(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 496 115 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.06.2019 Bulletin 2019/24

(51) Int Cl.:
H01F 3/10 *(2006.01)* ***H01F 27/38*** *(2006.01)*

(21) Application number: **17206183.0**

(22) Date of filing: **08.12.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

(71) Applicant: **Fideltronik Poland sp. z o.o.**
34-200 Sucha Beskidzka (PL)

(72) Inventors:
- **LIGENZA, Slawomir**
  32-340 Wolbrom (PL)
- **WOREK, Cezary**
  30-240 Kraków (PL)

(74) Representative: **Lukaszyk, Szymon**
Kancelaria Patentowa Lukaszyk
ul. Glowackiego 8/6
40-052 Katowice (PL)

(54) **AN INTEGRATED TRANSFORMER-INDUCTOR ASSEMBLY**

(57) The invention relates to an integrated transformer-inductor assembly (1) comprising a magnetic core (2) comprising a transformer column (23) around which transformer windings (3) are wound, inductor columns (22) around which inductor windings (4) are wound, and intermediate columns (24) constituting common magnetic elements of a magnetic circuit of the transformer windings (3) and magnetic circuits of the inductor windings. In order to provide decreased dimensions and reduced weight of such an assembly (1) as well as to ensure an efficient conduction and dissipation of heat generated in a core (2) of the assembly (1), the magnetic core (2) comprises at least two substantially identical component modules (21), wherein each component module (21) comprises a yoke (214) having a form of a plate comprising a rectangular part (2141) and two trapezoidal parts (2142) arranged symmetrically along a first longer side (21411) of the rectangular part (2141) and adjoining said first longer side of said rectangular part (2141) with longer bases (21421) thereof; a set of rectangular prism shaped component columns (211, 212, 213), parallel with each other and protruded on one side from the yoke (214) along a longitudinal axis (O) of the component module (21) which is perpendicular relative to the surface of the yoke (214), and including two outermost external component inductor columns (211) protruded from said rectangular part (2141) of the yoke (214); a central component transformer column (212); two component intermediate columns (213) having substantially the same length and disposed between the component inductor columns (211) and the component transformer column (212) and protruded from the rectangular part (2141) and the trapezoidal part (2142) of the yoke (214); wherein the second longer side (21412) of the rectangular part (2141) of theyoke (214) located on the side opposite relative to the trapezoidal parts (2142) of the yoke (214) and the internal lateral surfaces (2111, 2121, 2131) of all component columns (211, 212, 213) located at the side of this second longer side (21412) of the yoke (214) are coplanar with each other and form a contact plane (215); and wherein the external lateral surfaces (2133) of the intermediate columns (213) located on the opposite sides of these columns relative to the internal lateral surfaces (2131) thereof, are coplanar with shorter bases (21422) of the trapezoidal parts (2142) of the yoke (4); and wherein said component modules (21) are contacted with each other by means of contact frontal surfaces (2132) of the component intermediate columns (213) which are perpendicular relative to the longitudinal axis (O) of the module (21), and the longitudinal axes (O) of the modules (21) are positioned collinearly with each other; and wherein the component inductor columns (211) form the inductor columns (22), the component transformer columns (212) form the transformer column (23), and the component intermediate columns (213) form the intermediate columns (24).

Printed by Jouve, 75001 PARIS (FR)

(Cont. next page)

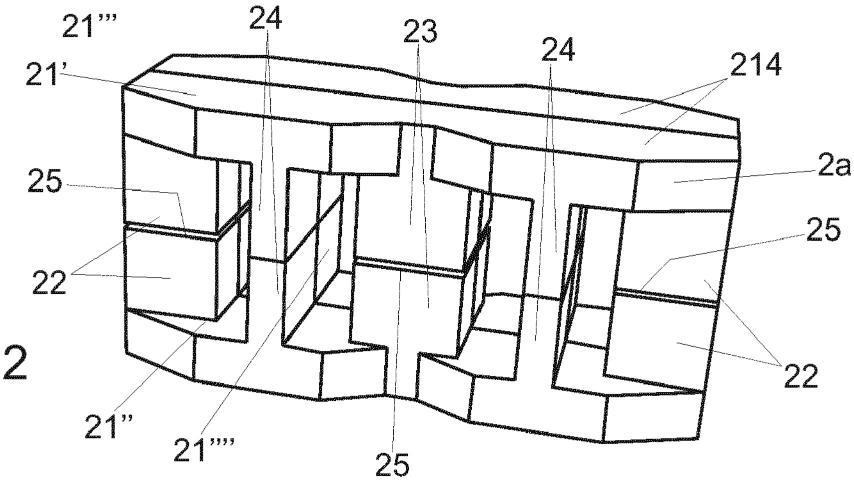
21'''
21'
24
23
24
214
2a
25
22
25
22
21''
21''''
25

