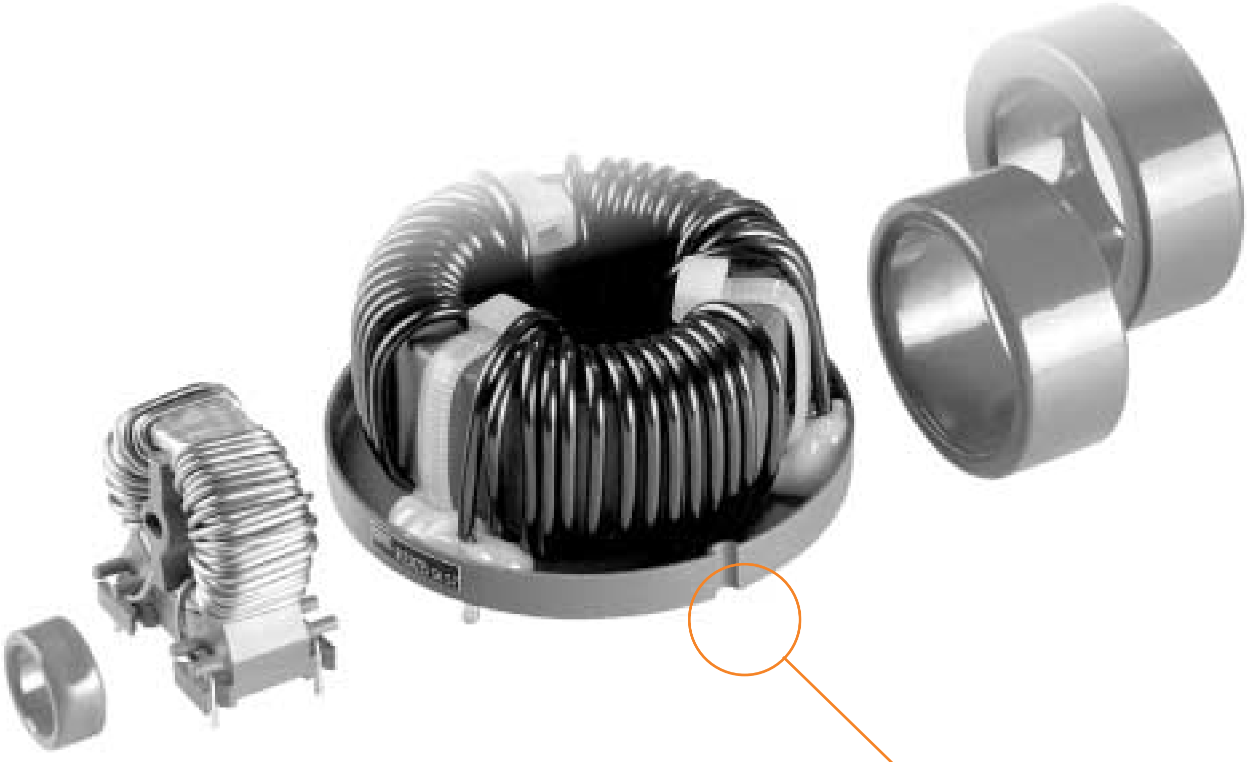


NANOCRYSTALLINE VITROPERM EMC COMPONENTS

ADVANCED MATERIALS – THE KEY TO PROGRESS

VACUUMSCHMELZE

NANOCRYSTALLINE VITROPERM® EMC COMPONENTS

VACUUMSCHMELZE GmbH & Co. KG (VAC) is one of the worldwide leading manufacturers of metallic materials and inductive components manufactured from these alloys. In the field of electromagnetic compatibility (EMC), VAC has been supplying high performance products for more than 20 years.

THE NEW COMMON MODE CHOKE SERIES

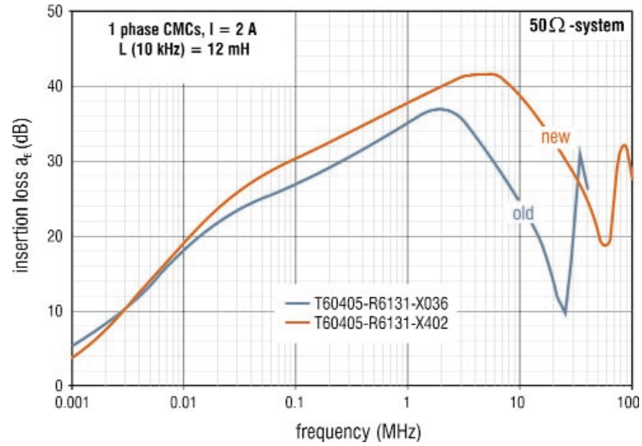
VAC has designed a new standard series of common mode chokes (CMCs). In addition to the well known superior properties at low and medium frequencies these chokes have an optimized performance in the high frequency range.

THE VITROPERM-APPROACH

Starting with something good can end in something even better.
Some years ago we have started our choke designs with nanocrystalline cores – certainly the best-performance material available for this application.
Additionally to the well known high attenuation in the NF range our new standard CMCs show an enhanced attenuation in the HF range. This offers a distinguished broadband behaviour which makes a single instead of a dual choke approach a real option, and enables stable and easy-to-achieve solutions.

