EPCOS Product Brief 2018

Ferrites and Accessories

Distributed Air Gaps in Ferrite Cores – E, EQ, ER, ETD, PM, PQ Cores

Applications

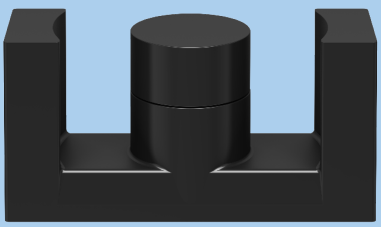
- Power chokes
- Flyback converters

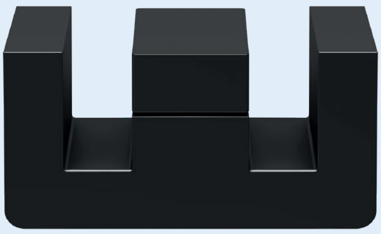
Technical overview

- Center post gapping increases the magnetic resistance in the circuit
- The gap delays core saturation
- Gapping increases the power handling capability
- The gap makes the core inductance independent of material permeability

Benefits

- Significantly increased power density
- Reduce proximity losses up to 70%
- Enable use of a larger winding area by reducing fringing flux
- Lower winding losses compared to a single large air gap
- Reduction of core size by one class thanks to lower winding losses, e.g.
  E 65 → E 55 or
  ETD 59 → ETD 54

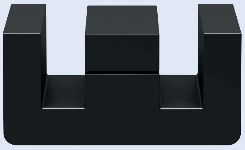




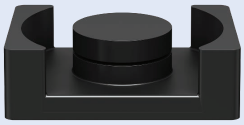
Distributed Air Gaps
Core Types and Technical Background

Core types

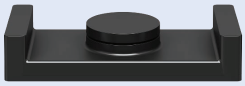
EPCOS offers six different core types, commonly used in the design of **power chokes** and **flyback converters**. Distributed air gaps are available or may be manufactured for the following cores and sizes:



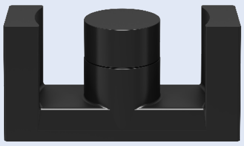
E core



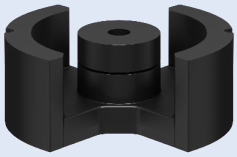
EQ core



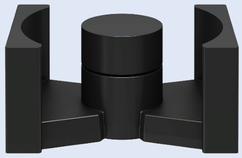
ER core



ETD core



PM core

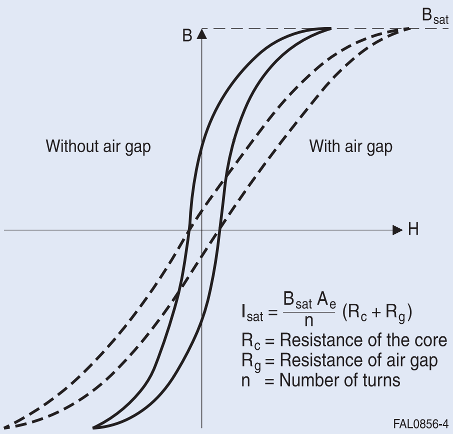


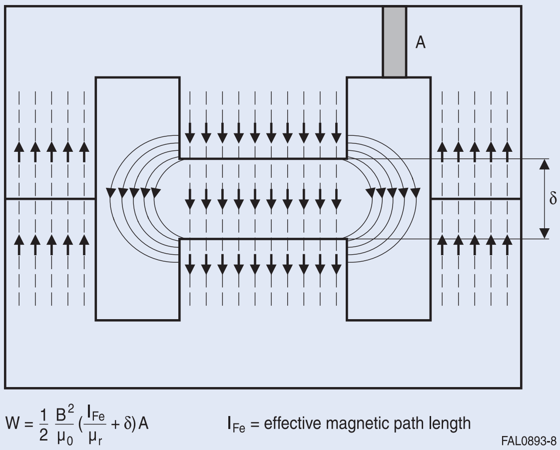
PQ core

The geometry and sizes range from E 42 to E 100, EQ 25 to EQ 30, ER 25 to ER 54, ETD 29 to ETD 59, PM 50 to PM 114 and PQ 32 to PQ 50. Other core sizes can be discussed with your Sales Representative. Thanks to this wide range of core types and sizes for distributed air gaps, EPCOS is the first manufacturer of ferrite cores to provide the marketplace with an **economical solution** with a focus on **downsizing**.

