xgap Technology and Product Overview

Prax introduces xgap technology as an optimal solution for EV magnetic components

The use of xgap technology allows for the creation of cost-effective solutions with maximum power density thanks to the reduction of core volume around 30%, while overall size reductions up to 20%. xgap technology also minimizes losses and offers optimal heat dissipation of windings in all type of cooling systems. All of these advantages match the requirements of magnetic components in EV applications.

What is xgap technology based upon?

A gap is a portion of air inside a magnetic core path. It is used for two main purposes:

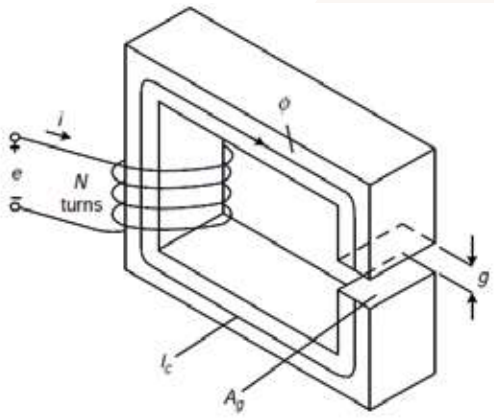
1. Energy storage in inductors or chokes

The energy stored in an inductor depends on current and inductance factor.
A gap or distributed airgap is commonly needed in cores to store such energy.

2. Inductance value and tolerance reduction

Introducing a gap decreases magnetic core permeability, which reduces its inductance factor.
Non-gapped cores inductance tolerance is around ±25%, while gapped cores can be reduced to ±10%

$$E = \frac{1}{2} \cdot L \cdot I^2$$

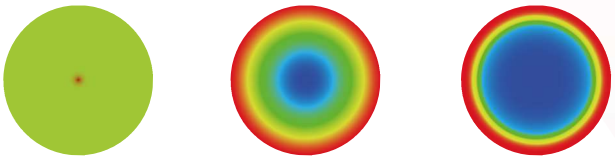


$$L = N^2 \cdot A_L$$

Main effects generating losses due to high frequency in windings

1. Skin effect

An isolated round conductor carrying AC current generates a concentric alternating magnetic field which induces Eddy Currents.
These currents oppose to normal current flow in the center of the conductor, increasing the effective current closer to the conductor surface.
The overall effect is that total current flows in a smaller perimetral area. This effect intensifies as frequency increases. Current flow concentrates in an equivalent perimetral cylinder at the surface of the conductor. This cylinder thickness δ is known as skin depth.

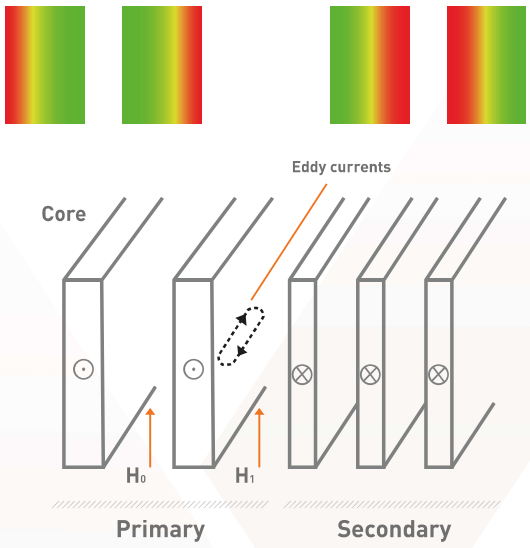


10 kHz 100 kHz 1 MHz

2. Proximity effect

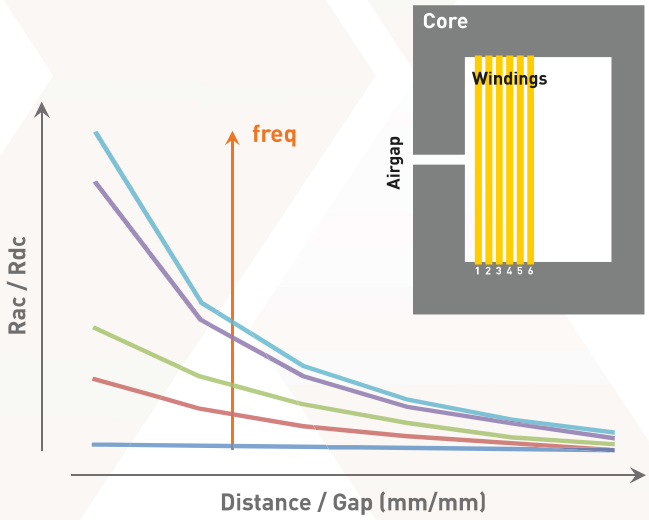
Proximity effect appears when the distribution of current in one layer of a winding influences the distribution in another layer, always in the same winding.