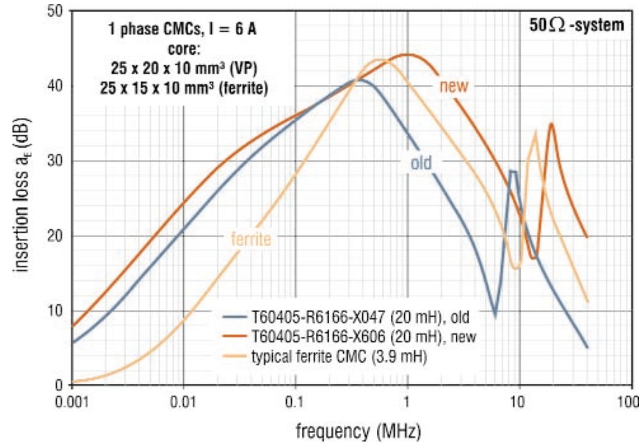
HF-Properties

Fig. 1:
Improved HF attenuation.
The performance in the HF range has been improved by optimized design and core material.



Broadband Behaviour

Fig. 2:
Optimized to application.
Due to the improved HF performance the attenuation characteristic exceeds that of a typical ferrite choke over the whole frequency range.



VITROPERM: 1st CHOICE FOR CMC CORES

VITROPERM 500F – the new Fe-based nanocrystalline soft magnetic high tech material is the universal solution for a wide range of EMC problems.
Ideal solutions are thus available for practically every EMC problem. The most important applications for our common mode chokes (CMC) are:

- Switched Mode Power Supplies (SMPS)
- Uninterruptable Power Supplies (UPS)
- Welding Machines
- Inverter (e.g. photovoltaic applications)
- Frequency Converters

VITROPERM 500F – TYPICAL DATA

Saturation flux density	B_S	1.2 T
Coercivity (static)	H_C	< 3 A/m
Saturation magnetostriction	λ_S	$10^{-8} \ldots 10^{-6}$
Electrical resistivity	ρ	115 $\mu\Omega$cm
Curie temperature	T_C	> 600 °C
Upper operation temperature	T_{max}	
continuous		120…150 °C *)
short time		180 °C *)
Permeability	μ_i	10000... 150000
Core losses (100 kHz, 0.3 T)	P_{Fe}	80 W/kg

*) please consult VAC for detailed information on the temperature limits of our casing and coating materials

BENEFITS OF NANOCRYSTALLINE CMCs

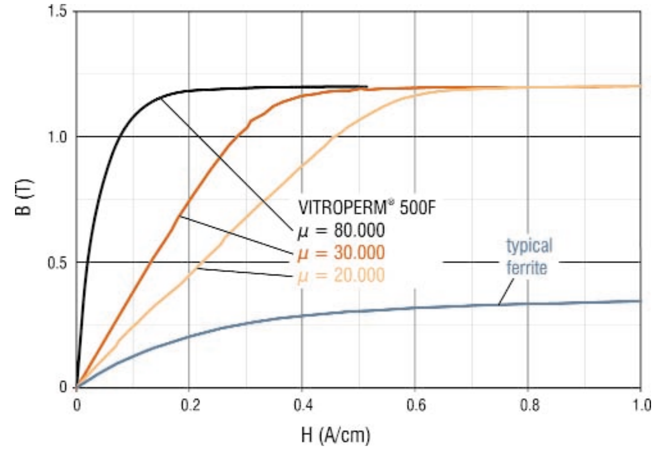
High permeability μ	→ small choke size → high attenuation at low frequencies → fewer turns → low winding capacitance → low conducting losses
Different permeability ranges	→ adaptable to different common mode currents e.g. for SMPS (high μ) or drives (low or medium μ)
Smooth permeability decrease towards high frequencies	→ high attenuation at high frequencies. Above the limit frequency: $\mu \leftrightarrow \frac{1}{\sqrt{f}}$ (ferrites: $\mu \leftrightarrow \frac{1}{f}$) Although the permeability drops by a factor of 3…4 with each frequency decade, the attenuation still rises by roughly 10 dB per decade
High maximum operating temperature	→ operation at high ambient temperatures possible → small size → mounting position is not critical
Small temperature drift of μ, B_S, λ_S	→ temperature independent attenuation properties
Very high saturation flux density B_S	→ high common mode current tolerance (bias current, unbalanced current, noise) → small size
Low Q-factor in the 150 kHz – range	→ broadband attenuation → absorption of noise energy in the core prevents its circulation within the filter
High linearity of magnetization characteristic	→ constant impedance over a wide common mode current range
Very low magnetostriction	→ insensitivity to mechanical stress → no acoustic noise in LF region

VITROPERM VS. FERRITES

VITROPERM has different properties compared to MnZn ferrites. This has to be considered in filter design. The relevant physical and magnetic properties are shown in the following diagrams.

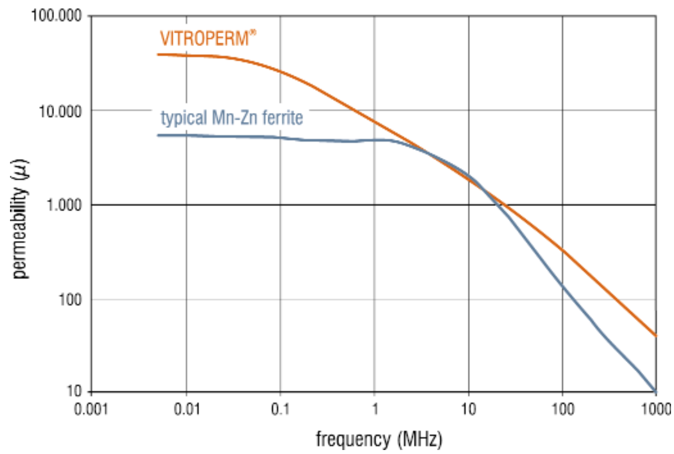
Magnetization Characteristic

Fig. 3: B(H)
Magnetization characteristics of VITROPERM 500F in comparison with a typical MnZn ferrite. Please note the difference in B_S: 1.2 T (VITROPERM 500F) vs. 0.43 T (Ferrite).



