(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 081 253 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.07.2009 Bulletin 2009/30

(51) Int Cl.:
H01Q 9/04 *(2006.01)*

(21) Application number: **08000929.3**

(22) Date of filing: **18.01.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(71) Applicant: **Laird Technologies AB**
164 22 Kista (SE)

(72) Inventors:
- **Braun, Christian**
  113 21 Stockholm (SE)
- **Erlandsson, Per**
  117 34 Stockholm (SE)

(74) Representative: **Dahnér, Christer et al**
Kransell & Wennborg AB
P.O. Box 27834
115 93 Stockholm (SE)

(54) Antenna device and portable radio communication device comprising such an antenna device

(57) A quad-band antenna device (10) for a portable radio communication device comprises an electrically conductive radiating element (11) having an electrical length selected to provide resonance in a first set of frequency bands frequency band. The element includes a first elongated section (12, 13, 14) having a first edge (22, 23, 24) and a second section (15) having a second edge (25, 26, 27) and being joined to the first section via an interconnecting section (16), which second edge (15) faces, is displaced from and stretches along the first edge. In this way a gap (G1, G2, G3) is formed between the first and second sections. The dimensions of this gap are selected to provide resonance of the first electrically conductive radiating element in a second set of frequency bands.

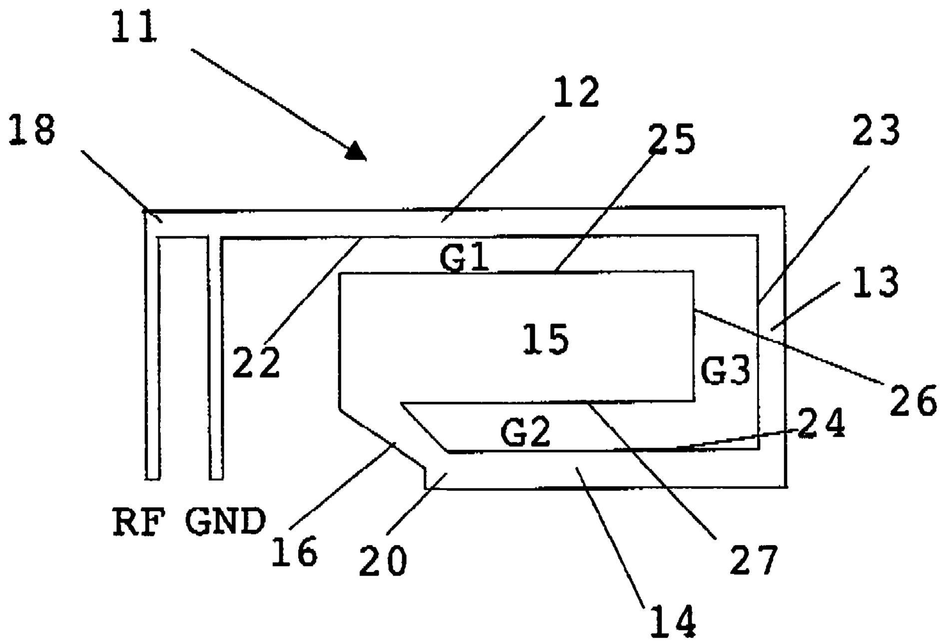

FIG. 2

EP 2 081 253 A1

Description

FIELD OF INVENTION

[0001] The present invention relates generally to antenna devices and more particularly to an antenna device for a portable radio communication device operable in at least two different frequency bands, such as in mobile phones. The invention also relates to a portable radio communication device comprising such an antenna device.

BACKGROUND

[0002] Internal antennas have been used for some time in portable radio communication devices. There are a number of advantages connected with using internal antennas, of which can be mentioned that they are small and light, making them suitable for applications wherein size and weight are of importance, such as in mobile phones. A type of internal antenna that is often used in portable radio communication devices is the monopole antenna. Such a solution is for instance known from EP 1858115.

[0003] However, the monopole antenna is inherently resonant in one frequency band. If multi-band operation is required, wherein the antenna is adapted to operate in two or more spaced apart frequency bands, two antenna branches with different resonance frequencies can be provided. It is here also possible to provide multi-band functionality with a PIFA structure.

[0004] In a typical dual band phone, the lower frequency band is centered on 900 MHz, the so-called GSM 900 band, whereas the upper frequency band is centered around 1800 or 1900 MHz, the DCS and PCS band, respectively. If the upper frequency band of the antenna device is made wide enough, covering both the 1800 and 1900 MHz bands, a phone operating in three different standard bands is obtained. However, with today's high demands on functionality, antenna devices operating in four or even more different frequency bands are sometimes in demand. With the limitations regarding cost and size of antenna devices this quad band operation is difficult to achieve.

[0005] When providing such multi-band functionality or only dual-band functionality, it is furthermore hard to make the lower band be as wide as may be desired.

