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(54) **PRINTED CIRCUIT BOARD WITH SHIELDED PATH AND METHOD OF MANUFACTURING PRINTED CIRCUIT BOARD WITH SHIELDED PATH**

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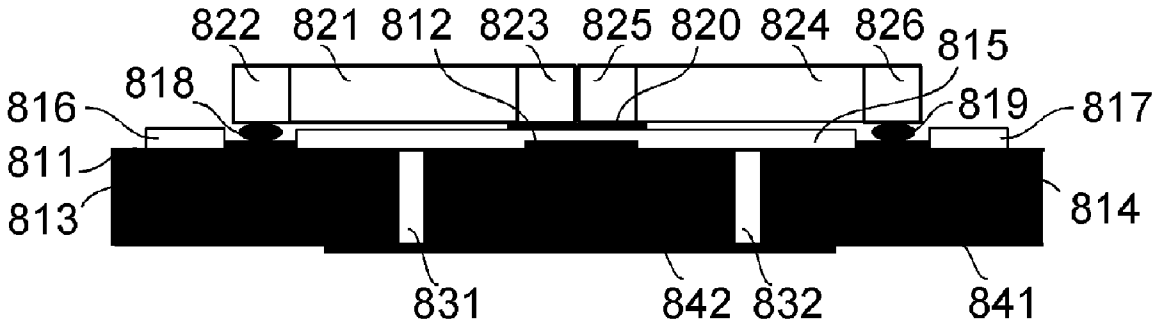
(52) **U.S. Cl.** **174/260**; 174/262

(57) **ABSTRACT**

A printed circuit board with at least one shielded path placed on an outer layer of the board is provided with a shield composed of SMD elements **(215)** and shielding paths and/or planes, placed at both sides along the shielded path. The shielding paths or planes **(213, 214)** are connected to the ground, and the SMD elements **(215)** create a line of SMD elements, which are placed over the shielded path **(212)**, and whose contacts, **(216, 217)** extending beyond the shielded path **(212)**, are connected with the shielding paths or planes **(213, 214)**, placed at both sides of the shielded path **(212)**.



