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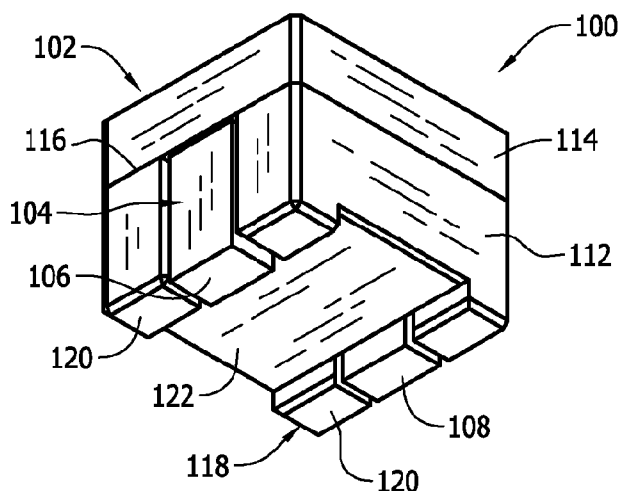


FIG. 1

(57) Abstract: A surface mount power inductor component for a circuit board includes a magnetic body, at least one conductive coil, and surface mount terminations for completing an electrical connection between the conductive coil and the circuit board. One of the body and the surface mount terminations is configured to accommodate a separately provided component in a vertically stacked relation with the separately provided circuit board component being located between the circuit board and the body.



SURFACE MOUNT POWER INDUCTOR
COMPONENT WITH STACKED COMPONENT
ACCOMMODATION

BACKGROUND OF THE INVENTION

The field of the invention relates generally to the construction and fabrication of components for circuit board applications, and more specifically to the construction and fabrication of electromagnetic components such as power inductors for use on circuit boards.

Electronic power converters are known and in widespread use to convert electrical energy from one form to another. For example, power may be converted from a first direct current (DC) voltage to another direct current (DC) voltage, commonly referred to as a DC to DC voltage conversion. Power may also be converted from a first alternating current (AC) voltage to another direct current (DC) voltage using converter circuitry, commonly referred to as an AC to DC voltage conversion. Hence, power converters are often referred to as DC to DC power converters or AC to DC power converters.

Some types of electronic power converters include an inductor, sometimes referred to as a power inductor, that stores and releases electrical energy to and from the circuit. Such converters including power inductors are utilized in for, example, switched mode power supply systems that are electronically controlled and supply power, for example, to a variety of handheld electronic devices having an ever increasing number of features. As current flows through a winding in the inductor, the current flow generates a magnetic field that may be stored as magnetic energy in either a physical gap or a distributed gap of a magnetic core of the inductor. The stored magnetic energy may likewise induce current flow in the inductor and return electrical energy back to the circuit. For this reason, such power converter circuits and inductor components are sometimes referred to as power magnetics. Power

magnetic converters may include, for example, boost converters, buck converters, and fly-back converters.

In view of the trend toward smaller and smaller electronic devices having ever more powerful features, demand for higher density of components on circuit boards has increased. To meet such demands, power inductors, like other components, have become increasingly miniaturized. There are practical challenges and tradeoffs, however, in providing increased power capabilities in components of smaller size. The electrical performance of conventional surface mount inductors is undesirably limited for certain power converter applications, particularly for relatively high current, high power applications. Improvements are desired.

BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting and non-exhaustive embodiments are described with reference to the following Figures, wherein like reference numerals refer to like parts throughout the various drawings unless otherwise specified.

Figure 1 is a bottom perspective view of a first exemplary embodiment of a surface mount power inductor.

Figure 2 is a first side elevational view of the power inductor component shown in Figure 1.

Figure 3 is a second side elevational view of the power inductor component shown in Figure 1.

Figure 4 is a bottom view of the power inductor component shown in Figure 1.

Figure 5 is a side view of a component assembly including the power inductor component shown in Figures 1-4 mounted to a circuit board in stacked relation with another circuit board component.

Figure 6 is a bottom perspective view of a second exemplary embodiment of a surface mount power inductor.

Figure 7 is a bottom view of the power inductor component shown in Figure 6.

Figure 8 is a first side elevational view of the power inductor component shown in Figure 6.

Figure 9 is a second side elevational view of the power inductor component shown in Figure 6.

Figure 10 is a side view of a component assembly including the component shown in Figures 6-9 mounted to a circuit board in stacked relation with another circuit board component.

DETAILED DESCRIPTION OF THE INVENTION

Circuit board mounting density has long been a pressing concern to electronic device manufacturers. Mounting an increased number of electronic components in a selected area of a circuit board allows either more components to be provided on a circuit board or a desirable reduction of the size of the circuit board needed in any device. Electronic devices accordingly may have more powerful features or may become smaller. Recent trends toward reducing the size of the electronic devices while simultaneously providing more powerful devices and features has pressured electronic component manufacturers to reduce the size of circuit board components, including but not limited to magnetic components such as inductors. Smaller components occupy less space on a circuit board and in turn increase the circuit board mounting density.

In power converter circuitry, magnetic components such as power inductors present performance issues in certain applications as their size is reduced. The performance requirements of higher power, higher current applications are difficult to reconcile with the desire for increasingly miniaturized components. The smaller coils and smaller magnetic bodies of miniaturized power inductors can handle smaller currents well, but not larger ones. In higher current, higher power applications, larger coils are needed. In turn, higher current and larger coils require larger magnetic cores to store energy.

Conventionally, power inductor components, like other circuit board components, are mounted on a circuit board in a horizontally spaced relation from other components on the board. In the power converter example, a power inductor is mounted in a horizontally spaced, but nearby, relation to an integrated circuit components providing power stage functionality. Thus, larger power inductors to meet increased power requirements are in conflict with the desire to increase circuit board density. A larger power inductor will occupy more area on the circuit board, not less.

Exemplary embodiments of power inductors are described below that overcome these and other disadvantages in the art. Power inductors are provided that are fully capable of meeting increased power and current demands of modern electronic devices while still offering overall space savings on circuit boards. This is achieved by configuring the power inductor with stacked component accommodation, such that instead of mounting the power inductor and another circuit board component side-by-side in a horizontally spaced relation as conventionally has been done, the power inductor component can be vertically stacked with another component, such that the other component extends between the circuit board and the power inductor. The other component may be nested within or underneath the power component when mounted to circuit board.

