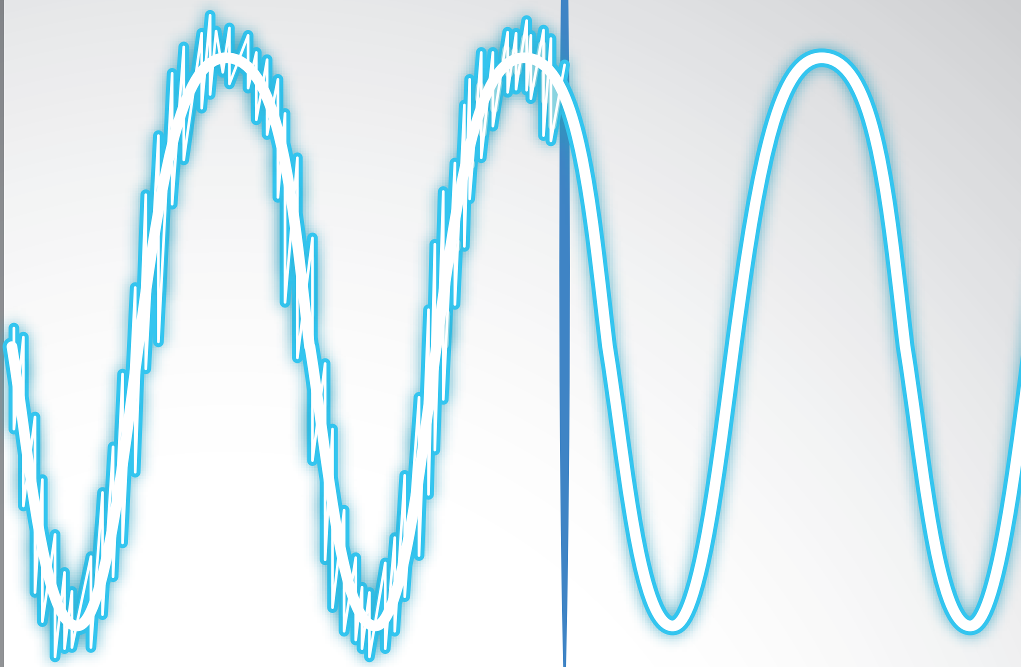
3N10
3N5
3N4
3N3
3N1



FERROXCUBE

Enjoy the silence with 3N series

MnZn ferrite materials for EMC compliance on conducted and radiated emissions

Introduction

Ferroxcube's new family of 3N ferrite materials reflect the market need for EMI suppression solutions with a wide frequency response under various working conditions. This brochure should help the designer in finding the optimum material for each specific design. The materials in this brochure cover the common requirements such as high permeability & high impedance at low frequency, cost effective solutions for 100 MHz filtering, or high saturation for combined common and differential mode chokes.

Ferroxcube's 3N family is based on cost effective Manganese Zinc (MnZn) material as an alternative to expensive nanocrystalline tape wound cores, low permeability Nickel Zinc (NiZn) ferrites, and powdered iron cores. 3N material is available in a wide variety of sizes and shapes including epoxy coated toroidal cores, low profile E and U cores for EMI suppression on bus bars, as well as custom shapes per customer specifications.

The 3N material family consists of 5 materials:

3N10 and 3N5:

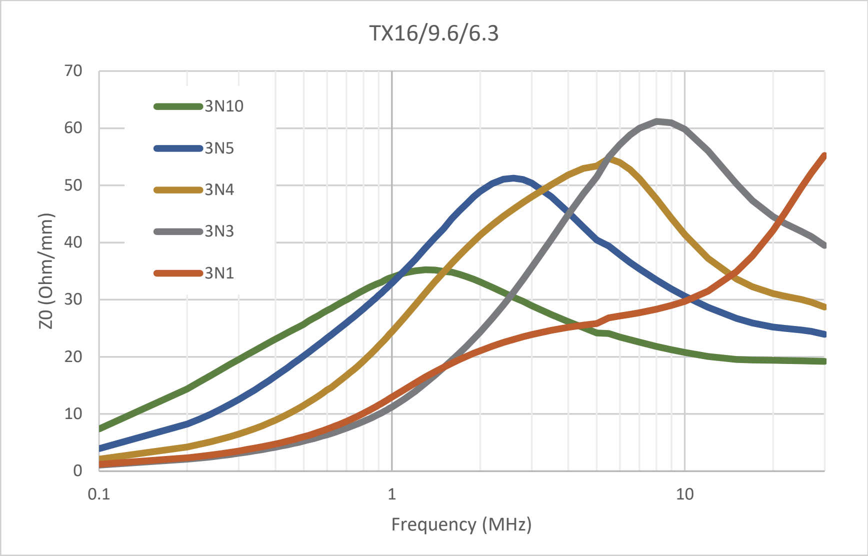
- o High permeability for low frequency EMI.
- o Exhibit excellent noise suppression below 10 MHz, making them the optimal choice for filtering common mode switching harmonics.

