



# Niobium Nb

## REPORT

**Common Mode Chokes**

Nanocrystalline vs Ferrite

# COMMON MODE CHOKES



## Concept

A **choke** uses an inductor cored with high permeable material to filter outside interferences while passing current in an electrical circuit. A **common-mode choke** uses two coils wound on a single core to suppress interference and prevent signal pollution.



## Function

Common mode chokes pass **equal but opposite currents**, creating a flux in the core that opposes any increase in common mode current, while presenting little inductance or impedance.



## Applications

Common mode chokes are useful for the prevention of **electromagnetic interference (EMI)** and **radio frequency interface (RFI)** from power supply lines and for preventing electronic equipment from malfunctioning.



## Industry

Common mode chokes are commonly used in **industrial, electrical, electronic, telecom and energy applications** to remove or decrease noise and related electromagnetic interference.



# COMMON MODE CHOKES

## WHY?

### Current filter alternatives

CMCs cored with nanocrystalline material provide better efficiency, are better suited for higher currents with higher inductances with high frequency ripples, typical of energy applications

#### Ferrite Bead

- **Suited for electronic circuits:** no direct competitors to Nanocrystalline
- **Less efficient**
- **Not suited** for higher currents
- **Less customizable**

Less adapted for  
energy applications

#### Common Mode Choke

- **Better efficiency** for knocking down the unwanted noise
- **Can operate** at high current with high inductance values
- Heavier gauge wire, allowing it to **run a higher current**
- Don't result in **saturation current**
- Don't distort **transmission signal**, only unwanted noise

