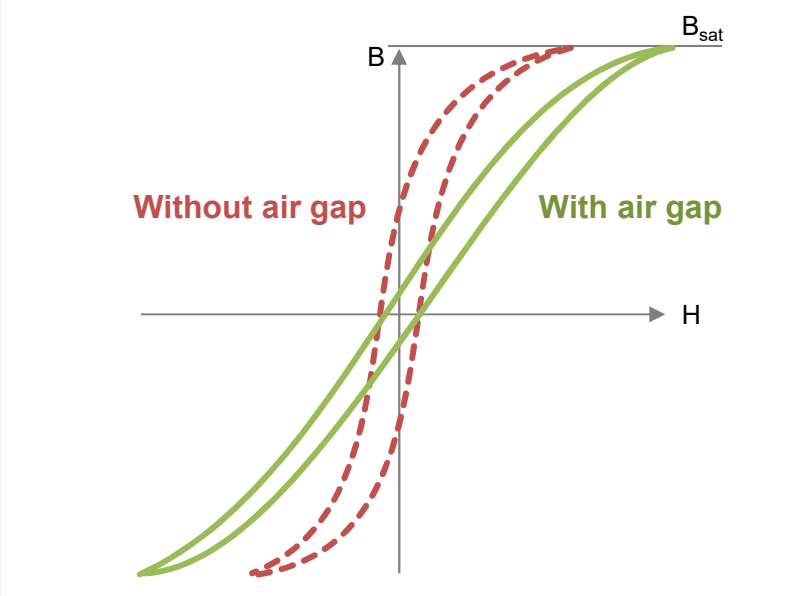
Attracting Tomorrow

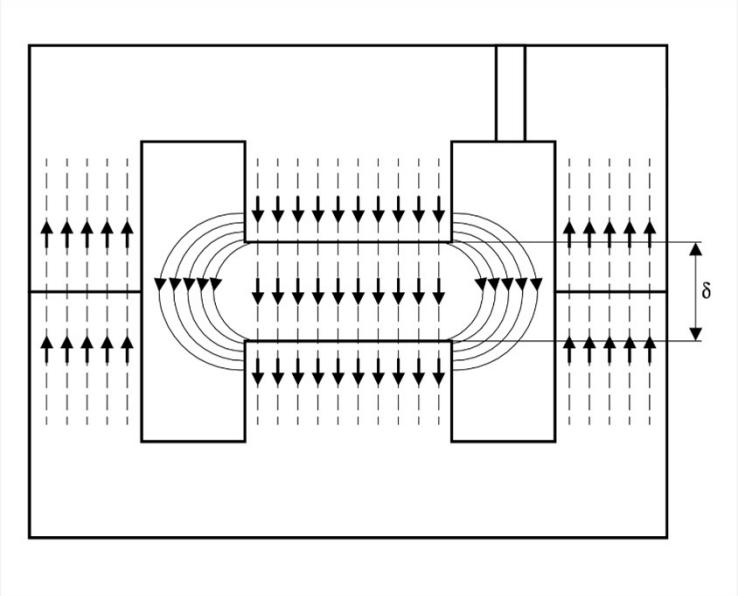
APEC 2018 – San Antonio

Advanced ferrite technology

Distributed air-gap cores improve performance of power electronics

Air gaps increase power handling capability and allow higher currents

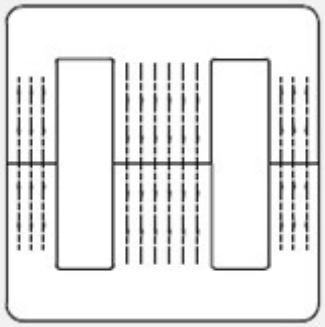




Limiting factors of solutions with only one air gap

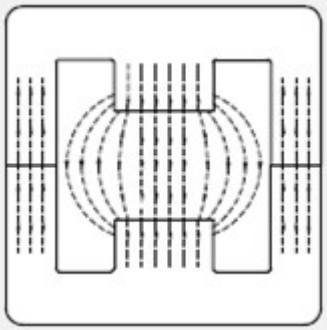
- Fringing flux close to the air gap induces eddy currents
- Additional proximity losses occur in high-frequency magnetics
- Fringing flux losses are proportional to the average of the square of the local flux density in the winding (B^2)

