

Ferrite Toroids

for LAN and EMI Applications

Ferrite cores rank among the indispensable key components in modern entertainment and industrial electronics, advanced information and communication technology. And what we can offer on products is just as wide-ranging as the variety of applications.

Design know-how, long time production experience and strict applied QC (quality control) are key issues – the contribution to create reliable high quality EPCOS ferrite products.

Our product line-up offers a wide range of toroids (ring cores) in different coating versions (epoxy resin or parylene coating for small cores).

Highlights

Toroids and material properties for LAN and EMI applications, e.g.

- High DC bias capability to meet requirements for LAN (T57)
- High temperature stability (T36)
- Excellent interference suppression required for line filters (T37, T38)
- Best capability to absorb interference energy at HF above 1MHz (K10)
- High permeability combined with high Curie temperature and saturation (T65)
- Highest permeability for small core volumes (T46)
- Thin parylene coating layer, but featuring outstanding high dielectric strength for small sizes
- Blue epoxy coating for both winding wire protection and high breakdown voltage

LAN (Local Area Network)

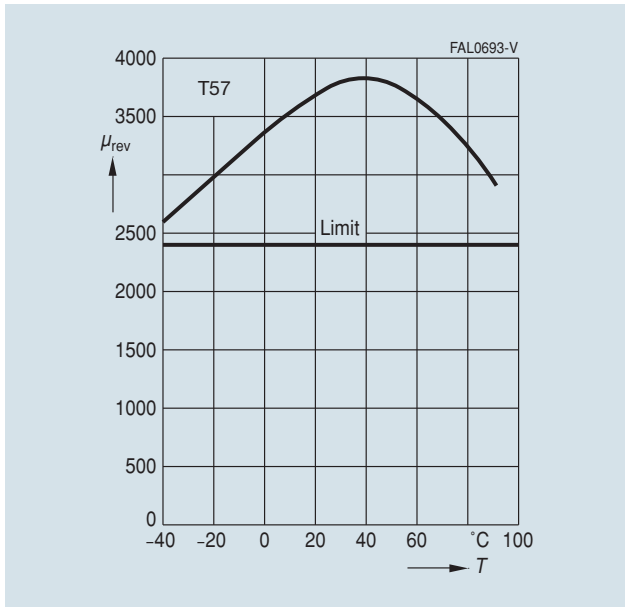


Figure 1: μ_{rev} versus temperature, measured on toroid R3.43/1.78/2.11; material T57, $f = 100$ kHz, $B = 6$ mT, $N = 26$, $H_{DC} = 27$ A/m, ($I_{DC} = 8$ mA)

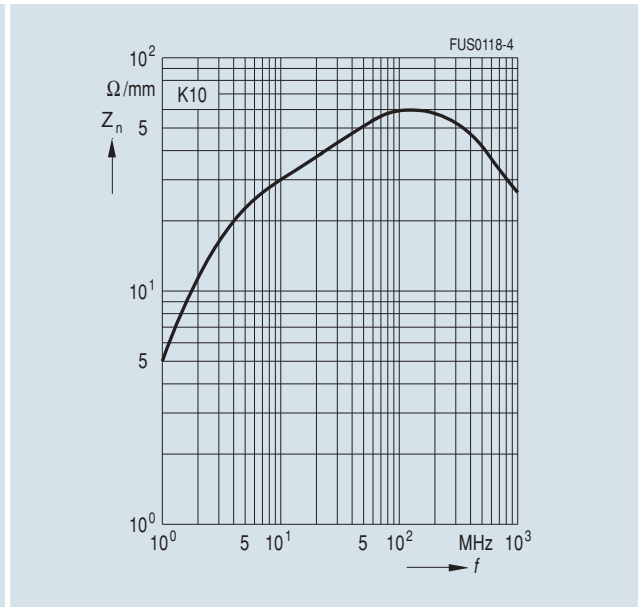


Figure 2: Normalized impedance curve, measured on toroid R10 ($N = 2$ turns)

LAN is a connection of local computers in most cases inside a building. The data transfer has to be managed in order to avoid packet collision errors. The transfer rate values between 10 Mbit/s and 100 Mbit/s.

