



BSI Standards Publication

Fixed capacitors for use in electronic equipment

Part 14: Sectional specification — Fixed capacitors for electromagnetic interference suppression and connection to the supply mains

National foreword

This British Standard is the UK implementation of EN IEC 60384-14:2023+A1:2025. It is identical to IEC 60384-14:2023, incorporating corrigendum October 2024 and amendment 1:2025. It supersedes BS EN IEC 60384-14:2023, which will be withdrawn on 31 August 2028.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by IEC corrigendum October 2024 is indicated in the text by AC1 AC1.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee W/-, Miscellaneous Standards.

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

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Published by BSI Standards Limited 2025

ISBN 978 0 539 32630 7

ICS 31.060.10

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2023.

Amendments/corrigenda issued since publication

Date	Text affected
30 November 2024	Implementation of IEC corrigendum October 2024
31 August 2025	Implementation of IEC amendment 1:2025 with CENELEC endorsement A1:2025

English Version

**Fixed capacitors for use in electronic equipment - Part 14:
Sectional specification - Fixed capacitors for electromagnetic
interference suppression and connection to the supply mains
(IEC 60384-14:2023)**

Condensateurs fixes utilisés dans les équipements
électroniques - Partie 14: Spécification intermédiaire -
Condensateurs fixes pour la suppression des interférences
électromagnétiques et la connexion au réseau
d'alimentation
(IEC 60384-14:2023)

Festkondensatoren zur Verwendung in Geräten der
Elektronik - Teil 14: Rahmenspezifikation -
Festkondensatoren zur Unterdrückung elektromagnetischer
Störungen, geeignet für Netzbetrieb
(IEC 60384-14:2023)

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 40/2985/FDIS, future edition 5 of IEC 60384-14, prepared by IEC/TC 40 "Capacitors and resistors for electronic equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60384-14:2023.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2023-12-01 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2026-03-01 document have to be withdrawn

This document supersedes EN 60384-14:2013 and all of its amendments and corrigenda (if any).

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The text of the International Standard IEC 60384-14:2023 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standard indicated:

IEC 60335-1 NOTE Approved as EN 60335-1
IEC 60384-14-1 NOTE Approved as EN 60384-14-1
IEC 60939-3:2015 NOTE Approved as EN 60939-3:2015 (not modified)
IEC 60940 NOTE Approved as EN 60940
IEC 61140 NOTE Approved as EN 61140
IEC 62368-1:2018 NOTE Approved as EN IEC 62368-1:2020 (not modified) +A11:2020

Endorsement notice

The text of the corrigendum IEC 60384-14:2023/COR1:2024 was approved by CENELEC as EN IEC 60384-14:2023/AC:2024-11 without any modification.

European foreword to amendment A1

The text of document 40/3220/FDIS, future edition 5 of IEC 60384-14/AMD1, prepared by TC 40 "Capacitors and resistors for electronic equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60384-14:2023/A1:2025.

The following dates are fixed:

- latest date by which the document has to be implemented at national (dop) 2026-08-31 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2028-08-31 document have to be withdrawn

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Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 60384-14:2023/AMD1:2025 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 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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60060-1	2010	High-voltage test techniques - Part 1: General definitions and test requirements	EN 60060-1	2010
IEC 60063	-	Preferred number series for resistors and capacitors	EN 60063	-
IEC 60068-1	2013	Environmental testing - Part 1: General and guidance	EN 60068-1	2014
IEC 60068-2-17	-	Basic environmental testing procedures - Part 2-17: Tests - Test Q: Sealing	EN 60068-2-17	-
IEC 60384-1	2021	Fixed capacitors for use in electronic equipment - Part 1: Generic specification	EN IEC 60384-1	2021
IEC 60664-1	-	Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests	EN IEC 60664-1	-
IEC 60695-11-10	-	Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods	EN 60695-11-10	-
IEC 61193-2	2007	Quality assessment systems - Part 2: Selection and use of sampling plans for inspection of electronic components and packages	EN 61193-2	2007
IEC 61210	-	Connecting devices - Flat quick-connect terminations for electrical copper conductors - Safety requirements	EN 61210	-
ISO 7000	-	Graphical symbols for use on equipment - Registered symbols	-	-
CISPR 17	-	Methods of measurement of the suppression characteristics of passive EMC filtering devices	EN 55017	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains

FOREWORD

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IEC 60384-14 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2013 and Amendment 1:2016. This edition constitutes a technical revision.

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

- a) in damp heat steady state test, all capacitor types are tested both with and without rated voltage; the number of test pieces has been increased;
- b) tangent of loss angle is added In Group 0 tests, in safety tests only;
- c) qualification approval based on safety and performance tests has been removed from the main text to a normative annex;
- d) the range of rated voltages is given instead of exact rated voltage values;

- e) normative annex for description of capacitor styles and of creepage/clearance distance measurement has been added;
- f) the importance of mechanical failures (cracks) in component encapsulation as a safety feature is highlighted in handling instructions and requirements after all relevant tests.

