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Transformers and inductors for use in electronic and telecommunication equipment -
Part 389: Measuring methods and test procedures

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FOREWORD

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IEC/IEEE 61007-389 was prepared by IEC technical committee 51: Magnetic components, ferrite and magnetic powder materials, in cooperation with Standards Committee of the IEEE Power Electronics Society, under the IEC/IEEE Dual Logo Agreement between IEC and IEEE. It is an International Standard.

This document is published as an IEC/IEEE Dual Logo standard.

This first edition of IEC/IEEE 61007-389 cancels and replaces IEC 61007:2020 and IEEE 389:2020, which has been technically revised.

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

a) added the following new test items:
   1) transformer capacitance (in 4.5.6.1);
   2) voltage transformation (VT) ratio (in 4.5.7.3);
   3) thermo-couple method (in 4.5.15.3);
   4) bridge circuit measurement (in 4.5.16.3);
   5) dynamic CM capacitance of a transformer (in 4.5.20);
   6) tests of the parameter in transformer equivalent circuit (in 4.5.21);
b) updated the following test items:
   1) added test purpose: AC resistance (in 4.5.1.2); dielectric withstand voltage test (in 4.5.2.1); effective inductance (in 4.5.4.1); capacitance unbalance (in 4.5.5.1); total harmonic distortion (in 4.5.13);
   2) testing fundamentals and equipment modification: DC winding resistance (in 4.5.1.1); AC resistance (in 4.5.1.2); winding continuity (in 4.5.1.3); excitation apparent-power measurements (in 4.5.3.4); capacitance unbalance (in 4.5.5.1); self-capacitance (distributed capacitance) (in 4.5.6.2); inter-winding capacitance (in 4.5.6.3); inherent self-resonance (in 4.5.8.1); resonant assemblies (in 4.5.8.2); insertion loss (in 4.5.9.1); return loss (in 4.5.9.2); crosstalk (in 4.5.10); pulse characteristics (in 4.5.11.1); transformer response measurements (in 4.5.11.2); total harmonic distortion (in 4.5.13); method utilizing the change in DC resistance of a winding (in 4.5.15.1); method using an additional series-opposing bifilar winding (in 4.5.15.2); safety screens (in 4.5.17.2); magnetic radiation (in 4.5.17.4); acoustic noise (in 4.5.18.1);
   3) procedure modification: dielectric withstand voltage test (in 4.5.2.1); induced voltage test (in 4.5.2.2); capacitance unbalance (in 4.5.5.1);
   4) Information to be stated modification: insulation resistance (in 4.5.2.4); excitation apparent-power measurements (in 4.5.3.4); stray-load losses (in 4.5.3.5); power factor (in 4.5.3.8); inherent self-resonance (in 4.5.8.1); parallel resonance and series resonance (in 4.5.8.3); transformer pulse response (in 4.5.11.3);
c) removed Annex D and Annex F in IEC 61007:2020.

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

Draft	Report on voting
51/1612/FDIS	51/1627/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with the rules given in the ISO/IEC Directives, Part 2, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications/.

A list of all parts in the IEC 61007 series, published under the general title *Transformers and inductors for use in electronic and telecommunication equipment*, can be found on the IEC website.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

– reconfirmed,
– withdrawn, or
– revised.

INTRODUCTION

IEC 61007 describes a number of tests to determine the important parameters and performance characteristics of transformers and inductors used in electronic and telecommunications equipment, aiming to check whether the product meets specific applications and is widely used in industrial manufacturing processes and customer acceptance tests. It includes the test method of electrical testing such as resistance strength, power loss, impedance, inductance value and quality factor, including the test purpose, test procedure and test principle, as well as the reliability test items for electronic transformers and inductors. IEEE Std 389:2020 specifies test and experimental methods applicable to the performance evaluation of electronic transformers and inductors, for the test and evaluation of transformers with lower power ratings (communications, instrumentation, control, small appliance and computer applications). It includes electrical strength, power loss, inductance, impedance and other test items, Kelvin bridge method, impedance bridge method and other measurement methods, but does not include reliability test items and test procedures.