Signal transformer

The signal 1:1 transformer, which is typically used is a small toroid. Its functions are impedance matching and network termination. Due to the restriction of space in such a LAN card in computers the core has to be the smallest possible, that still meets the inductance requirement under the given working conditions (100 kHz).

The mostly used core sizes are beginning from outer/inner diameters of 2.54/1.27 mm (0.1/0.05 inch) up to 3.94/2.24 mm (0.155/0.088 inch) with different variations of inner diameter and core height (refer also to product overview, page 6+7).

The multi-level coding of the digital waveform is not always symmetrical to the zero line. This imbalance results in an effective DC current, which is allowed to value 8 mA max. Therefore the inductance requirements of the ferrite toroid must be met under a constant DC current of 8 mA in the temperature range from 0 °C to 70 °C (indoor application).

There were inquiries of the telecom industry to use also the LAN technology for data transfer. In this case there is an outdoor application and the temperature range is extended from -40 °C to +85 °C with unchanged electrical specification.

For this application EPCOS has developed a special material T57 with an optimized DC bias performance (fig. 1).

To meet insulation requirements the toroid has to withstand 1 kV Hipot test. To protect the wire during the winding operation the ferrite cores

are coated with Parylene; achieving very high insulation resistance even by thin coating of 12.5 μm (0.0005 inch). The material data sheet specifies a breakdown voltage of 2.7 kV, if coated 12.5 μm .

Common-mode choke

For the suppression of common-mode interference in the frequency range from about 30 MHz to 300 MHz it is necessary to use current-compensated chokes in the LAN network.

The corresponding ferrite material is K10, which is a NiZn material with a permeability of approx. 700 for small Parylene coated cores. The impedance versus frequency curve of K10 is ideally adapted to the suppression requirement in the LAN network (fig. 2).

EMI (Electromagnetic Interference)