[0006] A problem in prior art antenna devices is thus to provide a multi-band antenna covering at least two frequency bands with a small size and volume and broad frequency bands which retains good performance and then especially has good coverage of the lowest band.

SUMMARY OF THE INVENTION

[0007] An object of the present invention is to provide an antenna device of the kind mentioned above having at least dual-band functionality together with improved low band coverage while still keeping the overall size of the antenna device small.

[0008] Another object is to provide an antenna device having better dual-band performance than prior art devices.

[0009] The invention is based on the realization that improved dual-band functionality can be provided in an antenna device by providing an electrically conductive radiating element having an electrical length selected to provide resonance in a first frequency band. The element includes a first elongated section having a first end in the direction of elongation, a second opposite end and a first edge joining the first end to the second end, where the first end is closer to the feed point than the second end in the electrical path of the first element. The element also includes a second section joined to the second end of the first section via an interconnecting section and having a second edge facing, displaced from and stretching along the first edge of the first section. In this way a gap is formed between the first and second sections. The dimensions of this gap are defined by the first edge of the first section and the second edge of the second section, together with the displacement of the second edge from the first edge. The dimensions of the gap are furthermore selected to provide resonance of the electrically conductive radiating element at least in a first frequency band in the second set.

[0010] According to a first aspect of the present invention there is provided an antenna device as defined in claim 1.

[0011] According to a second aspect of the present invention there is provided portable radio communication device as defined in claim 16.

[0012] Further preferred embodiments are defined in the dependent claims.

[0013] The invention provides an antenna device and a portable radio communication device wherein the problem of retaining good performance in a first set of lower frequencies when providing antenna performance in a second set of higher frequencies is solved through using an electrically conductive radiating element having a length that provides coverage of the first set of lower frequencies and through a gap between a first and a second section of this element that provides coverage of the second set of higher frequencies.

[0014] According to one embodiment of the present invention an antenna device and a portable radio communication device provides coverage of further or wider bands within each set by means of providing a switch. Thus, there is provided a small sized low cost multi-band antenna device operable in two sets of frequency bands.

BRIEF DESCRIPTION OF DRAWINGS

[0015] The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is an overall view of a portable radio communication device comprising an antenna device according to the invention;

Fig. 2 shows a schematic diagram of a first embodiment of an antenna device according to the invention;

Fig. 3 shows a schematic diagram of a second embodiment of an antenna device according to the invention including a parasitic element; and

Fig. 4 shows a schematic diagram of a third embodiment of an antenna device according to the invention with a parasitic element as well as with two conductors of differing lengths and a switching element.

DETAILED DESCRIPTION OF THE INVENTION

[0016] In the following, a detailed description of preferred embodiments of an antenna device according to the invention will be given. In the description, for purposes of explanation and not limitation, specific details are set forth, such as particular hardware, applications, techniques etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to one skilled in the art that the present invention may be utilized in other embodiments that depart from these specific details. In other instances, detailed descriptions of well-known methods, apparatuses, and circuits are omitted so as not to obscure the description of the present invention with unnecessary details.

[0017] Fig. 1 shows the outlines of a portable radio communication device 1, such as a mobile phone. An antenna device 10 is arranged at the top of the communication device, adjacent to a printed circuit board (PCB) 2, and being connected to RF feeding and grounding devices (not shown). As an alternative it should be realised that the antenna device may be provided for instance also at the bottom of the communication device.

[0018] In fig. 2, there is shown the antenna device according to a first embodiment of the present invention, which in this first embodiment comprises an elongated electrically conductive radiating element 11 made of an electrically conductive material, such as copper, as is conventional. This material may furthermore be provided on a flex film, which may in turn be bent or folded in order to fit within the portable radio communication device. The antenna device is in this embodiment an IFA antenna and therefore it includes two legs, one for connection to a feed point where a radio signal RF is provided, for instance by RF circuitry in the portable radio communication device 1 shown in fig 1. The other leg is to be connected to ground GND. The radiating element 11 includes a first elongated section 12, 13 and 14 that is at a first end 18 joined to the feeding and grounding legs and in an opposite end 20 joined to an interconnecting section 16. The first section is here furthermore provided with a first edge 22, 23 and 24, which joins the first end 18 to the second end 20. Since it is of an electrically conductive material, the first section 12, 13 and 14 provides an electrical path from the feeding legs to the interconnecting section 16.

[0019] The electrically conductive radiating element 11 also has a second section 15 that is joined to the second end 20 of the first section via the interconnecting section 16. The second section 15 here has a second edge 25, 26, 27 that faces, is displaced from and stretches along the first edge 22, 23, 24 of the first section 12, 13, 14. In this way there is formed a gap G1, G2, G3 between the first and-second sections. The dimensions of this gap G1, G2, G3 are defined by the first edge of the first section and the second edge of the second section, together with the displacement of the second edge from the first edge. The dimensions can also be seen as being defined by the amount of overlap between the first edge of the first section and the second edge of the second section together with said displacement of the second edge from the first edge.

