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(54) A PLANAR TRANSFORMER AND A METHOD FOR SHIELDING WINDINGS IN A PLANAR TRANSFORMER

(57) The present invention relates to a planar transformer that comprises a first winding (201, 413, 514) and a second winding (202, 415, 513), and a third winding (203, 416, 516) and a fourth winding (204, 417, 517) which are arranged between the first winding (201, 413, 514) and the second winding (202, 415, 513). In the planar transformer each of the third winding (203, 416, 516) and the fourth winding (204, 417, 517) comprises a shielding turn (208, 209, 418, 419, 518, 519) that covers at least 30 percent of a winding window of the planar transformer, said shielding turns (208, 209, 418, 419, 518, 519) being arranged in such a manner that the shielding turns (208, 209, 418, 419, 518, 519) together cover at least 50 percent of the winding window. The present invention also relates to a method for shielding windings (201, 202, 413, 415, 513, 514) in a planar transformer.

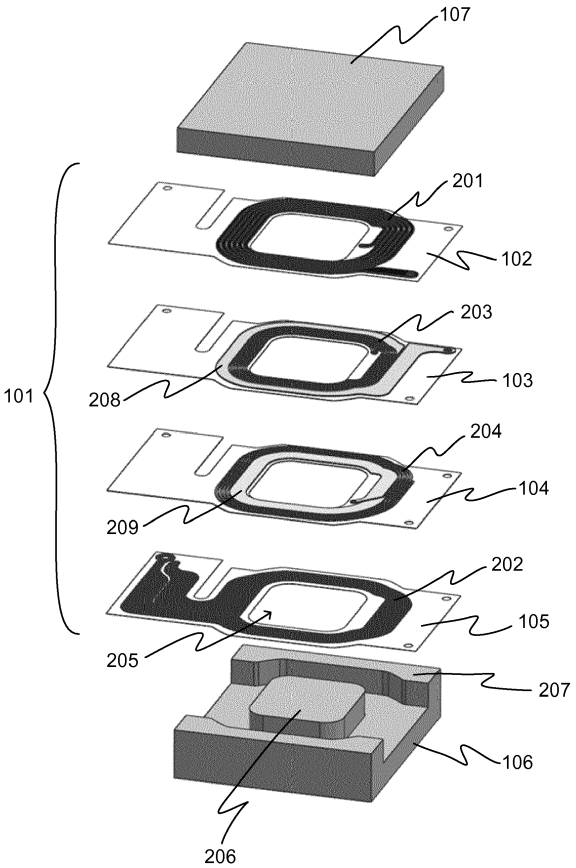

Fig. 2

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a planar transformer and a method for shielding windings in a planar transformer according to the preambles of the appended independent claims.

BACKGROUND OF THE INVENTION

[0002] Planar transformers are preferred in many small-sized and low-power applications such as switched-mode power supplies (SMPS) due to their low profile and good thermal characteristics. An example of a known planar transformer comprises an EI-core and a plurality of windings arranged concentrically with respect to each other on layers of a printed circuit board (PCB). The windings have a spiral pattern that is arranged to wind around an aperture provided in the layer. A centre leg of the EI-core is arranged through the apertures so that the windings surround the centre leg.

[0003] A planar transformer is prone to large values of capacitive coupling between a primary winding and a secondary winding. This is due to large surface areas and small inter-plane distances associated with the planar structure. The capacitive coupling permits a current to flow between a primary circuit and a secondary circuit. This is normally a common mode current in the sense that the current flows in one direction through the planar transformer and returns via some other path, often an ill-defined ground path. The capacitive coupling and its associated current flow is undesirable from the point of view of both safety issues as well as electromagnetic interference (EMI) issues.

[0004] A known technique to reduce the capacitive coupling is to place an electrostatic shield between the primary winding and the secondary winding. The electrostatic shield, that can be a single turn winding, is formed on a single layer of the PCB and it essentially covers the entire winding window of the planar transformer. The electrostatic shield is connected to some reference potential, such as ground, and it reduces the capacitive coupling by acting as a voltage barrier between the primary winding and the secondary winding. In practice, the electrostatic shield will not be everywhere at the same potential and therefore a constant voltage barrier cannot be achieved. This is because there will be an induced voltage along the electrostatic shield in the winding direction.

[0005] A problem of the known technique to reduce the capacitive coupling between a primary winding and a secondary winding in a planar transformer is that one layer of a PCB is allocated only for shielding purposes. This increases the total number of layers and thus the cost of the planar transformer.

OBJECTIVES OF THE INVENTION

[0006] It is the main objective of the present invention to reduce or even eliminate the prior art problems presented above.

[0007] It is an objective of the present invention to provide a planar transformer in which the capacitive coupling between windings, such as a primary winding and a secondary winding is minimised. It is also an objective of the present invention to provide a planar transformer in which the shielding of windings is implemented without a conventional shielding layer.

[0008] It is a further objective of the present invention to provide a method for shielding windings in a planar transformer so that the capacitive coupling between windings, such as a primary winding and a secondary winding is minimised. It is also an objective of the present invention to provide a method for shielding windings in a planar transformer without using a conventional shielding layer.

[0009] In order to realise the above-mentioned objectives, the planar transformer and the shielding method according to the invention are characterised by what is presented in the characterising parts of the appended independent claims. Advantageous embodiments of the invention are described in the dependent claims.

DESCRIPTION OF THE INVENTION

[0010] A planar transformer according to the invention comprises a first winding and a second winding, and a third winding and a fourth winding which are arranged between the first winding and the second winding. In the planar transformer according to the invention each of the third winding and the fourth winding comprises a shielding turn that covers at least 30 percent of a winding window of the planar transformer, said shielding turns being arranged in such a manner that the shielding turns together cover at least 50 percent of the winding window.

