

## **Ferrites and accessories**

Toroids (ring cores)  
General information and overview

Date: May 2017

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## Toroids (ring cores)

### General information

Our product line includes a wide range of toroids with finely graded diameters ranging from 2.5 to 202 mm.

Other core heights can be supplied on request. All cores are available in the usual materials.

#### 1 Applications

- Toroids are primarily used as EMC chokes for suppressing RF interference in the MHz region and in signal transformers.

Typical applications for toroids of NiZn ferrites are LAN chokes. One of the materials available for this purpose is K10; other materials on request.

The following high-permeability MnZn materials are available for interference suppression:

- R 2.5 through R 12.5 for telecommunications (N30, T38, T46)
- R 13.3 through R 26 for power line chokes (N30, T65, T35, T37, T38)
- >R 34 for chokes and filters in industrial use (T65)
- Toroids are also increasingly used for power applications. Here, the typical values for amplitude permeability and power loss, as summarized in the section on “*SIFERRIT Materials*” (page 36), are applicable to the special power materials.

#### 2 Coating

Toroids are available in different coating versions, thus offering the appropriate solution for every application. The coating not only offers protection for the edges but also provides an insulation function.

For small ring cores, we have introduced a parylene coating which features a low coating thickness and high dielectric strength.

A coating of the core will cause  $\mu_i$  to drop, depending on the core size. A similar effect might occur when the core is subjected to high winding forces, especially cores made of the high permeability materials, T38 and T46.

## Toroids (ring cores)

### General information

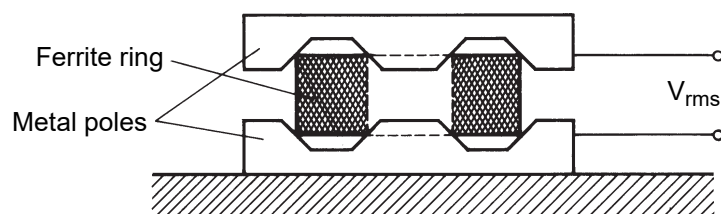
#### Coatings of ring cores

| Version                               | Epoxy<br>(blue)                                                                                  | Parylene<br>(transparent)     |
|---------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------|
| Main application                      | Medium/big sizes<br>( $\geq R 9.53$ )                                                            | Small sizes<br>( $< R 9.53$ ) |
| Layer thickness                       | $< 0.4$ mm                                                                                       | 0.012 or 0.025 mm             |
| Breakdown voltage<br>(minimum values) | $> 1.0$ kV (for R 9.53; R 10)<br>$> 1.5$ kV (for R 12.5 thru R 20)<br>$> 2.0$ kV (for $> R 20$ ) | $> 1$ kV<br>(standard value)  |
| Mechanical quality                    | High firmness                                                                                    | Smooth surface                |
| Maximum temperature<br>(short-time)   | approx. $180^{\circ}\text{C}$                                                                    | approx. $130^{\circ}\text{C}$ |
| Maximum temperature<br>(long-time)    | approx. $130^{\circ}\text{C}$                                                                    | approx. $130^{\circ}\text{C}$ |
| Advantage                             | Low influence on $A_L$ value                                                                     | Very low thickness            |
| UL rating                             | UL 94 V-0                                                                                        | UL 94 V-0                     |
| UL file number                        | E194412/E257941                                                                                  | E194412                       |
| Ordering code                         | B64290L...                                                                                       | B64290P...                    |

### 3 Dielectric strength test

The following test setup is used to test the dielectric strength of the insulating coating: A copper ring is pressed to the top edge of the ring. It touches the ferrite ring at the edges (see diagram).

The test duration is 2 seconds.



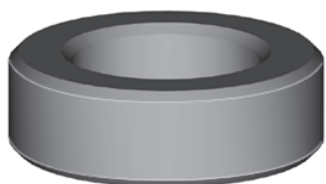
FUS0021-H

## Toroids (ring cores)

### General information

#### 4 Chamfer

Large toroidal cores use thick wires that are partially subjected to high mechanical stress during winding. This can damage the wire insulation as well as the coating of the cores, thus reducing the breakdown voltage. To avoid this, EPCOS toroids have a chamfer. This prevents any insulation damage, and produces uniform coating thickness at the same time.



