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(54) **Antenna device**

(57) The present invention relates to an antenna device for a communication device operable in at least two frequency intervals and comprising a generally planar electrically conductive driven radiating element (2) having a feeding portion (5) connectable to a feeding point (P) of a printed wire board (4) of the communication device and a generally planar elongated parasitic element (3) having a ground portion (6) connectable to a grounding point (G) of the printed wire board. The driven radiating element (2) and the parasitic element (3) are essentially coplanar and separated by a gap, wherein the

grounding portion (6) of the parasitic element (3) is positioned at a grounding point (G') along the parasitic element (3) so as to virtually divide the parasitic element (3) into a first and a second portion respectively with a first length (L1) and a second length (L2), wherein the first portion having a first length (L1) is longer than the second portion having a second length (L2).

By designing the parasitic element in this fashion, it is possible to easily modify and influence the impedance match of the resonance for the different frequencies, i.e. the Return Loss level for which the parasitic element is active.

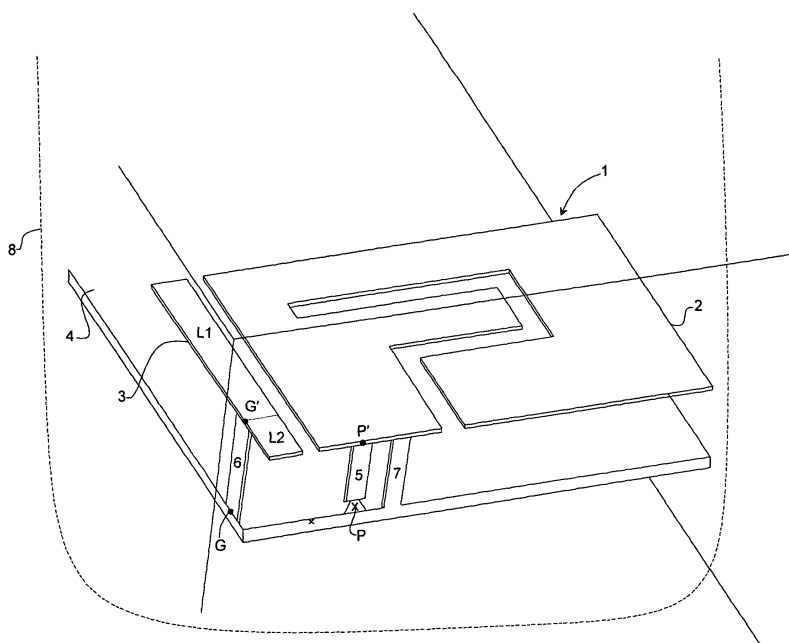


Fig. 1

Description

Field of the invention

[0001] The invention relates to the field of antenna devices and in particular to an internal multi-band antenna device with a parasitic element for use in communications devices. The invention also relates to a radio communication device comprising such an antenna device.

Background of the invention

[0002] In the art, parasitic elements have been used with multi-band antennas. The bandwidth of an antenna is the range of frequencies over which it is effective, usually centred around the resonance frequency. The length and shape of the parasitic element determine its capabilities, mostly regarding the different frequencies for which it is to be used. Typically, the parasitic elements are of elongated shape, thus having two long sides and two short sides with a grounding point at one of the short sides. Such a parasitic element is known from e.g. US 6456250. Typically, in prior art, the parasitic element is arranged in a parallel relationship to at least a first planar driven radiating element, denoted CP1 in US 6456250 and has a grounding portion or post located at one end of the parasitic element. Together the planar driven radiating element and the parasitic element form an electrical capacitor, as there exists a capacitive or parasitic coupling between the planar driven radiating element and the parasitic element.

[0003] The mechanical length of the parasitic element is closely correlated to the operating wavelength or frequency of the parasitic element.

