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(54) **Planar winding transformer**

Flachspuletransformator

Transformateur à bobine plane

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(56) References cited:
FR-A- 2 476 898 **US-A- 3 271 716**

• **PATENT ABSTRACTS OF JAPAN vol. 7 no. 99**
(E-172) [1244] ,27 April 1983 & JP-A-58 021806
(TOUKOU K.K.)

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Description

OBJECT OF THE INVENTION

This invention concerns a planar transformer of particular application in low-profile, switched power supply units that can attain working frequencies up to several megahertz.

BACKGROUND TO THE INVENTION

In switched power supply units, the reduction in size has been due to progress in the field of semiconductor technology. New semiconductor devices permit faster switching and an increased switching frequency of up to several megahertz. Consequently the capacitors and magnetic components can be reduced in weight and size; nonetheless, by raising the switching frequency, certain problems are aggravated, such as:

- increased parasitic effects, the behaviour of which can not be easily reproduced;
- being compact components, greater ventilation requirements are necessary.

In these power supply modules, which are often board-mounted, low-profile packaging is employed, consequently the use of planar components is extensive.

It is most important to control tolerances in the manufacturing process of the transformer windings to prevent variations in parasitic effects because of geometric deviations in the windings and their shape differing from that initially calculated by the designer, giving rise to magnetic elements, like transformers for example, that behave differently.

Up to now, depending on the application, the transformers used are either of the traditional type, which have a high copper density and in which the problems resulting from winding non-repeatability are more obvious, or planar transformers, in which the wire turn repeatability problem has been overcome thanks to the perfect control of the wire turn shape in the manufacturing process, whereby there is no variation in parasitic effects. Two types exist within this latter transformer class that differ from each other by their turns:

- windings formed by wire turns on printed circuit or multilayer boards that have a lower copper density, but greater losses than the conventional kind,
- windings formed by flat copper wire turns that have a greater occupancy coefficient in the core window than the previous type.

The disadvantage with this latter type of planar transformer is that the connection of the different wire turns in the winding is made outside the core window by means of drilled holes and interconnecting pins, which

implies a different wire turn design for each application, since the shape of the wire turn depends very directly on the number of turns in the winding, and the area of copper to be used is large since the connections have to be made only every two turns, the remainder being left outside the area occupied by this connection. A comparative study can be seen in the article by N. Dai, A.W. Lofti, G. Skutt, W.A. Tabisz and F.C. Lee entitled "A Comparative Study of High-Frequency Low-Profile Planar Transformer Technologies", 11th Annual VPEC (Virginia Power Electronics Center) Power Electronics Seminar, September 19-21, 1993, pages 153 to 161.

As shows the patent FR-A-2 476 898, the planar wire turns have connection flaps to be interconnected outside the window of the magnetic core. The amount of turns that can be placed in series is limited by the available space for the connection flaps and is determined by the core type.

TECHNICAL PROBLEM TO BE OVERCOME

Consequently the technical problem to be overcome is to simplify the interconnecting process of the wire turns of a planar winding, using a high density of conductive material and minimum size for its implementation in very varied designs with only minimal modifications.

CHARACTERISATION OF THE INVENTION

The planar winding transformer of the invention, consisting of a core of ferromagnetic material and windings formed by flat wire turns, each wire turn being an open ring of conductive material, coated with insulating material to isolate it electrically from the other wire turns, is characterised in that the wire turns are joined together electrically inside the window of the magnetic core. Thanks to this form of construction, the wire turns are easily reproduced without deviations occurring with respect to the original design.

To join together the wire turns of a winding, the open rings have at least two segments free of insulating material and they are joined together by a soldering process. This process is characterised in that the open rings are joined together electrically inside the window of the magnetic core with no requirement for external means such as interconnecting pins that make it necessary to form the connection outside the magnetic core window; or machining pre-processes, such as drilling the turns. This form of construction combines the advantages of the conventional transformers with those of planar transformers, like high conductive material density and winding repeatability, adding a simple method of interconnecting the wire turns within the transformer window and smaller size.

The end wire turns of the windings are characterised in that they have an extension which is used as a transformer terminal, facilitating its connection to other

components of the power supply module.

The open rings are characterised in that they are circular when the core has a circular window, and to facilitate their assembly inside the core, they are characterised in that they have a notch at an angle that shifts progressively with respect to an origin, the opening of the rings of a winding forming a helix.

BRIEF FOOTNOTES TO THE FIGURES

A fuller explanation of the invention is to be found in the following description based on the figures attached in which:

- figure 1 shows the cross-section of a planar transformer in which can be seen the window that forms the magnetic core and the positioning of the windings inside it,
- figure 2 shows an example of an end wire turn and an intermediate wire turn of a winding according to the invention, and
- figure 3 shows the helix that is formed by the openings of the rings of a winding once the rings have been joined electrically.