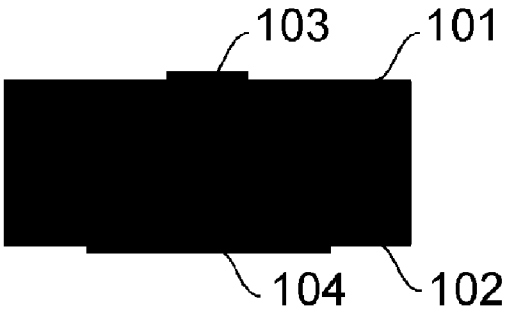


Fig. 1A

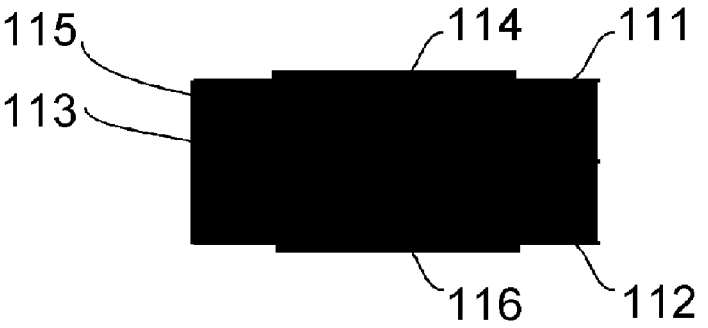


Fig. 1B

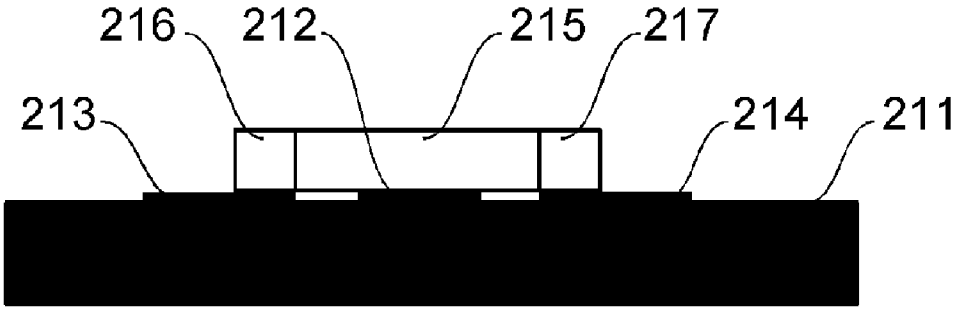


Fig. 2

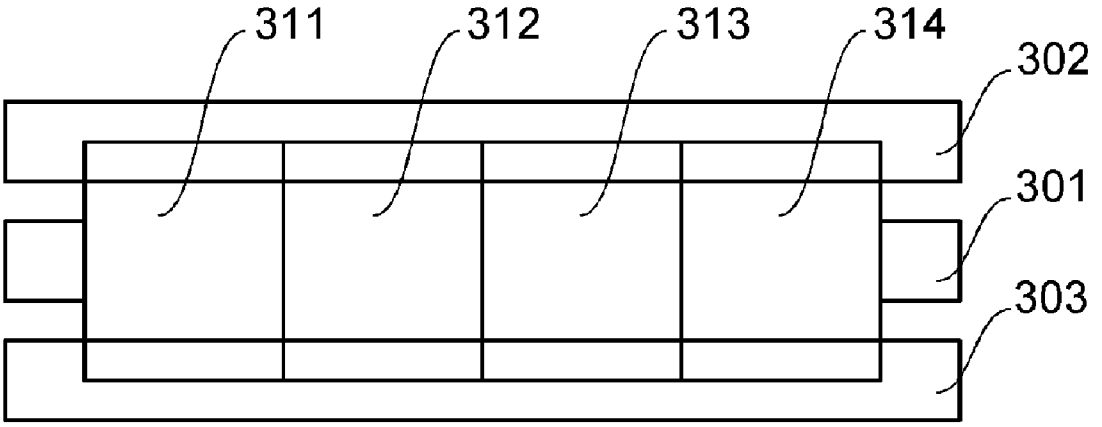


Fig. 3