Fig. 2

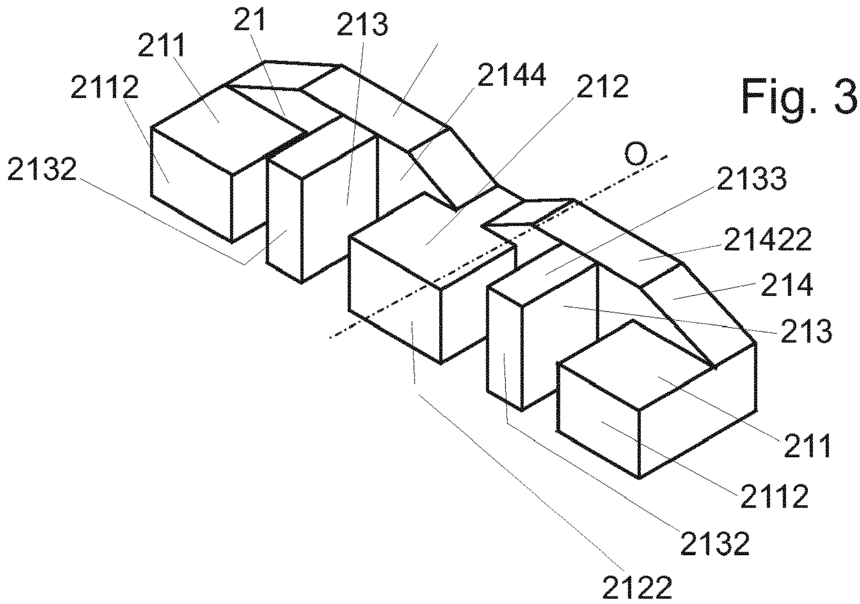
21
211
213
2112
2144
212
2132
O
2133
21422
214
213
211
2112
2132
2122

Fig. 3

Description

[0001] The present invention relates to an integrated transformer-inductor assembly comprising a magnetic core comprising a transformer column around which transformer windings are wound, inductor columns around which inductor windings are wound, and intermediate columns constituting common magnetic elements of a magnetic circuit of the transformer windings and magnetic circuits of the inductor windings.

Background of the invention

[0002] Prior art discloses a lot of different electric and electronic systems comprising different types of reactance elements provided with coils wound around ferromagnetic cores, such as for example inductors or transformers. In typical systems of this kind reactance elements have forms of separate individual components provided with their own separate individual magnetic cores. Prior art discloses also reactance assemblies comprising one common magnetic core on which coils of reactance elements - constituting individual elements from an electrical point of view - are installed. An exemplary solution of this type has been disclosed in the US patent application US2008224809. Obvious advantages of such an integration of reactance elements in one assembly is a reduction of a space occupied by such an assembly in a comparison to a space occupied by separate individual non-integrated elements, and facilitated mechanical assembly resulting from a decrease of a number of elements to be mounted.

[0003] In many known electric-electronic systems both transformers as well as inductors are employed together. As an example of such a system a resonant energy-conversion system may be given, an exemplary electric scheme of which is presented in Fig. 9. The scheme presents such a resonant converter in a series-parallel combination configuration which comprises: a transformer constituting a multi-winding inductor provided with windings denoted as L1, L3, L4 and L5; and two resonant inductors the windings of which are denoted as L2A and L2B. A change of the presented configuration into a series configuration may be realized in a simple manner by removing a capacitor C1.

[0004] In order to decrease a space occupied by electric-electronic systems of this type, it is advantageous to integrate at least some of reactance elements contained therein on one common ferromagnetic core. An exemplary integration of the above mentioned transformer in a form of a multi-winding inductor together with two resonant inductors has been disclosed in the European patent application EP 2 689 433 B1. The application describes an integrated inductor comprising a multi-winding inductor having a transformer winding and a resonant inductor. Sections of the magnetic circuit of the transformer winding are incorporated into magnetic circuits of two parts of a resonant inductor so as to form common parts of magnetic circuit of the multi-winding inductor and two-part resonant inductor. The objection of this integration was to reduce power losses occurring in the core. For this purpose the multi-winding inductor magnetic circuit comprises at least one air gap that enables for controlling the maximum magnetic induction value in the magnetic core and thus power losses occurring in the core. The width of the air gap is chosen so that magnetic induction produced by the two-part resonant inductor does not exceed 25% of the magnetic induction produced by the transformer winding of the multi-winding inductor. Power of the presented resonant converter - and also power of many different assemblies comprising reactance elements - is in an obvious manner dependent on a volume of ferromagnetic cores of reactance elements, and in this particular case on a volume of magnetic cores of the transformer and the resonant inductors. Therefore for example in a typical case, a change of power of the presented exemplary converter implies a necessity of designing and producing new ferromagnetic cores for the transformer and the resonant inductors, or new magnetic core for an integrated inductive assembly.

[0005] It has been the object of the present invention to provide a magnetic core of a modular construction for an assembly of integrated reactance elements comprising a transformer and an inductor, in particular one transformer and two inductors, which would feature decreased dimensions and reduced weight as well as would enable for efficient conduction and dissipation of heat generated in a core.

Summary of the Invention

[0006] According to the present invention there is provided an integrated transformer-inductor assembly comprising a magnetic core comprising a transformer column around which transformer windings are wound, inductor columns around which inductor windings are wound, and intermediate columns constituting common magnetic elements of a magnetic circuit of the transformer windings and magnetic circuits of the inductor windings, as defined at the outset, which is characterized in that the magnetic core comprises at least two substantially identical component modules, wherein each component module comprises

- a yoke having a form of a plate comprising a rectangular part and two trapezoidal parts arranged symmetrically along a first longer side of the rectangular part and adjoining said first longer side of said rectangular part with longer bases thereof;
- a set of rectangular prism shaped columns, parallel with each other and protruded on one side from the yoke along a longitudinal axis of the component module which is perpendicular relative to the surface of the yoke, and including
    - two outermost external component inductor col-

umns protruded from said rectangular part of the yoke;

