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(54) **Multi-band antenna device, parasitic element and communication device**

(57) The invention relates to an antenna device for a communication device operable in at least two frequency bands. The antenna device (1) comprises a generally planar driven radiating element (2) having a feeding portion (5) connectable to a feed device of the communication device (20) and a generally planar parasitic element (3, 3') having a grounding portion (G) connectable to a ground device of the communication device (20). The driven radiating element (2) and the parasitic element (3, 3', 3") are essentially coplanar and separated by a gap (7). In accordance with the invention the parasitic element (3, 3', 3") comprises a slit (6, 6'), by means of which a double-resonance is provided in a first frequency interval. The invention also relates to a parasitic element and to a communication device comprising such an antenna device.

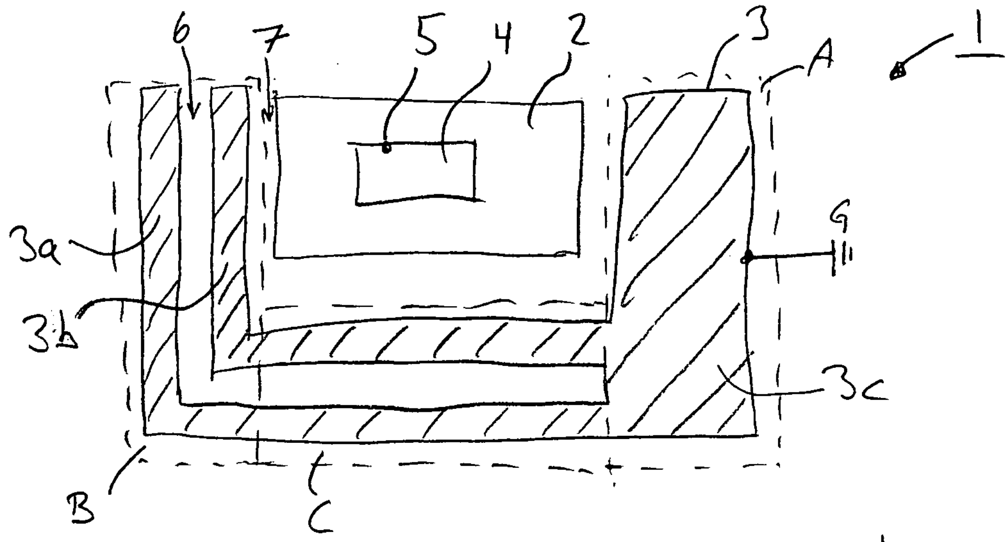

Fig. 1

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Description

Field of the invention

[0001] The invention relates to the field of antennas, and in particular to microstrip antennas comprising a driven element and a parasitic element. The invention also relates to a parasitic element and to a communication device comprising such antenna device.

Background of the invention

[0002] In the ever-increasing use and development of wireless communication systems, the demand for small and compact portable devices is likewise increasing. The miniaturization is possible owing to the rapidly reducing physical size and cost of wireless electronic components, this in turn enabled by the progress and technological improvements made in microelectronic technologies, such as semiconductors, packaging and interconnection technologies.

[0003] Antennas constitute a crucial part of such wireless communication system, and there is a corresponding desire to reduce their cost and size. The physical size of an antenna is not as much related to the improvements of the manufacturing methods used, as to the operating frequency or wavelength of the system in which it is to be used. Accordingly, as portable devices, such as mobile phones, become smaller and smaller, new requirements are placed on miniaturizing the antennas to be used within such devices as well.

[0004] The desire for smaller antennas is valid also for dual-band and multi-band wireless communication, although the communication devices are again getting somewhat larger with the introduction of this multi-band wireless communication system. The need to fit two or more antenna systems within the communication devices requires this size increase, unless the antennas cannot be made smaller. Making antennas smaller include several challenges, as the performance of the antenna should not be allowed to decrease. The cost of the antenna is also a very important consideration.