[0020] The first section in the embodiment in fig. 2 does furthermore have a first part 12 that is straight and preferably has a bar shape. This first part 12 of the first section may furthermore be provided at right angles to the feeding and grounding legs. The first part 12 of the first section is provided with a first side 22 of the first edge, which is also straight, and which is part of the interconnection between the first and second ends 18 and 20. The feeding and grounding legs are here joined to the first side 22 of the first edge. The first end 18 is, as can bee seen in fig. 2, closer to the feed point RF than the second end 20 in the electrical path of the first section. In the first embodiment the first section furthermore has a second straight part 13 which is perpendicular to the first part 12 and stretches from the end of the first part 12 of the first section being furthest from the first end 18 and in parallel with the feeding and grounding legs into a further third straight bar shaped part 14 leading back in a direction towards the feeding and grounding legs. The first edge therefore also has a second side 23 that bounds off the second part 13 and a further third side 24 that bounds of the further third part 14. Consequently the first edge has the first side 22 associated with the first part 12 and being joined at right angles to a second side 23 that is associated with the second part 13 followed by the further third side 24 associated with the further third part 14. Here the first, second and third sides define an enclosure.

[0021] The third straight bar shaped part 14 of the first section is followed by the interconnecting section 16, which in this embodiment is angled inwards towards the first part 12 of the first section. This angled interconnecting section 16 is joined to a first end of the second section 15, whose first end makes up one short side of the rectangle, where one of the long sides of the rectangle is said first straight side 25 and the other long side is a second straight side 27. These are joined by a second short side 26. The first and second straight sides 25 and

27 together with the second short side 26 here make up the second edge. The second section 15 therefore stretches from the interconnecting section 16 in parallel with the first part 12 of the first section in a direction away from the feeding and grounding legs into the enclosure, i.e. in a direction towards the second part 13 of the first section.

[0022] The second section 15, is in this embodiment provided on the same side of the first section as the feeding legs. The first straight side 25 of the second edge faces the first side 22 of the first edge. This first side 25 of the second edge is furthermore displaced a distance from the first side 22 of the first edge and stretches in parallel with it. In this way there is formed a first section G1 of the gap between the first straight side 25 of the second edge and the first straight side 22 of the first edge. The first section G1 of the gap is thus defined by the first side 22 of the edge or the first 25 side of the second edge, whichever is shortest and the width of it is defined by the distance between these sides. Here the first straight side 25 of the second edge is shortest and thus this side determines the length of the first section G1 of the gap.

[0023] Through the provision of the interconnecting section 16 and the third part 14 of the first section, there is provided a second section G2 of the gap between the second straight side 27 of the second edge and the third side 24 of the first edge provided on the straight bar shaped third part 14 of the first section and facing the second section 15. Thus this third straight side 24 of the first edge faces, is displaced a distance from and stretches in parallel with the second straight side 25 of the second edge for forming this second section G2 of the gap. The length of this second section G2 of the gap is defined by the second side 27 of the second edge or the third straight side 24 of the first edge, whichever is shortest, while the width of the second section G2 of the gap is defined by the distance between these sides. Here the second straight side 27 of the second edge is shortest and thus this side determines the length of the second section G2 of the gap. Finally there is a third part G3 of the gap, which is being defined by the length of the second side 23 of the first section and the second short side 26 of the second section in the same way as the first and second sections G1 and G2 of the gap.

[0024] The whole length of the electrically conductive radiating element 11, i.e. the length made up by the first section 12, 13, 14, the interconnecting section 16 and the second section 15 provides an electrical length that has been selected to provide resonance in a first set of frequency bands that here only includes a first frequency band. The dimensions of the gap are here selected to provide resonance of the electrically conductive radiating element 11 in a second set of higher frequency bands, which second set includes at least one first frequency band. the length and the width of the first section G1 of the gap is of importance in this selection. Also the length and the width of the second section G2 of the gap is of importance for providing this resonance . The second set of frequency bands may in this embodiment furthermore include more than one frequency band.

[0025] In this way an antenna that covers more than one frequency band is provided that provides good performance in the second set of frequency bands while retaining a good performance in the first set of frequency bands. It is improved for instance in relation to dual monopole or dual band PIFA designs. The first frequency band of the first lower set of frequency bands may here be the 850 or 900 MHz band, while the second set of frequency bands may include the 1800 and/or 1900 MHz band.

[0026] It should here be realised that as long as the required electrical length of the radiating element is obtained, the shape of the first, second and interconnecting sections can be varied in a multitude of ways. They do for instance not have to be straight. It is for instance possible that one or more of the sections have meandering shape. The number of sections in the gap can vary from one to several. Each such section may furthermore have varying shape and varying displacement of the second section from the first section. The width of a section can thus be variable.