- a central component transformer column;
- two component intermediate columns having substantially the same length and disposed between the component inductor columns and the component transformer column and protruded from the rectangular part and the trapezoidal part of the yoke;

wherein the second longer side of the rectangular part of the yoke located on the side opposite relative to the trapezoidal parts of the yoke and the internal lateral surfaces of all component columns located at the side of this second longer side of the yoke are coplanar with each other and form a contact plane; and wherein the external lateral surfaces of the intermediate columns located on the opposite sides of these columns relative to internal lateral surfaces thereof, are coplanar with shorter bases of the trapezoidal parts of the yoke;

and wherein said component modules are contacted with each other be means of contact frontal surfaces of the component intermediate columns which are perpendicular relative to the longitudinal axis of the module, and the longitudinal axes of the modules are positioned collinearly with each other;
and wherein the component inductor columns form the inductor columns, the component transformer columns form the transformer column, and the component intermediate columns form the intermediate columns.

[0007] In preferred embodiments, the integrated transformer-inductor assembly of the present invention comprises a pair of the component modules having collinearly positioned longitudinal axes and contacted with each other by means of the contact frontal surfaces of the component intermediate columns, which pair by means of the contact planes of the component modules is contacted with the second substantially identical pair of the component modules.

[0008] The modular construction of the magnetic core proposed according to the present invention enables for obtaining a compact construction of an integrated transformer-inductor assembly, an assembly of which features an assembly cost and time significantly reduced in comparison to an assembly cost and time of known prior art solutions. The present invention provides a significant limitation of a space volume occupied by an integrated transformer-inductor assembly and reduction of a total weight of such an assembly in comparison to known solutions. The present invention ensures also a decrease in a consumption of ferromagnetic material. The magnetic core of the integrated transformer-inductor assembly according to the present invention comprises a smaller number of magnetic elements and the magnetic elements have a smaller total volume in a result of which smaller magnetic losses occur in the magnetic core. The modular construction of the magnetic core as constructed of identical component modules features decreased production costs and provides a scalability of a magnetic core volume (and thus a scalability of power of transformer and inductor elements) by providing a possibility of juxtaposing different numbers of component modules together forming a complete magnetic core. The proposed geometry of the yoke of the component module of the present invention provides the yoke external frontal surface which is significantly enlarged in comparison to such surfaces in prior art solutions and through which a dissipation of heat from a core into an ambient environment or into a specific additional heat absorber and/or dissipater mounted on this frontal surface, may be effectively realized.

Brief description of drawings

[0009] The invention shall be described and explained below in connection with the attached schematic drawings on which:

Fig. 1 is an axonometric view of a first embodiment of an integrated transformer-inductor assembly according to the present invention;
Fig. 2 is an axonometric view of a magnetic core of the assembly presented in Fig. 1;
Figs. 3 and 4 show a component module of the magnetic core of the assembly depicted in Fig. 1 in an axonometric bottom and top view, respectively;
Figs. 5, 6 and 7 show the component module of the magnetic core of the assembly depicted in Fig. 1 respectively in a side view from the side of a contact plane, and in a bottom and top view; and
Fig. 8 is an axonometric view of a second embodiment of a magnetic core of an integrated transformer-inductor assembly according to the present invention.

Detailed description of preferred embodiments

[0010] Fig. 1 shows an axonometric view of a first embodiment of an integrated transformer inductor assembly 1a according to the present invention. The assembly 1a comprises a magnetic core 2a (depicted in details in Fig. 2) constituting a magnetic circuit comprising four identical component modules 21', 21", 21'" and 21"" depicted in details in Figs. 3-7, inductor bobbins 41 with inductor windings 4 and transformer bobbin 31 with transformer windings 3.

[0011] Each component module 21 of the magnetic core 2a comprises a yoke 214 and a set of five rectangular prism shaped columns projected in the same direction from the internal surface 2144 of the yoke 214 along the longitudinal axis O of the component module 21 and comprising: two outermost external component inductor columns 211, a central component transformer column 212 and two component intermediate columns 213.

[0012] An external frontal surface 2145 of the yoke 214, opposite in relation to the internal surface 2144 of the yoke 214, constitutes a surface - enlarged in comparison to prior art solutions - through which a dissipation of heat from the magnetic core 2 is carried out into an ambient environment and on which a specific additional heat absorber and/or dissipater may be installed (not shown in the figures).

[0013] The yoke 214 has a form of a plate having a length D4 and a thickness G4 and comprising a rectangular part 2141, two trapezoidal parts 2142 arranged symmetrically along a first longer side 21411 of the rectangular part 2141, and a triangular part 2143 located between the trapezoidal parts 2142. The trapezoidal parts 2142 contact the rectangular part 2141 by means of its longer bases 21421 of a length D5 (which in this embodiment equals to a half of the length D4 of the yoke 214), and contact with each other by means of corners thereof at said first longer side 21411 of the rectangular part 2141. The triangular part 2143 fills a corner area between legs of the trapezoidal parts 2142 that are contacted with each other.

[0014] The component module 21 of the core 2a constitutes a solid body symmetrical in relation to a plane of symmetry that is perpendicular relative to longer sides of the rectangular part 2141 of the yoke 214 and runs through the module 21 longitudinal axis O constituting an axis of symmetry of the rectangular part 2141 of the yoke 214.

