

Specification for

Fixed radio frequency inductors of assessed quality: generic data and methods of test

Spécification des inductances fixes haute
fréquence de qualité assurée:
Données génériques et méthodes d'essai

Spezifikation für feste Hochfrequenzinduktoren
bestätigter Güte:
Generische Daten und Prüfverfahren

Committees responsible for this British Standard

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Electronic Components Industry Federation
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National Supervising Inspectorate
Power Supply Manufacturers' Association (PSMA)
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Foreword

This revision of BS 9750 has been prepared under the direction of the Electronic Components Standards Policy Committee; it supersedes BS 9750 : 1978, which is withdrawn. This edition clarifies previous text where necessary and covers the needs of inductors intended for surface mounting, i.e. surface mounting devices (SMDs).

This standard is a generic specification for use in the BS 9000 scheme for electronic components of assessed quality. It includes the general information, terminology and methods of test required for the assessment of the performance of radio frequency (r.f.) inductors.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Section 1. General

1.1 Scope

This British Standard specifies the essential test procedures and other general requirements and information relating to fixed inductors of assessed quality, primarily for use at radio frequencies.

NOTE. Additional tests appear in BS 9720 and these may be used where relevant.

1.2 Related documents

BS 1852	(IEC 62) Specification for marking codes for resistors and capacitors
BS 2011	(IEC 68) Environmental testing
BS 2488	(IEC 63) Schedule of preferred numbers for the resistance of resistors and the capacitance of capacitors for telecommunication equipment
BS 3939	Guide for graphical symbols for electrical power, telecommunications and electronics diagrams
BS 4000	Specification for sizes of paper and board
BS 4727	Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms Part 3 Terms particular to telecommunications and electronics
BS 5775	Specification for quantities, units and symbols Part 5 Electricity and magnetism
BS 6001	Sampling procedures for inspection by attributes
BS 7151	Specification for representation of dates and times in information interchange
BS 9000	General requirements for a system for electronic components of assessed quality
BS 9720	Specification for custom-built transformers and inductors of assessed quality: generic data and methods of test
PD 9002	BS 9000, BS CECC and IECQ qualified products list

When reference to an IEC publication is given in parentheses, the British Standard is technically equivalent to the IEC publication.

1.3 Terminology

For the purposes of this British Standard the following definitions apply together with those given in BS 4727 and those given in clause 4 of BS 2011 : Part 1.1 : 1989 for terms relating to environmental testing procedures.

1.3.1 style

A variation within a sub-family of fixed inductors having specific properties for use in a particular application.

NOTE. Where a detail specification covers a range of styles, the limits of the range will be prescribed in the detail specification.

1.3.2 pattern

A variation within a style having specific ratings and characteristics.

1.3.3 type

A single value within a pattern.

1.3.4 rated inductance

The specified inductance value of the component as defined in the detail specification.

1.3.5 resistance

The d.c. resistance measured at the specified temperature.

1.3.6 Q factor

The ratio of reactance to effective resistance of a circuit element. It is a function of resistance and inductive reactance at a specified frequency.

1.3.7 self-resonant frequency (s.r.f.)

The frequency of self-oscillation of the component measured under specified conditions.

1.3.8 rated dissipation

The maximum power dissipation under specified conditions.

1.3.9 rated current

The direct current that will result in the rated dissipation of the component.

1.3.10 limiting winding voltage

The maximum peak voltage that can be applied across the component under specified conditions.

1.3.11 isolation voltage

The maximum peak voltage under continuous operating conditions which may be applied between any terminations of the inductor and a conducting mounting surface as determined by the test methods for insulation resistance and voltage proof.

NOTE. Applicable only to insulated styles.

1.3.12 effective parallel resistance

The dynamic impedance at resonance at a specified frequency.

1.3.13 superimposed direct current

That direct current which will cause a reduction in inductance to not less than 95 % of the zero direct current value as measured under specified conditions.

1.3.14 coupling factor

The ratio of mutual inductance to self-inductance of inductors of the same type and nominal value expressed as a percentage.

1.3.15 upper category temperature

The maximum ambient temperature at which the inductor has been designed to operate continuously.