[0011] The windings of the planar transformer according to the invention are arranged on layers that form a planar structure. The planar structure can be, for example, a multilayer printed circuit board (PCB). Each of the windings is formed on one or more layers, and on each layer the winding comprises an essentially spiral pattern that is arranged to wind around an aperture provided in the layer. The windings are preferably arranged concentrically with respect to each other. The winding direction, the number of the winding turns, the spacing between the winding turns and the track width in each winding can be chosen according to the application. In high frequency planar transformers that can be used in switched-mode power supplies, the number of the winding turns on the windings is typically small.

[0012] The planar transformer according to the invention may comprise a transformer core that is arranged in connection with the planar structure. A leg of the transformer core can be arranged through the apertures pro-

vided in the layers so that the windings surround the leg. The transformer core can be, for example, an EI-core, a centre leg of which is arranged through the apertures.

[0013] In the planar transformer according to the invention the third winding and the fourth winding are arranged between the first winding and the second winding. Each of the first winding and the second winding is formed on one or more layers. Each of the third winding and the fourth winding is formed on a single layer.

[0014] In the planar transformer according to the invention each of the shielding turns of the third winding and the fourth winding covers at least 30 percent and the shielding turns together cover at least 50 percent of the winding window of the planar transformer. The shielding turns may thus partly overlap each other. The winding direction of the shielding turn is the same as the winding direction of the other winding turns of the winding. The track width of the shielding turn is larger than the track width of the other winding turns of the winding. Preferably, each of the third winding and the fourth winding comprises only one shielding turn. Each of the shielding turns may alternatively cover, for example, at least 40 percent, at least 50 percent or at least 60 percent of the winding window. The shielding turns together may alternatively cover, for example, at least 60 percent, at least 70 percent or at least 80 percent of the winding window. By the winding window is meant the maximum usable area for winding turns in a layer. This can be, for example, the area between a centre leg and side legs of a transformer core.

[0015] The purpose of the shielding turns is to reduce the capacitive coupling between the first winding and the second winding. The more the shielding turns cover the winding window, the better the first winding and the second winding are shielded from each other.

[0016] The third winding together with the fourth winding provides an electrostatic shield between the first winding and the second winding. Each of the third winding and the fourth winding has also another function in the planar transformer so that three functions are combined into two layers. These functions can be, for example, acting as an auxiliary winding or a compensation winding.

[0017] The planar transformer according to the invention can be applied in various power supply applications. A preferred application is a switched-mode power supply (SMPS).

[0018] An advantage of the planar transformer according to the invention is that by providing the third winding and the fourth winding with shielding turns a separate shielding layer is not needed between the first winding and the second winding. Thus, the number of layers needed in a planar transformer is reduced. Another advantage of the planar transformer according to the invention is that the manufacturing costs of a planar transformer are decreased.

[0019] According to an embodiment of the invention each of the shielding turns covers at least 50 percent and the shielding turns together cover at least 90 percent of the winding window of the planar transformer. This enables to efficiently shield the first winding from the second winding.

[0020] According to an embodiment of the invention each of the third winding and the fourth winding is connected to a constant potential. Thus, the third winding and the fourth winding act as a voltage barrier between the first winding and the second winding. Preferably, the third winding and the fourth winding are connected to ground.

[0021] According to an embodiment of the invention one of the shielding turns is arranged on the inner half of the winding window and the other of the shielding turns is arranged on the outer half of the winding window. This means that one of the shielding turns is an inner winding turn of one winding and the other shielding turn is an outer winding turn of the other winding. The shielding turn of the third winding can cover the inner half of the winding window and the shielding turn of the fourth winding can cover the outer half of the winding window, or vice versa. An advantage of covering essentially the entire winding window of the planar transformer is that the capacitive coupling between the first winding and the second winding is efficiently reduced.

[0022] According to an embodiment of the invention the track width of the shielding turn is from 0.5 to 3 mm. The track width of the shielding turn is typically many times larger than the track width of the other winding turns of the winding. Preferably, the track widths of the shielding turns are essentially the same.

[0023] According to an embodiment of the invention the first winding is a primary winding, the second winding is a secondary winding, the third winding is an auxiliary winding and the fourth winding is a compensation winding. Preferably, the windings are arranged one on the other in the following order: the primary winding, the auxiliary winding, the compensation winding and the secondary winding.

[0024] The auxiliary winding is arranged on the primary side of the planar transformer. The auxiliary winding is connected to the primary circuit that contains the primary winding. The auxiliary winding provides an operating voltage to the primary circuit and/or an output voltage sensing circuit. The compensation winding is arranged on the primary side or the secondary side of the planar transformer. The compensation winding is connected to the primary circuit that contains the primary winding or the secondary circuit that contains the secondary winding. The compensation winding reduces the common mode noise by adjusting the common mode voltage closer to zero. The auxiliary winding and the compensation winding have opposite winding directions.

[0025] The number of winding turns in the primary winding can be, for example, 20-60. The number of winding turns in the secondary winding can be, for example, 1-10. The number of winding turns in the auxiliary winding can be, for example, 2-15. The number of winding turns in the compensation winding can be, for example, 2-30.

[0026] The planar transformer according to this em-

bodiment can be used in such a manner that a pulsed electrical current is supplied to the primary winding. The primary winding creates a cyclically changing magnetic field in and around a transformer core from which energy is discharged to the secondary winding. The energy is also discharged to the auxiliary winding that provides an operating voltage to a primary circuit and/or an output voltage sensing circuit, and to the compensation winding that reduces the common mode noise.