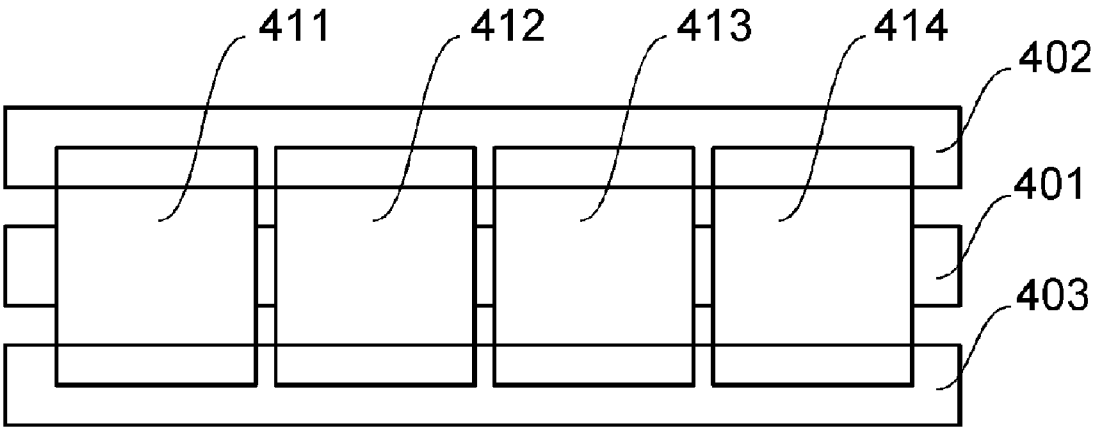


Fig. 4

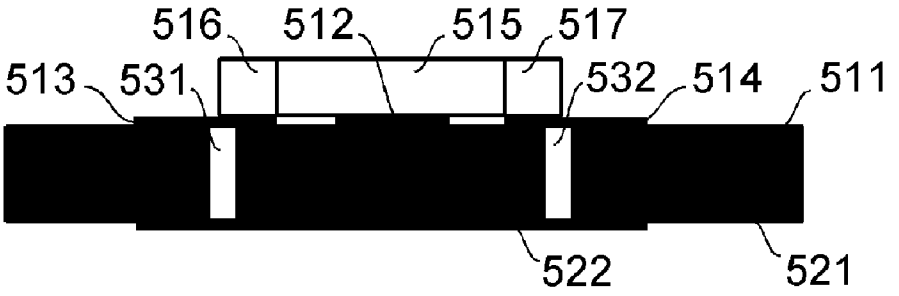


Fig. 5

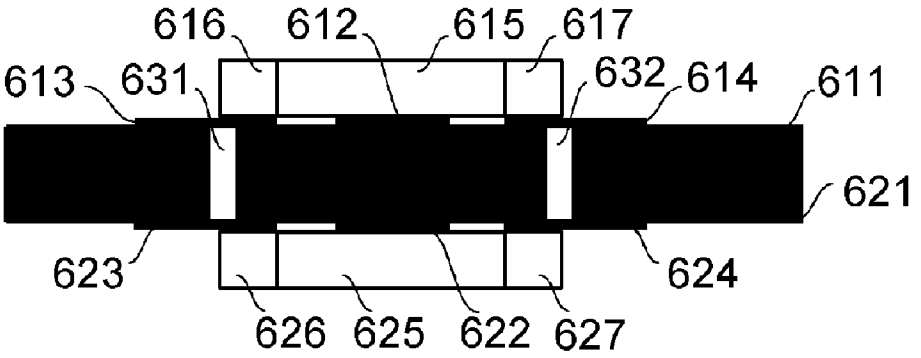


Fig. 6

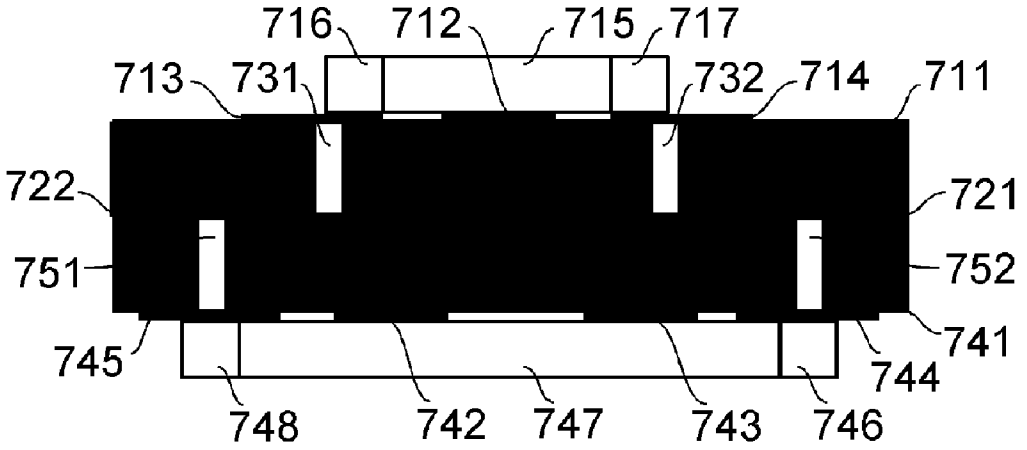
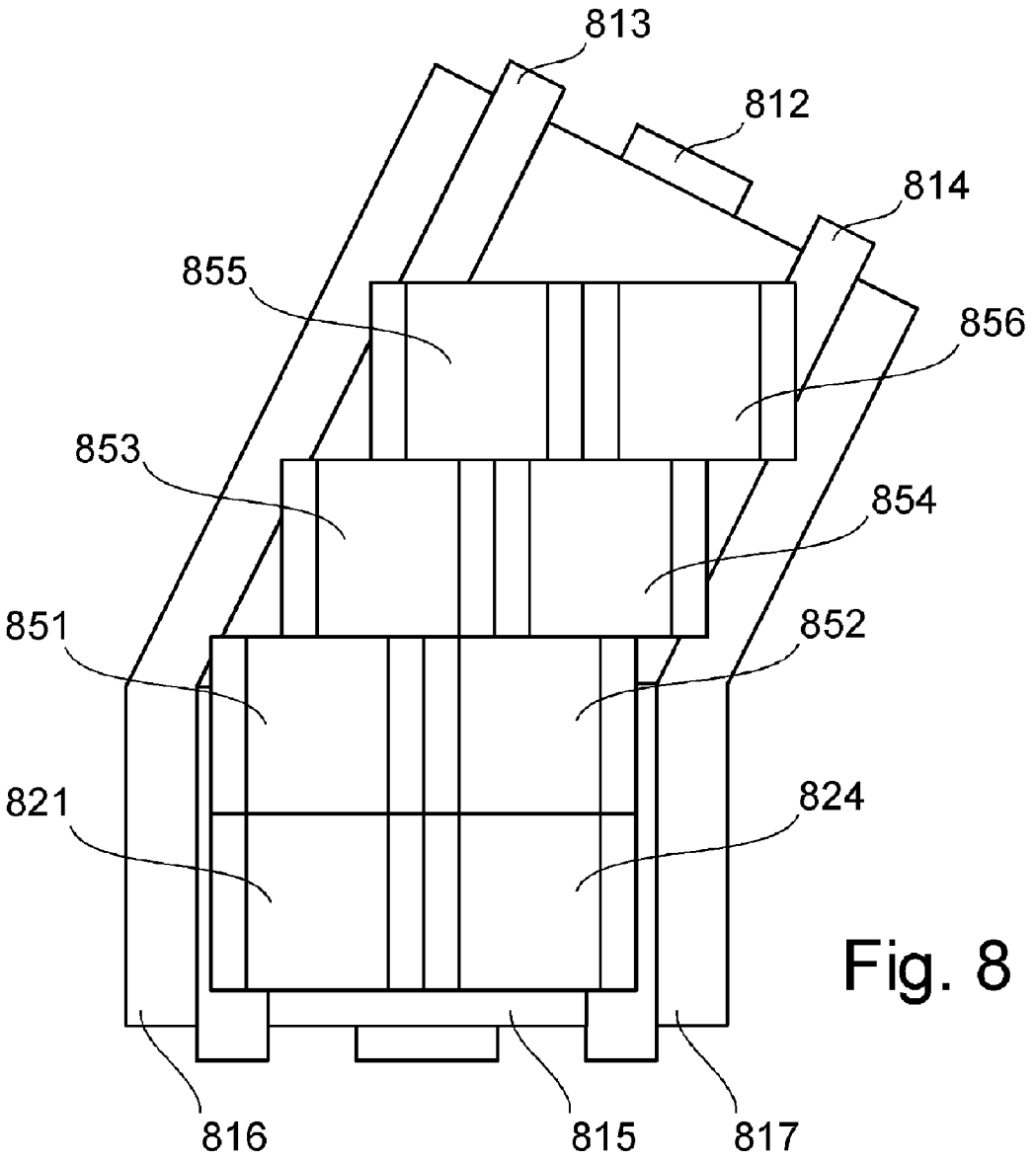