1.3.16 lower category temperature

The minimum ambient temperature at which the inductor has been designed to operate continuously.

1.3.17 temperature characteristic of inductance

The maximum reversible variation of inductance between the upper and lower category temperatures, expressed as a percentage of the inductance at the reference temperature of 20 °C, i.e.

Temperature characteristic of inductance

$$= \frac{\Delta L}{L} \times 100$$

where:

ΔL is the change in inductance between the two specified ambient temperatures;

L is the inductance at 20 °C.

1.3.17.1 (mean) temperature coefficient of inductance (α)

The relative variation of inductance between two given temperatures divided by the difference in temperature producing it, i.e.

$$\alpha = \frac{\Delta L}{L \Delta \theta}$$

where

ΔL is the change in inductance between the two specified ambient temperatures;

L is the inductance at 20 °C;

$\Delta \theta$ is the algebraic difference in °C between the specified ambient temperature and the reference temperature.

1.4 Letter symbols, signs and abbreviations

Any letter symbols, signs and abbreviations that are employed in documents derived from this specification shall comply with BS 5775 or shall be derived in accordance with the principles of that standard.

1.5 Graphical symbols

Any graphical symbols that are employed in documents derived from this specification shall comply with BS 3939 or shall be derived in accordance with the principles of that standard.

1.6 Marking**1.6.1 Inductor**

The symbols or codes for the following information (see 1.6.3 and 1.6.4) shall be clearly marked on the inductor in the following order of preference as far as is practicable:

- (a) rated inductance;
- (b) selection tolerance;
- (c) the number of the detail specification and the style designation;
- (d) date code in accordance with BS 7151;
- (e) manufacturer's type reference;
- (f) manufacturer's name, trade mark or identification.

1.6.2 Package

The information required in items (a) to (f) of 1.6.1 shall be marked on the package.

NOTE. Where a transparent package is used, the information may be marked on a label which can be read without opening the package.

1.6.3 Letter and digit code for inductance

Where letter and digit codes are used to designate inductance the following requirements shall apply.

- (a) The unit symbols μH and mH shall be shown in the position of the decimal point and signify the unit of measurement.
- (b) Four characters only shall be used to code a value with two significant figures (e.g. $\text{mH } 47$, not $470 \mu\text{H}$).
- (c) When a tolerance value is required it shall be marked as a percentage tolerance or by a code letter as given below.

Tolerance percentage	Code letter
± 5	J
± 10	K
± 20	M

1.6.4 Colour coding for inductance

Unless otherwise specified in the detail specification, colours shall be in accordance with those specified in table 1 of BS 1852 : 1975, and colour bands shall be as described in appendix A. The first band shall be silver to indicate that the component is an inductor.

1.7 Eligibility for qualification approval

The first stage of manufacture to come under the direct surveillance of the approved chief inspector shall be the coil winding.

1.8 Structurally similar components

NOTE 1. Structurally similar inductors are a range of styles as defined in 1.3.1 and are usually covered by a single detail specification.

The detail specification shall state whether results of tests are to be recorded separately for certified test record purposes.

NOTE 2. A recommended scheme for the inspection of structurally similar components is given in appendix B.

1.9 Delayed delivery

Fixed inductors held in store for a period exceeding 12 months following acceptance inspection shall be resubmitted for visual examination and inductance and solderability tests by the original manufacturer or an independent test laboratory, as specified in group A¹⁾ of the relevant detail specification, and shall meet the specified requirements prior to release.

1.10 Supplementary procedure for qualification approval

Not applicable.

1.11 Certified test records

Certified test records shall be prepared by the manufacturer when specifically required to do so by the detail specification, in which case they shall be published on A4 size paper (see BS 4000) in the style shown in appendix C.

