



Integrated Magnetics, Optimization of Common Mode Chokes (CMC) Integrated with Differential Mode Chokes (DMC)

Andres Arias & Risha Yu





Andres Arias
Engineering Manager
Premier Magnetics



Risha P. Yu
Engineer
Premier Magnetics



It has been known that CMCs can provide differential noise filtering by means of leakage inductance (LL).

Different winding techniques and modifications to the magnetic circuit are displayed to have comparative measures for practical use and manufacturing.



In the history of magnetics, there are multiple documents presenting analytical methods and other means to estimate LL. There have also been experiments and research to integrate CMC and DMC capabilities in a single component. Most approaches are difficult for high volume manufacturing, yet the magnetics component industry has released some CMC integrated products that have not gained popularity due to cost and/or manufacturing reliability.

The goal of this project is to provide a general idea on how to optimize a CMC to have higher LL by means of achievable manufacturing techniques.

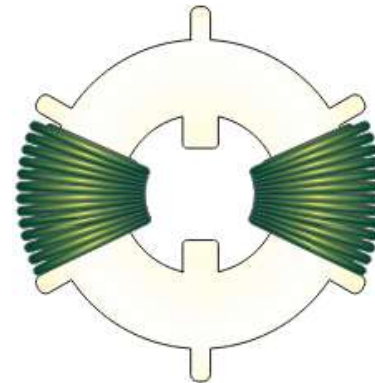
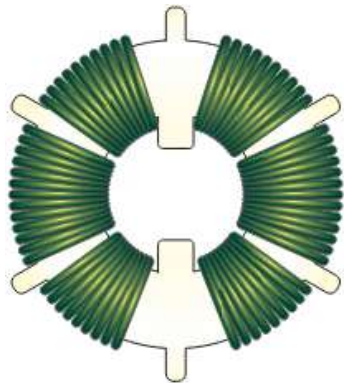
Control Parameters

- Toroid size = 31 x 19 x 12 (OD x ID x HT)
- Permeabilities = 3k μ , 5k μ , 10k μ
- Case = 33 x 17 x 15 (OD x ID x HT)
- Wire size = #19 AWG Heavy
- Turns = 30

Results shown are based on above mentioned parameters.

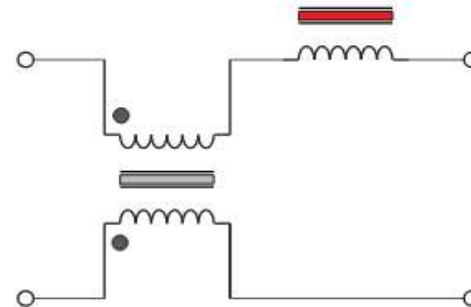
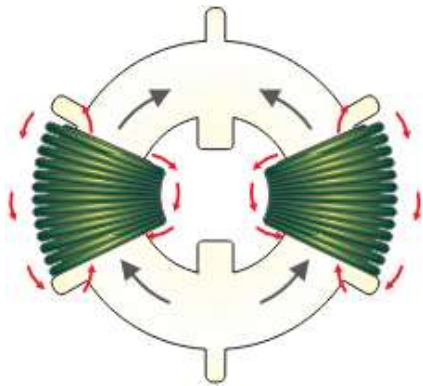
Increase LL by reducing coupling between windings

Smaller winding angles and larger cores will increase LL.



Increase LL by reducing coupling between windings

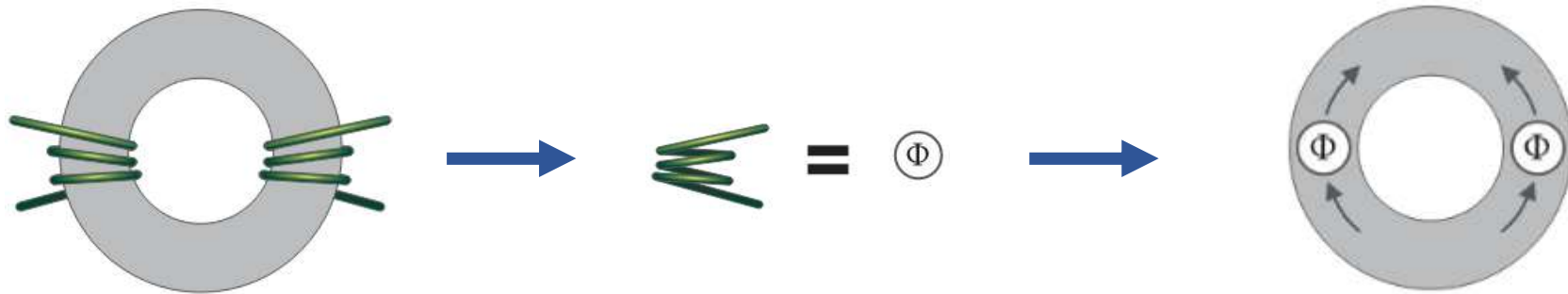
≈50% LL improvement, 55° vs 175°.