[0027] According to an embodiment of the invention the planar transformer comprises a fifth winding, and an electrostatic shield arranged between the second winding and the fifth winding. The fifth winding is formed on one or more layers. The electrostatic shield, that can be a single turn winding, is formed on a single layer. The electrostatic shield essentially covers the entire winding window of the planar transformer. The electrostatic shield is connected to a constant potential, which is preferably ground. Preferably, the electrostatic shield is connected to the same potential as the third winding and the fourth winding. The purpose of the electrostatic shield is to reduce the capacitive coupling between the second winding and the fifth winding.

[0028] According to an embodiment of the invention the electrostatic shield covers essentially the entire winding window. This enables to efficiently shield the second winding from the fifth winding.

[0029] According to an embodiment of the invention the first winding is a first winding section of a primary winding, the second winding is a secondary winding, the third winding is an auxiliary winding, the fourth winding is a compensation winding and the fifth winding is a second winding section of the primary winding. In the planar transformer according to this embodiment the primary winding is divided into two sections, each of which may be formed on one or more layers. The auxiliary winding is arranged on the primary side of the planar transformer. The auxiliary winding is connected to the primary circuit that contains the primary winding. The compensation winding is arranged on the primary side or the secondary side of the planar transformer. The compensation winding is connected to the primary circuit that contains the primary winding or the secondary circuit that contains the secondary winding. The auxiliary winding and the compensation winding have opposite winding directions.

[0030] According to an embodiment of the invention the first winding is a first winding section of a secondary winding, the second winding is a primary winding, the third winding is an auxiliary winding, the fourth winding is a compensation winding and the fifth winding is a second winding section of the secondary winding. In the planar transformer according to this embodiment the secondary winding is divided into two sections, each of which may be formed on one or more layers. The auxiliary winding is arranged on the primary side of the planar transformer. The auxiliary winding is connected to the primary circuit that contains the primary winding. The compensation winding is arranged on the primary side or the secondary side of the planar transformer. The compensation winding is connected to the primary circuit that contains the primary winding or the secondary circuit that contains the secondary winding. The auxiliary winding and the compensation winding have opposite winding directions.

[0031] According to an embodiment of the invention the auxiliary winding is connected to a primary side of the planar transformer with the same polarity as the primary winding. Alternatively, the auxiliary winding can be connected with the reversed polarity, but then the shielding turn should be at a GND/DC potential.

[0032] According to an embodiment of the invention the compensation winding is connected to a primary side of the planar transformer with the reversed polarity compared to the primary winding or a secondary side of the planar transformer with the reversed polarity compared to the secondary winding.

[0033] The present invention also relates to a method for shielding windings in a planar transformer that comprises a first winding and a second winding, and a third winding and a fourth winding which are arranged between the first winding and the second winding. The method according to the invention comprises providing each of the third winding and the fourth winding with a shielding turn that covers at least 30 percent of a winding window of the planar transformer, and which shielding turns together cover at least 50 percent of the winding window.

[0034] An advantage of the method according to the invention is that by providing the third winding and the fourth winding with shielding turns a separate shielding layer is not needed between the first winding and the second winding. Thus, the number of layers needed in a planar transformer is reduced. Another advantage of the method according to the invention is that the manufacturing costs of a planar transformer are decreased.

[0035] The exemplary embodiments of the invention presented in this text are not interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" is used in this text as an open limitation that does not exclude the existence of also unrecited features. The features recited in the dependent claims are mutually freely combinable unless otherwise explicitly stated.

[0036] The exemplary embodiments presented in this text and their advantages relate by applicable parts to the planar transformer as well as the shielding method according to the invention, even though this is not always separately mentioned.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037]

Fig. 1 illustrates a planar transformer according to a first embodiment of the invention,

fig. 2 illustrates an exploded view of the planar transformer according to fig. 1,

fig. 3 illustrates overlapping of an auxiliary winding and a compensation winding in the planar transformer according to fig. 1,

fig. 4 illustrates an exploded view of a planar transformer according to a second embodiment of the invention, and

fig. 5 illustrates an exploded view of a planar transformer according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0038] Fig. 1 illustrates a planar transformer according to a first embodiment of the invention. The planar transformer comprises a multilayer PCB 101 having four layers 102, 103, 104 and 105 on which windings (not shown in fig. 1) are formed. A transformer core consisting of an E-core 106 and an I-core 107 is attached in connection with the multilayer PCB 101.

[0039] Fig. 2 illustrates an exploded view of the planar transformer according to fig. 1. A primary winding 201 is formed on the layer 102 and a secondary winding 202 is formed on the layer 105. Between the layers 102 and 105 are the layers 103 and 104 on which an auxiliary winding 203 and a compensation winding 204 are formed, respectively. The auxiliary winding 203 and the compensation winding 204 are connected to a primary circuit that contains the primary winding 201 as well as to ground.

[0040] The layers 102, 103, 104 and 105 are provided with apertures 205 through which a centre leg 206 of the E-core 106 is intended to pass. Side legs 207 of the E-core 106 can be arranged around the multilayer PCB 101 so that the layers 102, 103, 104 and 105 are between the side legs 207. The I-core 107 is used to magnetically couple the centre leg 206 to the side legs 207 of the E-core 106.

[0041] Each of the windings 201, 202, 203 and 204 has a form of an essentially spiral pattern that is arranged to wind around the aperture 205. The windings 201, 202, 203 and 204 are arranged concentrically with respect to each other. The auxiliary winding 203 and the compensation winding 204 have opposite winding directions.

