core losses for the temperature rise. AC losses are highly affected by waveform, amplitude and frequency.

NOTE 2 It is not practical to set a standard for AC temperature rise limited current, because there are an unlimited number of different ways to apply AC current in an application. In DC to DC converters, often AC loss is far smaller than DC loss. Therefore, manufacturers and users have generally defined DC temperature rise limited current as a common point of reference. This standard does the same.

6.2 Test conditions

Unless otherwise specified in the detail specification, the test conditions shall be in accordance with Clause 4.

Since the value of DC current resistance increases as a function of temperature, some applications require a high ambient temperature such as 85 °C, 105 °C or 125 °C for the temperature rise test.

NOTE 1 The overall power loss of an inductor is a combination of DC power loss due to DC current resistance, as well as AC power loss due to AC current in the windings and losses due to the corresponding AC flux induced in the magnetic core. The value of AC and DC current resistance (the conductor resistance) increases with temperature, thus the power loss associated with conductor resistance increases with temperature. The loss associated with the magnetic core is all due to AC excitation. The core loss decreases with increasing temperature up to a temperature typically referred to as the core loss minima temperature, above which point this loss begins to increase. The minima temperature and magnitude of loss is dependent on the magnetic material type and grade. Most ferrites exhibit sharp minima temperatures, while powder alloys do not. These considerations must be taken into account when applying temperature rise currents to applications with high operating temperatures and a non-trivial amount of AC power loss in addition to DC power loss. The overall total loss at any given temperature may be dominated by DC loss or AC loss dependent on the power loss distribution at room temperature as well as the variation of each of these power losses with temperature.

NOTE 2 Regarding DC temperature rise limited currents at high temperatures, the variation in DC temperature rise limited current with ambient temperature variation can be predicted. Moreover, measurement of DC temperature rise limited currents at elevated temperatures is generally not practical. Therefore, the measurement at room temperature as provided by this standard is generally applied.

6.3 Measurement jig

The measurement jig shall be either printed-wiring board method given in 6.3.1 or lead wire method given in 6.3.2, and shall be specified in the detail specification.

6.3.1 Printed-wiring board method

Printed-wiring board shall be made of epoxide woven glass (FR4). Unless otherwise specified in the detail specification, the dimensions shall be as shown in Table 1 and Figure 2.

Table 1 – Width of circuits

Rated current of inductor I A	**Pattern width**[a] W mm
$I \leq 1$	1,0 ± 0,2
$1 < I \leq 2$	2,0 ± 0,2
$2 < I \leq 3$	3,0 ± 0,3
$3 < I \leq 5$	5,0 ± 0,3
$5 < I \leq 7$	7,0 ± 0,5
$7 < I \leq 11$	11,0 ± 0,5
$11 < I \leq 16$	16,0 ± 0,5
$16 < I \leq 22$	22,0 ± 0,5
$22 < I$	According to the detail specification
[a] See Figure 2.	

