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(54) An arragement of windings of a HV insulation transformer

(57) The subject of the invention is arrangement of windings of a HV insulated transformer for power supply devices with multiple outputs whose outputs must be insulated to withstand very high voltages. An arrangement of windings comprising a secondary winding (4) superimposed on a primary winding (2) forming a pair of windings (6) characterized in that at least two pairs of windings (6) are placed on the same one common transformer core (1) in such a way that any windings (2) and (4) of each pair of windings (6) are not overlapping the windings (2) and (4) of the neighboring pair of windings (6) and where the primary windings (2) are connected in parallel and each of the primary winding (2) has a current sensor (3) adapted for measuring the current of its respective secondary winding (4).

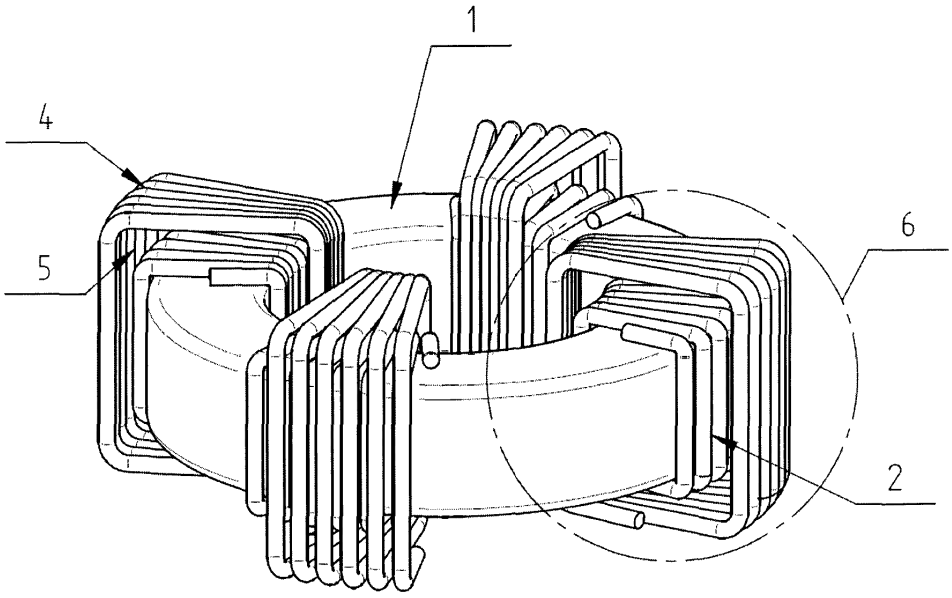

Fig. 2

EP 2 808 879 A1

Description

[0001] The subject of the invention is an arrangement of windings of a HV insulation transformer for power supply devices with multiple outputs whose outputs must be insulated from the primary side and between each other, to withstand very high voltages.

[0002] Multiple outputs power supply devices use various high voltage insulation transformers to provide high voltage galvanic insulation. This allows to isolate each output from the input of the power supply device as well as each output from the other output of the supply device. There are two ways to build a high voltage insulation transformer. One is to insulate the magnetic path of the transformer, by dividing a core into two pieces and introducing an insulation gap between them. The second way consist on using a HV insulated wires. This method creates an opportunity to look at an optimized way of transferring energy between primaries and secondaries in high voltage isolation power supply devices.

[0003] There are known high voltage power supply devices with multiple outputs provided with the separate high voltage insulation transformers where the primary and the secondary windings of a single transformer are wound on the same core and the high voltage insulation is provided by use of the wire insulating material. There are also known solutions, where the windings are wound with low voltage wires and the high voltage insulation is provided by use of the bobbins. There are known pulse transformers having a core composed of a two pieces, insulated between each other with air, resin or another insulating material, usually operating at the resonant frequency to reduce impact of leakage inductance. The known multiple transformers solution for the power supply device creates relatively bulky solutions. The power supply device become quite large and expensive, as every output of the power supply device uses a separate high voltage insulated transformer. In the known pulse power supply devices the controllers sense primary currents to protect the circuit against overload or shorted output. For a few separate transformers, the sensing circuits can be applied to monitor primary currents, which are dependent on secondary currents. There are known designs, where the isolating transformer comprises a single primary and multiple secondary windings, and the sensing circuit measures total primary current without the possibility of monitoring individual secondary currents. In the known versions of the power supply devices with HV insulated transformers having multiple outputs there are separate transformers for each of the outputs, providing galvanic isolation between primaries and secondaries as well as between all of the secondaries. It is essential in high voltage power supply devices to introduce current measurements for protection and/or monitoring on the primary side, since the secondary monitoring must be done at the high voltage site and isolation of the current feedback is expensive and difficult. The known solution with separate transformers for each of the outputs create relatively bulky solutions, so the idea is to use a single HV insulated transformer with multiple outputs, to save space and reduce costs of the power supply device. In typical transformers equipped with a single primary and multiple secondary windings, the current measurement performed on the primary side allows indirect monitoring of total output currents without the information about sharing between the secondary outputs.