Both documents cover test methods and procedures for electronic transformers and inductors, but they have different emphases and test methods, which bring a lot of inconvenience to users. There is a growing call for establishing an efficient and streamlined universal international standard to meet the needs of developers, customers and the market. Therefore, a proposal for a dual label (IEC/IEEE) standard is formulated to combine IEC 61007 and IEEE Std 389:2020 into one unified new standard.

The structural expression of this document refers to IEC 61007, and on this basis, the expression of test principles, test procedures and test conditions is added for each test item.

This document is a combined and shared standard.

1 Scope

This document describes a number of tests for use in determining the significant parameters and performance characteristics of transformers and inductors for use in electronics and telecommunication equipment. These test methods are designed primarily for transformers and inductors used in all types of electronics applications that can be involved in any specification for such components. Even though these tests could be applied supplementally for other types of transformers, such as those with larger power ratings used in the utility power industry, the tests discussed in this document are not intended to replace the tests in standards for those other transformers.

Some of the tests described are intended for qualifying a product for a specific application, while others are test practices used for manufacturing and customer acceptance testing. The test methods described here include those parameters most commonly used in the electronics transformer and inductor industry: electric strength, resistance, power loss, inductance, impedance, balance, transformation ratio and many others used less frequently.

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 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*, available at https://www.electropedia.org

IEC 60068-1:2013, *Environmental testing - Part 1: General and guidance*

IEC 60068-2-1, *Environmental testing - Part 2-1: Tests - Test A: Cold*

IEC 60068-2-2, *Environmental testing - Part 2-2: Tests - Test B: Dry heat*

IEC 60068-2-6, *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)*

IEC 60068-2-7, *Basic environmental testing procedures - Part 2-7: Tests - Test Ga and guidance: Acceleration, steady state*

IEC 60068-2-10, *Environmental testing - Part 2-10: Tests - Test J and guidance: Mould growth*

IEC 60068-2-13, *Environmental testing - Part 2-13: Tests - Test M: Low air pressure*

IEC 60068-2-14, *Environmental testing - Part 2-14: Tests - Test N: Change of temperature*

IEC 60068-2-17, *Environmental testing - Part 2-17: Tests - Test Q: Sealing*

IEC 60068-2-20, *Environmental testing - Part 2-20: Tests - Test Ta and Tb: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-21, *Environmental testing - Part 2-21: Tests - Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-27, *Environmental testing - Part 2-27: Tests - Test Ea and guidance: Shock*

IEC 60068-2-30, *Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-42, *Environmental testing - Part 2-42: Tests - Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60068-2-45, *Basic environmental testing procedures - Part 2-45: Tests - Test XA and guidance: Immersion in cleaning solvents*

IEC 60068-2-52, *Environmental testing - Part 2-52: Tests - Test Kb: Salt mist, cyclic (sodium chloride solution)*

IEC 60068-2-78, *Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state*

IEC 60695-11-2, *Fire hazard testing - Part 11-2: Test flames - 1 kW pre-mixed flame - Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-5, *Fire hazard testing - Part 11-5: Test flames - Needle-flame test method - Apparatus, confirmatory test arrangement and guidance*

IEC 61672-1, *Electroacoustics - Sound level meters - Part 1: Specifications*

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

IEC 62044-2, *Cores made of soft magnetic materials - Measuring methods - Part 2: Magnetic properties at low excitation level*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050 (all parts) and the following apply.

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

– IEC Electropedia: available at https://www.electropedia.org/
– ISO Online browsing platform: available at https://www.iso.org/obp
– *IEEE Standards Dictionary Online*: available at https://dictionary.ieee.org
– Electrical and magnetic terms used in this recommended practice are in accordance with those given in *IEEE Standards Dictionary Online*. Certain parameters and symbols of particular significance in the evaluation of electronics transformers are given where required in the text.