[0005] The bandwidth of an antenna is the range of frequencies over which it is effective, usually centred around the resonance frequency. The bandwidth of an antenna is an important aspect in antenna design, and may be increased by several techniques. For example, multiple antennas can be combined into a single assembly and allowing the natural impedance to select the correct antenna. Another way to improve the bandwidth for a specific resonance frequency is to use a parasitic element, an example being the use of a planar inverted F antenna (PIFA) with a parasitic element. However, in a multi-band application such a solution requires multiple parasitic elements, which in turn increases the size of the antenna device.

[0006] In view of the above it would be desirable to provide an antenna structure suitable for multi-band applications and which antenna structure does not entail an increased size of the communication device in which it is to be used.

Summary of the invention

[0007] It is a general object of the invention to provide a small-sized antenna device suitable for multi-band applications.

[0008] It is another object of the invention to provide an antenna device having wider bandwidth than comparable antenna devices with similar size.

[0009] It is yet another object of the invention to provide an antenna device providing well defined operating frequency bands.

[0010] It is still another object of the invention to provide an antenna device having a more space efficient design.

[0011] Further, it is an object of the invention to provide a parasitic element design enabling a space efficient solution.

[0012] Another object is to provide a radio communication device comprising such an antenna device.

[0013] These objects, among others, are achieved by an antenna device, by a parasitic element and by a communication device as claimed in the independent claims.

[0014] In accordance with the invention, an antenna device is provided suitable for a communication device operable in at least two frequency intervals. 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 of the invention comprises a slit, by means of which a double-resonance is provided in a first frequency interval of the frequency intervals in which the communication device is operable. In accordance with the invention, an increased bandwidth is provided by means of the parasitic element, without the drawbacks of using several separate parasitic elements. The inventive antenna device provides a more space efficient solution than known devices. Further, the inventive antenna device does not require separate groundings for the different parasitic elements. This feature, besides again providing a more space efficient solution, minimizes the manufacturing and assembly costs.

[0015] In various embodiments of the invention, the parasitic element comprises one or more slits arranged in different ways. The invention thus provides a flexible antenna device, which may easily be adapted for use in different communication devices. The double-resonance can for example be provided in a lower frequency interval, in a higher frequency interval or in both the lower and the higher frequency intervals.

[0016] In accordance with an embodiment of the communication device comprising the antenna device, the antenna device is arranged in a novel way. In particular, the antenna device is arranged with the driven radiating element arranged closest to the upper part of the communication device and the parasitic element surrounding the driven radiating element on the lower and vertical sides thereof. Improved radiation patterns are thereby obtained.

[0017] Further preferred embodiments are defined in the dependent claims.

[0018] The invention also relates to a radio communication device comprising such an antenna device whereby advantages similar to the above are achieved.

[0019] Further characteristics of the invention, and advantages thereof, will be evident from the following detailed description of embodiments of the present invention and the accompanying figures, which are given by way of illustration only and are not to be construed as limitative of the invention.

Brief description of the drawings

[0020]

Figure 1 illustrates an embodiment of an antenna device in accordance with the invention.

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

Figure 3 illustrates another embodiment of the antenna device in accordance with the invention.

Figure 4 illustrates schematically a frequency diagram for the antenna device of figure 3.

Figure 5 illustrates still another embodiment of the antenna device in accordance with the invention.

Figure 6 illustrates schematically a frequency diagram for the antenna device of figure 5.

Figure 7 illustrates a communication device comprising the antenna device.

Detailed description of embodiments

[0021] The invention will now be described with reference first to figure 1. 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.

[0022] The driven radiating element 2 is connected to a feed portion electrically connectable to radio frequency (RF) circuitry of an underlying printed circuit board (PCB) 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 of the driven radiating element 2. The contact pin 5 is preferably, but not necessarily, located on the edge of an opening or aperture 4 in the central part of the driven radiating element 2. The driven radiating element 2 is thus fed via the contact pin 5. The aperture 4 is used in order to increase the electrical size of the patch antenna.

[0023] The PCB of the communication device also functions as a ground plane for the internal antenna device 1, in the described embodiments a modified patch antenna.

