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Design Case: 11 kW Totem-Pole PFC Boost Inductor for an 800 V OBC

From a failed first build to a passing DVP — with the numbers and the lesson

Item	Detail
Document	Anonymized design case — 11 kW totem-pole PFC boost inductor (800 V OBC)
Confidentiality	Customer identity withheld; parameters anonymized and rounded
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A buyer-private case: figures are anonymized/rounded engineering values, representative of the real project.

Summary & key takeaways

Bottom line

An 11 kW totem-pole PFC boost inductor was first sized from initial inductance — and collapsed to 21 μH at the 75 A peak (spec ≥30 μH), failing DC bias. Rebuilt with stacked cores and turns cut from 30 to 21, it measured 31 μH at 75 A, 52 K temperature rise and 4.9 mΩ DCR — passing the full DVP. The one-line lesson: for powder-core inductors, always size turns from the biased inductance, never the initial value.

Key takeaways:

- **Scenario:** 800 V platform OBC, single-phase totem-pole PFC, 11 kW, fs=100 kHz, 50 A rms / 75 A peak.
- **Why V1 failed:** turns sized from initial AL; operating H ≈ 192 Oe left only ~55 % of permeability — inductance collapsed.
- **The fix:** stack cores to double Ae → AL doubles → turns 30→21 → H drops to ~134 Oe → ~68 % permeability retained.
- **Winding:** edge-wound flat wire (5×1.6 mm), 21 turns, 4.9 mΩ DCR — about 30 % lower than round wire in the same window.
- **Result:** 31 μH at 75 A, 52 K rise (55 K limit), hi-pot/PD pass — full DVP passed.

Anonymization Customer identity withheld; parameters anonymized and rounded, but magnitudes and engineering logic match the real project — which is the point: a real design-fail-fix sequence you can learn from.

1. The requirement

Parameter	Requirement (anonymized/rounded)
Application	800 V platform OBC · single-phase totem-pole PFC
Power	11 kW (rated)
Switching frequency	100 kHz (SiC)
Current	50 A rms · 75 A peak
Inductance	≥42 μH at 0 A; ≥30 μH at 75 A peak
DCR	≤ 5.5 mΩ
Temp rise	≤ 55 K (50 A rms, natural + duct airflow)
Insulation	800 V reinforced; hi-pot + PD
Environment	toward automotive Grade 1 (-40…+125 °C)

Table 1 — Customer requirement (anonymized)

The central tension is obvious: ≥30 μH still required at the 75 A peak — a DC-bias-dominated design where material and turns decide the outcome.

2. The first build: why it failed

V1 chose an Fe-Si powder core (high Bsat, low cost), single core, sized from the initial AL ≈ 51 nH/T²: 46 μH wanted, N = 30 turns. Perfect on paper — and at 75 A the sample measured only ~21 μH, thirty percent short of the 30 μH spec.

The root cause was treating initial inductance as operating inductance. One field-strength calculation shows it:

Operating field: H = 0.4π · N · I / le = 0.4π × 30 × 75 / 14.7 ≈ 192 Oe
Fe-Si %μ–H curve: ~55 % permeability left at 192 Oe
Actual inductance: L ≈ 46 μH × 0.55 ≈ 25 μH (measured ~21 μH with tolerance) → FAIL

Lesson A powder core's DC-bias curve is not 'reference information' — it is a design input. Turns must be derived from the biased inductance; skipping that step cost a full respin.

3. The fix: stacked cores + fewer turns

To hold inductance at 75 A there were two levers: switch to a more bias-tolerant material (High Flux, at a cost), or lower the operating H. We chose the latter — stacking two cores:

- **Ae doubles → AL doubles:** same inductance target with turns cut from 30 to 21.
- **H falls with N:** H = 0.4π×21×75/14.7 ≈ 134 Oe → ~68 % permeability retained.
- **Inductance passes:** L(75 A) ≈ 45 μH × 0.68 ≈ 31 μH ≥ 30 μH ✓