3.1
component
part of a device that cannot be divided into smaller parts without losing their specific functions

Note 1 to entry: The components mentioned in this file refer to transformers or inductors.

3.2
peak working voltage
maximum instantaneous voltage for which the winding insulation is rated under working circuit conditions

3.3 Pulse wave form parameters (see Figure 1)

3.3.1
peak pulse amplitude
U_m
maximum value of an extrapolated smooth curve through the top of the pulse, excluding any initial "spike" or "overshoot", the duration of which is less than 10 % of the pulse duration

3.3.2
pulse duration
t_d
time interval between the first and last instant at which the pulse amplitude equals 50 % of the peak pulse amplitude

3.3.3
pulse rise time
t_r
interval between the first instant at which the pulse amplitude reaches 10 % of the peak pulse amplitude and the first instant at which the pulse amplitude reaches 90 % of the peak pulse amplitude, excluding an unwanted or irrelevant portion of the waveform

3.3.4
pulse fall time
t_f
interval between the last instant at which the pulse amplitude reaches 90 % of the peak pulse amplitude and the next instant at which the pulse amplitude reaches 10 % of the peak pulse amplitude excluding any unwanted or irrelevant portion of the waveform

Note 1 to entry: Where the value of the droop approaches 10 % of the peak pulse amplitude, the upper point defining fall time can be replaced by the last instant at which the pulse amplitude reaches 80 % of the peak pulse amplitude.

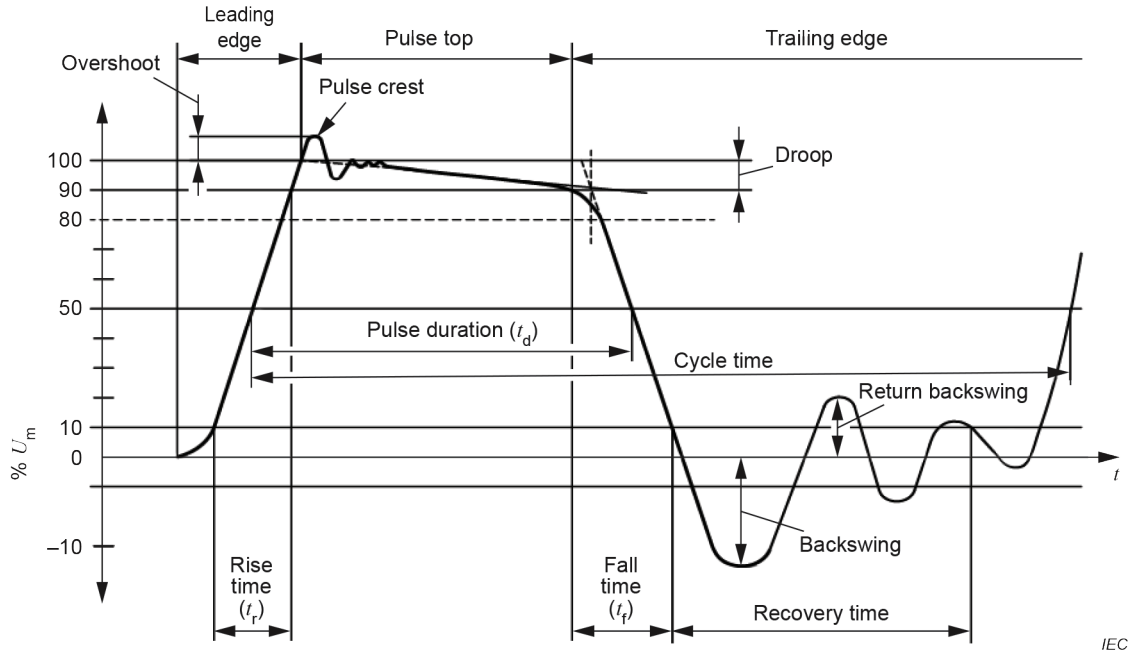
3.3.5
droop
difference between the peak pulse amplitude and the amplitude of the extrapolated smooth curve through the top of the pulse, excluding any initial "spike" of "overshoot", at its intersection with the straight line through the points defining the pulse fall time, expressed as a percentage of the peak pulse amplitude