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

Draft	Report on voting
40/2985/FDIS	40/3022/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.

A list of all the parts of the IEC 60384 series, published under the general title *Fixed capacitors for use in electronic equipment*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, 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.

The committee has 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,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains

1 Scope

This part of IEC 60384 applies to capacitors and resistor-capacitor combinations intended to be connected to AC mains or other supply with a nominal voltage not exceeding 1 000 V AC (RMS), and with a nominal frequency not exceeding 100 Hz. This document includes also additional specific conditions and requirements for the connection to DC supplies with a rated voltage not exceeding 1 500 V DC.

The principal object of this part of IEC 60384 is to prescribe preferred ratings and characteristics and to select, from IEC 60384-1, the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification are of equal or higher performance level; lower performance levels are not permitted.

This document also provides a schedule of safety tests to be used by national testing stations in countries where approval by such stations is required.

The overvoltage categories in combination with the AC mains voltages for the capacitors classified in this document are to be taken from IEC 60664-1.

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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60063, *Preferred number series for resistors and capacitors*

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

IEC 60068-2-17, *Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing*

IEC 60384-1:2021, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements, and tests*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

IEC 61210, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

CISPR 17, *Methods of measurement of the suppression characteristics of passive EMC filtering devices*

ISO 7000, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

3 Terms and definitions and classification

3.1 Terms and definitions

For the purposes of this document, the terms, and definitions of IEC 60384-1, as well as the following, apply.

ISO and IEC maintain terminological 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>

NOTE Some definitions of IEC 60384-1 have been expanded, as is indicated by a note.

3.1.1

AC capacitor

capacitor designed essentially for application with a power-frequency alternating voltage

Note 1 to entry: AC capacitors may be used on DC supplies having the same voltage as the AC RMS rated voltage of the capacitor. For use of capacitors with rated DC voltage greater than the rated AC voltage, see Annex H.

3.1.2

electromagnetic interference suppression capacitor radio interference suppression capacitor

AC capacitor used for the reduction of electromagnetic interference caused by electrical or electronic apparatus, or other sources

3.1.3

capacitor of Class X RC unit of Class X

capacitor or RC unit of a type suitable for use in situations where failure of the capacitor or RC unit would not lead to danger of electrical shock but could result in a risk of fire

3.1.4

capacitor of Class Y RC unit of Class Y

capacitor or RC unit of a type suitable for use in situations where failure of the capacitor could lead to danger of electric shock

3.1.5

two-terminal capacitor

electromagnetic interference suppression capacitor having two terminals

Note 1 to entry: See Figure 1.

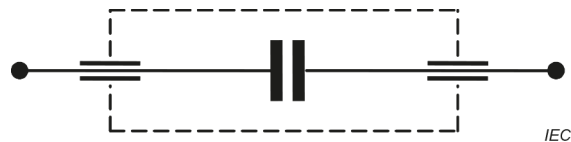


Figure 1 – Two-terminal EMI suppression capacitor

3.1.6

series RC unit

functional combination of a resistor in series with a capacitor of Class X or Y

Note 1 to entry: See Figure 2.

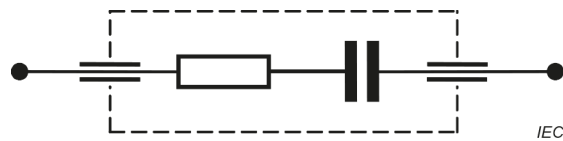


Figure 2 – RC unit

Note 2 to entry: In this document, where the word "capacitor" appears, the words "capacitor or RC unit" should be understood where the context permits.

3.1.7

lead-through capacitor

<coaxial> capacitor with a central current-carrying conductor surrounded by a capacitor element which is symmetrically bonded to the central conductor and to the outer casing to form a coaxial construction

Note 1 to entry: These lead-through capacitors are coaxially mounted (see Figure 3).

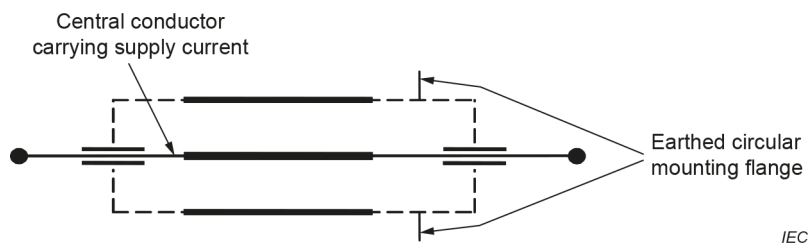


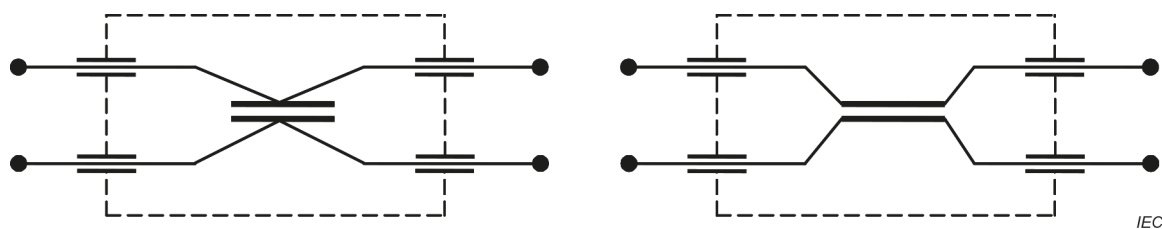
Figure 3 – Lead-through capacitor (coaxial)

