Ferrites and accessories

Toroids (ring cores)
General information and overview

Date: May 2017

EPCOS AG is a TDK Group Company.

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 μ_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.

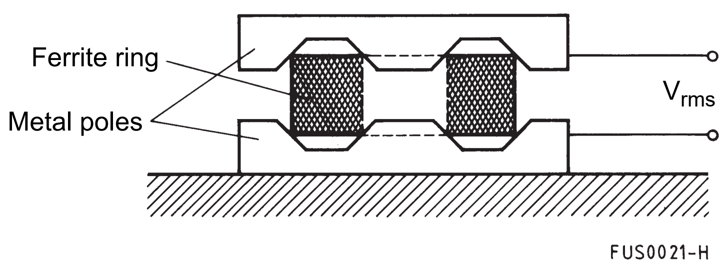
Coatings of ring cores

Version	Epoxy (blue)	Parylene (transparent)
Main application	Medium/big sizes (≥R 9.53)	Small sizes (<R 9.53)
Layer thickness	<0.4 mm	0.012 or 0.025 mm
Breakdown voltage (minimum values)	>1.0 kV (for R 9.53; R 10) >1.5 kV (for R 12.5 thru R 20) >2.0 kV (for >R 20)	>1 kV (standard value)
Mechanical quality	High firmness	Smooth surface
Maximum temperature (short-time)	approx. 180 °C	approx. 130 °C
Maximum temperature (long-time)	approx. 130 °C	approx. 130 °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	B64290**L**…	B64290**P**…

3 Dielectric strength test

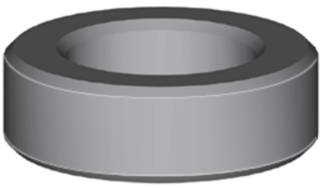
The following test setup is used to test the dielectric strength of the insulating coating: A copper ring is pressed to the top edge of the ring. It touches the ferrite ring at the edges (see diagram).

The test duration is 2 seconds.



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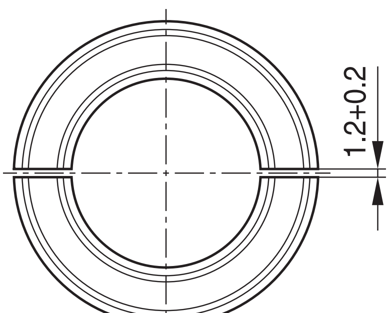
Core size	Design
Small	Edges rounded by tumbling
Medium	Chamfer on edges and/or radius on the surface
Medium/big	Chamfer on edges

5 Cutting

Middle size and large toroids are available with gap:

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



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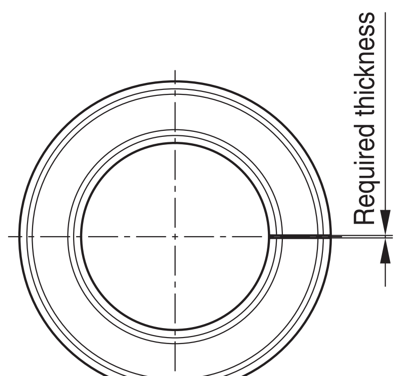
2.) Cut gap in required thickness.



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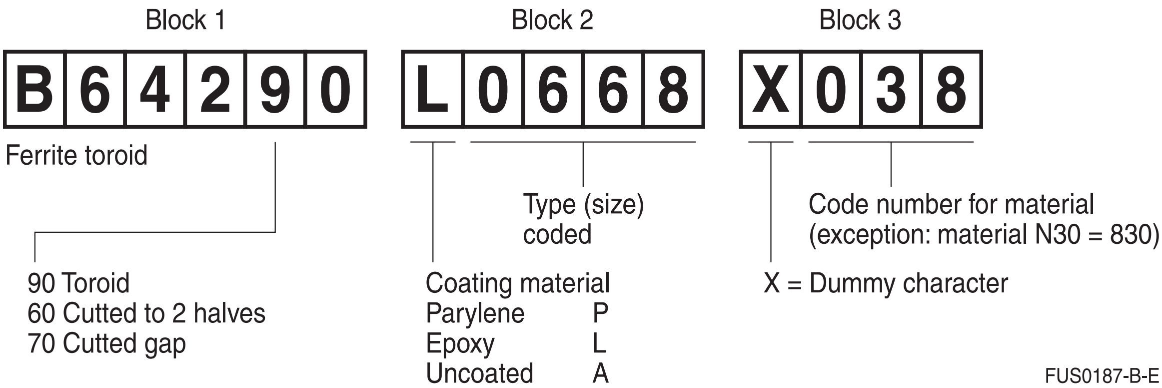
Three basic questions have to be answered during order:

- 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

6 Structure of the ordering code (part number)

Compilation of the ordering code



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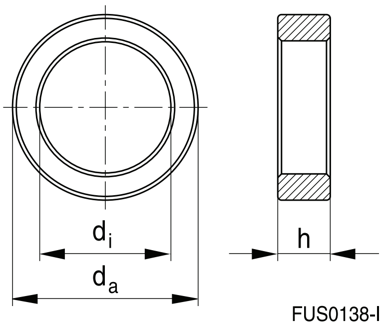
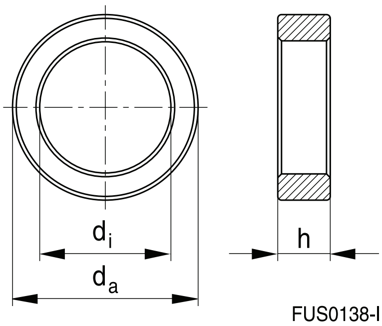


Overview of available sizes

Type Toroid size ($d_a \times d_i \times h$) mm	inch	Type code (ordering code, block 2)	Page (Data book)
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



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Overview of available sizes (continued)

Type Toroid size ($d_a \times d_i \times h$) mm	inch	Type code (ordering code, block 2)	Page (Data book)
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 Toroid size ($d_a \times d_i \times h$) mm	 inch	Type code (ordering code, block 2)	Page (Data book)
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

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.

