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(54) Toroidal transformer.

(57) Of special application in the output stage of high power, switched power supply units that work at high operating frequencies.

The toroidal transformer consists of a circular magnetic core (T) on which are wound the elements (D,P) of the turns that constitute the windings.

These turns are formed by elements connected in series; one of the elements that forms the turn is a prism of conductive material (D) with a slot in one of its sides; another of the elements that forms the turn consists of a conductive track (P) laid on an insulating surface, such as a printed circuit board; the tracks provide electrical continuity for the assembly of slotted prisms, forming in this way a winding wound around the toroid.

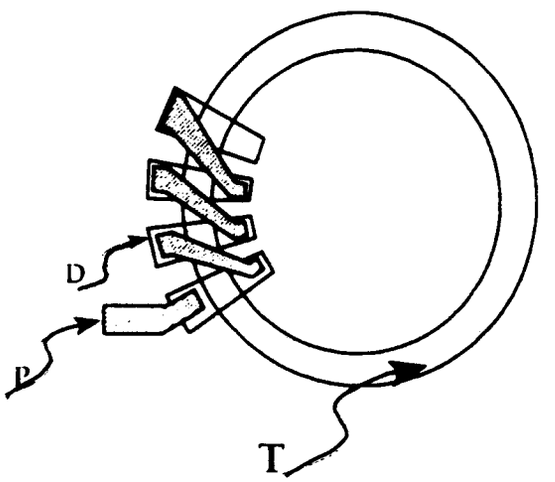

Fig. 3

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OBJECT OF THE INVENTION

This invention concerns a toroid on which are wound a number of windings, of particular application in the output stage of high power, switched power supply units that work with high operating frequencies.

BACKGROUND TO THE INVENTION

In high power, switched power supply units the tendency is to work at high frequencies since in this way it is possible to decrease the equipment size as a function of the increase in operating frequency; nevertheless, if the operating frequency is very high, the losses produced in the core and in the windings of the transformer increase to a greater degree.

The losses in the windings are due to the voltage drop in the conductive material through resistance, to the reduction in the useful cross-section of the conductive material because of the increased frequency and to the effects of parallel currents in nearby turns.

On the other hand, the core formed by magnetic material, constitutes a magnetic circuit that has losses because of hysteresis and eddy currents, which are also accentuated by the increase in frequency.

However if the shape of the transformer is altered, it is possible to improve its behaviour with respect to losses. The optimum transformer shape is toroidal; this transformer is constituted by a circular core, toroid, on which the windings are wound.

To wind a conductor around a toroid presents constructional difficulties that limit the cross-section of the conductor being used and necessitate the employment of a greater length of conductor, which penalises the design. To overcome this problem to the greatest extent possible, different types of conductor are employed, such as those termed Litz wires, which are formed by weaving together several wires of smaller cross-section and thereby obtaining a conductor that is more flexible than one constituted by a single wire, which is also used.

Because of the drawbacks presented by its construction, its use is limited to those cases where it is obligatory, such as in filters for electromagnetic interference (EMC) or in LC filters handling high amplitude current pulses.

Another way of constructing the toroidal transformer is to use layers of copper deposited on a plastic material in order to form a winding; because of the high working temperatures of power transformers, the plastic material has to be able to withstand such operating temperatures. This manner of construction requires a winding to be built up in the traditional form on the toroidal core and another winding to be formed by placing on the first winding a plastic sheet on which copper is deposited in layers. Nevertheless, this manufacturing procedure presents the classic problems resulting from not being able to automate the production of one of the windings, the one wound on the toroidal core. This is explained in the article "Técnicas de circuitos impresos tridimensionales para transformadores de potencia de alta frecuencia", NPE - Nuevos Productos Electrónicos, number 33, 1992, pages 37 to 40.

TECHNICAL PROBLEM TO BE OVERCOME

Consequently, the technical problem to be overcome is the automation of the winding of turns on a toroid, reducing the difficulties in its construction and making best use of the magnetic material of the toroid and of the conductive material.

CHARACTERISATION OF THE INVENTION

The toroidal transformer of the invention, consisting of a circular core, toroid, on which are wound the windings that are made up of a number of turns, is characterised in that these turns comprise at least two elements connected in series.

The toroidal transformer according to the invention, is characterised in that one of the elements of the turns is a prism of conductive material with a slot in one of its sides.

To give electrical continuity to the different slotted prisms, another element that forms the turns of the windings is a conductive track deposited on an insulating surface, the latter offering a good coefficient of thermal conduction if this should be necessary.

With the application of the toroidal transformer according to the invention, it is possible to implement the windings on a toroid in an automated fashion, forming the turns with a smaller quantity of conductive material and having the option of not using either connectors or supports since the transformer can make external connections via the conductive track whereby a toroid is obtained with windings occupying less space and weighting less which is combined with a better use of the window and of the magnetic material of the toroid, permitting a design for greater levels of induction in the core and greater current density in the windings thanks to the improved thermal coupling which it offers.

BRIEF FOOTNOTES TO THE FIGURES

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

- figure 1 shows one of the prisms of conductive material with a slot in one of its sides, used in the turns of the windings of the toroid of the invention,
- figure 2 shows how the toroid is located inside the slot of the prisms that form part of the turns, and
- figure 3 shows how the conductive tracks connect in series the different slotted prisms forming the turn assembly of the windings that are wound on the toroid.

DESCRIPTION OF THE INVENTION

As already stated, the use of a number of windings on a toroid as a filter or toroidal power transformer is limited by the difficulty presented by its construction, this being facilitated if the turns of the windings consists of two elements.