Effect of different air gaps in ferrite cores



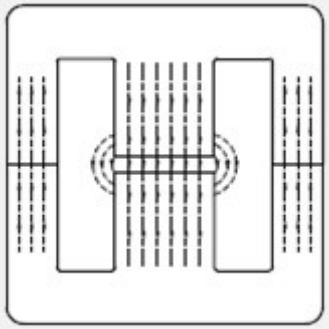
No air gap

- Low energy storage
- Highest inductance
- Lowest copper
- Lowest loss



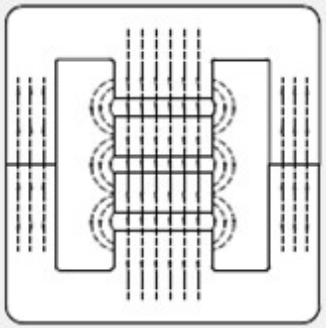
Big air gap

- High energy storage
- Low inductance
- Higher copper
- Highest fringing flux
- Highest loss



Small air gap

- Nominal energy storage
- Lower inductance
- Low copper
- Nominal fringing flux
- Moderate loss



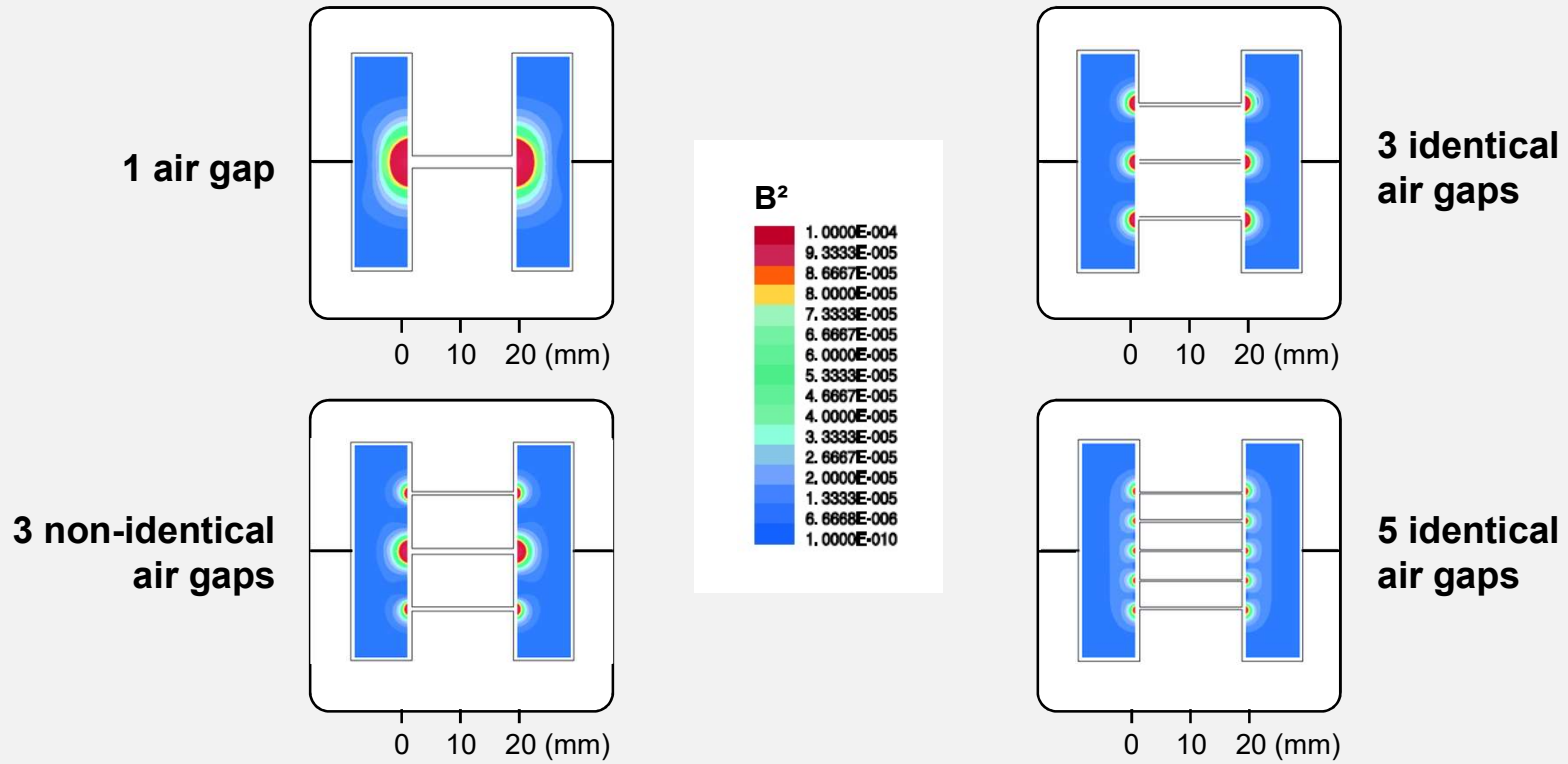
Distributed air gaps

- High energy storage
- Low inductance
- Low copper