[0042] The auxiliary winding 203 comprises a shielding turn 208 that is arranged on the outer half of a winding window of the planar transformer. The shielding turn 208 is an outer winding turn of the auxiliary winding 203 and it covers about 50 percent of the winding window. The compensation winding 204 comprises a shielding turn 209 that is arranged on the inner half of the winding window. The shielding turn 209 is an inner winding turn of the compensation winding 204 and it covers about 50 percent of the winding window. The shielding turns 208 and 209 together cover essentially the entire winding window so that the capacitive coupling between the primary winding 201 and the secondary winding 202 is efficiently reduced. The overlapping of the auxiliary winding 203 and the compensation winding 204 in the planar transformer according to fig. 1 is illustrated in fig. 3.

[0043] Fig. 4 illustrates an exploded view of a planar transformer according to a second embodiment of the invention. The planar transformer comprises a multilayer PCB 401 having six layers 402, 403, 404, 405, 406 and 407. The planar transformer also comprises a transformer core consisting of an E-core 408 and an I-core 409 to be attached in connection with the multilayer PCB 401. A centre leg 410 of the E-core 408 is intended to pass through apertures 411 provided in the layers 402, 403, 404, 405, 406 and 407. Side legs 412 of the E-core 408 are intended to be arranged around the multilayer PCB 401 so that the layers 402, 403, 404, 405, 406 and 407 are between the side legs 412.

[0044] The planar transformer of fig. 4 comprises a primary winding divided into winding sections 413 and 414, a secondary winding 415, an auxiliary winding 416, a compensation winding 417 and an electrostatic shield 418. The primary winding sections 413 and 414 are formed on the layers 402 and 407, respectively. The secondary winding 415 is formed on the layer 405. The auxiliary winding 416 is formed on the layer 403 and the compensation winding 417 is formed on the layer 404. The electrostatic shield 418 is formed on the layer 406.

[0045] The auxiliary winding 416 comprises a shielding turn 419 that is arranged on the outer half of a winding window of the planar transformer. The shielding turn 419 is an outer winding turn of the auxiliary winding 416 and it covers about 50 percent of the winding window. The compensation winding 417 comprises a shielding turn 420 that is arranged on the inner half of the winding window. The shielding turn 420 is an inner winding turn of the compensation winding 417 and it covers about 50 percent of the winding window. The shielding turns 419 and 420 together cover essentially the entire winding window so that the capacitive coupling between the primary winding section 413 and the secondary winding 415 is efficiently reduced.

[0046] The auxiliary winding 416 and the compensation winding 417 have opposite winding directions.

[0047] The electrostatic shield 418 essentially covers the entire winding window of the planar transformer. The electrostatic shield 418 is connected to the same potential as the auxiliary winding 416 and the compensation winding 417. The electrostatic shield 418 is used to reduce the capacitive coupling between the secondary winding 415 and the primary winding section 414.

[0048] Fig. 5 illustrates an exploded view of a planar transformer according to a third embodiment of the invention. The planar transformer comprises a multilayer PCB 501 having six layers 502, 503, 504, 505, 506 and 507. The planar transformer also comprises a transformer core consisting of an E-core 508 and an I-core 509 to

be attached in connection with the multilayer PCB 501. A centre leg 510 of the E-core 508 is intended to pass through apertures 511 provided in the layers 502, 503, 504, 505, 506 and 507. Side legs 512 of the E-core 508 are intended to be arranged around the multilayer PCB 501 so that the layers 502, 503, 504, 505, 506 and 507 are between the side legs 512.

[0049] The planar transformer of fig. 5 comprises a primary winding 513, a secondary winding divided into winding sections 514 and 515, an auxiliary winding 516, a compensation winding 517 and an electrostatic shield 518. The primary winding 513 is formed on the layer 505. The secondary winding sections 514 and 515 are formed on the layers 502 and 507, respectively. The auxiliary winding 516 is formed on the layer 503 and the compensation winding 517 is formed on the layer 504. The electrostatic shield 518 is formed on the layer 506.

[0050] The auxiliary winding 516 comprises a shielding turn 519 that is arranged on the outer half of a winding window of the planar transformer. The shielding turn 519 is an outer winding turn of the auxiliary winding 516 and it covers about 50 percent of the winding window. The compensation winding 517 comprises a shielding turn 520 that is arranged on the inner half of the winding window. The shielding turn 520 is an inner winding turn of the compensation winding 517 and it covers about 50 percent of the winding window. The shielding turns 519 and 520 together cover essentially the entire winding window so that the capacitive coupling between the primary winding 513 and the secondary winding section 514 is efficiently reduced. The auxiliary winding 516 and the compensation winding 517 have opposite winding directions.

[0051] The electrostatic shield 518 essentially covers the entire winding window of the planar transformer. The electrostatic shield 518 is connected to the same potential as the auxiliary winding 516 and the compensation winding 517. The electrostatic shield 518 is used to reduce the capacitive coupling between the primary winding 513 and the secondary winding section 515.

[0052] Only advantageous exemplary embodiments of the invention are described in the figures. It is clear to a person skilled in the art that the invention is not restricted only to the examples presented above, but the invention may vary within the limits of the claims presented hereafter. Some possible embodiments of the invention are described in the dependent claims, and they are not to be considered to restrict the scope of protection of the invention as such.

Claims

1. A planar transformer, comprising:

- a first winding and a second winding, and
- a third winding and a fourth winding which are arranged between the first winding and the second winding,

characterised in that each of the third winding and the fourth winding comprises a shielding turn that covers at least 30 percent of a winding window of the planar transformer, said shielding turns being arranged in such a manner that the shielding turns together cover at least 50 percent of the winding window.