[0004] It has not been possible to affect the impedance match of the resonance for the different frequencies, i.e. the Return Loss level, apart from utilizing a matching network, i.e. lumped or distributed components (inductors and/or capacitors). Further in prior art, the parasitic element had to be arranged close to and in parallel to the planar driven radiating element in order to create a capacitive or parasitic coupling between the planar driven radiating element and the parasitic element.

Summary of the invention

[0005] It is an objective of the invention to provide an antenna device having a parasitic element for which it is possible to easily modify and influence the impedance match of the resonance for the different frequencies, i.e. the Return Loss level.

[0006] It is further an objective of the invention to provide an antenna device having a parasitic element that need not be arranged in parallel to the planar driven radiating element in order to create a capacitive or parasitic coupling between the planar driven radiating element and the parasitic element.

[0007] In accordance with the invention, an antenna

device is provided which is suitable for a communication device operable in at least two frequency intervals or frequency bands. The antenna device comprises a generally planar driven radiating element having a feeding point connectable to a feed device of the communication device. The antenna device further comprises a generally planar parasitic element having a grounding portion connectable to a ground device of the communication device. The driven radiating element and the parasitic element are essentially coplanar and separated by a gap. The parasitic element preferably has a general elongated shape, e.g. rectangular. The parasitic element is connected to a grounding point, using a grounding pin or grounding portion. The grounding portion of said parasitic element is located at a point along the elongated parasitic element so as to virtually divide said parasitic element in a first and a second portion with respective lengths L1 and L2, wherein L1 is longer than L2.

[0008] As the grounding point in a printed wire board (PWB) is located close to the feeding point in the same, where the current density is relatively high, some current will be lead up through the grounding pin to the parasitic element. At the grounding point of the parasitic element, that is where the grounding pin is connected to the parasitic element, some current will go into the L1 part of the parasitic element and some current will go into the L2 part of the parasitic element. As L2 is relatively short, current will be reflected at the end of L2. The current going through L2 will determine the impedance of the whole parasitic antenna. This impedance will directly affect the matching of the impedance of the resonance, i.e. the Return Loss level. Depending on in which phase this reflected current is, when added to the current from the grounding point of the parasitic element, the impedance is determined. The phase of the reflected current in the grounding point of the parasitic element is directly dependant on the length L2. Therefore, the length L2 determines the impedance of the parasitic element and thus directly determines the impedance matching of the resonance for which frequency the parasitic element is responsive or active. An impedance of 50 ohms will cause the resonance depth or the Return Loss level to be infinite, provided that an interface of 50 ohms is employed. If an interface with other impedance/resistance is employed, the impedance matching will have to be done around that impedance accordingly. Hereinafter, the description will be focused on the 50 ohms impedance matching by way of example. It is therefore possible to design a parasitic element that is effective for a certain frequency band, due to L1, and that has optimal resonance depth or Return Loss level for that particular frequency band, due to L2.

Brief description of the drawings

[0009]

Figure 1 illustrates an overview of an antenna device

in accordance with the invention.

Figure 2 illustrates schematically a frequency diagram for the antenna device of figure 1.

Figures 3a and 3b illustrate other embodiments of antenna devices in accordance with the invention.

Figures 4a, 4b and 4c illustrate other embodiments of a parasitic element used in an antenna device in accordance with the invention.

Detailed description of the invention

[0010] The invention will now be described with reference to the accompanying drawings. Figure 1 illustrates an antenna device in accordance with an embodiment of the invention. The antenna device 1 comprises a first radiating element 2, which is an active element, also known as a driven element, and in the following denoted driven radiating element 2. The driven radiating element 2 is made of a suitable electrically conductive material, such as a metal sheet, or a conductive flex film or the like. The driven radiating element 2 may have any suitable shape, for example square, rectangular, thin strip, circular, elliptical or triangular.

