Technical Article

High Density PCB Layout of DC/DC Converters, Part 2

Timothy Hegarty

As I mentioned in part 1, the printed circuit board (PCB) area dedicated to power management is an immense constraint for system designers. Reducing converter losses is an essential requirement to enable a compact realization in space-constrained applications with limited PCB real estate.

The ability to flexibly deploy a converter at a strategic location on the board is also important – take for instance a high-current point-of-load (POL) module, optimally located adjacent to a load for smaller conduction drop and better load transient performance.

Consider the power stage layout in Figure 1 of a miniaturized form-factor buck converter. As an embedded POL module implementation, it uses an all-ceramic capacitor design, an efficient shielded inductor, vertically stacked MOSFETs, a voltage-mode controller and a six-layer PCB with 2oz copper.

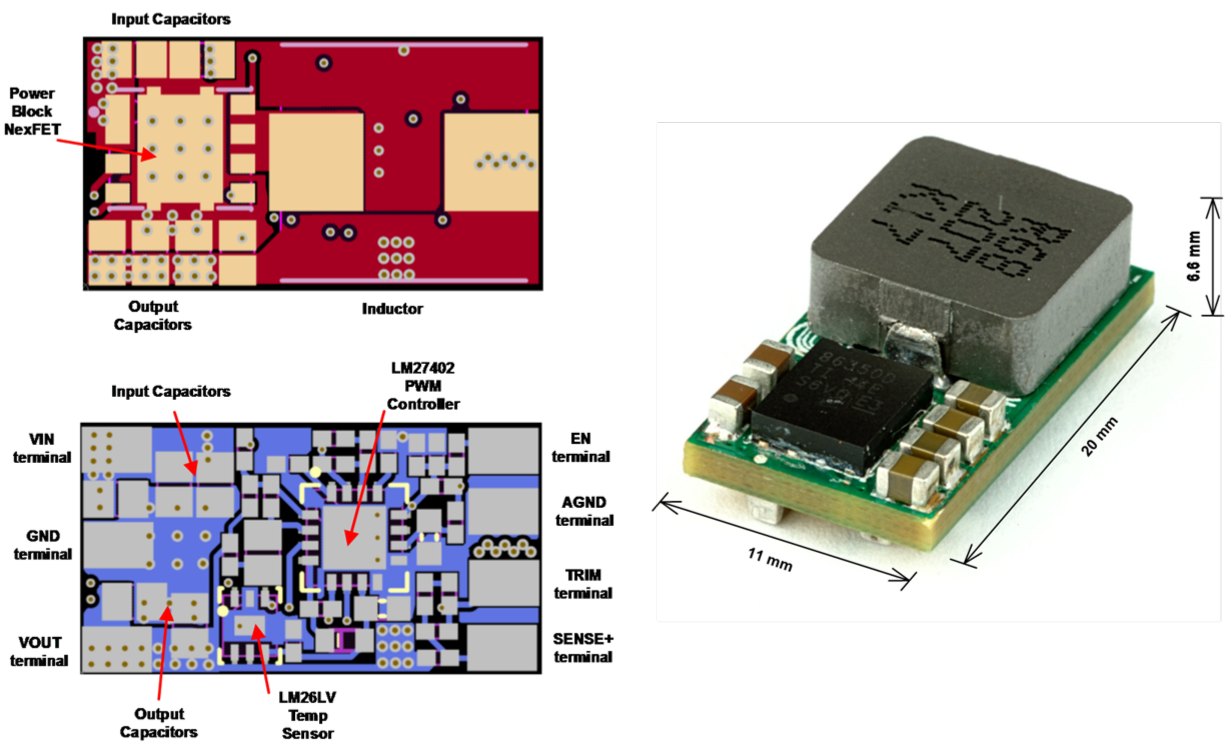

Figure 1. 25A Synchronous Buck Converter PCB Layout and Implementation.

The main tenets of this design are high power density and low bill-of-materials (BOM) cost. It occupies a total PCB area of 2.2cm^2 (0.34in^2), yielding an effective current density per unit area of 11.3A/cm^2 (75A/in^2). Power density per unit volume at 3.3V output is 57W/cm^3 (930W/in^3).

The normal approach to attaining high power density is to increase switching frequency. By contrast, you can achieve miniaturization through strategic component selection while retaining a relatively low switching frequency of 300kHz to lessen frequency proportional losses such as MOSFET switching loss and inductor core loss. Table 1 lists the essential components for this design.

Table 1. POL Module Components, Package Sizes and Recommended Pad Dimensions.

Power train components	Footprint and profile (mm)	Recommended land pattern outer dimensions (mm)
CSD86350Q5D NexFETÔ Power Block	5.0 x 6.0 x 1.5 (SON5x6)	5.15 x 6.24
LM27402 3V-20V PWM controller	4.0 x 4.0 x 0.8 (WQFN-16)	4.2 x 4.2
0.68µH 1.6mΩ 33A filter inductor	11.5 x 10.3 x 4.0	4.1 x 13.6
22µF input and 47µF output X5R capacitors	2.0 x 1.25 x 1.35 (0805)	2.2 x 1.3
Terminal connections	2.0 x 3.0	2.0 x 3.0 (on host board)

Value Proposition of High-density PCB Designs

Clearly, the PCB is an important (and sometimes most expensive) component in a design. The value proposition of a well-planned and carefully executed PCB layout for a high-density DC/DC converter lies in:

- More functionality in space-constrained designs (reduced solution volume and footprint).
- Reduced switching-loop parasitic inductance, contributing to:
- – Lower power MOSFET voltage stress (switch-node voltage spike) and ringing.
  - Reduced switching loss.
  - Lower electromagnetic interference (EMI), magnetic field coupling and output noise signature.
  - Extra margin to survive input rail-transient-voltage disturbances, especially in wide-V_{IN}-range applications.
- Increased reliability and robustness (lower component temperatures).
- Cost savings related to a smaller PCB, fewer filtering components and the elimination of snubbers.
- Differentiated designs provide a competitive advantage, capture customer attention, and increase revenue.

It's fair to say that PCB layout defines the performance ultimately achieved from a switching power converter. Of course, the designer is quite happy to avoid countless hours of debugging time for EMI, noise, signal integrity, and other issues related to a poor layout.

Additional Resources:

- Read parts 1, 2 and 3 of "DC/DC Converter PCB Layout" on EDN.
- Watch a video on the salient characteristics of high-density buck converter solutions.
- Review the schematic, layout and test reports of these high-density designs from the PowerLabreference design library:
  - High-efficiency small form factor 112W sync buck TI Designs reference design.
  - High power density voltage regulator module for CPU core power in enterprise switching TI Designs reference design.
  - High power density 12Vin, 100W synchronous DC/DC step-down buck converter with inductor-on-top TI Designs reference design.
- Order the high-density LM27403EVM-POL600 30A 600kHz POL evaluation module (EVM).
- Start a design now with WEBENCH® Power Designer.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.