Because of the stacked component accommodation provided in the power inductors, the physical size of power inductors may be increased to accommodate larger coils and larger magnetic cores to more capably perform in higher power, higher current circuitry occupy. While the larger power inductors occupy an increased area on the circuit board, because the other component (e.g., an integrated circuit component) occupies a smaller area within the confines of the larger area occupied by the power inductor, space savings on the circuit board are still achievable. Method aspects will be in part apparent and in part discussed in the description below.

Turning now to Figures 1-5, a first embodiment of a power inductor 100 is illustrated. The power inductor 100 generally includes a magnetic body 102,

sometimes referred to as a core, a coil 104 (Figures 1 and 2), and surface mount terminations 106 and 108 (Figures 1 and 4). The surface mount terminations 106, 108 complete electrical connections to circuit traces or conductive paths of a circuit board 110 (Figure 5). The electrical connections to the circuit path may be established via soldering to complete a circuit path through the coil 104 of the inductor component 100.

The magnetic body 102 in the example shown is fabricated from a first magnetic core piece 112 and a second magnetic core piece 114. The magnetic body may include a physical gap 116 for energy storage. The core pieces 112, 114 may be fabricated from suitable magnetic materials known in the art. Exemplary magnetic materials include magnetic powder particles such as, in various embodiments, Ferrite particles, Iron (Fe) particles, Sendust (Fe-Si-Al) particles, MPP (Ni-Mo-Fe) particles, HighFlux (Ni-Fe) particles, Megaflux (Fe-Si Alloy) particles, iron-based amorphous powder particles, cobalt-based amorphous powder particles, or other equivalent materials known in the art. When such magnetic powder particles are mixed with a polymeric binder material the resultant magnetic material may exhibit distributed gap properties that avoids any need to physically gap or separate different pieces of magnetic materials. For high current applications, a pre-annealed magnetic amorphous metal powder may be considered advantageous.

For power inductor applications, metal powder materials may be preferred over ferrite materials for use as the magnetic powder materials in higher power inductor applications because metal powders, such as Fe-Si particles have a higher B_{sat} value. The B_{sat} value refers the maximum flux density B in a magnetic material attainable by an application of an external magnetic field intensity H . A magnetization curve, sometimes referred to as a B-H curve wherein a flux density B is plotted against a range of magnetic field intensity H may reveal the B_{sat} value for any given material. The initial part of the B-H curve defines the permeability or propensity of the material to become magnetized. B_{sat} refers to the point in the B-H curve where a maximum state of magnetization or flux of the material is established, such that the magnetic flux stays more or less constant even if the magnetic field

intensity continues to increase. In other words, the point where the B-H curve reaches and maintains a minimum slope represents the flux density saturation point (Bsat).

Metal powder particles, such as Fe-Si particles have a relatively high level of permeability, whereas ferrite materials such as FeNi (permalloy) have a relatively low permeability. Generally speaking, a higher permeability slope in the B-H curve of the metal particles used, the greater the ability of the magnetic core to store magnetic flux and energy at a specified current level, which induces the magnetic field generating the flux.

The first core piece 112 in the example shown includes a bottom side 118 that abuts the circuit board 110 in use, and the surface mount terminals 106, 108 are exposed on the bottom side 118 for mounting to the circuit board 118. The bottom side 118, as best seen in Figure 4) has a length dimensions A and a width dimension B, the product of which defines a first area that the power inductor 100 occupies on the circuit board 110 when mounted. The bottom side 118 further includes a bottom surface defining a terminal surface 120 on each opposing lateral side edge of the bottom side 118, and a component accommodation surface 122 extending therebetween. The component accommodation surface 122 extends in a spaced relation from, but extends generally parallel to, the terminal surface 120. In the illustrated example, the component accommodation surface 122 is recessed relative to the terminal surface 120, such that when the terminal surface 120 is abutted in surface contact with the circuit board 110, the component accommodation surface 122 is spaced from the circuit board 110. The component accommodation surface 122 defines a channel or space on the bottom side 118 of the body 102 in which another component 130 may reside, with the component 130 being in a vertically stacked arrangement with the power inductor 100 as shown in Figure 5.

The terminal surface 120 in the example shown extends at the four corners of the bottom side 118, and the surface mount terminations 106 and 108 extend therebetween on opposing edges of the bottom side 118. The surface mount terminations 106 and 108 define surface mount areas identified with dimensions D

and E in Figure 4. The dimensions D and E are selected in view of the high current demands of the power inductor application, and in contemplated embodiments are larger than has been conventionally been provided in more recent miniaturized magnetic component constructions. The terminal surfaces 120 also share the dimension E in the embodiment illustrated.

The component accommodation surface 122 extends between the terminal surfaces 120 and the surface mount terminations 106, 108. In the example, shown, the component accommodation surface 122 has a length dimension F (Figure 3) that is smaller than the dimension A (Figure 4) of the bottom side. Specifically, the dimension F is equal to the dimension A minus the dimension E of the first terminal surface 120 and minus the dimension E of the opposing terminal surface 120. The component accommodation surface 122 also has a width dimension equal to the dimension B of the bottom side 118 (Figure 4), and a height dimension G (Figure 3) that defines the vertical spacing with the circuit board 110. Accordingly, the component accommodation surface 122 defines a component accommodation area that is within the confines of the larger area of the bottom side 118 including the terminal surfaces 120 and the surface mount terminations 106, 108. The height dimension G, in combination with the component accommodation area, defines a volume or three dimensional space that is sufficient to receive the other component 130. The component accommodation area is selected in view of the length, width, and height dimensions of the other component 130. The width and height dimensions of the component 130 are indicated with dimensions H and I in Figure 3, and the length dimension in contemplated embodiments is less than the dimension A (Figure 4) on the bottom side 118.

The coil 104 shown in Figures 1 and 4 (and also in phantom in Figure 5) is formed from a conductive material and in the example shown includes a horizontally extending main winding section 124, opposing vertical winding sections 126 and 128 at either opposing end of the main winding section, and the surface mount terminations 106 and 108 as seen in Figure 5. The coil 104 extends in a C-shape with the ends of the coil 104 inwardly turned to define the surface mount terminations 106

and 108. The coil 104, as can be seen in Figure 5, completes less than one complete turn of an inductor winding, and is beneficially provided for certain high current, high power applications. The coil 104 has a cross sectional area selected for the current requirements at hand for the power application, and the integrally formed surface mount terminations 106, 108 provide a sufficient area or footprint to ensure reliable electrical connection to the circuit board 110. While a single coil 104 is shown in the exemplary embodiment depicted, more than one coil may be provided in further and/or alternative embodiments.