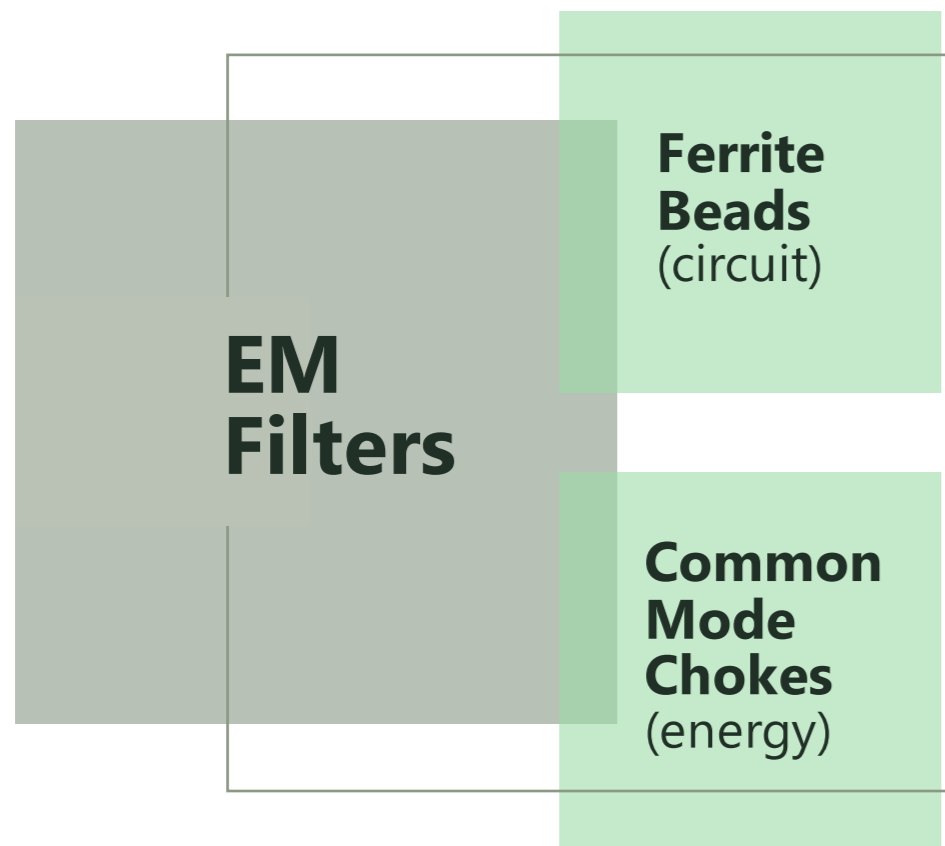
More adapted for  
energy applications

# COMMON MODE CHOKES

# MARKET

# AND

# DRIVERS



## EM FILTERS

**Segments:**  
CMCs and  
Ferrite Beads

## COMMON MODE CHOKES

- **Verticals:** Automotive, Renewables, Data Center
- **Segments:** EMI and RFI



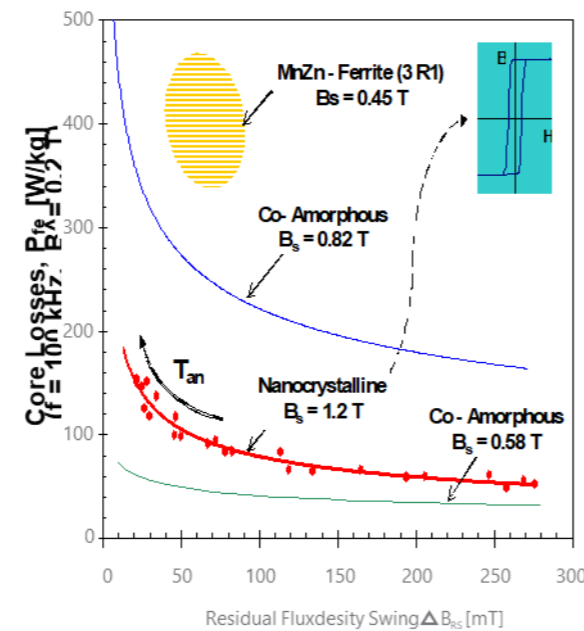
## DRIVERS

- National policies as growth catalysts
- Rapid development of downstream industries for consumer electronics
