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(IEC 60384-1 : 2008)

(JEITA/JSA)

**Fixed capacitors for use in
electronic equipment—
Part 1: Generic specification**

ICS 31.060

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Electronics and Information Technology Industries Association (JEITA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14. Consequently **JIS C 5101-1:1998** has been replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS C 5101 series consists of the following 45 parts under the general title “*Fixed capacitors for use in electronic equipment*”:

JIS C 5101-1 *Part 1: Generic specification*

JIS C 5101-2 *Part 2: Sectional specification: Fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors*

JIS C 5101-2-1 *Part 2-1: Blank detail specification: Fixed metallized polyethylene-terephthalate film dielectric d.c. capacitors—Assessment levels E and EZ*

JIS C 5101-3 *Part 3: Sectional specification—Surface mount fixed tantalum electrolytic capacitors with manganese dioxide solid electrolyte*

JIS C 5101-3-1 *Part 3-1: Blank detail specification—Surface mount fixed tantalum electrolytic capacitors with manganese dioxide solid electrolyte—Assessment level EZ*

JIS C 5101-4 *Part 4: Sectional specification—Aluminium electrolytic capacitors with solid (MnO₂) and non-solid electrolyte*

JIS C 5101-4-1 *Part 4-1: Blank detail specification—Fixed aluminium electrolytic capacitors with non-solid electrolyte—Assessment level EZ*

JIS C 5101-4-2 *Part 4-2: Blank detail specification—Fixed aluminium electrolytic capacitors with solid (MnO₂) electrolyte—Assessment level EZ*

JIS C 5101-8 *Part 8: Sectional specification: Fixed capacitors of ceramic dielectric, Class 1*

JIS C 5101-8-1 *Part 8-1: Blank detail specification: Fixed capacitors of ceramic dielectric, Class 1 Assessment level EZ*

JIS C 5101-9 *Part 9: Sectional specification: Fixed capacitors of ceramic dielectric, Class 2*

- JIS C 5101-9-1 *Part 9-1: Blank detail specification: Fixed capacitors of ceramic dielectric, Class 2 Assessment level EZ*
- JIS C 5101-11 *Part 11: Sectional specification: Fixed polyethylene-terephthalate film dielectric metal foil d.c. capacitors*
- JIS C 5101-11-1 *Part 11: Blank detail specification: Fixed polyethylene-terephthalate film dielectric metal foil d.c. capacitors Assessment level E*
- JIS C 5101-13 *Part 13: Sectional specification—Fixed polypropylene film dielectric metal foil d.c. capacitors*
- JIS C 5101-13-1 *Part 13-1: Blank detail specification—Fixed polypropylene film dielectric metal foil d.c. capacitors—Assessment levels E and EZ*
- JIS C 5101-14 *Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*
- JIS C 5101-14-1 *Part 14-1: Blank detail specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains—Assessment level D*
- JIS C 5101-14-2 *Part 14-2: Blank detail specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains—Safety tests only*
- JIS C 5101-14-3 *Part 14-3: Blank detail specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains—Assessment level DZ*
- JIS C 5101-15 *Part 15: Sectional specification: Fixed tantalum capacitors with non-solid or solid electrolyte*
- JIS C 5101-15-1 *Part 15: Blank detail specification: Fixed tantalum capacitors with non-solid electrolyte and foil electrode Assessment level E*
- JIS C 5101-15-2 *Part 15: Blank detail specification: Fixed tantalum capacitors with non-solid electrolyte and porous anode Assessment level E*
- JIS C 5101-15-3 *Part 15: Blank detail specification: Fixed tantalum capacitors with solid electrolyte and porous anode Assessment level E*
- JIS C 5101-16 *Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors*
- JIS C 5101-16-1 *Part 16-1: Blank detail specification: Fixed metallized polypropylene film dielectric d.c. capacitors—Assessment levels E and EZ*
- JIS C 5101-17 *Sectional specification: Fixed metallized polypropylene film dielectric a.c. and pulse capacitors*
- JIS C 5101-17-1 *Part 17-1: Blank detail specification: Fixed metallized polypropylene film dielectric a.c. and pulse capacitors—Assessment levels E and EZ*
- JIS C 5101-18 *Part 18: Sectional specification—Fixed aluminium electrolytic surface mount capacitors with solid (MnO₂) and non-solid electrolyte*
- JIS C 5101-18-1 *Part 18-1: Blank detail specification—Fixed aluminium electrolytic surface mount capacitors with solid (MnO₂) electrolyte—Assessment level EZ*

- JIS C 5101-18-2 *Part 18-2: Blank detail specification—Fixed aluminium electrolytic surface mount capacitors with non-solid electrolyte—Assessment level EZ*
- JIS C 5101-20 *Part 20: Sectional specification—Fixed metallized polyphenylene sulfide film dielectric surface mount d.c. capacitors*
- JIS C 5101-20-1 *Part 20-1: Blank detail specification—Fixed metallized polyphenylene sulfide film dielectric surface mount d.c. capacitors—Assessment level EZ*
- JIS C 5101-21 *Part 21: Sectional specification: Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1*
- JIS C 5101-21-1 *Part 21-1: Blank detail specification: Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1—Assessment level EZ*
- JIS C 5101-22 *Part 22: Sectional specification: Fixed surface mount multilayer capacitors of ceramic dielectric, Class 2*
- JIS C 5101-22-1 *Part 22-1: Blank detail specification: Fixed surface mount multilayer capacitors of ceramic dielectric, Class 2—Assessment level EZ*
- JIS C 5101-23 *Part 23: Sectional specification—Fixed surface mount metallized polyethylene naphthalate film dielectric DC capacitors*
- JIS C 5101-23-1 *Part 23-1: Blank detail specification—Fixed surface mount metallized polyethylene naphthalate film dielectric DC capacitors—Assessment level EZ*
- JIS C 5101-24 *Part 24: Sectional specification—Surface mount fixed tantalum electrolytic capacitors with conductive polymer solid electrolyte*
- JIS C 5101-24-1 *Part 24-1: Blank detail specification—Surface mount fixed tantalum electrolytic capacitors with conductive polymer solid electrolyte—Assessment level EZ*
- JIS C 5101-25 *Part 25: Sectional specification—Surface mount fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte*
- JIS C 5101-25-1 *Part 25-1: Blank detail specification—Surface mount fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte—Assessment level EZ*
- JIS C 5101-26 *Part 26: Sectional specification—Fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte (to be published)*
- JIS C 5101-26-1 *Part 26-1: Blank detail specification—Fixed aluminium electrolytic capacitors with conductive polymer solid electrolyte—Assessment level EZ (to be published)*

Fixed capacitors for use in electronic equipment—Part 1: Generic specification

Introduction

This Japanese Industrial Standard has been prepared based on the fourth edition of **IEC 60384-1** published in 2008 without modifying the technical contents.