While a specific coil configuration including integrally formed surface mount terminations has been described, other configurations are of course possible and may be utilized in other embodiments. Alternative coil configurations may include any number of turns, including fractional or partial turns less than one complete turn as in the coil 104 or more than one complete turn, to achieve a desired inductance value the inductor component. As non-limiting examples, the turns or loops in a coil winding may include a number of straight conductive paths joined at their ends, curved conductive paths, spiral conductive paths, serpentine conductive paths or still other known shapes and configurations. Coils may also be formed as generally planar elements, or may alternatively be formed as a three dimensional, free standing coil element. As those in the art will appreciate, an inductance value of the winding of a coil depends primarily upon the number of turns completed in the winding, the specific conductive material(s) used to fabricate the coil, and the cross sectional area of the coil winding. As such, inductance ratings of the power inductor component 100 may be varied considerably for different applications by varying the number of turns in the winding, the arrangement of the turns, and the cross sectional area of the coil turns.

The second magnetic core piece 114 in the embodiment shown is generally rectangular, and is bonded to the first magnetic core piece 112 such that the main winding section 124 of the coil 104 extends between the two core pieces 112 and 114. While a two piece core construction having core pieces with different shapes is

described, in other embodiments the core pieces could have the same shape. A single core piece construction could alternatively be used in still another embodiment.

The component 130 may in contemplated embodiments be a an integrated circuit (IC) component configured for power stage functionality in a power converter application. The IC component 130 may include switching and control components that, in combination with the power inductor 100, provide power converter functionality. As non-limiting examples, the IC component 130 may configured to provide boost converter, buck converter, or fly-back converter functionality. Other types of voltage regulation are likewise possible, as well as other types of IC components providing different structure and functionality to a circuit board. Still further, non-IC components may be accommodated by the power inductor 100. Any other circuit board component desired having dimensions compatible with the bottom side 118 and the recessed accommodation surface 122 may be utilized.

Also, while described in the context of power inductor applications, the vertical stack accommodation feature is not limited to power inductor applications, and as such the component 100 may be configured as another type of inductor or as another type of surface mount component. For example, a transformer component could be provided with a similar vertical stack accommodation feature. As another example, a circuit protection fuse, or a surge suppressor component may be provided with a similar vertical stack accommodation feature. Still other variations are possible. Depending on the type of component desired, the body 102 may or not be fabricated from magnetic materials, and may or may not be formed in two pieces.

In the assembly shown in Figure 5, the vertical stack accommodation effectively reduces a voltage regulator footprint on the circuit board 100 in a power magnetics application without sacrificing electrical performance. While the inductor 100 is larger than many conventional surface mount inductor components, the stacked arrangement with the IC component 130 between the inductor 100 and the circuit board 100 actually occupies less space on the circuit board 110 than a smaller inductor and the IC component would occupy if mounted horizontally in a spaced

apart arrangement on the circuit board per conventional techniques. Also, the vertical stacked arrangement provides additional benefit in that it allows for short conductive paths between the components 100 and 130 on the circuit board 100. The shorter paths on the boards slightly reduce power losses that longer paths would inevitably introduce.

Figures 6-10 illustrate a second exemplary embodiment of a surface mount power inductor component 200 that also offers vertical stack accommodation with the component 130 on a circuit board 110 as best shown in Figure 10.

The component 200 includes a body 202, sometimes referred to as a magnetic core, which in exemplary embodiment may be defined by a first piece 204 and a second piece 206 bonded to another and encasing at least a portion of a coil 208. The first and second core pieces 204, 206 are formed from magnetic materials such as those described above, and are formulated to provide a desired relative magnetic permeability for a power inductor application. In the illustrated embodiment, the core pieces 204, 206 are similarly sized and shaped, and the body 202 may include a physical gap 210 extending between the core pieces 204 and 206. Depending on the magnetic materials utilized, however, the gap 210 may be considered optional in some embodiments. Also, while two core pieces are shown in the example of the component 200, single piece core constructions are possible and may be provided in other embodiments.

The coil 208 as shown is fabricated from a conductive material and defines a winding completing more than one complete turn of an inductor winding. Specifically, the exemplary coil 208 includes a first surface mount terminal 212, a vertical winding section 214 extending from the surface mount terminal 212, a first horizontal winding section 216 (shown Figure 9 and in phantom in Figure 10), a second vertical winding section 218, a second horizontal winding section 220, a third vertical winding section 222, a third horizontal winding section 224 (shown in Figure 9), a fourth vertical winding section 226, and a second surface mount terminal 228. The coil winding and its sections 214, 216, 218, 220, 222, 224 and 226 wrap around

the respective sides of the first core piece 204, with the winding sections 216 and 224 extending between the first and second core pieces 204 and 206. The surface mount terminations 212 and 228 are inwardly turned and generally coplanar to one another in spaced apart relation to the bottom side surface 230. The surface mount terminations 212 and 228 may be surface mounted to conductive circuit traces or circuit paths on a circuit board using known techniques such as soldering to complete a circuit through the coil 208.

The coil 208 is provided with a cross-sectional area selected with the current requirements in mind for the power inductor application, and the coil is integrally provided with the surface mount terminations 212, 228. While an exemplary coil winding configuration is shown, other configurations are of course possible. As those in the art will appreciate, an inductance value of the winding of a coil depends primarily upon the number of turns completed in the winding, the specific conductive material(s) used to fabricate the coil, and the cross sectional area of the coil winding. As such, inductance ratings of the power inductor component 200 may be varied considerably for different applications by varying the number of turns in the winding, the arrangement of the turns, and the cross sectional area of the coil turns. Also, more than one coil could be provided in the component 200 if desired.

The surface mount terminations 212, 228 are, as best seen in Figures 6, 8 and 10 vertically spaced apart from a bottom side surface 230 of the body 202, and more specifically of the magnetic core piece 204. As such, the component body 202 is elevated from the circuit board 110 in use as shown in Figure 10. A three dimensional space is defined between the surface mount terminations 212, 228 and the bottom side surface 230 such that the other component 130 can be accommodated in a vertically stacked relation in between the component body 202 and the circuit board 110 when mounted thereto. Like the first component 100, the length, width, and height of the other component 130 is such that the second component 130 can be received in the space between the surface mount terminations 212, 228 and the body 202. Also like the component assembly shown in Figure 5, the other component 130 in the assembly shown in Figure 10 defines a smaller area on the circuit board within

110 that is a portion of the larger area occupied by the component 200. Even though the physical package size of the inductor 200 is enlarged, space savings on the circuit board 110 are still realized because the other component 130 is mounted to the board vertically beneath the inductor 200, rather than horizontally beside it per conventional practices