1.12 Standard ratings and characteristics

Ratings and characteristics shall, wherever possible, be taken from the following list. If additional items are included in the detail specification, the values and conditions under which they apply shall be stated. Any interdependence of ratings and characteristics and any limiting conditions of use shall be stated:

- (a) *rated inductance* shall be taken from a series of preferred numbers as given in BS 2488 (IEC 63);

- (b) *inductance selection tolerance*, $\pm 5\%$, $\pm 10\%$ and $\pm 20\%$;

- (c) *limiting winding voltage: peak voltage*, 50, 100, 150, 200 and 250 V;

- (d) *isolation voltage: peak voltage*, 100, 250, 500, 750 and 1000 V;

- (e) *rated dissipation*, at 70 °C (*unless otherwise stated*) 0.125, 0.2, 0.25, 0.33, 0.5, 1.0, 2.0, 5.0 and 10 W;

- (f) *preferred groupings of climatic categories* (see BS 2011 : Part 1.1)

55/155/56	55/100/56
55/155/21	55/100/04
55/155/04	25/085/21
55/125/56	10/100/21
55/125/21	10/070/21
55/125/04	10/070/04
55/100/21	

- (g) *preferred severities for vibration, bump and low air-pressure:*

- (1) *vibration* (sinusoidal) (see BS 2011 : Part 2.1Fc : 1983 (IEC 68-2-6 : 1982)),

frequency range, in Hz	either	10 to 500
	or	10 to 2000
displacement amplitude below cross-over frequency, in mm		0.75

acceleration amplitude above cross-over frequency, in $\text{m} \cdot \text{s}^{-2}$	98 ($10g_n$)
--	----------------

number of sweep cycles per axis	10
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- (2) *bump* (see BS 2011 : Part 2.1Eb : 1987 (IEC 68-2-29)),

peak acceleration	$40g_n$
number of bumps	4000 ± 10

- (3) *low air pressure* (see BS 2011 : Part 2.1M : 1984 (IEC 68-2-13 : 1983)),

8.5 kPa (85 mbar) or 4.4 kPa (44 mbar);

¹⁾ For the significance of the terms 'group A, B, C, D' see A.4.7 of BS 9000 : Section 8.1 : 1989.

(h) *temperature characteristic of inductance* shall be as shown in table 1.

Table 1. Temperature characteristic of inductance	
Standard values of temperature characteristic over the range 20 °C to 70 °C	Temperature coefficient
%	°C-1
± 0.625	± 125 × 10 ⁻⁶
± 1.000	± 200 × 10 ⁻⁶
± 2.50	± 500 × 10 ⁻⁶
± 6.50	± 1300 × 10 ⁻⁶
± 14.0	± 2800 × 10 ⁻⁶
± 25.0	± 5000 × 10 ⁻⁶

For other ranges of temperature, the temperature characteristic shall be taken to have the values obtained from the use of the following formulae:

(1) *for the range 70 °C to upper category temperature*

$$\text{Characteristic} = \frac{(A - 70)}{(70 - 20)} \times \text{value selected from table 1}$$

where

A is the highest temperature reached, i.e. upper category temperature;

(2) *for the range 20 °C to lower category temperature*

$$\text{Characteristic} = \frac{(B - 20)}{(70 - 20)} \times \text{value selected from table 1}$$

where

B is the numerical value of the lowest temperature reached, i.e. the lower category temperature;

(i) *permissible drift after endurance tests*

(1) inductance, 2 %, 5 %, 10 % and 20 %;

(2) *Q* factor, 5 %, 10 % and 20 %;

any recovery after an endurance test other than that laid down in this generic specification shall be specified in the detail specification;

(j) *preferred diameter of wire terminations*

Minimum	Nominal	Maximum
mm	mm	mm
0.45	0.50	0.55
0.55	0.60	0.66
0.65	0.70	0.77
0.75	0.80	0.88
0.95	1.00	1.10

1.13 Additional information (not for inspection purposes)

The detail specification may include information which is not normally required to be verified by the inspection procedure e.g. circuit diagrams, curves, drawings and notes needed for the clarification of the detail specification.

1.14 Procedure to be followed in the event of failure at group C or D inspection

The procedure specified in 7.6 of BS 9000 : Part 5 : 1989 shall be applied.

1.15 Ordering information

When ordering inductors, the following information shall be given:

- (a) rated inductance;
- (b) selection tolerance;
- (c) the BS number of the detail specification;
- (d) pattern.

