the corresponding output inductor. The high-side transistor of each power stage switchably connects the load to an input voltage of the DC-DC converter and the corresponding low-side transistor switchably connects the load to ground at different periods. Each power stage die can include active semiconductor components such as MOSFETs (metal oxide semiconductor field effect transistors), drivers, etc. and corresponding passive components. The passive components can be excluded from the die and provided as separate components. In each case, the power stage die includes at least the active semiconductor components needed to provide an output phase of the DC-DC converter to the load and is placed under the corresponding output inductor when attached to a board such as a PCB to form a DC-DC converter assembly.

[0017] Figure 1, which includes Figures 1A through 1D, illustrates different views of an output inductor 100 shaped to accommodate a power stage die of a DC-DC converter under the inductor 100. Figure 1A shows an angled perspective of the output inductor 100, Figure 1B shows a side view of the output inductor 100, Figure 1C shows a front view of the output inductor 100, and Figure 1D shows a bottom view of the output inductor 100.

[0018] The output inductor 100 comprises a magnetic core 102 and an electrical conductor 104 having first and second terminals 106, 108 for attaching to a board such as a PCB. The electrical conductor 104 can be shaped as a staple, for example. Regardless, the magnetic core 102 has a cutout 110 having a width (F) and length (L) to accommodate i.e. provide room for the power stage die. In addition, the terminals 106, 108 are spaced apart at opposing sides of the magnetic core 102 so that the power stage die fits between the terminals 106, 108. This way, the power stage die can be interposed between the magnetic core 102 and the board when the output inductor 100 and power stage die are attached to the same side of the board. The power stage die and board are not shown in Figure 1 for ease of illustration.

[0019] According to this embodiment, the output inductor 100 is manufactured by forming first and second sections 112, 114 of the magnetic core 102. The second section 114 has a thinner inner region (T1) and a thicker outer region (T2). The thinner inner region T1 is thin enough to accommodate a power stage die of a DC-DC converter positioned under the second section 114 of

CLAIMS

1. A DC-DC converter assembly, comprising:

a board having a first side and a second side opposite the first side;

a power stage die of a DC-DC converter attached to the first side of the board;

an output inductor electrically connected to an output of the power stage die and disposed over the power stage die on the first side of the board, the output inductor comprising a magnetic core and an electrical conductor having first and second terminals attached to the first side of the board, the output inductor accommodating the power stage die under the magnetic core so that the power stage die is interposed between the magnetic core and the board;

a load attached to the first side of the board;

a plurality of input capacitors electrically connected to input terminals of the power stage die, the input capacitors that provide a shortest current commutation loop for the power stage die being attached to the first side of the board and the other input capacitors being attached to the second side of the board;

an output capacitor electrically connected between the output inductor and the load, and attached to the second side of the board; and

a plurality of decoupling capacitors electrically connected to power terminals of the power stage die, and attached to the second side of the board,

wherein a total footprint of the power stage die, the output inductor, the plurality of input capacitors, the output capacitor and the plurality of decoupling capacitors is at least a third of the combined surface area of the power stage die, the output inductor, the plurality of input capacitors, the output capacitor and the plurality of decoupling capacitors.

2. The DC-DC converter assembly of claim 1, wherein the magnetic core is spaced apart from the power stage die.

3. The DC-DC converter assembly of claim 1, wherein the magnetic core has a thinner inner region and a thicker outer region so that a gap exists between the thinner inner region and the first side of the board, and wherein the gap accommodates a thickness of the power stage die.

4. The DC-DC converter assembly of claim 3, wherein the thickness of the power stage die and the gap between the thinner inner region and the first side of the board are both less than 1mm.

5. The DC-DC converter assembly of claim 1, wherein the magnetic core has a planar side facing the first side of the board, and wherein the first and second terminals of the output inductor extend from a periphery of the magnetic core beyond the planar side by a distance corresponding to at least a thickness of the power stage die to realize a gap between the planar side of the magnetic core and the board that accommodates the power stage die.

6. The DC-DC converter assembly of claim 1, wherein the first and second terminals of the magnetic core are attached to the first side of the board by first and second blocks at a periphery of the magnetic core, and wherein the first and second blocks each have a thickness corresponding to at least a thickness of the power stage die to realize a gap between the magnetic core and the board that accommodates the power stage die.