As best seen in Figure 6, the coil 208 may also include support legs 230, 232 integrally formed therewith and extending in spaced relation from the surface mount terminals 212, 228 in a direction perpendicular to the bottom side surface 230. The support legs 232, 236 extend for a distance from the bottom side 230 equal to the distance at which the surface mount terminals 212, 228 extend. The support legs 230, 232 may rest upon the circuit board 110 and provide additional stability for mounting operations. In combination with the surface mount terminals 212, 228, the support legs 230, 232 provide stable support for the component 200 on the surface of the board 210 and simplify establishing electrical connections of the surface mount terminals 212, 228 to the surface of the board 110. In contemplated embodiments, the support legs 230 serve mechanical purposes to provide a more stable structure, rather than an electrical purpose, and thus do not themselves establish electrical connection with the circuit board 110. In some embodiments, and depending on the coil configuration(s) provided, the support legs 230, 232 may be considered optional. Likewise, while support legs integrated in the coil 208 have been described, support legs or other support features could be integrated into the construction of the body 200 or otherwise provided by separately provided support components. Numerous variations are possible in this regard,

The benefits of the elevated body 202 via the spaced surface mount terminals 212, 228 are similar to the benefits of the recessed accommodation area of the component 100 described above, and likewise are not necessarily limited to power inductor components. Various different types of inductor components and non-inductor circuit board components may utilize similar features with similar benefit. For example, a transformer component could be provided with a similar vertical stack accommodation feature having a body elevated from a circuit board. As another

example, a circuit protection fuse or a surge suppression component may be provided with a similar vertical stack accommodation feature. Still other variations are possible. Depending on the type of component desired, the body 202 may or not be fabricated from magnetic materials, and may or may not be formed in two pieces.

It is contemplated that in still other embodiments, combinations of the vertical stack accommodation features are possible that combine the features described in relation to the components 100 and 200. That is, the same component may utilize a recessed component accommodation area and surface mount terminals spaced from the magnetic body to elevate the component body and define a three dimensional space in which another component may be received. Part of another component may be accommodated by the recessed component accommodation area and part of the other component may be accommodate by the spaced surface mount terminals elevating the component body from the circuit board. The accommodation areas defined by the recessed component accommodation area and the spaced surface mount terminals elevating the component body from the circuit board may be the same or different in such an embodiment.

The benefits of the invention are now believed to have been amply illustrated in relation to the exemplary embodiments disclosed.

An embodiment of a surface mount component for a circuit board has been disclosed, including: a body; and surface mount terminations for completing an electrical connection to the circuit board, wherein one of the body and the surface mount terminations is configured to accommodate a separately provided circuit board component in a vertically stacked relation to the body, and wherein the separately provided circuit board component is located between the circuit board and the body.

Optionally, the body may define a recessed area dimensioned to accommodate the separately provided surface mount component. The body may have a bottom surface, wherein the surface mount terminations are spaced from the bottom surface, and whereby the bottom surface may be elevated from the circuit board to define an area dimensioned to accommodate the separately provided surface mount component.

The body may be magnetic, and may include a first magnetic core piece and a second magnetic core piece. The body may also include at least one physical gap.

The body may operationally include at least one conductive coil. The at least one conductive coil may define more than one complete turn of an inductor winding. The at least one conductive coil may alternatively define less than one complete turn of an inductor winding. The surface mount terminations may be integrally provided on opposing ends of the at least one conductive coil. The coil may define at least one support leg for supporting the component on a circuit board with the body elevated from the circuit board. The component may define a power inductor.

The separately provided circuit board component may include an integrated circuit component. The integrated circuit component may define a power stage of a power converter.

Another embodiment of a surface mount component for a circuit board has been disclosed, including: a magnetic body; at least one conductive coil; and surface mount terminations for completing an electrical connection between the conductive coil and the circuit board, wherein one of the body and the surface mount terminations is configured to accommodate a separately provided component in a vertically stacked relation with the separately provided circuit board component being located between the circuit board and the body.

Optionally, the body may define a recessed area dimensioned to accommodate the separately provided component. The magnetic body may also have a bottom surface, and the bottom surface may be elevated from the circuit board to define an area dimensioned to accommodate the separately provided surface mount component. The magnetic body may include a first magnetic core piece and a second magnetic core piece. The magnetic body may include a physical gap.

The at least one conductive coil may define more than one complete turn of a winding, or alternatively may define less than one complete turn of a winding. The surface mount terminations may be integrally provided on opposing ends of the at

least one conductive coil. The coil may define at least one support leg for supporting the component on a circuit board with the body elevated from the circuit board. The magnetic body and the coil may define a power inductor.

The separately provided component may include an integrated circuit component, and the integrated circuit component may define a power stage of a power converter.

An embodiment of a circuit board component assembly has been disclosed including: a first surface mount component including a body and first surface mount terminations, the body including a bottom surface being dimensioned to occupy a first area on a circuit board; and a second component dimensioned to occupy a second area on the circuit board; wherein the first surface mount component is configured to accommodate the second component in a vertically stacked relation to the first surface mount component with the second component between the circuit board and the body of the first component; and wherein the second area is a portion of the first area when the first and second components are mounted to the circuit board.

Optionally, the first surface mount component may define a power inductor. The second component may define an integrated circuit component. The integrated circuit component may define a power stage of a power converter. The body may include a bottom surface having a recessed area dimensioned to accommodate the separately provided component. The body may also include a bottom surface, and the bottom surface may be elevated from the circuit board to define an area dimensioned to accommodate the separately provided surface mount component.

The first surface mount component may include a coil completing at least part of a turn of an inductor winding. The first surface mount terminations may be integrally formed with the coil. The coil may include at least one support leg spaced from the first surface mount terminations.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated

methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

CLAIMS

1. A surface mount component for a circuit board, comprising:
a body; and
surface mount terminations for completing an electrical connection to the circuit board, wherein one of the body and the surface mount terminations is configured to accommodate a separately provided circuit board component in a vertically stacked relation to the body, and wherein the separately provided circuit board component is located between the circuit board and the body.
2. The surface mount component of claim 1, wherein the body defines a recessed area dimensioned to accommodate the separately provided surface mount component.
3. The surface mount component of claim 1, wherein the body has a bottom surface, and wherein the surface mount terminations are spaced from the bottom surface, whereby the bottom surface is elevated from the circuit board to define an area dimensioned to accommodate the separately provided surface mount component.
4. The surface mount component of claim 1, wherein the body is magnetic.
5. The surface mount component of claim 1, wherein the body comprises a first magnetic core piece and a second magnetic core piece.
6. The surface mount component of claim 1, wherein the body includes at least one physical gap.
7. The surface mount component of claim 1, wherein the body further includes at least one conductive coil.
8. The surface mount component of claim 7, wherein the at least one conductive

coil defines more than one complete turn of an inductor winding.

