IEC 62024-2

Edition 2.0 2020-03
REDLINE VERSION

INTERNATIONAL STANDARD

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, ferrite and magnetic powder materials.

This second edition cancels and replaces the first edition published in 2008. This edition constitutes a technical revision.

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

a) addition of Table 2 and Figure 2 b).

The text of this International Standard is based on the following documents:

CDV	Report on voting
51/1303/CDV	51/1325/RVC

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

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

A list of all parts of IEC 62024 series, published 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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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 document 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 document (no larger than a 12 mm × 12 mm footprint approximately). These inductors are typically used in DC-to-DC converters built on PCBs, 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 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 60068-1:2013, *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.

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
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 60068-1:2013, 4.3):

- 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 60068-1:2013, 4.2, 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 document, 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 is 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 document does the same.

5.2 Test conditions

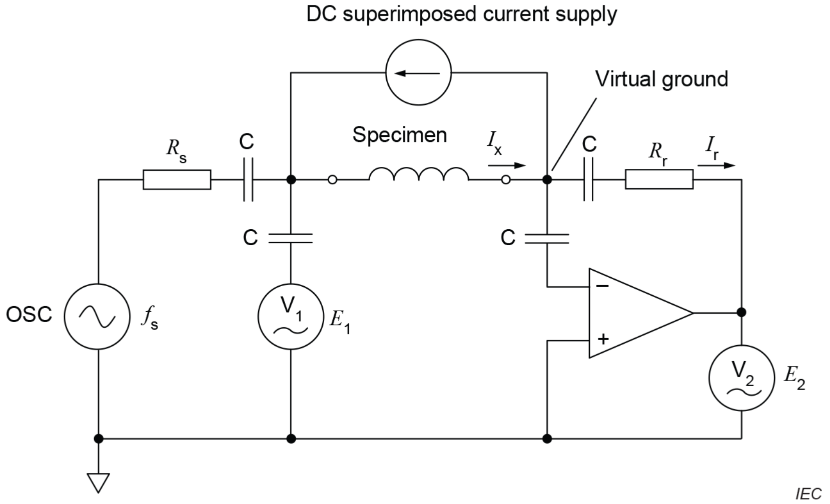
Unless otherwise specified in the detail specification, the test conditions shall be in accordance with Clause 4.

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 document 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~~ Measuring circuit and calculation

5.3.1 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~~ measuring circuit under application of DC saturation condition

5.3.2 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 formulae.

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

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

$$Z_x = R_x + jX_x$$

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

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 the applied voltage to the specimen;

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

θ is the phase angle difference between E_1 and E_2.

5.4 Attachment jig of inductor

The attachment jig of the specimen shall be specified in the detail specification.

5.5 Measuring method

a) 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 formulae of 5.3.2.

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 document defines the temperature rise induced only by DC currents. ~~In specific applications, it is necessary to consider~~ AC copper losses and AC core losses are considered 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 is 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 document does the same.

6.2 Test conditions

Unless otherwise specified in the detail specification, for example an elevated ambient temperature, 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 are dependent on the magnetic material type and grade. ~~Most~~ Some ferrites exhibit sharp minima temperatures~~, while powder alloys do not~~. These considerations ~~must be~~ are 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~~ can be dominated by DC loss or AC loss depending 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~~ modeled. ~~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.~~ Measurement at room temperature is commonly applied for detail specifications. In any event, the ambient temperature for the test is specified in the detail specification.

6.3 ~~Measurement~~ Measuring jig

6.3.1 General

The ~~measurement~~ measuring jig shall be either printed-wiring board method given in 6.3.2 or lead wire method given in 6.3.3, and shall be specified in the detail specification.

6.3.2 Printed-wiring board method

The 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, Table 2 and Figure 2.

Table 1 – Width of circuits

Rated current class	Rated current of inductor I A	Pattern width~~[a]~~ W mm
$I_{\text{class A}}$	$I \leq 1$	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]~~ NOTE See Figure 2a).

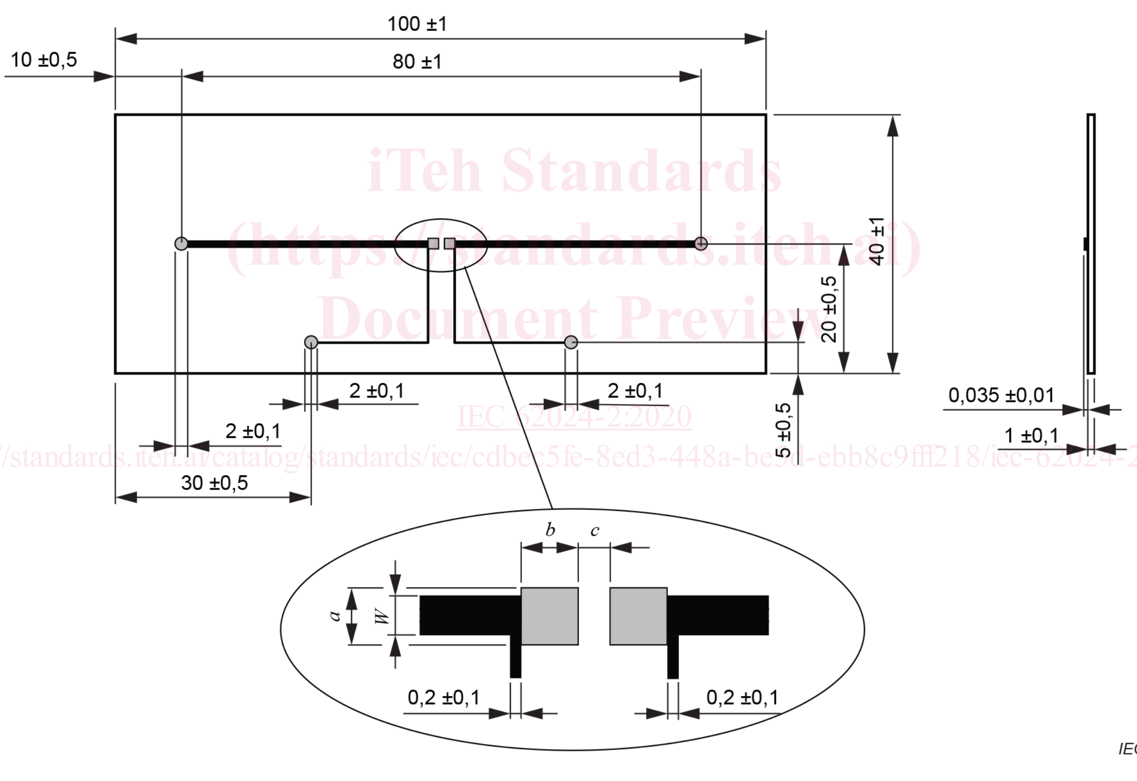
Table 2 – Circuit pattern width and thickness