Such proximity effect, therefore, increases winding resistance (Rac)



3. Fringing effect

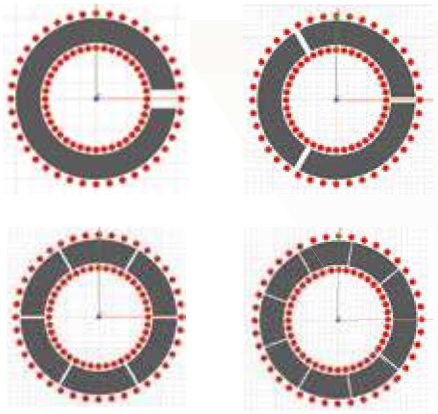
Fringing effect happens when a magnetic flux near a core airgap bends out.
The distance over which these flux fringes out is basically proportional to the length of the airgap.
One single gap can be splited into several smaller gaps, preserving total volume and length. By doing so, effective permeability and energy storage capabilities are still the same, but the flux fringing is significantly reduced.

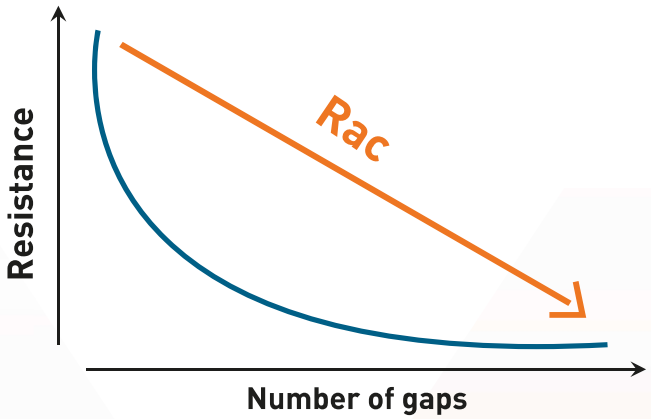


What is xgap Technology?

xgap technology is a multi-gap approach for inductors and transformers highly recommended for resonant topologies and widely used in DC charging applications.

This multi-gap technology has been developed by PRAX to reduce winding AC losses. It allows a large air gap to be evenly distributed on a toroid to minimize fringing effect by splitting the gap into smaller gaps. With these evenly distributed gaps (up to 12 or 15 on a single toroid), losses are reduced exponentially because of the Rac reduction.





Prax's expertise allows many possibilities by applying this technology:

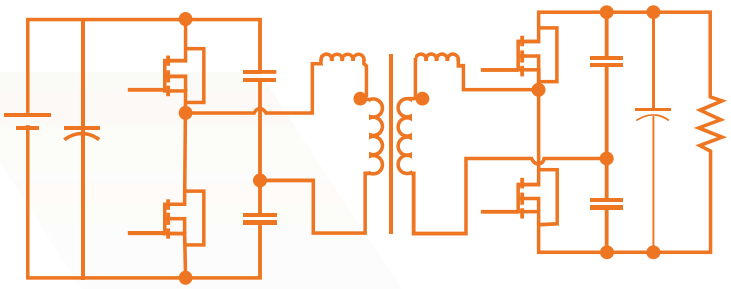
- xgap technology-based set of transformers and chokes
- Multi-gap core solution with triple-insulated litz wire

Advantages of xgap technology:

- Winding area increases by means of using toroid formats
- High current and high frequency capabilities by low loss ferrite material
- Distributed gap component, minimizing fringing losses
- Tighter inductance tolerance (from ± 8% to ± 15%)
- Best heat dissipation of windings in any type of cooling systems
- Finite Elements Analysis (FEA) simulations available for extra accurate loss calculation
- Reduction of core volume around 30%, allowing an overall size reduction up to 20%
- Cost-effective solution compared with PQ or PM core formats

xgap technology used as

- A transformer in converters and SMPS up to 30kW
- A resonant inductor in resonant topologies including LLC, CLLC, DAB and Phase Shift where inductance needs to remain flat as current increases
- A PFC, input or output choke where ripple current is high (>35%) and frequencies are higher than 50kHz, such as interleaved PFCs



prax Differentials

- Finite Elements Analysis (FEA) simulations available for accurate loss calculations
- Narrow tolerance for the inductance value (from ± 8% to ± 15%)
- Wide inductance value range by adjusting gap thicknesses
- Off-the-shelf solutions and quick, easy and cost-effective custom adaptations available
- 10+ experience years in custom multi-gap magnetic component solutions

Product Overview

Custom as Standard – Within Prax magnetic components subcategories, our default way of co-operation with our customers' R&D teams is to offer customized designs that are optimized to the specific requirements of every application.

