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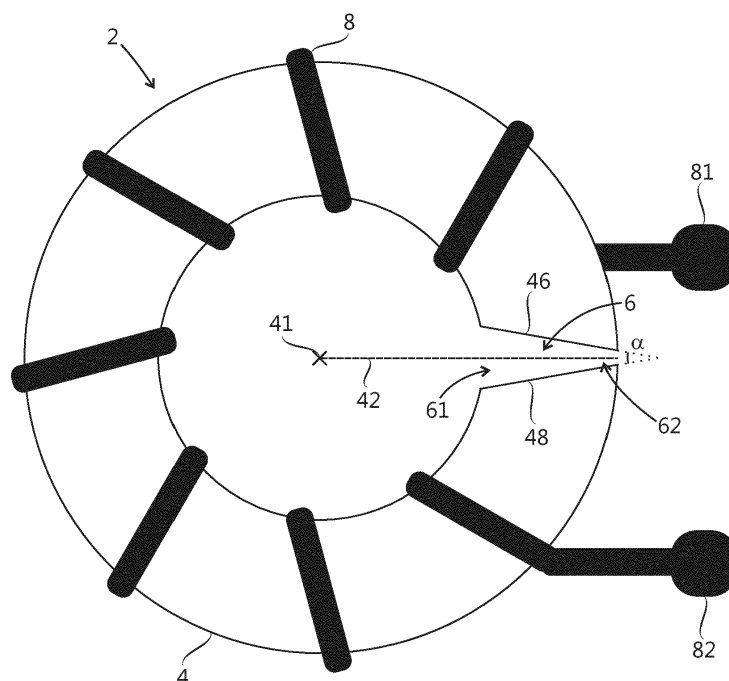
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(54) **Inductor**

(57) An inductor comprising a magnetic core (2) forming a closed loop path for a magnetic flux, the magnetic core (2) having a high permeance element (4) interrupted by a low-permeance gap (6), the low-permeance gap (6) having an inner portion (61) and an outer portion (62), a distance between a centre (41) of the magnetic core (2) and the outer portion (62) being greater

than a distance between the centre (41) of the magnetic core (2) and the inner portion (61), and a conductor (8) coiled around the magnetic core (2). The inner portion (61) of the low-permeance gap (6) has a substantially greater dimension in a circumferential direction than the outer portion (62) of the low-permeance gap (6).

Fig. 1**EP 2 816 572 A1**

Description

FIELD OF THE INVENTION

[0001] The invention relates to an inductor according to a preamble of independent claim 1.

[0002] A known inductor comprises a magnetic core and a conductor coiled around the magnetic core. The magnetic core forms a closed loop path for a magnetic flux, and has a high permeance element interrupted by a low-permeance gap.

[0003] One of the problems associated with said known inductor is that a reluctance of a magnetic path of the inductor is not uniform for each part of a cross-section of the magnetic core. Value of the reluctance of the magnetic path increases as the distance from a centre point of the inductor increases. The variable length of magnetic path causes variable value of reluctance and non-uniform distribution of magnetic flux density. The highest value of the magnetic flux density occurs in an inner portion of the magnetic core while the lowest value of the magnetic flux density occurs in an outer portion of the magnetic core. It means that the inner portion of the magnetic core will be saturated before the outer portion and that it is not possible to utilize a full potential of the magnetic core.

BRIEF DESCRIPTION OF THE INVENTION

[0004] An object of the present invention is to provide an inductor so as to solve the above problems. The objects of the invention are achieved by an inductor which is characterized by what is stated in the independent claim. The preferred embodiments of the invention are disclosed in the dependent claims.

[0005] The invention is based on the idea of forming a low-permeance gap of a magnetic core as a non-uniform gap, the non-uniform gap being wider in an inner portion of the magnetic core than in an outer portion of the magnetic core. The wider gap in the inner portion of the magnetic core has a higher reluctance than the narrower gap in the outer portion of the magnetic core. Due to the non-uniform low-permeance gap a reluctance of a magnetic path of an inductor may be designed substantially uniform for each part of a cross-section of a magnetic core.

[0006] An advantage of the inductor of the invention is that the non-uniform gap decreases the problem with saturation in the inner portion of the magnetic core by providing more uniform distribution of the magnetic flux density. The invention also enables increasing power density of an inductor.