Example: 1 µ H0 ± 10 % BS 9XXX NXXX Issue Y Pattern Z.

1.16 Release for delivery before the completion of group B tests

When the conditions of BS 6001 (IEC 410) for reduced inspection have been satisfied for all group B tests, the manufacturer is permitted to release components before the completion of such tests.

Section 2. Tests

2.1 Conditions of test

2.1.1 General

Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions for testing as specified in BS 2011 (IEC 68). For electrical tests, all voltages and currents are sinusoidal and values are given as r.m.s.

Before the measurements are made, the inductor shall be stored at the required temperature long enough for the inductor to reach this temperature.

NOTE. The recovery period called for after conditioning is 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. In this case the temperature during the measurements shall be stated in the test report.

During measurements the inductor shall not be exposed to influences likely to cause error, e.g. draught, direct sun-rays. All values in this generic specification are true values, and accordingly the accuracy of test equipment shall be taken into account when assessing the results.

2.1.2 Measurement uncertainty

The limits quoted in detail specifications shall be absolute. The tolerance values applying to the actual measurement system shall be taken into account when the measurements are assessed against specification limits. Where tolerances in respect of set conditions or instrument error have been specified, these shall be regarded as additional minimum requirements.

2.1.3 Alternative test methods

The test and measurement methods given in the relevant specification shall not be regarded as the only methods to be used. However, the manufacturer shall satisfy the National Supervising Inspectorate (NSI) that any alternative methods will give results equivalent¹⁾ to those obtained by the methods specified. In case of dispute, for referee and reference purposes only the specified methods shall be used. Alternative test methods shall not be shown in detail specifications.

2.1.4 Mounting procedures for surface mounting devices (SMDs)

2.1.4.1 General

Where it is necessary to test SMDs which are mounted on test substrates, the procedures described in 2.1.4.2 and 2.1.4.3 or 2.1.4.4, as appropriate, shall be followed. The inductors shall be mounted on a substrate appropriate for the intended test. The substrate material shall not

contribute to failures intended to be checked by the test for which the material is used. The substrate shall have surface metallized land areas of proper spacing to permit mounting of inductors and shall provide electrical access to inductors.

NOTE. Either of the mounting procedures described in 2.1.4.2 and 2.1.4.3 may be used for reflow soldering of the inductors. Mounting is also permitted using a soldering iron method, for which the procedure of 2.1.4.4 is preferred.

All visible traces of flux shall be removed by immersion in a neutral organic solvent at room temperature, particular attention being paid to any remaining at the SMD/substrate interface. Care shall be taken to maintain cleanliness in test chambers and during post-test measurements.

2.1.4.2 Mounting by the use of solder paste preforms

The procedure for mounting by the use of solder paste preforms shall be as follows.

- (a) The solder used in preform or pasteform mounting shall be silver bearing (2 % min.) eutectic tin/lead solder together with a non-active flux of water-white gum-rosin and isopropyl alcohol composition.
- (b) The inductor shall be placed across the metallized land areas of the test substrate so as to make contact between the SMD and substrate land areas.
- (c) The substrate shall be heated at a temperature which shall be maintained between 215 °C and 260 °C until the solder melts and reflows forming a homogeneous solder bond, but for no longer than 10 s.

The heating shall be achieved by placing the substrate in or on a suitable heat transfer unit (molten solder, hot plate or tunnel oven, for example) or by using hot gas reflow equipment.

2.1.4.3 Mounting of solder-dipped (pre-tinned) inductors

The procedure for mounting of solder-dipped (pre-tinned) inductors shall be as follows.

- (a) The terminations shall be pre-tinned using a solder comprising tin, lead and silver in the following proportion, 62 : 36 : 2 (i.e. 62/36/2 tin/lead/silver solder).
- (b) Proceed as described in 2.1.4.2 (b), 2.1.4.4 (c) and 2.1.4.2 (c).

2.1.4.4 Mounting by the use of a soldering iron

The procedure for mounting by the use of a soldering iron shall be as follows.

- (a) The substrate lands shall be pre-tinned, using 62/36/2 tin/lead/silver solder.

