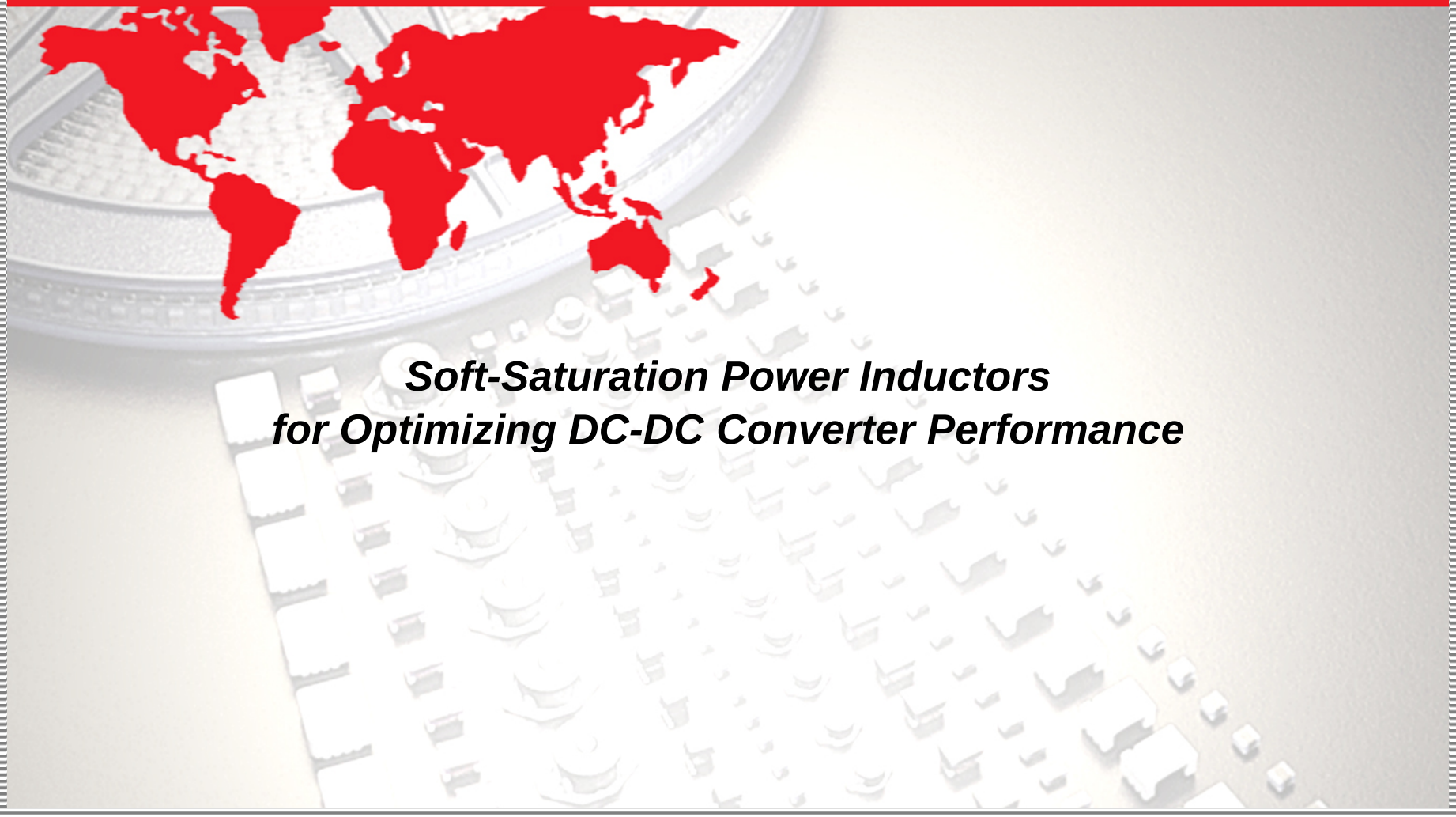
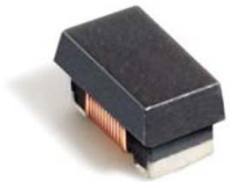
Coilcraft



Soft-Saturation Power Inductors for Optimizing DC-DC Converter Performance

Soft-saturation, molded inductors

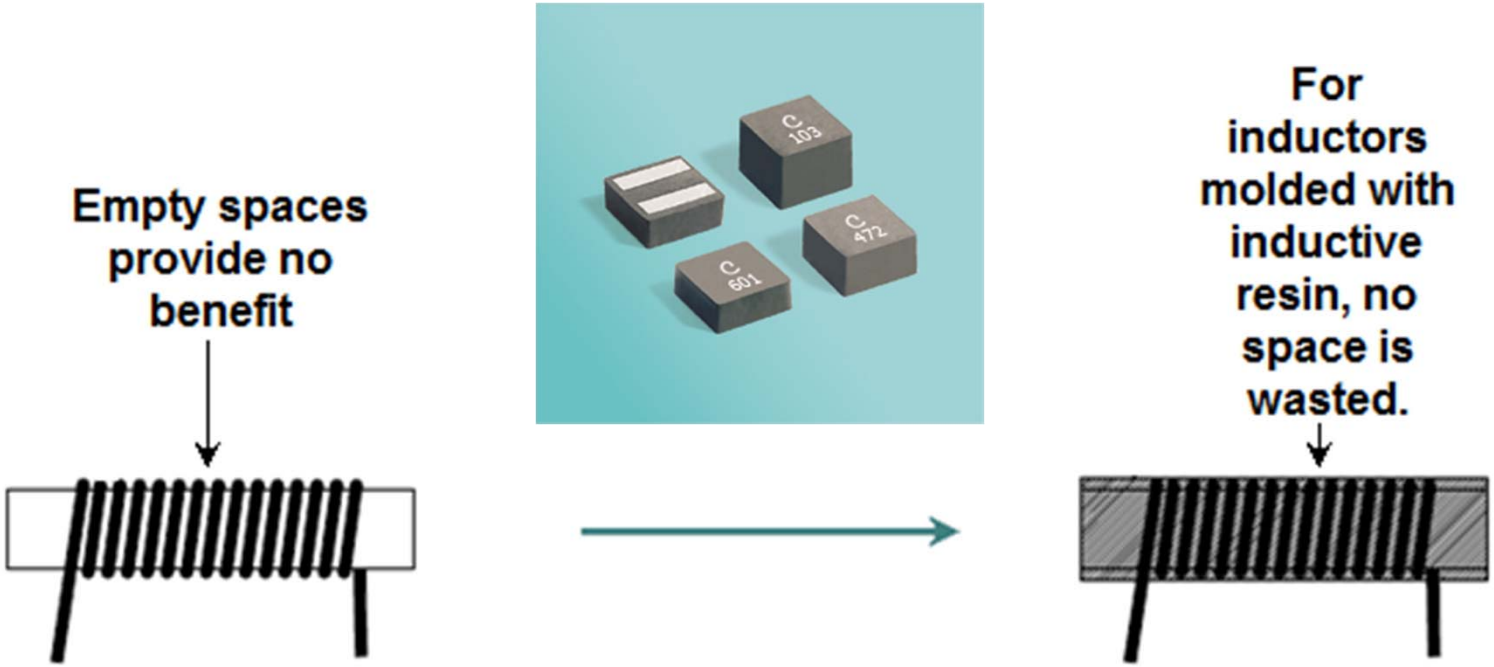
The development of high performance power inductors with molded, distributed air-gap cores leads to size reduction and improvements in power supply efficiency.



Crucial parameters must be properly understood and specified clearly in order to maximize the benefits of these new inductor types.

What is a molded style inductor?

The distinguishing feature of these inductors is the special use of magnetic materials to form a solid combination body shape. This eliminates wasted space between windings and gives better Isat and DCR in the same size part.



The General Power Inductor Design Challenge:

The goal is to maximize the L and Isat, and at the same time minimize R, size, and cost.

Therefore, we must understand the relationship between these parameters.