3N3 and 3N4:

- o Combines high impedance up to 30 MHz with high saturation for applications with strong harmonics such as motor drives or inverters.

3N1:

- o Wide frequency suppression to prevent both conducted and radiated emissions up to 300 MHz.
- o Relatively high permeability provides also a reasonable low frequency impedance.



Normalized Impedance

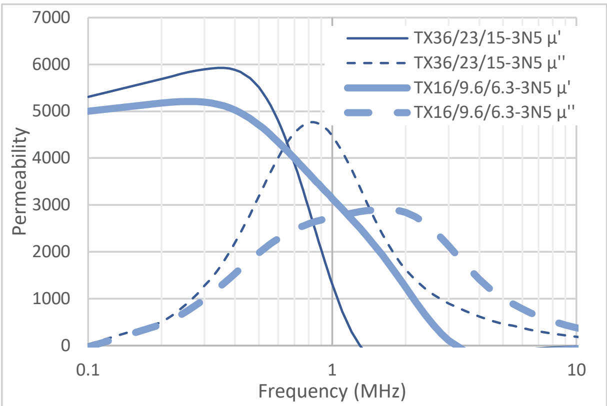
3N series material specifications are based on typical application requirements. Included is an impedance specification in the form of the normalized impedance Zo. This makes the parameter independent of the measured core size:

$$Z_0 = Z \times \frac{l_e}{A_e} \times \frac{1}{N^2}$$

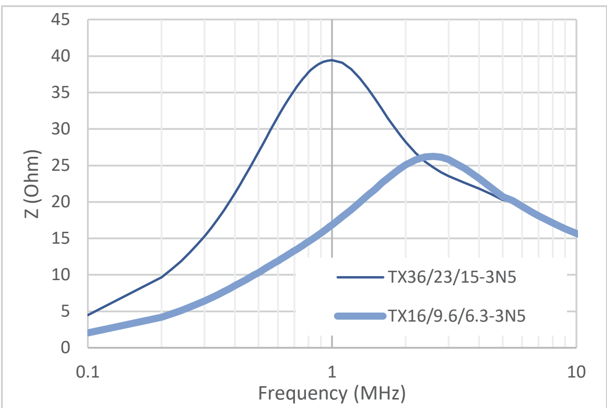
Where Ae and le (magnetic path length) are the core effective parameters and N is the number of turns.
Using this it is possible to simulate the performance of a core with a size similar to the original one used for the Zo formula calculation.
It is important to note that the impedance performance is strongly influenced by the core size. Large cores suffer from eddy currents limiting their frequency response.

The following example shows how the three parameters (permeability, impedance, and normalized impedance Zo) behave on the same material when the size of the core changes.

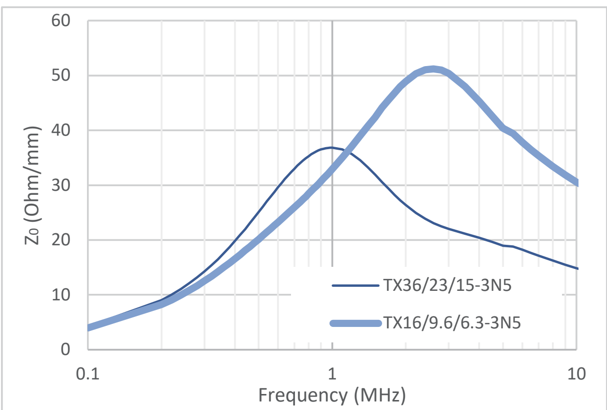
Ferroxcube always includes the size of the sample which the spec is based on. See charts below:



Starting from the same level of permeability, the TX16 shows wider frequency stability which reflects mainly in µ''. This µ'' is responsible for the resistive component of the core's impedance.



When comparing the impedance of the TX16 and TX36, the TX36 shows higher impedance mainly in the low frequency region due to its larger Ae. The TX16 performs almost the same at high frequency even though it is much smaller due to the shift in peak impedance at low frequency.