[0011] The driven radiating element 2 is connected to a feed portion electrically connectable to radio frequency (RF) circuitry of an underlying printed wire board (PWB) 4 of a communication device in which the antenna device 1 is to be used. For example, the feed portion could be a contact pin 5 having an extension essentially perpendicular to the plane of the driven radiating element 2. In the following a contact pin 5 is used as an exemplary feed means, although it is noted that other feeding means could be used. The contact pin 5 functions as a feeding point P of the driven radiating element 2. The driven radiating element 2 is thus fed via the contact pin 5. In the figure, a PIFA antenna arrangement is shown. As such, the driven radiating element 2 comprises a grounding portion or grounding pin 7 having an extension essentially perpendicular to the plane of the driven radiating element 2 and the PWB.

[0012] The PWB 4 of the communication device also functions as a ground plane for the internal antenna device 1.

[0013] The antenna device 1 further comprises a parasitic element 3. The parasitic element 3 is, like the driven radiating element 2, made of a suitable electrically conductive material. The parasitic element 3 has a general elongated shape, e.g. rectangular and is connected to a grounding point G in the PWB 4, using a grounding pin 6. The grounding pin 6 of said parasitic element is located at a point G' along the parasitic element so as to virtually divide said parasitic element in two portions with respective lengths L1 and L2, wherein L1 is longer than L2.

[0014] The grounding point G in the PWB 4 is preferably located close to the feeding point P, they are typically

0.5-3 cm apart. As the grounding point preferably is located close to the feeding point, where the current density is relatively high, some current will be conducted or directed up through the grounding pin 6 to the parasitic element 3. At the grounding point G' of the parasitic element 3, that is, where the grounding pin 6 is connected to the parasitic element 3, some current will go into the L1 part of the parasitic element 3 and some current will go into the L2 part of the parasitic element 3. As L2 is relatively short, current will be reflected at the end of L2. The current going through L2 will determine the impedance of the whole parasitic element. This impedance will directly affect the impedance matching of the resonance, i.e. the Return Loss level. Depending on in which phase this reflected current is, when added to the current from the grounding point G', the impedance is determined. The phase of the reflected current at the grounding point of the parasitic element G' is directly dependant on the length L2. Therefore, the length L2 determines the impedance of the parasitic element and thus directly determines the impedance matching of the resonance, i.e. the Return Loss level, for the operating frequency of the parasitic element. An impedance of 50 ohms will cause the resonance depth or the Return Loss level to be infinite, provided that an interface of 50 ohm is employed. An impedance around 50s ohms is thus desirable. It is therefore possible to design a parasitic element that is effective for a certain frequency band, due to L1, and that has optimal resonance depth for that particular frequency band, due to L2. By placing the grounding point G in locations on the PWB 4 close to the feeding point P where the current density is relatively high, it is possible to design a parasitic element with optimal resonance depth by adjusting the length of L2 accordingly. It is noted that it is the high current density at the grounding point G of the PWB 4 that is of importance. Thus the grounding point G and the feeding point P need not be close if there are other locations on the PWB 4 with high current density.

[0015] There is no need for the parasitic element 3 itself to be close to the driven radiating element 2 as it is the current density in the PWB 4 at the grounding point G together with the length of L2 that determine the impedance of the parasitic element 3. In more detail, the length L2 determines the phase of the reflected current in the grounding point G' of the parasitic element 3. It is the phase of the reflected current when added to the current from the grounding point G' of the parasitic element 3 that determines the impedance of the parasitic element 3. The amplitude of the current is of less importance.

[0016] The resonance frequencies of the parasitic element 3 are dependent the length L1 of the parasitic element 3. In other words, the length L1 of a parasitic element according to the invention corresponds to the total length of a parasitic element according to prior art. As such, a longer L1 will make the parasitic element 3 effective for a lower frequency band and a shorter L1 will make the parasitic element 3 effective for a higher fre-

quency band accordingly.

[0017] The driven radiating element 2 and the parasitic element 3 are supported by a frame made of an electrically non-conductive material, such as plastic (not shown). By means of the frame the radiating elements 2, 3 are easily positioned essentially parallel to the PWB of the communication device. It is however noted that the parasitic element 3 and the driven radiating element 2 need not be in parallel according to the present invention.