Leakage flux exits from the core and completes its magnetic path through air. It is also contained within the winding layers.

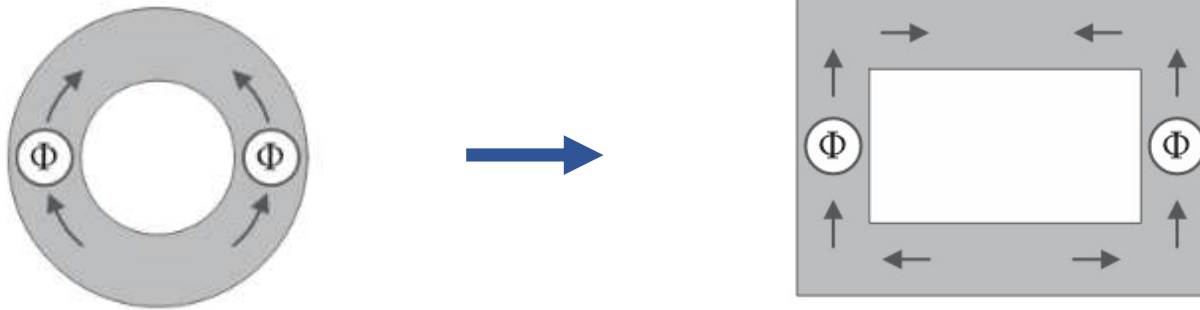
Analysis simplification

Each winding is a flux source.



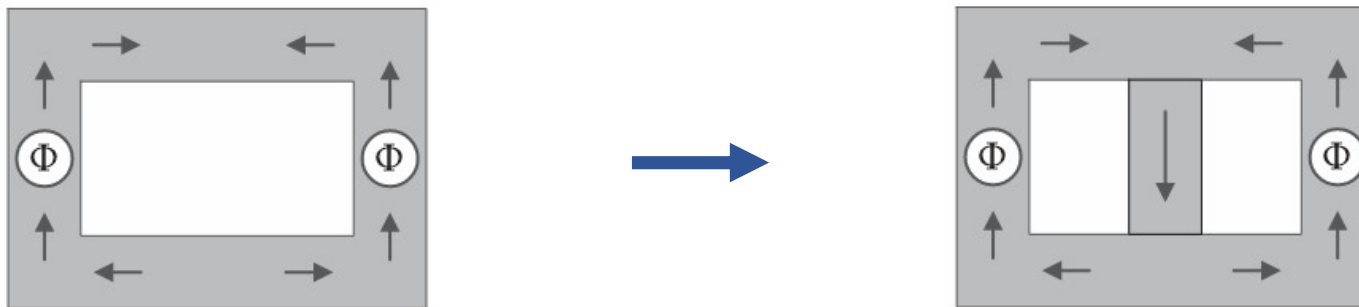
Analysis simplification

Assume a rectangular core.



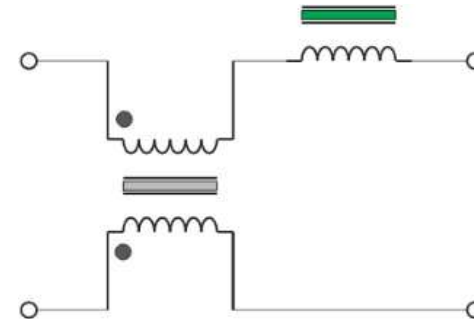
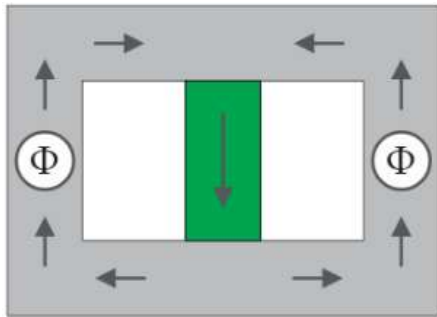
Increase LL by enhancing inner magnetic circuit

Increasing the effective permeability of the inner magnetic path, or lowering its effective reluctance provides an easier path for additional leakage flux, therefore increasing LL.