7. The DC-DC converter assembly of claim 1, wherein the DC-DC converter is a multi-phase converter and the power stage die provides one phase of the multi-phase converter.

8. The DC-DC converter assembly of claim 1, wherein the power stage die dissipates less than 2W at a thermal design current of the DC-DC converter.

9. The DC-DC converter assembly of claim 1, wherein the output inductor accommodates the input capacitors attached to the first side of the board under the magnetic core so that the power stage die and

the input capacitors attached to the first side of the board are interposed between the magnetic core and the board after attachment to the first side of the board.

10. The DC-DC converter assembly of claim 1, wherein at least some of the capacitors attached to the second side of the board are disposed at least partly within a footprint of the output inductor attached to the first side of the board.

11. The DC-DC converter assembly of claim 1, wherein the electrical conductor is shaped like a staple and the terminals are spaced apart at opposing sides of the magnetic core so that power stage die fits between the terminals.

12. The DC-DC converter assembly of claim 1, wherein the output inductor completely covers the power stage die.

13. A method of manufacturing a DC-DC converter assembly, the method comprising:

attaching a power stage die of a DC-DC converter to a first side of a board, the board further having a second side opposite the first side;

positioning an output inductor over the power stage die on the first side of the board, the output inductor comprising a magnetic core and an electrical conductor having first and second terminals, the output inductor accommodating the power stage die under the magnetic core so that the power stage die is interposed between the magnetic core and the board;

attaching the first and second terminals of the output inductor to the first side of the board so that the output inductor is electrically connected to an output of the power stage die;

attaching a load to the first side of the board;

attaching input capacitors that provide a shortest current commutation loop for the power stage die to the first side of the board, the input capacitors being electrically connected to input terminals of the power stage die;

attaching additional input capacitors to the second side of the board, the additional input capacitors being electrically connected to the input terminals of the power stage die;

attaching an output capacitor to the second side of the board, the output capacitor being electrically connected between the output inductor and the load; and

attaching a plurality of decoupling capacitors to the second side of the board, the decoupling capacitors being electrically connected to power terminals of the power stage die;

wherein a total footprint of the power stage die, the output inductor, the plurality of input capacitors, the output capacitor and the plurality of decoupling capacitors is at least a third of the combined surface area of the power stage die, the output inductor, the plurality of input capacitors, the output capacitor and the plurality of decoupling capacitors.

14. The method of claim 13, wherein the magnetic core has a thinner inner region and a thicker outer region so that a gap exists between the thinner inner region and the first side of the board, and wherein the gap accommodates a thickness of the power stage die.

15. The method of claim 13, wherein the magnetic core has a planar side facing the first side of the board, and wherein the first and second terminals of the output inductor extend from a periphery of the magnetic core beyond the planar side by a distance corresponding to at least a thickness of the power stage die to realize a gap between the planar side of the magnetic core and the board that accommodates the power stage die.

16. The method of claim 13, comprising attaching the first and second terminals of the output inductor to the first side of the board by first and second blocks at a periphery of the magnetic core, and the first and second blocks each having a thickness corresponding to at least a thickness of the power stage die to realize a gap between the magnetic core and the board that accommodates the power stage die.

17. The method of claim 13, wherein the DC-DC converter is a multi-phase converter and the power stage die provides one phase of the multi-phase converter.

18. The method of claim 13, wherein the power stage die dissipates less than 2W at a thermal design current of the DC-DC converter.

19. The method of claim 13, wherein the output inductor accommodates the input capacitors attached to the first side of the board under the magnetic core so that the power stage die and the input capacitors attached to the first side of the board are interposed between the magnetic core and the board after attachment to the first side of the board.

20. A method of manufacturing an output inductor, the method comprising:

forming first and second sections of a magnetic core, the second section having a thinner inner region and a thicker outer region, the thinner inner region being thin enough to accommodate a power stage die of a DC-DC converter positioned under the second section of the magnetic core without the power stage die contacting the thinner inner region and the thicker outer region of the second section;

placing an electrical conductor on the second section; and

attaching the first section to the second section so that the magnetic core secures the electrical conductor and the electrical conductor has contactable terminals.

21. The method of claim 20, wherein forming the second section of the magnetic core comprises molding a magnetic material in a mold shaped to form the thinner inner region and the thicker outer region of the second section.