(1) Inductor value is a function of material properties and geometry

$$L = 4\pi\mu \frac{N^2 A_e}{l_e} \times 10^{-9}\ H$$

μ = Relative permeability

- **This is a material property.**
- **Limited range of materials.**

N = Turn count

- **Wide range possible.**
- **Effective due to turns squared.**

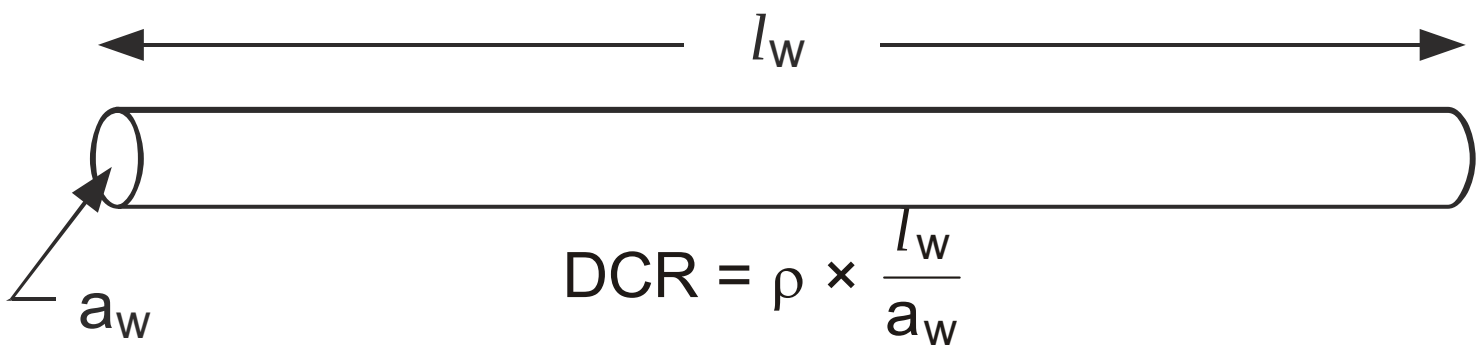
a_e = Winding cross-section area (cm^2)

- **Effective but increased size penalty.**

l_e = Magnetic path length (cm)

- **Interesting inverse relationship.**

(2) DC Resistance is also function of material property and geometry



ρ = Volume Resistivity of the wire ($\Omega \times$ cm)

- This is a material property

l_W = Winding wire length (cm)

- Winding length depends both on the turn count and geometry

a_W = Winding wire cross-section area (cm)

- Wire tables

(3) Saturation Current is a function of Material Properties and Geometry

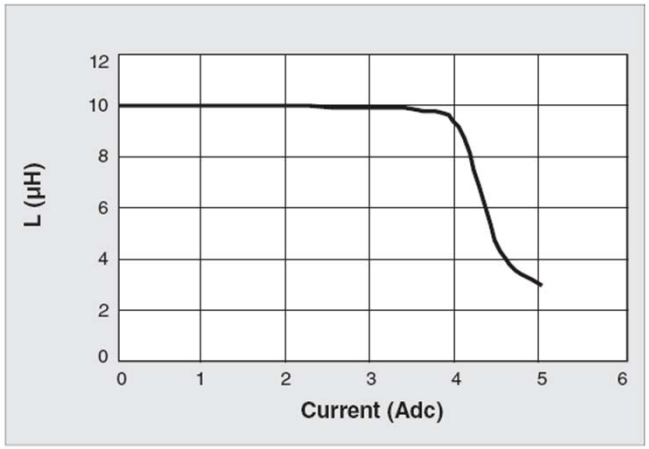
$$I_{sat} \propto \left(B_{sat} \times N \times A_e\right) / L$$

Bsat = Material Property

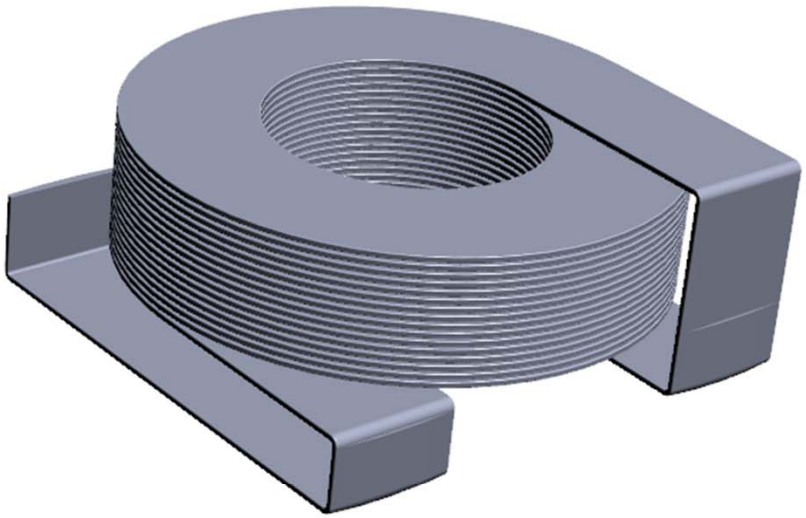
Ae = Core cross section

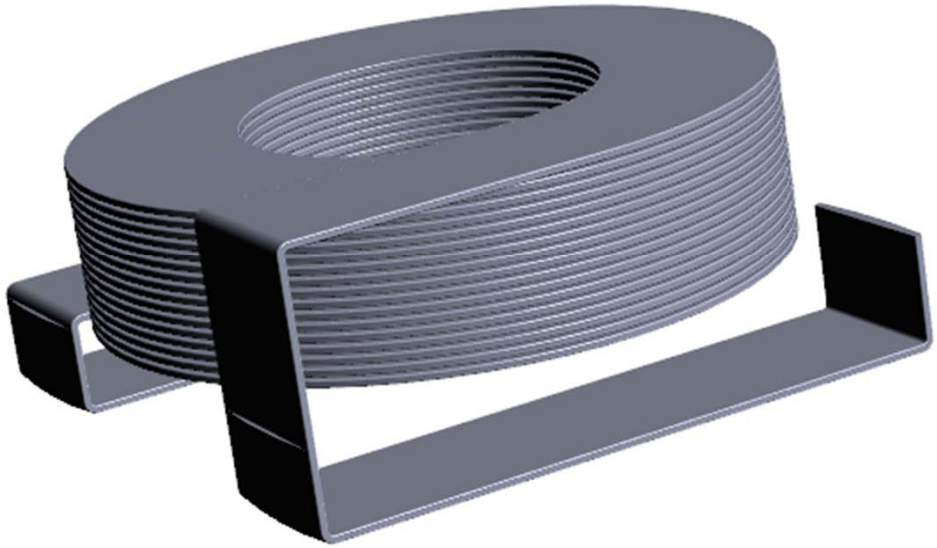
L = Needed Inductance

N = Turn Count



Self-lead inductor design





Example of molded inductor performance

Series	Height (mm)	Footprint (mm)	DCR (Ω)	Isat
Traditional Core Style	1.8	4 x 4	.042	4.0
XFL Molded Style	**2.0**	**4 x 4**	**.011**	**5.1**

Better DCR

Better Isat

Example of size reduction achieved by molded inductors

Series	Height (mm)	Footprint (mm)	DCR (Ω)	Isat
MOS Traditional	2.0	6.8 x 6	.040	3.6
XAL Molded Style	**2.0**	**4 x 4**	**.021**	**3.7**

61% size reduction with molded power inductor.

Benchmark

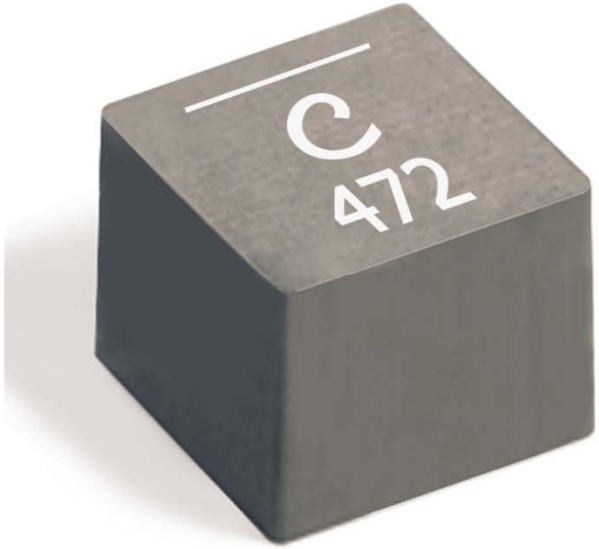
The XAL7030 performance is shown here against the closest industry standard inductor family, but these should not be viewed as alternates. The Coilcraft XAL inductor families represent the next-generation of superior technology. The example here shows Coilcraft XAL7030 to have superior, low DCR, about half the competition.