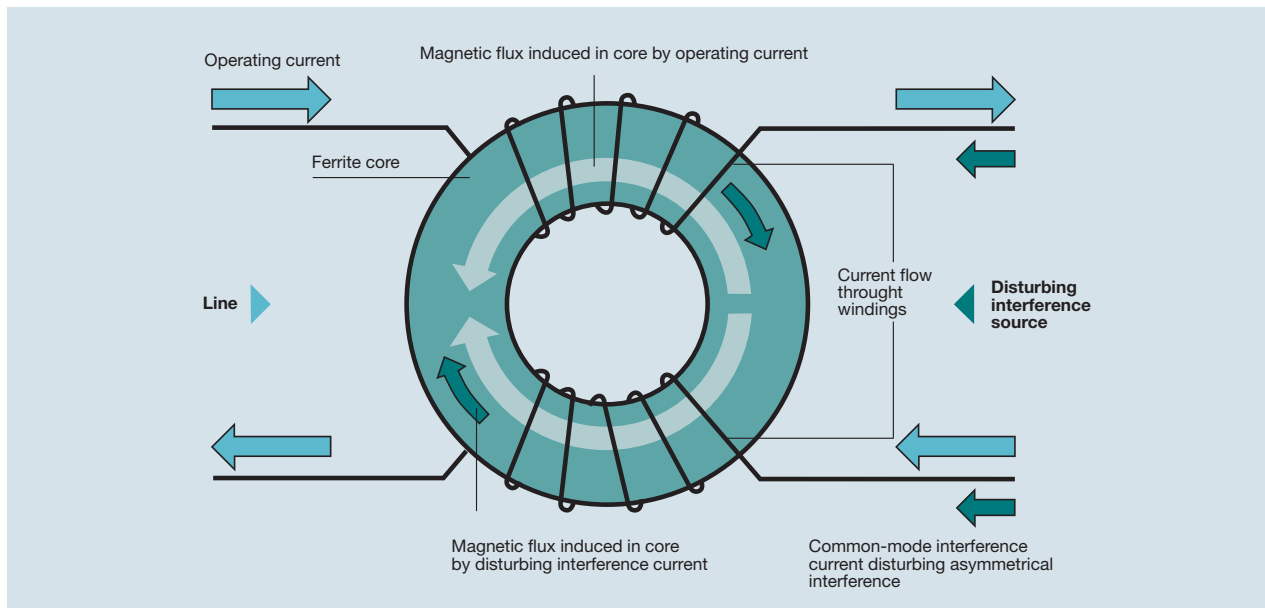


Figure 3: Current-compensated ring core choke; double choke shown as an example

Compact electrical and electronic equipment primarily generates common-mode interference. In order to be able to meet the safety requirements (keeping within the leakage current limits), chokes with a high asymmetrically effective inductance must be used.

Current-compensated chokes with a closed core topology are especially suitable for this purpose. The problem of core material saturation due to the operating current is solved in these designs by winding two coils with equal number of turns and opposite winding direction on

the core (fig.3). The flux induced by the operating current flowing through the coils is opposite each other and hence compensate each other.

The new Magnetic Design Tool of EPCOS contains the normalized impedance versus frequency curves of all ferrite materials, which are suitable for EMI applications.

Mn Ferrites

For the application as current-compensated chokes MnZn ferrites are widely used in the whole range of sizes. The advantage of the MnZn materials is the much higher perme-

ability, which can be realised together with a sufficiently high Curie temperature.

Small cores R2.5 up to R12.5 in ferrite materials N30, T38, T46 can be used for example in Telecom Networks like ISDN.

Cores of mid range sizes from R13.3 to R26 are used as chokes in power lines usually in electronic ballasts in lamps, switch-mode power supplies in TV sets, washing machines and chargers.

Ferrite materials:
N30, T65, T35, T36, T37, T38, T46

EMI (Electromagnetic Interference)

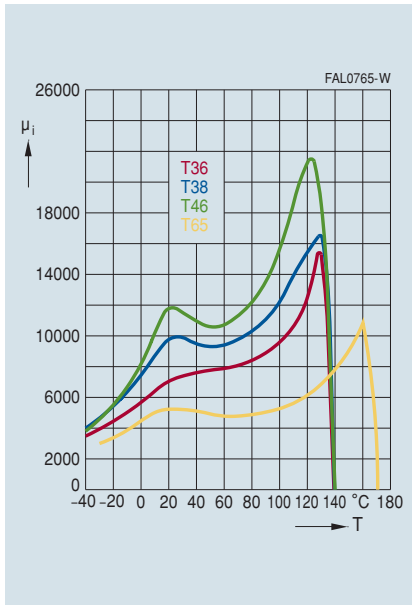


Figure 4: Initial permeability μ_i versus temperature
 T36 measured on R22, $\bar{B} \leq 0.25$ mT
 T38 measured on R10, $\bar{B} \leq 0.25$ mT
 T46 measured on R9.5, $\bar{B} \leq 0.25$ mT
 T65 measured on R29, $\bar{B} \leq 0.25$ mT

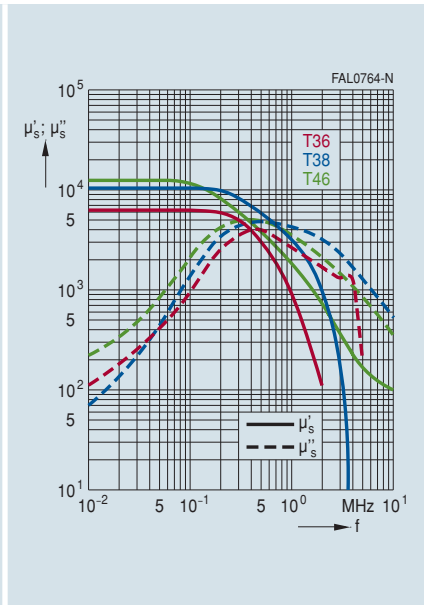


Figure 5: Complex permeability versus frequency
 T36 measured on R22, $\bar{B} \leq 0.25$ mT
 T38 measured on R10, $\bar{B} \leq 0.25$ mT
 T46 measured on R9.5, $\bar{B} \leq 0.25$ mT