- Nominal fringing flux
- Moderate loss

Distributed air gaps combine the advantages of small and big air gaps

Distributed air gaps lower loss due to fringing flux

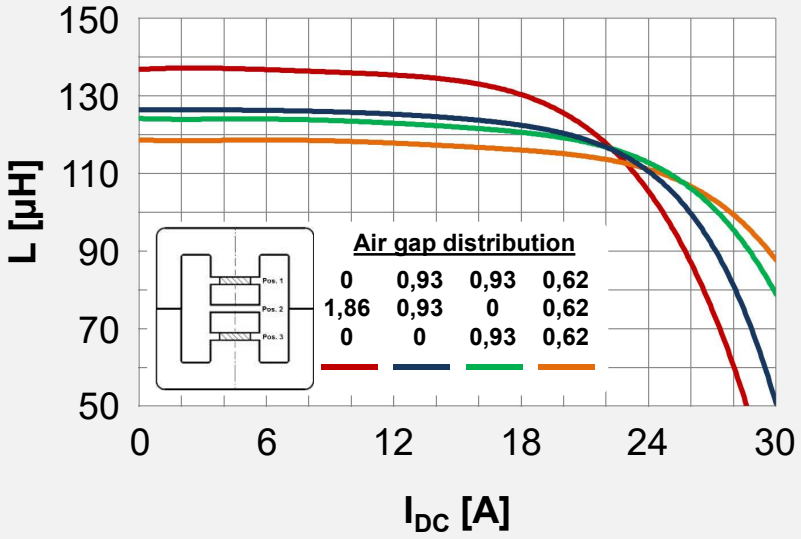
Simulation of fringing flux losses with E 55/28/25 cores



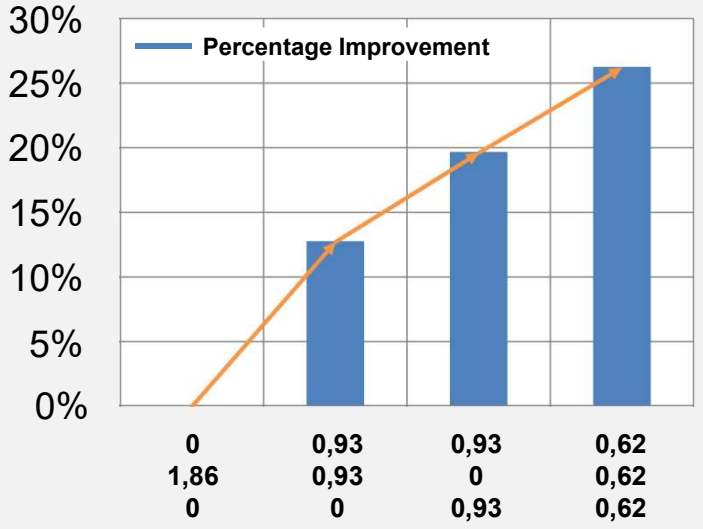
Loss due to fringing flux get decreased in proportion to B^2 with an increasing number of identical air gaps

Identically distributed air gaps delay core saturation

Inductance vs. I_{DC} for different distribution of air gaps in the center post of E 55 cores