Part No.	L	DCR typ.	Isat (20% Ldrop)
IHLP2525CZ-01	1 µH	9.00 mΩ	22 A
IHLP2525CZ-06	1 µH	8.44 mΩ	22 A
XAL7030	1 µH	4.55 mΩ	20A

The winner.

Mechanically Strong

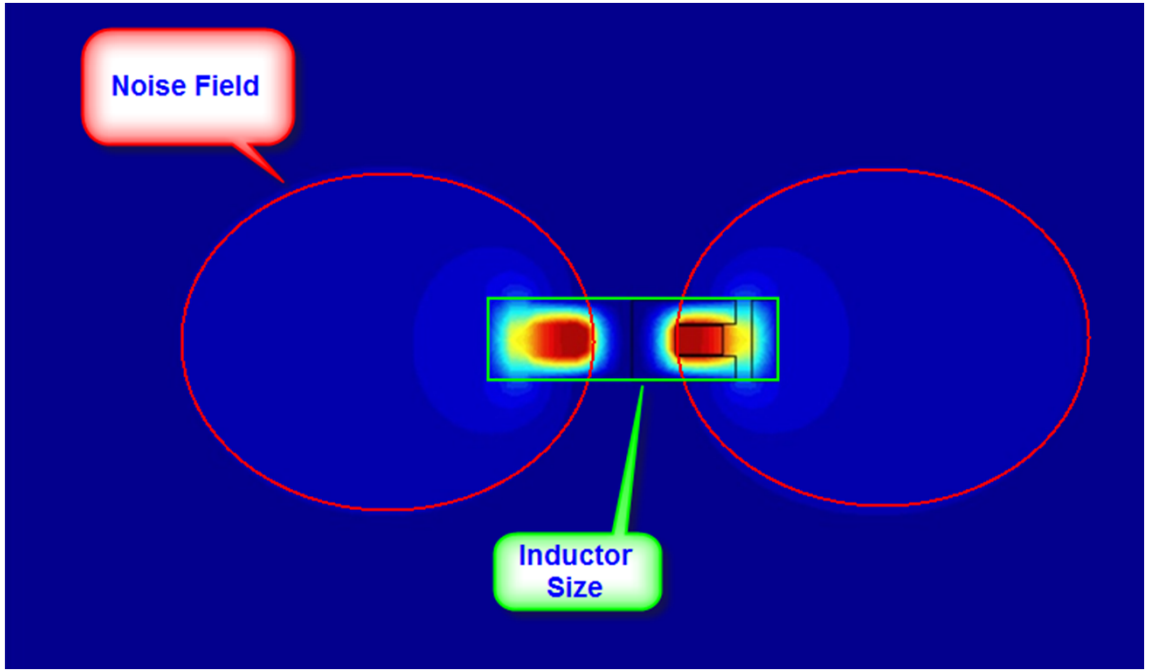
These inductors are solid, strong shapes. They are quite rugged and suitable for high stress environments like portable electronics and automotive.



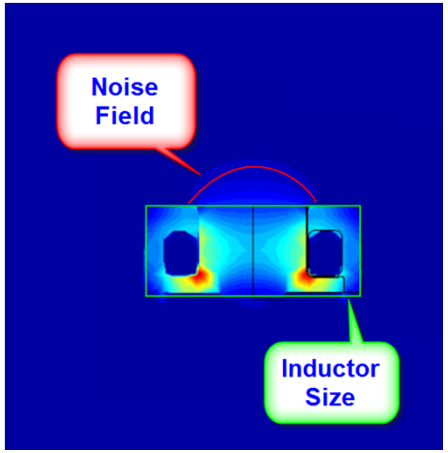
Magnetic Shielding

The use of magnetic resins throughout the coil body insures the best possible reduction of harmful EMI emissions. Components can be placed closer together for highest pcb density.