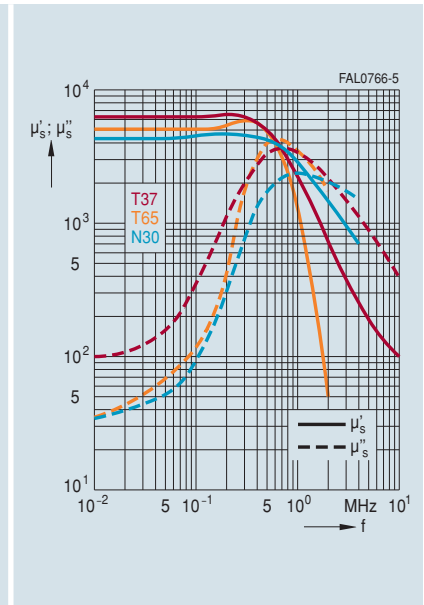


Figure 6: Complex permeability versus frequency
 N30 measured on R10, $\bar{B} \leq 0.25$ mT
 T37 measured on R16, $\bar{B} \leq 0.25$ mT
 T65 measured on R29, $\bar{B} \leq 0.25$ mT

The usage for core sizes R34 and bigger are in industrial applications, in filters for frequency converters (lifts, pumps, traction systems, conveyer systems, air conditioning systems), general-purpose application in power electronics, UPS and wind farms.

Especially for high temperature or/ and high current application in these fields our material T65 is the most suitable because of its high saturation flux density of 460 mT and high Curie temperature of >160 °C. The initial permeability on big cores is about 4500 to 5000.

If there is not especially high current or high temperature applied, we recommend to use our materials N30 ($\mu_i=4300$) and T37 (μ_i approx. 5500 to 6000 on big cores). The choice of material depends on the frequency

range, which has to be covered by the attenuation. This is determined by the characteristic of μ .

NiZn Ferrites

Toroidal cores of NiZn ferrites are especially suitable for the suppression of high frequency interference, because of the high ohmic resistance of these materials (approx. $10^5 \Omega\text{m}$).

Therefore the negative effect of eddy current is negligible and the usage of these materials allow relatively high impedance values even at frequency well above 100 MHz.

There is a limiting factor to create NiZn ferrites with higher initial permeability, because with increasing permeability the Curie temperature decreases. For example the Curie

temperature for a NiZn ferrite of $\mu_i=2300$ (M13) is specified > 105 °C, which is at the limit for many applications.

An application example in the automotive sector is the CAN bus choke, where core sizes from outer diameter 2.5 mm to 6.3 mm (0.1 to 0.29 inch) in material K10 are used. As the transmission frequencies in the telecom industry are rising, it is also expected, that the demand for NiZn ferrites will grow.

Another application example for NiZn ferrite toroids is the usage of cores alone on component leads or in board level circuitry either to prevent any parasitic oscillations or to attenuate unwanted signal pickup or transmissions which might travel along component leads or interconnecting wires, traces, or cables.

Coatings for Toroids

Coating versions		
	Epoxy (blue)	Parylene (transparent)
Main application	Medium/big sizes ($\geq R9.53$)	Small sizes ($< R9.53$)
Layer thickness	< 0.4 mm	0.012 or 0.025 mm
Breakdown voltage (minimum values)	> 1.0 kV (for R9.53; R10) > 1.5 kV (for R12.5 thru R20) > 2.0 kV (for $> R20$)	> 1 kV (standard value)
Mechanical quality	High firmness	Smooth surface
Maximum temperature (short-time)	approx. 180 °C	approx. 130 °C
Advantage	Low influence on A_L value	Very low thickness
UL rating	UL 94 V-0	UL 94 V-0
Ordering code	B64290L ...	B64290P ...