Technical background

An air gap increases the magnetic resistance in the magnetic circuit. Magnetic saturation then occurs only at higher field strengths and reduces the slope of the B-H loop. The air gap is required to increase the power handling capability and makes the core inductance independent of the material permeability.





However, the bigger the air gap, the higher is the fringing flux that spreads around it, e.g. into the copper winding. This phenomenon leads to higher losses (e.g. copper losses).

EPCOS offers a **technical solution** designed to significantly **reduce the fringing flux** effect in order to reduce electromagnetic emissions and heating.

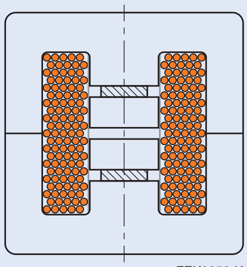
 For further information please contact your EPCOS sales office.

Distributed Air Gaps
Simulation E 55/28/25

Simulation with ferrite cores E 55/28/25

The main effect of gaps of different sizes and locations is to change the losses in the adjacent winding. The magnitude of this effect depends on the fringing flux which enters the winding. The total gap remains identical, only the location and the individual size per gap are changed.

The average of the square of the local flux density in the winding is used to compare the results, as they would induce eddy currents which lead to losses and heating according to **P = R × I²**.



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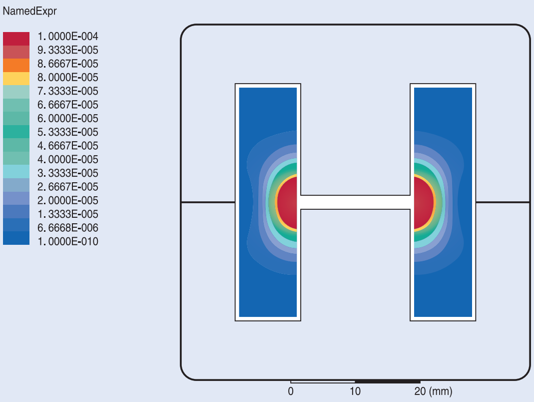

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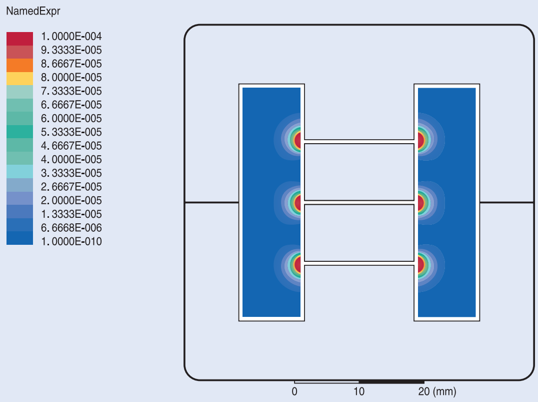
High fringing flux spreads around a single large air gap.



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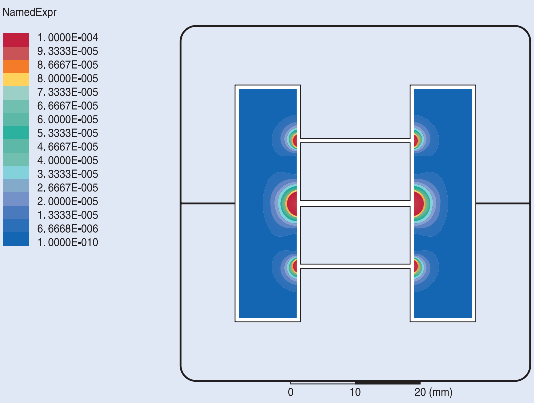
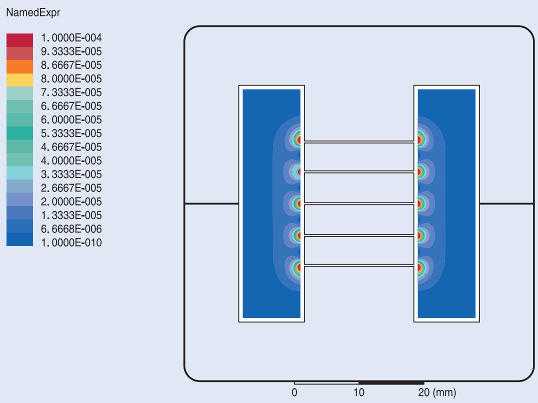
Creating several smaller air gaps improves the situation compared to a single large air gap.