Permeability: Frequency Response

Fig. 4: μ(f)
Frequency response of the permeability of VITROPERM 500F (μ=80000) in comparison with a typical MnZn ferrite (μ=5000). A high attenuation choke requires a high impedance. This can be better achieved by using a high permeability core material than by a high number of turns. A low number of turns leads to a low winding capacitance which gives an improved high frequency performance.

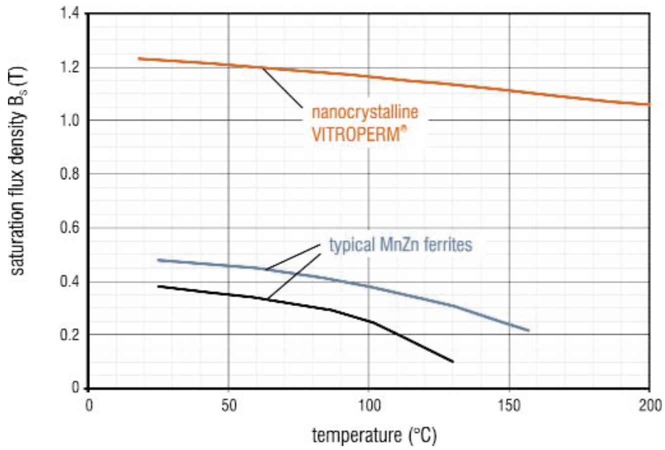


Saturation Flux Density

Fig. 5: $B_s(T)$

The saturation flux density of VITROPERM 500F drops by only 8 % from room temperature to 100 °C (1.23 T ⟶ 1.15 T), while the ferrite decreases by 40 % in the same temperature range (0.43 T ⟶ 0.26 T). Due to the high Curie temperature of more than 600 °C the maximum operating temperature of VITROPERM 500F is 150 °C *) and for a limited time even 180 °C *). For typical ferrites the operating temperature is limited to 100…120 °C.

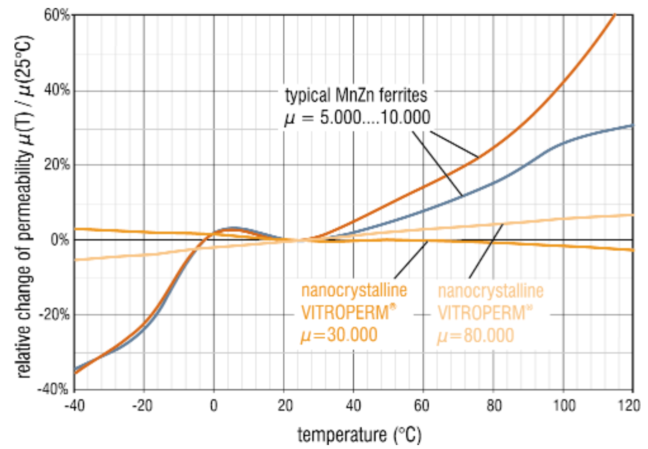
*) please consult VAC for detailed information on the temperature limits of our casing and coating materials



Permeability: Temperature Dependence

Fig. 6: $\mu(T)$

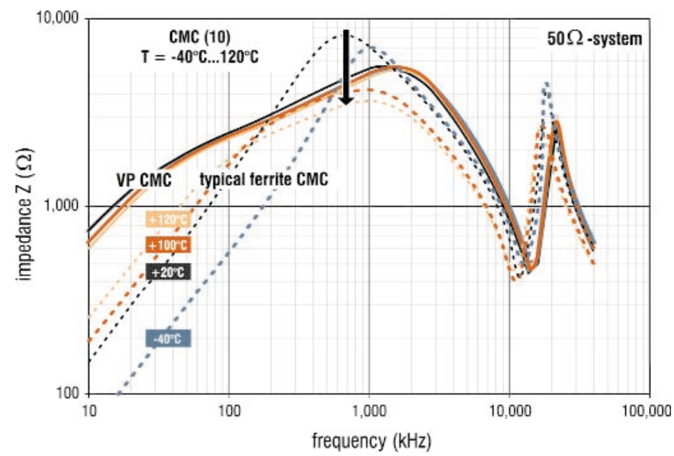
VITROPERM 500F has a small temperature dependence of the permeability in comparison to ferrites which show a strong variation over temperature.



Insertion Loss: Temperature Dependence

Fig. 7: aE(f)

The attenuation characteristic of a VITROPERM 500F choke is almost independent of temperature, while a typical ferrite choke shows a strong variation in the magnitude of attenuation, the self resonance frequency and the Q-factor.



DESIGN ADVANTAGES WITH VITROPERM 500F

The superior material properties of VITROPERM 500F enable a high inductance/impedance of a common mode choke with a moderate number of turns. This leads to low copper losses, small winding capacitance and an excellent HF performance.

Due to the high initial permeability, low winding capacitance and a low Q-factor (above 100 kHz) common mode chokes with VITROPERM 500F cores typically have a broadband behaviour of insertion loss from 10 kHz up to several MHz.

The insertion loss of common mode chokes made of VITROPERM 500F and ferrite with similar core dimensions and the same number of turns are demonstrated in figure 8. VITROPERM chokes offer a distinct broadband behaviour from some kHz up to the high MHz range enabling an easy design approach.