The coating of ferrite toroids is necessary to create an insulation barrier between wire and ferrite core (direct winding on the core without coil former), in order to avoid a short circuit, because the MnZn ferrite materials have relatively low ohmic resistance (approx. 1 to 10 Ωm).

Another point is, that ferrite is a very hard ceramic material, which could damage the insulation of the wire during the winding process.

Epoxy coating (blue)

Epoxy is applied by electrostatic powder coating process to be carried out very careful.

Parylene coating

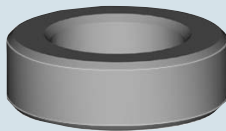
Parylene is widely used and well known. This is a protective polymer material called di-para-xylylene C.

Parylene is applied by a vacuum process at ambient temperature and provides a non-reactive pin-hole-free barrier.

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.

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



Product Overview

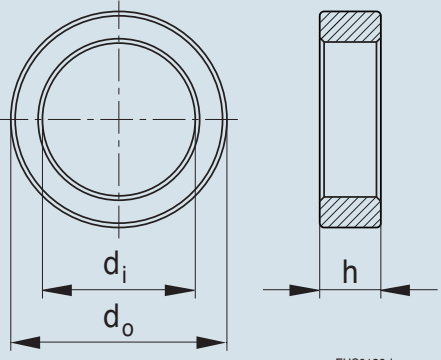
Technical data														
Type Toroid size (d _o x d _i x h) (Outer diameter x inner diameter x height) mm		Material (Code number for ordering code, Block 3)												
		A _L values (nH) / approx. initial permeability μ _i												
		K10 (X010)		N30 (X830)		T57 (X057)		T65 (X065)		T35 (X035)		T37 (X037)		
inch		A _L	μ _i	A _L	μ _i	A _L	μ _i	A _L	μ _i	A _L	μ _i	A _L	μ _i	
R 2.50 x 1.50 x 1.00	R 0.098 x 0.059 x 0.039	70	700			410	4000	470	4600					
R 2.54 x 1.27 x 1.27	R 0.100 x 0.050 x 0.050	120	700			690	3900	800	4500					
R 3.05 x 1.27 x 1.27	R 0.120 x 0.050 x 0.050	160	700			830	3700	1000	4500					
R 3.05 x 1.27 x 2.54	R 0.120 x 0.050 x 0.100	330	700			1700	3800	2000	4500					
R 3.05 x 1.78 x 2.03	R 0.120 x 0.070 x 0.080	160	700			870	4000	1000	4600					
R 3.43 x 1.78 x 1.78	R 0.135 x 0.070 x 0.070	160	700			930	4000	1050	4500					
R 3.43 x 1.78 x 2.03	R 0.135 x 0.070 x 0.080	190	700			1060	4000	1200	4500					
R 3.43 x 1.78 x 2.11	R 0.135 x 0.070 x 0.083	200	700			1100	4000	1300	4700					
R 3.94 x 1.78 x 1.78	R 0.155 x 0.070 x 0.070	200	700			1100	3900	1350	4800					
R 3.94 x 2.24 x 1.30	R 0.155 x 0.088 x 0.051	100	700			550	3800	700	4800					
R 4.00 x 2.40 x 1.60	R 0.157 x 0.094 x 0.063			700	4300			750	4600					
R 5.84 x 3.05 x 3.00	R 0.230 x 0.120 x 0.118			1680	4300			1800	4600					
R 6.30 x 3.80 x 2.50	R 0.248 x 0.150 x 0.098			1090	4300			1160	4600					
R 8.00 x 4.00 x 4.00	R 0.315 x 0.158 x 0.158			2400	4300			2550	4600					
R 9.53 x 4.75 x 3.17	R 0.375 x 0.187 x 0.125			1900	4300			2050	4600	2650	6000			
R 10.0 x 6.00 x 4.00	R 0.394 x 0.236 x 0.157			1760	4300			1900	4700	2460	6000	2660	6500	
R 12.5 x 7.50 x 5.00	R 0.492 x 0.295 x 0.197			2200	4300			2400	4700	3060	6000	3320	6500	
R 12.7 x 7.90 x 6.35	R 0.500 x 0.311 x 0.250			2600	4300			2850	4700	3620	6000	3920	6500	