Normal Type



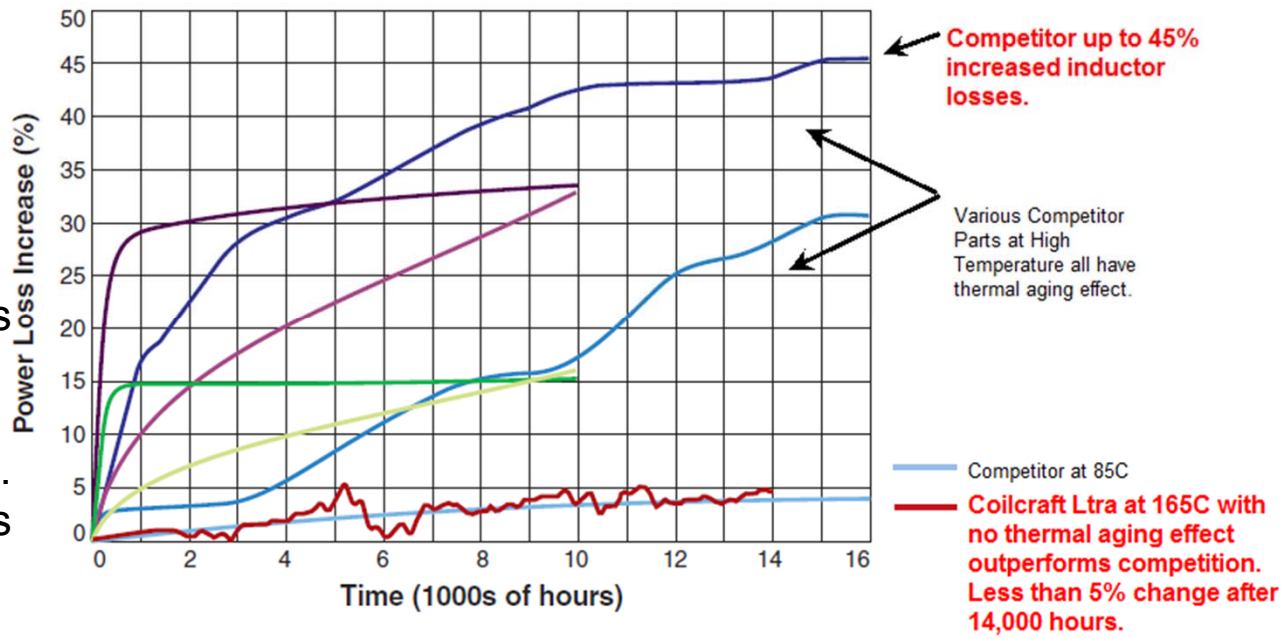
Ltra Type



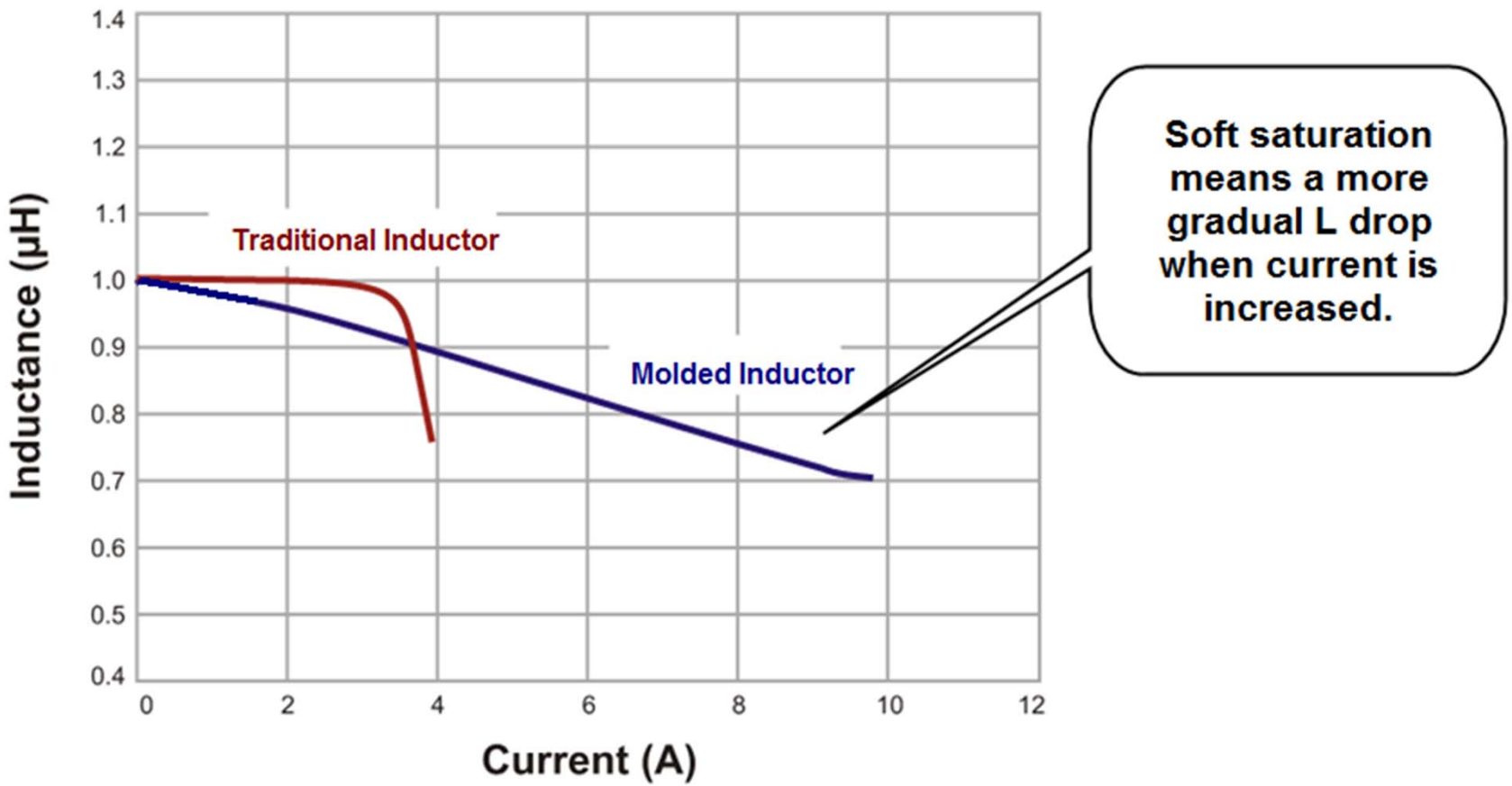
Ltra means Reliability – Superior Materials

Some inductor core materials exhibit a negative property called thermal aging. When thermal aging happens to inductors, the efficiency gets worse with the application of time and temperature. The efficiency loss causes more heat, which again lowers the efficiency, leading to more heat….and so on…inductors and circuits can be heated beyond acceptable ratings…sometimes with disastrous effects.

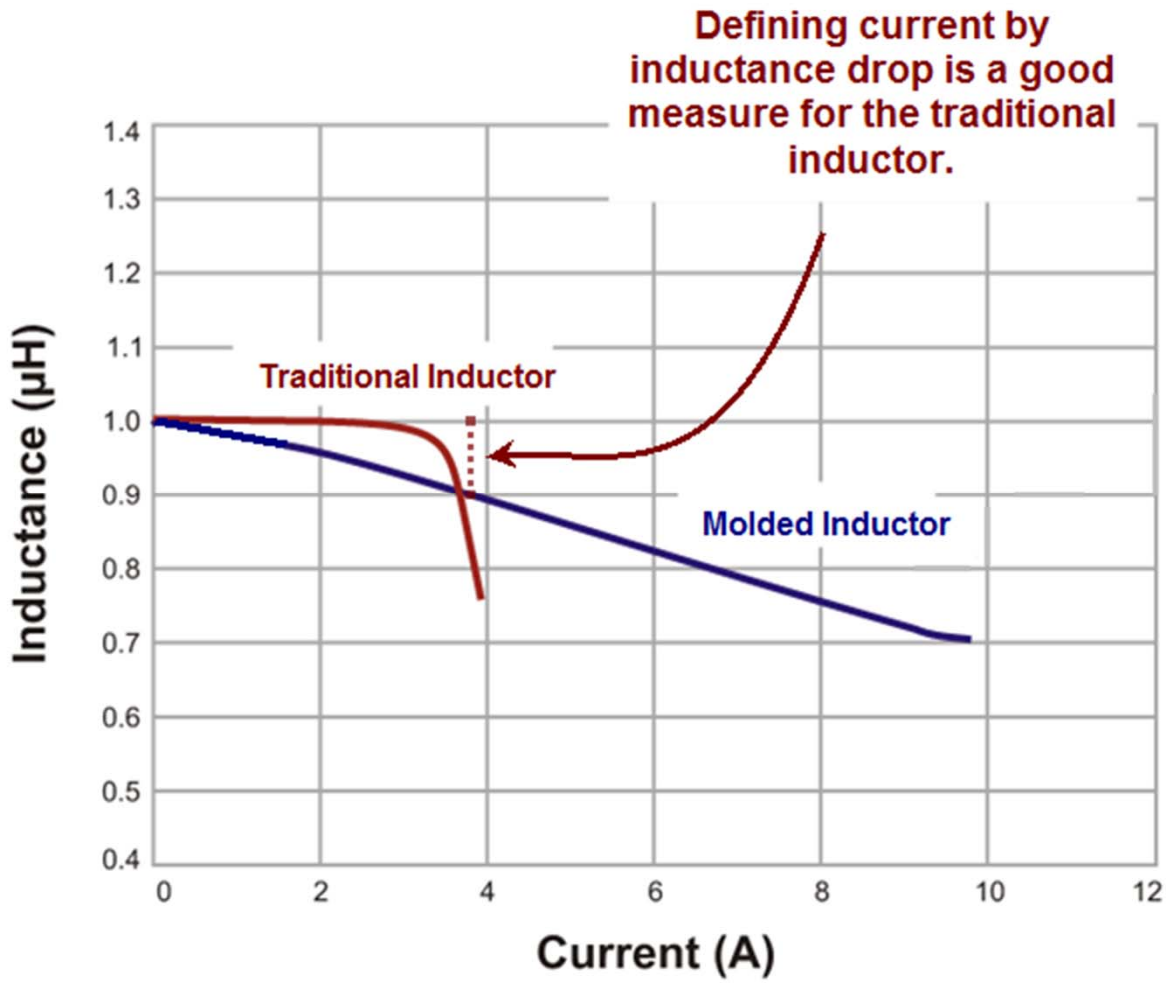
Coilcraft Ltra materials have been specially engineered to eliminate thermal aging concerns. The comparison below shows how some inductors sold today exhibit increased loss when subjected to thermal aging. The Coilcraft Ltra inductors have no such problem.