3.1.8

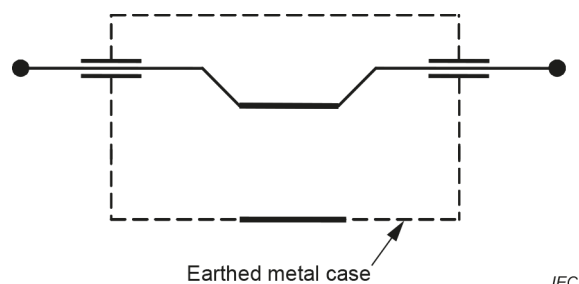
lead-through capacitor

<non-coaxial> capacitor in which the supply currents flow through or across the electrodes

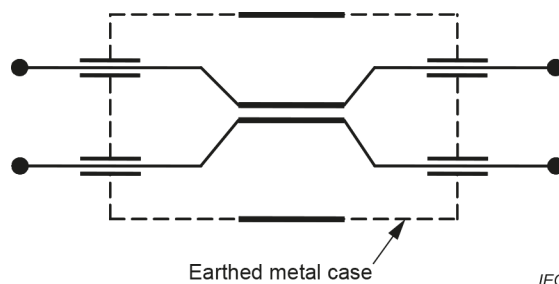
Note 1 to entry: See Figure 4 a), Figure 4 b), Figure 4 c) and Figure 4 d).



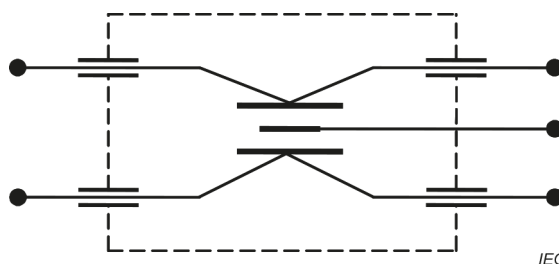
a) Lead-through capacitor for symmetrical use (non-coaxial)



b) Lead-through capacitor for asymmetrical use (non-coaxial)



c) Multiple unit lead-through capacitor (non-coaxial) for symmetrical and asymmetrical use



d) Multiple unit lead-through capacitor

Figure 4 – Lead-through capacitors**3.1.9****by-pass capacitor**

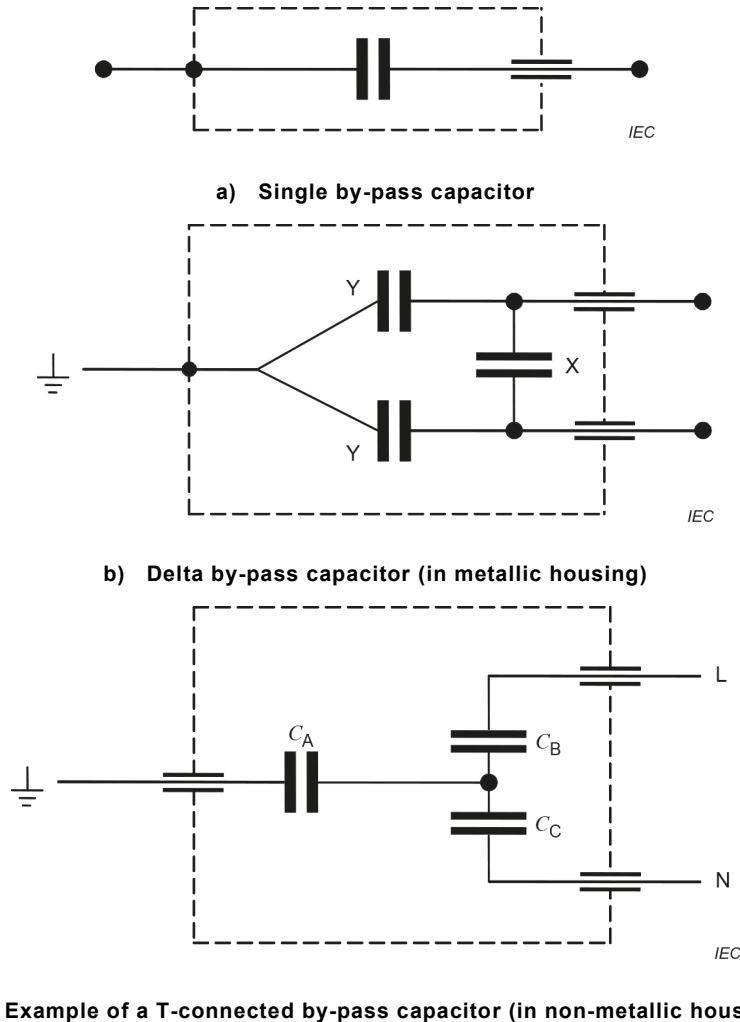
capacitor where radiofrequency interference currents are by-passed