DETAILED DESCRIPTION OF THE INVENTION

[0007] In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached Figure 1 which shows an inductor according to an embodiment of the invention. The

inductor comprises a magnetic core 2 and a conductor 8 coiled around the magnetic core 2. The conductor 8 is electrically insulated from the magnetic core 2. An electric current flowing in the conductor 8 creates a magnetic field around the conductor 8. The magnetic core 2 forms a closed loop path for a magnetic flux, the magnetic core 2 having a high permeance element 4 interrupted by a low-permeance gap 6.

[0008] The low-permeance gap 6 has an inner portion 61 and an outer portion 62, a distance between a centre 41 of the magnetic core 2 and the outer portion 62 being greater than a distance between the centre 41 of the magnetic core 2 and the inner portion 61. The inner portion 61 of the low-permeance gap 6 has a substantially greater dimension in a circumferential direction than the outer portion 62 of the low-permeance gap 6. Herein the circumferential direction is a direction perpendicular to a radial direction of the magnetic core 2.

[0009] Surfaces 46 and 48 of the high permeance element 4 defining the low-permeance gap 6 are substantially planar surfaces. A gap angle α between the surfaces 46 and 48 is 20 degrees. The surfaces 46 and 48 are located symmetrically with relation to a radial direction 42 of the magnetic core 2. The radial direction 42 of the magnetic core 2 bisects the gap angle α .

[0010] A dimension of the inner portion 61 of the low-permeance gap 6 in the circumferential direction is approximately fourfold compared to a dimension of the outer portion 62 of the low-permeance gap 6 in the circumferential direction. In other words the inner portion 61 is approximately 300% wider than the outer portion 62.

[0011] A form of a non-uniform low-permeance gap varies depending on the embodiment. In an alternative embodiment a gap angle between the surfaces of the high permeance element defining the low-permeance gap is 10 degrees, and a dimension of the inner portion of the low-permeance gap in the circumferential direction is double compared to a dimension of the outer portion of the low-permeance gap in the circumferential direction.

[0012] Material of the high permeance element 4 comprises ferrite, and material of the low-permeance gap 6 comprises air. In an alternative embodiment material of a high permeance element may comprise iron powder, amorphous material, oriented steel or non-oriented steel, and material of a low-permeance gap may comprise resins, plastics or carbon fibres. Typically materials of high permeance element and low-permeance gap are selected such that permeability of material of the high permeance element is at least ten times greater than permeability of material of the low-permeance gap.

[0013] The inductor of Figure 1 is a toroidal inductor. The magnetic core 2 is a ring-shaped magnetic core. The ring-shaped magnetic core has a form of a solid of revolution. The toroidal shape provides a high value of inductance and decreases leakage flux. However, the non-uniform low-permeance gap of the invention may be incorporated in any inductor whose magnetic core forms a closed loop path for a magnetic flux, and has a high

permeance element interrupted by a low-permeance gap.

[0014] The conductor 8 has seven turns, and terminals 81 and 82 of the conductor 8 are adjacent the low permeance gap 6, located on opposite sides of the low permeance gap 6. Number of turns of conductor is selected based on desired inductance. Therefore the number of turns of conductor varies in different embodiments. Further, locations of terminals of conductor may be selected based on requirements of an embodiment.

[0015] The magnetic core of the inductor depicted in Figure 1 comprises one low-permeance gap. Alternatively a low-permeance gap may be divided into several low-permeance gap sections. An inductor according to the invention may have one or more low-permeance gaps whose inner portion has a substantially greater dimension in a circumferential direction than outer portion. An inductor according to the invention may additionally comprise one or more conventional low-permeance gaps whose inner portion and outer portion have substantially equal dimensions in a circumferential direction.

[0016] It will be obvious to a person skilled in the art that the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. An inductor comprising:

a magnetic core (2) forming a closed loop path for a magnetic flux, the magnetic core (2) having a high permeance element (4) interrupted by a low-permeance gap (6), the low-permeance gap (6) having an inner portion (61) and an outer portion (62), a distance between a centre (41) of the magnetic core (2) and the outer portion (62) being greater than a distance between the centre (41) of the magnetic core (2) and the inner portion (61); and
a conductor (8) coiled around the magnetic core (2);

characterized in that the inner portion (61) of the low-permeance gap (6) has a substantially greater dimension in a circumferential direction than the outer portion (62) of the low-permeance gap (6).

2. An inductor according to claim 1, **characterized in that** surfaces (46, 48) of the high permeance element (4) defining the low-permeance gap (6) are substantially planar surfaces.

3. An inductor according to claim 2, **characterized in that** a gap angle (α) between the surfaces (46, 48) of the high permeance element (4) defining the low-

permeance gap (6) is at least 10 degrees.