- Rapid growth of automobile electronics
- Rising vehicle electrification
- Investment in renewables requires DC grids and converters
- Rising demand from China
- Rising power quality standards and requirements
- Increasing consumer awareness

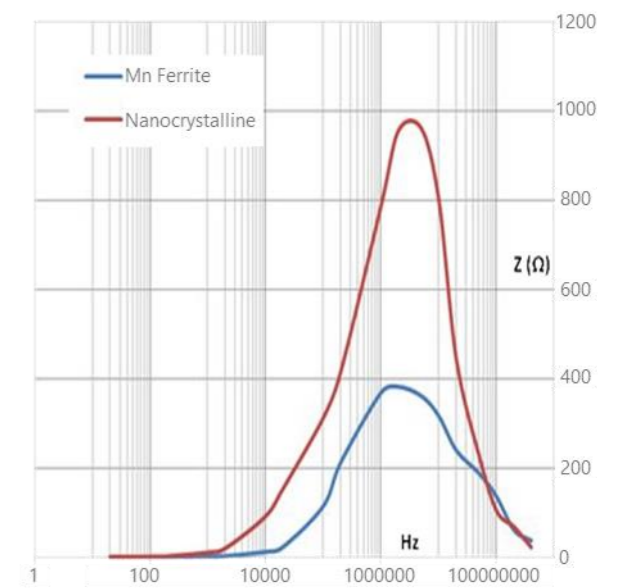
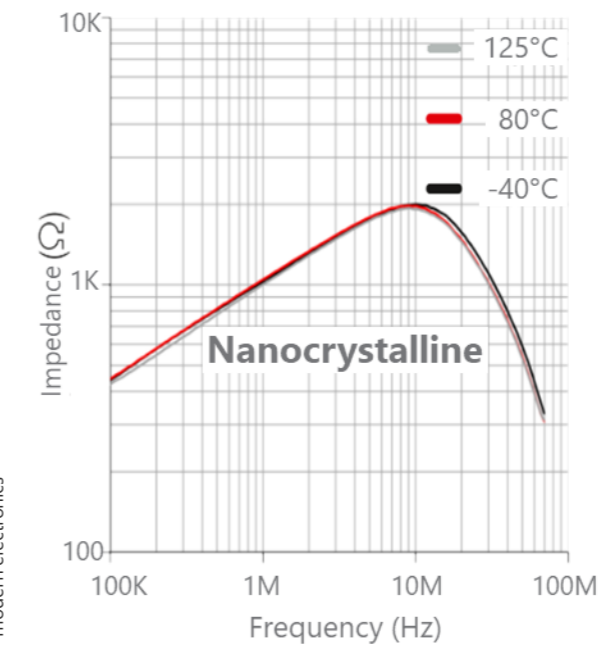
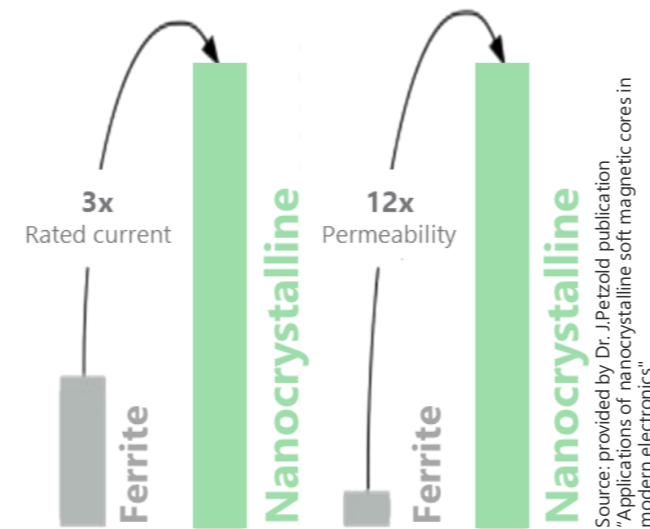
# COMMON MODE CHOKES: CORE AND COIL COMPOSITION AND ALTERNATIVES