The portions with continuous sidelines or dotted underlines and Annex JA to Annex JC are the matters not given in corresponding International Standard.

1 General

1.1 Scope

This Standard is a generic specification and is applicable to fixed capacitors for use in electronic equipment.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications of electronic components for quality assessment or any other purposes.

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows:

IEC 60384-1:2008 *Fixed capacitors for use in electronic equipment—Part 1: Generic specification* (IDT)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified) and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and any revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

JIS C 0025:1988 *Basic environmental testing procedures Part 2: Tests Test N: Change of temperature*

NOTE : Corresponding International Standards: IEC 60068-2-14:1984 *Environmental testing—Part 2: Tests—Test N: Change of temperature* and Amendment 1:1986 and IEC 60068-2-33:1971 *Environmental testing—Part 2: Tests. Guidance on change of temperature tests* and Amendment 1:1978 (overall evaluation: MOD)

JIS C 0617 series *Graphical symbols for diagrams*

NOTE : Corresponding International Standard: IEC 60617 (all parts) *Graphical symbols for diagrams* (IDT)

JIS C 5062 *Marking codes for resistors and capacitors*

NOTE : Corresponding International Standard: IEC 60062:2004 *Marking codes for resistors and capacitors* (MOD)

JIS C 5063 *Preferred number series for resistors and capacitors*

NOTE : Corresponding International Standard: IEC 60063:1963 *Preferred number series for resistors and capacitors* and Amendment 1:1967 and Amendment 2:1977 (IDT)

JIS C 6484:2005 *Base materials for printed circuits—Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test)*

NOTE : Corresponding International Standards: IEC 61249-2-7:2002 *Materials for printed boards and other interconnecting structures—Part 2-7: Reinforced base materials clad and unclad—Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test)*, copper-clad and IEC 61249-2-8:2003 *Materials for printed boards and other interconnecting structures—Part 2-8: Reinforced base materials clad and unclad—Modified brominated epoxide woven fibreglass reinforced laminated sheets of defined flammability (vertical burning test)*, copper-clad (overall evaluation: MOD)

JIS C 60068-1:1993 *Environmental testing Part 1: General and guidance*

NOTE : Corresponding International Standard: IEC 60068-1:1988 *Environmental testing. Part 1: General and guidance* and Amendment 1:1992 (IDT)

JIS C 60068-2-1 *Environmental testing—Part 2-1: Tests—Test A: Cold*

NOTE : Corresponding International Standard: IEC 60068-2-1:2007 *Environmental testing—Part 2-1: Tests—Test A: Cold* (IDT)

JIS C 60068-2-2 *Environmental testing—Part 2-2: Tests—Test B: Dry heat*

NOTE : Corresponding International Standard: IEC 60068-2-2:2007 *Environmental testing—Part 2-2: Tests—Test B: Dry heat* (IDT)

JIS C 60068-2-6 *Environmental testing—Part 2-6: Tests—Test Fc: Vibration (sinusoidal)*

NOTE : Corresponding International Standard: IEC 60068-2-6:2007 *Environmental testing—Part 2-6: Tests—Test Fc: Vibration (sinusoidal)* (IDT)

JIS C 60068-2-13:1989 *Basic environmental testing procedures Part 2: Tests, Test M: Low air pressure*

NOTE : Corresponding International Standard: IEC 60068-2-13:1983 *Environmental testing—Part 2: Tests. Test M: Low air pressure* (IDT)

JIS C 60068-2-17:2001 *Basic environmental testing procedures—Part 2: Tests—Test Q: Sealing*

NOTE : Corresponding International Standard: IEC 60068-2-17:1994 *Basic environmental testing procedures—Part 2: Tests—Test Q: Sealing* (IDT)

JIS C 60068-2-20 *Environmental testing—Part 2-20: Tests—Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

NOTE : Corresponding International Standard: IEC 60068-2-20:2008 *Environmental testing—Part 2-20: Tests—Test T: Test methods for solderability and resistance to soldering heat of devices with leads* (IDT)

JIS C 60068-2-21 *Environmental testing—Part 2-21: Tests—Test U: Robustness of terminations and integral mounting devices*

NOTE : Corresponding International Standard: IEC 60068-2-21:2006 *Environmental testing—Part 2-21: Tests—Test U: Robustness of terminations and integral mounting devices* (MOD)

JIS C 60068-2-27 *Basic environmental testing procedures Part 2: Tests, Test Ea and guidance: Shock*

NOTE : Corresponding International Standard: IEC 60068-2-27:2008 *Environmental testing—Part 2-27: Tests—Test Ea and guidance: Shock* (IDT)

JIS C 60068-2-29:1995 *Basic environmental testing procedures Part 2: Tests Test Eb and guidance: Bump*

NOTE : Corresponding International Standard: IEC 60068-2-29:1987 *Environmental testing—Part 2: Tests—Test Eb and guidance: Bump* (IDT)

JIS C 60068-2-30 *Basic environmental testing procedures Part 2: Tests Test Db: Damp heat, cyclic (12 + 12-Hour cycle)*

NOTE : Corresponding International Standard: IEC 60068-2-30:2005 *Environmental testing—Part 2-30: Tests—Test Db: Damp heat, cyclic (12 h + 12 h cycle)* (IDT)

JIS C 60068-2-45:1995 *Environmental testing procedures of electronic and electrical resistance to solvents (immersion in cleaning solvents)*

NOTE : Corresponding International Standard: IEC 60068-2-45:1980 *Environmental testing. Part 2: Tests. Test XA and guidance: Immersion in cleaning solvents* and Amendment 1:1993 (IDT)

JIS C 60068-2-54:2009 *Environmental testing—Part 2-54: Tests—Test Ta: Solderability testing of electronic components by the wetting balance method*

NOTE : Corresponding International Standard: IEC 60068-2-54:2006 *Environmental testing—Part 2-54: Tests—Test Ta: Solderability testing of electronic components by the wetting balance method* (MOD)

JIS C 60068-2-58:2006 *Environmental testing—Part 2: Tests—Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

NOTE : Corresponding International Standard: IEC 60068-2-58:2004 *Environmental testing—Part 2-58: Tests—Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)* (MOD)

JIS C 60068-2-69 *Environmental testing—Part 2-69: Tests—Test Te: Solderability testing of electronic components for surface mounting devices (SMD) by the wetting balance method*

NOTE : Corresponding International Standard: IEC 60068-2-69:2007 *Environmental testing—Part 2-69: Tests—Test Te: Solderability testing of electronic components for surface mounting devices (SMD) by the wetting balance method* (IDT)

JIS C 60068-2-78:2004 *Environmental testing—Part 2-78: Tests—Test Cab: Damp heat, steady state*