Calculating the normalized impedance Zo for both, the TX16 exhibits a wider and higher Zo due to lower eddy current losses.

TX - epoxy coated toroidal core

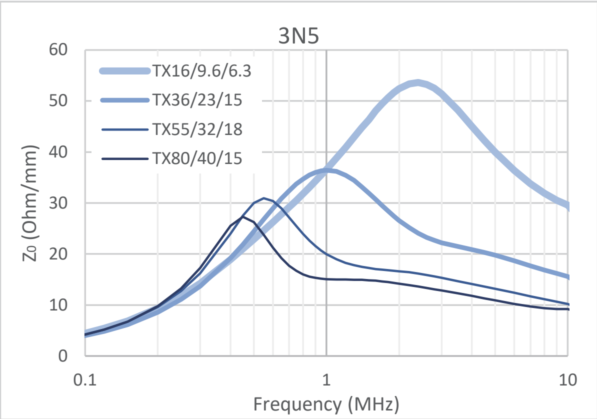
3N5 and 3N10 Low frequency EMI suppression

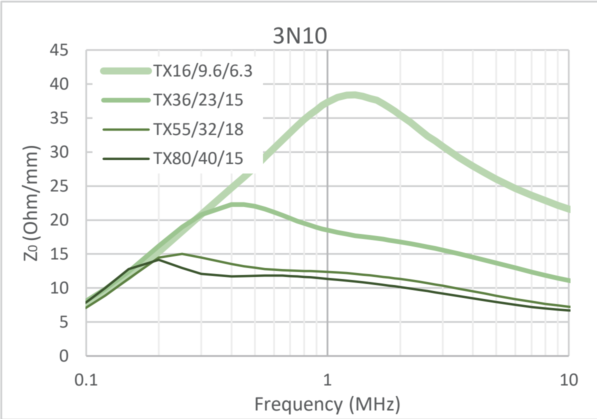
Low Frequency Common Mode Filtering

When targeting low frequency common mode filtering, the key material property is high permeability. However, it is also essential to maintain the performance over a wide bandwidth to ensure filtering beyond a few MHz. In addition, some applications require operation under high temperature.

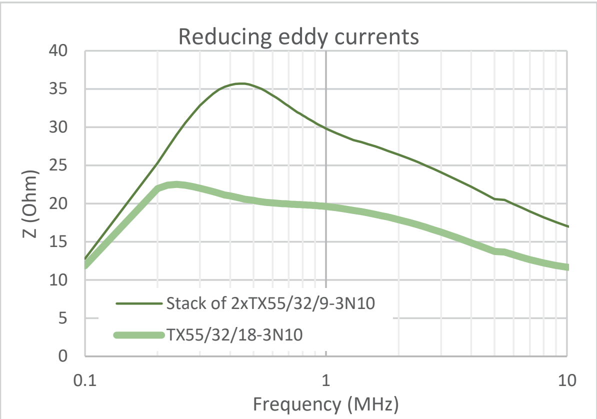
Ferroxcube 3N5 and 3N10 materials target low frequency EMI suppression, offering a good balance of high permeability along with extended frequency bandwidth. The Curie temperature of 3N10 is 130°C and 150° for 3N5.

Available in toroid, U, E, and bus bar shapes.





Effect of size



Due to the limited electrical resistivity of MnZn ferrites, the frequency bandwidth of their impedance is linked to the cross section of the core.

Cores with large cross section will suffer from eddy currents that limit their upper bandwidth limit.

Presenting impedance in the form of the normalized impedance Zo helps to compare this effect. Normalized impedance shows the impact of size on the material high frequency behavior.

Using the Zo parameter, it is possible to predict the behavior of custom sizes using as a reference core with a similar cross section. Simply multiply Zo by the coefficient Ae/le from the target core.

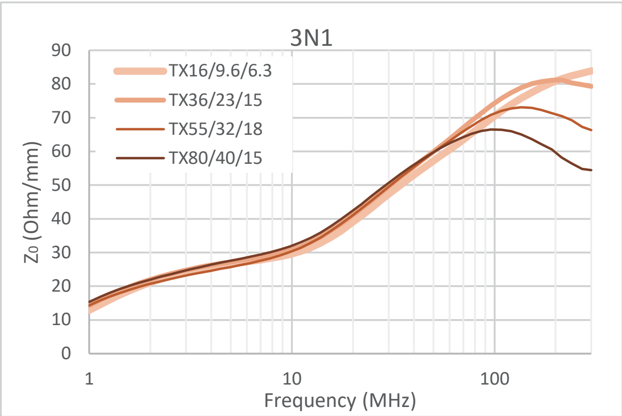
By knowing the impact of size on impedance it is possible to optimize the inductor by selecting the best performing size*. It is possible to go one step beyond reducing the impact of eddy currents by splitting the Ae in smaller sections. The graph compares the impedance of TX55/32/18 with the same size but split in 2 stacked cores of TX55/32/9.