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.

Symbol	Meaning	Unit
A	Cross section of coil	mm^2
A_e	Effective magnetic cross section	mm^2
A_L	Inductance factor; $A_L = L/N^2$	nH
A_{L1}	Minimum inductance at defined high saturation ($\triangleq \mu_a$)	nH
A_{min}	Minimum core cross section	mm^2
A_N	Winding cross section	mm^2
A_R	Resistance factor; $A_R = R_{Cu}/N^2$	$\mu\Omega = 10^{-6}\ \Omega$
B	RMS value of magnetic flux density	Vs/m^2, mT
ΔB	Flux density deviation	Vs/m^2, mT
$\hat{B}$	Peak value of magnetic flux density	Vs/m^2, mT
$\Delta \hat{B}$	Peak value of flux density deviation	Vs/m^2, mT
B_{DC}	DC magnetic flux density	Vs/m^2, mT
B_R	Remanent flux density	Vs/m^2, mT
B_S	Saturation magnetization	Vs/m^2, mT
C_0	Winding capacitance	F = As/V
CDF	Core distortion factor	$mm^{-4.5}$
DF	Relative disaccommodation coefficient DF = d/μ_i	
d	Disaccommodation coefficient	
E_a	Activation energy	J
f	Frequency	s^{-1}, Hz
f_{cutoff}	Cut-off frequency	s^{-1}, Hz
f_{max}	Upper frequency limit	s^{-1}, Hz
f_{min}	Lower frequency limit	s^{-1}, Hz
f_r	Resonance frequency	s^{-1}, Hz
f_{Cu}	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_{DC}	DC field strength	A/m
H_c	Coercive field strength	A/m
h	Hysteresis coefficient of material	10^{-6} cm/A
h/μ_i^2	Relative hysteresis coefficient	10^{-6} cm/A
I	RMS value of current	A
I_{DC}	Direct current	A
$\hat{I}$	Peak value of current	A
J	Polarization	Vs/m^2
k	Boltzmann constant	J/K
k_3	Third harmonic distortion	
k_{3c}	Circuit third harmonic distortion	
L	Inductance	H = Vs/A

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	Ω
R_{Cu}	Copper (winding) resistance (f = 0)	Ω
R_h	Hysteresis loss resistance of a core	Ω
ΔR_h	R_h change	Ω
R_i	Internal resistance	Ω
R_p	Parallel loss resistance of a core	Ω
R_s	Series loss resistance of a core	Ω
R_{th}	Thermal resistance	K/W
R_V	Effective loss resistance of a core	Ω
s	Total air gap	mm
T	Temperature	°C
ΔT	Temperature difference	K
T_C	Curie temperature	°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 $H \to 0$	
$\tan \delta_e$	Relative loss factor	
$\tan \delta_h$	Hysteresis loss factor	
$\tan \delta/\mu_i$	Relative loss factor of material at $H \to 0$	
U	RMS value of voltage	V
$\hat{U}$	Peak value of voltage	V
V_e	Effective magnetic volume	mm^3
Z	Complex impedance	Ω
Z_n	Normalized impedance $\lvert Z\rvert_n = \lvert Z\rvert / N^2 \times \Sigma (l_e/A_e)$	Ω/mm

Symbols and terms

Symbol	Meaning	Unit
α	Temperature coefficient (TK)	1/K
α_F	Relative temperature coefficient of material	1/K
α_e	Temperature coefficient of effective permeability	1/K
ε_r	Relative permittivity	
Φ	Magnetic flux	Vs
η	Efficiency of a transformer	
η_B	Hysteresis material constant	mT^{-1}
η_i	Hysteresis core constant	$A^{-1}H^{-1/2}$
λ_s	Magnetostriction at saturation magnetization	
μ	Relative complex permeability	
μ_0	Magnetic field constant	Vs/Am
μ_a	Relative amplitude permeability	
μ_{app}	Relative apparent permeability	
μ_e	Relative effective permeability	
μ_i	Relative initial permeability	
μ_p'	Relative real (inductive) component of $\overline{\mu}$ (for parallel components)	
μ_p''	Relative imaginary (loss) component of $\overline{\mu}$ (for parallel components)	
μ_r	Relative permeability	
μ_{rev}	Relative reversible permeability	
μ_s'	Relative real (inductive) component of $\overline{\mu}$ (for series components)	
μ_s''	Relative imaginary (loss) component of $\overline{\mu}$ (for series components)	
μ_{tot}	Relative total permeability derived from the static magnetization curve	
ρ	Resistivity	Ωm^{-1}
$\Sigma l/A$	Magnetic form factor	mm^{-1}
τ_{Cu}	DC time constant $\tau_{Cu} = L/R_{Cu} = A_L/A_R$	s
ω	Angular frequency; $\omega = 2\,\Pi f$	s^{-1}

All dimensions are given in mm.

SMD 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.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
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