[0004] In this case it is impossible to determine which output is overloaded, because the total primary current could be within the overall load limit of the transformer. It was found that for a certain winding arrangement, the primary measurements allow to determine output current for each output separately.

[0005] The essence of the invention comprising a secondary winding superimposed on a primary winding forming a pair of windings wound on a transformer core is that at least two pairs of windings are placed on the same one common core in such a way that any windings of each pair of windings are not overlapping the neighboring pair of windings. The primary windings are connected in parallel and each of the primary winding has a current sensor adapted for measuring the current of its respective secondary winding.

[0006] Preferably each pair of windings has an insulation gap situated between the external surface of the primary windings and the internal surface of the secondary windings.

[0007] Preferably the gap between the external surface of the primary winding and the internal surface of the secondary winding, an insulation shell is inserted having a shape compatible with the shape of the core.

[0008] Preferably on the outer side of the insulation shell a series of press-fits are placed for positioning the secondary windings exactly in superposition area on the primary windings.

[0009] Preferably the insulation shell is provided with ribs which are distributed radially along the internal side of shell walls on both sides of the shell for proper positioning the core and primary windings.

[0010] Alternatively the insulation shell is made in the form of a insulation mesh.

[0011] Preferably around the perimeter of the core transformer the four pairs of windings are place uniformly.

[0012] Preferably the primary windings and the secondary windings are coated with one or more insulation layers.

[0013] Preferably the transformer core is made as a solid ferromagnetic body in the shape of a toroid.

[0014] Alternatively the transformer core is made as one body with the insertion of the other magnetic material having different magnetic permittivity in its magnetic path.

[0015] Alternatively the transformer core is made as a stack of separate ring plates situated one on a top of the other.

[0016] The advantage of the inventive transformer is that it assures the assessment of the individual second-

ary current of each outputs of the power supply device by sensing the primary current. The use of single common core transformer as opposed to the multiple transformers allows the size reduction of the power supply device.

[0017] The subject of the invention is presented in the drawing, where fig.1 shows the schematic circuit diagram of the transformer, fig. 2 - the first embodiment of the transformer windings in an axonometric view, fig. 3 - the second embodiment of the transformer windings in an axonometric view, fig.4 - transformer windings from fig. 3 after detaching a half of the transformer shell.

[0018] The transformer for the power supply device has a magnetic core ring 1, on which at least two separated primary windings 2 are wound. The primary windings are connected in parallel. Each primary winding 2 is equipped with a current sensor 3. Around each of the primary winding 2 a separate secondary winding 4 is wound in such a way that winding 4 is spatially superimposed on the primary winding 2, where a certain distance is present between the external surface of the winding 2 and the internal surface of the winding 4 forming an insulation gap 5 between them.

[0019] The gap 5 can be filled with a potting insulation material assuring the proper insulation level between both windings 2 and 4, which is not shown in the drawing. The primary windings 2 and the secondary windings 4 are forming pairs of windings 6 having one primary and one secondary winding in each pair. All pairs of the windings 6 are distributed uniformly along the perimeter of the core 1 in such a way that the neighboring pairs are not overlapping each other.

[0020] In the second embodiment of the invention an insulation shell 7 made of plastic is inserted in the gap 5. The shell 7 is composed of two halves 7a and 7b and has a shape similar to core 1, thus covers the core 1 except of primary windings terminals leaded out of the shell 7, which is not shown in the drawing. The outer side of the side wall of the shell 7 is provided with a series of press-fits 8 placed on its perimeter in order to position the secondary windings 4 on top of the primary winding 2. The shell 7 is provided with ribs 9 which are distributed radially along both inner sides of the side walls.

[0021] The insulation shell 7 can be realized as mesh construction which is not shown in the drawing. In such a case the press-fits 8 are needless.

[0022] In both embodiments of the invention the primary windings 2 and the secondary windings 4 can be coated with one or more insulation layers. In such embodiment where the primary and the secondary windings are coated with the insulating layer, the gap 5 can be eliminated, which means that the primary and the secondary windings of the pair 6 remain in contact.