DESCRIPTION OF THE INVENTION

The planar winding transformer of the invention is formed by a core (N) of ferromagnetic material in the window (V) of which are lodged the wire turns of the windings (D) of the transformer, as can be seen in figure 1. The wire turn is an open circular ring (E,C), as is shown in figure 2. The rings are of a conductive material and are isolated from each other by means of a coating of insulating material. To connect the rings (E,C) electrically to each other, the insulating material at their ends is removed and the rings (E,C) are joined by a soldering process for each winding (D), in such a way that the join is made within the transformer window (V).

The soldering process takes place in an oven in which the rings (E,C) are placed mounted on a metallic piece or cylinder with the shape of the central part of the core (N) and which is equipped with a clamping mechanism. Once the rings have been positioned and placed under pressure on the device, the assembly is introduced into the oven for the wire turn soldering process to be carried out. The task of situating the rings on the cylinder is facilitated if the latter has a projection equivalent to the notch (H) which each ring (E,C) has. The notch (H) of each wire turn is shifted progressively by a determined angle from an origin whereby the openings of the rings (E,C) of each winding (D) form a helix, as can be seen from figure 3. Once the winding (D) has been formed, it is mounted inside the core.

For the rings (E,C) to be as equal as possible, a series of notches (H) can be practised, incremented by a determined angle starting from a given origin. In the event that a core (N) is employed with an inside in the

form of a polygon, the openings of the wire turns will also form a helix once the windings are constituted and mounted inside the core.

The end rings (E) of each winding (D) are different from the internal rings (C) of the winding (D). The difference lies in that the end rings (E) have an extension (P) that facilitates the connection of the planar transformer to other elements in the power supply unit.

Claims

1. Planar winding transformer formed by a core of ferromagnetic material (N) and by windings (D) constituted by planar wire turns, each wire turn being an open ring (E, C) of a conductive material coated with an insulated material, characterized in that the wire turns are joined together electrically inside the window (V) of the magnetic core.
2. Planar winding transformer according to claim 1, characterized in that each wire turn (E, C) has two segments free of insulating material in order to practice the electrical connection between wire turns (E, C).
3. Planar winding transformer according to claim 2, characterized in that at least the end wire turns (E) of the windings (D) have a minimum of one extension (P) to be employed as a transformer terminal.
4. Planar winding transformer according to claim 1, characterized in that each wire turn (E, C) is an open circular ring of a conductive material coated with an insulating material
5. Planar winding transformer according to claim 4, characterized in that the rings (E, C) have, at least, one notch (H) to facilitate their positioning within the transformer window(V).
6. Planar winding transformer according to claim 5, characterized in that the position of each notch (H) within each ring (E, C) shifts progressively by an angle with respect to an origin, so that the openings of the rings (E, C) that constitute a winding form a helix.

Patentansprüche

1. Planarwicklungstransformator, gebildet durch einen Kern ferromagnetischen Materials (N) und durch Wicklungen (D), die aus flachen Drahtwindungen aufgebaut sind, wobei jede Windung aus einem offenen Ring (E, C) eines leitfähigen Materials überzogen mit einem isolierendem Material besteht, dadurch gekennzeichnet, daß die Drahtwin-

dungen innerhalb des Fensters (H, V) des magnetischen Kerns elektrisch miteinander verbunden sind.

2. Planarwicklungstransformator gemäß Anspruch 1, dadurch gekennzeichnet, daß jede Drahtwindung (E, C) zwei Abschnitte besitzt, die frei von isolierendem Material sind, um die elektrischen Verbindungen zwischen den Drahtwindungen (E, C) auszuführen.

3. Planarwicklungstransformator gemäß Anspruch 2, dadurch gekennzeichnet, daß mindestens die sich jeweils am Ende der Wicklungen (D) befindlichen Drahtwindungen (E) eine minimale Verlängerung (P) aufweisen, die als Transformatoranschluß verwendet werden soll.

4. Planarwicklungstransformator gemäß Anspruch 1, dadurch gekennzeichnet, daß jede Drahtwindung (E, C) ein offener kreisförmiger Ring eines leitfähigen Materials überzogen mit einem isolierenden Material ist.

5. Planarwicklungstransformator gemäß Anspruch 4, dadurch gekennzeichnet, daß die Ringe (E, C) mindestens eine Kerbe (H) besitzen, um ihre Positionierung innerhalb der Transformatorfensters (V) zu erleichtern.

6. Planarwicklungstransformator gemäß Anspruch 5, dadurch gekennzeichnet, daß die Position jeder Kerbe (H) innerhalb jedes Ringes (E, C) bezüglich eines Ausgangspunktes um einen bestimmten Winkel verschoben ist, so daß die Öffnungen der Ringe (E, C), die eine Wicklung bilden, eine Schraubenlinie ergeben.

Revendications

1. Transformateur à bobines planes constitué d'un noyau de matériau ferromagnétique (N) et de bobines (D) comprenant des spires de fil planes, chaque spire de fil étant un anneau ouvert (E, C) d'un matériau conducteur revêtu d'un matériau isolé, caractérisé en ce que les spires de fil sont réunies électriquement ensemble à l'intérieur de la fenêtre (V) du noyau magnétique.