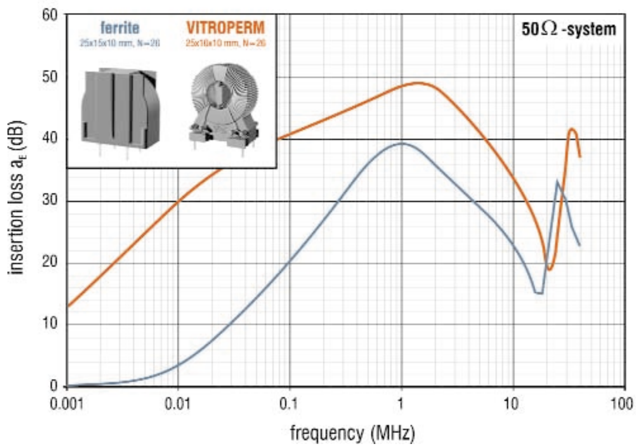
Better attenuation properties and a higher operational temperature range allow a reduction of component volume by up to a factor of 3 or more under similar nominal data (see figure 9). Note that the insertion loss characteristic of the small VITROPERM choke in figure 9 performs similar to that of ferrite material at frequencies of about 600 – 900 kHz and is superior below 500 kHz and above about 1 MHz.

The excellent attenuation of VITROPERM 500F chokes can help to simplify the whole filter design for the whole frequency range.

For laboratory tests VAC offers an EMC-Kit with selected standard cores and chokes.

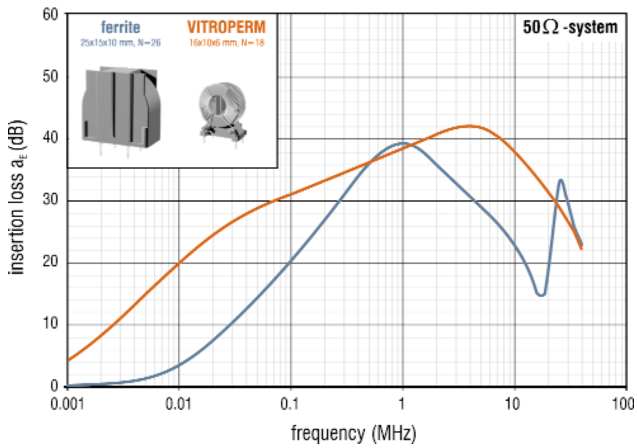
Comparison VITROPERM – Ferrite

Fig. 8:
Comparison of insertion loss characteristic of CMCs with VITROPERM 500F core (red curve) and ferrite core (blue curve) of similar size and with the same number of turns.



Comparison VITROPERM – Ferrite

Fig. 9:
Comparison of insertion loss characteristic of CMCs with VITROPERM 500F core (red curve) and ferrite core (blue curve) of similar performance in the MHz range.



STANDARD CORE SERIES

Our VITROPERM 500F cores are available in different A_L-value ranges. This makes them suitable for different common mode currents. Common mode currents can be noise, bias currents but first of all unbalanced currents. The higher A_L-values are designated for typical single phase applications with low unbalanced currents (e.g. SMPS). The lower A_L-values better suit to high power three phase applications with high unbalanced currents (e.g. frequency converters with long motor cables).

NANOCRYSTALLINE VITROPERM 500F TAPE WOUND CORES / EPOXY COATED, MORE WINDING SPACE

core dimensions d_{out} x d_{in} x h mm	finished dimensions OD mm	ID mm	H mm	cross-section A_{Fe} cm^2	mean path-length l_{Fe} cm	A_L*) (10 kHz) nominal value* µH	A_L*) (100 kHz) µH	part number T6000…
16 x 12.5 x 6	17.8	10.7	8	0.08	4.48	6.0	3.9	4-L2016-W619
						15	4.8	4-L2016-W620
22 x 17 x 6	24.0	15.2	8.0	0.12	6.1	16.4	≥ 3.2	4-L2022-W867
22 x 17 x10	24.0	15.2	12.3	0.20	6.1	27.4	≥ 5.3	4-L2022-W868
25 x 20 x 10	27.3	17.5	12.3	0.19	7.1	9.0	5.8	4-L2025-W621
						22.5	7.2	4-L2025-W622
30 x 20 x 10	32.5	17.8	12.5	0.40	7.85	18.8	t.b.d.**)	4-L2030-W483
						56	13.4	4-L2030-W911
30 x 25 x 15	32.3	22.7	17.5	0.27	8.64	6.8	5.1	4-L2030-W675
						26.5	8.5	4-L2030-W676
40 x 32 x 15	42.3	29.1	17.8	0.438	11.3	13.0	8.4	4-L2040-W623
						32.5	10.3	4-L2040-W624
45 x 32 x 15	47.3	29.8	17.8	0.71	12.1	19.7	12.8	4-L2045-W886
50 x 40 x 20	52.3	37.1	22.8	0.73	14.1	11.2	10.0	4-L2050-W583
						17.0	11.2	4-L2050-W625
63 x 50 x 20	65.5	46.6	22.8	0.95	17.8	11.5	10.4	4-L2063-W721
						18.0	11.6	4-L2063-W627
80 x 63 x 20	83	59.5	22.8	1.24	22.5	11.9	10.7	4-L2080-W722
						18.5	12.0	4-L2080-W628
100 x 80 x 20	104	75	23	1.46	28.3	11.2	10.0	4-L2100-W723
						17.3	11.2	4-L2100-W629
130 x 100 x 25	134.5	95	28.5	2.74	36.1	16.4	14.7	4-L2130-W587
						25.4	16.5	4-L2130-W630
160 x 130 x 25	165	125	28.5	2.74	45.6	13.0	11.7	4-L2160-W720
						20.0	13.1	4-L2160-W631

*) A_L = inductance for N = 1 (tolerance +45 % / -25 %)

**) = to be defined

The epoxy coating is generally suitable for direct winding. However, we recommend additional isolation between core and winding for enhanced isolation requirements. The epoxy coating meets UL94-V0, UL file no: E214934.