Dimension in millimetres

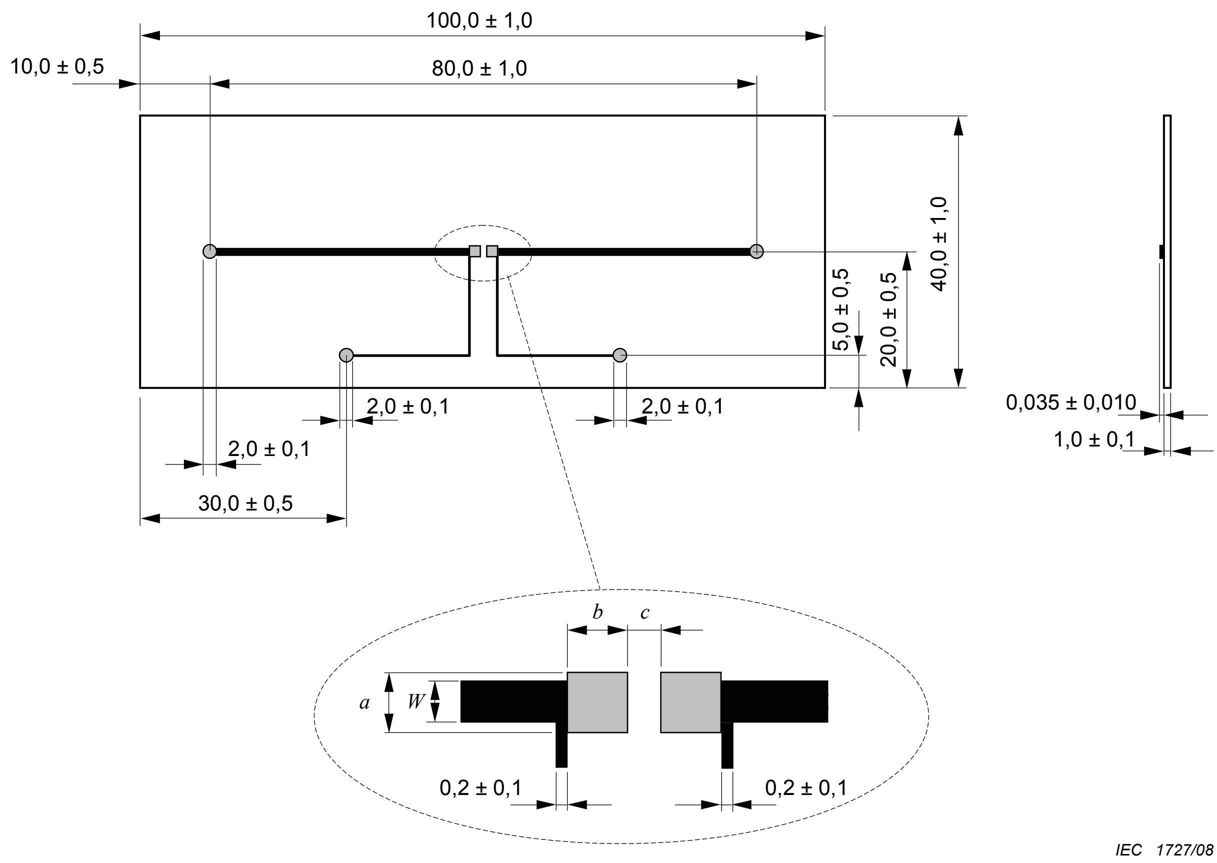


Figure 2a) – Example of printed-wiring board for SMD type

Dimension in millimetres

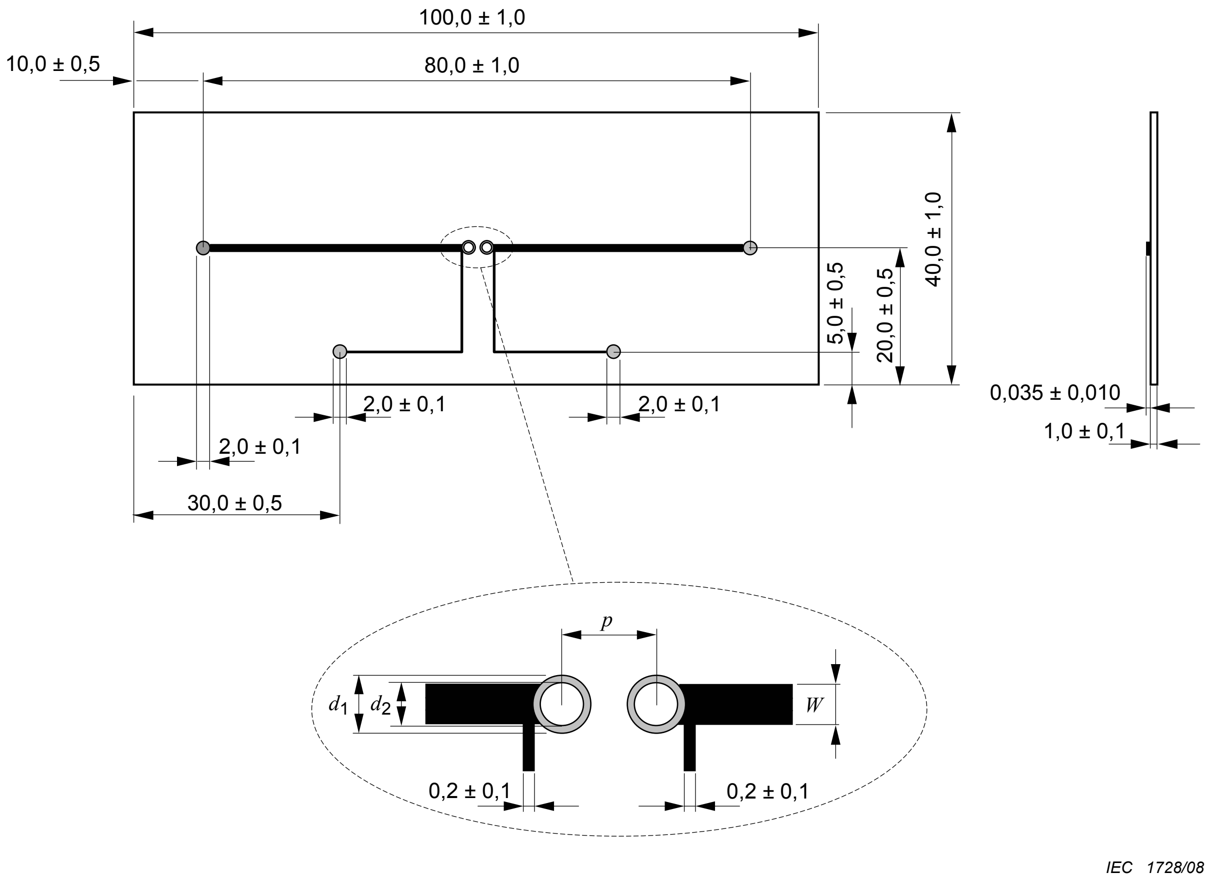


Figure 2b) – Example of printed-wiring board for leaded type

Key

solderable areas

non-solderable areas (covered with non-solderable lacquer)

NOTE 1 a, b, c, d_1, d_2 and p: according to the detail specification.

NOTE 2 Materials of substrate: epoxide woven glass (FR4).

NOTE 3 Materials of pattern: copper.

NOTE 4 Thickness of pattern: 0,035 mm ± 0,010 mm.

NOTE 5 Pattern width (W): see Table 1.

Figure 2 – Example of printed-wiring board

6.3.2 Lead wire method

Unless otherwise specified in the detail specification, the wire diameter of lead wire to connect the inductor and the measurement circuit shall be in accordance with Table 2.

Table 2 – Wire size of circuits

Rated current of inductors I A	Wire size	
	mm	AWG (for reference)
$I \leq 3$	0,50 ± 0,05	24
$3 < I \leq 5$	0,65 ± 0,05	22
$5 < I \leq 11$	0,8 ± 0,1	20
$11 < I \leq 16$	1,0 ± 0,1	18
$16 < I \leq 22$	1,3 ± 0,1	16
$22 < I$	According to the detail specification	
NOTE 1 The wire size refers to MIL standard (MIL-PRF-15733).		
NOTE 2 AWG is a wire diameter number of American Wire Gauge.		

6.4 Measuring method and calculation

Measuring method shall be either the resistance substitution method of 6.4.1 or the thermocouple method of 6.4.2, and shall be specified in the detail specification.

6.4.1 Resistance-substitution method

a) The specimen shall be connected to the circuit shown in Figure 3, by using the measurement jig specified in 6.3.