NOTE : Corresponding International Standard: IEC 60068-2-78:2001 *Environmental testing—Part 2-78: Tests—Test Cab: Damp heat, steady state* (IDT)

JIS C 60695-11-5:2007 *Fire hazard testing—Part 11-5: Test flames—Needle-flame test method—Apparatus, confirmatory test arrangement and guidance*

NOTE : Corresponding International Standard: IEC 60695-11-5:2004 *Fire hazard testing—Part 11-5: Test flames—Needle-flame test method—Apparatus, confirmatory test arrangement and guidance* (IDT)

JIS Z 8115 *Glossary of terms used in dependability*

NOTE : Corresponding International Standard: IEC 60050 (191):1990 *International Electrotechnical Vocabulary. Chapter 191: Dependability and quality of service* (MOD)

JIS Z 8203 *SI units and recommendations for the use of their multiples and of certain other units*

NOTE : Corresponding International Standard: ISO 1000:1992 *SI units and recommendations for the use of their multiples and of certain other unit and Amendment 1:1998* (IDT)

JIS Z 8601 *Preferred numbers*

NOTE : Corresponding International Standard: ISO 3 *Preferred numbers—Series of preferred numbers* (IDT)

IEC 60027 (all parts) *Letter symbols to be used in electrical technology*

IEC 60294 *Measurement of the dimensions of a cylindrical component having two axial terminations*

IEC 60410:1973 *Sampling plans and procedures for inspection by attributes*

NOTE : Corresponding Japanese Industrial Standard: JIS Z 9015-1 *Sampling procedures for inspection by attributes—Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection* (MOD)

IEC 60717 *Method for determination of the space required by capacitors and resistors with unidirectional terminations*

IEC 61193-2 *Quality assessment systems—Part 2: Selection and use of sampling plans for inspection of electronic components and packaging*

IEC QC 001002-3 *IEC Quality Assessment System for Electronic Components (IECQ)—Rules of Procedure—Part 3: Approval procedures*

2 Technical data

2.1 Units and symbols

Units, graphical symbols and letter symbols should, whenever possible, be taken from the following publications:

- **JIS C 0617** (series);
- **JIS Z 8203**;
- **IEC 60027** (series);
- **IEC 60050** (series) or **JIS Z 8115**.

When further items are required, they should be derived in accordance with the principles of the publications listed above.

2.2 Terms and definitions

For the purposes of this Standard, the following terms and definitions apply, in alphabetical order.

2.2.1 a.c. capacitor

capacitor designed essentially for application with alternating voltages

2.2.2 bipolar capacitor (for electrolytic capacitors)

electrolytic capacitor designed to withstand an alternating voltage and/or reversal of the applied direct voltage

2.2.3 category of passive flammability

category of passive flammability is given by the maximum burning time after a specified time of flame application

2.2.4 category temperature range

range of ambient temperatures for which the capacitor has been designed to operate continuously; this is given by the lower and upper category temperature

2.2.5 category voltage (U_C)

maximum voltage which may be applied continuously to a capacitor at its upper category temperature

2.2.6 d.c. capacitor

capacitor designed essentially for application with direct voltage

NOTE : A d.c. capacitor may not be suitable for use on a.c. supplies.

2.2.7 family (of electronic components)

group of components which predominantly displays a particular physical attribute and/or fulfils a defined function

2.2.8 grade

term to indicate an additional general characteristic concerning the intended application of the component

2.2.9 insulated capacitor

capacitor in which all terminations of a section may be raised to a potential different (but not less than the rated voltage) from that of any conducting surface with which the case is liable to come into contact in normal use

2.2.10 lower category temperature

minimum ambient temperature for which a capacitor has been designed to operate continuously

2.2.11 maximum storage temperature

maximum ambient temperature which the capacitor withstands in the non-operating condition without damage

2.2.12 maximum temperature of a capacitor

temperature at the hottest point of its external surface

NOTE : The terminations are considered to be part of the external surface.

2.2.13 minimum storage temperature

minimum ambient temperature which the capacitor withstands in the non-operating condition without damage

2.2.14 minimum temperature of a capacitor

temperature at the coldest point of the external surface

NOTE : The terminations are considered to be part of the external surface.

2.2.15 nominal capacitance (C_N)

designated capacitance value usually indicated on the capacitor

2.2.16 passive flammability

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

2.2.17 polar capacitor (for electrolytic capacitors)

capacitor intended for use with a unidirectional voltage connected according to the polarity indication

2.2.18 pulse capacitor

capacitor for use with pulses of current or voltage

NOTE 1 The definitions of **IEC 60469-1** and **IEC 60469-2** apply.

NOTE 2 The terms defined in **IEC 60469-1** are described as follows for reference.

— **(2.2.1) wave**

a modification of the physical state of a medium which propagates in that medium as a function of time as a result of one or more disturbances

— **(2.2.2) pulse**

a wave which departs from a first nominal state, attains a second nominal state and ultimately returns to the first nominal state

In IEC 60469-1 “pulse” is included in “wave”.

2.2.19 pulse equivalent circuit of a capacitor

equivalent circuit consisting of an ideal capacitor in series with its residual inductance and the equivalent series resistance (ESR)

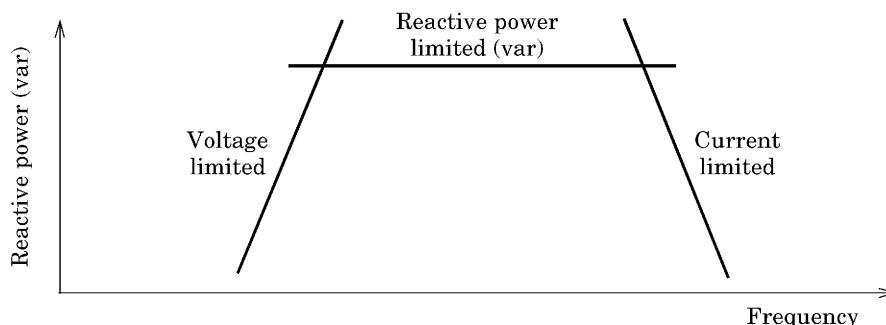
NOTE : For pulse operation the equivalent series resistance will be similar to, but not identical with, the ESR measured with a sinusoidal voltage. The pulse ESR should take into account the series of harmonics in the pulse and the variation of the losses with frequency.

2.2.20 rated a.c. load

maximum sinusoidal a.c. load which may be applied continuously to the terminations of a capacitor at any temperature between the lower category temperature and the rated temperature (see 2.2.24); it may be expressed:

- a) at low frequencies as a rated a.c. voltage;
- b) at high frequencies as a rated a.c. current;
- c) at intermediate frequencies as a rated reactive power (var).

This is shown in figure 1.



NOTE 1 For a particular type of capacitor, it may be necessary to specify one or more of the above characteristics.