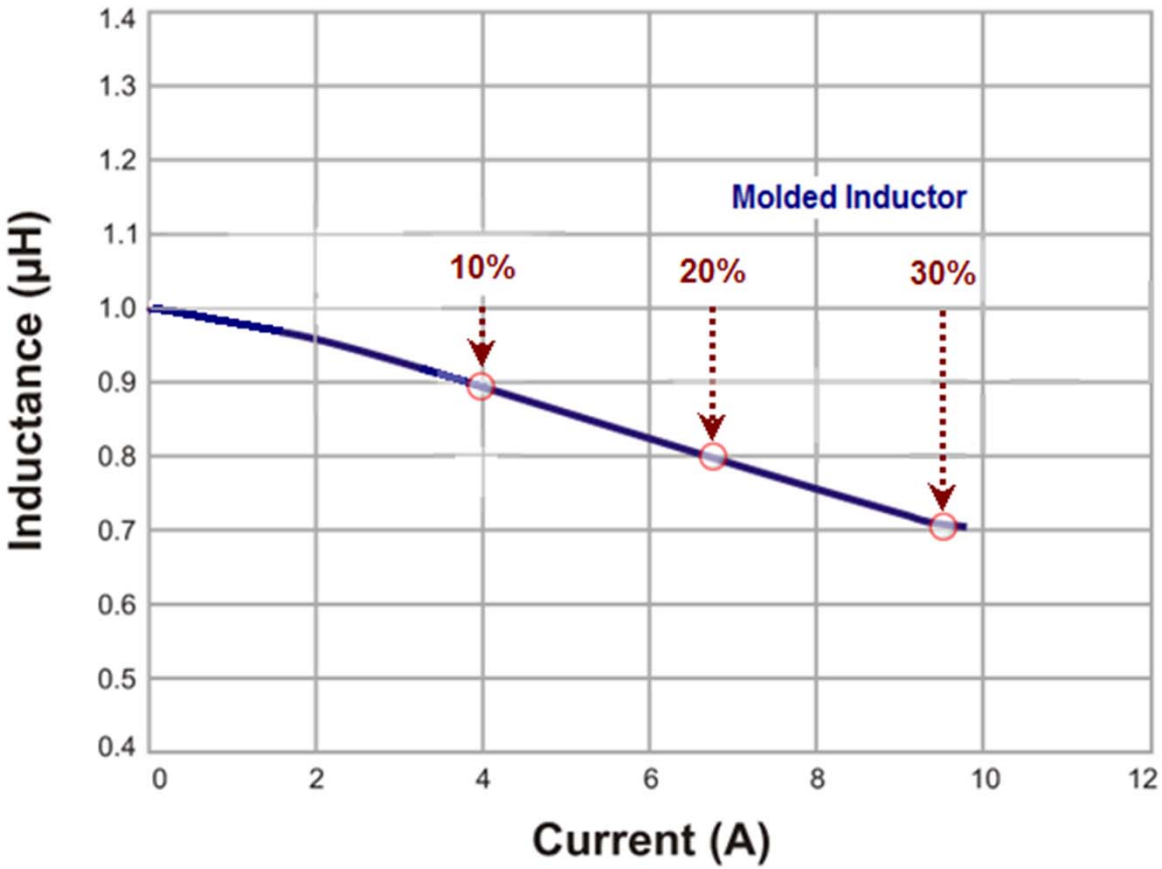
Soft saturation



The soft saturation characteristic for molded inductors requires rethinking the definition of saturation. Where does saturation begin for the molded style?

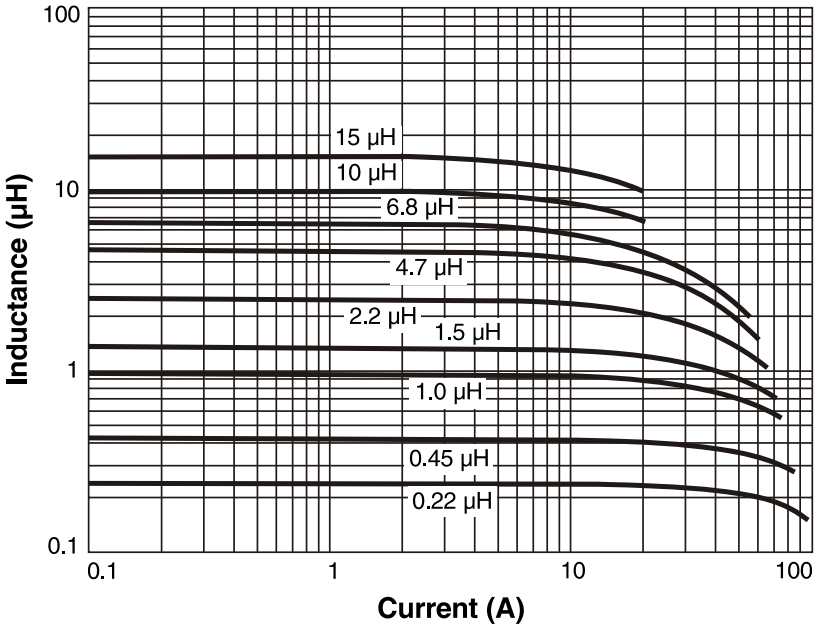


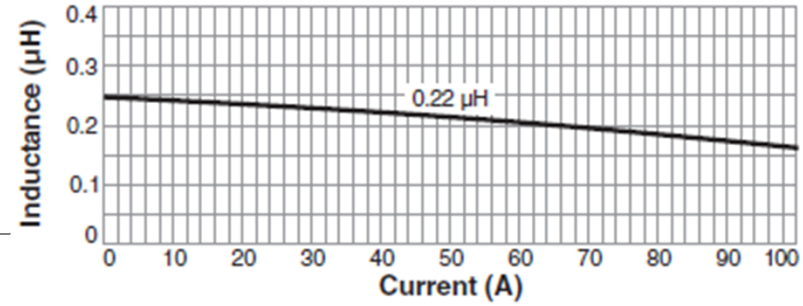
Saturation defined the traditional way, by inductance drop.

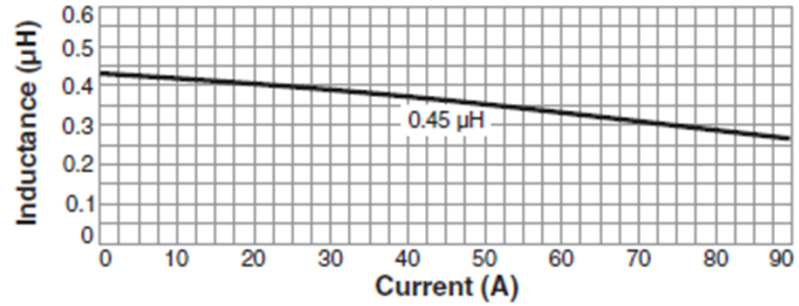


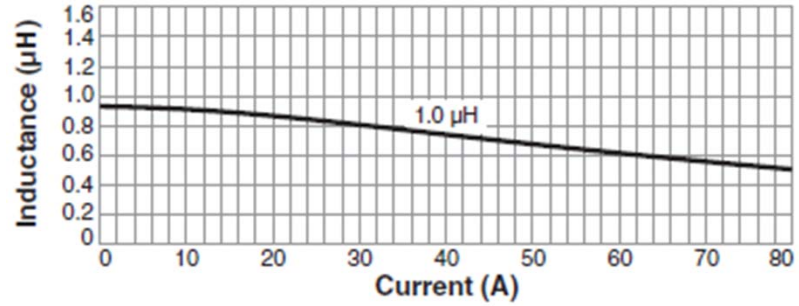
The concept of Inductance @ Current.

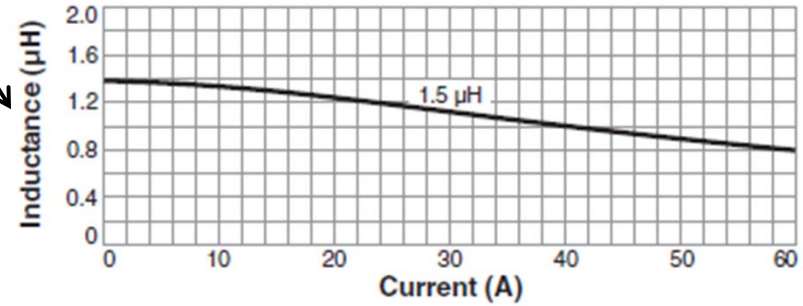
The linearity of the “curves” makes it feasible to read the pertinent information directly for the exact operating point of interest.