Note 1 to entry: There are three common forms: single, delta and T-connected. The single capacitor consists of a capacitor in a metal case with one termination connected to the case as in Figure 5 a); the delta form consists of an X-capacitor and two $\overline{AC1}$ Y-capacitors $\overline{AC1}$ arranged in a delta network as in Figure 5 b); the T-connected form consists of three capacitors C_A , C_B and C_C connected in T as shown in Figure 5 c).

The delta and T-connected forms are electrically equivalent (star-delta transformation). In the T-connected form the X-capacitor is the result of the series connection of $C_B - C_C$ and the Y-capacitors are the results of the series connections of $C_A - C_B$ and $C_A - C_C$.

When T-connected capacitors are submitted to tests, and it is stated that voltages shall be applied across the X-capacitors, such voltages shall be applied between the line (L) and neutral (N) terminations. Similarly, when it is stated that voltages shall be applied across the Y-capacitors, such voltages shall be applied between the line and neutral terminations connected together and the earth termination.

Note 2 to entry: See Figure 5a), Figure 5b) and Figure 5c)



NOTE For capacitors with non-metallic housings, the earth connection is brought out as a separate termination as is shown in Figure 5c).

Figure 5 – By-pass capacitors

3.1.10

rated voltage

<for capacitor> RMS operating voltage of rated frequency or the DC operating voltage that can be applied continuously to the terminations of a capacitor at any temperature between the lower and the upper category temperatures

Note 1 to entry: This implies, for capacitors covered by this document, that the category voltage is the same as the rated voltage.

3.1.11

rated DC voltage

U_R DC

maximum DC operating voltage, which can be applied continuously to the terminations of a capacitor at any temperature between the lower and the upper category temperatures

Note 1 to entry: This term and designation (U_R DC) are used only for a capacitor specified with rated DC voltage exceeding its rated AC voltage (RMS).

3.1.12**rated power**

<of a series RC unit> maximum power that can be dissipated by the RC unit at the rated temperature during continuous operation

3.1.13**upper category temperature**

maximum surface temperature for which the capacitor has been designed to operate continuously

Note 1 to entry: For lead-through capacitors and series RC units, the external surface temperature can be affected by internal heating due to the lead-through current. The terminations of a capacitor are considered to be part of the external surface.

Note 2 to entry: This definition replaces that given in IEC 60384-1:2021, 3.41, because suppression capacitors in accordance with this document are intended to be connected to the mains network and can have internal heat generation as a result.

3.1.14**lower category temperature**

minimum surface temperature for which the capacitor has been designed to operate continuously

Note 1 to entry: This definition replaces that given in IEC 60384-1:2021, 3.10.

3.1.15**rated temperature**

<of a lead-through capacitor or series RC unit> maximum ambient temperature at which a lead-through capacitor can carry its rated lead-through current or a series RC unit can dissipate its rated power

Note 1 to entry: This definition replaces that given in IEC 60384-1:2021, 3.24.

3.1.16**insertion loss**

<for capacitors> ratio of the voltage before and after the insertion of the suppressor as measured at the terminations

Note 1 to entry: When measured in decibels, the insertion loss is 20 times the logarithm to base 10 of the ratio stated.

3.1.17**rated current of the conductor**

<of a lead-through capacitor> maximum permissible current flowing through the conductors of the capacitor at the rated temperature during continuous operation

3.1.18**main resonant frequency**

<of a two-terminal capacitor> lowest frequency at which the impedance of the capacitor is a minimum when applying a sinusoidal voltage

3.1.19**impulse voltage**

periodic transient voltage of a defined waveform as described in IEC 60060-1

3.1.20**passive flammability**

ability of a capacitor to burn with a flame as a consequence of the application of an external source of heat

3.1.21

active flammability

ability of a capacitor to burn with a flame as a consequence of electric loading

3.1.22

surface mount capacitor

capacitor whose small dimensions and nature of shape of terminations make it suitable for surface mounting in hybrid circuits and on printed boards

3.2 Classifications

3.2.1 Classification of X capacitors

Class X capacitors are divided into two subclasses (see Table 1) according to the peak voltage of the impulses superimposed on the mains voltage to which they may be subjected in service. Such impulses can arise from lightning strikes on outside lines, from switching in neighbouring equipment, or switching in the equipment in which the capacitor is used.