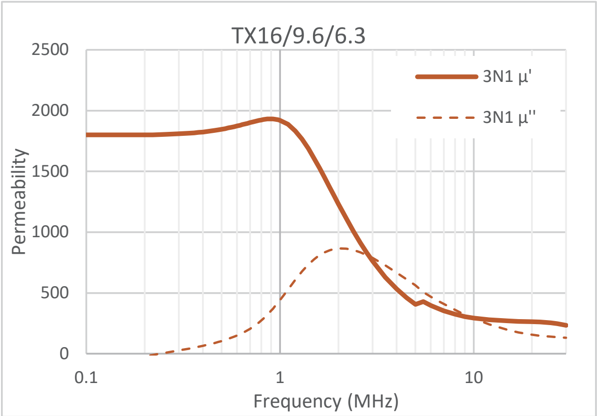
*The best performing core may not always be the largest size

3N1 wideband EMI suppression

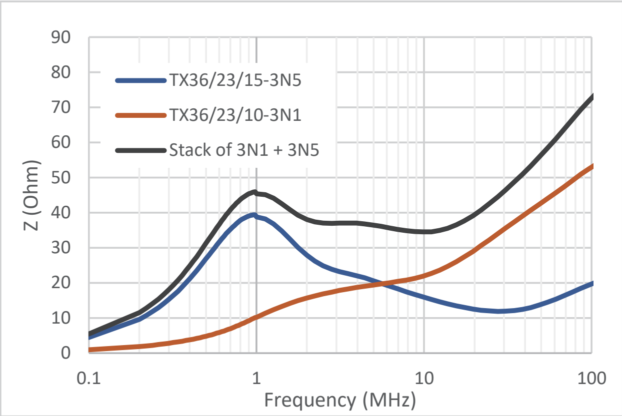
High Frequency Common Mode Filtering

High frequency EMI suppression is traditionally accomplished by extremely expensive nano-crystalline materials or NiZn ferrites. Ferroxcube has developed 3N1 as a new cost effective MnZn ferrite material with maximum impedance in the range of 30 to 300 MHz. The Curie temperature of 3N1 exceeds 150°C, making it appropriate for most applications.





Full band EMI suppression



For dealing with EMI emissions on both low and high frequency, the solution is to combine 2 or more materials to extend the high permeability low band with a high resistivity material on the high band. The chart shows the performance of a stack of 3N5 and 3N1 toroidal cores. Other alternatives are possible depending on the frequency requirements. Ferroxcube can offer support on predicting the performance of such combinations aiming to provide the best balance between materials and suppression ranges.

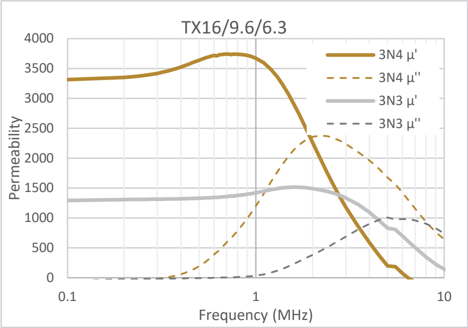
*Ferroxcube 3N1 material is available in toroidal shape, but also as snap-fit solution to be clamped on wires and bus-bars.

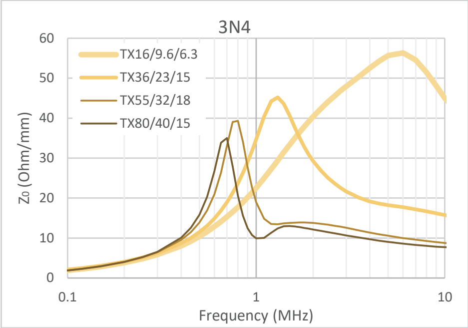
3N3 and 3N4 high saturation EMI filtering

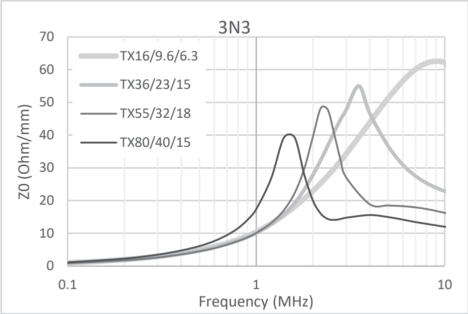
High Power Noise Suppression

Often common mode noise reaches relatively high amplitude that would drive standard EMI materials into saturation. Applications such as inverters and motor drives would fall in this area where longer wiring or the noise created by the motor tend to generate strong common mode noise.