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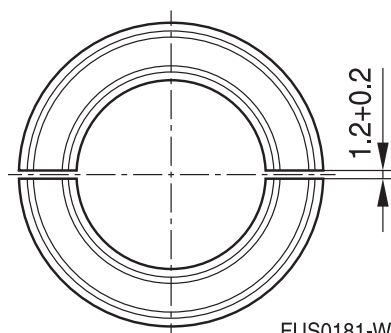
| Core size  | Design                                        |
|------------|-----------------------------------------------|
| Small      | Edges rounded by tumbling                     |
| Medium     | Chamfer on edges and/or radius on the surface |
| Medium/big | Chamfer on edges                              |

#### 5 Cutting

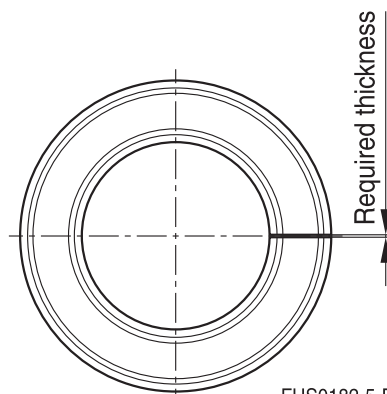
Middle size and large toroids are available with gap:

1.) Cut into 2 halves with typical cutting wheel thickness 1.2 mm.

2.) Cut gap in required thickness.



FUS0181-W



FUS0182-5-E

Three basic questions have to be answered during order:

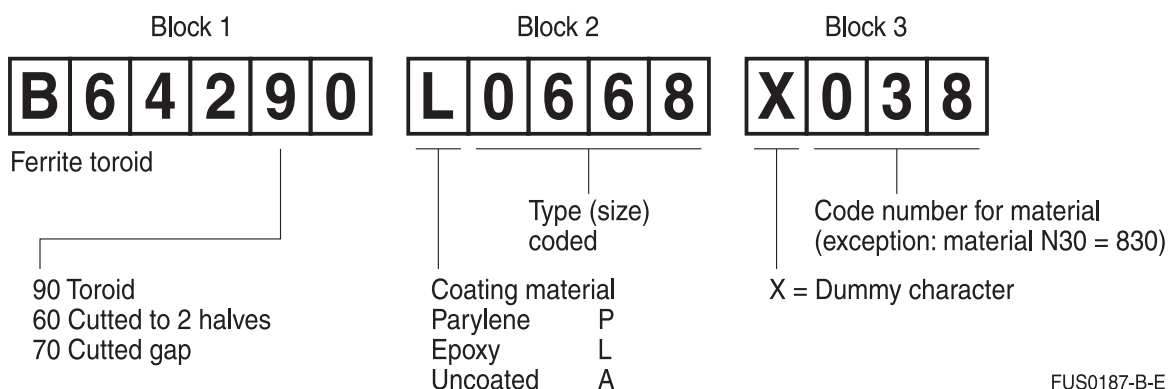
- toroid cuts into 2 halves/only gap (picture 1 or 2)
- cutting before/after coating
  - before: air gap is coated
  - after: air gap is not coated, a measurement fixture can be placed into the air gap
- required thickness of the gap

## Toroids (ring cores)

### General information

#### 6 Structure of the ordering code (part number)

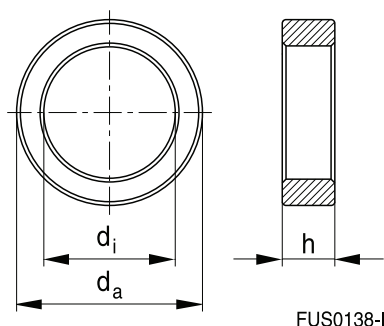
Compilation of the ordering code



# Toroids (ring cores)

## Overview

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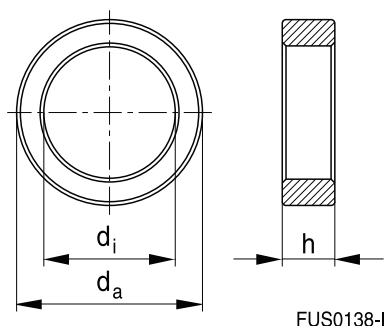
## Overview of available sizes