2. The planar transformer according to claim 1, **characterised in that** each of the shielding turns covers at least 50 percent and the shielding turns together cover at least 90 percent of the winding window of the planar transformer.

3. The planar transformer according to claim 1 or 2, **characterised in that** each of the third winding and the fourth winding is connected to a constant potential.

4. The planar transformer according to any of claims 1 to 3, **characterised in that** one of the shielding turns is arranged on the inner half of the winding window and the other of the shielding turns is arranged on the outer half of the winding window.

5. The planar transformer according to any of claims 1 to 4, **characterised in that** the track width of the shielding turn is from 0.5 to 3 mm.

6. The planar transformer according to any of claims 1 to 5, **characterised in that** each of the first winding and the second winding is formed on one or more layers.

7. The planar transformer according to any of claims 1 to 6, **characterised in that** each of the third winding and the fourth winding is formed on a single layer.

8. The planar transformer according to any of claims 1 to 7, **characterised in that** the first winding is a primary winding, the second winding is a secondary winding, the third winding is an auxiliary winding and the fourth winding is a compensation winding.

9. The planar transformer according to any of claims 1 to 7, **characterised in that** the planar transformer comprises:

- a fifth winding, and
- an electrostatic shield arranged between the second winding and the fifth winding.

10. The planar transformer according to claim 9, **characterised in that** the electrostatic shield covers essentially the entire winding window.

11. The planar transformer according to claim 9 or 10, **characterised in that** the first winding is a first winding section of a primary winding, the second winding is a secondary winding, the third winding is an auxiliary winding, the fourth winding is a compensation winding and the fifth winding is a second winding section of the primary winding.

12. The planar transformer according to claim 9 or 10, **characterised in that** the first winding is a first winding section of a secondary winding, the second winding is a primary winding, the third winding is an auxiliary winding, the fourth winding is a compensation winding and the fifth winding is a second winding section of the secondary winding.

13. The planar transformer according to any of claims 8, 11 or 12, **characterised in that** the auxiliary winding is connected to a primary side of the planar transformer with the same polarity as the primary winding.

14. The planar transformer according to any of claims 8 or 11 to 13, **characterised in that** the compensation winding is connected to a primary side of the planar transformer with the reversed polarity compared to the primary winding or a secondary side of the planar transformer with the reversed polarity compared to the secondary winding.

15. A method for shielding windings in a planar transformer that comprises a first winding and a second winding, and a third winding and a fourth winding which are arranged between the first winding and the second winding, **characterised in that** the method comprises:

- providing each of the third winding and the fourth winding with a shielding turn that covers at least 30 percent of a winding window of the planar transformer, and which shielding turns together cover at least 50 percent of the winding window.