[0024] 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 is connected to a grounding portion, indicated in the figure at G. The parasitic element 3 has a general shape resembling a "C" turned 90 degrees counter-clockwise. That is, the parasitic element 3 comprises two parallel planar portions. For illustration purposes, the two parallel planar portions of the parasitic element 3 are indicated as portions A, B surrounded by dashed lines. The two parallel planar portions A, B are interconnected by means of a third planar portion C, also surrounded by dashed lines for illustration. The planar portion C is thus perpendicular to the two parallel planar portions A, B. However, it is to be noted that the parasitic element 3 is preferably made in a single piece, for example stamped out from a suitable material. The shape of the parasitic element 3 can thereby be made to conform to the shape of the driven radiating element 2 when the driven radiating element 2 has a rectangular or square shape. The parasitic element 3 thus partially surrounds the driven radiating element 2 on three of the four sides of the driven radiating element 2. Stated differently, the parasitic element 3 is arranged along three sides of the driven radiating element 2. There is a gap 7 between the driven radiating element 2 and the parasitic element 3.

[0025] The driven radiating element 2 and the parasitic element 3 are supported by a frame made of a 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 PCB of the communication device.

[0026] The antenna device 1 is a multi-band antenna. In a way that is know 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 multiband communication device adapted for the GSM850, GSM900 and/or GSM1800/GSM1900/WCDMA2100 bands.

[0027] Regarding adjustment of the resonance frequency, reference is made to International publication WO 02/50948, incorporated herein by reference. Briefly, the capacitive coupling between the driven radiating element 2 and the parasitic element 3 can be used for determining the characteristics of the antenna device 1. The shape of the driven radiating element 2 can be adjusted in a controlled way in order to obtain the desired antenna characteristics. For example, the width of the gap 7 between the driven radiating element 2 and the parasitic element 3 can be altered; if, for example, the width of the driven radiating element 2 is decreased, then the size of the gap 7 between the radiating driven element 2 and the parasitic element 3 is increased and thereby the resonance frequency of an upper band is lowered. The size of the slit 6 also affects the antenna characteristics.

[0028] With reference again to figure 1, the above is described somewhat more in detail: the width of the gap 7 lying closest to part A in combination with the distance from the grounding portion G to the upper part of branch 3c, determines the resonance frequency for the higher frequency band/bands. The width of the gap 7 lying closest to the branches 3a and 3b (i.e. closest to part B) and the respective lengths of branches 3a and 3b, determines the resonance frequency for the lower frequency band/bands. The width of the gap 7 lying closest to part C controls the resonance frequencies for both the upper and lower frequency bands.

[0029] In accordance with the invention, the parasitic element 3 is slitted or branched. The slit is indicated at reference numeral 6. By means of the slit 6, the parasitic element 3 comprises frequency specific branches 3a, 3b, 3c originating from the grounding portion G, or from a common branch of the parasitic element 3. Providing the parasitic element 3 with a slit 6 as shown in the figure enables a double-resonance for the lower frequency band. For example, resonance frequencies of 850 MHz and 900 MHz may be provided in the lower frequency band.

[0030] The resonance frequencies of the parasitic element 3 are dependent on the interrelation of the dimensions of the element branches 3a, 3b, 3c.

[0031] The parasitic element 3 can be used to widen one or several of the operating frequency bands. The resonating frequencies of the driven radiating element 2 and the parasitic element branches 3a, 3b, 3c are then made somewhat different, in a manner know as such. Due care should be taken so that the matching of the antenna device 1 remains good enough over the whole range between the resonating frequencies.

[0032] Figure 2 illustrates schematically curves representing voltage standing wave ration (VSWR) as a function of frequency. The resonance frequencies obtained in the lower frequency band by means of the antenna device 1 shown in figure 1 is indicated schematically. No specific frequencies are indicated in the figure, but it should be evident that any desired resonance frequencies can be obtained by altering the dimensions of and distances between the radiating elements 2, 3.

[0033] Figure 3 illustrates another embodiment of the parasitic element of the antenna device 1'. In the figure same reference numerals are used as in figure 1, for denoting same elements. The slit 6' of the parasitic element 3' in this embodiment is arranged at the other, higher frequency band, thereby providing a double-resonance at the higher frequency band interval instead.