9. The surface mount component of claim 7, wherein the at least one conductive coil defines less than one complete turn of an inductor winding.

10. The surface mount component of claim 7, wherein the surface mount terminations are integrally provided on opposing ends of the at least one conductive coil.

11. The surface mount component of claim 7, wherein the coil defines at least one support leg for supporting the component on a circuit board with the body elevated from the circuit board.

12. The surface mount component of claim 1, wherein the component defines a power inductor.

13. The surface mount component of claim 1, wherein the separately provided circuit board component comprises an integrated circuit component.

14. The surface mount component of claim 13, wherein the integrated circuit component defines a power stage of a power converter.

15. A surface mount component for a circuit board, comprising:

a magnetic body;

at least one conductive coil; and

surface mount terminations for completing an electrical connection between the conductive coil and the circuit board, wherein one of the body and the surface mount terminations is configured to accommodate a separately provided component in a vertically stacked relation with the separately provided circuit board component being located between the circuit board and the body.

16. The surface mount component of claim 15, wherein the body defines a recessed area dimensioned to accommodate the separately provided component.

17. The surface mount component of claim 15, wherein the magnetic body has a bottom surface, and the bottom surface is elevated from the circuit board to define an area dimensioned to accommodate the separately provided surface mount component.

18. The surface mount component of claim 17, wherein the magnetic body comprises a first magnetic core piece and a second magnetic core piece.

19. The surface mount component of claim 17, wherein the magnetic body includes a physical gap.

20. The surface mount component of claim 15, wherein the at least one conductive coil defines more than one complete turn of a winding.

21. The surface mount component of claim 15, wherein the at least one conductive coil defines less than one complete turn of a winding.

22. The surface mount component of claim 15, wherein the surface mount terminations are integrally provided on opposing ends of the at least one conductive coil.

23. The surface mount component of claim 15, wherein the coil defines at least one support leg for supporting the component on a circuit board with the body elevated from the circuit board.

24. The surface mount component of claim 15, wherein magnetic body and the coil define a power inductor.

25. The surface mount component of claim 15, wherein the separately provided

component comprises an integrated circuit component.

26. The surface mount component of claim 25, wherein the integrated circuit component defines a power stage of a power converter.

27. A circuit board component assembly comprising:

a first surface mount component including a body and first surface mount terminations, the body including a bottom surface being dimensioned to occupy a first area on a circuit board; and

a second component dimensioned to occupy a second area on the circuit board;

wherein the first surface mount component is configured to accommodate the second component in a vertically stacked relation to the first surface mount component with the second component between the circuit board and the body of the first component; and

wherein the second area is a portion of the first area when the first and second components are mounted to the circuit board.

28. The circuit board component assembly of claim 27, wherein the first surface mount component defines a power inductor.

29. The circuit board component assembly of claim 27, wherein the second component defines an integrated circuit component.

30. The circuit board component assembly of claim 31, wherein the integrated circuit component defines a power stage of a power converter.

31. The circuit board component assembly of claim 27, wherein the body includes a bottom surface having a recessed area dimensioned to accommodate the separately provided component.

32. The circuit board component assembly of claim 27, wherein the body

includes a bottom surface, and the bottom surface is elevated from the circuit board to define an area dimensioned to accommodate the separately provided surface mount component.

33. The circuit board component assembly of claim 27, wherein the first surface mount component includes a coil completing at least part of a turn of an inductor winding.

34. The circuit board component assembly of claim 33, wherein the first surface mount terminations are integrally formed with the coil.

35. The circuit board component assembly of claim 33, wherein the coil includes at least one support leg spaced from the first surface mount terminations.

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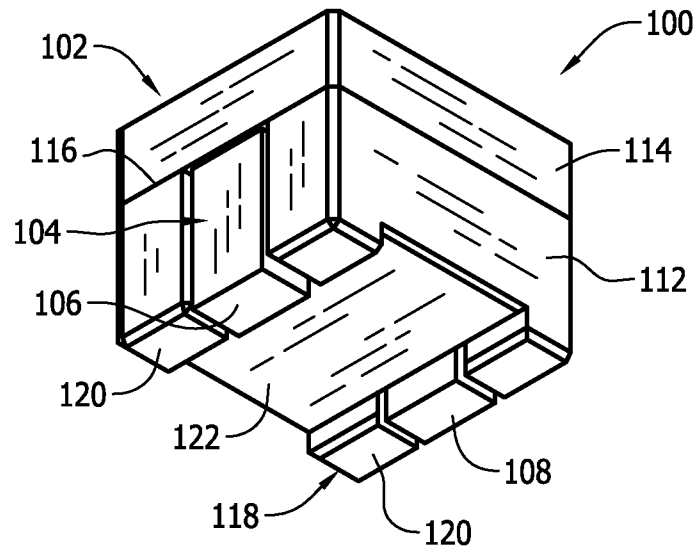