FEK0861-5

Uneven distribution of air gaps leads to higher local losses close to the larger air gap but to lower losses close to the smaller air gaps.



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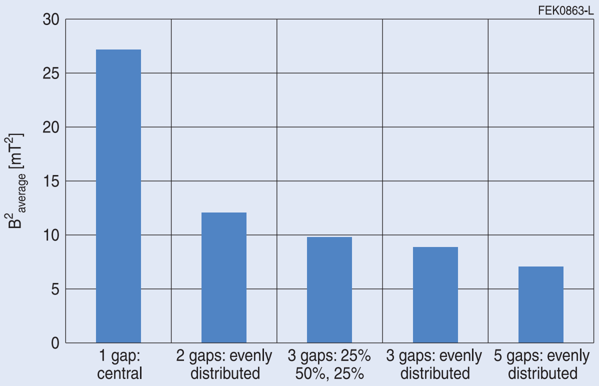
Five evenly distributed air gaps[1] induce very low losses over the whole core compared to a single large air gap.

[1] Only on request

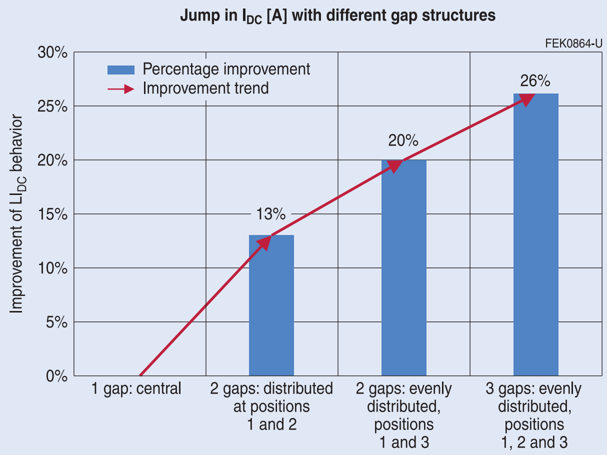
Distributed Air Gaps
Simulation E 55/28/25 and Conclusion

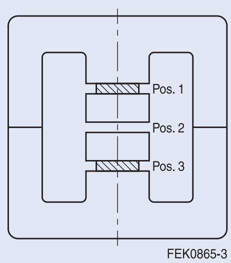
Simulation with ferrite cores E 55/28/25

The average of the square of the local flux density in the winding, $B^2_{average}$, depends on the size and location of each gap (the total air gap size is the same).



The LI_{DC} behavior depends on the size and location of each gap size (the total air gap size is the same).





The different air gap structures shown above feature in lower losses from left to right and a correspondingly lower rise in temperature. As a result, the temperature of the core-coil system is lowest for core geometry with 3 evenly spaced gaps. Because the flux density of a ferrite is very temperature-sensitive decreases with increasing temperature, the LI_{DC} parameter exhibits a visible improvement depending on the number and position of the air gaps.

Conclusion

A comparison between a single large air gap and several smaller distributed air gaps shows that:

- The average of the square of the local flux density, $B^2_{average}$ (relevant for the winding losses) decreases as the number of smaller air gaps increases
- Evenly distributed and spaced air gaps are more efficient than an uneven distribution
- The best performance/cost compromise is to use three evenly distributed air gaps

EPCOS distributed air gaps cores are realized with nonmagnetic spacers glued in between the ferrite slugs.
The **required priority** for distributed air gaps is the **A_L value**.

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