Fig. 7


813
812
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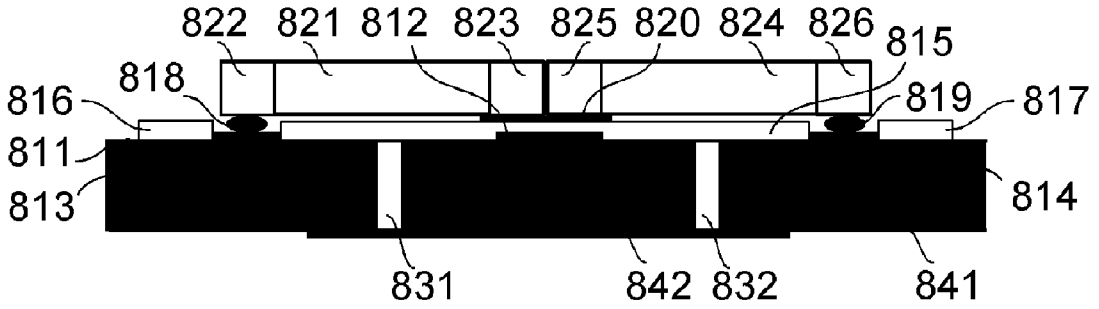
817

Fig. 8


822
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812
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825
820
824
826
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832
841

Fig. 9

PRINTED CIRCUIT BOARD WITH SHIELDED PATH AND METHOD OF MANUFACTURING PRINTED CIRCUIT BOARD WITH SHIELDED PATH

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Polish Patent Application No. P-368337, filed Jun. 2, 2004, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a printed circuit board with a shielded path and a method of manufacturing a printed circuit board with a shielded path.