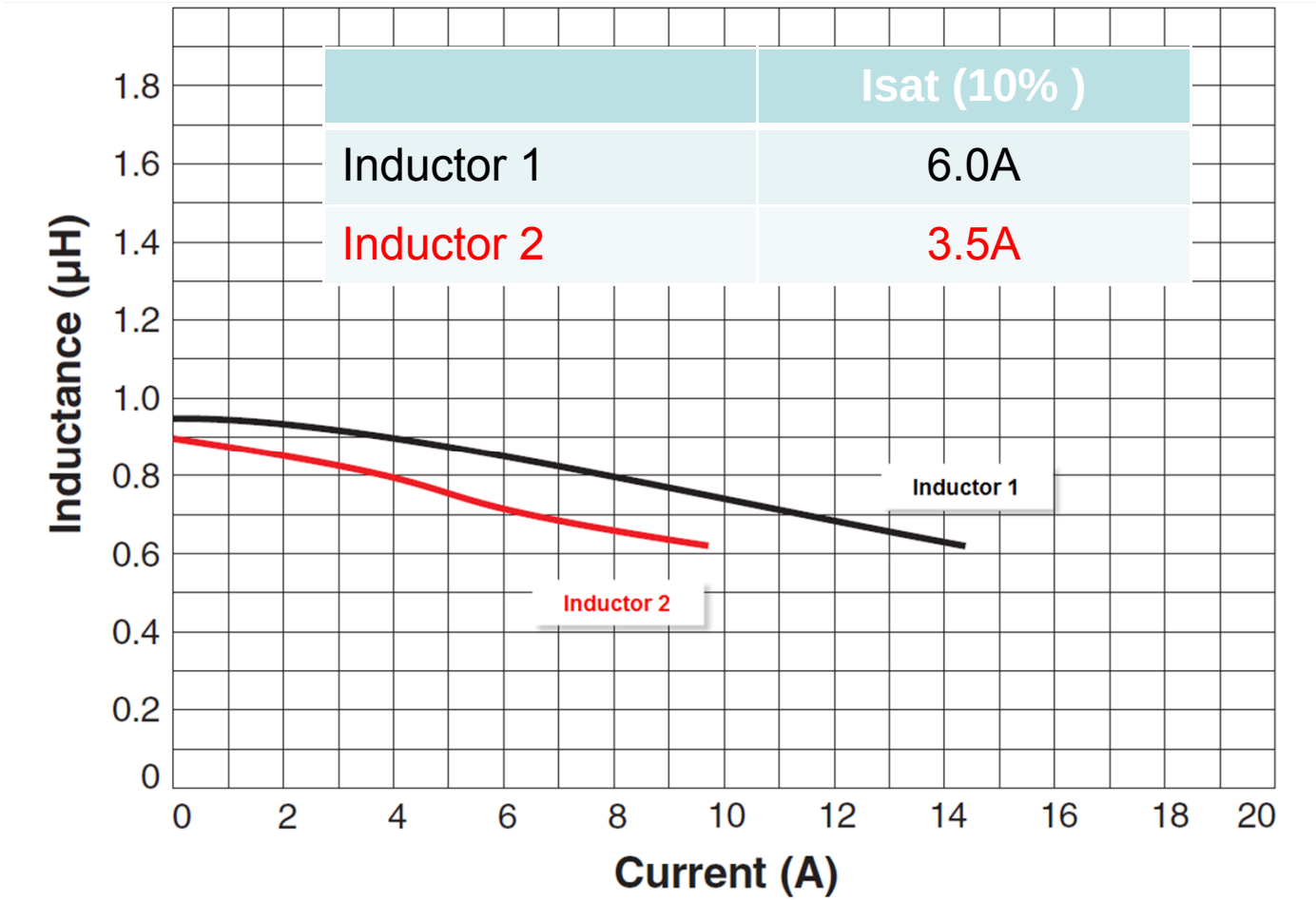
Example – consider a comparison of power inductors.

	Isat (10%)
Inductor 1	6.0A
Inductor 2	3.5A

The higher Isat rating of Inductor 1 comes with a tradeoff of higher DCR.

	Isat (10%)	DCR
Inductor 1	6.0A	.015 Ω
Inductor 2	3.5A	.010 Ω

Here are the saturation curves for Inductor 1 and Inductor 2. Is inductor 1 two times better?



	Isat (10%)
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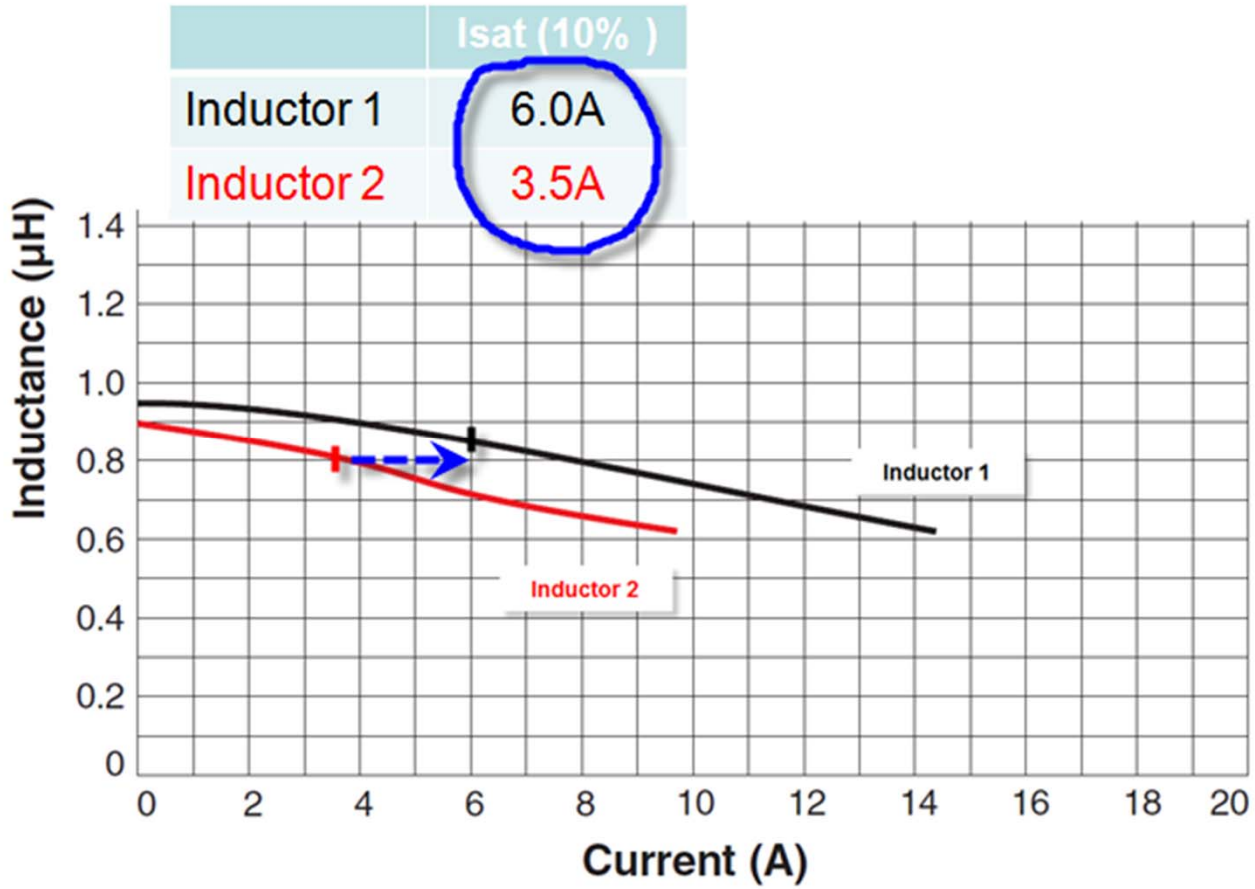
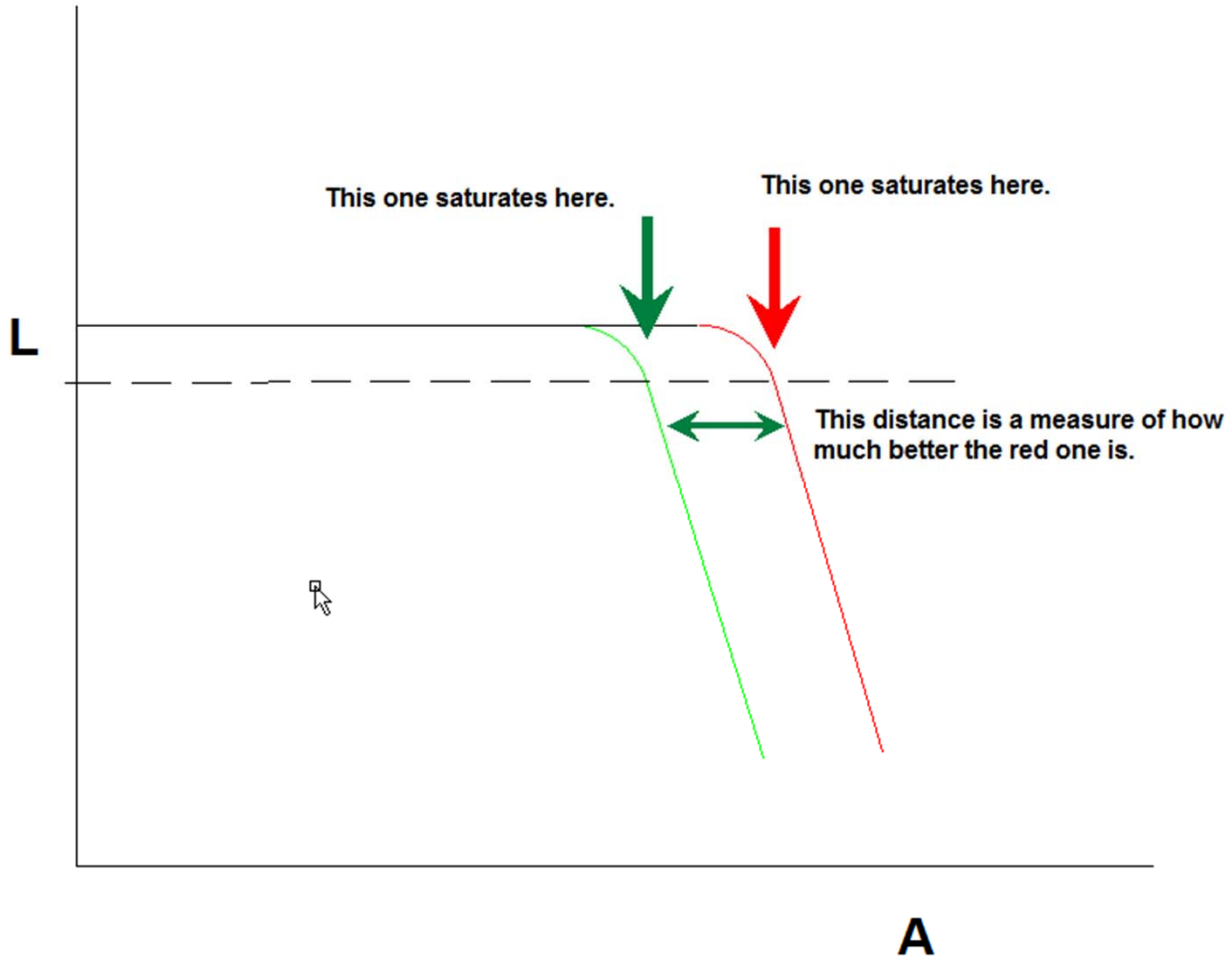
Inductor 2	3.5A