- Optimal core properties of common mode choke are essential for efficient noise filtering: high permeability, high rated current and inductance, low DC resistance, temperature stability, wide frequency range

- Nanocrystalline** (3% at. Nb) and **Ferrite** (Mn-Zn) cores provide the best characteristics for maximum efficiency



High rated Current & Low DC Resistance      High Permeability



Source: provided by seminar organized by "Haus der Technik" seminar magnetic technique and magnetic material

**Material** cored with

**Rated Current**

**DC Resistance**

**Rated Inductance**

**Frequency Range**

**MnZn Ferrite**

0.3 – 12A

2-3000 m $\Omega$

0.15 – 0.80 mH

5 kHz-10MHz

**Nanocrystalline**

0.6 – 50A

1-500m $\Omega$

1.4 – 6.9 mH

1 kHz–30MHz



# COMPETITIVE ADVANTAGES OF NANOCRYSTALLINE

Material Advantages



## Reduction in weight and size

Up to a 50% reduction in weight and 75% reduction in size, leading to cost reductions compared to ferrite



## Wider frequency range

Nanocrystalline provides noise damping over a wider frequency range, helping to reduce stages



## Outstanding Thermal Stability

Operational temperature stable up to 130°C

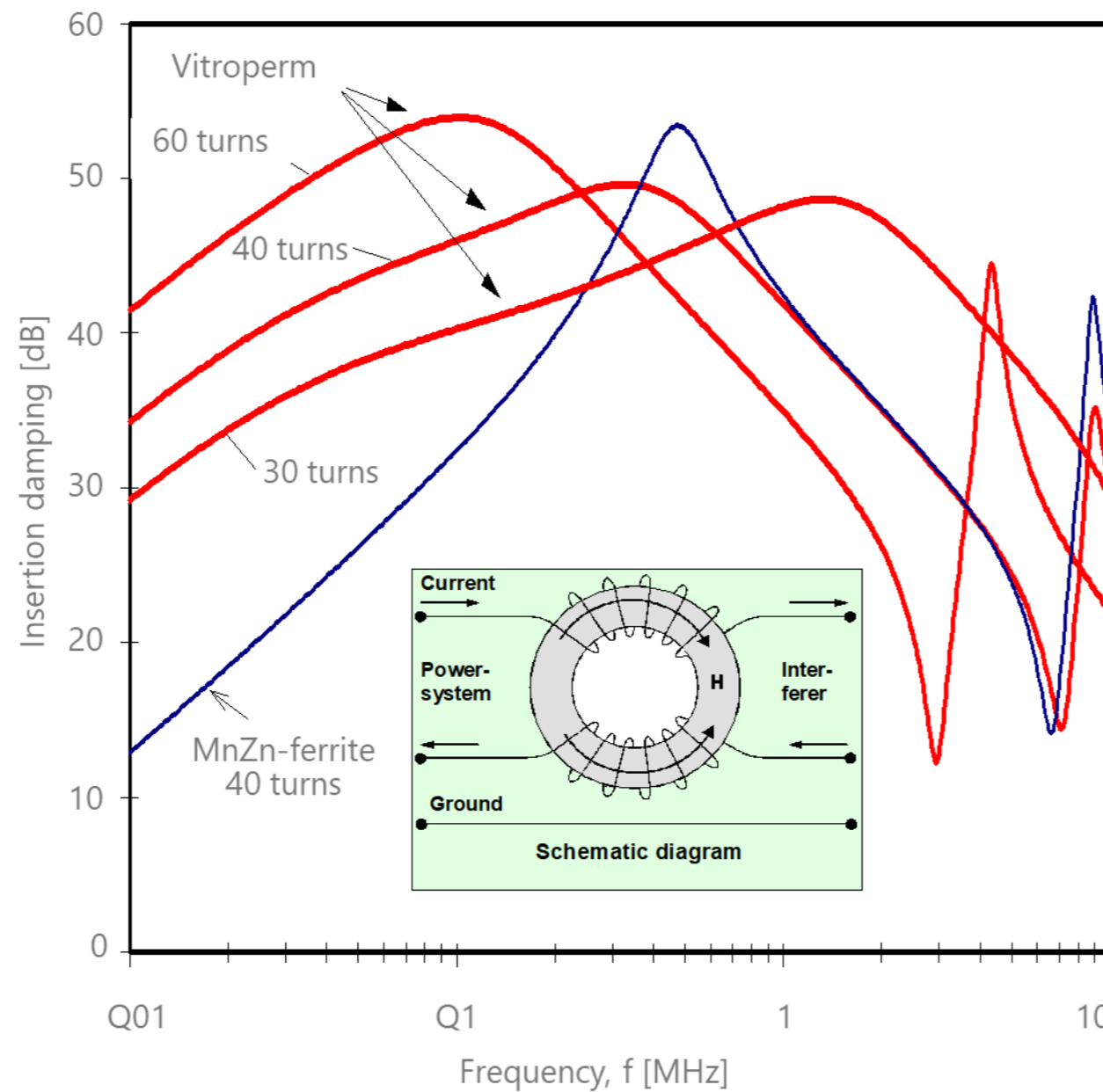


## Improved damping at low freq.

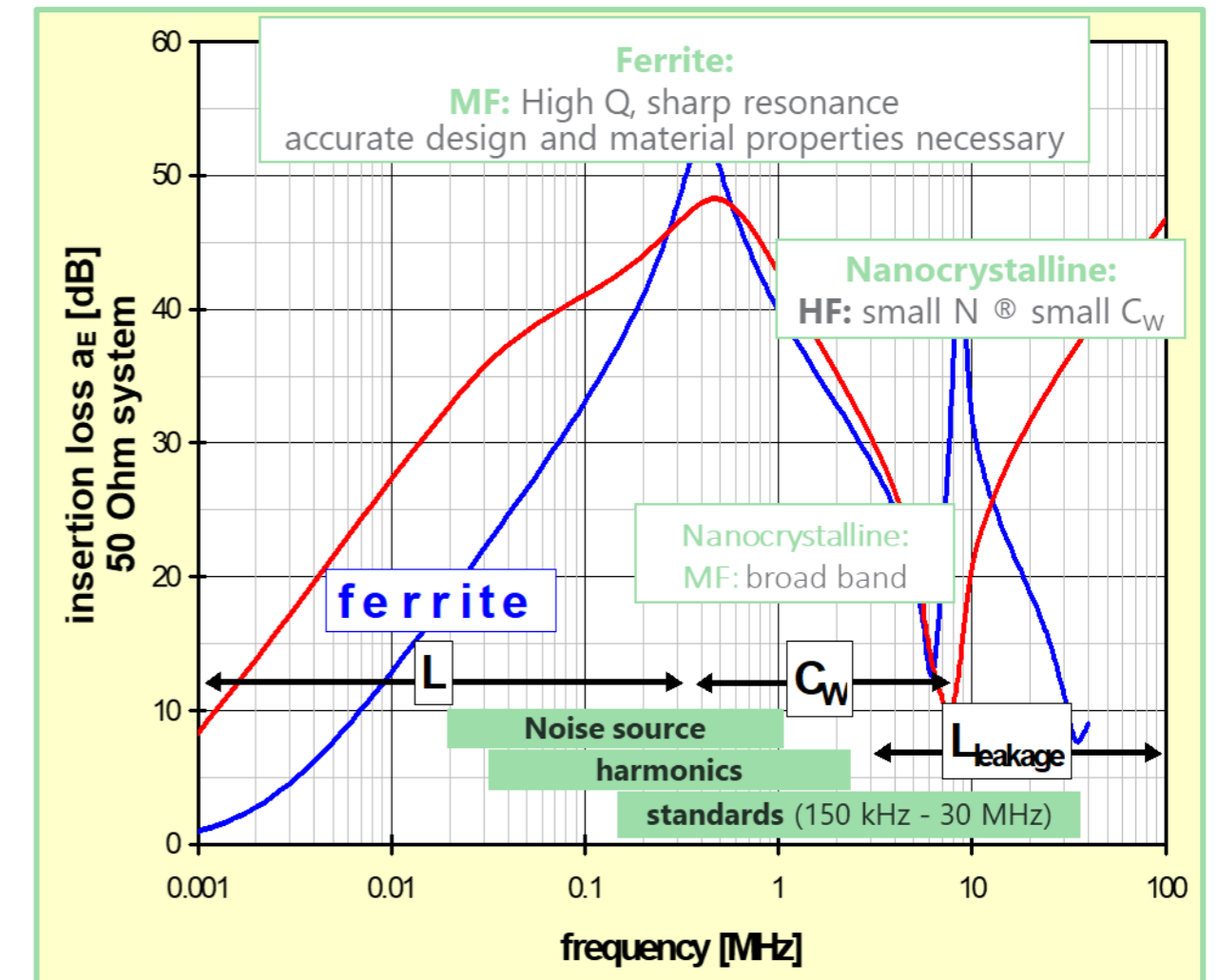
Better insertion loss/gain at low frequency and large rated current

# COMPETITIVE ADVANTAGES OF NANOCRYSTALLINE

- Because of **high permeability**, less turns are needed
- Less copper, less cost for **single stage design**,
- Better frequency spectrum to **remove further stages**
- Design skill** to maximize the material advantage
- Validation of **specifications** remains key



## Material Advantages





## **APPLICATIONS:** **AUTOMOTIVE/EV**

### **Charging Stations**

**High-power CMCs** are required to filter high frequency while maintaining low impedance. Additionally, nanocrystalline CMCs are **highly adapted for wireless charging**, allowing compact designs with excellent attenuation of noise radiated from radio signals, unshielded electronics, inverters and motors

### **On-Board Chargers**

EV batteries require HV DC power for charging. As a result, high CMC efficiency and the differential mode interferences are **essential for battery sensitivity**. Additionally, an output filter is also required to eliminate EMI

### **Traction Inverters**

Three-phase CMCs are widely used in electric motor drives as a means to limit ground current, **shaft voltage, and electromagnetic interference emission**