[0018] The antenna device is connected to a communication device, shown in figure 1 by a dashed line.

[0019] The antenna device 1 is a multi-band antenna. In a way that is known per se, the driven radiating element 2 and the parasitic element 3 can be dimensioned in order to obtain any desired resonance frequencies. The antenna device 1 may for example be dimensioned so as to produce a resonance at the lower bands with central frequencies substantially at 850 MHz and 900 MHz and/or to produce a resonance at the higher frequency bands with central frequencies substantially at 1800 MHz, 1900 MHz or 2100 MHz, making it suitable for use in a multi-band communication device adapted for the GSM850, GSM900 and/or GSM1800/GSM1900/WCDMA2100 bands.

[0020] Figure 2 illustrates schematically a frequency diagram for the antenna device of figure 1. The different values "b" in the diagram denote different lengths of L2. As is shown in the diagram, the length of L2 greatly affects the Return Loss level, for the operating frequency of the parasitic element.

[0021] Figure 3a illustrates a parasitic element in accordance with the present invention when employed to a monopole antenna arrangement.

[0022] Figure 3b illustrates a parasitic element in accordance with the present invention when employed to a patch antenna arrangement.

[0023] Figures 4a, 4b and 4c illustrate an embodiment of the parasitic element in accordance with the present invention wherein the parasitic element is curved. Although the figures illustrate just one curve, it is to be understood that the parasitic element could be curved in other ways, e.g. in the shape of an S. The different figures 4a, 4b, 4c illustrate a curved parasitic element in accordance with the present invention when employed to a PI-FA, monopole and patch antenna arrangement respectively.

[0024] Inside the communication device, having the antenna arrangement as described above, there is provided the printed wire board (PWB) 4 with a size essentially corresponding to the size of the communication device. On the PWB 4 there are mounted electronic circuits etc. (not shown) for the operation of the communication device. These circuits are generally not part of the present invention and will not be discussed further. However, the antenna device is to be connected to the PWB 4 and this comprises radio frequency (RF) circuitry for operation of the antenna device. In particular, the parasitic element 3 is connected to the grounding portion 6

extending essentially perpendicular thereto. The grounding portion 6 is connected to a ground device of the underlying PWB 4. The driven radiating element 2 is electrically connected to a feed device of the PWB 4 by means of the contact pin 5.

[0025] It should be understood that also the width of the parasitic element 3 is of importance and affects the capabilities of the parasitic element 3. A lesser width of the parasitic element 3 would lead to a decrease of the overall length of the parasitic element 3. Accordingly, a greater width of the parasitic element 3 would lead to an increase of the overall length of the parasitic element 3. In other words, it is the circumference of L1 and L2 that determines their respective characteristics.

[0026] The invention has been described by means of different embodiments thereof. It is to be noted that the invention can be modified in a number of ways. For example, the size or length of the parasitic element 3 can be varied. Also other shapes besides the elongated shape described here could be used without departing from the scope of the invention. The grounding point and feeding point can be located differently than shown in the figures. Further yet, the term radiating element should be understood to cover any antenna element adapted to receive and/or transmit electromagnetic waves.

[0027] It is also to be understood that the invention is applicable to any communication device having an internal multi-band antenna arrangement, both handsets and more stationary communication devices. It is also to be understood that the impedance matching around 50 ohm is due to the impedance of the interface, which in this case would be 50 ohm. A different interface with another impedance would require the impedance matching of the parasitic element to be made around that impedance.

[0028] Although an antenna device for a portable radio communication device has been described with reference to its use in a mobile phone, it will be appreciated that the inventive idea is also applicable to other portable radio communication devices, also devices that are portable but primarily intended for stationary use. Examples thereof could be small clocks, such as travel alarm clocks, TV receivers, or game consoles. Yet a possible application of the antenna device according to the invention is in personal digital assistants (PDAs), MP3 and CD players, FM radio receivers, and laptop computers. A further application is in cars. Thus, the term portable radio communication device should be construed in a broad sense.