R 13.3 x 8.30 x 5.00	R 0.524 x 0.327 x 0.197			2030	4300			2300	4900	2830	6000	3060	6500	
R 14.0 x 9.00 x 5.00	R 0.551 x 0.354 x 0.197			1900	4300			2300	5200	2650	6000	2880	6500	
R 15.0 x 10.4 x 5.30	R 0.591 x 0.409 x 0.209			1670	4300			2020	5200	2330	6000	2520	6500	
R 15.8 x 8.90 x 4.70	R 0.622 x 0.350 x 0.185			2320	4300			2800	5200	3240	6000	3500	6500	
R 16.0 x 9.60 x 6.30	R 0.630 x 0.378 x 0.248			2770	4300			3350	5200	3870	6000	4190	6500	
R 17.0 x 10.7 x 6.80	R 0.669 x 0.421 x 0.268			2710	4300			3250	5200	3770	6000	4080	6500	
R 18.4 x 5.90 x 5.90	R 0.724 x 0.232 x 0.232			5770	4300			6680	5000	8020	6000	8690	6500	
R 20.0 x 10.0 x 7.00	R 0.787 x 0.394 x 0.276			4160	4300			5050	5200	5000	5100	6280	6500	
R 22.1 x 13.7 x 6.35	R 0.870 x 0.539 x 0.250			2610	4300			3160	5200	3200	5300	3950	6500	
R 22.1 x 13.7 x 7.90	R 0.870 x 0.539 x 0.311			3250	4300			3930	5200	4000	5300	4900	6500	
R 22.1 x 13.7 x 12.5	R 0.870 x 0.539 x 0.492			5140	4300			6200	5200	6000	5000	7770	6500	
R 22.6 x 14.7 x 9.20	R 0.890 x 0.579 x 0.362			3420	4300			4100	5200	4200	5300	5170	6500	
R 25.3 x 14.8 x 10.0	R 0.996 x 0.583 x 0.394			4620	4300			5350	5000	5400	5000	6970	6500	
R 25.3 x 14.8 x 15.0	R 0.996 x 0.583 x 0.590			6930	4300			8000	5000			10460	6500	
R 25.3 x 14.8 x 20.0	R 0.996 x 0.583 x 0.787			9160	4300			10600	5000	10700	5000	13800	6400	
R 29.5 x 19.0 x 14.9	R 1.142 x 0.748 x 0.587			5630	4300			6800	5200			8500	6500	
R 30.5 x 20.0 x 12.5	R 1.201 x 0.787 x 0.492			4540	4300			5400	5100			6400	6100	
R 34.0 x 20.5 x 10.0	R 1.339 x 0.807 x 0.394			4360	4300			5100	5000			6100	6000	
R 34.0 x 20.5 x 12.5	R 1.339 x 0.807 x 0.492			5460	4300			6400	5000			7600	6000	
R 36.0 x 23.0 x 15.0	R 1.417 x 0.906 x 0.591			5750	4300			6700	5000			8000	6000	
R 38.1 x 19.05 x 12.7	R 1.500 x 0.750 x 0.500			7570	4300			8800	5000			10500	6000	
R 40.0 x 24.0 x 16.0	R 1.575 x 0.945 x 0.630			7000	4300			8200	5000			9800	6000	
R 41.8 x 26.2 x 12.5	R 1.646 x 1.031 x 0.492			5000	4300			5800	5000			7000	6000	
R 50.0 x 30.0 x 20.0	R 1.969 x 1.181 x 0.787			8700	4300			10000	4900			12000	6000	
R 58.3 x 32.0 x 18.0	R 2.295 x 1.260 x 0.709			9300	4300							13000	6000	
R 58.3 x 40.8 x 17.6	R 2.295 x 1.606 x 0.693			5400	4300			6250	5000			7160	5700	
R 58.3 x 40.8 x 20.2	R 2.295 x 1.606 x 0.795			6200	4300			7200	5000			8000	5600	
R 63.0 x 38.0 x 25.0	R 2.480 x 1.496 x 0.984			10800	4300			12600	5000			13900	5500	
R 68.0 x 48.0 x 13.0	R 2.677 x 1.890 x 0.512			3890	4300			4500	5000			5000	5500	
R 87.0 x 54.3 x 13.5	R 3.425 x 2.138 x 0.531			5400	4300			6280	5000			7000	5500	
R 102 x 65.8 x 15.0	R 4.016 x 2.591 x 0.591			5500	4200			6500	5000					
R 140 x 103 x 25.0	R 5.512 x 4.055 x 0.984			6200	4000									
R 202 x 153 x 25.0	R 7.953 x 6.024 x 0.984			5200	3700									
Tolerance of A _L value		± 25%		± 25%		± 25%		± 30%		± 25%		± 25%		