4. An inductor according to claim 2 or 3, **characterized in that** the surfaces (46, 48) of the high permeance element (4) defining the low-permeance gap (6) are located symmetrically with relation to a radial direction of the magnetic core (2).

5. An inductor according to any one of the preceding claims, **characterized in that** a dimension of the inner portion (61) of the low-permeance gap (6) in the circumferential direction is at least double compared to a dimension of the outer portion (62) of the low-permeance gap (6) in the circumferential direction.

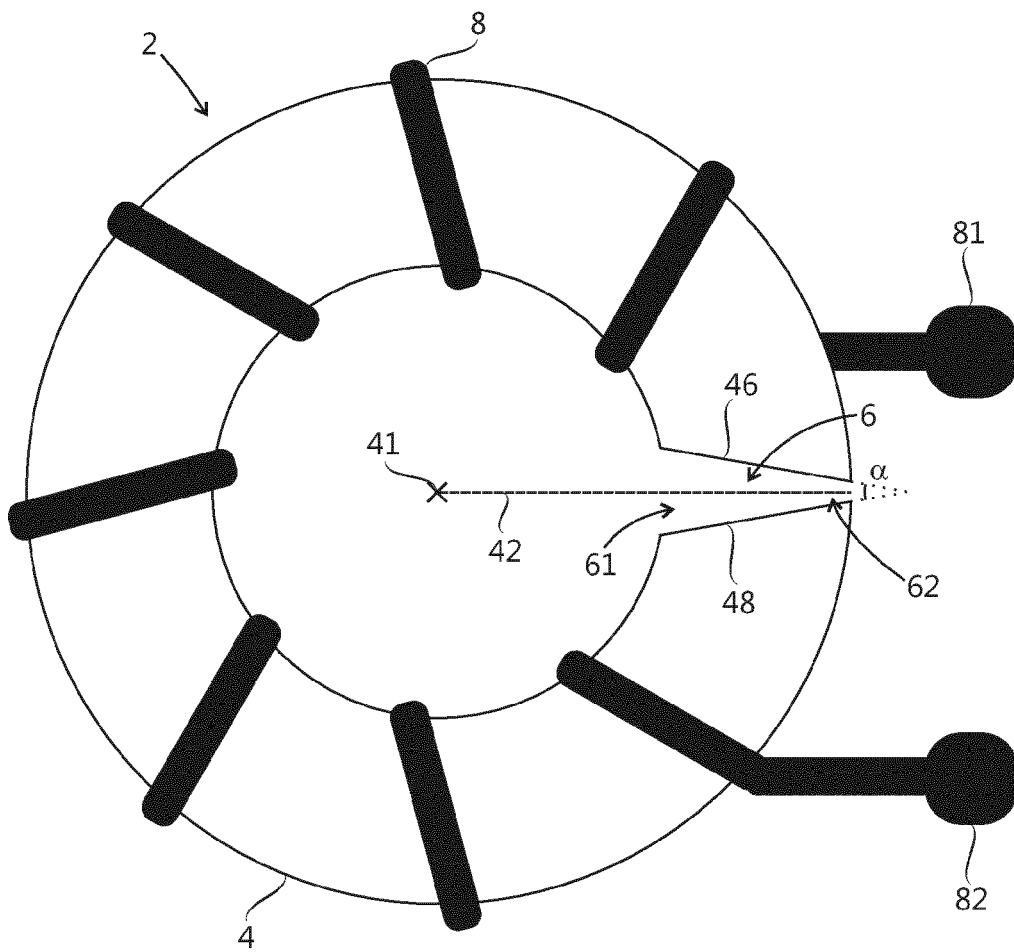
6. An inductor according to any one of the preceding claims, **characterized in that** permeability of material of the high permeance element (4) is at least ten times greater than permeability of material of the low-permeance gap (6).

7. An inductor according to claim 6, **characterized in that** material of the low-permeance gap (6) comprises air, resins, plastics or carbon fibres.

8. An inductor according to claim 6 or 7, **characterized in that** material of the high permeance element (4) comprises ferrite, iron powder, amorphous material, oriented steel or non-oriented steel.

9. An inductor according to any one of the preceding claims, **characterized in that** the inductor is a toroidal inductor, and the magnetic core (2) is a ring-shaped magnetic core.

Fig. 1





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Application Number
EP 13 17 2269

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 November 2013	Examiner Van den Berg, G
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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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
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