[0023] The transformer according to the both embodiments of the invention could be placed in an insulating housing and covered with an insulating cover which is not presented in the drawing. The housing can be made out of a resin by molding and in such a case, the shell can be omitted, because the resin insulation between the windings replaces the shell.

[0024] In the exemplary embodiment of the invention the magnetic core 1 is made as a solid ferromagnetic body in the shape of toroid, but it can be made as one body with the insertions of the other magnetic material having different magnetic permittivity. Also the core 1 could be made of some separate ring plates situated one on the top of the other forming a stack. The number of the pairs of windings in the exemplary embodiment is four, but it may be different on the assumption that the pairs 6 do not overlap each other.

[0025] The principle of operation of the inventive transformer is the following. All the primary windings 2 equipped with current sensors 3 are connected in parallel and driven from an AC source inducing voltages in the secondary windings 4. The sensors 3 measure primary currents which are dependent on the secondary ones, so indirectly the sensors sense secondary currents. Even though all pairs of the windings 6 are placed on the same common core 1, the individual currents flowing through the primary windings 2 are dependent on the currents of their respective secondary windings 4 with negligible impact of the currents of neighboring pairs 6. Each pair of the windings 6 acts like an independent transformer, since the magnetic coupling within each pair of the windings is much higher than between the neighboring pairs, hence the crosstalk between the neighboring windings is negligible. This is a very important feature, which simplifies detection of the overload or short circuit of any individual secondary winding. This is a very essential feature of the transformer operating in HV applications where there is no feedback from the secondaries to the primary controller, which is a part of the supply device.

[0026] In the presented embodiment of the invention the pair of winding 6 is formed such that the secondary windings 4 are placed on top of the primary windings 3 but it is understand to those skilled in the art that the reverse relation between windings is possible. When the secondary windings is placed under the primary windings, the scope of the protection will be the same.

Claims

1. An arrangement of windings of a HV insulated transformer for power supply device comprising a secondary winding (4) superimposed on a primary winding (2) forming a pair of windings (6) wound on a transformer core (1), **characterized in that** at least two pairs of windings (6) are placed on the same one common transformer core (1) in such a way that any windings (2) and (4) of each pair of windings (6) are not overlapping the windings (2) and (4) of the neighboring pair of windings (6) and where the primary windings (2) are connected in parallel and each of the primary winding (2) has a current sensor (3) adapted for measuring the current of its respective

secondary winding (4).

2. An arrangement according to claim 1, **characterized in that** each pair of windings (6) has an insulation gap (5) situated between the external surface of the primary windings (2) and the internal surface of the secondary windings (4).

3. An arrangement according to claim 2, **characterized in that** in the gap (5) between the external surface of the primary winding (2) and the internal surface of the secondary winding (4) an insulation shell (7) is inserted having a shape compatible with the shape of the transformer core (1).

4. An arrangement according to claim 3, **characterized in that** on the outer side of the insulation shell (7) a series of press-fits (8) are placed for positioning the secondary windings (7) exactly in superposition area on the primary windings (2).

5. An arrangement according to claim 3, **characterized in that** the shell (7) is provided with ribs (9) which are distributed radially along the internal side of shell walls on both sides of the shell for proper positioning the core (1) and primary windings (2).

6. An arrangement according to claim 3, **characterized in that** the insulation shell (7) is made in the form of a insulation mesh.

7. An arrangement according to claim 1, **characterized in that** the four pairs of windings (6) are place uniformly around the perimeter of the transformer core (1).

8. An arrangement according to any previous claims, **characterized in that** the primary windings (2) and the secondary windings (4) are coated with one or more insulation layers.

9. An arrangement according to any previous claims, **characterized in that** the transformer core (1) is made as a solid ferromagnetic body in the shape of a toroid.

10. An arrangement according to any previous claims, **characterized in that** the transformer core (1) is made as one body with the insertion of the other magnetic material having different magnetic permittivity in its magnetic path.

11. An arrangement according to any previous claims, **characterized in that** the transformer core (1) is made as a stack of separate ring plates situated one on a top of the other.