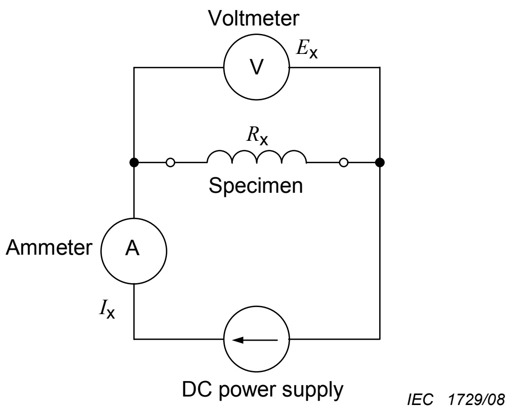


Figure 3 – Temperature rise measurement circuit by resistance substitution method

b) When the specimen is connected by soldering, it shall be left until it becomes cool enough.

c) The specimen should be measured inside a cubic box of roughly 20 cm on each side to prevent temperature change from air flow. The box may have some vents in the top to prevent trapping heat inside.

The specimen shall be measured on the condition that it does not contact directly to the test board. When it is measured by mounting on the printed-wiring board, the printed-circuit board on which the specimen is mounted shall not contact directly to the test board.

d) The resistance value of the specimen and ambient temperature t_{a1} shall be measured before DC current is supplied.

e) DC current shall be supplied to the specimen from a direct power supply. After the DC voltage value of the specimen becomes steady, DC current value I_x and DC voltage value E_x shall be measured by the ammeter and the voltmeter, and also ambient temperature t_{a2} shall be measured. Then the resistance value R_x shall be calculated by the following formula.

$$R_x = \frac{E_x}{I_x}$$

where

I_x is the DC current value;

E_x is the DC voltage;

R_x is the resistance of the specimen.

f) The temperature rise value t of the specimen shall be calculated by the following formula, by using the resistivity coefficient of the metal and the resistance of the specimen. $|t_{a1} - t_{a2}|$ shall be 5 °C or less.

$$t = t_2 - t_{a2} = \left(\frac{R_2 - R_1}{R_1} \right) (C + t_{a1}) + t_{a1} - t_{a2}$$

where

t is the temperature rise value (°C);

t_2 is the temperature of the specimen when DC current is supplied (°C);

t_{a1} is the initial ambient temperature (°C);

t_{a2} is the ambient temperature when DC current is supplied (°C);

R_1 is the resistance of winding at temperature $t_1 = t_{a1}$ (Ω);

R_2 is the resistance of winding at temperature t_2 (Ω);

C is a material constant. C for copper = 234,5.

g) The value of the supplied DC current shall be modulated and the temperature rise value shall be measured.

h) Temperature rise limited current shall be determined by measuring DC current when the temperature rise value becomes the specified value in the detail specification.

i) The temperature rise value that is specified in the detail specification should be 20 °C or 40 °C.

6.4.2 Thermo-couple method

a) The specimen shall be connected to the circuit shown in Figure 4, by using the measurement jig specified in 6.3.

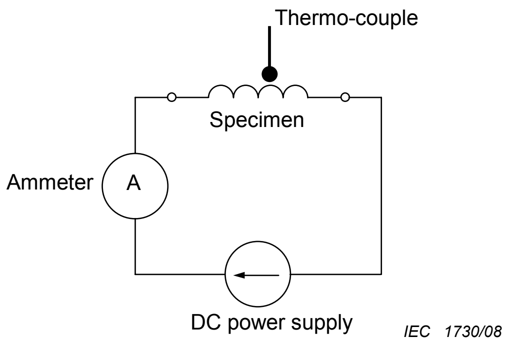


Figure 4 – Temperature rise measurement circuit by thermo-couple method

b) When the specimen is connected by soldering, it shall be left until it becomes cool enough.

c) The specimen should be measured inside a cubic box of roughly 20 cm on each side to prevent temperature change from air flow. The box may have some vents in the top to prevent trapping heat inside.

The specimen shall be measured on the condition that it does not contact directly to the test board. When it is measured by mounting on the printed-wiring board, the printed-wiring board on which the specimen is mounted shall not contact directly to the test board.

d) Consideration shall be given to the correct measurement position of the thermo-couple for the temperature measurement. It should be placed at the location where the maximum temperature of the inductor will occur. The best location may be direct contact at the surface of the specimen, or within the coil by placing the thermo-couple inside, or under the coil by positioning it prior to winding.