NOTE 2 Capacitors within the scope of this specification are normally less than 500 var at 50 Hz to 60 Hz. Low frequencies may be 50 Hz to 60 Hz, 100 Hz to 120 Hz, or 400 Hz. Voltages may be up to 600 V r.m.s. at 50 Hz to 60 Hz. However, capacitors for filters, transmitter or converter circuits may be required to operate under power over a wide range of frequencies and up to 10 kvar at the higher frequencies with voltages up to 1 000 V r.m.s.

Figure 1 Reactive power against frequency

2.2.21 rated pulse load

maximum pulse load which may be applied at a certain pulse repetition frequency to the terminations of a capacitor at any temperature between the lower category temperature and the rated temperature (see 2.2.24); it may be expressed as **a)** and **b)** and any of the remaining items:

- a) peak current per μF or du/dt ($\text{V}/\mu\text{s}$);
- b) relative duration of charge and discharge periods;
- c) current;
- d) peak voltage;
- e) peak reverse voltage;
- f) pulse repetition frequency (see NOTE 1);
- g) maximum active power.

NOTE 1 In the case of intermittent pulses, the duty cycle should be specified. In the case of random pulses, the total number expected over a given time period should be stated.

NOTE 2 The r.m.s. pulse current should be calculated in accordance with **IEC 60469-1, 2.5.2.4**. In the case of intermittent or random pulses, the time interval should be chosen to correspond with the maximum temperature rise.

NOTE 3 The matters defined in **IEC 60469-1, 2.5.2.4** are described as follows for reference.

— **(2.5.2.4) root-mean-square: r.m.s.**

pertaining to the square root of the average of the squares of the values of the magnitude

If the magnitude takes on n discrete values, m , its root-mean-square value is;

$$m_{\text{rms}} = \left[\left(\frac{1}{n} \right) \sum_{j=1}^n m_j^2 \right]^{\frac{1}{2}}$$

wherein the time intervals between adjacent values of m_j are equal.

If the magnitude is a continuous function of time, $m(t)$, its r.m.s. value is;

$$m_{\text{rms}} = \left[\left(\frac{1}{t_2 - t_1} \right) \int m^2(t) dt \right]^{\frac{1}{2}}$$

The summation or the integral extends over the interval of time for which the r.m.s. magnitude is desired or, if the function is periodic, over any integral number of periodic repetitions of the function.

2.2.22 rated ripple current

r.m.s. value of the maximum allowable alternating current of a specified frequency, at which the capacitor may be operated continuously at a specified temperature

NOTE : As the ripple current will generate a ripple voltage across the capacitor, the sum of the direct voltage and the peak value of the alternating voltage

applied to the capacitor should not exceed the rated voltage or temperature derated voltage as applicable.

2.2.23 rated ripple voltage

r.m.s. value of the maximum allowable alternating voltage at a specified frequency superimposed on the d.c. voltage at which the capacitor may be operated continuously at a specified temperature

NOTE : The sum of the direct voltage and the peak value of the alternating voltage applied to the capacitor should not exceed the rated voltage or temperature derated voltage, as applicable.

2.2.24 rated temperature

maximum ambient temperature at which the rated voltage may be continuously applied

2.2.25 rated voltage (U_R)

2.2.25.1 rated d.c. voltage

maximum d.c. voltage which may be applied continuously to a capacitor at the rated temperature

NOTE : Maximum d.c. voltage is the sum of the d.c. voltage and peak a.c. voltage or peak pulse voltage applied to the capacitor.

2.2.25.2 rated a.c. voltage

maximum r.m.s. alternating voltage which may be applied continuously to a capacitor at the rated temperature and at a given frequency

2.2.25.3 rated pulse voltage

peak value of the pulse voltage within a given pulse wave form which may be applied continuously to a capacitor at the rated temperature

2.2.26 reverse voltage (for polar capacitors only)

voltage applied to the capacitor terminations in the reverse polarity direction

2.2.27 self-healing

process by which the electrical properties of the capacitor, after a local breakdown of the dielectric, are rapidly and essentially restored to the values before the breakdown

2.2.28 style

subdivision of a type, generally based on dimensional factors, which may include several variants, generally of a mechanical order

2.2.29 subfamily (of electronic components)

group of components within a family manufactured by similar technological methods

2.2.30 surface mount capacitor

fixed capacitor whose small dimensions and nature or shape of terminations make it suitable for use in hybrid circuits and on printed boards

2.2.31 surge voltage ratio

quotient of the maximum instantaneous voltage which may be applied to the terminations of the capacitor for a specified time at any temperature within the category temperature range and the rated voltage or the temperature derated voltage, as appropriate

NOTE : The number of times per hour that this voltage may be applied should be specified.

2.2.32 tangent of loss angle ($\tan \delta$)

power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage at a specified frequency

2.2.33 temperature characteristics of capacitance

maximum variation of capacitance produced over a given temperature range within the category temperature range, normally expressed as a percentage of the capacitance related to a reference temperature of 20 °C

NOTE : The term characterizing this property applies mainly to capacitors of which the variations of capacitance as a function of temperature, linear or non-linear, cannot be expressed with precision and certainty.

2.2.34 temperature coefficient of capacitance (α)

rate of change of capacitance with temperature measured over a specified range of temperature, normally expressed in parts per million per kelvin ($10^{-6}/\text{K}$)

NOTE : The term characterizing this property applies to capacitors of which the variations of capacitance as a function of temperature are linear or approximately linear and can be expressed with a certain precision.

2.2.35 temperature cyclic drift of capacitance

maximum irreversible variation of capacitance observed at room temperature during or after the completion of a number of specified temperature cycles; it is expressed normally as a percentage of the capacitance related to a reference temperature, usually 20 °C

NOTE 1 The term characterizing this property applies to capacitors of which the variations of capacitance as a function of temperature are linear or approximately linear and can be expressed with a certain precision.

NOTE 2 The conditions of measurement, during or after temperature cycling, a description of the temperature cycle and the number of cycles, should be stated.

2.2.36 temperature derated voltage

maximum voltage that may be applied continuously to a capacitor, when it is at any temperature between the rated temperature and the upper category (see figure 2)

NOTE : Information on the voltage/temperature dependence at temperatures between the rated temperature and the upper category temperature should, if applicable, be given in the relevant specification.