| Type                                      | Type code                | Page        |
|-------------------------------------------|--------------------------|-------------|
| Toroid size ( $d_a \times d_i \times h$ ) | (ordering code, block 2) | (Data book) |
| mm                                        | inch                     |             |
| R 2.50 × 1.50 × 1.00                      | R 0.098 × 0.059 × 0.039  | P0035 624   |
| R 2.50 × 1.50 × 1.30                      | R 0.098 × 0.059 × 0.051  | P0072 624   |
| R 2.54 × 1.27 × 1.27                      | R 0.100 × 0.050 × 0.050  | P0734 625   |
| R 3.05 × 1.27 × 1.27                      | R 0.120 × 0.050 × 0.050  | P0683 625   |
| R 3.05 × 1.27 × 2.54                      | R 0.120 × 0.050 × 0.100  | P0739 626   |
| R 3.05 × 1.78 × 2.03                      | R 0.120 × 0.070 × 0.080  | P0733 626   |
| R 3.43 × 1.78 × 1.78                      | R 0.135 × 0.070 × 0.070  | P0731 627   |
| R 3.43 × 1.78 × 2.03                      | R 0.135 × 0.070 × 0.080  | P0745 627   |
| R 3.94 × 1.78 × 1.78                      | R 0.155 × 0.070 × 0.070  | P0732 628   |
| R 3.94 × 2.24 × 1.30                      | R 0.155 × 0.088 × 0.051  | P0061 628   |
| R 3.94 × 2.24 × 2.30                      | R 0.155 × 0.088 × 0.090  | P0723 629   |
| R 4.00 × 2.40 × 1.60                      | R 0.157 × 0.094 × 0.063  | P0036 629   |
| R 4.00 × 2.40 × 1.80                      | R 0.157 × 0.094 × 0.071  | P0692 630   |
| R 5.84 × 3.05 × 1.52                      | R 0.230 × 0.120 × 0.060  | P0056 630   |
| R 5.84 × 3.05 × 3.00                      | R 0.230 × 0.120 × 0.118  | P0687 631   |
| R 6.30 × 3.80 × 2.50                      | R 0.248 × 0.150 × 0.098  | P0037 631   |
| R 8.00 × 4.00 × 4.00                      | R 0.315 × 0.158 × 0.158  | P0751 632   |
| R 9.53 × 4.75 × 3.17                      | R 0.375 × 0.187 × 0.125  | L0062 632   |
| R 10.0 × 6.00 × 4.00                      | R 0.394 × 0.236 × 0.157  | L0038 633   |
| R 10.0 × 6.00 × 7.00                      | R 0.394 × 0.236 × 0.318  | L0783 633   |
| R 12.5 × 7.50 × 5.00                      | R 0.492 × 0.295 × 0.197  | L0044 634   |
| R 12.7 × 7.90 × 6.35                      | R 0.500 × 0.311 × 0.250  | L0742 634   |
| R 13.3 × 8.30 × 5.00                      | R 0.524 × 0.327 × 0.197  | L0644 635   |
| R 14.0 × 9.00 × 5.00                      | R 0.551 × 0.354 × 0.197  | L0658 635   |
| R 15.0 × 10.4 × 5.30                      | R 0.591 × 0.409 × 0.209  | L0623 636   |
| R 15.8 × 8.90 × 4.70                      | R 0.622 × 0.350 × 0.185  | L0743 636   |
| R 16.0 × 9.60 × 6.30                      | R 0.630 × 0.378 × 0.248  | L0045 637   |