Claims

1. An antenna device for a communication device operable in at least two frequency intervals said antenna device comprising:

- a generally planar electrically conductive driven radiating element (2) having a feeding portion (5) connectable to a feeding point (P) of a printed

wire board (4) of said communication device and
 - a generally planar elongated parasitic element (3) having a ground portion (6) connectable to a grounding point (G) of the printed wire board (4) of said communication device, wherein said driven radiating element (2) and said parasitic element (3) are essentially coplanar and separated by a gap,

characterised in that

said grounding portion (6) of said parasitic element (3) is positioned at a grounding point (G') along said parasitic element (3) so as to virtually divide said parasitic element (3) in a first and a second portion with respective first length (L1) and second length (L2), wherein the first portion having a first length (L1) is longer than the second portion having a second length (L2).

2. The antenna device according to claim 1 **characterised in that** the position of said grounding point (G') along said parasitic element (3) virtually dividing said parasitic element (3) in two portions is chosen so that the length of first portion (L1) is matched so as to be responsive to a predetermined frequency interval.
3. The antenna device according to claim 2 **characterised in that** the length of the second portion (L2) of the parasitic element (3) is chosen to obtain an impedance close to 50 ohms for the parasitic element (3) for the predetermined frequency interval determined by the length of first portion (L1).
4. The antenna device according to any of claims 1-3 **characterised in that** the length of the first portion (L1) of the parasitic element (3) is between 15-25 mm.
5. The antenna device according to any of claims 1-4 **characterised in that** the length of the second portion (L2) of the parasitic element (3) is between 1-14 mm.
6. The antenna device according to any of claims 1-5 **characterised in that** the width of the parasitic element is between 1-5 mm.
7. The antenna device according to any of claims 1-6 **characterised in that** the generally planar elongated parasitic element has a substantially rectangular shape.
8. The antenna device according to any of claims 1-6 **characterised in that** the generally planar elongated parasitic element is curved.
9. The antenna device according to any of claims 1-8

characterised in that the antenna device is any of a PIFA antenna, a monopole antenna or a patch antenna.

- 5 10. A mobile communication device **characterised in that** said mobile communication device comprises an antenna device comprising:

- a generally planar electrically conductive driven radiating element (2) having a feeding portion (5) connected to a feeding point (P) of a printed circuit board (4) of said communication device and

- a generally planar elongated parasitic element (3) having a ground portion (6) connected to a grounding point (G) of the printed circuit board (4) of said communication device, wherein said driven radiating element (2) and said parasitic element (3) are essentially coplanar and separated by a gap,

wherein said grounding portion (6) of said parasitic element (3) is positioned at a grounding point (G') along said parasitic element (3) so as to virtually divide said parasitic element (3) into a first and a second portion respectively with a first length (L1) and a second length (L2), wherein the first portion having a first length (L1) is longer than the second portion having a second length (L2).