[0004] 2. Brief Description of the Background of the Invention Including Prior Art

[0005] Various improvements have been made to shielding the paths of printed circuit boards and adjusting the impedance of their paths. This can be achieved by providing additional paths or planes placed in the proximity of the path to be shielded. The two most common examples are a "microstrip" shown in **FIG. 1A** and a "stripline" shown in **FIG. 1B**. In the "microstrip" example, a signal path **103** on a layer **101** is shielded by a path **104** connected to the ground, being placed on layer **102**. This does not provide protection against interference from all sides. A better protection is provided by the "stripline", where a signal path **115** on an inner layer **113** is shielded by paths **114** and **116**, placed on layers **111** and **112**. This requires at least a three-layer board.

[0006] The European patent application no. EP0800338 entitled "Devices for minimizing electromagnetic radiation in printed circuit boards and other electronic circuit carriers" presents a method for shielding of elements on the PCB by covering them with an insulating element. However, the insulating element is specific and must be suited to the shielded element. The manufacture of such a specific element, as well as its assembly on the PCB, complicates the production process and increases its cost.

[0007] An article "*Circuit board guarding techniques*" published in June 1990 in *Research Disclosure Journal*, number 31482, presents a method for shielding a path on an inner layer of a printed circuit board by means of paths placed on each side of it and on the upper and lower layers, which are connected to the ground. This method thus requires paths on the inner layer of the board, and the shield is created only by paths.

[0008] There is no known shielding solution that would allow effective shielding of paths on the outer layers, i.e. the upper and lower layers of printed circuit boards in a way that does not complicate the normal process and does not increase production costs.

SUMMARY OF THE INVENTION

PURPOSE OF THE INVENTION

[0009] It is an object of the present invention to provide effective shielding of paths on the outer layers in avoiding or at least greatly diminishing the drawbacks of prior art.

[0010] This and other objects and advantages of the present invention will become apparent from the detailed description, which follows.

BRIEF DESCRIPTION OF THE INVENTION

[0011] The idea of the invention is that in a printed circuit board with a shielded path placed on its outer layer, the shield consists of an arrangement of elements, comprising paths or planes placed along the shielded path on both sides, which are connected to the shielding arrangement, placed on the lower layer and enclosing the shielded path and connected to the ground, and a line of SMD elements placed over the shielded path, whose contacts extending outside the shielded path are connected to paths placed at both sides of the shielded path.

[0012] The shielded path can be additionally covered with a solder mask layer, and the line of SMD elements is composed of at least two SMD elements connected in series, whose contacts are interconnected. The said elements are connected by means of solder paste placed on the solder mask layer.

[0013] Distances between the SMD elements in the line can be as small as is possible using current state-of-the-art technology.

[0014] In parallel to the shielded path there can be sited on the same layer a second path to be shielded and thereby the arrangement of the elements constituting the shield can enclose both paths.

[0015] Preferably, the shielding arrangement placed on the lower layer is a conductive path or plane, and the shielding arrangement placed on the lower layer is placed on the opposite outer layer.

[0016] Preferably, symmetrically to the shielded path, there placed on the opposite layer a second path to be shielded, and the shielding arrangement placed on the lower layer is a second line of SMD elements, placed over the second path to be shielded.

[0017] The board can have three layers. There can be a path or a plane placed on its inner layer between the shielded paths, which may be in contact with the upper and lower line of SMD elements.

[0018] Preferably, the SMD elements are resistors with resistance close to zero.