[0027] In fig. 3 there is shown an antenna device according to a second embodiment of the present invention. This embodiment is similar to the first embodiment in that it includes the same radiating element 11. However it also includes a parasitic element 30. This parasitic element 30 is a conductive elongated parasitic element 30 provided close to the feeding and grounding legs of the radiating element. Thus it is also provided close to the first end of the first section 12 of the radiating element 11. This parasitic element 30, which is grounded in one end, broadens the frequency bands in the second set of frequency bands covered by the radiating element 11 through the use of the gap.

[0028] In fig. 4, there is shown an antenna device according to a third embodiment of the present invention. Here there is a radiating element 11 made up of the first 12, 13, 14, second 15, and intermediate 16 sections, , as in the first and second embodiments together with a parasitic element 30 as in the second embodiment. Here it should also be realized that the parasitic element may be omitted. Also this antenna is an IFA antenna.

[0029] The first section 12 of the radiating element 11 is at the first end 18 connected to a first elongated conductor 32. The first conductor 32 is in turn connected to the source of radio frequency signals RF, such as RF circuitry in the portable radio communication device 1 shown in Fig. 1.

[0030] The first conductor 32 and the radiating element 11, which are connected in series, are together arranged to resonate in a first lower frequency band in the first set of frequency bands, such as the GSM 850 band, as well as in a first higher frequency band in a second set of frequency bands, such as the GSM 1800 MHz band. It should here be realized that resonance may be provided also in a second higher frequency band in the second set such as in the 1900 MHz band.

[0031] A second conductor 34 is connected in parallel with the first conductor, the second conductor being electrically shorter than the first conductor 32. A switch element SW is provided in series with this second conductor. This switch element may be of an on/off nature, such as a single pole, single throw (SPST) switch.

[0032] A high pass filter F1 is also provided between the first and second conductors, the function of which will be explained below. This high pass filter may be implemented through a capacitance. Finally both the first and second conductors 32, 34 are connected to ground via a low pass filter F2. The low pass filter F2 can be arranged either in the antenna device itself or in electronic circuitry arranged on the PCB 2.

[0033] A DC control input, designated V_{Switch} in the figure, for controlling the operation of the switch SW is connected to the RF input via a filter block (not shown) in order to not affect the RF characteristics of the antenna device. This means that the filter characteristic of this filter block is designed so as to block all radio frequency signals. In the embodiment in fig. 4, the filter block comprises a low pass filter. The control signal V_{Switch} is used for opening and closing the switch SW.

[0034] The above mentioned filter block may be arranged in electronic circuitry arranged on the PCB 2.

[0035] The antenna is preferably designed to 50 Ohms.

[0036] With the switch closed, the electrical length of the second conductor 34, which is shorter than the first conductor 32, will determine the total electrical length of the antenna device. Thus, the second conductor 34 and the radiating element 11, which are connected in series, are together arranged to resonate in a second frequency band of the first set of frequency bands, such as the GSM 900 band. The first conductor 16 and the radiating element 11 are also arranged to modify the frequency range of the second higher set of frequency bands through this change of electrical length.

[0037] In summary, the size and configuration of the radiating element 11 and the two conductors 32, 34 are chosen so as to obtain the desired resonance frequencies, such as the first frequency band of the first set of frequency bands and at least the first frequency band of the second set of frequency bands, with the switch open, and the second frequency band of the first set of frequency bands and at least the second frequency band of the second set of frequency bands, with the switch closed. Here it should be realized that the change of length of the conductors can also be provided through the use of an inductor in series with a conductor.

[0038] This change of geometry of the effective radiating elements adjusts the resonance frequencies of the antenna device. This means that an antenna device that can operate in four different frequency bands is obtained, such as the above mentioned 850/900/1800/1900 MHz bands.

[0039] The parasitic element 30, which may as an alterative be omitted, does in this third embodiment provide a broadening of the frequency bands covered in the second set of frequency bands through the use of the first and second gaps. This may be used to additionally cover further high frequency bands, such as the Bluetooth frequency band operating around 2.4 GHz or the WCDMA frequency bands around 2 GHz ().

[0040] The adjustment of the resonance frequencies can be used to an advantage in so-called fold phones. In this kind of communication devices, the resonance frequency of an internal antenna element tends to move downwards in frequency when the position of the phone is changed from folded to unfolded mode. With the antenna device according to the third embodiment, when the phone is unfolded, the movement of the resonance frequencies can be counteracted by closing the switch SW. The antenna device then operates as a dual band antenna with essentially constant resonance frequency irrespective of the operating mode of the communication device (folded/unfolded).