[0015] A second longer side 21412 of the rectangular part 2141 of the yoke 214 located oppositely relative to the first longer side 21411 with the trapezoidal parts 2142 as well as internal lateral surfaces 2111, 2121, 2131 of all component columns 211, 212, 213 located at the side of this second longer side 21412 of the yoke 214 are coplanar with relation to each other and form a contact plane 215 of the module 21.

[0016] The component intermediate columns 21 are arranged between the component inductor columns 211 and the component transformer column 212. Both component intermediate columns 213 have substantially the same length D1, width S1 and thickness G1 that equals the sum of the width S2 of the rectangular part 2141 of the yoke 214 and the width S3 of the trapezoidal part 2142 of the yoke 214. The bases of the component intermediate columns 213 which are opposite relative to the yoke 214 are perpendicular relative the longitudinal axis O and constitute contact frontal surfaces (planes) 2132 which are coplanar with each other. In order to obtain a high degree of flatness of the contact frontal surfaces 2132, these surfaces are appropriately ground or polished.

[0017] Each component intermediate column 213 is projected from the rectangular part 2141 and one trapezoidal part 2142. The external lateral surfaces 2133 of the component intermediate columns 213 located on the opposite sides of these columns relative to their internal lateral surfaces 2131, are coplanar relative to shorter bases 21422 of the trapezoidal parts 2142 of lengths D6.

[0018] Both component inductor columns 211 have substantially the same length D2 which is not longer than the length D1 of the component intermediate columns 213, a width S4 greater than the width S1 of the component intermediate columns 213, and thickness G2 which equals the width S2 of the rectangular part 2141 of the yoke 214. The component inductor columns 211 are projected as whole from the rectangular part 2141 of the yoke 214. The bases of the component inductor columns 211 which are opposite relative to the yoke 214, are perpendicular relative to the longitudinal axis O and constitute frontal surfaces (planes) 2112.

[0019] The component transformer column 212 has a length D3 which is not greater than the length D1 of the component intermediate columns 213, a width S5 slightly greater than the width S4 of the component inductor column 211, and a thickness G3 which equals the sum of the width S2 of the rectangular part 2131 of the yoke 214 and the width S6 of the triangular part 2143 of the yoke 214. The component transformer column 212 is projected from the rectangular part 2141, the triangular part 2143 and the areas of the adjoining corners of the trapezoidal parts 2142 of the yoke 214. The base of the component transformer column 212 which is opposite relative to the yoke 214, is perpendicular relative to the longitudinal axis O and constitutes the frontal surface (plane) 2122.

[0020] Distances A1 between the component intermediate columns 213 and the central component transformer column 212 in the direction perpendicular relative to the longitudinal axis O of the module 21 are greater than distances A2 extending in the same direction between the component intermediate columns 213 and the component inductor columns 211.

[0021] For the purposes of the present invention, in regard to columns, including the component columns, the term "length" means a column dimension in the direction parallel relative to the longitudinal axis O of the module 21; the term "width" means a dimension in the direction perpendicular relative to the longitudinal axis O and parallel relative to the longer sides 21411 and 21412; whereas the term "thickness" means a dimension in the direction perpendicular relative to the longitudinal axis O and perpendicular relative to the longer sides 21411 and 21412.

Whereas in regard to the yoke and its component parts, for the purposes of the present invention, the term "length" means a dimension in the direction perpendicular relative to the longitudinal axis O of the yoke 213 and parallel relative to the longer sides 21411 and 21412 of the rectangular part 2141 of the yoke 214; the term "width" means a dimension in the direction perpendicular relative to the longitudinal axis O of the yoke 213 and perpendicular relative to the longer sides 21411 and 21412 of the rectangular part 2141 of the yoke 214; and the term "thickness" means a dimension in the direction parallel relative to the longitudinal axis O of the module.

[0022] According to some preferred embodiments of the present invention, the component module 21 has the following dimensions expressed in [mm]: D1 = 13, D2 ≅ 13 (but D2 ≤ D1 = 13), D3 ≅ 13 (but D3≤D1 = 13), D4 = 84.2, G1 = 15.6, G2 = 10, G3 = 11.2, G4 = 7, S1 = 6, S2 = 10, S3 = 5.6, S4 = 14.1, S5 = 16, S6 = 1.2, A1 = 8, A2 = 6.

[0023] In the magnetic core 2a of the assembly 1a, each of the component modules 21 is brought into contact with the adjacent component modules 21 by means of the internal contact plane 215 and contact frontal surfaces 2132 of the component intermediate columns 213.

[0024] The magnetic core 2a of the assembly 1a comprises two pairs of the modules 21'-21" and 21'"-21"", wherein each of the pairs comprises two component modules 21 of coaxially positioned longitudinal axes O, faced to each other with the component columns 211, 212, 213 and contacted with each other by means of the contact frontal surfaces 2132 of the component intermediate columns 213. Each one of the pairs of the modules 21 adjoining to each other with the component intermediate columns 213 abuts in turn the other pair with the internal contact planes 215 of the modules 21 of these pairs.

[0025] As a result of slightly smaller lengths D2, D3 of the component inductor columns 211 and the component transformer columns 212 in comparison to the length D1 of the intermediate component columns 213, air gaps 25 of a thickness B are formed in the magnetic core 2a between the frontal surfaces 2112, 2122 opposite relative to the yoke 214 and belonging to the component inductor columns 211 and the component transformers columns 212 that are faced oppositely to each other in pairs. Thicknesses B of the air gaps 25 are very small, and therefore the frontal surfaces 2112, 2122 of the component columns 211, 212 have to be formed with a high precision that is typically achieved by using a grinding or polishing process.