# Toroids (ring cores)

## Overview

B64290



FUS0138-I

## Overview of available sizes (continued)

| Type                                      | Type code                | Page        |
|-------------------------------------------|--------------------------|-------------|
| Toroid size ( $d_a \times d_i \times h$ ) | (ordering code, block 2) | (Data book) |
| mm                                        | inch                     |             |
| R 17.0 × 10.7 × 6.80                      | R 0.669 × 0.421 × 0.268  | L0652 638   |
| R 18.4 × 5.90 × 5.90                      | R 0.724 × 0.232 × 0.232  | L0697 638   |
| R 20.0 × 10.0 × 7.00                      | R 0.787 × 0.394 × 0.276  | L0632 639   |
| R 20.0 × 10.0 × 10.0                      | R 0.787 × 0.394 × 0.394  | L0631 639   |
| R 20.0 × 10.0 × 15.0                      | R 0.787 × 0.394 × 0.591  | L0710 640   |
| R 22.1 × 13.7 × 6.35                      | R 0.870 × 0.539 × 0.250  | L0638 640   |
| R 22.1 × 13.7 × 7.90                      | R 0.870 × 0.539 × 0.311  | L0719 641   |
| R 22.1 × 13.7 × 12.5                      | R 0.870 × 0.539 × 0.492  | L0651 641   |
| R 22.6 × 14.7 × 9.20                      | R 0.890 × 0.579 × 0.362  | L0626 642   |
| R 25.3 × 14.8 × 10.0                      | R 0.996 × 0.583 × 0.394  | L0618 642   |
| R 25.3 × 14.8 × 15.0                      | R 0.996 × 0.583 × 0.590  | L0615 643   |
| R 25.3 × 14.8 × 20.0                      | R 0.996 × 0.583 × 0.787  | L0616 643   |
| R 29.5 × 19.0 × 14.9                      | R 1.142 × 0.748 × 0.587  | L0647 644   |
| R 30.5 × 20.0 × 12.5                      | R 1.201 × 0.787 × 0.492  | L0657 644   |
| R 34.0 × 20.5 × 10.0                      | R 1.339 × 0.807 × 0.394  | L0058 645   |
| R 34.0 × 20.5 × 12.5                      | R 1.339 × 0.807 × 0.492  | L0048 645   |
| R 36.0 × 23.0 × 15.0                      | R 1.417 × 0.906 × 0.591  | L0674 646   |
| R 38.1 × 19.05 × 12.7                     | R 1.500 × 0.750 × 0.500  | L0668 646   |
| R 40.0 × 24.0 × 16.0                      | R 1.575 × 0.945 × 0.630  | L0659 647   |
| R 41.8 × 26.2 × 12.5                      | R 1.646 × 1.031 × 0.492  | L0022 647   |
| R 50.0 × 30.0 × 20.0                      | R 1.969 × 1.181 × 0.787  | L0082 648   |
| R 58.3 × 32.0 × 18.0                      | R 2.295 × 1.260 × 0.709  | L0043 649   |
| R 58.3 × 40.8 × 17.6                      | R 2.295 × 1.606 × 0.693  | L0040 650   |
| R 58.3 × 40.8 × 20.2                      | R 2.295 × 1.606 × 0.795  | L0042 651   |
| R 63.0 × 38.0 × 25.0                      | R 2.480 × 1.496 × 0.984  | L0699 652   |
| R 68.0 × 48.0 × 13.0                      | R 2.677 × 1.890 × 0.512  | L0696 653   |
| R 87.0 × 54.3 × 13.5                      | R 3.425 × 2.138 × 0.531  | L0730 654   |
| R 102 × 65.8 × 15.0                       | R 4.016 × 2.591 × 0.591  | L0084 655   |

## Toroids (ring cores)

### Overview

| Type                                      |                         | Type code<br>(ordering code,<br>block 2) | Page<br>(Data<br>book) |
|-------------------------------------------|-------------------------|------------------------------------------|------------------------|
| Toroid size ( $d_a \times d_i \times h$ ) |                         |                                          |                        |
| mm                                        | inch                    |                                          |                        |
| R 140 × 103 × 25.0                        | R 5.512 × 4.055 × 0.984 | A0705                                    | 656                    |
| R 202 × 153 × 25.0                        | R 7.953 × 6.024 × 0.984 | A0711                                    | 657                    |



## Ferrites and accessories

### Cautions and warnings

#### Mechanical stress and mounting

Ferrite cores have to meet mechanical requirements during assembling and for a growing number of applications. Since ferrites are ceramic materials one has to be aware of the special behavior under mechanical load.