[0041] The adjustment of the resonance frequencies can also be used to an advantage in dual band bar phones. In the frequency bands used for mobile communication, the transmit (TX) and receive (RX) frequencies are separated by approximately 45-90 MHz. By using frequency adjustment, near optimum efficiency can be obtained by adjusting the frequencies to the TX and RF frequencies instead of the broader frequency band incorporating the TX and RX frequencies.

[0042] It is possible to provide the switching element as a PIN diode. The switching of the antenna device then functions as follows. The RF source and other electronic circuits of the communication device operate at a given voltage level, such as 1.5 Volts. The criterion is that the voltage level is high enough to create the necessary voltage drop across the PIN diode, i.e. about 1 Volt. This means that the control voltage V_{Switch} is switched between the two voltages "high" and "low", such as 1.5 and 0 Volts, respectively. When V_{Sitch} is high, there is a DC current flowing from the DC control input, through the low pass filter and switch SW and part of the second conductor 34, and finally through the low pass filter F2 and to ground. This DC current creates a voltage drop across the switch SW and a corresponding current there through of about 5-15 mA. This voltage drop makes the diode conductive, effectively making the second conductor 34 conductive with respect to RF signals. With the control voltage V_{Switch} "low", there is an insufficient voltage drop across the PIN diode SW to make it conductive, i.e., it is "open", effectively blocking any RF signals in the second conductor 34.

[0043] In one variation of the present invention there may be provided a second switching element in the form of an additional PIN diode provided between the high pass filter F1 and the first conductor 32 at an end of the second conductor opposite to where the first switch element SW is provided. This improves the decoupling of the second conductor 34 when operating with the switch-es open.

[0044] For the purpose of matching ground may be connected to the antenna device via an inductor or a capacitor. These may furthermore be variable. In the case of an inductor, this may furthermore be provided as a part of the second filter block F2.

[0045] Preferred embodiments of an antenna device according to the invention have been described. However, it will be appreciated that these can be varied within the scope of the appended claims. Thus, a GaAs switch or a PIN diode switch have been described. It will be appreciated that other kinds of switch elements can be used as well. The placing of the switch may furthermore be made in a multitude of ways. It can for instance as an alternative be placed in the first conductor. The important thing is that it connects the radiating element with one of the conductors based on which frequency range that is to be covered.

[0046] Therefore the present invention is only to be limited by the following claims.

Claims

1. An antenna device (10) for a portable radio communication device (1) operable in a first set of frequency bands and a second set of frequency bands, where each set includes at least one frequency band, the antenna device comprising:

- an electrically conductive radiating element (11) for connection to an antenna feed point and having an electrical length selected to provide resonance at least in a first frequency band in the first set;
- where said electrically conductive radiating element comprises a first elongated section (12, 13, 14) having a first end (18) in the direction of elongation, a second opposite end (20) and a first edge (22, 23, 24) joining the first end to the second end, where said first end (18) is closer to the feed point than the second end (20) in the electrical path of the first element,
- said electrically conductive radiating element having a second section (15) joined to the second end (20) of the first section via an interconnecting section (16) and having a second edge (25, 26, 27) facing, displaced from and stretching along the first edge (22, 23, 24) of the first section (12, 13, 14), thereby forming a gap (G1, G2, G3) between the first and second sections,
- wherein the dimensions of said gap (G1, G2, G3) are defined by the first edge of the first section and the second edge of the second section, together with the displacement of the second edge from the first edge, where the dimensions of the gap are selected to provide resonance of the electrically conductive radiating element at least in a first frequency band in the second set.

2. The antenna device (10) according to claim 1, wherein the second section is the last section of the electrically conductive radiating element in the electrical path of the radiating element (11).

3. The antenna device (10) according to any previous claim, wherein said first section has a first part (12) provided at said first end (18), the first edge comprises a first side (22) of this first part and the second edge has a first side (25) facing, displaced a distance from and stretching in parallel with the first side (22) of the first edge, thereby forming a first section (G1) of the gap between the first and second sections, where the length of said first section (G1) of the gap is defined by the first side (22) of the first edge or said first side (25) of the second edge, whichever is shortest, the width of the first section of the gap is defined by the distance between these sides and the length and the width of the first section of the gap are selected to provide resonance of the first electrically conductive radiating element at least in a first frequency band in the second set.

4. The antenna device (10) according to claim 3, wherein the second edge includes a second side (27) and the first section (12) includes a further part (14) and the first edge comprises a further side (24) of this further part that faces, is displaced a distance from and stretches in parallel with the second side (27) of the second edge, thereby forming a second section (G2) of the gap between the first and second sections, the length of said second section of the gap being defined by the second side of the second edge or said further side of the first edge, whichever is shortest, the width of the second section of the gap being defined by the distance between these sides, and the length and the width of the second gap being selected to provide resonance of the first electrically conductive radiating element at least in the second frequency band in the second set.