[0034] Figure 4 is similar to figure 2, and illustrates schematically curves representing VSWR as a function of frequency. The resonance frequencies obtained in the higher frequency band by means of the antenna device 1' shown in figure 3 is indicated schematically. Again, specific frequencies are not indicated in the figure.

[0035] Figure 5 illustrates schematically yet another embodiment of the invention. In this embodiment, the parasitic element 3" of the antenna device 1" is provided with two slits 6_1", 6_2". One slit 6_1", is arranged at the higher frequency band, thereby providing a double-resonance at the higher frequency band interval. The other slit 6_2" , is arranged at the lower frequency band, thereby providing a double-resonance at the lower frequency band interval.

[0036] Figure 6 is similar to figures 2 and 4, and illustrates schematically curves representing VSWR as a function of frequency. The resonance frequencies obtained in the higher and lower frequency bands by means of the antenna device 1" shown in figure 5 is indicated schematically. Again, specific frequencies are not indicated in the figure.

[0037] The parasitic element of the invention can be provided with further additional slits in order to provide further resonance frequencies. However, it is realized that additional slits are made at the cost of an increased space requirement.

[0038] An advantage of the parasitic element 3, 3', 3" is that the different parasitic branches 3a, 3b, 3c, 3d, 3e, 3f do not require separate groundings portions. The number of contact points between the PCB of the communication device to which the antenna device 1 is to be connected and the antenna device 1 can thereby be minimized. This gives a less expensive manufacturing since the assembly is facilitated.

[0039] By means of the inventive antenna device 1, the bandwidth can be increased by at least 30% compared to using a conventional, non-slitted parasitic element.

[0040] With reference now to figure 7, the invention is also related to a communication device 20 comprising the antenna device 1 as described above. The communication device 20, for example a second generation or third generation cellular phone, comprises a keypad 24, display and other conventional means. Inside the communication device 20 there is provided a printed circuit board (PCB) 26 with a size essentially corresponding to the size of the communication device 20. On the PCB 26 there are mounted electronic circuits etc. (not shown) for the operation of the communication device 20. 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 PCB and the PCB 26 comprises radio frequency (RF) circuitry for operation of the antenna device. In particular, the parasitic element 3 is connected to the grounding portion G extending essentially perpendicular thereto. The grounding portion G is connected to a ground device of the underlying PCB 26. The driven radiating element 2 is electrically connected to a feed device of the PCB 26 by means of the contact pin 5.

[0041] In the figure, the antenna device 1 is shown to be arranged on the PCB 26 with the driven radiating element 2 closest to the upper part of the communication device 20 and the parasitic element 3 partially surrounding the driven radiating element 2 on the lower and vertical sides thereof. That is, the parasitic element 3 is arranged along three sides of the driven radiating element 2, wherein the lower side of it (i.e. the part denoted C in figure 1) is arranged closest to the key pad 24 and wherein the parallel parts (i.e. parts A and B in figure 1) are pointing upward, i.e. towards the upper part of the communication device 20. It has been found that such placement provides optimized radiation patterns as compared to turning the antenna device 180°, which is the typical way of arranging the antenna device.

[0042] 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 of the grounding portion G can be used as a parameter when adjusting the characteristics of the antenna device 1. The grounding portion G may further 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 or transmit electromagnetic waves.

Claims

1. An antenna device (1) for a communication device (20) operable in at least two frequency intervals, said antenna device (1) comprising:

- a generally planar driven radiating element (2) having a feeding portion (5) connectable to a feed device of said communication device (20) and
- a generally planar parasitic element (3, 3') having a grounding portion (G) connectable to a ground device of said communication device (20), wherein said driven radiating element (2) and said parasitic element (3, 3', 3") are essentially coplanar and separated by a gap (7),

characterized in that

- said parasitic element (3, 3', 3") comprises a slit (6, 6'), by means of which a double-resonance is provided in a first frequency interval.

2. The antenna device (1) as claimed in claim 1, wherein said parasitic element (3, 3', 3") comprises two parallel planar portions (A, B) connected to each other by means of a third planar portion (C) perpendicular to said two parallel planar portions (A, B), whereby said parasitic element (3, 3', 3") is arranged along three sides of said driven radiating element (2).