[0019] The idea of the invention is also that, in the method for manufacturing a printed circuit board with a shielded path placed on its outer layer, the shield is composed of an arrangement of elements, including paths or planes placed along the shielded path at its both sides, which are connected by means of vias with the shielding arrangement, which is placed on the lower layer and encloses the shielded path and is connected to the ground, and a line of SMD elements, placed over the shielded path, whose contacts, extending outside the shielded path, are connected with the planes or paths placed along the shielded path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In the accompanying drawings one of the possible embodiments of the present invention is shown, where:

[0021] **FIG. 1A** presents a "microstrip" arrangement;

[0022] **FIG. 1B** presents a "stripline" arrangement;

[0023] **FIG. 2** presents a cross section of a single-layer printed circuit board with a shielded path;

[0024] **FIG. 3** presents a top plan view of a PCB with SMD elements placed close to each other;

[0025] **FIG. 4** presents a top plan view of a PCB with SMD elements placed at a certain distance to each other;

[0026] **FIG. 5** presents a cross section of a double-layer PCB with a shielded path at its top outer layer;

[0027] **FIG. 6** presents a cross section of a double-layer PCB with shielded paths on both outer layers block;

[0028] **FIG. 7** presents a cross section of a multi-layer PCB with a shielded path at its top outer layer;

[0029] **FIG. 8** presents a top plan view of a PCB with a shielded path with a width greater than a length of a single SMD element; and

[0030] **FIG. 9** presents a detailed view of the cross section of the PCB shown in **FIG. 8**.

DESCRIPTION OF INVENTION AND PREFERRED EMBODIMENT

[0031] **FIG. 2** presents a cross section of a single-layer PCB with a shielded path. Over the path **212**, placed on the layer **211**, there is placed an SMD element **215**, which ends with in contact surfaces, called contacts **216** and **217**. The contacts **216** and **217** are connected respectively to paths **213** and **214**, which are connected to the ground, and are placed along the shielded path **212** at its both sides. In this embodiment, the path **212** is shielded only from one side. Such shielding is preferable especially when the bottom layer of the board is metallized. This feature makes it possible to obtain a specific path impedance.

[0032] **FIG. 3** presents a top view of a PCB with a shielded path **301**. On both sides of the path **301** there are placed paths and/or planes **302** and **303** connected to the ground. Over the path there is placed a line of resistors **311**, **312**, **313** and **314**, whose contacts are connected to the paths and/or the planes **302** and **303**. The contacts of the resistors **311**, **312**, **313** and **314** extend beyond the shielded path **301**. The chain of SMD elements **311**, **312**, **313**, **314**, for example the resistors, constitutes the top part of the tunnel, which encompasses the shielded path **301**. The SMD elements **311**, **312**, **313**, **314** are placed adjacent to each other, acting additionally as the insulation for the path **301** from external influences, such as dust, and in this way preventing possible short-circuits and positively improving the durability of the design.

[0033] **FIG. 4** presents an arrangement, in which there are spaces between the elements **411**, **412**, **413**, **414**, which result from the production process. Such shielding is less efficient, but it ensures a certain level of path shielding. In order to provide a fully effective shield, the distances between the SMD elements should be as small as possible (for example—the smallest distances allowed by the production process). Spacings between the SMD elements **411**, **412**, **413**, **414** can be deliberately introduced to ensure better cooling of the path **401**. This provides both shielding for the path **401** and a free flow of air. The air flows, for example, through the clearance between the elements **411**, **412**, inside the tunnel composed of the elements **412**, **402**, **403**, **401** and the board surface, on which paths **401**, **402** and **403** are placed, and next through the clearance between the elements **412** and **413**.

[0034] **FIG. 5** presents a path **512** to be shielded, which is placed on the top layer **511** of a double-layer PCB. There is an SMD element **515** placed on the path, which ends with contact surfaces **516** and **517**. The contacts **516** and **517** are connected with shielding planes or paths **513** and **514**, which are placed along the shielded path **512** on both sides. At the bottom surface **521** of the board, there is placed a path **522**, connected to the ground, which extends along the path **512**, and which constitutes the shielding arrangement. The path **522** is connected with the paths **513** and **514** by means of metallised holes, so-called vias **531** and **532**. Therefore, the path **522**, the vias **531** and **532**, the paths **513** and **514** and the SMD element **515** surround the path **512** on all sides, so that they constitute a shield, which effectively protects the path **512** against any interference, as well as other elements against internal interference generated by the path. The SMD element might be a resistor with a resistance close to zero. For example, it can be a 1210-type SMD resistor, having the length of 3.1 mm, the width of 2.6 mm, the height of 0.6 mm, and with the width of contact surfaces of 0.5 mm. However, it is possible to use other SMD elements, for example non-zero resistors, capacitors or inductors, in order to achieve appropriate shield parameters, which allows appropriate path impedance to be achieved