FIG. 1

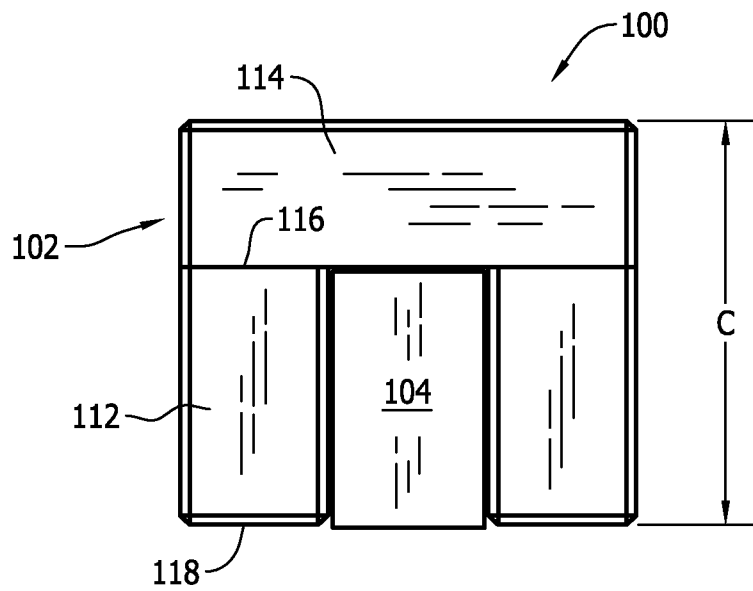


FIG. 2

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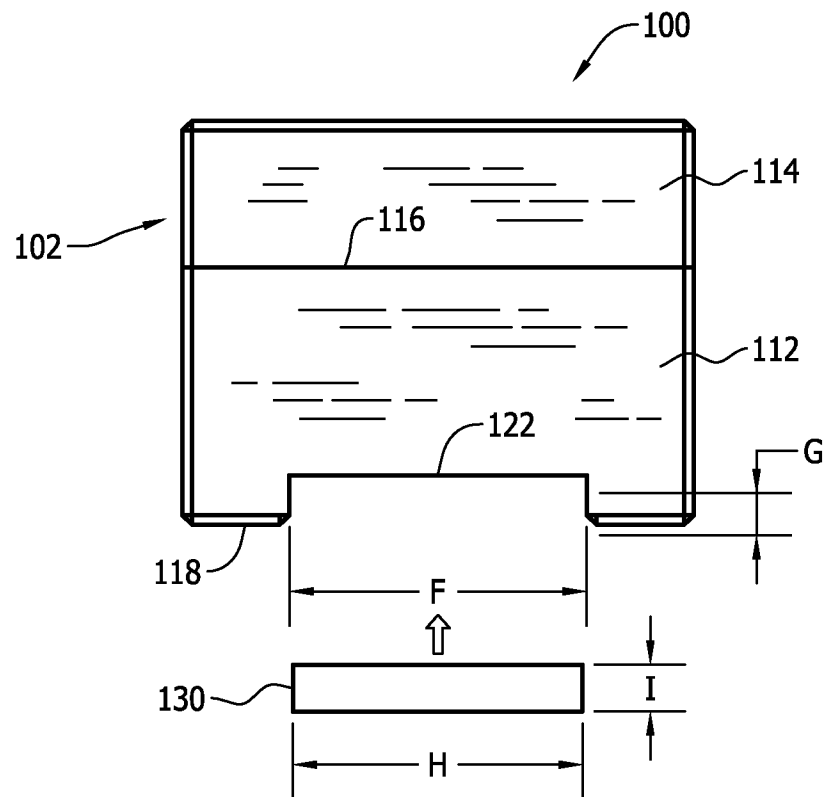


FIG. 3

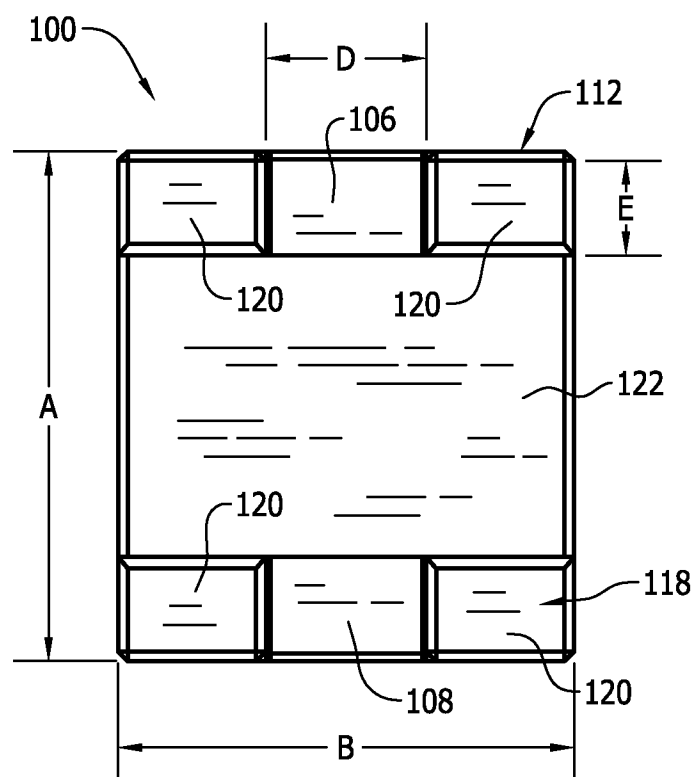


FIG. 4

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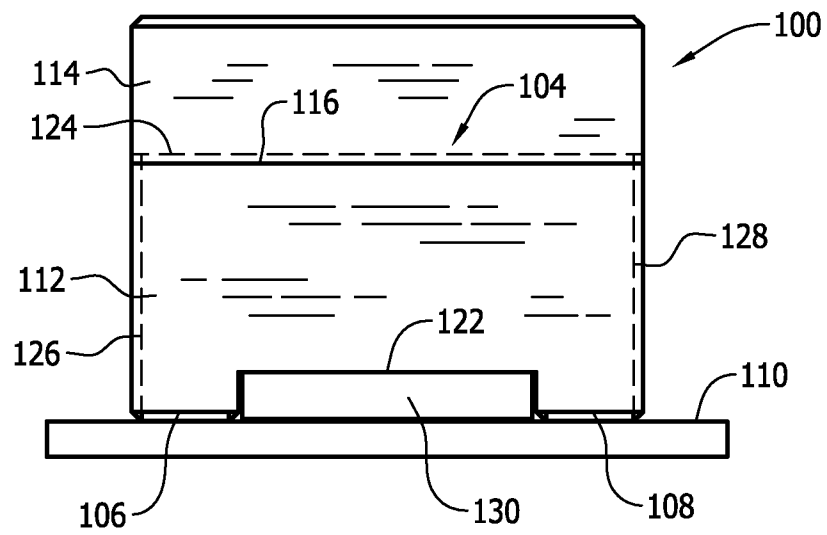