Table 1 – Classification of Class X capacitors

Subclass	Peak impulse voltage in service	Application	Peak impulse voltage U_P applied before endurance test	
			$C_N \leq 1,0 \mu\text{F}$	$C_N > 1,0 \mu\text{F}$
X1	>2,5 kV ≤4,0 kV	High pulse application	4 kV	$U_P = \frac{4}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV
X2	≤2,5 kV	General purpose	2,5 kV	$U_P = \frac{2,5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}}$ in kV
X1 capacitors may be substituted by Y2 or Y1 capacitors of the same or higher U_R . X2 capacitors can be substituted with X1 or Y2 or Y1 capacitors of the same or higher U_R .				
NOTE 1 The factor used for the reduction of U_P for capacitance values above $1,0 \mu\text{F}$ maintains $0,5 \times C_N U_P^2$ constant for these capacitance values; C_N is in F.				
NOTE 2 Overvoltage categories in association with rated impulse voltage and rated mains voltage are found in IEC 60664-1.				

3.2.2 Classification of Y capacitors

Class Y capacitors are further divided into three subclasses, Y1, Y2 and Y4, as shown in Table 2.

Table 2 – Classification of Class Y capacitors

Subclass	Type of insulation bridged	Range of rated voltages	Peak impulse voltage U_P applied before endurance test	
Y1	Double insulation or reinforced insulation	≤ 500 V	8,0 kV	
Y2	Basic insulation or supplementary insulation	≥ 150 V ≤ 500 V	$C_N \leq 1,0 \mu\text{F}$	$C_N > 1,0 \mu\text{F}$
			5 kV	$U_P = \frac{5}{\sqrt{\frac{C_N}{10^{-6} \text{ F}}}} \text{ kV}$
Y4	Basic insulation or supplementary insulation	< 150 V	2,5 kV	
Y2 capacitors may be substituted by Y1 capacitors of the same or higher U_R .				
NOTE 1 For definitions of basic, supplementary, double, and reinforced insulation, see IEC 61140.				
NOTE 2 The factor used for the reduction of U_P for capacitance values above $1,0 \mu\text{F}$ maintains $0,5 \times C_N U_P^2$ constant for these capacitance values; C_N is in F.				
NOTE 3 Overvoltage categories in association with rated impulse voltage and rated mains voltage are found in IEC 60664-1.				

One Y1-capacitor may bridge double insulation or reinforced insulation.

The enclosure of a Y1-capacitor shall not contain other components.

Assemblies, like Delta by-pass or T-connected by-pass capacitors, may be constructed from Y-capacitors and X-capacitors provided these capacitors fulfil the requirements for the relevant X and Y subclasses.

One Y-capacitor may bridge basic insulation. One Y-capacitor may bridge supplementary insulation. If combined basic and supplementary insulations are bridged by two or more Y2- or Y4-capacitors in series, they shall have the same class and sub-class, the same rated voltage, and the same nominal capacitance value.

4 Preferred ratings and characteristics

4.1 Preferred climatic categories

The values given in detail specifications should be selected from this paragraph.

The capacitors covered by this document are classified into climatic categories according to the general rules given in IEC 60068-1:2013, Annex A.

The lower and upper category temperatures and the duration of the damp heat, steady state test shall be chosen from the following:

- lower category temperature: -65 °C, -55 °C, -40 °C, -25 °C and -10 °C;
- upper category temperature: $+85$ °C, $+100$ °C, $+105$ °C, $+110$ °C, $+125$ °C and $+155$ °C;
- duration of the damp heat, steady state test: 21 days and 56 days.

The severities for the cold and dry heat tests are the lower and upper category temperatures, respectively.

For guidance on the application of the categories described above, see IEC 60940:2015.

4.2 Preferred values of ratings

4.2.1 Nominal capacitance (C_N)

The preferred values of nominal capacitance are:

1; 1,5; 2,2; 3,3; 4,7; 6,8 and their decimal multiples.

These values conform to the E6 series of preferred values given in IEC 60063.

4.2.2 Tolerance on nominal capacitance

The maximum tolerance on nominal capacitance is $\pm 20\%$.

4.2.3 Selection of rated voltages (U_R)

The range of rated AC voltages is from 125 V to 1 000 V.

The range of rated DC voltages is from 125 V to 1 500 V.

Electromagnetic interference suppression capacitors should be chosen to have a rated voltage equal to, or greater than, the nominal voltage of the supply system to which they are connected. The design of the capacitors shall take into account the possibility that the voltage of the system can rise by up to 10 % above the system's nominal voltage. In star connections, the maximum voltage over the capacitors shall be calculated in the worst possible case when the nominal capacitance tolerances of the capacitors used are considered.

4.2.4 Nominal resistance (R_N)

Preferred values of nominal resistance shall be taken from the E6 series of IEC 60063.

4.2.5 Rated temperature

The rated temperature for lead-through capacitors and series RC units shall be not less than $+40\text{ }^{\circ}\text{C}$.