Product Overview

						Ordering code			Magnetic characteristics				Approx. weight
T38 (X038)		T46 (X046)		N87 (X087)		Block 1	Block 2	Block 3	$\Sigma I/A$ mm ⁻¹	I_e mm	A_e mm ²	V_e mm ³	g
A_L	μ_i	A_L	μ_i	A_L	μ_i								
1020	10000	1530	15000			B64290	P0035	X***	12.30	6.02	0.49	3.0	0.02
1760	10000	2640	15000			B64290	P0734	X***	7.14	5.53	0.77	4.29	0.03
2200	9900	3340	15000			B64290	P0683	X***	5.65	5.99	1.06	6.4	0.04
4200	9400	6500	15000			B64290	P0739	X***	2.82	5.99	2.12	12.7	0.08
2150	9900	3250	15000			B64290	P0733	X***	5.75	7.23	1.26	9.1	0.06
2300	10000	3400	15000			B64290	P0731	X***	5.38	7.63	1.42	10.7	0.06
2650	10000	4000	15000			B64290	P0745	X***	4.72	7.63	1.62	12.2	0.07
2770	10000	4000	15000			B64290	P0709	X***	4.54	7.63	1.68	12.7	0.07
2830	10000	4200	15000			B64290	P0732	X***	4.44	8.10	1.82	14.8	0.08
1470	10000	2200	15000			B64290	P0061	X***	8.56	9.21	1.08	9.9	0.05
1630	10000	2450	15000			B64290	P0036	X***	7.96	9.63	1.25	12.0	0.05
3900	10000	5850	15000			B64290	P0687	X***	3.22	13.03	4.04	52.6	0.3
2530	10000	3600	14000	560	2200	B64290	P0037	X***	4.97	15.21	3.06	46.5	0.2
5500	10000	8000	15000	1200	2200	B64290	P0751	X***	2.26	17.42	7.70	134	0.7
4410	10000	6400	15000	970	2200	B64290	L0062	X***	2.85	20.72	7.28	151	0.8
4090	10000	6000	15000	900	2200	B64290	L0038	X***	3.07	24.07	7.83	188	0.9
5110	10000			1120	2200	B64290	L0044	X***	2.46	30.09	12.23	368	1.8
6030	10000			1330	2200	B64290	L0742	X***	2.08	31.17	14.96	466	2.4
4700	10000			1040	2200	B64290	L0644	X***	2.67	32.70	12.27	401	1.8
4420	10000			970	2200	B64290	L0658	X***	2.84	34.98	12.30	430	2.0
3880	10000			850	2200	B64290	L0623	X***	3.24	39.02	12.05	470	2.4
5400	10000			1190	2200	B64290	L0743	X***	2.33	36.75	15.78	580	3.0
6440	10000			1420	2200	B64290	L0045	X***	1.95	38.52	19.73	760	3.7
6280	10000			1390	2200	B64290	L0652	X***	2.00	42.00	21.04	884	4.4
13400	10000			2950	2200	B64290	L0697	X***	0.94	31.03	33.14	1029	6.9
9740	10000			2130	2200	B64290	L0632	X***	1.30	43.55	33.63	1465	7.6
6070	10000			1340	2200	B64290	L0638	X***	2.07	54.15	26.17	1417	6.8
7570	10000			1660	2200	B64290	L0719	X***	1.66	54.15	32.55	1763	8.4
12000	10000			2630	2200	B64290	L0651	X***	1.05	54.15	51.15	2789	14
7900	10000			1740	2200	B64290	L0626	X***	1.59	56.82	35.78	2033	9.8
10700	10000			2360	2200	B64290	L0618	X***	1.17	60.07	51.26	3079	16
16100	10000			3500	2200	B64290	L0615	X***	0.78	60.07	76.89	4619	24
21300	10000			4680	2200	B64290	L0616	X***	0.59	60.07	102.5	6157	33
13100	10000			2880	2200	B64290	L0647	X***	0.96	73.78	76.98	5680	27