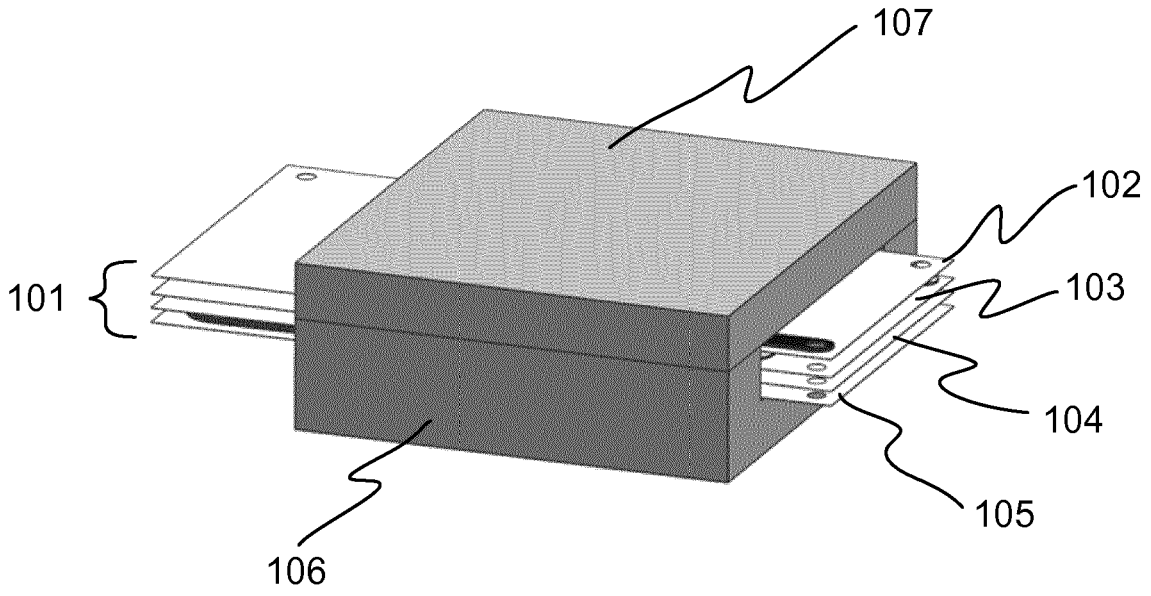

Fig. 1

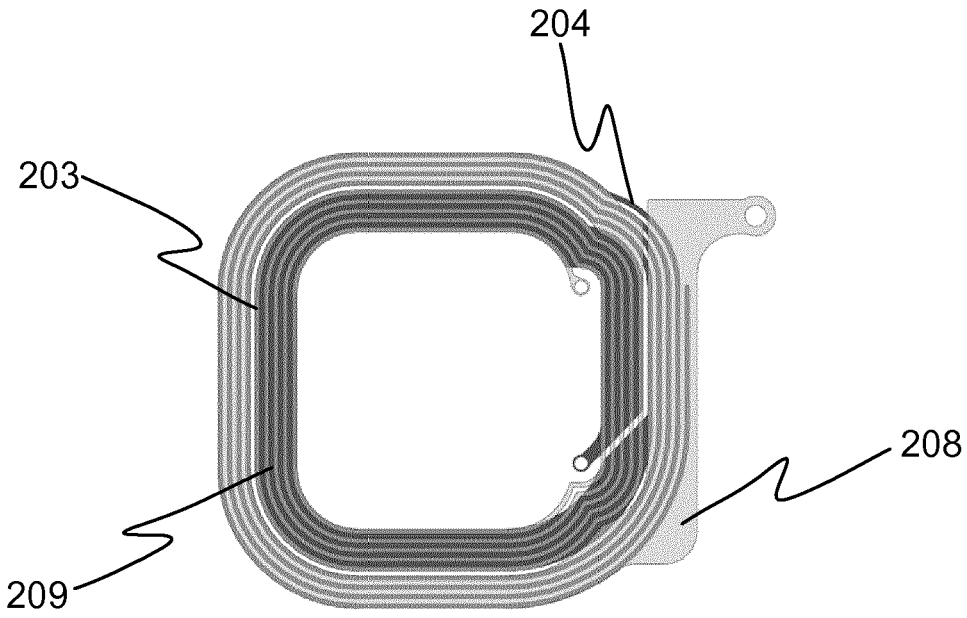

Fig. 3

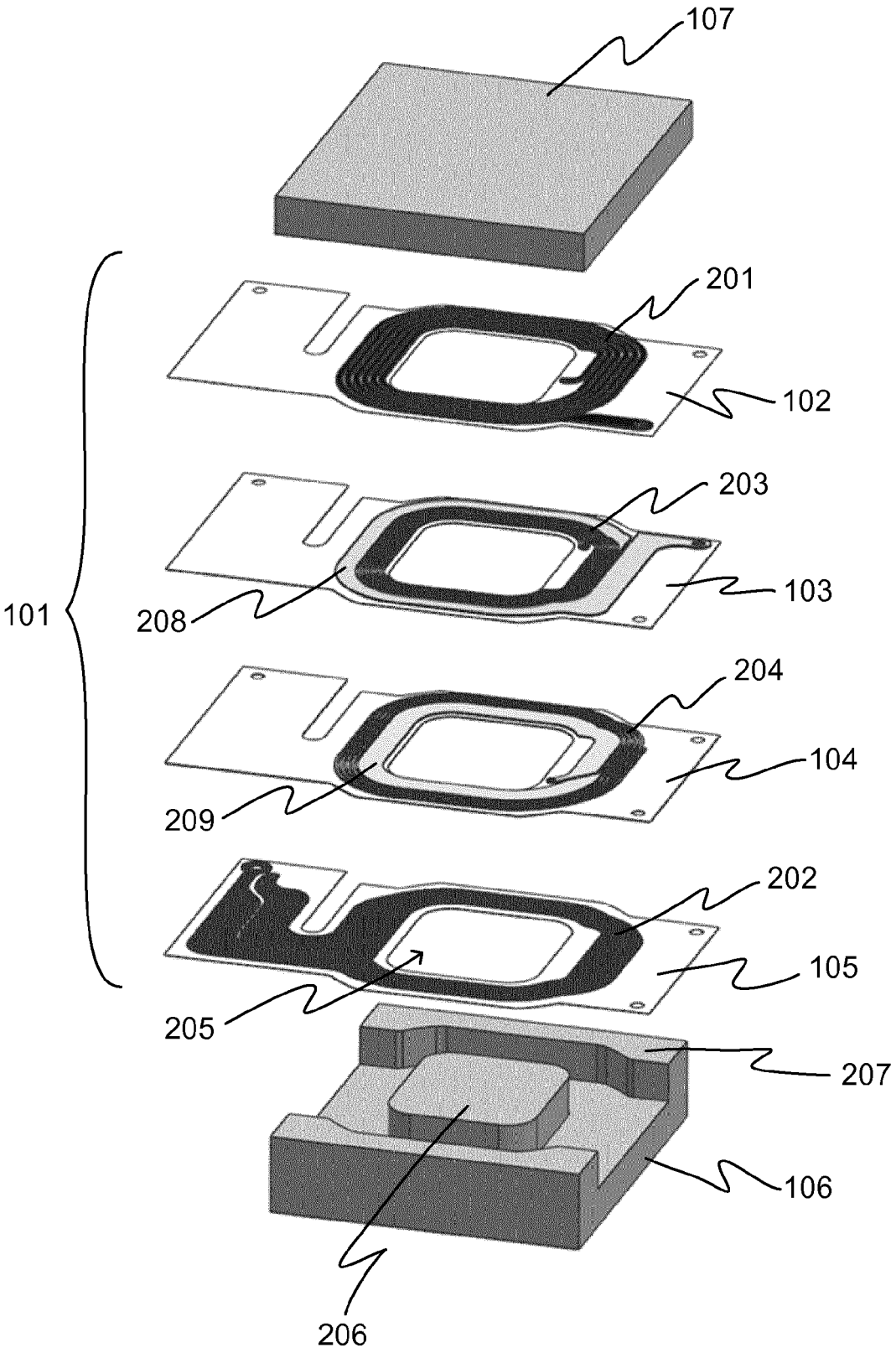