[0026] In a result of such a juxtaposition of the four component modules 21'-21"", the magnetic core 2a has been constructed comprising two outermost inductor columns 22 each one formed of four component inductor columns 211, two intermediate columns 24 each one formed of four component intermediate columns 213, and a central transformer column 23 formed of four component transformer columns 212. The inductor columns 22 and the transformer column 23 are arranged in the interiors of cylindrical bodies 411, 311 of the inductor bobbins 41 and the transformer bobbin 31 corresponding thereto, and provided with flanges 412, 312 facilitating an installation of inductor windings 4 and transformer windings 3 thereon and also ensuring for dissipating heat. The cylindrical bodies 311, 411 of the bobbins 31, 41 have rectangular cross-sections fitted to the cross-sections of the inductor columns 22 and the transformer columns 23 which are located in the bodies. The intermediate columns 24 constitute common magnetic elements forming parts of a magnetic circuit of the transformer windings 3 as well as parts of magnetic circuits of inductor windings 4, through which parts the paths of magnetic fluxes generated by these windings are closed.

[0027] Fig. 7 shows the second simpler embodiment of a magnetic core 2b that may be employed in different variants of an integrated transformer-inductor assembly of the present invention. The magnetic core 2b comprises only two component modules 21' and 21" of a construction analogical to the construction of the assembly 1a component modules. The modules 2b abut each other with the contact frontal surfaces 2132 of the component intermediate columns 213. The frontal surfaces 2112 and 2122 of the remaining component inductor columns 211 and the remaining component transformer columns 212 are positioned slightly distanced from each other and in a result thereof air gaps are formed inbetween. In order to construct a complete integrated transformer-inductor assembly according to the present invention, appropriate inductor bobbins with inductor windings and transformer bobbin with transformer windings (not shown in Fig. 8) are appropriately installed on the inductor columns 22b and the transformer columns 23b of the magnetic core 2b. The cross-sections of the bodies 311, 411 of the bobbins 31, 41 are obviously fitted to the cross-sections of the columns 23b (212) and 22b (211) corresponding thereto. An integrated transformer-inductor assembly constructed based on the magnetic core 2b shall obviously feature a decreased power in comparison to the assembly 1a of Fig. 1 in a result of a two times smaller volume of ferromagnetic material.

List of reference numerals

[0028]

1 transformer-inductor assembly
2 magnetic core
21 component module
211 component inductor column
2111 internal lateral surface
2112 frontal surface
212 central component transformer column
2121 internal lateral surface
2122 frontal surface
213 component intermediate column
2131 internal lateral surface
2132 contact frontal surface
2133 external lateral surface
214 yoke
2141 rectangular part
21411 first longer side
21412 second longer side
2142 trapezoidal part
21421 longer base
21422 shorter base
2143 triangular part
2144 internal surface
2145 frontal surface
215 contact plane
22 inductor column

23 transformer column
24 intermediate column
25 gap
3 transformer winding
31 transformer bobbin
311 body
312 flange
4 inductor winding
41 inductor bobbin
411 body
412 flange

Claims

1. An integrated transformer-inductor assembly (1) comprising a magnetic core (2) comprising a transformer column (23) around which transformer windings (3) are wound, inductor columns (22) around which inductor windings (4) are wound, and intermediate columns (24) constituting common magnetic elements of a magnetic circuit of the transformer windings (3) and magnetic circuits of the inductor windings (4), **characterized in that**
the magnetic core (2) comprises at least two substantially identical component modules (21), wherein each component module (21) comprises

- a yoke (214) having a form of a plate comprising a rectangular part (2141) and two trapezoidal parts (2142) arranged symmetrically along a first longer side (21411) of the rectangular part (2141) and adjoining said first longer side of said rectangular part (2141) with longer bases (21421) thereof;
- a set of rectangular prism shaped component columns (211, 212, 213), parallel with each other and protruded on one side from the yoke (214) along a longitudinal axis (O) of the component module (21) which is perpendicular relative to the surface of the yoke (214), and comprising
    - two outermost external component inductor columns (211) protruded from said rectangular part (2141) of the yoke (214);
    - a central component transformer column (212);
    - two component intermediate columns (213) having substantially the same length and disposed between the component inductor columns (211) and the component transformer column (212) and protruded from the rectangular part (2141) and the trapezoidal part (2142) of the yoke (214);

wherein the second longer side (21412) of the rectangular part (2141) of the yoke (214) located on the side opposite relative to the trapezoidal parts (2142) of the yoke (214) and the internal lateral surfaces (2111, 2121, 2131) of all component columns (211, 212, 213) located at the side of this second longer side (21412) of the yoke (214) are coplanar with each other and form a contact plane (215); and wherein the external lateral surfaces (2133) of the intermediate columns (213) located on the opposite sides of these columns relative to the internal lateral surfaces (2131) thereof, are coplanar with shorter bases (21422) of the trapezoidal parts (2142) of the yoke (4);
and wherein said component modules (21) are contacted with each other by means of contact frontal surfaces (2132) of the component intermediate columns (213) which are perpendicular relative to the longitudinal axis (O) of the module (21), and the longitudinal axes (O) of the modules (21) are positioned collinearly with each other;
and wherein the component inductor columns (211) form the inductor columns (22), the component transformer columns (212) form the transformer column (23), and the component intermediate columns (213) form the intermediate columns (24).