5. The antenna device (10) according to any previous claim, wherein at least the first set includes two different frequency bands and the device further comprises a first and a second conductor (32, 34) between the radiating element (11) and the feeding point, where the second conductor (34 has an electrical length that is shorter than the electrical length of the first conductor (32), as well as a first switching element (SW) for selectively connecting either the first or the second conductor to the radiating element.

6. The antenna device (10) according to claim 5, wherein said first switching element (SW) is provided in series with the second conductor.

7. The antenna device (10) according to claim 6, wherein, said first switching element is controllable by a current flowing through the switching element.

8. The antenna device (10) according to any of claims 5 - 8, further comprising a first filter block (F1) provided between the first and second conductors, said first filter block being arranged to block signals with a frequency lower than the different frequency bands of the two sets.

9. The antenna device (10) according to claim 8, further comprising an adjustable inductor between the conductors and ground, wherein the adjustable inductor is arranged for allowing matching of the antenna device to be made.

10. The antenna device (10) according to any of claims 5 - 9, further comprising a further filter block arranged between the first conductor and a control voltage input (V_{Switch}) for the first switching element.

11. The antenna device (10) according to any of claims 5 - 10, wherein the first switching element (SW) comprises a PIN diode.

12. The antenna device (10) according to any of claims 5 - 10, wherein the first switching element (SW) comprises a GaAs switch.

13. The antenna device (10) according to any previous claim, wherein the first radiating element (11) is at least a part of an inverted F antenna.

14. The antenna device (10) according to any of claims 5 - 13, further comprising a second switching element provided between the first filter block (F1) and the first conductor (32) at an end of the second conductor opposite to where the first switching element (SW) is provided.

15. The antenna device (10) according to any previous claim, further comprising a conductive parasitic element (30) provided close to the first end (18) of the first section (12) of the radiating element (11).

16. A portable radio communication device (1) comprising an antenna device (10) operable in a first set of frequency bands and a second set of frequency bands, where each set includes at least one frequency band, the antenna device comprising:

- an electrically conductive radiating element (11) for connection to an antenna feed point and having an electrical length selected to provide resonance at least in a first frequency band in the first set;
- where said electrically conductive radiating element comprises a first elongated section (12, 13, 14) having a first end (18) in the direction of elongation, a second opposite end (20) and a first edge (22, 23, 24) joining the first end to the second end, where said first end (18) is closer to the feed point than the second end (20) in the electrical path of the first element,
- said electrically conductive radiating element having a second section (15) joined to the second end (20) of the first section via an interconnecting section (16) and having a second edge (25, 26, 27) facing, displaced from and stretching along the first edge (22, 23, 24) of the first section (12, 13, 14), thereby forming a gap (G1, G2, G3) between the first and second sections,
- wherein the dimensions of said gap (G1, G2, G3) are defined by the first edge of the first section and the second edge of the second section, together with the displacement of the second edge from the first edge, where the dimensions of the gap are selected to provide resonance of the electrically conductive radiating element at least in a first frequency band in the second set.