Rated current class	Pattern width W mm	Pattern thickness t µm	Example application
$I_{\text{class A}}$	(1,0 to 22,0) ± 0,2 to 0,5	35 ± 10	Consumer application (single-sided printed circuit boards application)
$I_{\text{class B}}$	40 ± 0,2	35 ± 10	Consumer application (double-sided printed circuit boards application)
$I_{\text{class C}}$	40 ± 0,2	105 ± 10	Consumer application (multilayer printed circuit boards application)
$I_{\text{class D}}$	40 ± 0,2	1000 ± 50	Automotive or large current power line application

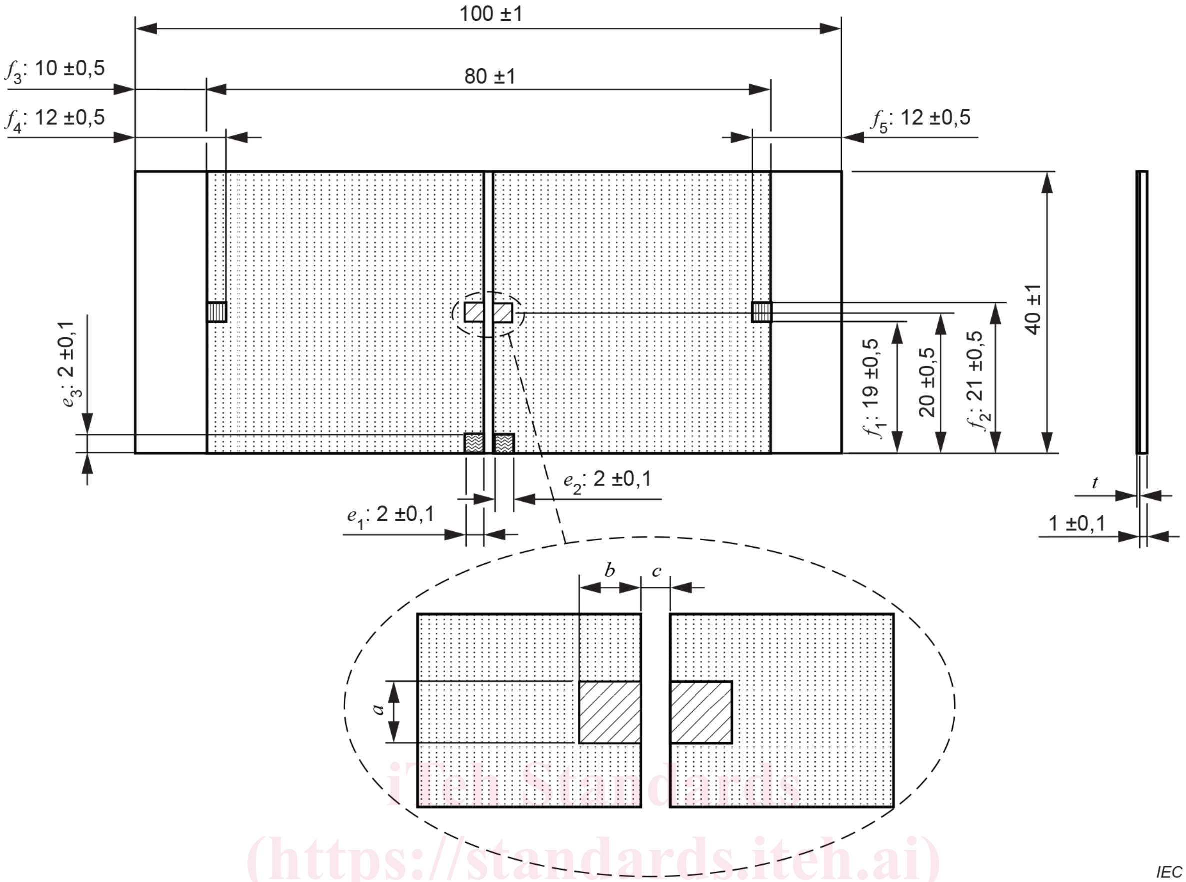
NOTE 1 $I_{\text{class A}}$: see Figure 2a).

NOTE 2 $I_{\text{class B}}$, $I_{\text{class C}}$, $I_{\text{class D}}$: see Figure 2b).

Dimensions in millimetres



a) Example of printed-wiring board for SMD type (I class A)



b) Example of printed-wiring board for SMD type (*I* class B,C,D)