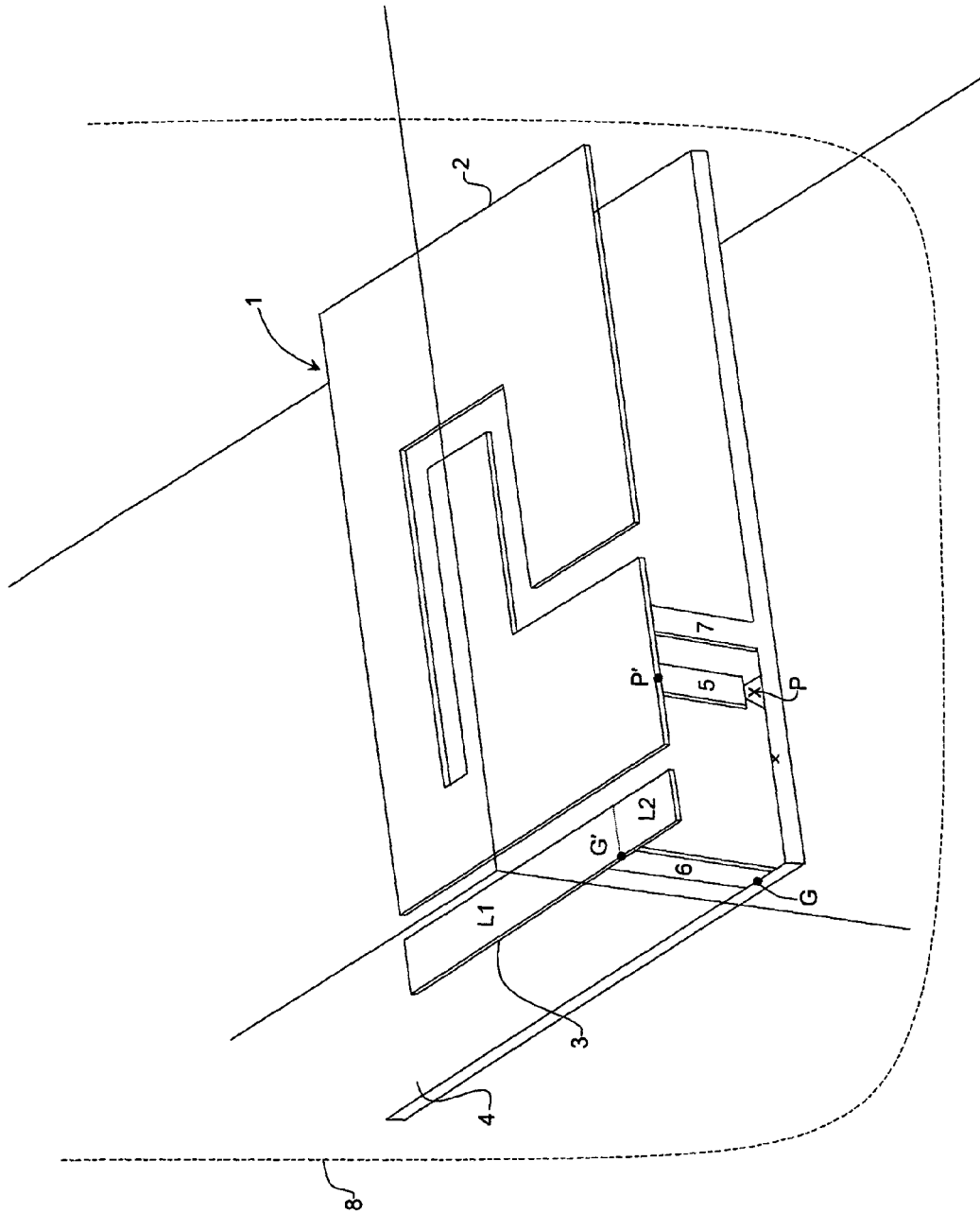


Fig. 1

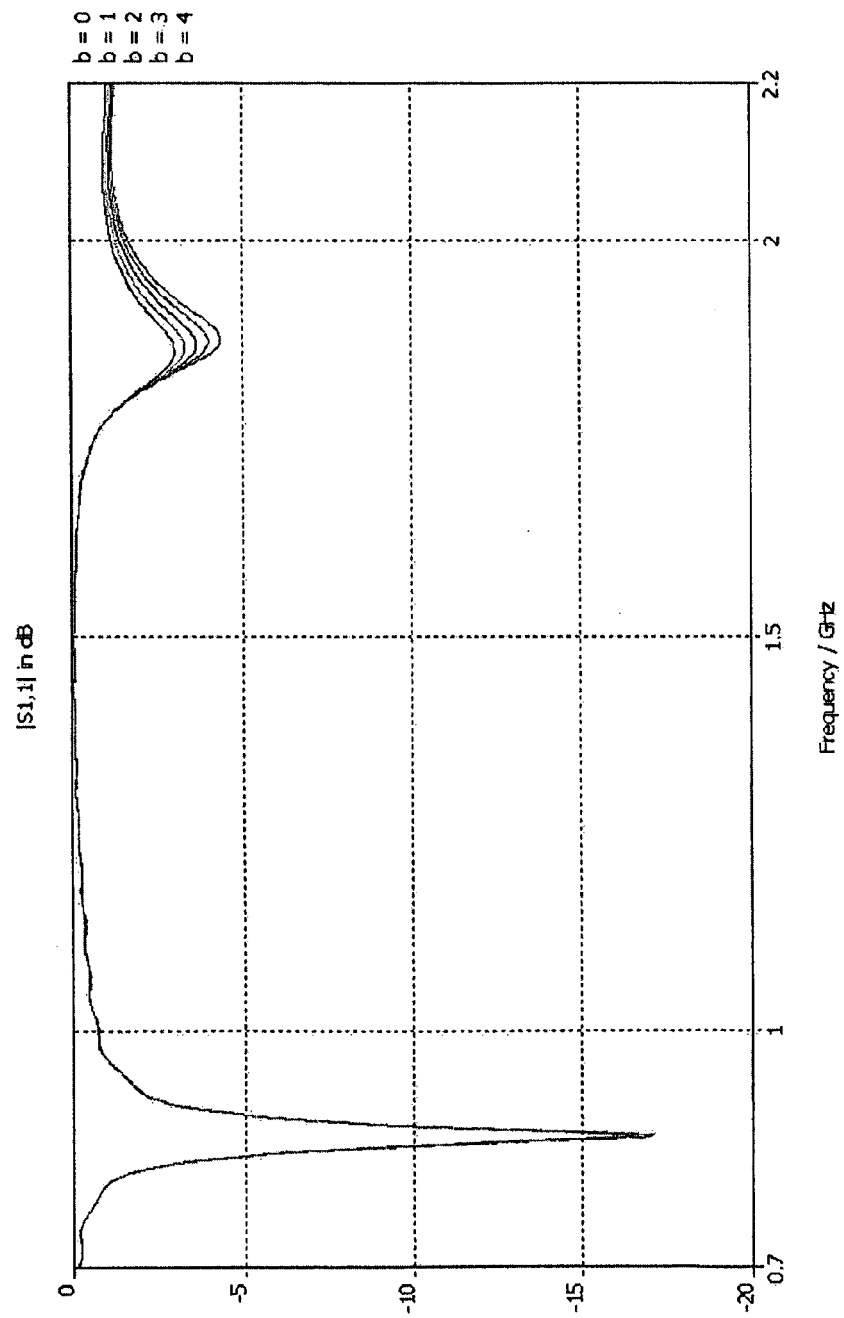


Fig. 2

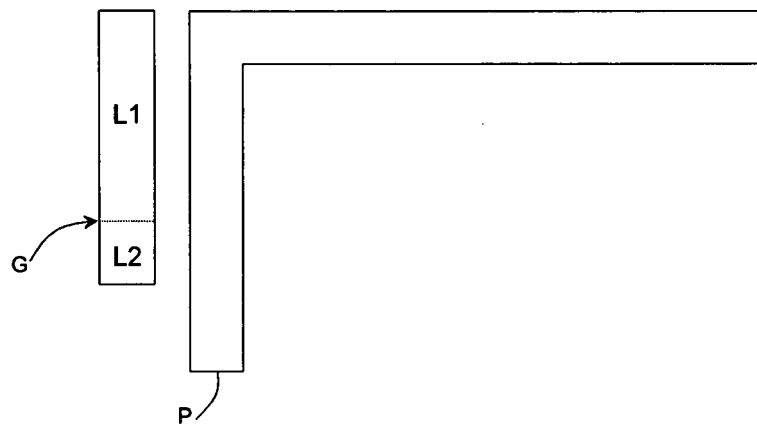


Fig. 3a

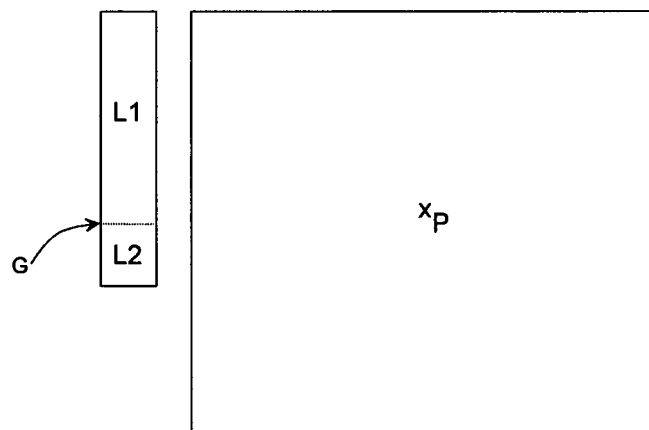


Fig. 3b

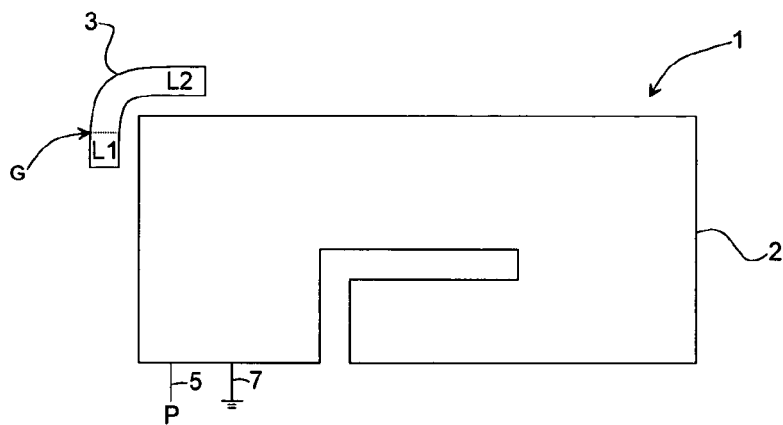


Fig. 4a