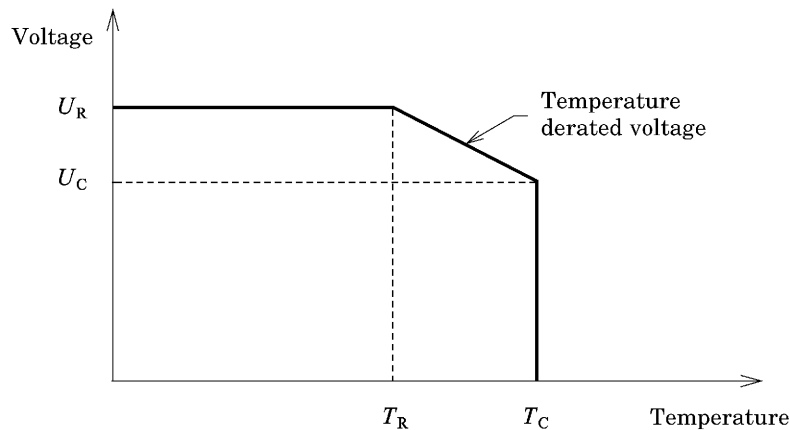


Figure 2 Relation between category temperature range and applied voltage

2.2.37 temperature rise

temperature rise of the capacitor relative to the ambient temperature resulting from the losses in the capacitor due to operation under a.c., pulse or charge/discharge conditions

2.2.38 time constant

product of the insulation resistance and the capacitance, normally expressed in seconds

2.2.39 type

group of components having similar design features and manufacturing techniques, enabling them to be considered together, either for qualification approval or for quality conformance inspection; they are generally covered by a single detail specification

NOTE : Components described in several detail specifications, may, in some cases, be considered as belonging to the same type.

2.2.40 uninsulated capacitor

capacitor in which one or more of the terminations of a section cannot be raised to a potential different (but not less than the rated voltage) from that of any conducting surface with which the case is liable to come into contact in normal use

2.2.41 upper category temperature

maximum ambient temperature for which a capacitor has been designed to operate continuously

2.2.42 variation of capacitance with temperature

variation of capacitance with temperature expressed either as the temperature characteristics of capacitance or as the temperature coefficient of capacitance

2.2.43 visible damage

visible damage which reduces the usability of the capacitor for its intended purpose

2.3 Preferred values

2.3.1 General

Each sectional specification shall prescribe the preferred values appropriate to the subfamily; for nominal capacitance see also **2.3.2**.

NOTE : It is preferable to specify preferred values stated below corresponding to subfamilies of capacitors in each sectional specification in addition to nominal capacitance and rated voltage

— **Category temperature range** (see table JA.3)

— **Principal dimensions of capacitor** It is preferred to employ R standard series specified in **JIS Z 8601** or a regular series for dimensions such as principal dimensions of capacitors.

2.3.2 Preferred values of nominal capacitance

The preferred values of nominal capacitance shall be taken from the series specified in **JIS C 5063**.

NOTE : The specified E standard series consists of E3, E6, E12, E24, E48, E96 and E192, and E3 to E24 series which are mainly used are shown in table 0A.

Table 0A E standard series

Series	E3	E6	E12	E24	E3	E6	E12	E24	E3	E6	E12	E24
Numerical value	1.0	1.0	1.0	1.0	2.2	2.2	2.2	2.2	4.7	4.7	4.7	4.7
				1.1				2.4				5.1
			1.2	1.2			2.7	2.7			5.6	5.6
				1.3				3.0				6.2
		1.5	1.5	1.5		3.3	3.3	3.3		6.8	6.8	6.8
				1.6				3.6				7.5
			1.8	1.8			3.9	3.9			8.2	8.2
				2.0				4.3				9.1
Corresponding tolerance	Over $\pm 20\%$	$\pm 20\%$	$\pm 10\%$	$\pm 5\%$	Over $\pm 20\%$	$\pm 20\%$	$\pm 10\%$	$\pm 5\%$	Over $\pm 20\%$	$\pm 20\%$	$\pm 10\%$	$\pm 5\%$

2.3.3 Preferred values of rated voltage

The preferred values of the rated voltage are the values of the R10 series of **JIS Z 8601**: 1.0, 1.25, 1.6, 2.0, 2.5, 3.15, 4.0, 5.0, 6.3, 8.0 and their decimal multiples ($\times 10^n$, n : integer).

NOTE 1 It is preferable to select from R5 standard series as far as possible.

R5 standard series: 1.0, 1.6, 2.5, 4.0, 6.3

NOTE 2 If especially required, the rated voltage of R20 standard series, i.e. 35 V, 350 V and 450 V may be employed.

2.4 Marking

2.4.1 General

The sectional specification shall indicate the identification criteria and other information to be shown on the capacitor and/or packing.

The order of priority for marking small capacitors shall be specified (see Annex JA).

2.4.2 Coding

When coding is used for capacitance value, tolerance or date of manufacture, the method shall be selected from those given in **JIS C 5062** (see Annex JA).

3 Quality assessment procedures

When this Standard and related standards are used for the purpose of a full quality assessment system such as IEC Quality Assessment System for Electronic Components (IECQ), the relevant clauses of Annex Q apply.

NOTE : Clause **3** has been moved to Annex Q. To maintain reference to previous editions of this Standard, the clause numbers of clause **3** have been converted into the clause numbers of Annex Q as shown by the following examples:

Subclause **3.1** → Clause **Q.1**

Subclause **3.1.2** → Subclause **Q.1.2**

4 Tests and measurement procedures

Classification by category and test items	Subclause
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General information on test and measurement procedures

General	4.1
Standard atmospheric conditions	4.2
Drying	4.3
Storage	4.25
Mounting (for Surface mount capacitors only)	4.33

Electrical tests and measurements

Insulation resistance	4.5
Voltage proof	4.6
Capacitance	4.7
Tangent of loss angle and equivalent series resistance (ESR)	4.8
Leakage current	4.9
Impedance	4.10
Self-resonant frequency and inductance	4.11
Variation of capacitance with temperature	4.24
Surge	4.26
High surge current test	4.39
Charge and discharge tests and inrush current test	4.27
Dielectric absorption	4.36
Voltage transient overload (for aluminium electrolytic capacitors with non-solid electrolyte)	4.40

Mechanical tests and measurements

Visual examination and check of dimensions	4.4
Outer foil termination	4.12
Robustness of terminations	4.13
Vibration	4.17
Bump	4.18
Shock	4.19
Container sealing	4.20
Shear test	4.34
Substrate bending test	4.35

Classification by category and test items	Subclause
Environmental and climatic tests	
Rapid change of temperature	4.16
Climatic sequence	4.21
Damp heat (Steady state)	4.22
Endurance	4.23
Characteristics at high and low temperature	4.29
Thermal stability test	4.30
Accelerated damp heat, steady state (for multilayer ceramic capacitors only)	4.37
Tests related to component assembly	
Resistance to soldering heat	4.14
Solderability	4.15
Component solvent resistance	4.31
Solvent resistance of marking	4.32
Test related to safety	
Pressure relief (for aluminium electrolytic capacitors)	4.28
Passive flammability	4.38

4.1 General

The sectional and/or blank detail specification shall indicate the tests to be made, which measurements are to be made before and after each test or subgroup of tests, and the sequence in which they shall be made. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national specifications within any quality assessment system include methods other than those specified in the above specifications, they shall be fully described.