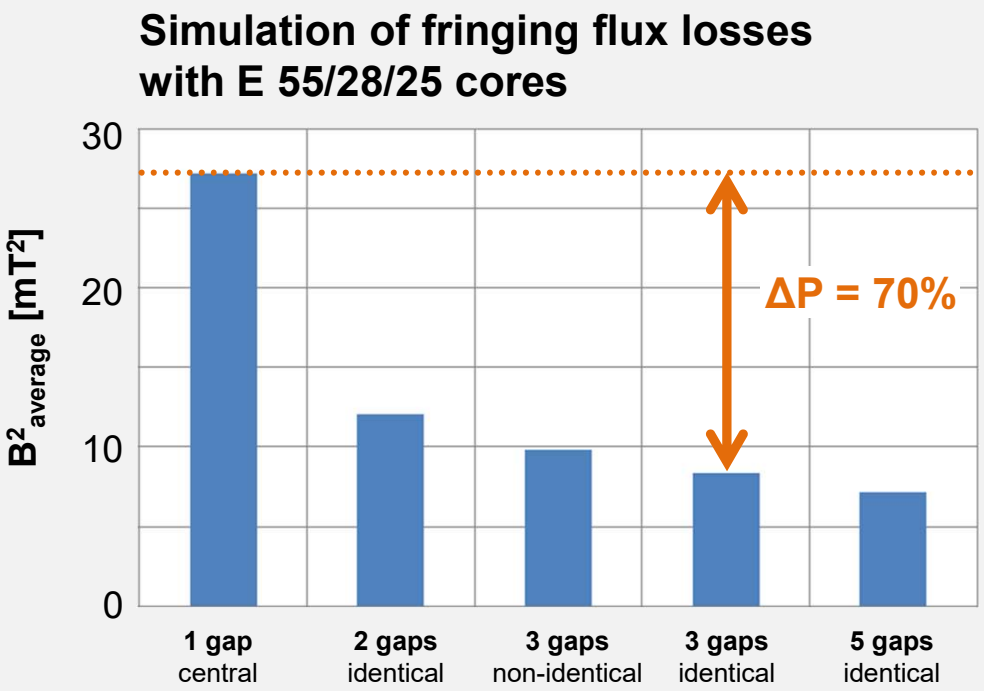


Jump in I_{DC} [A] with different gap structure for 20% roll off in inductance



The delayed core saturation is realized due to the lower temperature rise which is around 1/3rd for wire coil

Identically distributed air gaps improve the performance/cost ratio



ΔP = reduction of proximity losses

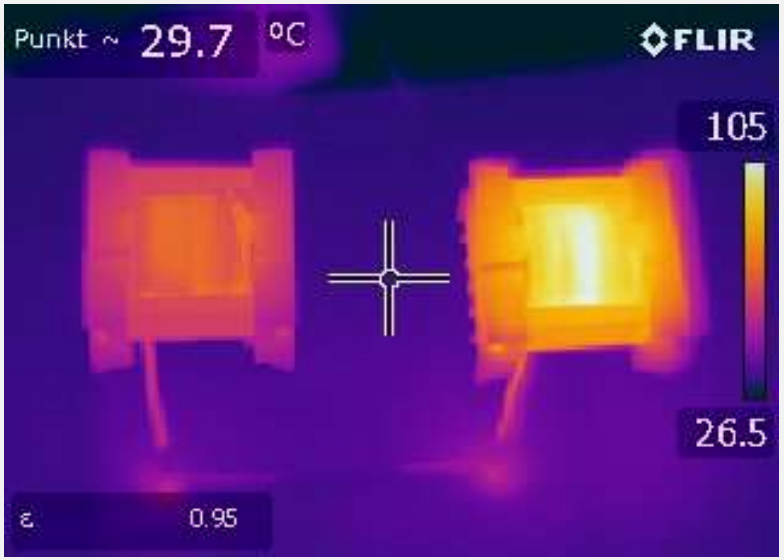
- Proximity losses decrease as the number of smaller air gaps increases
- Identical distributed air gaps are more efficient than non-identical air gaps

The best performance/cost ratio is achieved with three identical air gaps

Distributed air gaps improve the temperature increase

Measurement of temperature after 60 min of 5 A_{pp} @ 50 kHz with ETD 29/16/10 cores in N87 with three distributed air gaps (left) and single air gap (right) with wire coils