One of the elements that forms the turn is a prism of conductive material D with a slot in one of its sides, as can be seen in figure 1; this is such that the toroid T is housed in the slot of the prisms, as can be seen in figure 2.

The other element that forms the turn is in the form of a conductive track P deposited on an insulated surface capable of providing a good heat transfer coefficient. The conductive track provides the necessary electrical continuity for the assembly of slotted prisms D, as can be seen in figure 3.

According to the invention, it is possible to wind the windings on the toroid T in an automated manner given that one of the elements of the turn is a set of conductive tracks P of a printed circuit board and permitting the slotted prisms D and the toroid T to undergo the same surface mounting process as for any other electronic component on a printed circuit board; in this way the necessary turns are obtained with less quantity of conductive material and having the option of not employing connectors or supports since the toroid T can be connected to the other electronic components of the equipment to which it pertains via the conductive tracks P. Through this process a toroid is obtained that is smaller in size and of less weight, as well as making better use of the window and of the magnetic material of the toroid.

Consequently the designer has a greater degree of freedom since he does not need to employ conductors of constant cross-section and can design the transformer with higher levels of induction in the core and current density in the windings without being penalised in efficiency or size.

Claims

1. **TOROIDAL TRANSFORMER** consisting of a toroid (T) on which are wound windings formed by a certain number of turns, **characterised** in that these turns comprises at least two elements (D,P) connected in series.

2. **TOROIDAL TRANSFORMER** according to claim 1, **characterised** in that at least one of the elements of each turn is a conductive prism (D) with a slot in one of its sides.

3. **TOROIDAL TRANSFORMER** according to claim 2, **characterised** in that the slotted prism is a cylindrical segment of conductive material with a slot in one of its bases.

4. **TOROIDAL TRANSFORMER** according to claim 1, **characterised** in that another of the elements of the turn consists of a conductive track (P) deposited on an insulating surface.

5. **TOROIDAL TRANSFORMER** according to claim 4, **characterised** in that the insulating surface is a printed circuit board.

6. **TOROIDAL TRANSFORMER** according to claim 5, **characterised** in that the printed circuit board is double-sided.

7. **TOROIDAL TRANSFORMER** according to claim 5, **characterised** in that the printed circuit board is multilayer.

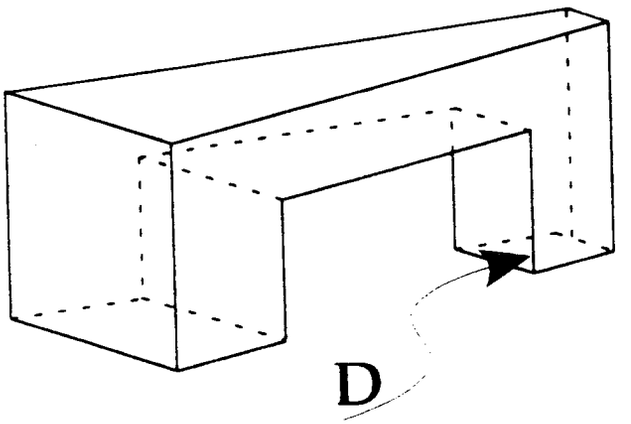

Fig. 1

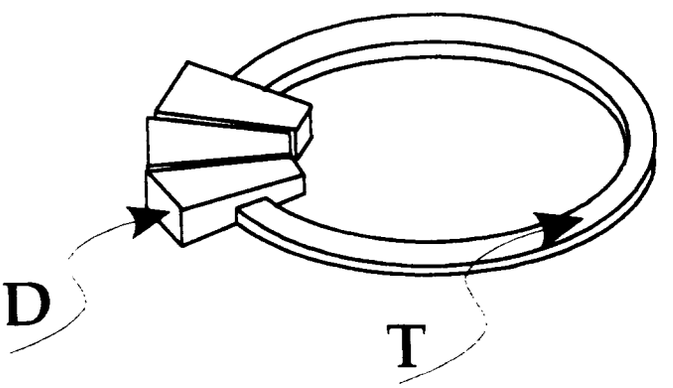

Fig. 2

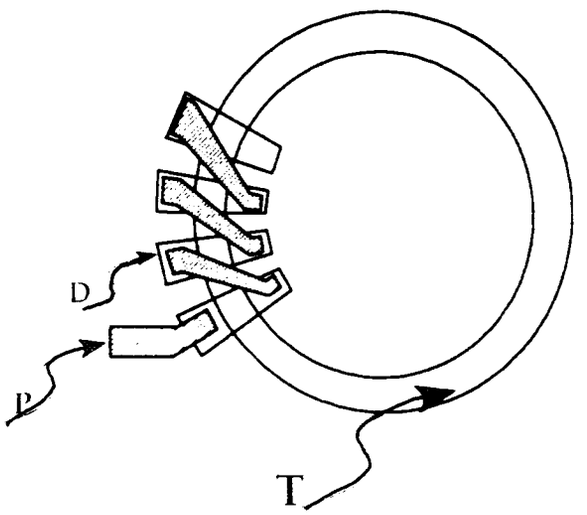

Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 1978

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP-A-0 540 958 (ASEA BROWN BOVERI) 12 May 1993 * column 3, line 19 - line 50 *	1,2	H01F27/28
A	US-A-4 536 733 (SHELLY RANDOLPH D) 20 August 1985 * column 3, line 38 - column 5, line 4 *	4-6	
A	FR-A-1 388 880 (J. STROZECKI)		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 May 1995	Vanhulle, R

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
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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