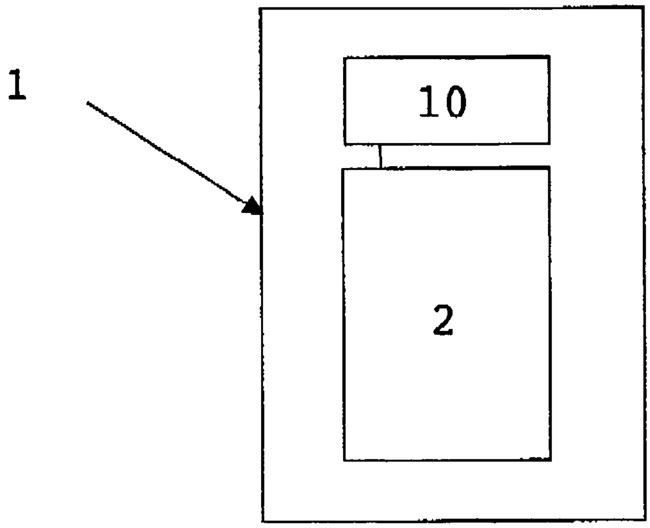

FIG. 1

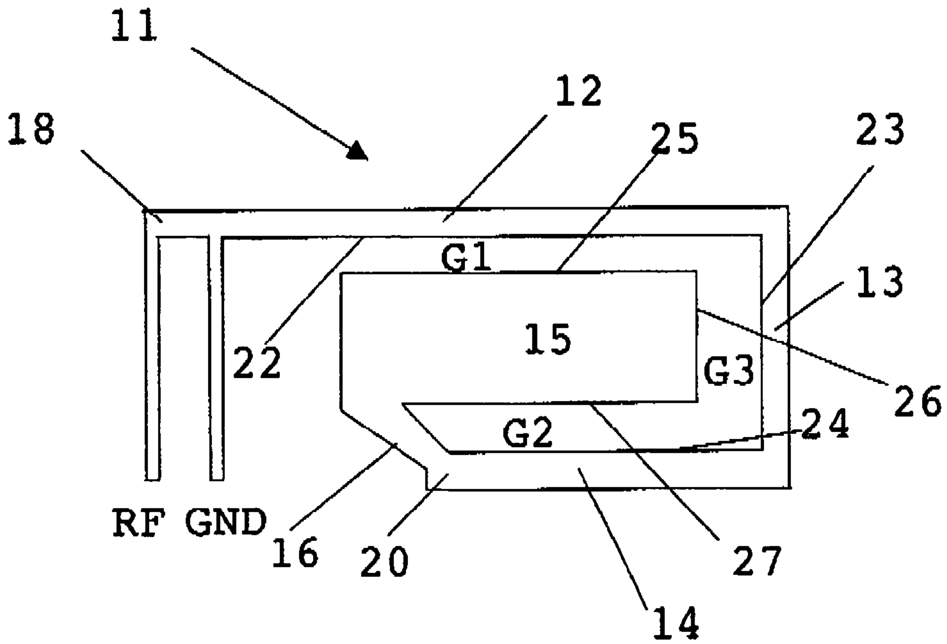

FIG. 2

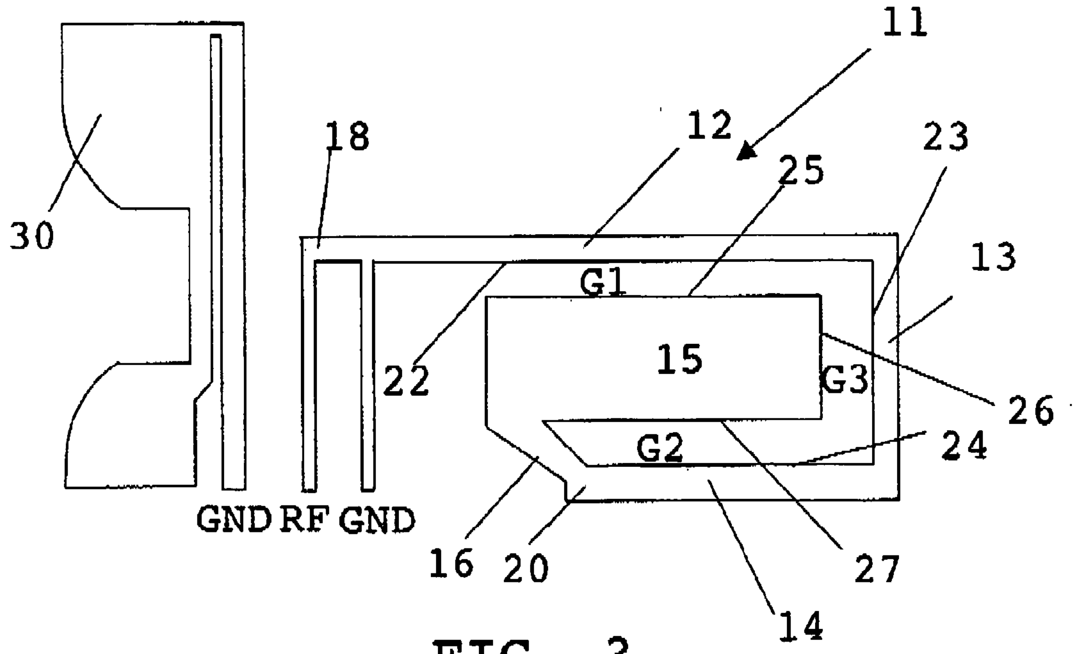
11
12
18
25
23
13
30
G1
22
15
G3
26
G2
24
GND RF GND
16
20
27
14