Fig. 2

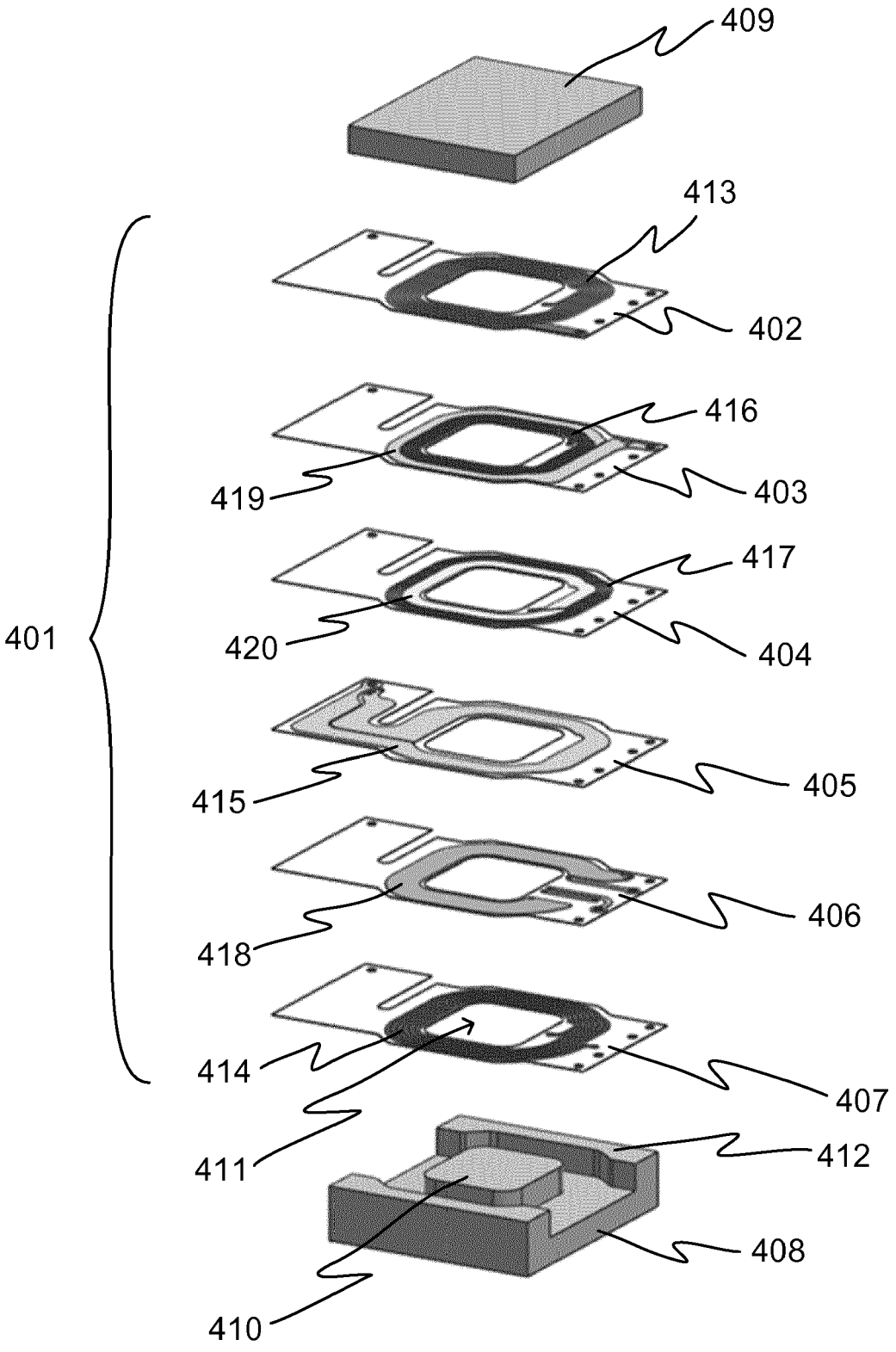
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Fig. 4