3. The antenna device (1) as claimed in claim 2, wherein said slit (6) is arranged to extend along one of the two parallel planar portions (A, B) and along said third planar portion (C), whereby three parasitic branches (3a, 3b, 3c) are formed and whereby said double-resonance is provided in a lower frequency interval.

4. The antenna device (1) as claimed in claim 2, wherein said slit (6') is arranged to extend along one of the two parallel planar portions (A, B), whereby three parasitic branches (3d, 3e, 3f) are formed and whereby a double-resonance is provided in the higher frequency interval.

5. The antenna device (1) as claimed in claim 2, wherein said parasitic element (3") comprises two slits (61", 6_2").

6. The antenna device (1) as claimed in claim 5, wherein a first slit (61") is arranged to extend along one of the two parallel planar portions (A, B), and a second slit (6_2") is arranged to extend along the other of the two parallel planar portions (A, B) and along said third planar portion (C).

7. The antenna device (1) as claimed in any of the preceding claims, wherein said parasitic element (3, 3', 3") comprises a single grounding portion (G).

8. The antenna device (1) as claimed in claim 7, wherein said single grounding portion (G) is arranged along an edge of said parasitic element (3, 3', 3").

9. The antenna device (1) as claimed in any of the preceding claims, wherein said driven radiating element (2) is essentially rectangular.

10. The antenna device (1) as claimed in any of the preceding claims, wherein said driven radiating element (2) comprises an aperture (4).

11. The antenna device (1) as claimed in claim 10, wherein said feeding portion (5) is located on an edge of said aperture (4).

12. A parasitic element (3, 3', 3") having a grounding portion (G) connectable to a ground device of a communication device (20), said parasitic element (3, 3', 3") being electromagnetically connectable to a driven radiating element (2), **characterized in that**

- said parasitic element (3, 3', 3") comprises a slit (6, 6', $6_{1,2}$"), by means of which a double-resonance is provided in a first frequency interval.

13. The parasitic element (3, 3') as claimed in claim 12, wherein said parasitic element (3, 3', 3") comprises two parallel planar portions (A, B) connected to each other by means of a third planar portion (C) perpendicular to said two parallel planar portions (A, B), whereby said parasitic element (3, 3', 3") has a design so as to be able to be arranged along three sides of said driven radiating element (2).

14. The parasitic element (3, 3', 3") as claimed in claim 13, wherein said slit (6) is arranged to extend along one of the two parallel planar portions (A, B) and along said third planar portion (C), whereby at least three parasitic branches (3a, 3b, 3c) are formed and whereby said double-resonance is provided in the lower frequency interval.

15. The parasitic element (3, 3', 3") as claimed in claim 13, wherein said slit (6') is arranged to extend along one of the two parallel planar portions (A, B), whereby at least three parasitic branches (3d, 3e, 3f) are formed and whereby a double-resonance is provided in the higher frequency interval.

16. The parasitic element (3, 3', 3") as claimed in claim 13, wherein said parasitic element (3") comprises two slits (61", 62").

17. The antenna device (1) as claimed in claim 16, wherein a first slit (6_1") is arranged to extend along one of the two parallel planar portions (A, B), and a second slit (6_2") is arranged to extend along the other of the two parallel planar portions (A, B) and along said third planar portion (C).

18. A communication device (20) having a printed circuit board (26) with radio frequency circuitry and a grounding device and a feed device, **characterized by** an antenna device (1) as claimed in any of claims 1-11.

19. The communication device (20) as claimed in claim 18, wherein said antenna device (1) is arranged with the driven radiating element (2) closest to the upper part of the communication device (20) and the parasitic element (3, 3', 3") being arranged along the lower and vertical sides of the driven radiating element (2).