As valid for any ceramic material, ferrite cores are brittle and sensitive to any shock, fast temperature changing or tensile load. Especially high cooling rates under ultrasonic cleaning and high static or cyclic loads can cause cracks or failure of the ferrite cores.

For detailed information see data book, chapter “*General - Definitions, 8.1*”.

#### Effects of core combination on $A_L$ value

Stresses in the core affect not only the mechanical but also the magnetic properties. It is apparent that the initial permeability is dependent on the stress state of the core. The higher the stresses are in the core, the lower is the value for the initial permeability. Thus the embedding medium should have the greatest possible elasticity.

For detailed information see data book, chapter “*General - Definitions, 8.1*”.

#### Heating up

Ferrites can run hot during operation at higher flux densities and higher frequencies.

#### NiZn-materials

The magnetic properties of NiZn-materials can change irreversible in high magnetic fields.

#### Ferrite Accessories

EPCOS ferrite accessories have been designed and evaluated only in combination with EPCOS ferrite cores. EPCOS explicitly points out that EPCOS ferrite accessories or EPCOS ferrite cores may not be compatible with those of other manufacturers. Any such combination requires prior testing by the customer and will be at the customer's own risk.

EPCOS assumes no warranty or reliability for the combination of EPCOS ferrite accessories with cores and other accessories from any other manufacturer.

#### Processing remarks

The start of the winding process should be soft. Else the flanges may be destroyed.

- Too strong winding forces may blast the flanges or squeeze the tube that the cores can not be mounted any more.
- Too long soldering time at high temperature (>300 °C) may effect coplanarity or pin arrangement.
- Not following the processing notes for soldering of the J-leg terminals may cause solderability problems at the transformer because of pollution with Sn oxyde of the tin bath or burned insulation of the wire. For detailed information see chapter “*Processing notes*”, section 2.2.
- The dimensions of the hole arrangement have fixed values and should be understood as a recommendation for drilling the printed circuit board. For dimensioning the pins, the group of holes can only be seen under certain conditions, as they fit into the given hole arrangement. To avoid problems when mounting the transformer, the manufacturing tolerances for positioning the customers' drilling process must be considered by increasing the hole diameter.

## Ferrites and accessories

### Cautions and warnings

#### Display of ordering codes for EPCOS products

The ordering code for one and the same product can be represented differently in data sheets, data books, other publications and the website of EPCOS, or in order-related documents such as shipping notes, order confirmations and product labels. **The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products.** Detailed information can be found on the Internet under [www.epcos.com/orderingcodes](http://www.epcos.com/orderingcodes).