2. Transformateur à bobines planes selon la revendication 1, caractérisé en ce que chaque spire de fil (E, C) comporte deux segments exempts de matériau isolant de manière à effectuer la connexion électrique entre les spires de fil (E, C).

3. Transformateur à bobines planes selon la revendication 2, caractérisé en ce qu'au moins les spires

de fil (E) des extrémités des bobines (D) présentent un minimum d'une partie en prolongement (P) destinée à être employée en borne du transformateur.

4. Transformateur à bobines planes selon la revendication 1, caractérisé en ce que chaque spire de fil (E, C) est un anneau circulaire ouvert d'un matériau conducteur revêtu d'un matériau isolant.

5. Transformateur à bobines planes selon la revendication 4, caractérisé en ce que les anneaux (E, C) présentent au moins une encoche (H) pour faciliter leur mise en place à l'intérieur de la fenêtre (V) du transformateur.

6. Transformateur à bobines planes selon la revendication 5, caractérisé en ce que chaque encoche (H) est progressivement décalée à l'intérieur de chaque anneau (E, C) d'un angle par rapport à l'origine, de sorte que les ouvertures des anneaux (E, C) qui constituent une bobine forment une hélice.

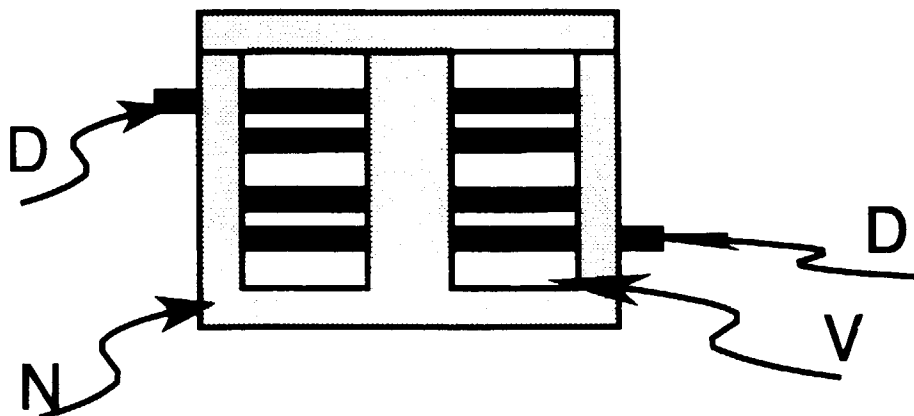


Fig. 1

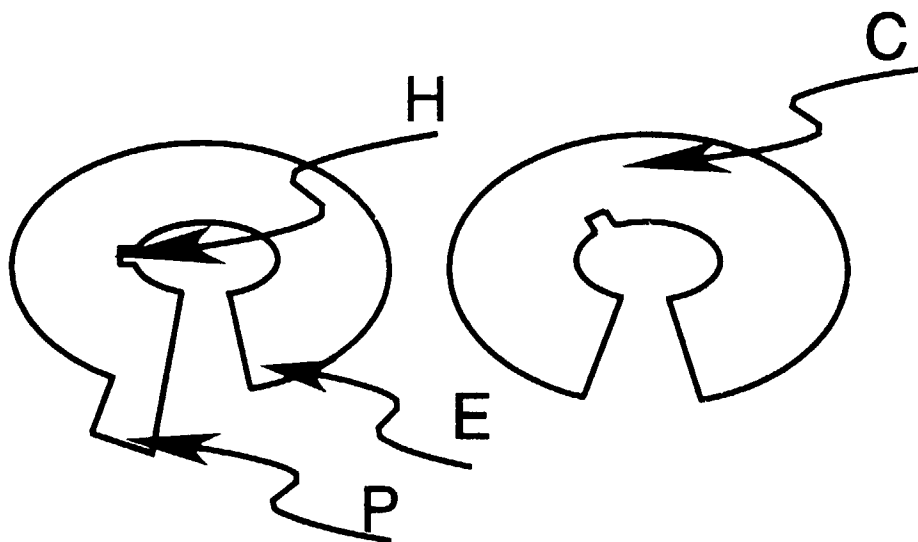


Fig. 2

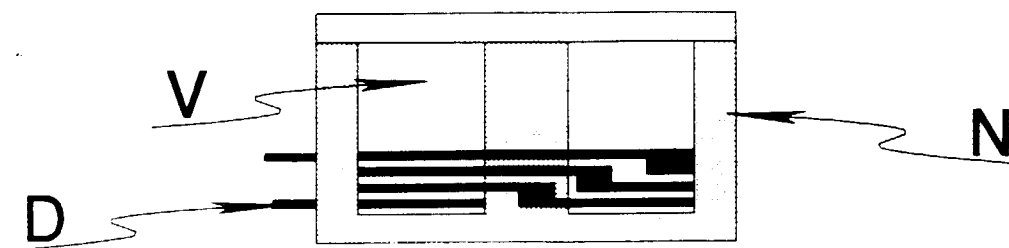


Fig. 3