FIG. 5

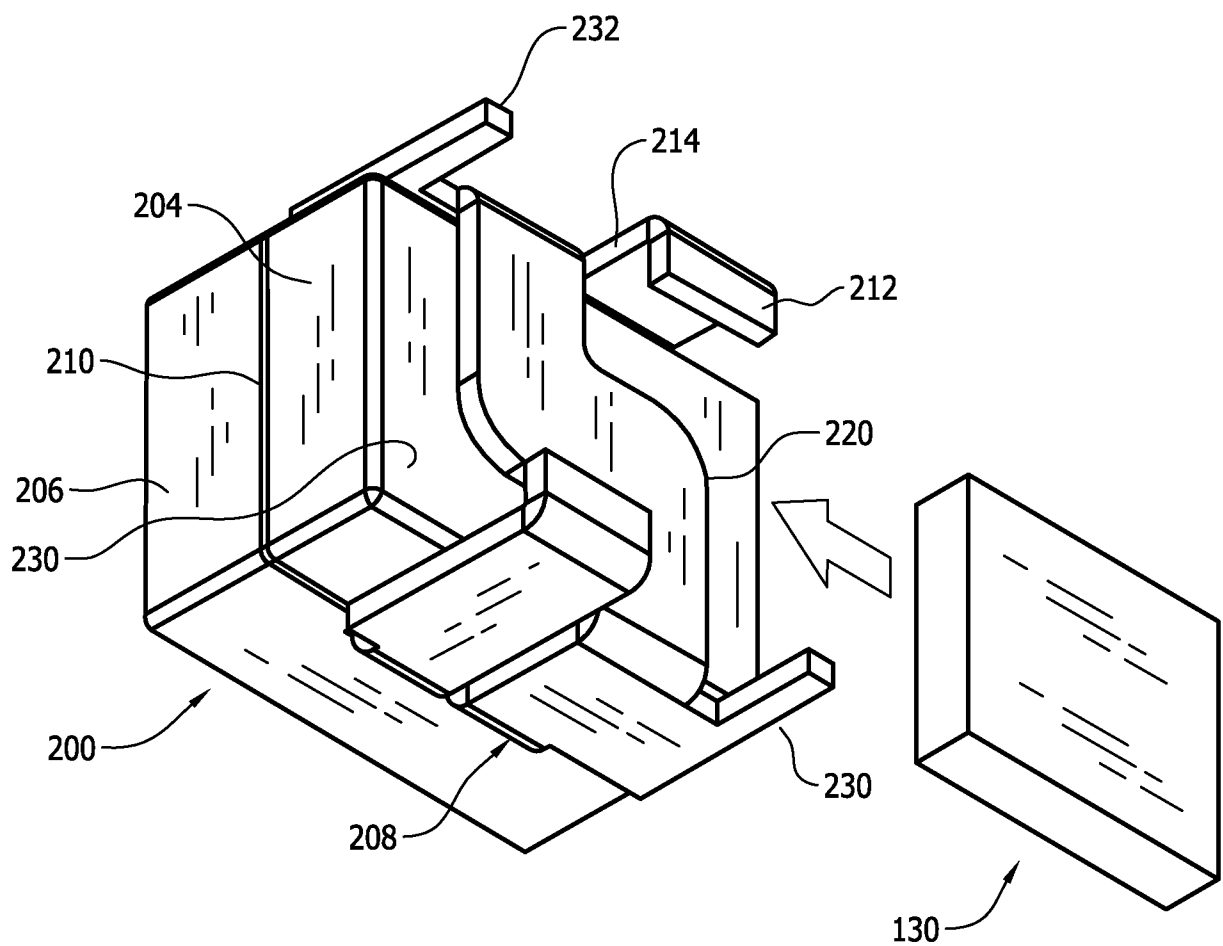


FIG. 6

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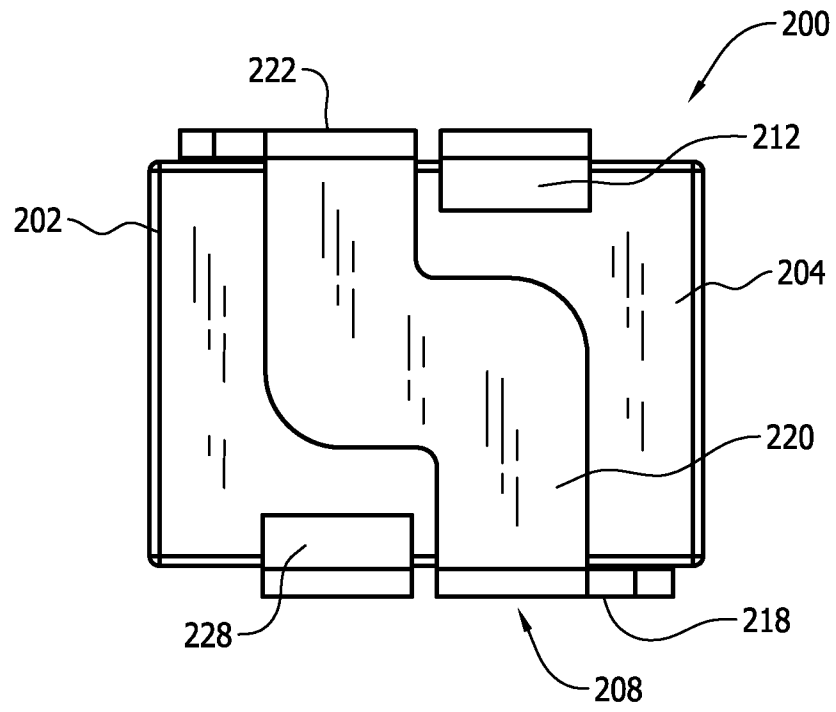