3.3.6
overshoot
amount by which the pulse crest (the maximum amplitude of the pulse) exceeds the peak pulse amplitude, expressed as a percentage of the peak pulse amplitude

3.3.7
recovery time
time interval between the end of the pulse fall time and the time at which the pulse amplitude last reaches 10 % of the peak pulse amplitude

Note 1 to entry: Exceptionally, a value of less than 10 % may be used, in which case the interval is termed "the X % recovery time".

3.3.8
pulse repetition frequency
average number of pulses in unit time independent of the period over which it is measured



NOTE 1 Leading edge: the interval between the first instant at which the pulse amplitude begins and the first instant at which the pulse amplitude reaches the peak pulse amplitude.

NOTE 2 Pulse top: the interval between the first instant at which the pulse amplitude equals the peak pulse amplitude and the last instant at which the pulse amplitude equals 90 % of the peak pulse amplitude.

NOTE 3 Trailing edge: the interval between the last instant at which the pulse amplitude equals 90 % of the peak pulse amplitude and the first instant at which the pulse amplitude of the second cycle begins.

NOTE 4 For clarity in illustrating droop, the 80 % and 10 % points have been used in constructing the line which determines the border between the pulse top and the trailing edge.

Figure 1 – Pulse waveform parameters

3.4
quality factor
***Q* factor**
ratio of the energy stored to the energy dissipated during one cycle at a particular frequency in a specified winding

Note 1 to entry: The Q factor is expressed in terms of either the series or the parallel components of reactance and loss resistance.

3.5
harmonic distortion
square root of the sum of the square of all harmonic voltages up to and including the seventh harmonic (excluding the fundamental) expressed as a percentage or as a ratio in decibels of the fundamental

3.6
winding temperature
mean temperature rise of any winding of the component under full load at ambient temperature, when thermal stability has been achieved, added to the specified ambient temperature

3.7
voltage-time product rating
voltage pulse amplitude multiplied by the time interval between the first and last instants at which the pulse amplitude equals 50 % of the peak pulse amplitude

Note 1 to entry: The start of the pulse within which the non–linearity of the magnetizing current does not exceed a specified value.

3.8
background noise
acoustic noise
noise measured at a measuring point with the component under test not electrically excited

3.9 Current transformer parameters

3.9.1
current transformation ratio
k
ratio of the RMS value of the primary current to the RMS value of the secondary current under specified conditions

Note 1 to entry: The opposite of current transformation ratio is turn ratio.

3.9.2
phase angle
angular displacement of the fundamental frequency between the vector representing the primary and secondary currents of the transformer

Note 1 to entry: The phase angle is positive when the secondary current leads the primary current.

3.10
safety screen
conducting screen inserted between windings that, when it is connected to earth, effectively prevents fault currents flowing between those windings, in the event of an insulation failure

3.11
polarity
<single–phase windings> property of a single–phase winding such that a terminal on one winding has the same polarity as a terminal on another winding if, when the other ends of the windings are connected to form a common terminal and the transformer or inductor is energized with a sinusoidal voltage, the induced voltage appearing between each of the two terminals and the common terminal rise positively through zero at the same instant of time

3.12
uniformly-insulated winding
winding in which the insulation to earth is, at all points, designed to withstand an electric strength test of a value appropriate to the maximum voltage potential to be applied at the high voltage end

3.13
graded-insulated winding
winding in which insulation to earth is graded from the amount at the high-voltage end to a smaller amount at the low-voltage end

Note 1 to entry: Such a winding should withstand an electric strength test of a value appropriate to the insulation of the low-voltage end.

3.14
end turn drop
fault of wire or wires from an upper layer of a concentric winding configuration dropping past the interlayer insulation

Note 1 to entry: Can also define wires placed erroneously adjacent to wires from an earlier layer within the same winding where no insulation exists.