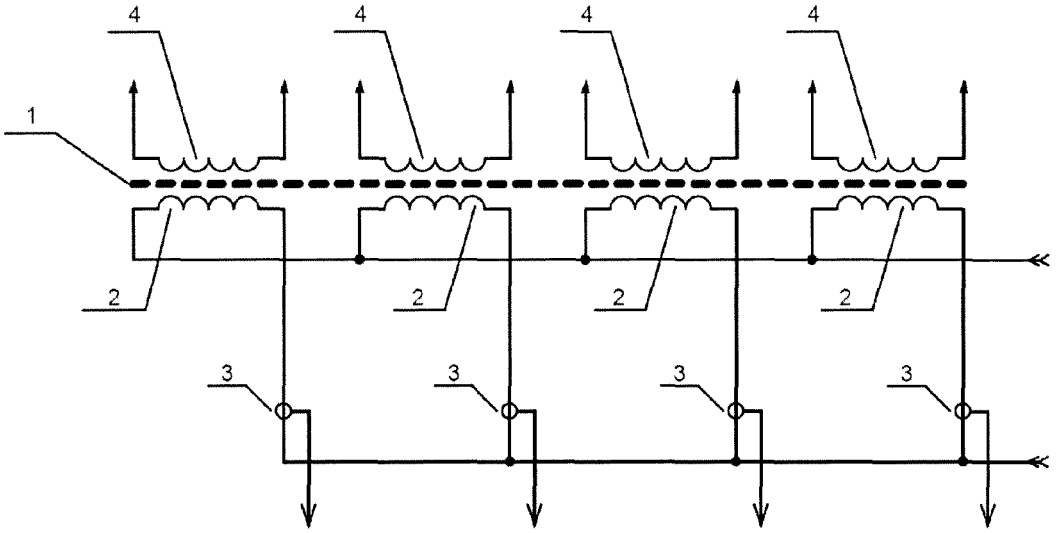

Fig. 1

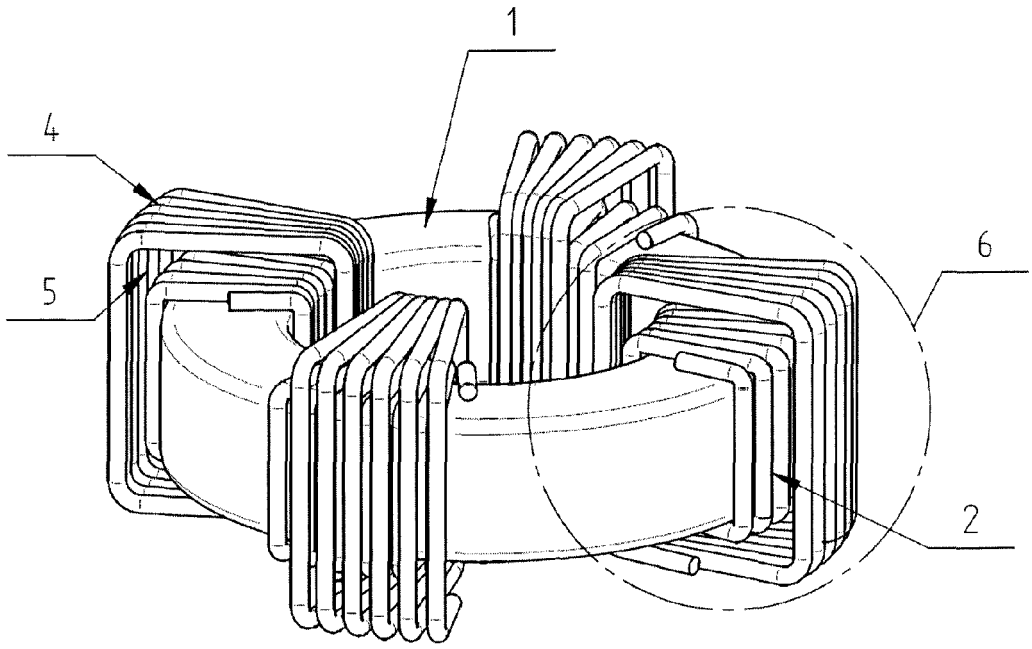

Fig. 2

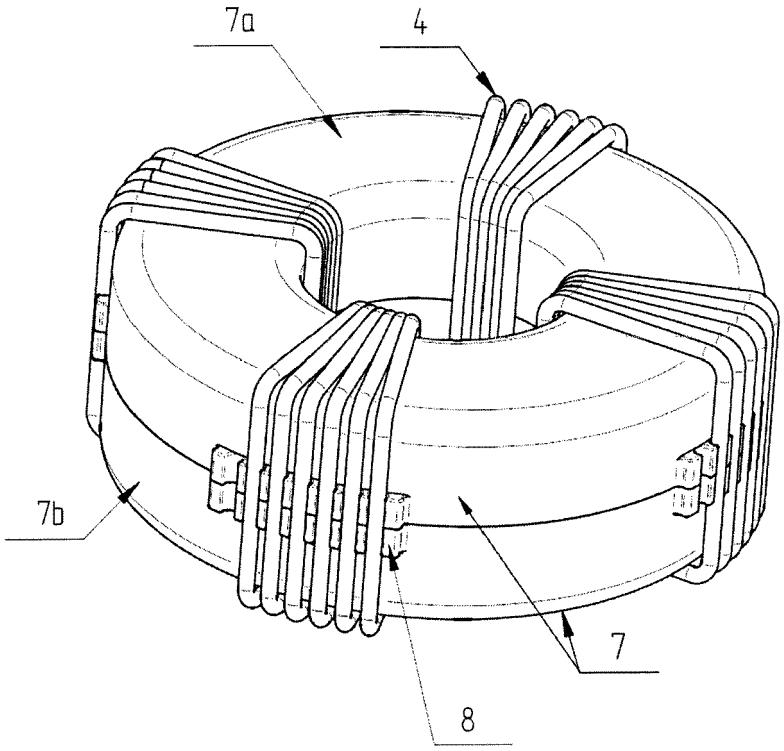

Fig. 3

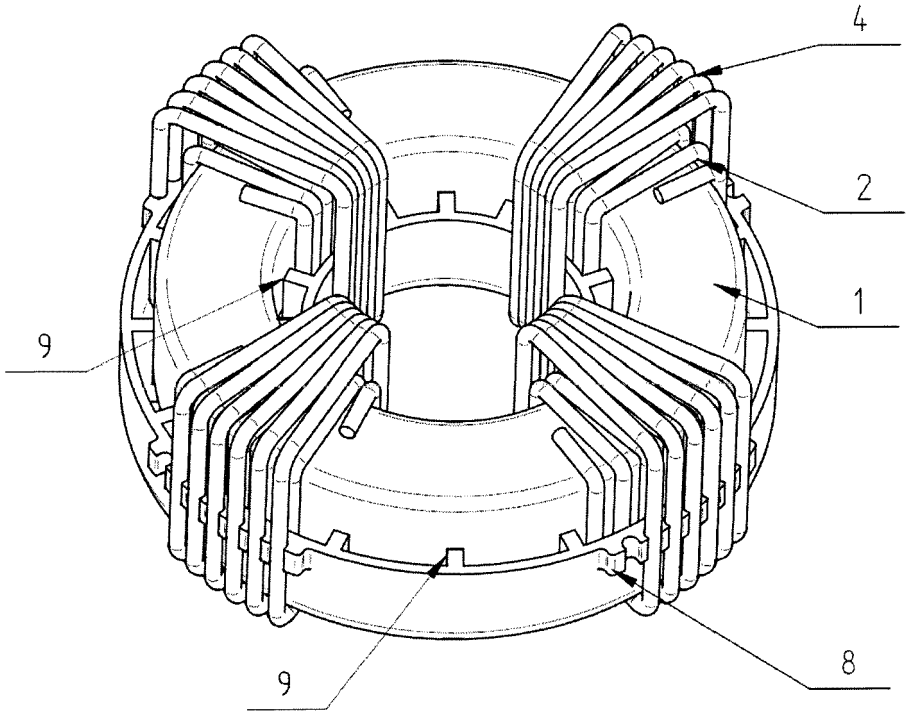

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 13 46 0035

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	WO 2009/138099 A1 (ABB TECHNOLOGY AG [CH]; JOHNSON CHARLES W [US]; LEANDER JAN [CN]; BILE) 19 November 2009 (2009-11-19) * abstract * * page 3, paragraph 5 - page 5, paragraph 4 * * page 6, last paragraph - page 8, paragraph 4 * * figures 1,2,3 *	1-11	INV. H01F30/04 H01F30/16 H01F27/40 ADD. H01F27/32 H01F27/28
A	WO 2005/057769 A1 (NUJIRA LTD [GB]; WILSON MARTIN PAUL [GB]) 23 June 2005 (2005-06-23) * column 8, paragraph 58 - column 12, paragraph 89 * * figures 6,7 *	1-11	
A	EP 2 061 043 A1 (HAMILTON SUNDSTRAND CORP [US]) 20 May 2009 (2009-05-20) * abstract; figures 1-5a *	4-6	
			TECHNICAL FIELDS SEARCHED (IPC) H01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 November 2013	Kardinal, Ingrid

CATEGORY OF CITED DOCUMENTS

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