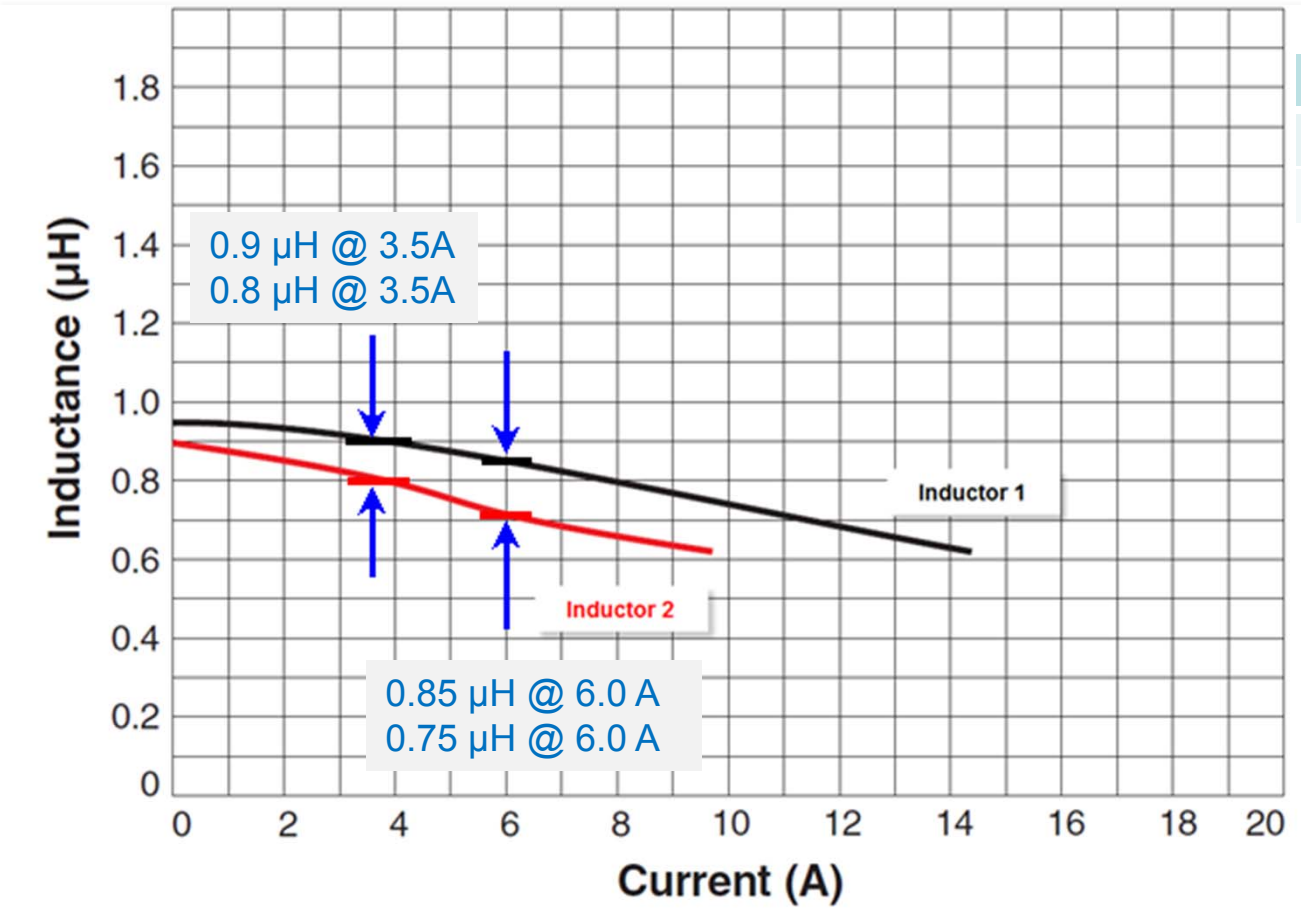
Ldrop comparison



The "inductance drop" definition assumes there is a distinct saturation region. It is the vertical portions of the curves that can be meaningfully compared in the horizontal direction.



A more meaningful comparison…might be…
L@ Current



	Isat (10%)
Inductor 1	6.0A
Inductor 2	3.5A

Preview – New tool coming soon

The *Inductance at Current Finder* provides results for the exact operating conditions of interest to the converter designer.

Inductance at Current Finder

- Find power inductors that have the actual inductance value you need at a specific current.
- Enter your desired inductance value and current, then press GO.

INPUTS **Desired Inductance** (uH) 4.7 **Current** (Amps) 10 *(Use . for decimal)* GO

Part number	Inductance at 10 A (uH)	DCR (Ohms)	L max (mm)	W max (mm)	H max (mm)	Price @1,000	Graph (4 max)	Samples (8 max)
XAL1010-472	4.2	0.0057	11.80	10.50	10.00	$1.39	☐	☐
XAL1580-532	4.9	0.0052	16.20	15.20	7.50	$0.76	☐	☐
XAL1010-562	4.9	0.0069	11.80	10.50	10.00	$1.39	☐	☐
XAL7070-682	5.6	0.0196	8.00	7.70	7.00	$0.87	☐	☐

Select parts of interest for more detailed analysis.