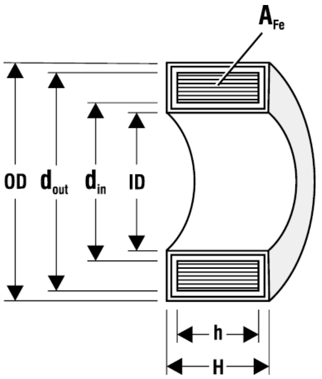
NANOCRYSTALLINE VITROPERM 500F TAPE WOUND CORES / PLASTIC CASE, HIGHER RUGGEDNESS

core dimensions d_{out} x d_{in} x h mm	finished dimensions OD mm	ID mm	H mm	cross-section A_{Fe} cm^2	mean path-length l_{Fe} cm	A_L*) (10 kHz) nominal value* µH	A_L*) (100 kHz) µH	part number T6000…
9.8 x 6.5 x 4.5	11.2	5.1	5.8	0.059	2.56	25.5	6.4	6-L2009-W914
						≥ 5.8	t.b.d.**)	6-L2009-W651
12 x 8 x 4.5	14.1	6.6	6.3	0.072	3.14	28.0	t.b.d.	6-L2012-W902
12.5 x 10 x 5	14.0	8.5	6.7	0.050	3.53	10.0	t.b.d.	6-L2012-W498
15 x 10 x 4.5	17.1	7.9	6.5	0.090	3.93	27.0	t.b.d.	6-L2015-W865
16 x 10 x 6	17.8	8.6	8.0	0.140	4.10	41.4	t.b.d.	6-L2016-W403
						11.7	t.b.d.	6-L2016-W308
17.5 x 12.6 x 6	19.0	11.0	8.0	0.118	4.73	30.0	t.b.d.	6-L2017-W515
19 x 15 x 10	21.2	13.0	12.3	0.160	5.34	36.1	8.8	6-L2019-W838
20 x 12.5 x 8	22.5	10.4	10.1	0.240	5.10	55.2	13.0	6-L2020-W409
						14.3	t.b.d.	6-L2020-W450
25 x 20 x 10	27.6	17.4	12.8	0.200	7.07	28.4	6.47	6-L2025-W523
25 x 16 x 10	27.8	13.7	12.7	0.360	6.44	65.5	t.b.d.	6-L2025-W380
						17.0	t.b.d.	6-L2025-W451
30 x 20 x 10	32.7	17.7	12.5	0.400	7.85	59.3	14.0	6-L2030-W423
						15.5	11.0	6-L2030-W358
40 x 32 x 15	43.1	28.7	18.5	0.456	11.3	47.2	t.b.d.	6-L2040-W422
						12.2	t.b.d.	6-L2040-W452
40 x 25 x 15	43.1	22.5	18.5	0.855	10.2	101.0	22.9	6-L2040-W424
						25.4	17.2	6-L2040-W453
50 x 40 x 20	53.5	36.3	23.4	0.760	14.1	18.0	10.0	6-L2050-W565
						45.3	t.b.d.	6-L2050-W516
63 x 50 x 25	67.3	46.5	28.6	1.240	17.8	58.6	t.b.d.	6-L2063-W517
80 x 50 x 20	86.0	44.7	25.7	2.280	20.4	35.0	t.b.d.	6-L2080-W531
90 x 60 x 20	95.4	56.1	24.7	2.280	23.6	81.0	t.b.d.	6-L2090-W518
102 x 76 x 25	108.1	70.0	30.3	2.470	28.0	≥ 55.0	t.b.d.	6-L2102-W468

*) A_L = inductance for N = 1 (tolerance +45 % / -25 %)

**) = to be defined

The plastic cases are suitable for direct winding and offer good mechanical protection for the nanocrystalline core material. This allows best magnetic properties, e.g. highest permeabilities. The plastic materials used are according to UL94V-1/0 (UL file no. E41871).



STANDARD CMC SERIES:

GENERAL DATA OF OUR CMCs

I_N = nominal current in each winding
U_B= operational voltage = 250 V (3-Phasen CMCs: 500 V)
U_P= test voltage = 1.5 kV (3-Phasen CMCs: 2.5 kV)
L_N= nominal inductance, tolerance +50 % / -30 %
Ambient temperature T_a = –40 °C...+60 °C
(short time +90 °C)
Operating temperature T_{op} = –40 °C...+120 °C
(short time +150 °C)
CMCs are designed for a temperature rise
ΔT = 55….60 °C
at T_a = 60 °C and I = I_N in each winding.
UL listed plastic material