## Ferrites and accessories

### Symbols and terms

| Symbol              | Meaning                                                         | Unit                         |
|---------------------|-----------------------------------------------------------------|------------------------------|
| A                   | Cross section of coil                                           | mm <sup>2</sup>              |
| A <sub>e</sub>      | Effective magnetic cross section                                | mm <sup>2</sup>              |
| A <sub>L</sub>      | Inductance factor; $A_L = L/N^2$                                | nH                           |
| A <sub>L1</sub>     | Minimum inductance at defined high saturation ( $\cong \mu_a$ ) | nH                           |
| A <sub>min</sub>    | Minimum core cross section                                      | mm <sup>2</sup>              |
| A <sub>N</sub>      | Winding cross section                                           | mm <sup>2</sup>              |
| A <sub>R</sub>      | Resistance factor; $A_R = R_{Cu}/N^2$                           | $\mu\Omega = 10^{-6} \Omega$ |
| B                   | RMS value of magnetic flux density                              | Vs/m <sup>2</sup> , mT       |
| $\Delta B$          | Flux density deviation                                          | Vs/m <sup>2</sup> , mT       |
| $\hat{B}$           | Peak value of magnetic flux density                             | Vs/m <sup>2</sup> , mT       |
| $\Delta \hat{B}$    | Peak value of flux density deviation                            | Vs/m <sup>2</sup> , mT       |
| B <sub>DC</sub>     | DC magnetic flux density                                        | Vs/m <sup>2</sup> , mT       |
| B <sub>R</sub>      | Remanent flux density                                           | Vs/m <sup>2</sup> , mT       |
| B <sub>S</sub>      | Saturation magnetization                                        | Vs/m <sup>2</sup> , mT       |
| C <sub>0</sub>      | Winding capacitance                                             | F = As/V                     |
| CDF                 | Core distortion factor                                          | mm <sup>-4.5</sup>           |
| DF                  | Relative disaccommodation coefficient $DF = d/\mu_i$            |                              |
| d                   | Disaccommodation coefficient                                    |                              |
| E <sub>a</sub>      | Activation energy                                               | J                            |
| f                   | Frequency                                                       | s <sup>-1</sup> , Hz         |
| f <sub>cutoff</sub> | Cut-off frequency                                               | s <sup>-1</sup> , Hz         |
| f <sub>max</sub>    | Upper frequency limit                                           | s <sup>-1</sup> , Hz         |
| f <sub>min</sub>    | Lower frequency limit                                           | s <sup>-1</sup> , Hz         |
| f <sub>r</sub>      | Resonance frequency                                             | s <sup>-1</sup> , Hz         |
| f <sub>Cu</sub>     | Copper filling factor                                           |                              |
| g                   | Air gap                                                         | mm                           |
| H                   | RMS value of magnetic field strength                            | A/m                          |
| $\hat{H}$           | Peak value of magnetic field strength                           | A/m                          |
| H <sub>DC</sub>     | DC field strength                                               | A/m                          |
| H <sub>c</sub>      | Coercive field strength                                         | A/m                          |
| h                   | Hysteresis coefficient of material                              | 10 <sup>-6</sup> cm/A        |
| h/ $\mu_i^2$        | Relative hysteresis coefficient                                 | 10 <sup>-6</sup> cm/A        |
| I                   | RMS value of current                                            | A                            |
| I <sub>DC</sub>     | Direct current                                                  | A                            |
| $\hat{I}$           | Peak value of current                                           | A                            |
| J                   | Polarization                                                    | Vs/m <sup>2</sup>            |
| k                   | Boltzmann constant                                              | J/K                          |
| k <sub>3</sub>      | Third harmonic distortion                                       |                              |
| k <sub>3c</sub>     | Circuit third harmonic distortion                               |                              |
| L                   | Inductance                                                      | H = Vs/A                     |

## Ferrites and accessories

### Symbols and terms

| Symbol              | Meaning                                                          | Unit               |
|---------------------|------------------------------------------------------------------|--------------------|
| $\Delta L/L$        | Relative inductance change                                       | H                  |
| $L_0$               | Inductance of coil without core                                  | H                  |
| $L_H$               | Main inductance                                                  | H                  |
| $L_p$               | Parallel inductance                                              | H                  |
| $L_{rev}$           | Reversible inductance                                            | H                  |
| $L_s$               | Series inductance                                                | H                  |
| $l_e$               | Effective magnetic path length                                   | mm                 |
| $l_N$               | Average length of turn                                           | mm                 |
| $N$                 | Number of turns                                                  |                    |
| $P_{Cu}$            | Copper (winding) losses                                          | W                  |
| $P_{trans}$         | Transferrable power                                              | W                  |
| $P_V$               | Relative core losses                                             | mW/g               |
| PF                  | Performance factor                                               |                    |
| $Q$                 | Quality factor ( $Q = \omega L/R_s = 1/\tan \delta_L$ )          |                    |
| $R$                 | Resistance                                                       | $\Omega$           |
| $R_{Cu}$            | Copper (winding) resistance ( $f = 0$ )                          | $\Omega$           |
| $R_h$               | Hysteresis loss resistance of a core                             | $\Omega$           |
| $\Delta R_h$        | $R_h$ change                                                     | $\Omega$           |
| $R_i$               | Internal resistance                                              | $\Omega$           |
| $R_p$               | Parallel loss resistance of a core                               | $\Omega$           |
| $R_s$               | Series loss resistance of a core                                 | $\Omega$           |
| $R_{th}$            | Thermal resistance                                               | K/W                |
| $R_V$               | Effective loss resistance of a core                              | $\Omega$           |
| $s$                 | Total air gap                                                    | mm                 |
| $T$                 | Temperature                                                      | $^{\circ}\text{C}$ |
| $\Delta T$          | Temperature difference                                           | K                  |
| $T_C$               | Curie temperature                                                | $^{\circ}\text{C}$ |
| $t$                 | Time                                                             | s                  |
| $t_v$               | Pulse duty factor                                                |                    |
| $\tan \delta$       | Loss factor                                                      |                    |
| $\tan \delta_L$     | Loss factor of coil                                              |                    |
| $\tan \delta_r$     | (Residual) loss factor at $H \rightarrow 0$                      |                    |
| $\tan \delta_e$     | Relative loss factor                                             |                    |
| $\tan \delta_h$     | Hysteresis loss factor                                           |                    |
| $\tan \delta/\mu_i$ | Relative loss factor of material at $H \rightarrow 0$            |                    |
| $U$                 | RMS value of voltage                                             | V                  |
| $\hat{U}$           | Peak value of voltage                                            | V                  |
| $V_e$               | Effective magnetic volume                                        | mm <sup>3</sup>    |
| $Z$                 | Complex impedance                                                | $\Omega$           |
| $Z_n$               | Normalized impedance $ Z _n =  Z /N^2 \times \epsilon (l_e/A_e)$ | $\Omega/\text{mm}$ |