4.2.6 Passive flammability

The preferred category of passive flammability permitted is Category B (see 5.18). If category C is used, it shall be agreed between the A1 component manufacturer A1 and the customer. See 5.18 also for alternative passive flammability testing.

Exemption: for components smaller than $1\,750\text{ mm}^3$, the passive flammability category C is permitted.

NOTE A1 Passive flammability categories better than C can require flame retardant additives, which can be considered to cause environmental impact. These categories are subject to discussion between manufacturers and customers to find a compromise between safety and environmental requirements. A1

4.3 Requirements for sleeving, tape, tubing and wire insulation

Sleeving, tape, tubing, and wire insulation used in the components falling under this document shall be rated for the voltage involved and the temperature attained under any condition of actual use. Sleeving, tubing and wire insulation shall have flame retardant rating Class VW1. Tape shall be flame retardant.

If insulated terminals are requested, the preferable colours should be transparent or white.

5 Test and measurement procedures, and performance requirements

5.1 General

This clause supplements the information given in IEC 60384-1:2021, from Clause 4 to Clause 10.

AC tests carried out at a frequency between 50 Hz and 100 Hz are considered valid for any nominal frequency between 50 Hz and 100 Hz. In case of doubt, 50 Hz shall be the reference frequency for measurements.

During handling, testing and inspection, unintended damages to the insulation on component body and leads shall be avoided. The handling instructions as provided by the manufacturer shall be followed.

5.2 Visual examination and check of dimensions

5.2.1 General

See IEC 60384-1:2021, 7.1 with the additional details in 5.2.2.

5.2.2 Creepage distances and clearances

Creepage distances and clearances on the outside of the capacitor between live parts of different polarity or between live parts and a metal case shall be not less than the appropriate values given in Table 3.

Table 3 is based on IEC 60664-1, but equipment safety standards IEC 60335-1 and IEC 62368-1 have also been considered. Further information can be obtained from IEC 60664-1.

Table 3 is generated using the following environmental conditions as main guideline:

Pollution degree 2, altitude $\leq 2\,000$ m and CTI (Comparative Tracking Index) of materials ≥ 100 .

The creepage distances smaller than those in Table 3 can be used, if rules given in IEC 60664-1 for CTI of materials in components allow that. Creepage distance shall always be larger or equal to the clearance distance indicated in this table. Equipment standards can require larger distances than ones given here.

Compliance shall be checked by measurement in accordance with the rules laid down in IEC 60664-1 for measurements on the outside of the capacitor. Additional requirements can be necessary, for example for capacitors intended to be used in other environments than pollution degree 2 (e.g. drip-proof and splash-proof capacitors) or for the use of capacitors in altitudes higher than 2 000 m. See IEC 60664-1 for guidance.

Table 3 – Creepage distances and clearances

Points of measurement	Rated voltage (RMS)									
	$U_R \leq 130 \text{ V}$		$130 \text{ V} < U_R \leq 250 \text{ V}$		$250 \text{ V} < U_R \leq 500 \text{ V}$		$500 \text{ V} < U_R \leq 760 \text{ V}$		$760 \text{ V} < U_R \leq 1\,000 \text{ V}$	
	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm	Creepage distance mm	Clearance mm
Between live parts of different polarity (functional insulation) ^a	2,0	1,5	3,0	2,5	4,0	3,0	6,3	5,5	8,0	5,5
Between live parts and other metal parts over basic insulation ^b	2,0	1,5	4,0	3,0	5,0	4,0	6,3	5,5	8,0	7,5
Between live parts and other metal parts over reinforced insulation ^c	8,0	8,0	8,0	8,0	10,0	8,0	12,6	11,0	16,0	11,0
NOTE The reinforced insulation figures for voltages >500 V are given for information only. In this standard Y1 capacitors are limited to 500 V.										
^a These limits shall be used for measurements between terminals of an X-capacitor.										
^b These limits shall be used for measurements between each terminal and the metal case of an X-capacitor and for measurements between terminals or between each terminal and the metal case of an Y2- or Y4-capacitor.										
^c These limits shall be used for measurements between terminals of an Y1- capacitor (up to 500 V).										

Annex J describes different styles of capacitors, and how the creepage and clearance distances are measured for them. Precautions required for handling the capacitors, for example when the leads are bent, are also described.

5.3 Electrical tests

5.3.1 Voltage proof

5.3.1.1 General

See IEC 60384-1:2021, 6.2 with the details from 5.3.1.2 to 5.3.1.5.

5.3.1.2 Test circuit for DC tests

Omit the capacitor C_1 if the capacitor under test, or a section of it, is a metallized film or metallized paper capacitor.

The product of R_1 and $(C_1 + C_X)$ shall be less than, or equal to, 1 s and greater than 0,01 s.

R_1 includes the internal resistance of the power supply.

R_2 shall limit the discharge current to a value equal to, or less than, 0,05 A.