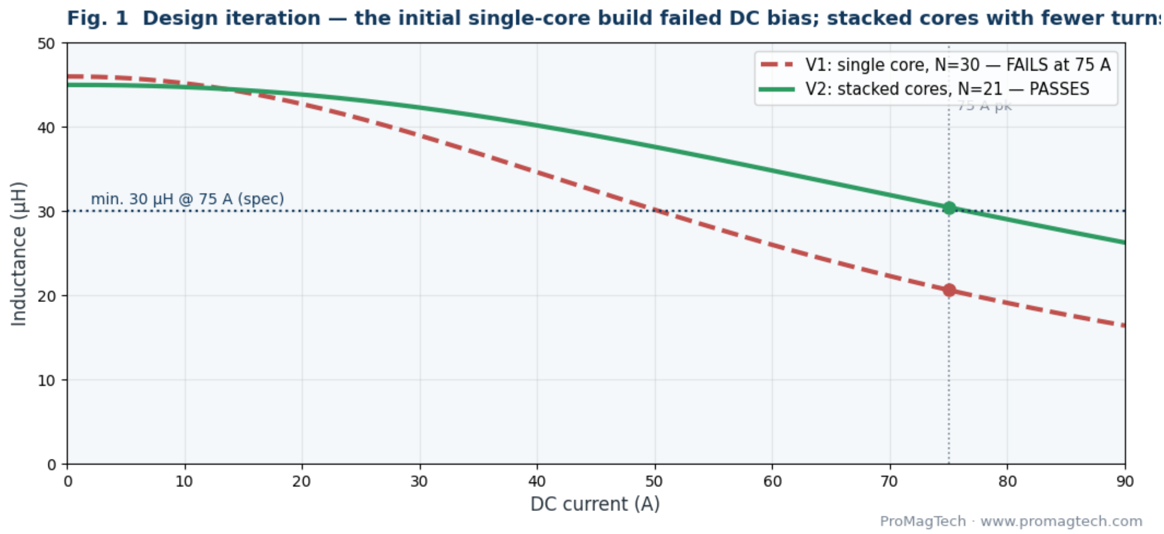


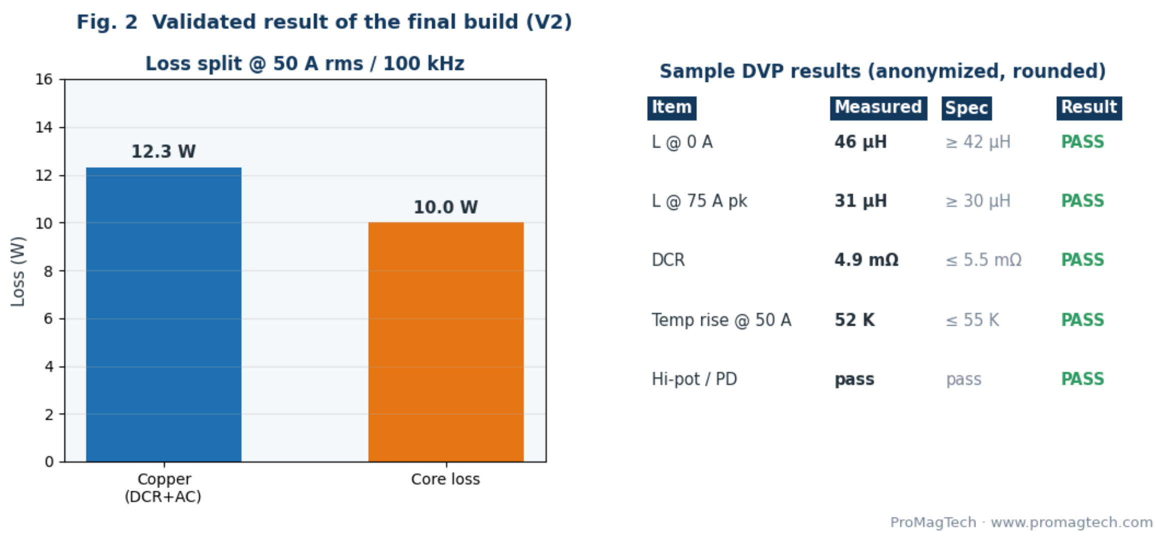
Fig. 1 — Iteration: V1 single core collapsed to ~21 μH at 75 A; V2 stacked cores + fewer turns passed at 31 μH.

