CircuitClarity RESOURCE

Inductor nonidealities

https://circuitclarity.com/resources/inductor-nonidealities/

The decision this guide supports

Inductance is only one part of an inductor decision. Saturation current, DC resistance, core loss, AC loss, tolerance, temperature, and self-resonance determine whether a nominal value behaves as intended.

A useful calculation is not the finish line. It becomes useful when its method, units, source conditions, and omitted effects fit the actual design question. Use this reference to identify that boundary before treating a nominal result as an implementation decision.

DECISION MAP

From first estimate to defensible next step

1. **State current waveform and frequency.**
   Start by naming the physical quantity, operating condition, and decision at stake. A number without that context cannot establish a design margin.

2. **Check inductance tolerance and saturation at the peak current.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

3. **Estimate copper and core loss at temperature.**
   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

4. **Validate the selected inductor in the actual layout.**
   Treat this as the handoff point. Compare the result with selected-part evidence, the real layout or assembly, and a measurement method that can reveal the remaining uncertainty.

Worked design review

Consider a designer using this method to make a first selection. The initial estimate establishes the nominal target, but it should not silently absorb a rating, curve, parasitic, temperature condition, or measurement setup from a different scenario. The correct outcome is often not a single chosen value: it is a short list of conditions that must be satisfied together.

Begin with the first two steps above, then ask whether the value still fits when the most consequential real-world condition changes. If it does, the estimate has earned a more detailed check. If it does not, the discrepancy identifies the design variable that deserves attention before a board, part, or test plan is committed.

> **Practical interpretation**
>
> An ideal RLC calculation cannot predict saturation, heating, audible behavior, or EMI. That is not a weakness in the method. It is the cue to use the correct next source of evidence.

Questions to take into a design review

Has the saturation-current curve been checked at the actual worst-case peak current, including the effect of inductance tolerance?

Was core and copper loss estimated using the actual operating frequency and ripple current, not a single generic data point?

Has the selected inductor been validated in the real layout for thermal rise and, if relevant, audible noise?

These questions prevent a common failure mode: moving a correct equation into a context where its assumptions no longer hold. They also make it easier for another engineer to reproduce the reasoning and identify which condition needs more evidence.

Common ways this reasoning goes wrong

Sizing an inductor from the nominal inductance value without checking the saturation-current curve at the actual peak current

Effective inductance falls as current approaches saturation, so a part that looks adequate at its nominal inductance can behave very differently, with much higher ripple, right at the operating point it was chosen for.

Ignoring inductance tolerance when checking peak current against saturation

A wide inductance tolerance (common in low-cost power inductors) shifts the calculated ripple current and peak current; the worst-case tolerance corner, not the nominal value, is what needs to clear the saturation limit.

Estimating core loss from a single data point instead of the frequency- and flux-dependent loss curve

Core loss rises nonlinearly with both frequency and peak flux density; a single tabulated loss number at one operating condition does not extrapolate reliably to a different frequency or ripple current.

Where this guide stops

An ideal RLC calculation cannot predict saturation, heating, audible behavior, or EMI.

For a consequential design, preserve the inputs and conditions used here, then compare them with the selected component or system evidence. That makes the follow-up review faster and keeps a useful first estimate from becoming an unsupported claim.

Frequently asked questions

▶ **Why did my converter's ripple current increase sharply as load current rose?**

▶ **Does inductor tolerance matter as much as capacitor tolerance?**

▶ **Why does my inductor make an audible noise at certain load currents?**

Related engines

- **RLC resonance, damping, and Q**
- **Inductor current-ramp estimator**
- **Inductor network**
- **Inductor saturation and ripple-current screen**

Method authorities and source conditions

Use this guide alongside the engine-specific method and selected component or system data. The underlying reference families are TI power design references. Those sources establish condition-specific behavior; CircuitClarity uses them to frame the decision and its limits.