2. The integrated transformer-inductor assembly (1) according to Claim 1, **characterized in that** it comprises a pair of the component modules (21) having collinearly positioned longitudinal axes (O) and contacted with each other by means of the contact frontal surfaces (2132) of the component intermediate columns (213), which pair by means of the contact planes (215) of the component modules (21) is contacted with the second substantially identical pair of the component modules (21).

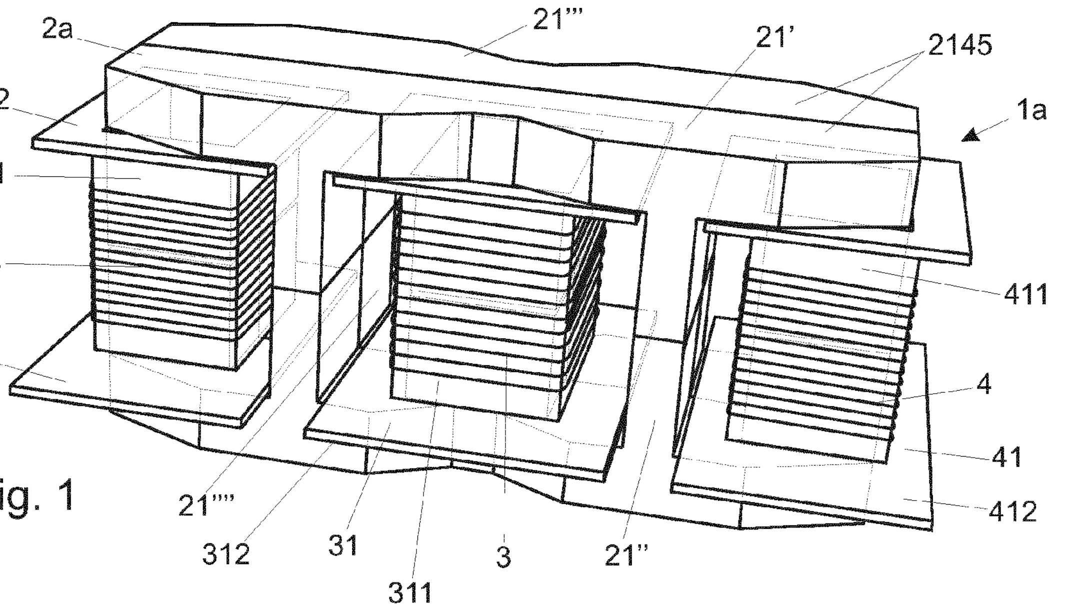

Fig. 1

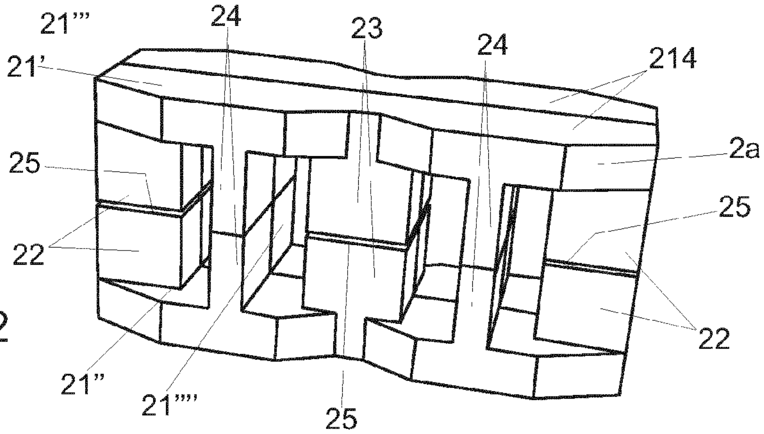

Fig. 2

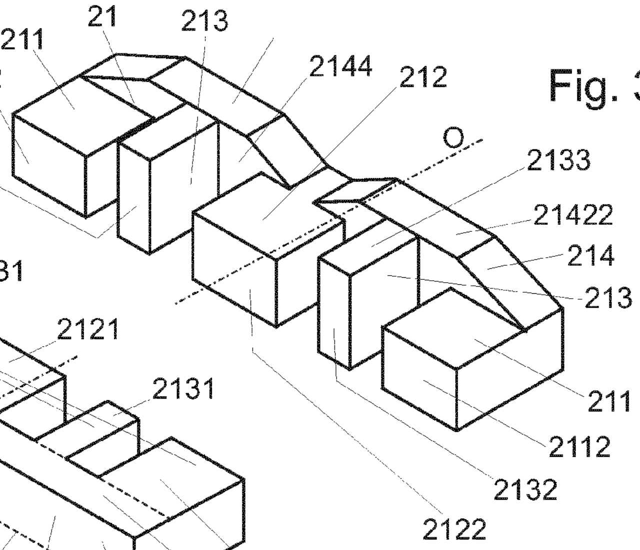

Fig. 3

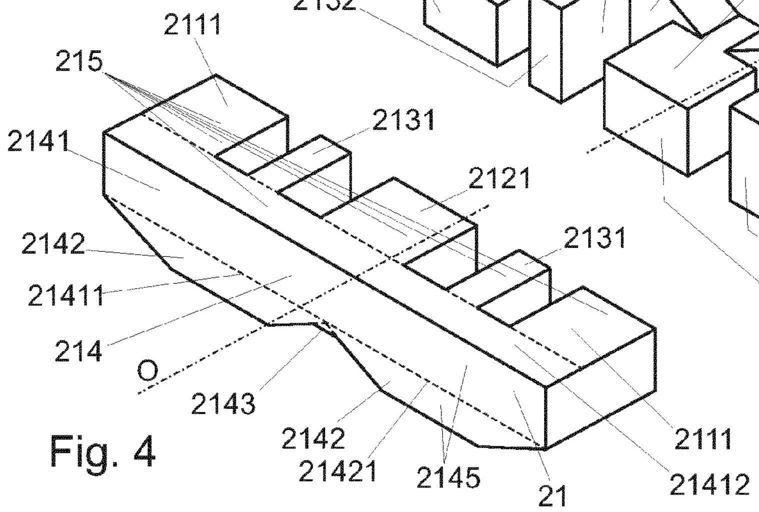

Fig. 4

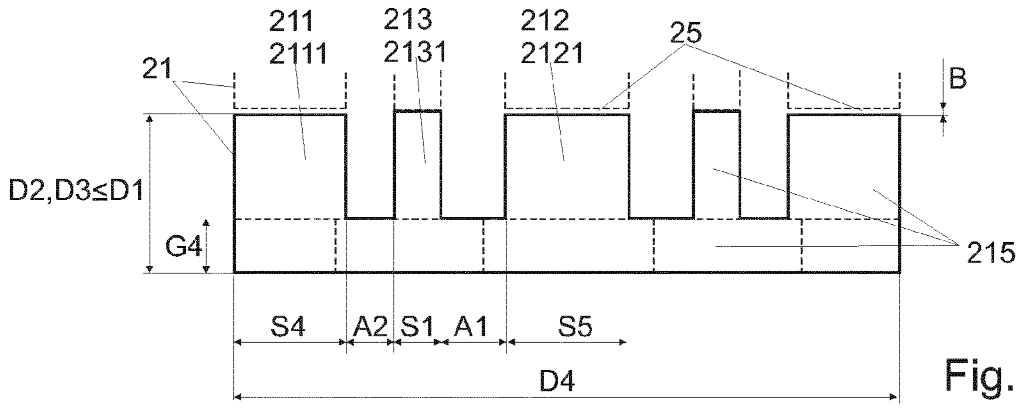

Fig. 5

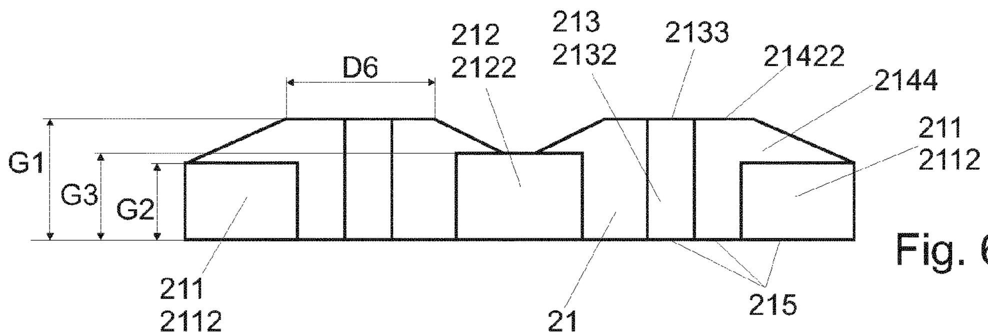

Fig. 6

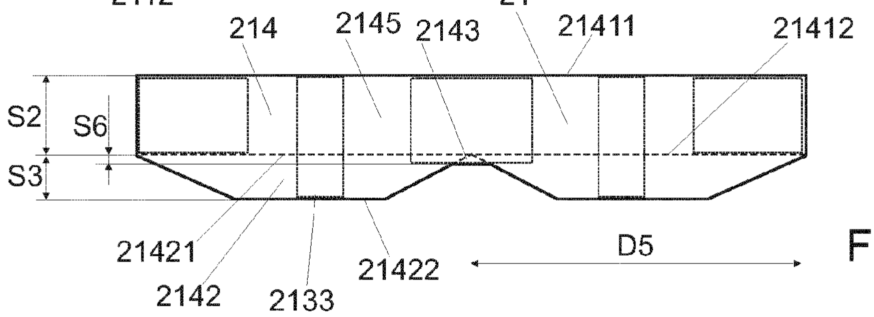

Fig. 7