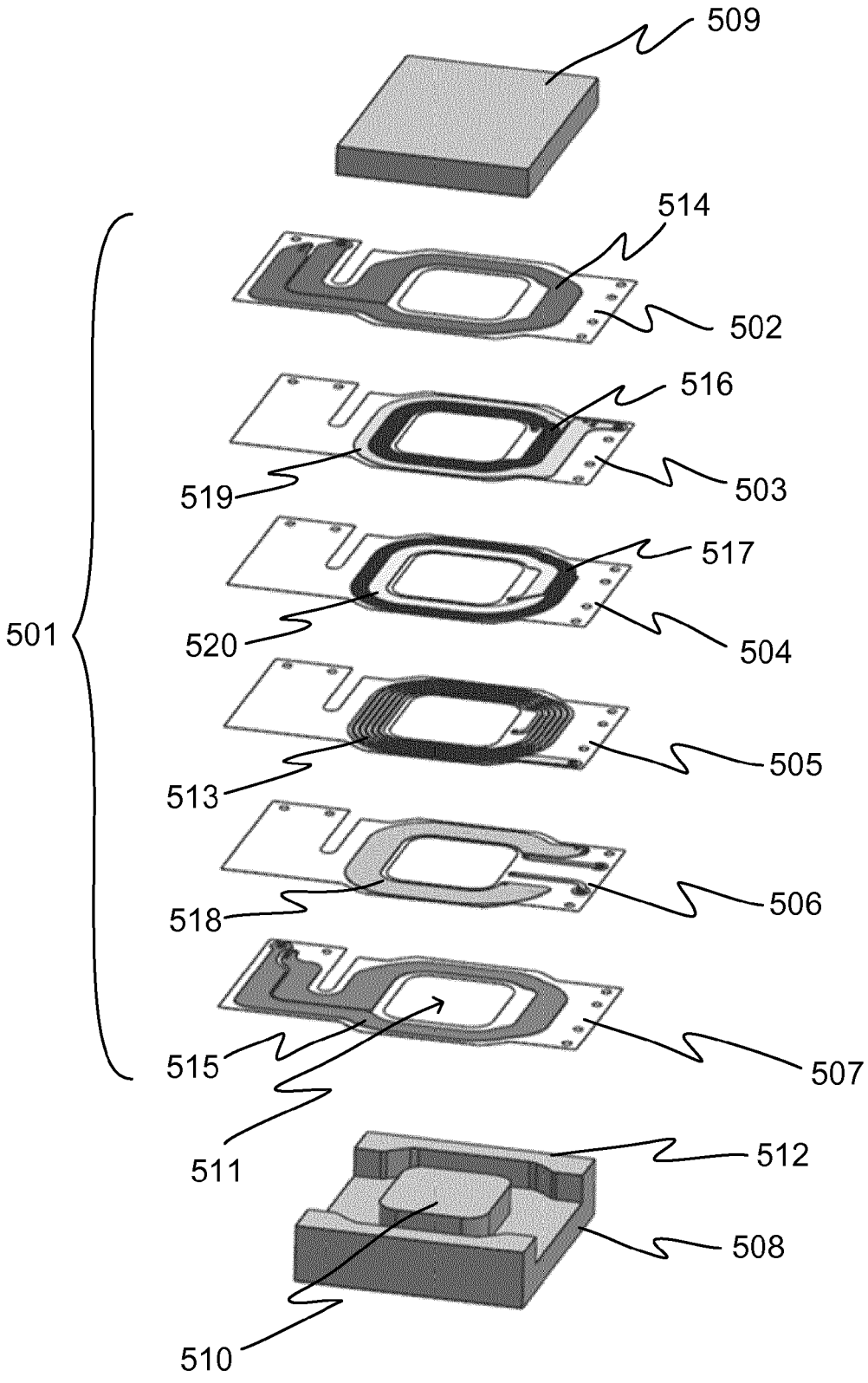
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Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 18 17 5348

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 023 214 A (OHTA SATOSHI [JP] ET AL) 8 February 2000 (2000-02-08) * abstract * * * column 5, lines 12-20; figures 13,14 * * column 3, lines 24-36; figures 1-3 *	1-3,5-7, 15	INV. H01F27/28 H01F27/38
X	US 5 781 077 A (LEITCH JIM RODGER [GB] ET AL) 14 July 1998 (1998-07-14) * abstract * * * column 3, line 66 - column 4, line 30; figure 5 * * column 5, lines 1-10; figure 7 *	1-3,5-7, 15	
X	US 2013/200982 A1 (ADACHI HIROSHI [JP] ET AL) 8 August 2013 (2013-08-08) * abstract * * * pages 2,3, paragraph 42-60 *	1-3,5-7, 15	
X	US 2010/289610 A1 (JACOBSON BORIS S [US] ET AL) 18 November 2010 (2010-11-18) * abstract * * * paragraphs [0026] - [0033]; figures 1,2,6,7,9 * * paragraph [0007] *	1-3,5-7, 15	TECHNICAL FIELDS SEARCHED (IPC) H01F
X	DE 199 12 634 A1 (KNICK ELEKTRONISCHE MESGERAETE [DE]) 21 September 2000 (2000-09-21) * abstract * * * column 3, line 36 - column 6, line 14; figures 1-5 * * claim 1 *	1-3,5-7, 15	
X	US 2013/207767 A1 (WORTHINGTON KENNETH R [GB]) 15 August 2013 (2013-08-15) * paragraphs [0032] - [0054]; figures 1-3 *	1-3,5-7, 15	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 November 2018	Reder, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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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 2014/347159 A1 (ZUO ZHUANG [TW] ET AL) 27 November 2014 (2014-11-27) * abstract * * * paragraphs [0064] - [0067]; figure 4 *	11	
A	CN 106 971 828 A (DONGGUAN AOHAI POWER TECH CO LTD) 21 July 2017 (2017-07-21) * abstract *; figure 2 *	12	
A	CN 107 993 814 A (SALCOMP TECH SHENZHEN CO LTD) 4 May 2018 (2018-05-04) * paragraphs [0031] - [0033]; figures 2,3 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 November 2018	Reder, Michael

CATEGORY OF CITED DOCUMENTS

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21-11-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6023214 A	08-02-2000	DE 19906261 A1	23-09-1999
		JP H11265831 A	28-09-1999
		US 6023214 A	08-02-2000
US 5781077 A	14-07-1998	NONE	
US 2013200982 A1	08-08-2013	JP 5682615 B2	11-03-2015
		JP 2013179262 A	09-09-2013
		US 2013200982 A1	08-08-2013
US 2010289610 A1	18-11-2010	NONE	
DE 19912634 A1	21-09-2000	NONE	
US 2013207767 A1	15-08-2013	EP 2589054 A2	08-05-2013
		US 2013207767 A1	15-08-2013
		WO 2012001398 A2	05-01-2012
US 2014347159 A1	27-11-2014	CN 104183373 A	03-12-2014
		JP 5709283 B2	30-04-2015
		JP 2014229894 A	08-12-2014
		TW 201445590 A	01-12-2014
		US 2014347159 A1	27-11-2014
		US 2017186529 A1	29-06-2017
CN 106971828 A	21-07-2017	NONE	
CN 107993814 A	04-05-2018	NONE	

EPO FORM P0459

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