10600	10000			2320	2200	B64290	L0657	X***	1.19	77.02	64.66	4980	25
10100	10000			2230	2200	B64290	L0058	X***	1.24	82.06	66.08	5423	27
12700	10000			2790	2200	B64290	L0048	X***	0.99	82.06	82.60	6778	33
13500	10000			2940	2200	B64290	L0674	X***	0.94	89.65	95.89	8597	43
17600	10000			3870	2200	B64290	L0668	X***	0.71	82.97	116.2	9644	52
				3590	2200	B64290	L0659	X***	0.77	96.29	125.3	12070	61
				2560	2200	B64290	L0022	X***	1.08	103.0	95.75	9862	50
				4460	2200	B64290	L0082	X***	0.62	120.4	195.7	23560	120
				4800	2200	B64290	L0043	X***	0.58	134.0	230.0	30710	160
				2760	2200	B64290	L0040	X***	1.00	152.4	152.4	23230	115
				3200	2200	B64290	L0042	X***	0.87	152.4	174.9	26660	130
				5000	2200	B64290	L0699	X***	0.50	152.1	305.9	46530	240
				1990	2200	B64290	L0696	X***	1.39	178.6	128.7	22980	115
				2790	2200	B64290	L0730	X***	0.99	213.9	216.7	46360	235
				2880	2200	B64290	L0084	X***	0.96	255.3	267.2	68220	330
						B64290	A0705	X830	0.82	375.8	458.9	172440	860
						B64290	A0711	X830	0.90	550.5	608.6	335030	1600
± 30%		± 30%		± 25%									

Compilation of ordering code see page 8 ►

General

Dimensional drawing	Compilation of ordering code
 <p>FUS0138-I</p>	<p>B64290L0668X065</p> <p>Block 1 Ferrite toroid</p> <p>Block 2 Coating material: Parylene P Epoxy L no coating A Type coded</p> <p>Block 3 X = Dummy character Code number for material</p>

Toroidal cores for EMC and LAN applications

Toroidal cores 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 K 10; other materials upon request.

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

- R2.5 through R12.5 for telecommunications, e.g. ISDN. Materials: N30, T38, T46 (through R6.3)
- R13.3 through R26 for power line chokes. Materials: N30, T65, T35
- > R34 for chokes and filters in industrial use. Material: T65

Important information: 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. We expressly point out that these statements cannot be regarded as binding statements about the suitability of our products for a particular customer application. It is incumbent on the customer to check and decide whether a product is suitable for use in a particular application. This publication is only a brief product survey which may be changed from time to time. Our products are described in detail in our data sheets. The Important Notes (www.epcos.com/ImportantNotes) and the product-specific warnings and cautions must be observed. All relevant information is available through our sales offices.