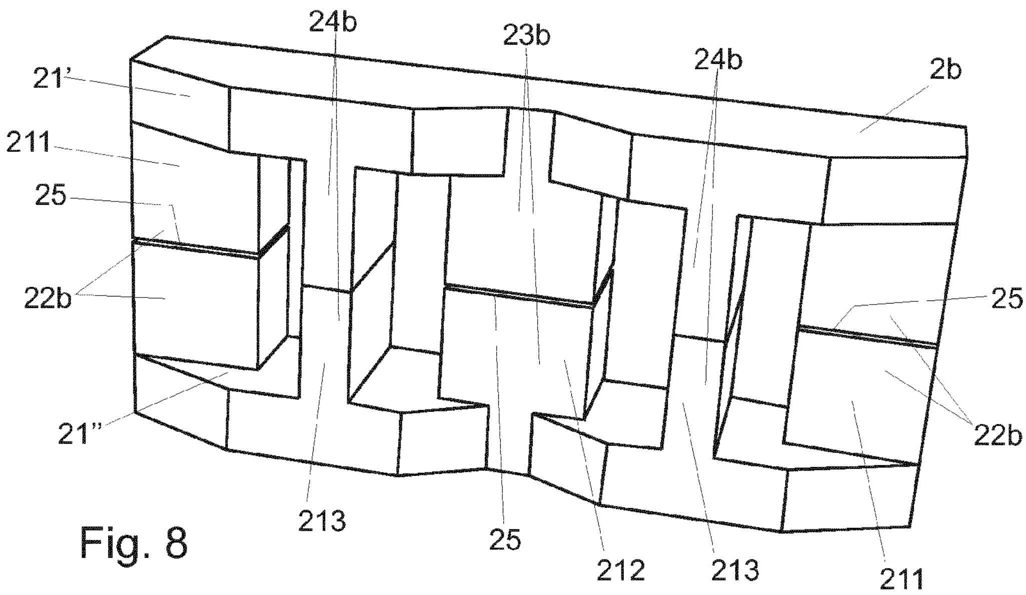

Fig. 8

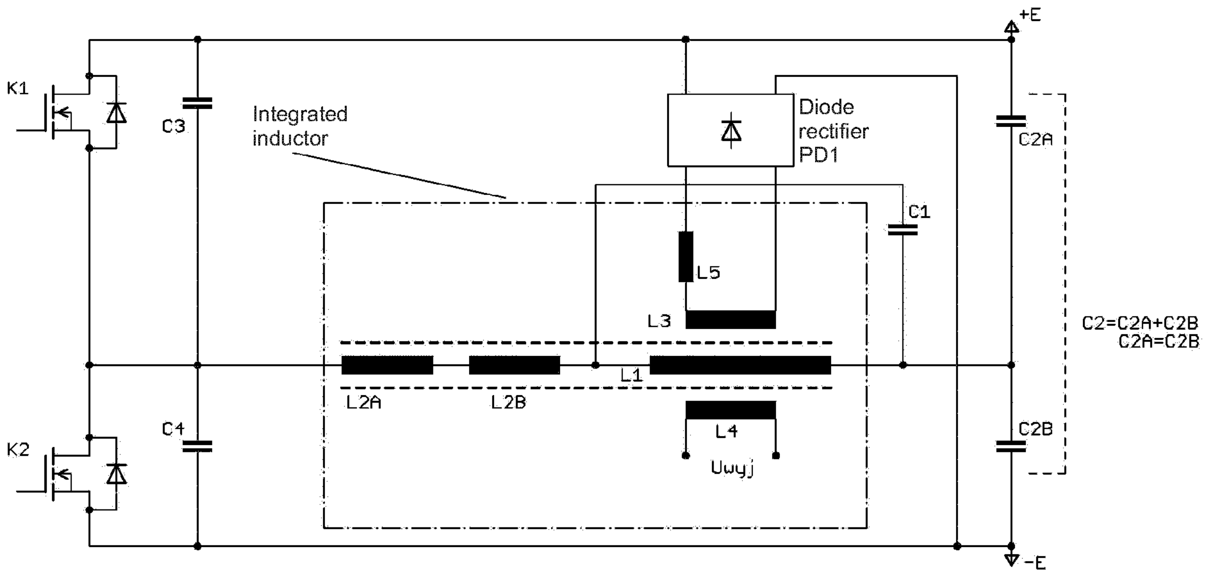
+E
K1
C3
Integrated
inductor
Diode
rectifier
PD1
C2A
C1
L5
L3
C2=C2A+C2B
C2A=C2B
L1
L2A
L2B
C4
K2
L4
C2B
Uwyj
-E

Fig. 9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 20 6183

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2015/282370 A1 (YANG HAIJUN [CN] ET AL) 1 October 2015 (2015-10-01) * paragraphs [0031], [0037] * -----	1,2	INV. H01F3/10 H01F27/38
A	JP 2005 303103 A (MATSUSHITA ELECTRIC IND CO LTD) 27 October 2005 (2005-10-27) * abstract * * paragraphs [0016], [0028] * -----	1,2	
A	US 2010/194306 A1 (SUGIMURA TOMOHIRO [JP] ET AL) 5 August 2010 (2010-08-05) * paragraphs [0052] - [0056] * -----	1,2	
A	EP 2 299 456 A1 (DET INT HOLDING LTD [KY]) 23 March 2011 (2011-03-23) * paragraphs [0002], [0028], [0029], [0084] * -----	1,2	

TECHNICAL FIELDS SEARCHED (IPC)

H01F
H01L

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	17 May 2018	Gols, Jan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 17 20 6183

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

17-05-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015282370 A1	01-10-2015	CN 104980003 A	14-10-2015
		US 2015282370 A1	01-10-2015
JP 2005303103 A	27-10-2005	JP 4424045 B2	03-03-2010
		JP 2005303103 A	27-10-2005
US 2010194306 A1	05-08-2010	CN 101802941 A	11-08-2010
		JP 4930596 B2	16-05-2012
		JP WO2009037822 A1	06-01-2011
		US 2010194306 A1	05-08-2010
		WO 2009037822 A1	26-03-2009
EP 2299456 A1	23-03-2011	CN 102064699 A	18-05-2011
		EP 2299456 A1	23-03-2011
		HK 1153860 A1	12-05-2017
		US 2011063065 A1	17-03-2011

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 2008224809 A **[0002]**
- EP 2689433 B1 **[0004]**