Ferroxcube 3N3 and 3N4 offer high Bsat (much higher than common EMI materials) and keep a broad bandwidth for suppression of conducted emissions below 30 MHz. They are suitable for high temperature operation due to their Curie Temperature of up to 200 deg C.







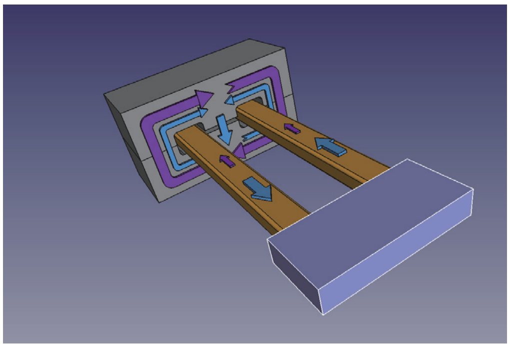
Combining Differential and Common Mode Filtering: Coupled Inductors

Frequently, applications have differential and common mode noise requiring two different inductors.

Ferroxcube 3N3 and 3N4 enable the integration of both functions in one ferrite core:

- High Bsat ratings prevents saturation of the differential mode path.
- Relatively high permeability and extended frequency stability for the common mode path.

The blue arrows show differential mode noise and purple arrows show common mode noise. CM is suppressed in the outer path, while DM is suppressed in the center gapped leg.

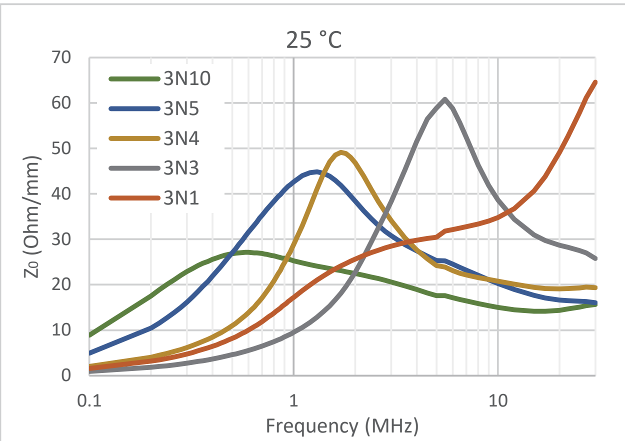


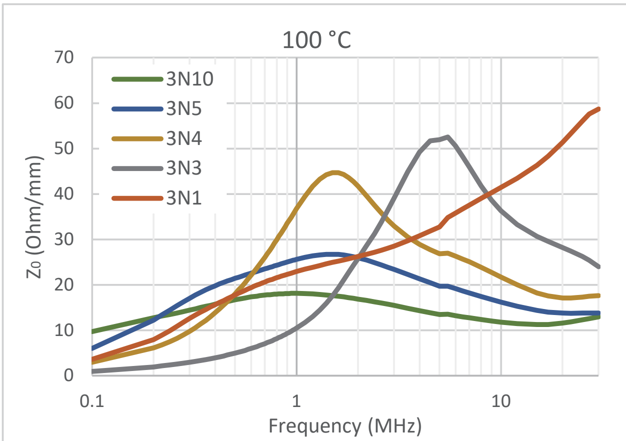
*Ferroxcube 3N3 and 3N4 are available in Epoxy coated toroids and also in other shapes such as gapped E cores, U cores and others.