Common Mode Chokes

Common noise filtering chokes. For a discrete component EMC filtering approach, Prax offers a wide range of CMCs in any format and with world-class materials (soft ferrite, nanocrystaline).

Current Transformers

AC current measuring magnetic components for low and high frequency applications. Different material grades allow either high accuracy for critical low frequency metering applications or consumption control in high frequency (SMPS).

EMC Filters

EMC filtering solutions in single-phase and three-phase for various industrial and renewable energy applications.

Input and Output Chokes

Mid-power range chokes, for various high frequency switching applications. Copper foil, flat and round wire, combined with several magnetic materials (soft ferrite, Sendust, iron powder, amorphous) and multiple formats (E-cores, C-cores, toroidal) allow Prax to meet virtually any customer requirement.

PFC Chokes

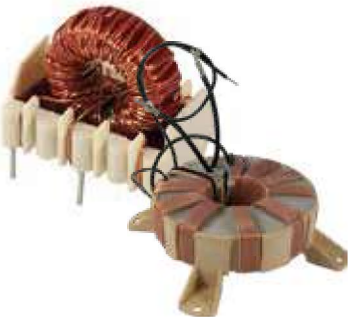
PFC chokes specifically designed to maximize power of a circuit by driving voltage and current with the same phase.

Planar Transformers

If low profile, high efficiency and mechanical reliability are a must for customer final application, planar transformers are the optimal solution for high frequency converters.
Combinations of specially shaped soft ferrite cores with multilayer PCBs and copper tracks make a very compact component in a high power density solution.

Power Inductors

Standard power inductors are proven to have limitations for new high current demanding applications. Prax advanced high current power inductors combine special materials and shapes with flat wire helical winding for a very compact and efficient design.



Pulse Transformers

Design and manufacturing of Pulse and Gate Drive transformers for transmitting a control signal assuring isolations between low and high voltage circuits.

SMPS Transformers

Switch-mode power supply main transformers requirements depend on power range, topology, isolation and frequency. Therefore, a wide range of materials, formats and winding technologies are available. Our aim is to optimize size, efficiency and cost.
Designs available for topologies such as flyback, forward, push-pull, half-bridge, full-bridge and advanced resonant topologies.

Application case 1

11kW Onboard Charger for BEV

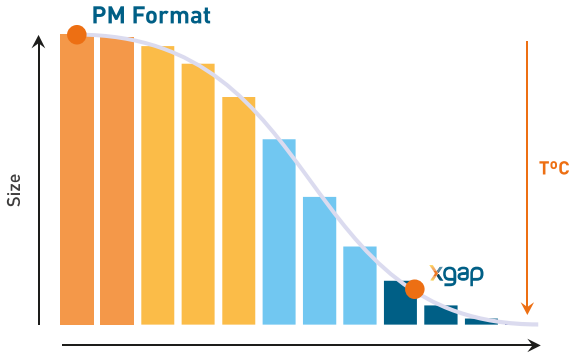
Transformer and Resonant Choke for LLC.

Requirement

- Compact, yet fully functional transformer and choke for LLC topology for an 11KW onboard charger

Solution

- xgap technology-based transformer and choke
- Multi-gap core solution with triple-insulated litz wire
- Toroid format for both components
- Interconnected components



Benefits

- Reduction in number of components used
- Volume savings of around 30% compared to other traditional formats such as PQ or PM
- Optimal cooling capabilities

Application case 2

30kW DC Fast Charger

30kW Transformer for Bi-Directional Phase Shifted Dual Active Bridge

Requirement

- Optimized power density
- Safety and reliability
- Suitable for use in high demand cutting-edge resonant topologies
- Easy mounting

Solution

- Litz wire for high frequency
- MultiGap technology xgap for minimizing fringe effect losses
- High insulation
- Toroidal shape for high magnetic path optimization
- Integrated custom mechanical solution

Benefits

- 20% size reduction vs traditional multi-E core structure
- ~16% reduction in losses
- Optimized transformer shape for maximum heat dissipation

Do you like this solution?
Please contact Heynen for distribution in BENELUX.

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