Inductance at Current Finder

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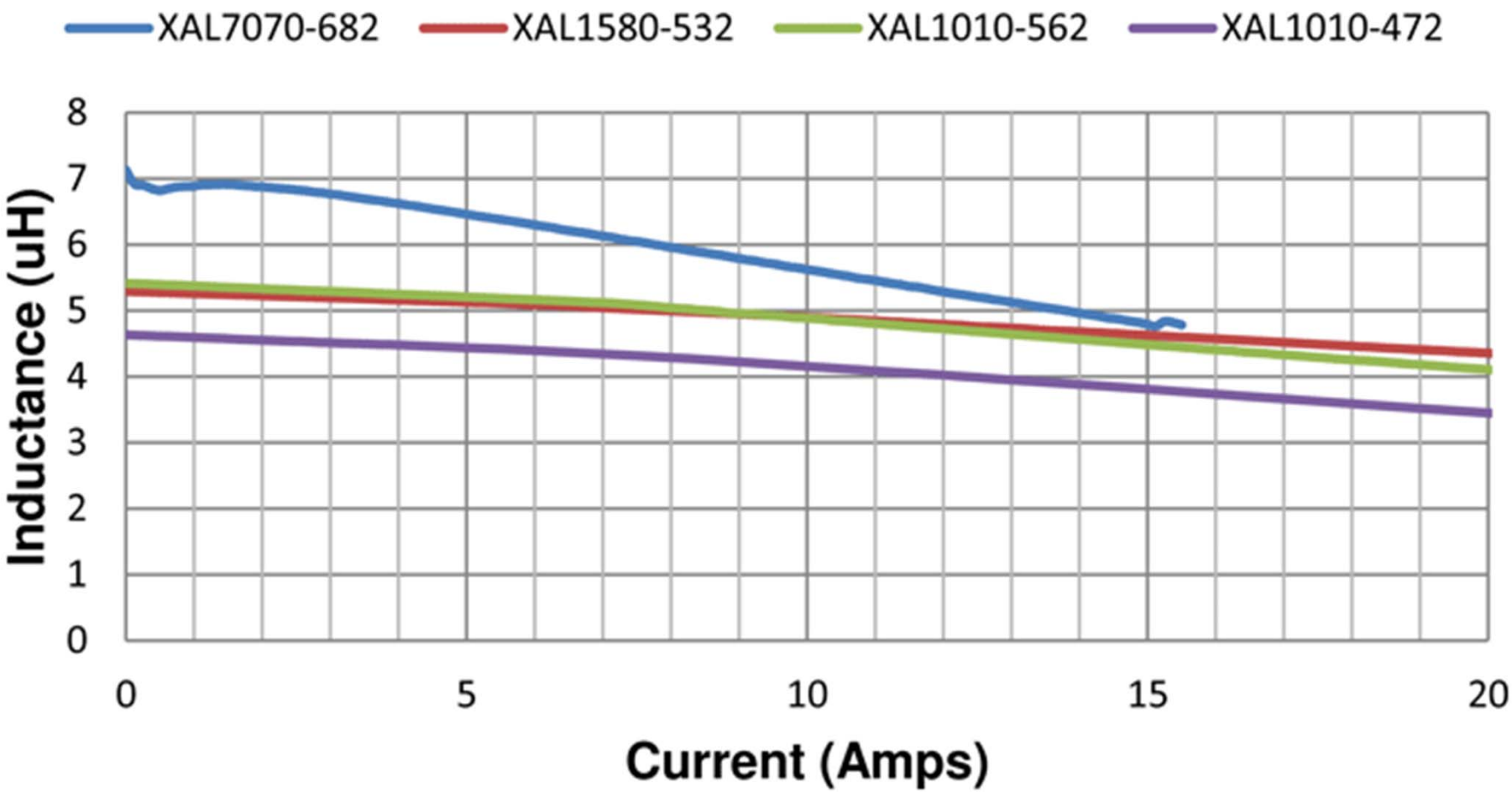
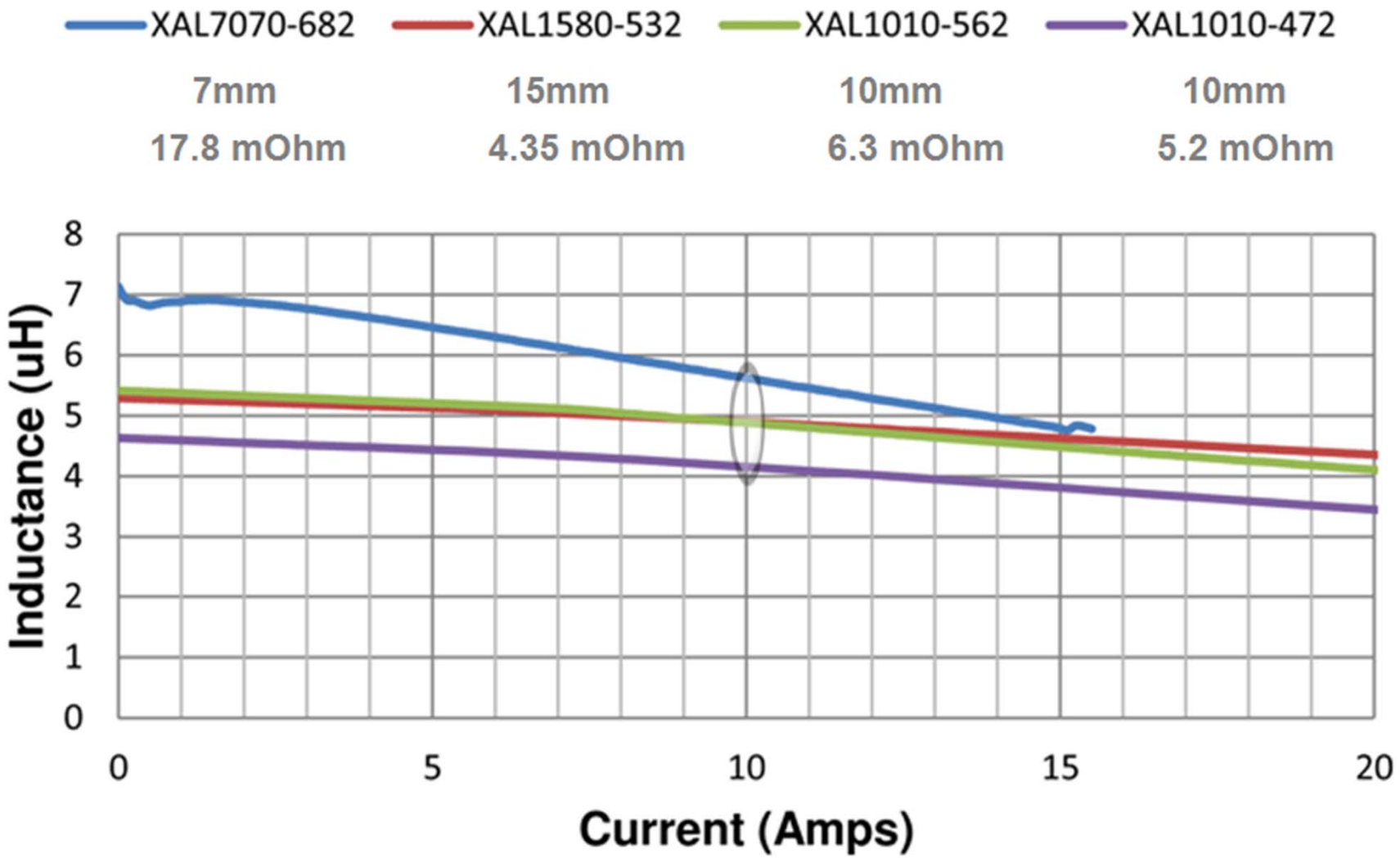
For a closer look.

"Curves on Demand"



Inductance @ Current "Curves on Demand" a key feature



Conclusions

New characterization data allows the user to take full advantage of the possibilities for size and efficiency improvement offered by new power inductors.