Limits given in all specifications are absolute limits. The principle to take measurement uncertainty into account shall be applied (see **IEC QC 001002-3**, Annex C to clause 2).

4.2 Standard atmospheric conditions

4.2.1 Standard atmospheric conditions for testing

Unless otherwise specified in the sectional, blank detail or detail specification, all tests and measurements shall be made under standard atmospheric conditions for testing as given in **JIS C 60068-1**, 5.3:

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

Before the measurements are made, the capacitor shall be stored at the measuring temperature for a time sufficient to allow the entire capacitor to reach this temperature. The period as prescribed for recovery at the end of a test is normally sufficient for this purpose.

When measurements are made at a temperature other than the specified temperature, the results shall, where necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a dispute, the measurements shall be repeated using one of the referee temperatures (as given in 4.2.3) and such other conditions as are prescribed in this specification.

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the succeeding test.

During measurements the capacitor shall not be exposed to draughts, direct sunlight or other influences likely to cause error.

4.2.2 Recovery conditions

Unless otherwise specified recovery shall take place under the standard atmospheric conditions for testing (4.2.1).

If recovery under closely controlled conditions is necessary, the controlled recovery conditions of **JIS C 60068-1, 5.4.1** shall be used.

Unless otherwise specified in the relevant specification, a duration of 1 h to 2 h shall be used.

The definition of recovery is as given in **JIS C 60068-1, 4.1.3**, being further restricted for capacitors as follows:

When recovery period is specified as, for example, 1 h to 2 h, this means that measurement (or other subsequent action) on a batch of capacitors may start after 1 h and shall be completed before 2 h from the beginning of the recovery period.

The preferred method of specifying a recovery period is in the form “x h to y h”.

4.2.3 Referee conditions

For referee purposes, one of the standard atmospheric conditions for referee tests taken from **JIS C 60068-1, 5.2**, as given in table 1 below, shall be selected.

Table 1 Referee conditions

Temperature °C	Relative humidity %	Air pressure kPa
20 ± 1	63 to 67	86 to 106
23 ± 1	48 to 52	86 to 106
25 ± 1	48 to 52	86 to 106
27 ± 1	63 to 67	86 to 106

4.2.4 Reference conditions

For reference purposes, the standard atmospheric conditions for reference given in **JIS C 60068-1, 5.1** apply:

- temperature: 20 °C;
- air pressure: 101.3 kPa.

4.3 Drying

Unless otherwise specified in the relevant specification, the capacitor shall be conditioned for $96\text{ h} \pm 4\text{ h}$ by heating in a circulating air oven at a temperature of $55\text{ °C} \pm 2\text{ °C}$ and a relative humidity not exceeding 20 %.

The capacitor shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

4.4 Visual examination and check of dimensions

4.4.1 Visual examination

The condition, workmanship and finish shall be satisfactory, as checked by visual examination (see **2.2.43**).

Marking shall be legible, as checked by visual examination and shall conform with the requirements of the detail specification.

4.4.2 Dimensions (gauging)

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values prescribed in the detail specification.

When applicable, measurements shall be made in accordance with **IEC 60294** or **IEC 60717**.

NOTE : Contents of provisions of **IEC 60294** and **IEC 60717** are translated and added as Annex JB and Annex JC, respectively.

4.4.3 Dimensions (detail)

All dimensions prescribed in the detail specification shall be checked and shall comply with the values prescribed.

4.5 Insulation resistance

4.5.1 Preconditioning

Before this measurement is made, the capacitors shall be fully discharged.

4.5.2 Measuring conditions

Unless otherwise specified in the relevant specification, the insulation resistance shall be measured at the voltage specified in table 2.

The insulation resistance shall be measured after the voltage has been applied for $60\text{ s} \pm 5\text{ s}$, unless otherwise prescribed in the detail specification.

Table 2 Measurement of insulation resistance

Voltage rating of capacitor or category voltage V	Measuring voltage V
U_R or $U_C < 10$	U_R or $U_C \pm 10\%$
$10 \leq U_R$ or $U_C < 100$	$10 \pm 1^a)$
$100 \leq U_R$ or $U_C < 500$	100 ± 15
$500 \leq U_R$ or U_C	500 ± 50
Note ^{a)} When it can be demonstrated that the voltage has no influence on the measuring result, or that a known relationship exists, measurements can be performed at voltages up to the rated or category voltage. In case of dispute, 10 V shall be used, unless otherwise specified by the sectional specification.	

U_R is the rated voltage for use in defining the measuring voltage to be used under standard atmospheric conditions for testing.

U_C is the category voltage for use in defining the measuring voltage to be used at the upper category temperature.

4.5.3 Test points

The insulation resistance shall be measured between the measuring points defined in table 3, specified in the relevant specification.

Test A, between terminations, applies to all capacitors, whether insulated or not.

Test B, internal insulation, applies to insulated capacitors in uninsulated metal cases and to insulated and uninsulated multiple section capacitors.

Test C, external insulation, applies to insulated capacitors in non-metallic cases or in insulated metal cases. For this test, the measuring voltage shall be applied using one of the four following methods as specified in the relevant specification:

4.5.4 Test methods

4.5.4.1 Foil method

A metal foil shall be closely wrapped around the body of the capacitor.

For capacitors with axial terminations this foil shall extend beyond each end by not less than 5 mm, provided that a minimum distance of 1 mm can be maintained between the foil and the terminations. If this minimum distance cannot be maintained, the extension of the foil shall be reduced by as much as is necessary to establish the distance of 1 mm.

For capacitors with unidirectional terminations, a minimum distance of 1 mm shall be maintained between the edge of the foil and each termination.

4.5.4.2 Method for capacitors with mounting devices

The capacitor shall be mounted in its normal manner on a metal plate, which extends at least 12.7 mm in all directions beyond the mounting face of the capacitor.

4.5.4.3 V-block method

The capacitor shall be clamped in the trough of a 90° metallic V-block of such size that the capacitor body does not extend beyond the extremities of the block.

The clamping force shall be such as to guarantee adequate contact between the capacitor and the block.

The capacitor shall be positioned in accordance with the following:

- a) **for cylindrical capacitors:** the capacitor shall be positioned in the block so that the termination furthest from the axis of the capacitor is nearest to one of the faces of the block;
- b) **for rectangular capacitors:** the capacitor shall be positioned in the block so that the termination nearest the edge of the capacitor is nearest to one of the faces of the block.

For cylindrical and rectangular capacitors having axial terminations any out-of-centre positioning of the terminations at their emergence from the capacitor body shall be ignored.

NOTE : Small metallic ball method is not specified in the corresponding International Standard **IEC 60384-1**, but may be used by agreement between the parties concerned.