## APPLICATIONS:

# RENEWABLES

Photovoltaic, Wind and Battery Energy Storage

### Photovoltaic: Solar Inverters

**CMC:** EMI filter to suppress leakage current for grid-connected systems



### Wind: Turbine Generators

**CMC:** EMI filter to suppress leakage current from pulse-width modulated power converters



### Battery Energy Storage: Frequency Converters

**CMC:** EMI filter to reduce conducted and radiated emission from frequency converter



## APPLICATIONS:

# POWER SUPPLY AND DATA CENTER

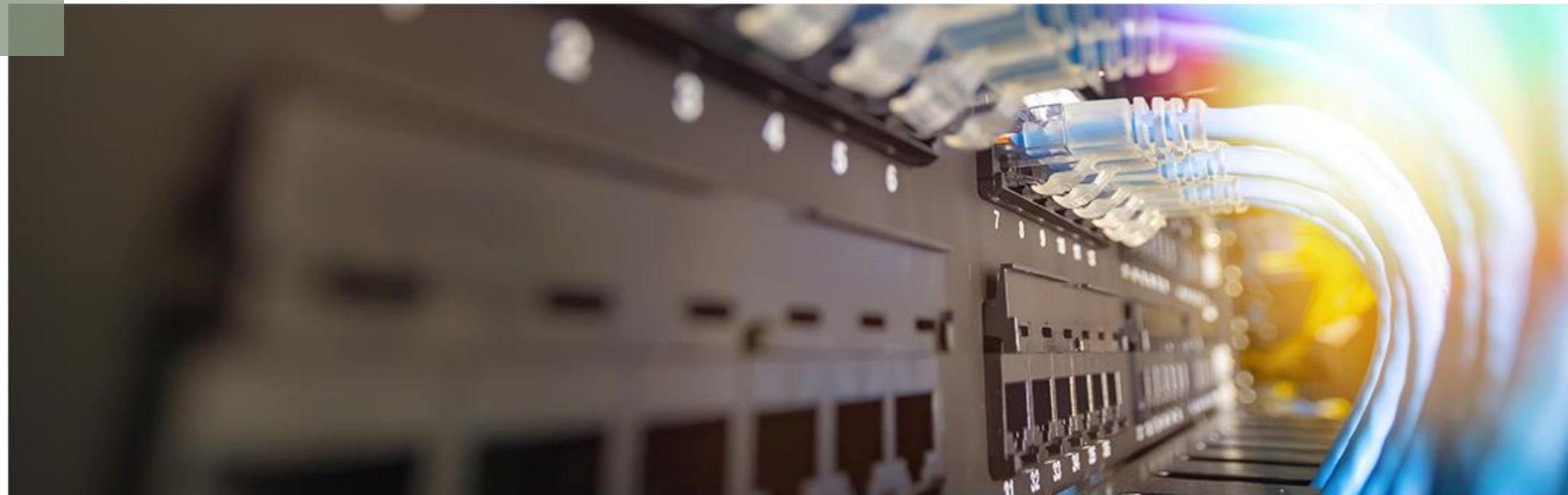
### Uninterruptible Power Supplies (UPS)

- Suited for noise suppression on **AC/DC** power supply lines
- Protect network from the **high-frequency noise** from SMPS and UPS

### Switched Mode Power Supplier (SMPS)

### Data Center Power

Protect equipment against the penetration of **high-frequency noise** from power supply



## APPLICATIONS

# KEY TRENDS



## Demand for higher currents

- Nanocrystalline only solution for **high rated currents**
- Need for **larger, thicker** conductor wires
- Ferrite would require impossibly **heavy equipment**
- **No ferrite** solution in sight

## Ferrite replacement underway

- Ferrite is main **competition** for nanocrystalline
- **Ferrite is not as suited** due to size, weight and performance range
- **Manufacturers** already introducing nanocrystalline

## Higher EMC standards

- **Strict standards:** IEC61000, wider spectrum
- EMI **critical for strategic technological** assets
- Need for efficient **broadband noise suppression**
- Essential for **grid reliability**

## EMI Filters always required

- **Power electronics** needs EMI filters to suppress noise in a wide range of situations
- CMCs are an essential component of **EMI filters**
- **Ferrite and nanocrystalline** provide best alternatives

# CONCLUSIONS



1.

## **Better and more efficient EMI Filters are required by the industry**

EMI filters are constantly improving as a result for a continuous need for noise suppression in an increasing number of applications.

2.

## **Nanocrystalline is better suited for Common Mode Chokes than Ferrite**

In terms of damping effect, losses, temperature stability, size/weight requirements, range of frequency, rated current and rated inductance, nanocrystalline is consistently the best option.

3.

## **Market conditions and trends also favor Nanocrystalline adoption**

High-potential applications, need for clean and high-quality filtering, requirements for compact filters and large frequency ranges, combined with a strengthening of global standards, reinforce the need for nanocrystalline.

4.

## **China and EU pushing Nanocrystalline and already replacing Ferrite**

Both the industry and emerging contribute to Nanocrystalline adoption. Still potential to attract new adopters among key manufacturers, but awareness needs to be increased.