5.3.1.3 Test circuit and method for AC tests

When a 50/60 Hz voltage is applied for qualification approval and periodic tests, the voltage shall be supplied from a transformer fed from a variable autotransformer, and the voltage shall be raised from near zero to the test voltage at a rate not exceeding 150 V/s. The test time shall be counted from the time the test voltage is reached. At the end of the test time, the test voltage shall be reduced to near zero and the capacitor discharged through a suitable resistor.

For lot-by-lot and 100 % testing, the voltage shall be applied directly at the full test voltage, but overvoltage peaks should be avoided.

5.3.1.4 Applied voltage

The voltages of Table 4 shall be applied between the respective measuring points shown in IEC 60384-1:2021, Table 3, for a period of 1 min for qualification approval and periodic testing and for a period of not less than 1 s for lot-by-lot quality conformance testing, with the following details:

- a) the test in accordance with 2c of IEC 60384-1:2021, Table 3, shall not be carried out;
- b) for encapsulated units with a non-metallic case, a voltage proof test such as Test C shall be carried out only for qualification approval tests and periodic tests;
- c) the method of applying the test voltage for Test C shall be given in the detail specification. For qualification testing, the foil method given in IEC 60384-1:2021, 6.2.3.4. shall be used, unless otherwise specified in the detail specification;

NOTE This test is applicable only to insulated capacitors in non-metallic case or in insulated metallic case. See IEC 60384-1:2021, [\[AC1\]](#) 6.2.3.4 [\[AC1\]](#).

- d) for testing during a period between 1 s and 2 s, the voltage of Table 4 shall be increased as indicated in Figure 9;
- e) when a capacitor is qualified for DC applications in accordance with Annex H, the test voltage as calculated in accordance with Table H.1 for the voltage proof test A shall be applied for lot-by-lot (100 %) tests and qualification tests, if its value is higher than the value as determined in accordance with Table 4.

Attention is drawn to the fact that repetition of the voltage proof test by the user can damage the capacitor. If repetition of the voltage proof test is made by the user, the applied voltage should not be greater than 66 % of the test voltage specified in Table 4.

Table 4 – Voltage proof

Class	Range of rated voltages	Test A ^d	Test B or Test C
X1 X2	≤ 1 000 V	4,3 U_R (DC) ^c	2 U_R + 1 500 V (AC) with a minimum of 2 000 V (AC) ^a
Y1	≤ 500 V	4 000 V (AC)	4 000 V (AC)
Y2	≥ 150 V ≤ 500 V	U_R + 1 200 V (AC) with a minimum of 1 500 V (AC) ^b	2 U_R + 1 500 V (AC) with a minimum of 2 000 V (AC) ^b
Y4	< 150 V	900 V (AC) ^b	900 V (AC) ^b
^a For Delta and T-connected capacitor units in accordance with Figure 5b and Figure 5c, the test voltage for terminals to case shall be the appropriate test voltage for the Y-capacitors. ^b For lot-by-lot tests of Class Y2- and Y4-capacitors, the AC test voltage may be replaced by a DC voltage of 1,5 times the prescribed AC voltage. ^c The U_R in this DC test is the rated AC voltage value. ^d For capacitors qualified in accordance with Annex H, see 5.3.1.4 e).			

5.3.1.5 Requirements

There shall be no permanent breakdown or flashover during the test period.

NOTE The occurrence of self-healing breakdowns during the application of the test voltages on metalized film capacitors is allowed.

In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured).

5.3.2 Capacitance

5.3.2.1 General

See IEC 60384-1:2021, 6.3 with the details in 5.3.2.2 and 5.3.2.3.

5.3.2.2 Measuring conditions

The capacitance measured shall be the series equivalent capacitance.

The measuring frequency shall be 1 kHz, but the measuring frequency shall be 1 MHz for ceramic capacitors with $C_N < 100$ pF (class 2) and $C_N \leq 1\,000$ pF (class 1).

The measuring temperature shall be in accordance with IEC 60384-1:2021, 5.2.1.

The measuring voltage shall not exceed the rated voltage. For ceramic capacitors, the measuring voltage shall be $1,0\text{ V} \pm 0,2\text{ V}$.

As the nominal capacitance of ceramic capacitors, as measured above, is the small-signal capacitance, the manufacturer shall supply the following information for ceramic capacitors:

- a) the maximum expected 50/60 Hz current through the capacitor at rated voltage taking into account capacitance tolerance and temperature characteristic (or coefficient) of capacitance;
- b) the minimum expected capacitance taking into account the capacitance tolerance and temperature characteristic (or coefficient) of capacitance.

5.3.2.3 Requirements

The capacitance value shall be within the specified tolerance.

5.3.3 Tangent of loss angle

A1 This test is not applicable to RC units. **A1**

See IEC 60384-1:2021, 6.4 with the following details:

The measuring frequency shall be 10 kHz for $C_N \leq 1\text{ }\mu\text{F}$ and 1 kHz for $C_N > 1\text{ }\mu\text{F}$. For ceramic capacitors, the measuring frequency shall be 1 kHz, but for capacitors with $C_N < 100$ pF (class 2) and $C_N \leq 1\,000$ pF (class 1), the measuring frequency shall be 1 MHz.