3 identical air gaps

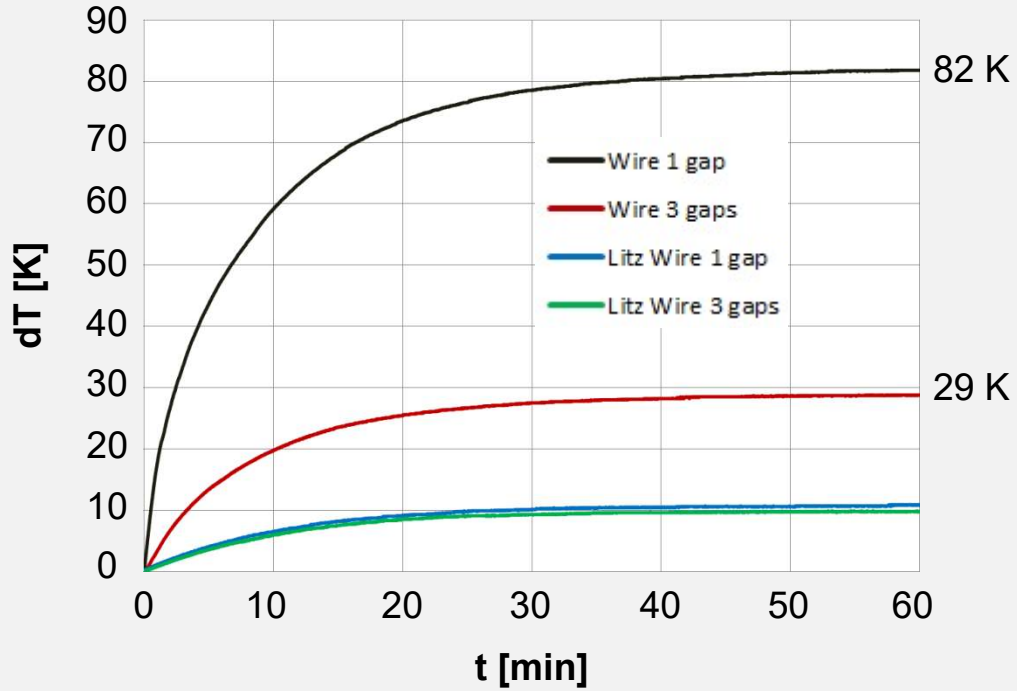


1 air gap

Temperature increase improves with distributed air gap cores

Distributed air gaps improve significantly the temperature increase with wire coils

Measurement of temperature increase for 60 min of 5 A_{pp} @ 50 kHz with ETD 29/16/10 cores in N87

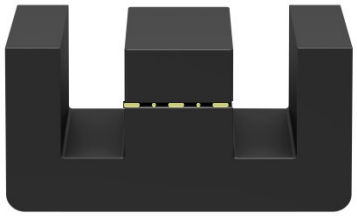


- Temperature increase can be reduced by the factor 3 for wire coils
- Effect of temperature difference is already noticeable at low frequencies for wire coils

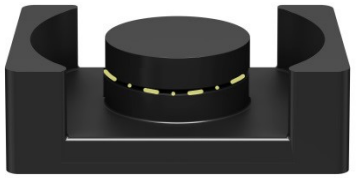
Proximity losses can be reduced by the factor 3 for wire coils

Wide range of core types with distributed air gaps

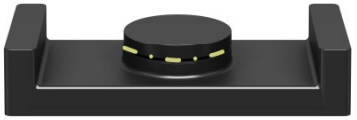
E cores
Sizes: E 42 to 100



EQ cores
Sizes: EQ 25 to 30

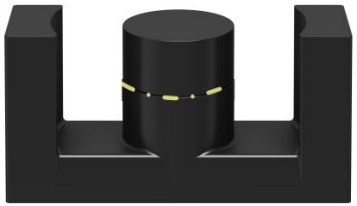


ER cores
Sizes: ER 28 to 54

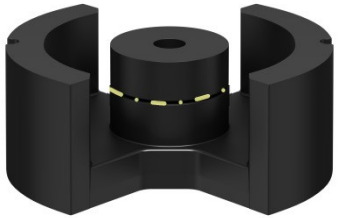


PQ cores
Sizes: PQ 32 to 50

ETD cores
Sizes: ETD 29 to 59



PM cores
Sizes: PM 50 to 114



All core types are available in all materials

Customer benefits

Distributed air gaps

- Reduce proximity losses by up to 70%
- Enable use of a larger winding area by reducing the fringing flux
- Lower winding losses than with a single large air gap for the factor 3
- Enable reduction of the core size by one class thanks to lower winding losses, e.g.
  - E 65 to E 55
  - ETD 59 to ETD 54
- Offer significantly increased power density

Identical air gaps increase the efficiency of applications

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