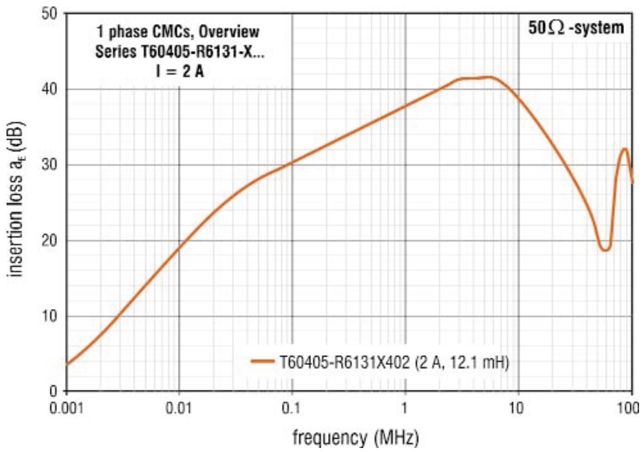
SINGLE PHASE CMCs WITH VITROPERM 500F SERIES CORES / VERTICAL DESIGN

I_N	L_N at 10 kHz	L_N at 100 kHz	IZI at 100 kHz typical	I_{bias} at 10 kHz typical	dimensions*) w x d x h	part number
A	mH	mH	Ω	mA	mm (max)	T6040…
2	2 x 12.1	2 x 2.8	3000	17	22 x 12 x 25	5-R6131-X402
4	2 x 7.3	2 x 2.3	2300	20	23 x 14 x 25	5-R6161-X404
4.5	2 x 28.3	2 x 6.9	6500	18	27 x 17 x 29	5-R6161-X504
6	2 x 20.3	2 x 6.5	6000	24	35 x 21 x 35	5-R6166-X606
8	2 x 13	2 x 4.15	4000	30	35 x 21 x 35	5-R6166-X608
10	2 x 9	2 x 2.9	2800	36	35 x 21 x 35	5-R6166-X510
13	2 x 11.4	2 x 2.6	3000	30	36 x 21 x 31.5	5-R6122-X513
15	2 x 6.3	2 x 3.8	3300	135	42 x 27 x 40	5-R6128-X615
30	2 x 6.3	2 x 1.5	1400	90	52 x 27 x 47	5-R6128-X530

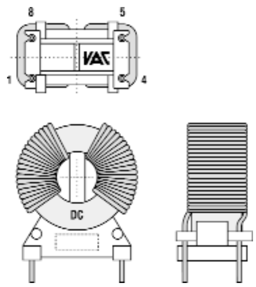
Common Mode Chokes for different currents and/or different properties are available on request.„

*) details see data sheet

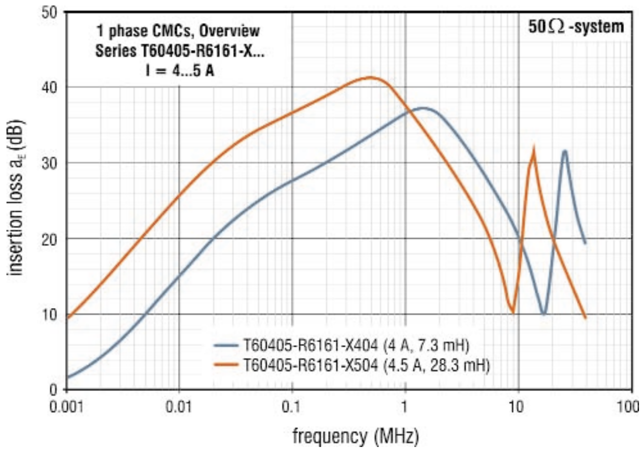
DESIGN T60405-R6131-X…



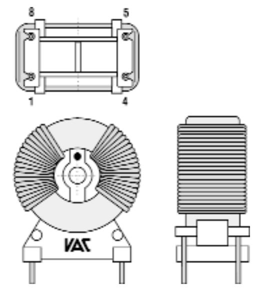
Examples:



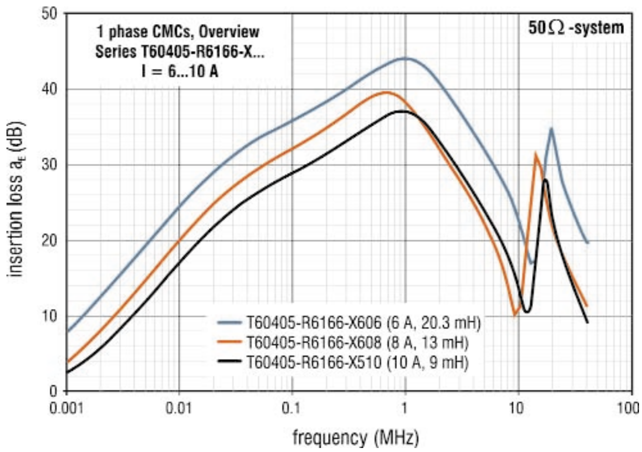
DESIGN T60405-R6161-X…



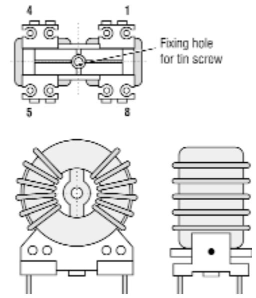
Examples:



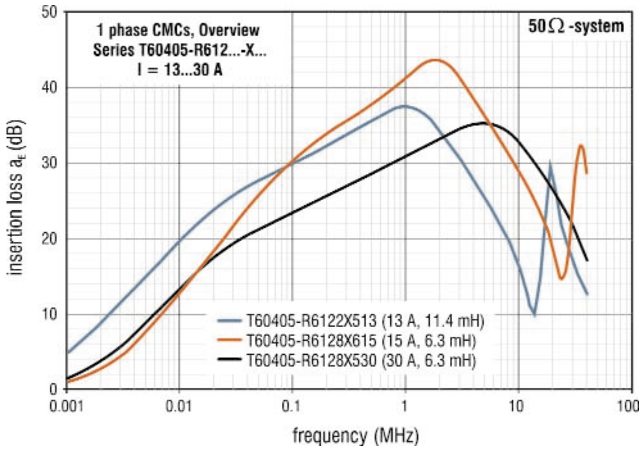
DESIGN T60405-R6166-X…



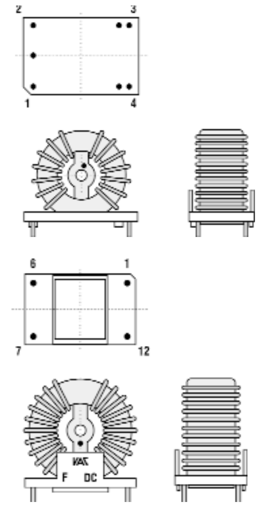
Examples:



DESIGN T60405-R6122-X…, T60405-R6126-X…, T60405-R6128-X…



Examples:



STANDARD CMC SERIES:

GENERAL DATA OF OUR CMCs

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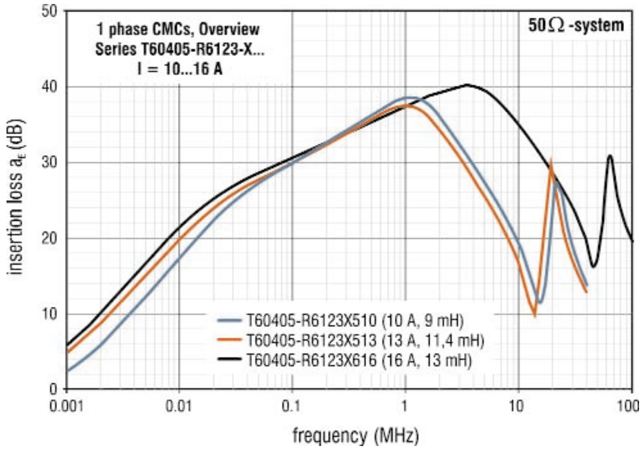
U_P = test voltage = 1.5 kV (3-Phasen CMCs: 2.5 kV)
L_N = nominal inductance, tolerance +50 % / -30 %
Ambient temperature T_a = –40 °C...+60 °C (short time +90 °C)
Operating temperature T_{op} = –40 °C...+120 °C (short time +150 °C)
CMCs are designed for a temperature rise ΔT = 55….60 °C at T_a = 60 °C and I = I_N in each winding.
UL listed plastic material

SINGLE PHASE CMCs WITH VITROPERM 500F SERIES CORES / LOW PROFILE DESIGN

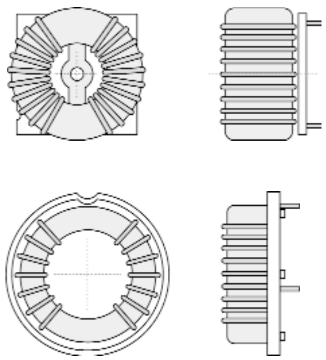
I_N	L_N at 10 kHz	L_N at 100 kHz	IZI at 100 kHz typical	I_{bias} at 10 kHz typical	dimensions*) w x d x h	part number
A	mH	mH	Ω	mA	mm (max)	T6040…
10	2 x 9	2 x 2.9	2900	36	33 x 30 x 20	5-R6123-X510
13	2 x 11.4	2 x 2.6	3000	30	36 x 20 x 23.5	5-R6123-X513
16	2 x 13	2 x 2.7	3000	37	Ø 38 x 24	5-R6123-X616
20	2 x 1.65	2 x 0.46	410	90	33 x 30 x 20	5-R6123-X420
20	2 x 4.9	2 x 3.4	2750	205	Ø 53 x 31	5-R6123-X620
25	2 x 1.25	2 x 0.9	620	240	Ø 40 x 24	5-R6123-X425
25	2 x 3.6	2 x 2.5	2000	240	Ø 53 x 31	5-R6123-X625
32	2 x 2.6	2 x 0.84	750	125	Ø 51 x 26	5-R6123-X532

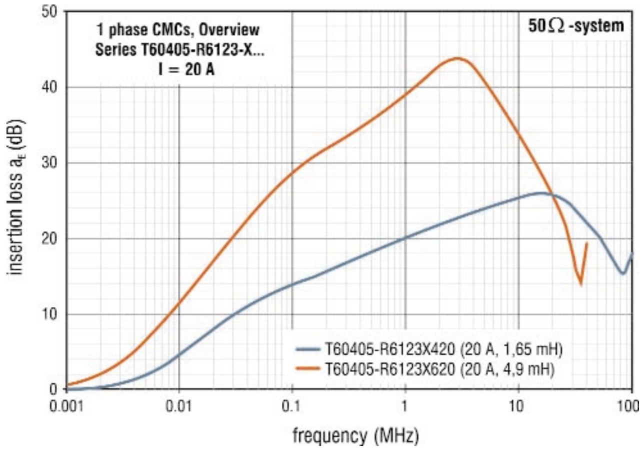
Common Mode Chokes for different currents and/or different properties are available on request. *) details see data sheet

DESIGN T60405-R6123-X…

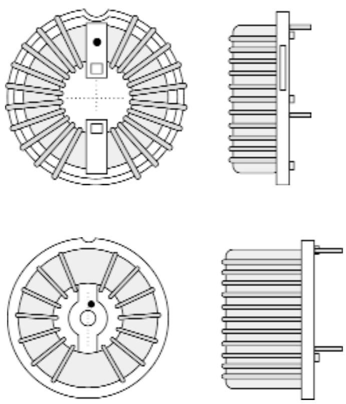


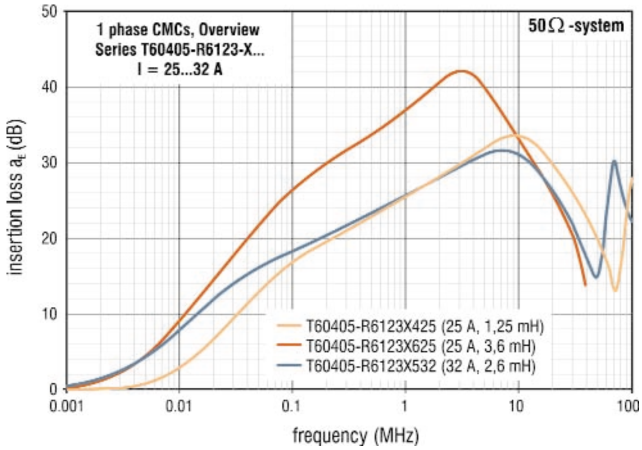
Examples:





Examples:





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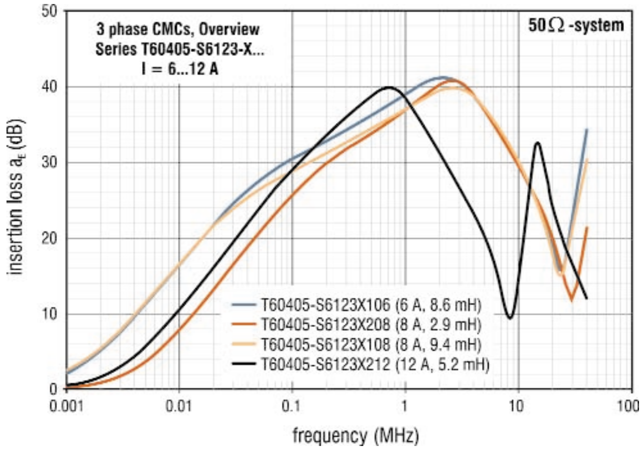
I_N = nominal current in each winding
U_B = operational voltage = 250 V (3-Phasen CMCs: 500 V)
U_P = test voltage = 1.5 kV (3-Phasen CMCs: 2.5 kV)
L_N = nominal inductance, tolerance +50 % / -30 %
Ambient temperature T_a = –40 °C...+60 °C (short time +90 °C)
Operating temperature T_{op} = –40 °C...+120 °C (short time +150 °C)
CMCs are designed for a temperature rise ΔT = 55….60 °C at T_a = 60 °C and I = I_N in each winding.
UL listed plastic material

THREE PHASE CMCs WITH VITROPERM 500F SERIES CORES / LOW PROFILE DESIGN

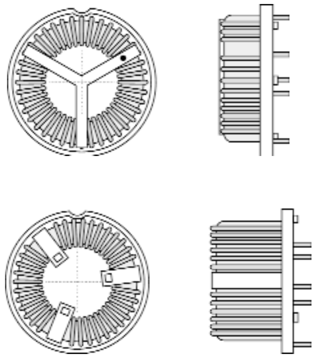
I_N	L_N at 10 kHz	L_N at 100 kHz	IZI at 100 kHz typical	I_{bias} at 10 kHz typical	dimensions*) w x d x h	part number
A	mH	mH	Ω	mA	mm (max)	T6040…
6	3 x 8.6	3 x 2.75	3000	48	Ø 38 x 27	5-S6123-X106
8	3 x 9.4	3 x 3.0	2600	67	Ø 51 x 28	5-S6123-X108
8	3 x 2.9	3 x 2.6	1850	220	Ø 38 x 30	5-S6123-X208
12	3 x 5.2	3 x 3.4	2700	142	Ø 51 x 28	5-S6123-X212
16	3 x 4.4	3 x 2.9	2200	204	Ø 59 x 28	5-S6123-X216
25	3 x 3.5	3 x 2.0	1700	255	Ø 70 x 38	5-S6123-X225
40	3 x 2.5	3 x 0.6	550	130	Ø 51 x 31	5-S6123-X140
40	3 x 1.5	3 x 0.8	650	395	Ø 70 x 37	5-S6123-X240

Common Mode Chokes for different currents and/or different properties are available on request. *) details see data sheet

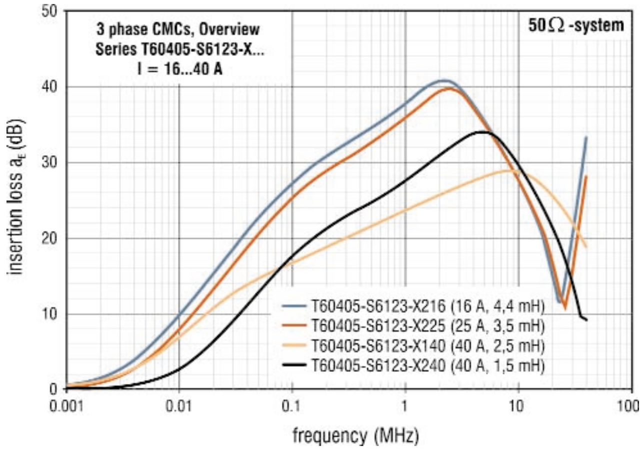
DESIGN T60405-S6123-X…



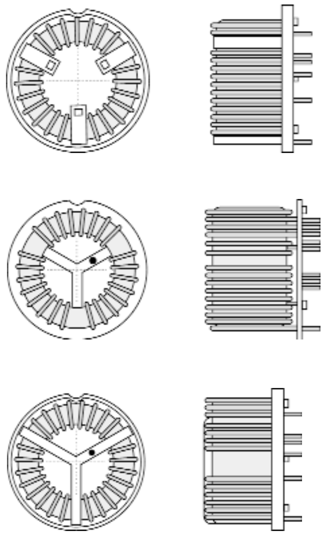
Examples:



DESIGN T60405-S6123-X…



Examples:



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