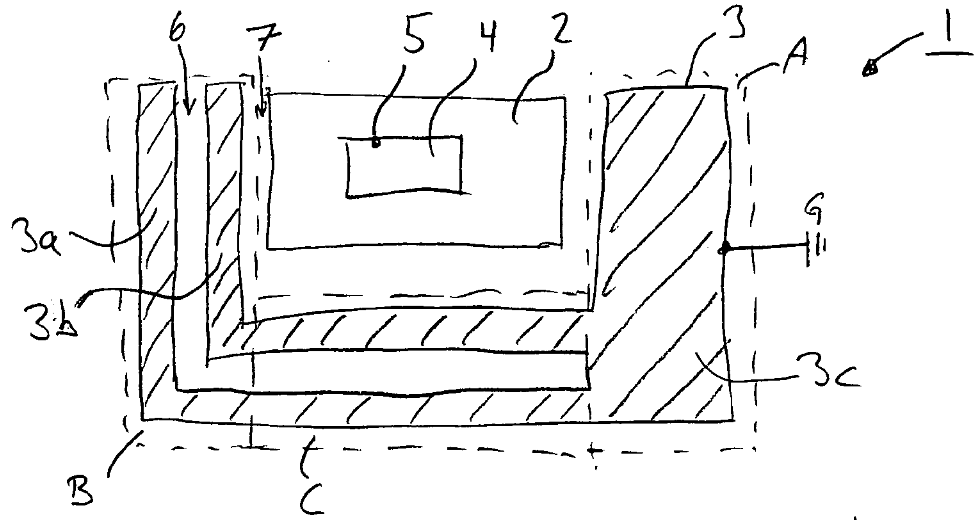

Fig. 1

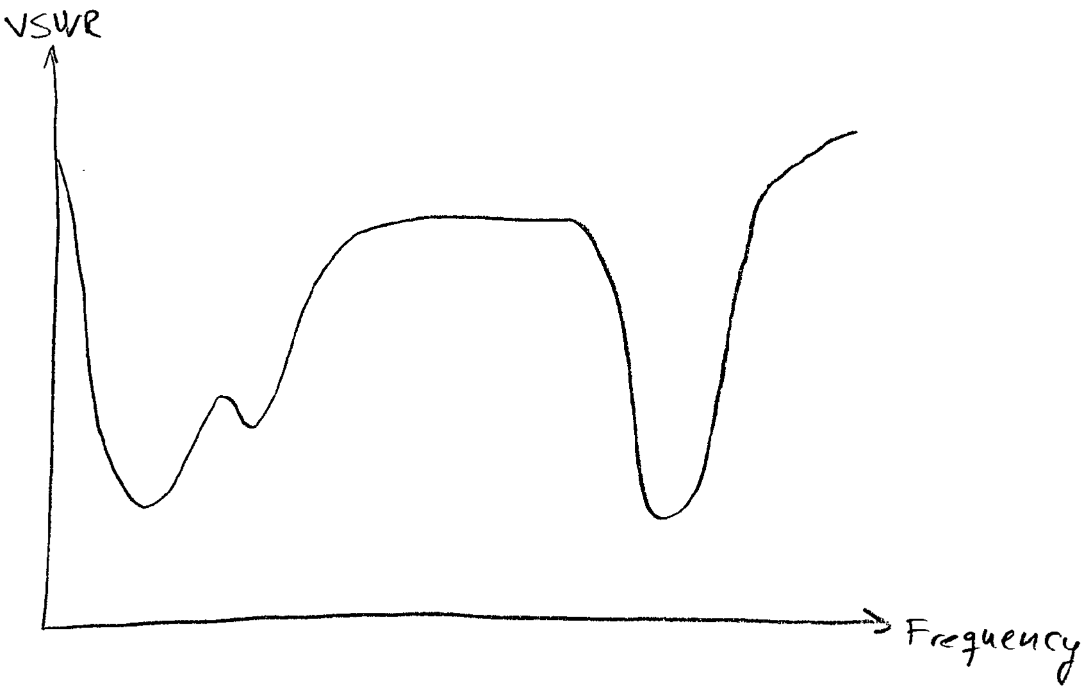

Fig. 2

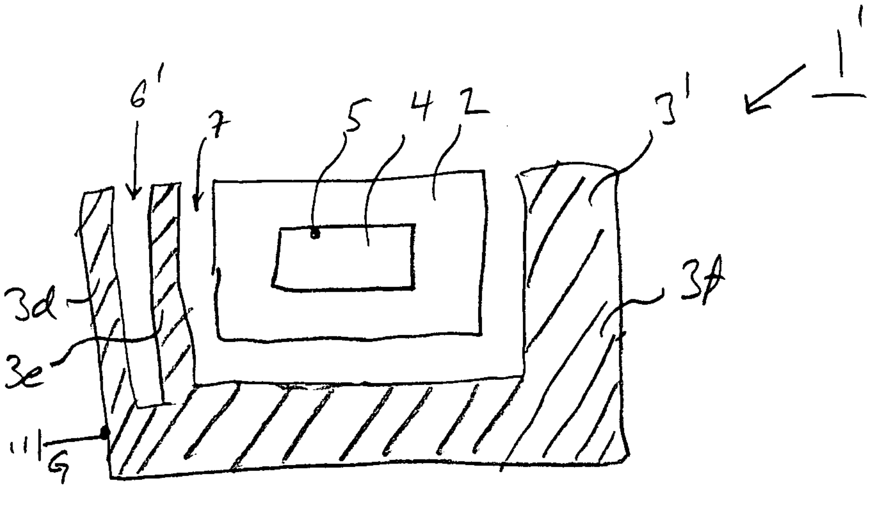

Fig. 3

Fig. 4

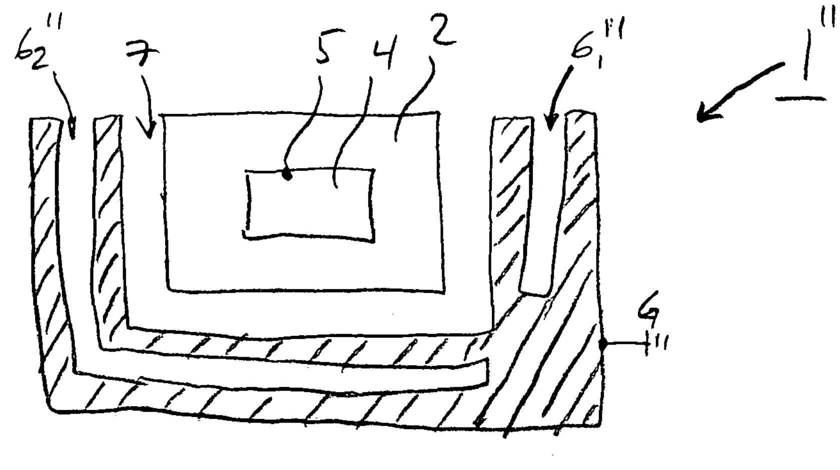

Fig. 5