[0035] The SMD elements in the line may be identical or may be made up of a line of different elements. The advantage of using the SMD elements is that no additional procedures are necessary for the production of the board. On a typical printed circuit board there are many different SMD elements. Hence the addition of further components does not pose a significant time-factor for production. Placing additional elements does not require the introduction of any special additional process which might be much more time-consuming and impose additional costs. In the presented embodiment, the indicators **513**, **514**, **522** are related to the paths. However, the paths may be replaced by larger planes, which are connected to the ground. The vias **531**, **532** need not necessarily be placed immediately underneath the contact surfaces of the resistors, but they can be located elsewhere, the only requirement being that they connect the paths **513** and **514** with the path **522**. The path **522** is presented as an example. An alternative shielding arrangement may be placed on the lower surface instead, such as for example, a resistor or another element, or a specific a conductive plane in a specific form.

[0036] **FIG. 6** presents a cross section of a printed circuit board with paths **612**, **622** to be shielded, which are placed in parallel to each other at the outer layers **611** and **621**. The shield around the paths is composed of a line of resistors **615** connected by contacts **616** and **617** with the paths **613**, **614**, which are connected by vias **631** and **632** with the paths **623**, **624**, which are connected with the line of resistors **625** with contacts **626**, **627**. Such shielding is effective also when the paths **612**, **622** are paths transmitting a differential signal. It allows reduction of production costs, because elements to shield the paths from the lower layer are not necessary. Moreover, a decrease of production cost is obtained by miniaturizing the whole printed circuit board by placing its components on the bottom part of the printed circuit board.

[0037] **FIG. 7** presents a cross section of a multilayer, for example a three-layer printed circuit board, whose path to be shielded **712** is placed on the top outer layer **711**, while a shielding path or plane **722** is placed on the inner layer **721**. The shield consists of a resistor **715**, whose contacts **716**, **717** are connected to paths **713**, **714**, which by means of vias **731**, **732** are connected to the path **722**. It allows the placement of other paths, **742** and **743**, on the second outer layer **741**. The paths **742**, **743** can also be shielded, and their shield consists the resistor **747**, whose contacts **746**, **748** are connected to the paths **744**, **745**, which by means of vias **751**, **752** are connected to the path **722**. Such solution is characterized by better shielding properties than the solution depicted in **FIG. 6**, although production costs are raised due to the need to create the additional layer **741** of the PCB.

[0038] **FIG. 8** shows a top-view of the PCB with a shielded path having a width greater than the length of a single SMD element, additionally having a variable angle of placement. The path **812** is covered with a solder mask layer made of epoxy resin. The outer layer of the shield is composed of a line of elements connected in series marked with the numbers **821** and **824**, **851** and **852**, **853** and **854**, **855** and **856**, whose contacts extending outside the solder mask layer **815** are soldered to the paths **813**, **814**, connected to the ground. The contacts **823**, **825** of the SMD elements placed on the solder mask layer **815** are connected with each other by means of solder paste **820**, put on the solder mask. Should a path **812** be required, more than two elements connected with each other in series can be emplaced. At the sides of paths **813**, **814** there can also be a solder mask placed **816**, **817**. The solder mask can be placed on the path **812** also in the case when it is covered only with a line consisting of single SMD elements, which ensures that it has additional shielding and protection against mechanical damage.

[0039] **FIG. 9** presents a cross section of the board presented in **FIG. 8**. There is a solder mask **815** placed on the path **812**, placed on the top layer of **811** PCB, which is also placed on the sides **816**, **817** of the paths **813**, **814**, which by means of vias **831**, **832** are connected to the path **842**, connected to the ground, placed on the bottom layer **841** of the PCB. The elements **821** and **824** adhere to each other by means of contacts **823**, **824**, which are connected together by means of solder paste **820**, put on the solder mask **815**. The outer contacts **822** and **826** are connected by means of solder paste **818**, **819** with the paths **813** and **814**. The placement of additional solder masks **815**, **816**, **817** additionally isolates the path **812** from external influences, leading to an increase of the durability and the resistance of the PCB.