The winding was optimized in the same pass: edge-wound flat wire (5×1.6 mm), 21 turns on the stacked toroid, measured DCR 4.9 mΩ (spec ≤5.5 mΩ). Round wire in the same window would run roughly 30 % higher — flat wire's copper fill is a real thermal advantage at this current.

4. Loss & temperature: do the numbers add up

Loss accounting at 50 A rms / 100 kHz (rounded):

Copper: P(Cu) = I²rms × DCR = 50² × 4.9 mΩ ≈ 12.3 W
Core: ΔB = L·ΔI/(N·Ae) ≈ 0.047 T pk-pk → from loss curve ≈ 10 W
Total: ≈ 22 W → measured rise 52 K (55 K limit, natural + duct) ✓



Item	Measured	Spec	Result
L @ 0 A	46 µH	≥ 42 µH	PASS
L @ 75 A pk	31 µH	≥ 30 µH	PASS
DCR	4.9 mΩ	≤ 5.5 mΩ	PASS
Temp rise @ 50 A	52 K	≤ 55 K	PASS
Hi-pot / PD	pass	pass	PASS

Fig. 2 — Final-build loss split and sample DVP results (anonymized/rounded).

5. Full DVP results

Item	Measured	Spec	Result
Inductance @ 0 A	46 µH	≥ 42 µH	PASS
Inductance @ 75 A pk	31 µH	≥ 30 µH	PASS
DCR	4.9 mΩ	≤ 5.5 mΩ	PASS
Temp rise @ 50 A rms	52 K	≤ 55 K	PASS
Hi-pot	pass	per 800 V platform	PASS
Partial discharge (PD)	pass	per reinforced insulation	PASS
Batch consistency (pilot)	±4 %	< ±7 %	PASS

Table 2 — Sample DVP results (anonymized/rounded)

6. Three lessons to take away

- **1. Derive turns from biased inductance:** compute operating H → read %µ → correct AL → then set N. V1 skipped exactly this.
- **2. Core stacking is an under-used lever:** doubling Ae cuts turns, pressing H and copper loss down together — often cheaper than upgrading material.
- **3. Flat wire is thermal insurance at high current:** ~30 % lower DCR buys direct temperature margin; default to flat wire for 800 V high-current PFC.

7. Frequently asked questions (FAQ)

Q Why not just switch to High Flux?

A Possible, but cost rises noticeably. Stacking cores and cutting turns pushed the operating H back into Fe-Si's usable range at lower cost. When space forbids stacking, High Flux becomes the first choice.

Q Are the numbers real?

A They are anonymized, rounded engineering values consistent in magnitude and logic with the real project. Any specific project should be confirmed by sample test to your own spec.

Q Does this method scale to other power levels?

A Yes. Compute H, read the curve, size turns from biased inductance — the procedure is universal for powder-core inductors; 11 kW or 60 kW only changes the numbers.

Q Can ProMagTech build the same kind of sample?

A Yes. Send power/topology/current/inductance/temperature limit and we run this exact procedure — selection, sampling, and a DVP report delivered with the parts.

8. Further reading

This case belongs to the ProMagTech 800 V Power Magnetics Selection Reference; the methodology behind it:

- 800 V Power Magnetics Selection Reference (the pillar map)
- OBC PFC boost inductor selection (methodology)
- Choosing a powder core: Fe-Si / Sendust / High Flux / MPP (materials)
- AEC-Q200 & automotive reliability (validation framework)
- Flat wire vs round wire inductors (winding)
- Anonymized case: 120 V/40 A/66 kHz flat-wire inductor (sister case)

9. About ProMagTech

SHENZHEN PROMAGTECH CO.,LTD (founded 2013, Shenzhen) designs and manufactures flat-wire inductors, planar transformers, common-mode chokes and PFC inductors for 800 V EV OBC and DC charging, AI-datacenter power, energy-storage PCS, solar inverters and industrial power.

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