FIG. 3

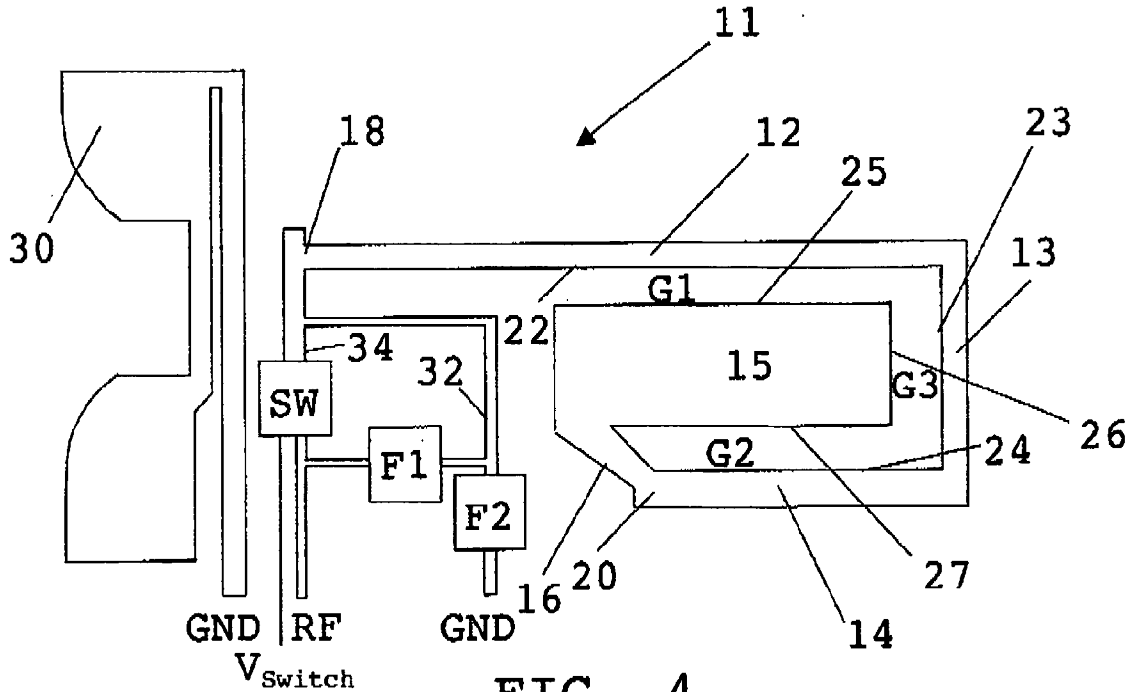
11
18
12
23
25
13
30
G1
22
34
15
32
SW
G3
26
G2
24
F1
F2
20
27
16
GND
RF
GND
14
V_{Switch}

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 00 0929

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	WO 2004/114464 A (SIEMENS AG [DE]; PAN SHENG-GEN [DE]; PAN PATRICK [DE]) 29 December 2004 (2004-12-29) * abstract; claim 1; figure 1 * * page 6, line 11 - page 8, line 4 * -----	1-3,16	INV. H01Q9/04
X	WO 03/094290 A (KONINKL PHILIPS ELECTRONICS NV [NL]; BOYLE KEVIN R [GB]) 13 November 2003 (2003-11-13) * abstract; figures 1,2,5 * * page 4, column 15 - page 6, column 28 * -----	1-4,16	
A	WO 2007/012697 A (PULSE FINLAND OY [FI]; MILOSAVLJEVIC ZLATOLJUB [FI]; LESKELAE ANTTI [F) 1 February 2007 (2007-02-01) * abstract; figures 3,4 * * page 5, line 29 - page 8, line 21 * -----	1-16	
A	WO 01/91235 A (ERICSSON TELEFON AB L M [SE]; HAYES GERARD JAMES [US]; SADLER ROBERT A) 29 November 2001 (2001-11-29) * abstract; figures 4,5 * * page 11, line 6 - page 16, line 21 * -----	1-16	TECHNICAL FIELDS SEARCHED (IPC)
			H01Q
A	WO 01/29927 A (SIEMENS AG [DE]; SCHREIBER MICHAEL [DE]; HUBER STEFAN [DE]) 26 April 2001 (2001-04-26) * abstract; figures 1,2 * * page 5, line 27 - page 8, line 17 * -----	1-16	
A	EP 1 662 608 A (NIPPON ELECTRIC CO [JP]) 31 May 2006 (2006-05-31) * abstract; figures 2,3 * * paragraphs [0012] - [0014] * -----	1-16	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	23 April 2008	Unterberger, Michael

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

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 00 0929

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

23-04-2008

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 2004114464	A	29-12-2004	CN	1813376	A	02-08-2006
			DE	10328361	A1	20-01-2005
			EP	1654781	A1	10-05-2006
			US	2007035446	A1	15-02-2007
WO 03094290	A	13-11-2003	AT	332017	T	15-07-2006
			AU	2003226592	A1	17-11-2003
			CN	1650469	A	03-08-2005
			DE	60306513	T2	21-06-2007
			EP	1502322	A1	02-02-2005
			JP	2005524322	T	11-08-2005
			US	2006055606	A1	16-03-2006
WO 2007012697	A	01-02-2007	EP	1908146	A1	09-04-2008
WO 0191235	A	29-11-2001	AT	285127	T	15-01-2005
			AU	5704401	A	03-12-2001
			DE	60107838	D1	20-01-2005
			DE	60107838	T2	16-06-2005
			EP	1287587	A1	05-03-2003
			TW	513831	B	11-12-2002
			US	6662028	B1	09-12-2003
WO 0129927	A	26-04-2001	NONE			
EP 1662608	A	31-05-2006	CN	1780055	A	31-05-2006
			JP	2006148728	A	08-06-2006
			US	2006109180	A1	25-05-2006

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 1858115 A **[0002]**