[0040] The preferred embodiment having been thus described, it will now be evident to those skilled in the art that further variation thereto may be contemplated. Such variations are not regarded as a departure from the invention, the true scope of the invention being set forth in the claims appended hereto.

What is claimed is:

1. A printed circuit board comprising

a board;

at least one shielded path **(212)** placed on an outer layer **(211)** of the board; and

a shield constituted by elements connected to the ground, wherein the elements constituting the shield comprise

shielding paths and/or planes **(213, 214)** placed at both sides along the shielded path **(212)**, and

a line of SMD elements **(215)** placed over the shielded path **(212)** and having contacts **(216, 217)** extending beyond the shielded path **(212)** and connected with the shielding paths and/or planes **(213, 214)**.

2. The board according to claim 1, wherein the shielded path **(812)** is additionally covered with a solder mask layer **(815)**.

3. The board according to claim 2, wherein the line of SMD elements is created by at least two SMD elements **(821** and **824, 851** and **852, 853** and **854, 855** and **856)** connected in series, whose contacts **(823825)**, which are adjacent, are connected by solder paste **(820)** placed on a solder mask layer **(815)**.

4. The board according to claim 1, wherein distances between SMD elements **(311, 312, 313, 314)** and **(411, 412, 413, 414)** in the line are the smallest distances allowed by a production process.

5. The board according to claim 1, wherein in parallel to the shielded path **(742)** there is placed at the same layer a second path **(743)** to be shielded, and the elements constituting the shield enclose the shielded path and the second path **(742, 743)**.

6. The board according to claim 1, wherein the elements constituting the shield are additionally connected, by vias **(531, 532)**, with a shielding arrangement, which encloses the shielded path **(512)** and which is placed on the lower or the second outer layer **(521)**.

7. The board according to claim 6, wherein the shielding arrangement placed on the lower or the second outer layer is a conductive path or plane **(522)**.

8. The board according to claim 6, wherein symmetrically to the shielded path **(612)** there is placed on the opposite layer a second path **(622)** to be shielded, and the shielding arrangement placed on the lower layer is a second line of SMD elements **(625)** placed over the second path **(622)** to be shielded.

9. The board according to claim 6, wherein the board has at least three layers and the shielding arrangement **(722)** placed on the lower layer is placed on the inner layer and is common for the arrangement of elements constituting the shield at the first **(711)** and the second **(741)** outer layer.

10. The board according to claim 1, wherein the SMD elements are resistors with resistance close to zero.

11. A method for manufacturing a printed circuit board with a shielded path placed on an outer layer of the board, the shield being constituted by an arrangement of elements connected to the ground, the method comprising the following steps:

forming shielding paths and/or planes at both sides along the shielded path;

forming a shielding arrangement enclosing the shielded path on a lower layer;

forming vias connecting the shielded paths or planes with the shielding arrangement;

placing a line of SMD elements with contacts over the shielded path; and

connecting the contacts of the SMD elements extending beyond the shielded path with the shielding paths and/or the planes.

12. The method according to claim 11, wherein the shielded path is covered with a solder mask layer.

13. The method according to claim 12, wherein the line of SMD elements is created from at least two SMD elements connected in series, whose contacts, which are adjacent, are connected by solder paste, placed on the solder mask layer.

14. The method according to claim 13, wherein the distances between the SMD elements in the line are the smallest distances allowed by the production process.

15. The method according to claim 11, wherein in parallel to the shielded path there is formed at the same layer a second path to be shielded, and the arrangement of elements constituting the shield includes both paths.

16. The method according to claim 11, wherein the arrangement of elements constituting the shield is additionally connected, by vias, with a shielding arrangement enclosing the shielded path, which is placed on the second outer layer.

17. The method according to claim 16, wherein the shielding arrangement, placed on the lower or the second outer layer is a conductive path or plane.

18. The method according to claim 16, wherein symmetrically to the shielded path, there is placed on the opposite layer a second path to be shielded, and the shielding arrangement placed on the lower layer is a second line of SMD elements, placed over the second path to be shielded.

19. The method according to claim 16, wherein the board has at least three layers and there is placed on its inner layer, between the shielded paths, a path or plane, which is in contact with the vias connecting the top and the bottom line of the SMD elements.

20. The method according to claim 12, wherein the SMD elements are resistors with resistance close to zero.

* * * * *