5.3.4 Resistance (Equivalent Series Resistance (ESR)) (for RC units only)

The ESR shall be measured in a series equivalent circuit at the following frequency:

100 kHz for $R_N \times C_N < 50\text{ }\mu\text{s}$;

1 kHz for $R_N \times C_N \geq 50\text{ }\mu\text{s}$

where

R_N is the nominal resistance in ohms, and

C_N is the nominal capacitance in farads.

5.3.5 Insulation resistance

5.3.5.1 General

See IEC 60384-1:2021, 6.1 with the details in 5.3.5.2 and 5.3.5.3.

In lot-by-lot quality conformance testing, the measuring may be interrupted at the time that the value of the insulation resistance exceeds the limits of Table 5 or Table 6, which can be shorter than 60 s.

5.3.5.2 Temperature correction

When stated in the detail specification, the temperature at which the measurement is made shall be noted. If this temperature differs from 20 °C, a correction shall be made to the measured value by multiplying it by the appropriate correction factor stated in the sectional specification for the relevant dielectric or that given in the detail specification.

5.3.5.3 Requirements

The insulation resistance shall exceed the values of Table 5 or Table 6, as appropriate.

Table 5 – Insulation resistance – Safety tests only

Test A		Test B or Test C
When $C_N > 0,33 \mu\text{F}$ RC_N in s	When $C_N \leq 0,33 \mu\text{F}$ R in $\text{M}\Omega$	R in $\text{M}\Omega$
2 000 ^{a, b}	6 000	6 000
<ul style="list-style-type: none"> C_N is the nominal capacitance and R the measured insulation resistance. Limits more severe and related to the dielectric may be given in the detail specification for performance tests only, where possible by reference to the appropriate IEC publication. For capacitors having one termination connected to the case, the insulation resistance limits for Test A should be used. <p>For capacitors with a discharge resistor, measurement should be carried out with the discharge resistor disconnected. If the resistor cannot be disconnected without the capacitor being destroyed, the test should be omitted in Group A; and, for qualification approval and periodic tests, the test should be carried out on half of the specimens in the sample, which should consist of capacitors specially made without discharge resistors.</p>		
^a Also for mixed plastic/paper dielectrics. ^b For capacitors with ester-impregnated paper dielectric, the values of the table shall be replaced respectively by the values 500, 1 500 and 2 000.		

Table 6 – Insulation resistance – Safety and performance tests

Dielectric	Test A		Test B or Test C
	When $C_N > 0,33 \mu\text{F}$ RC_N in s	When $C_N \leq 0,33 \mu\text{F}$ R in M Ω	R in M Ω
Paper ^{a, b}	2 000	6 000	6 000
Plastic	5 000	15 000	30 000
Ceramic	–	6 000	3 000
<ul style="list-style-type: none"> C_N is the nominal capacitance and R the measured insulation resistance. Limits more severe and related to the dielectric may be given in the detail specification for performance tests only, where possible by reference to the appropriate IEC publication. For capacitors having one termination connected to the case, the insulation resistance limits for Test A should be used. For capacitors with a discharge resistor, measurement should be carried out with the discharge resistor disconnected. If the resistor cannot be disconnected without the capacitor being destroyed, the test should be omitted in Group A; and, for qualification approval and periodic tests, the test should be carried out on half of the specimens in the sample, which should consist of capacitors specially made without discharge resistors. 			
<p>^a Also for mixed plastic/paper dielectrics.</p> <p>^b For capacitors with ester-impregnated paper dielectric, the values of the table shall be replaced respectively by the values 500, 1 500 and 2 000.</p>			

5.4 Robustness of terminations

See IEC 60384-1:2021, 7.3 with the following details.

The test method and degree of severity to be used shall be specified in the detail specification.

The test for snap-in contacts shall be specified in the detail specification; the test methods and severity shall comply with the applicable clauses of IEC 61210.

The test shall be carefully conducted in accordance with the instructions so that the coating of the capacitor is not broken due to mishandling of the part. In visual inspection after the test, the coating of the capacitor shall not have any cracks exposing internal live parts or in defined insulated areas (the creepage distance and clearance specified in Table 3 shall be ensured).

5.5 Resistance to soldering heat

5.5.1 General

This test is not applicable to capacitors with insulated leads longer than 10 mm, or to capacitors with terminations not intended to be soldered (such as screw and fast-on terminations).

When preconditioning is performed, initial measurements shall be carried out after preconditioning.

When, for fixed capacitors of ceramic dielectric Class 2, a precise measurement of capacitance drift is required, preconditioning should be performed as advised by the manufacturer (see Annex G).

See IEC 60384-1:2021, 9.1 with the details in 5.5.2 and 5.5.3.

5.5.2 Test conditions

There shall be no pre-drying.