— **Small metallic ball method** A capacitor of unidirectional terminations connected together is put into a vessel filled with small metallic balls of about 1 mm diameter with the root of termination being apart 2 mm from the small metallic balls. The test voltage shall be applied across the terminations connected together of capacitor and the small metallic balls.

4.5.5 Temperature compensation

When prescribed by 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 the value by the appropriate correction factor prescribed in the sectional specification.

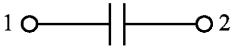
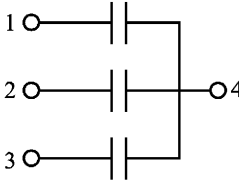
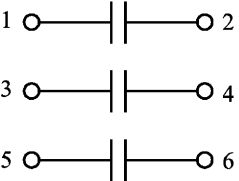
4.5.6 Conditions to be prescribed the relevant specification

The relevant specification shall prescribe:

- a) the measuring points and the measuring voltage corresponding to each of these test points;
- b) the method of applying the voltage (one of the methods described in **4.5.4**);
- c) time of electrification if other than 1 min;
- d) any special precautions to be taken during measurements;
- e) any correction factors required for measurement over the range of temperatures covered by the standard atmospheric conditions for testing;
- f) the temperature of measurement if other than the standard atmospheric conditions for testing;

g) the minimum value of insulation resistance for the various measuring points (see table 3).

Table 3 Measuring points

Test	Applicable to:	1: Single-section capacitors	2: Multiple-section capacitors having common termination for all sections	3: Multiple-section capacitors having no common termination
				
A. Between terminations (see NOTE 1)	All capacitors	1a: Between terminations (Between 1-2)	2a: Between each of the terminations and the common termination (Between 1-4, 2-4, 3-4)	3a: Between terminations of each section (Between 1-2, 3-4, 5-6)
B. Internal insulation	Insulated single- and multiple-section capacitors in uninsulated metal cases (1b, 2b, 3b)	1b: Between terminations connected together and the case (Between 1 and 2 connected together and the case)	2b: Between all terminations connected together and the case (Between 1, 2, 3 and 4 connected together and the case)	3b: Between all terminations connected together and the case (Between 1, 2, 3, 4, 5 and 6 connected together and the case)
	Insulated and uninsulated multiple-section capacitors (2c and 3c)	—	2c: Between the non-common termination of each section and all the other terminations connected together (For element with termination 2, between 2 and 1, 3 and 4 connected together and the case)	3c: Between the terminations of separate sections, the two terminations of each section being connected together (For element with terminations 1-2, between 1-2 connected together and 3, 4, 5 and 6 connected together)
C. External insulation	Insulated capacitors in non-metallic cases or in insulated metal cases	1c: Between the two terminations connected together and, as appropriate, the metal foil, the metal plate, the metal V-block or small metallic balls (Between 1 and 2 connected together)	2d: (Between 1, 2, 3 and 4 connected together) Between all terminations connected together and, as appropriate: the metal foil, the metal plate, the metal V-block or small metallic balls	3d: (Between 1, 2, 3, 4, 5 and 6 connected together)
NOTE 1 Where a capacitor has more than two terminations, the measuring points are the two terminations which are insulated from one another by the capacitor's element dielectric. For example, for a coaxial lead-through capacitor, the measuring points should be one of the terminations connected to the central conductor and the coaxial metal case or mounting face. NOTE 2 The circuit diagrams and portions underlined with dots are not stated in the corresponding International Standard and are to supplement the measuring points.				

4.6 Voltage proof

The test prescribed below is a d.c. test. When the relevant specification prescribes an a.c. test, the test circuit shall be prescribed by that specification.

4.6.1 Test circuit (for the test between terminations)

The test circuit elements shall be selected in such a way as to ensure that the conditions relating to the charging and discharging currents and the time constant for charging, prescribed in the relevant specification, are maintained.

Figure 3 specifies the characteristics of a suitable test circuit.

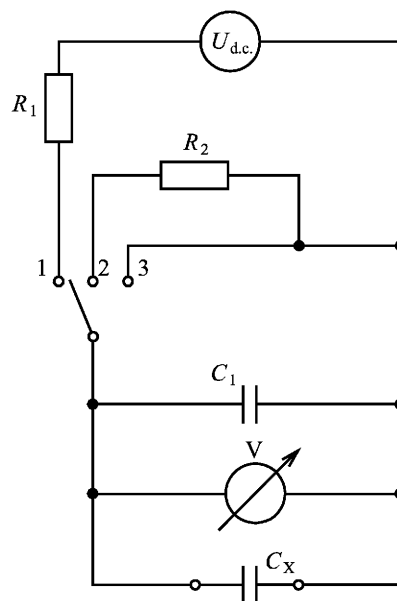
The resistance of the voltmeter shall be not less than 10 000 Ω/V .

The resistor R_1 includes the internal resistance of the voltage source.

The resistors R_1 and R_2 shall have a value sufficient to limit the charging and discharging current to the value prescribed in the relevant specification.

The capacitance of capacitor C_1 shall be not less than 10 times the capacitance of the capacitor under test.

If applicable, the time constant $R_1 \times (C_X + C_1)$ shall be less than, or equal to, the value prescribed in the relevant specification.



NOTE : The capacitor C_1 may be omitted for the testing of certain types of capacitors. This should be stated in the sectional specification.

Figure 3 Voltage-proof test circuit

4.6.2 Test

Depending on the case, the test comprises one or more parts in accordance with table 3 and the requirements of the relevant specification.

Repeated application of the voltage proof test may cause permanent damage to the capacitor and should be avoided as far as possible.

4.6.2.1 Test A—Between terminations

4.6.2.1.1 Test points

The test voltage is applied to 1a, 2a, 3a of table 3 in accordance with the requirements of the relevant specification.

4.6.2.1.2 Procedure

With the switch in position 2, connect the two terminals in figure 3 to a variable d.c. supply of sufficient power adjusted to the required test voltage.

Connect the capacitor to be tested (C_X) to the test circuit as indicated in figure 3.

Move the switch to position 1 so as to charge capacitors C_1 and C_X via R_1 .

The switch remains in this position for the time specified after the test voltage has been reached.

Discharge the capacitors C_1 and C_X through R_2 by moving the switch to position 2. As soon as the voltmeter reading has fallen to zero, short-circuit the capacitors by moving the switch to position 3 and disconnect the capacitor C_X .

4.6.2.2 Test B—Internal insulation

4.6.2.2.1 Test points

The test voltage is applied to 1b, 2b, 2c, 3b, 3c of table 3 in accordance with the requirements of the relevant specification.

4.6.2.2.2 Procedure

The specified test voltage is applied instantaneously via the internal resistance of the power supply for the time specified in the relevant specification. For point 2c use the test circuit and the procedure indicated for the test between terminations (4.6.1 and 4.6.2.1).