## Ferrites and accessories

### Symbols and terms

| Symbol       | Meaning                                                                      | Unit                              |
|--------------|------------------------------------------------------------------------------|-----------------------------------|
| $\alpha$     | Temperature coefficient (TK)                                                 | 1/K                               |
| $\alpha_F$   | Relative temperature coefficient of material                                 | 1/K                               |
| $\alpha_e$   | Temperature coefficient of effective permeability                            | 1/K                               |
| $\epsilon_r$ | Relative permittivity                                                        |                                   |
| $\Phi$       | Magnetic flux                                                                | Vs                                |
| $\eta$       | Efficiency of a transformer                                                  |                                   |
| $\eta_B$     | Hysteresis material constant                                                 | mT <sup>-1</sup>                  |
| $\eta_i$     | Hysteresis core constant                                                     | A <sup>-1</sup> H <sup>-1/2</sup> |
| $\lambda_s$  | Magnetostriction at saturation magnetization                                 |                                   |
| $\mu$        | Relative complex permeability                                                |                                   |
| $\mu_0$      | Magnetic field constant                                                      | Vs/Am                             |
| $\mu_a$      | Relative amplitude permeability                                              |                                   |
| $\mu_{app}$  | Relative apparent permeability                                               |                                   |
| $\mu_e$      | Relative effective permeability                                              |                                   |
| $\mu_i$      | Relative initial permeability                                                |                                   |
| $\mu_p'$     | Relative real (inductive) component of $\bar{\mu}$ (for parallel components) |                                   |
| $\mu_p''$    | Relative imaginary (loss) component of $\bar{\mu}$ (for parallel components) |                                   |
| $\mu_r$      | Relative permeability                                                        |                                   |
| $\mu_{rev}$  | Relative reversible permeability                                             |                                   |
| $\mu_s'$     | Relative real (inductive) component of $\bar{\mu}$ (for series components)   |                                   |
| $\mu_s''$    | Relative imaginary (loss) component of $\bar{\mu}$ (for series components)   |                                   |
| $\mu_{tot}$  | Relative total permeability<br>derived from the static magnetization curve   |                                   |
| $\rho$       | Resistivity                                                                  | $\Omega m^{-1}$                   |
| $\Sigma l/A$ | Magnetic form factor                                                         | mm <sup>-1</sup>                  |
| $\tau_{Cu}$  | DC time constant $\tau_{Cu} = L/R_{Cu} = A_L/A_R$                            | s                                 |
| $\omega$     | Angular frequency; $\omega = 2 \pi f$                                        | s <sup>-1</sup>                   |

All dimensions are given in mm.



Surface-mount device

## Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application**. As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether an EPCOS product with the properties described in the product specification is suitable for use in a particular customer application.
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