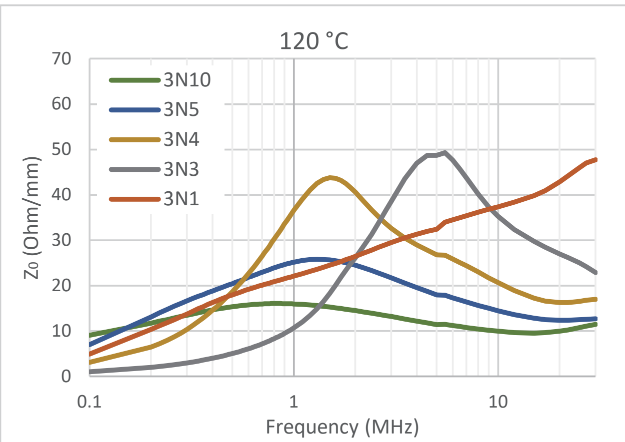
Material specifications

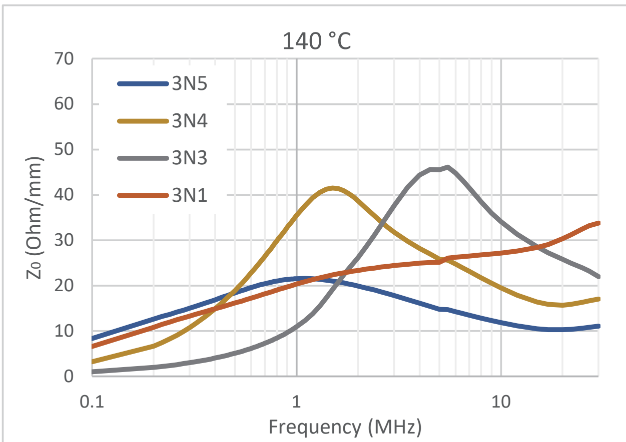
				3N10	3N5	3N4	3N3	3N1	
µi	10 kHz	0.25 mT	25°C	≈ 8000	≈ 6000	≈ 2500	≈ 1250	≈ 1800	
B	10 kHz	1200 A/m	25°C	≈ 460	≈ 460	≈ 530	≈ 520	≈ 420	mT
			100°C	≈ 270	≈ 300	≈ 410	≈ 420	≈ 280	
$Z \times \frac{l_e}{A_e} \times \frac{1}{N^2}$	0.3 MHz	0.25 mT	25°C	≈ 14					Ω/mm
	1 MHz			≈ 16	≈ 22				
	3 MHz				≈ 41	≈ 42			
	5 MHz					≈ 47	≈ 40		
	10 MHz						≈ 50		
	30 MHz							≈ 40	
	100 MHz							≈ 59	
ρ_{DC}			25°C	≈ 0.5	≈ 0.5	≈ 10	≈ 15	≈ 10^3	Ωm
T_C				≥ 130	≥ 150	≥ 200	≥ 200	≥ 150	°C
Density				≈ 5000	≈ 4850	≈ 4800	≈ 4750	≈ 4800	kg/m^3

Impact of Temperature









FERROXCUBE - A GLOBAL COMPANY

HQ

Taipei, Taiwan
Ferroxcube Taiwan
Tel: +886 963 767 858
Fax: +886 2 6629 9999
Mail: wiki.hsiung@ferroxcube.com

ASIA

Dongguan, China
Ferroxcube China
Tel: +86 769 8681 8777
Fax: +86 769 8733 9561
Mail: King.lee@ferroxcube.com

Suzhou, China
Ferroxcube China
Tel: +86 512 6841 2350
Ext.203
Fax: +86 512 6841 2356
Mail: Eric.Xu@ferroxcube.com

Singapore
Ferroxcube South Asia
Tel : +65 6412 0875
Fax : +65 6412 0808
Mail:
adrian.toh.wee.yong@ferro
xcube.com

Europe

Hamburg, Germany
Ferroxcube Germany
Tel: +49 40 883 66 020
Fax: +49 40 883 66 022
Mail:
saleseurope@ferroxcube.com

Lissone, (MB), Italy
Ferroxcube Italy
Tel: +39 0392 143 599
Fax: +39 0392 459 472
Mail:
saleseurope@ferroxcube.com

North America

El Paso (TX), USA
Tel: +1 915 599 2328
Fax: +1 915 599 2555
Mail: juan.carlos.gardea@ferroxcube.com

San Diego (CA), USA
Tel: +1 619 207 0061
Fax: +1 619 207 0062
Mail: joel.salas@ferroxcube.com

Phoenix (AZ), USA
Tel: +1 480 821 2634
Mail: ken.blasor@ferroxcube.com

Pittsburgh (PA), USA
Tel: +1 412 226 0048
Mail: michael.horgan@ferroxcube.com

Rochester (NY), USA
Tel:+1 585 364-3395
Mail: owen.davies@ferroxcube.com

For a complete listing of all Ferroxcube sales offices, distributors, and representatives, please visit "contact us" at

www.ferroxcube.com

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