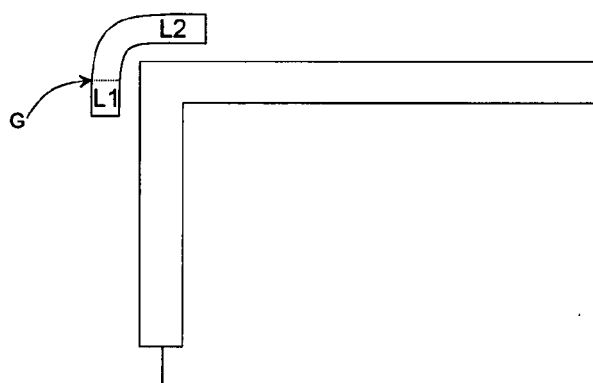


Fig. 4b

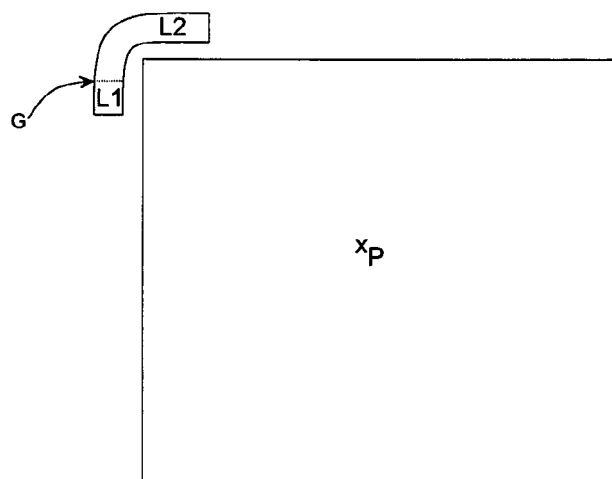


Fig. 4c



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 07 44 5027

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search The Hague		Date of completion of the search 17 September 2007	Examiner Hüschelrath, Jens
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 P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 07 44 5027

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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