NOTE. Land dimensions should exceed termination dimensions.

¹⁾ The term 'equivalent' means that the value of a characteristic established by such an alternative method, and acceptable in accordance with the limits ascribed to that method, will fall within the specified limits when measured by the specified method.

(b) Both the substrate and the SMDs to be mounted shall be placed flat on the clean surface of a hot plate at $125 \pm 10^\circ\text{C}$ for a minimum of 10 min.

(c) The SMD shall be placed flat on substrate lands, flooded with flux (40 % by weight water-white gum-rosin, 60 % by weight isopropyl alcohol) and left for a minimum of 5 s.

(d) The tip of a temperature controlled pencil-type soldering iron bit, maintained at $315 \pm 20^\circ\text{C}$, shall be flooded with 62/36/2 tin/lead/silver solder.

(e) The SMD shall be held in the required position with tweezers.

(f) Solder shall be applied to one termination effecting a well-contoured fillet between the vertical faces of the termination and the substrate land. The soldering iron shall not be held in contact with the SMD for more than 10 s. When the solder has solidified, the procedure shall be repeated for the opposite termination. The termination/land interface shall be tinned.

NOTE. Tinning of the remaining horizontal surface is optional.

(g) Steps (a) to (f) above shall be repeated for the remaining SMD to be assembled.

(h) The substrate shall then be removed from the hotplate and left for 30 min under controlled recovery conditions (see 5.4.1 of BS 2011 : Part 1.1 : 1989).

Appendix D gives details of a typical test substrate for SMDs.

2.2 Test fixtures (electrical measurements)

Tests shall be performed using one of the standard test fixtures, as described in appendix E, where applicable. For styles of component not suitable for use with the fixtures of appendix E, the detail specification shall give the required information.

The inductance and capacitance of the test fixture shall be taken into account when making measurements.

2.3 Visual inspection

Unless otherwise specified, visual inspection shall be performed under normal factory lighting conditions without visual aids. The condition, workmanship, marking and finish shall be satisfactory.

2.4 Dimensioning and gauging procedure

2.4.1 General

The dimensions shall be checked and shall comply with those given in the detail specification. The methods given below shall be used unless otherwise specified in the detail specification.

2.4.2 Measurement of the dimensions of a cylindrical inductor having two axial wire terminations

2.4.2.1 Length of body and terminations

The length of the body and terminations of an inductor shall be measured by one of the following methods as appropriate.

(a) *Components without glass/metal seals and without discontinuities in the wire terminations*

The length of the body shall be measured by inserting the terminations into slots (or holes) in two parallel gauge plates and by moving these plates towards each other until the component body is clamped without deforming the body or the termination (see figure 1). The plates shall be considered sufficiently close to parallel if the uncertainty in length due to the plates does not exceed 0.2 mm.

The length of the body shall be taken to be equal to the measured length L_1 , and the length of the termination shall be taken to be equal to L_2 .

The width of the slot, W (or the diameter of the hole) in the gauge plate shall depend on the diameter of the wire termination in the manner given in table 2.

Table 2. Slot width for gauge plates

Nominal diameter of wire terminations	Width of slots in gauge plates (W) ¹⁾
mm	mm
Up to and including 0.45	0.8 ± 0.02
Above 0.45 to 0.7 inc.	1.0 ± 0.02
Above 0.7 to 0.9 inc.	1.2 ± 0.02
Above 0.9 to 1.15 inc.	1.5 ± 0.02
Above 1.15 to 1.32 inc.	1.8 ± 0.02
Above 1.32 to 2.0 inc.	3.0 ± 0.02

¹⁾ The tolerances shown need only be maintained in the locality of the point where the termination will lie during measurement.

(b) *Components over 5 mm in diameter with glass/metal seals or with discontinuities in the wire terminations*

Important note. If there is a discontinuity in the wire termination, e.g. on components with welded terminations outside the case and on components provided with glass seals, the width of the slot in the gauge plate has no significance in the measurement of length.

The length of the component shall be taken as the distance between the inside faces of the gauge plates (L_1), and the length of the terminations shall be taken as equal to L_2 (see figure 2).