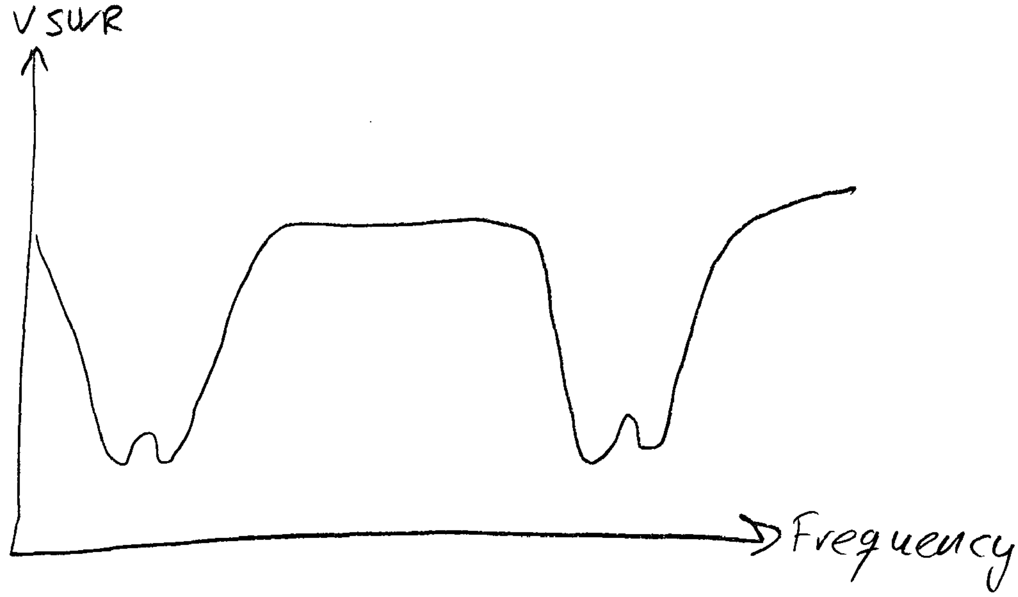

Fig. 6

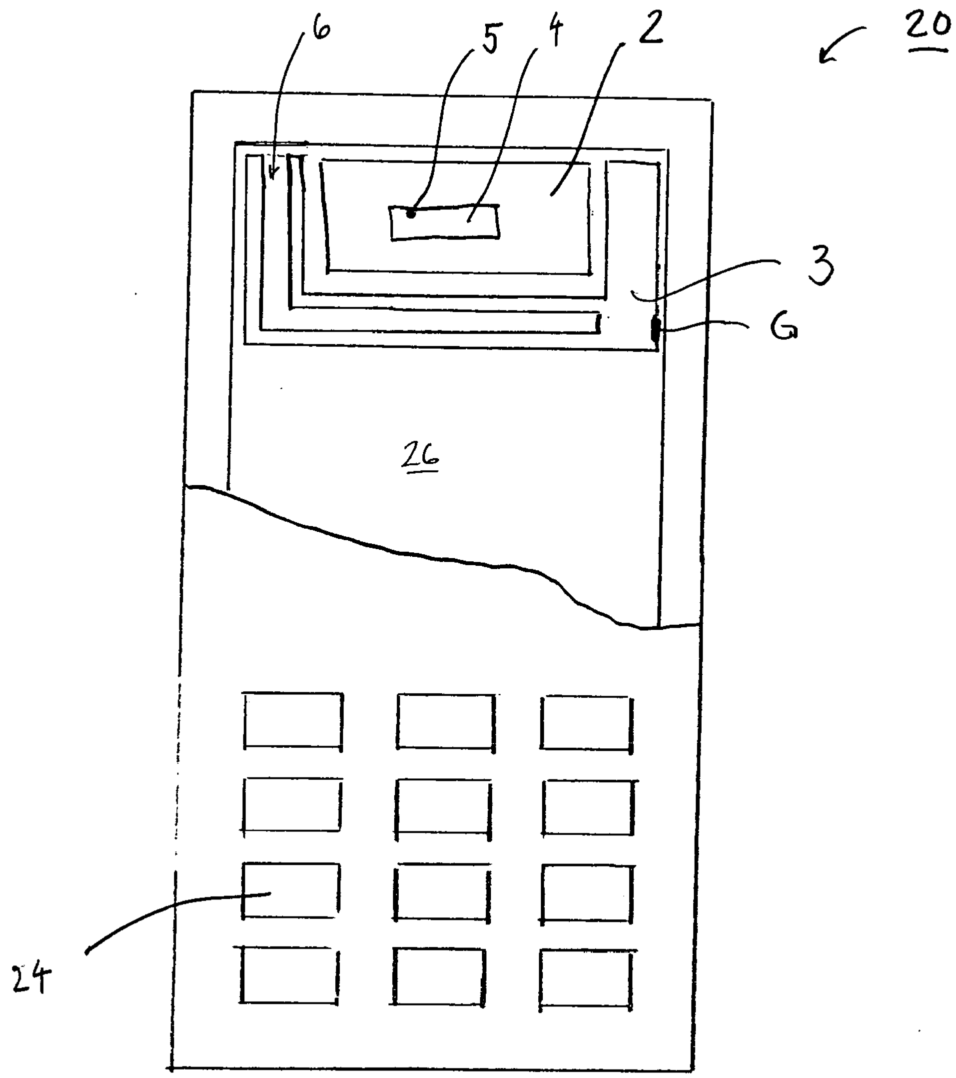

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 07 44 5010

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TECHNICAL FIELDS SEARCHED (IPC)

H01Q

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	20 August 2007	Jäschke, Holger

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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