FIG. 7

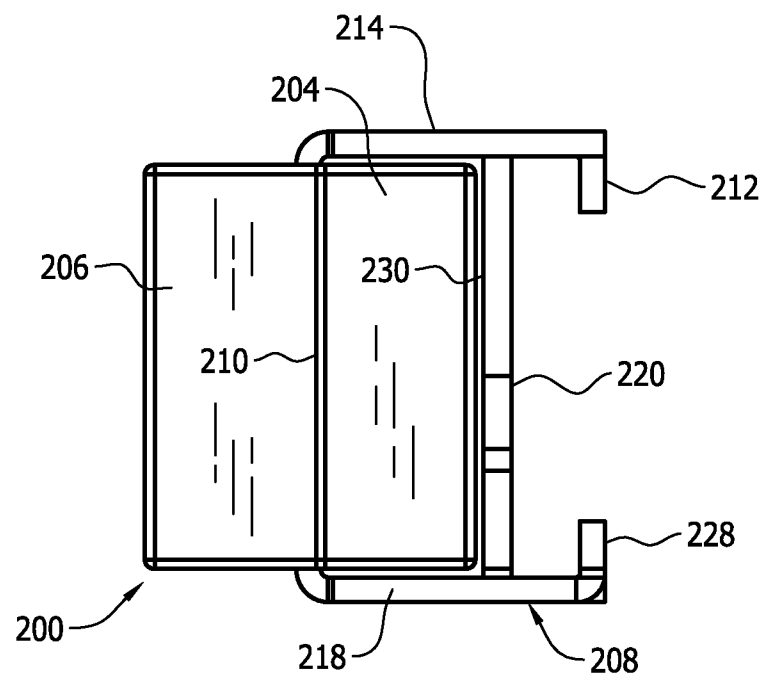


FIG. 8

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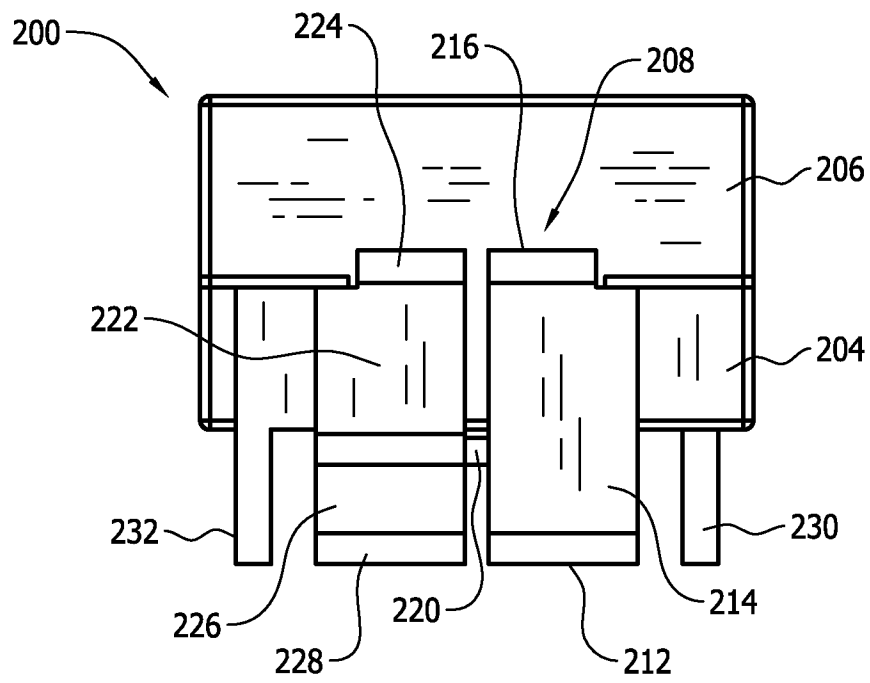


FIG. 9

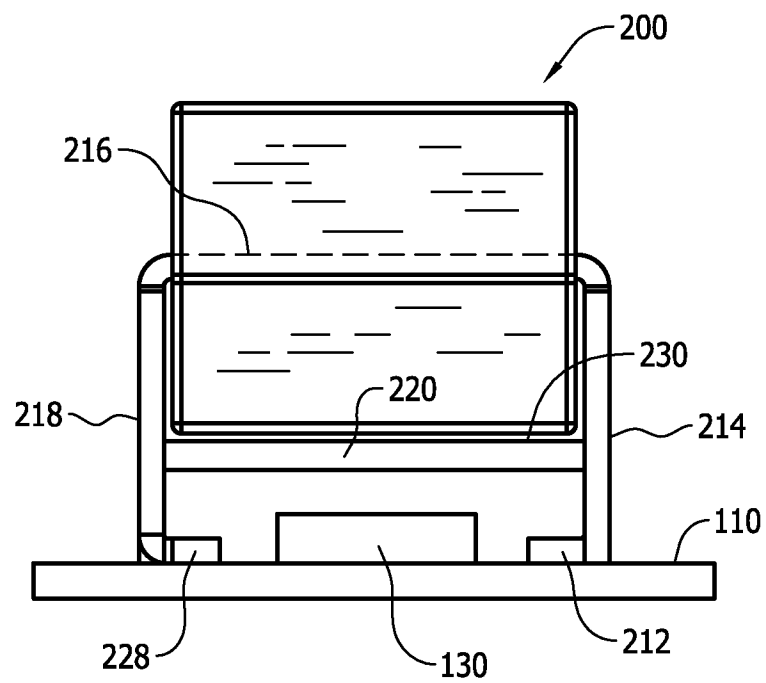


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2013/087690

A. CLASSIFICATION OF SUBJECT MATTER

H01F 17/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, WPI, EPODOC, CNKI: inductor, accommodate, groove, recess, IC, chip, integrated circuit

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102763178 A (MURATA POWER SOLUTIONS) 31 October 2012 (2012-10-31) description pages 2-5 and figures 1-4	1-35
E	CN 203552914 U (ZHONGSHAN HERUI ELECTRONICS CO., LTD.) 16 April 2014 (2014-04-16) description page 2 and figures 1-7	1,3-4,7,12-13,15, 17,24-25,27-29,32
A	CN 102592781 A (CYNTEC CO., LTD.) 18 July 2012 (2012-07-18) the whole document	1-35
A	CN 102612720 A (COOPER TECHNOLOGIES CO.) 25 July 2012 (2012-07-25) the whole document	1-35
A	US 6344786 B1 (ARTESYN TECHNOLOGIES INC.) 05 February 2002 (2002-02-05) the whole document	1-35

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

“A”	document defining the general state of the art which is not considered to be of particular relevance	“T”	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
“E”	earlier application or patent but published on or after the international filing date	“X”	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
“L”	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	“Y”	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
“O”	document referring to an oral disclosure, use, exhibition or other means	“&”	document member of the same patent family
“P”	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

07 August 2014

Date of mailing of the international search report

25 August 2014

Name and mailing address of the ISA/

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Telephone No. (86-10)82245265

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2013/087690

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	102763178	A	31 October 2012	US	8253521	B2	28 August 2012
				JP	2013520802	A	06 June 2013
				WO	2011103420	A2	25 August 2011
				WO	2011103420	A3	22 December 2011
				JP	5509346	B2	04 June 2014
				EP	2537166	A2	26 December 2012
				US	2011205008	A1	25 August 2011
CN	203552914	U	16 April 2014	Non			e
CN	102592781	A	18 July 2012	Non			e
CN	102612720	A	25 July 2012	EP	2462595	A1	13 June 2012
				US	2013099886	A1	25 April 2013
				CN	102612720	B	16 July 2014
				KR	20120052339	A	23 May 2012
				WO	2011016883	A1	10 February 2011
				US	8400245	B2	19 March 2013
				SG	178236	A1	29 March 2012
				JP	2013501376	A	10 January 2013
				TW	201112281	A	01 April 2011
				US	2010013587	A1	21 January 2010
				CA	2770152	A1	10 February 2011
				WO	2010042308	A1	15 April 2010
				EP	2345046	A1	20 July 2011
				KR	20110063620	A	13 June 2011
				CN	102105953	A	22 June 2011
				JP	2012505545	A	01 March 2012
				CA	2726727	A1	15 April 2010
				TW	201019351	A	16 May 2010
US	6344786	B1	05 February 2002	Non			e