The measurement position shall be specified in the detail specification.

e) Temperature of the specimen t_1 and ambient temperature t_{a1} shall be measured before DC current is supplied.

f) DC current shall be supplied to the specimen from a DC power supply. After the temperature of the specimen becomes steady, temperature of the specimen t_2 and ambient temperature t_{a2} shall be measured again.

g) The value of the supplied DC current shall be modulated and the temperature rise value shall be calculated by the following formula.

$$t = (t_2 - t_{a2}) - (t_1 - t_{a1})$$

where

t is the temperature rise value (°C);

t_1 is the initial temperature of the specimen (°C);

t_2 is the temperature of the specimen when DC current is supplied (°C);

t_{a1} is the initial ambient temperature (°C);

t_{a2} is the ambient temperature when DC current is supplied (°C).

h) Temperature rise limited current shall be determined by measuring DC current when the temperature rise value becomes the specified value in the detail specification.

i) The temperature rise value that is specified in the detail specification should be 20 °C or 40 °C.

6.5 Quality conformance inspection

The DC current specified in the detail specification shall be supplied to a specimen in accordance with the methods specified in 6.3 to 6.4, and then the temperature rise value shall be measured.

The temperature rise value of the specimen shall be within the specified value.

7 Determination of rated current

For any inductor that is given a current rating, a DC saturation limited current value or a temperature rise limited current value, whichever is less, defined and measured as shown in this standard, shall be adopted as the rated current.

8 Information to be given in the detail specification

The following information shall be given in the detail specification.

8.1 Measuring method of DC saturation limited current

a) Frequency f_s and voltage E_s (see 5.3 b), 5.5 d)).

b) Attachment jig (see 5.4).

c) The allowable decrease in inductance (see 5.5 f).)

d) DC saturation limited current (see 5.6).

8.2 Measuring method of temperature rise limited current

a) Measurement jig (see 6.3).
b) Measuring method (see 6.4).
c) Temperature rise value (see 6.4.1 h), 6.4.2 h)).
d) Measurement position (if thermo-couple method applied) (see 6.4.2 d)).
e) Temperature rise limited current (see 6.5).

Annex A
(informative)

Example of recommended description on product specification sheets and catalogues

Both the DC saturation limited current value and the temperature rise limited current value should be described on product specification sheets and catalogues.

It should be specified whether the DC saturation limited current value is determined when the allowable decrease in inductance value is at 10 % or 30 %.

Sharp saturation is defined as inductance that decreases by more than 8 % for a 10 % increase in bias current, measured where bias current has already reduced the inductance by 30 % compared with the unbiased inductance. Soft saturation is defined as inductance that decreases by less than 8 % for a 10 % increase in bias current, measured where bias current has already reduced the inductance by 30 % compared with the unbiased inductance.

Sharp saturating inductors have a steep drop in inductance beyond an inflection point, and therefore they are specified and designed to operate at load currents that are less than the current at the inflection point. 10 % is used for a standard specification point because it is a typical design point. Other values, such as 20 % or 30 %, may be used by mutual agreement between manufacture and user.

Soft saturating inductors have a continual and gradual drop in inductance, without a well-defined inflection point, and therefore they are specified and designed to operate at load currents that typically push inductance down by 20 % to 50 %, or even more as the application allows. 30 % is used for a standard specification point because it is a typical design point (but not necessarily a requisite design point). Other values, such as 20 % or 50 %, may be used by mutual agreement between manufacture and user.

It should be specified whether the temperature rise limited current value is determined when the temperature rise of the inductor is at 20 °C or 40 °C.

When the definition called a rated current is used, it should be the lower one of the DC saturation limited current value and the temperature rise limited current value.

NOTE Unless otherwise specified in the detail specification, operating temperature is ambient temperature plus temperature rise of inductors.

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