NOTE : “Instantaneously via the internal resistance” means that the resistance of R_1 is the internal resistance of the d.c. power supply only. Therefore no resistor is inserted in the position of R_1 in the diagram. The voltage of power supply is previously adjusted to the specified test voltage and the voltage is applied by-charge-over of the switch because instantaneous application is specified.

4.6.2.3 Test C—External insulation (applicable only to insulated capacitors in non-metallic case or in insulated metal case)

4.6.2.3.1 Test points

The test voltage is applied to 1c, 2d or 3d, using one of the four following methods for the application of the voltage in accordance with the requirements of the relevant specification.

4.6.2.3.2 Foil method

A metal foil shall be closely wrapped around the body of the capacitor.

For capacitors with axial terminations this foil shall extend beyond each end by not less than 5 mm, provided that a minimum distance of 1 mm/kV can be maintained between the foil and the terminations. If this minimum cannot be maintained, the

extension of the foil shall be reduced by as much as is necessary to establish the distance of 1 mm/kV of test voltage.

For capacitors with unidirectional terminations, a minimum distance of 1 mm/kV shall be maintained between the edge of the foil and each termination.

In no case shall the distance between the foil and the terminations be less than 1 mm.

4.6.2.3.3 Method for capacitors with mounting devices

The capacitor shall be mounted in its normal manner on a metal plate which extends by not less than 12.7 mm in all directions beyond the mounting face of the capacitor.

4.6.2.3.4 V-block method

The capacitor shall be clamped in the trough of a 90° metallic V-block of such a size that the capacitor body does not extend beyond the extremities of the block.

The clamping force shall be such as to guarantee adequate contact between the capacitor and the block.

The capacitor shall be positioned as follows:

- a) **for cylindrical capacitors:** the capacitor shall be positioned in the block so that the termination furthest from the axis of the capacitor is nearest to one of the faces of the block;
- b) **for rectangular capacitors:** the capacitor shall be positioned in the block so that the termination nearest the edge of the capacitor is nearest to one of the faces of the block.

For cylindrical and rectangular capacitors having axial terminations any out-of-centre positioning of the termination at its emergence from the capacitor body shall be ignored.

NOTE : Small metallic ball method is not specified in the corresponding International Standard **IEC 60384-1**, but may be used by agreement between the parties concerned.

— **Small metallic ball method** A capacitor of unidirectional terminations connected together is put into a vessel filled with small metallic balls of about 1 mm diameter with the root of termination being apart 2 mm from the small metallic balls. The test voltage shall be applied across the terminations connected together of capacitor and the small metallic balls.

4.6.2.3.5 Procedure

The specified test voltage is applied instantaneously through the internal resistance of the power source for the time specified in the relevant specification.

NOTE : “Instantaneously through the internal resistance” means that the resistance of R_1 is the internal resistance of the d.c. power supply only. Therefore no resistor is inserted in the position of R_1 in the diagram. The voltage of power supply is previously adjusted to the specified test voltage and the voltage is applied by-charge-over of the switch because instantaneous application is specified.

4.6.3 Requirements

For each of the specified test points there shall be no sign of breakdown or flash-over during the test period.

4.6.4 Conditions to be prescribed in the relevant specification

The relevant specification shall prescribe:

- a) the test points (see table 3) and the test voltage corresponding to each of these points;
- b) for the external insulation test (test C), the method of applying the test voltage (one of the methods described in 4.6.2.3);
- c) the time for which the voltage is applied;
- d) the maximum charging and discharging currents;
- e) when applicable, the maximum value of the time constant for charging [$R_1 \times (C_1 + C_X)$].

4.7 Capacitance

4.7.1 Measuring frequency and measuring voltage

The capacitance shall be measured at one of the following frequencies, unless otherwise prescribed by the relevant specification:

— electrolytic capacitors:	100 Hz to 120 Hz
— other capacitors:	$C_N \leq 1 \text{ nF}$: 100 kHz, 1 MHz or 10 MHz (1 MHz shall be reference)
	$1 \text{ nF} < C_N \leq 10 \text{ }\mu\text{F}$: 1 kHz or 10 kHz (1 kHz shall be reference)
	$10 \text{ }\mu\text{F} < C_N$: 50 Hz (60 Hz) or 100 Hz (120 Hz)

The tolerance on all frequencies for measuring purposes shall not exceed $\pm 20 \%$.

The measuring voltage shall not exceed 3 % of U_R or 5 V, whichever is the smaller, unless otherwise prescribed in the relevant specification.

4.7.2 Measuring equipment

The accuracy of the measuring equipment shall be such that the error does not exceed:

- a) **for absolute capacitance measurements:** 10 % of the capacitance tolerance or 2 % absolute, whichever is the smaller;
- b) **for measurement of variation of capacitance:** 10 % of the specified maximum change of capacitance.

In neither case **a)** nor case **b)** need the accuracy be better than the minimum absolute measurement error (for example 0.5 pF) prescribed in the relevant specification.

4.7.3 Conditions to be prescribed in the relevant specification

The relevant specification shall prescribe:

- a) the temperature for measurement if other than the standard atmospheric conditions for testing;
- b) the frequencies for measurement and the capacitance range over which they apply, if different from those specified in **4.7.1**;
- c) the absolute measurement error, when applicable (for example 0.5 pF);
- d) measuring voltage if different from those specified in **4.7.1**;
- e) the applied polarizing voltage, when applicable.

4.8 Tangent of loss angle and equivalent series resistance (ESR)

4.8.1 Tangent of loss angle

4.8.1.1 Measuring frequency

The tangent of loss angle shall be measured under the same conditions as those given for the measurement of capacitance at one or more frequencies taken from the list in **4.7.1**, as prescribed in the relevant specification.

4.8.1.2 Measuring accuracy

Unless otherwise specified in the sectional specification, the measuring method shall be such that the error does not exceed 10 % of the specified value or 0.000 3, whichever is the greater.

4.8.2 Equivalent series resistance (ESR)

4.8.2.1 Measuring frequency

The ESR shall be measured at one of the following frequencies, unless otherwise prescribed by the relevant specification:

50 Hz, 60 Hz, 100 Hz, 120 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz and 10 MHz.

4.8.2.2 Measuring accuracy

The accuracy of the measuring equipment shall be such that the error does not exceed 10 % of the requirement, unless otherwise specified in the relevant specification.

4.8.2.3 Conditions to be prescribed in the relevant specification

The relevant specification shall prescribe

- a) the frequency of measurement;
- b) the absolute error measurement;
- c) the measuring voltage, if different from that specified in **4.7.1**;
- d) the applied polarizing voltage, where applicable;
- e) the temperature at which measurements shall be made, if other than the standard atmospheric conditions for testing.