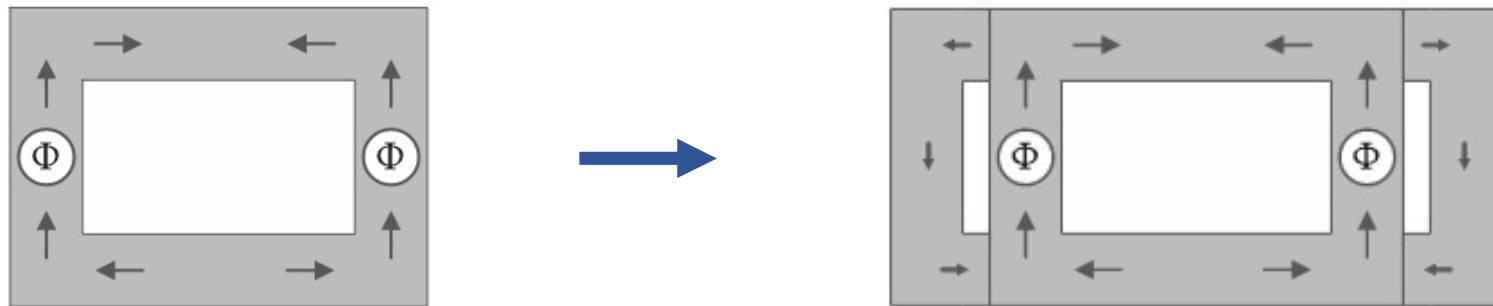
Increase LL by enhancing inner magnetic circuit

30% to 100% LL improvement, depending on magnetic circuit.



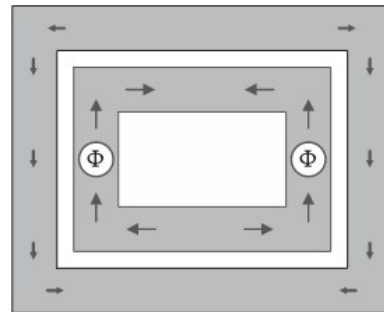
Increase LL by enhancing outer magnetic circuit

Similarly, we can increase LL by modifying the outer magnetic path.



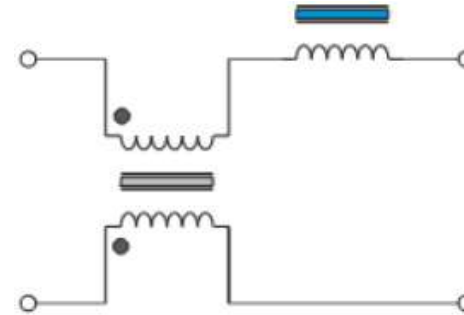
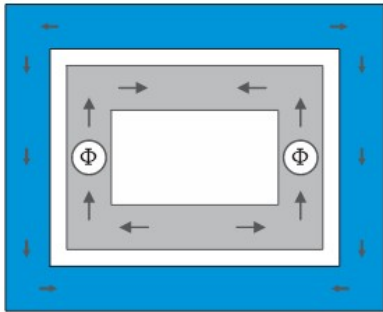
Increase LL by enhancing outer magnetic circuit

The outer magnetic path can be modified further for manufacturing.

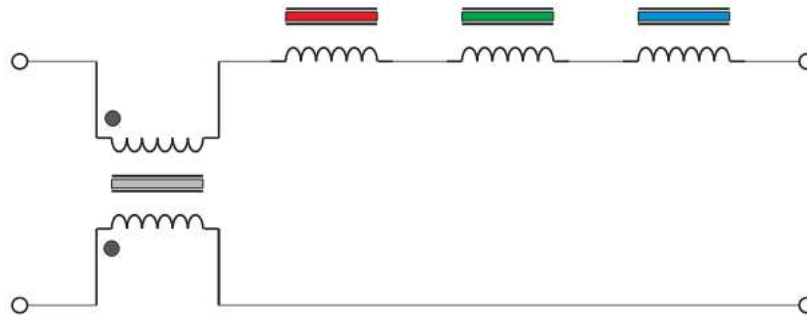


Increase LL by enhancing outer magnetic circuit

5% to 60% LL improvement, depending on magnetic circuit.



Increase LL by combining any of the above methods



Conclusion

LL can increase by:

- Reducing windings coupling.
- Increasing the flux leakage by modifying the inner magnetic path with higher permeability.
- Harnessing the external flux leakage with a modified outer magnetic path. This can be extended in all directions of the CMC, but it would present higher manufacturing challenges.

Thank you

for your attention

