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

(57) An antenna device operable in at least a first lower frequency band and a second higher frequency band comprises a single solid unbranched radiating element (16) having a first (18) and a second (20) opposite end, a first feeding connection (FC1) to the first end (18), a first connection path (P1) between the radiating element and a first frequency band signal handling unit (34), a tuning element (T1) connected to the radiating element for tuning the radiating element for resonance in the first band, a first signal passing and blocking arrangement (24) allowing signals in the first band to pass and blocking signals in the second band, a second connection path (P2) between the radiating element and a second frequency band signal handling unit (32) and a second signal passing and blocking arrangement (28) allowing signals in the second band to pass and blocking signals in the first band. At least one connection path is connected to the first feeding connection.

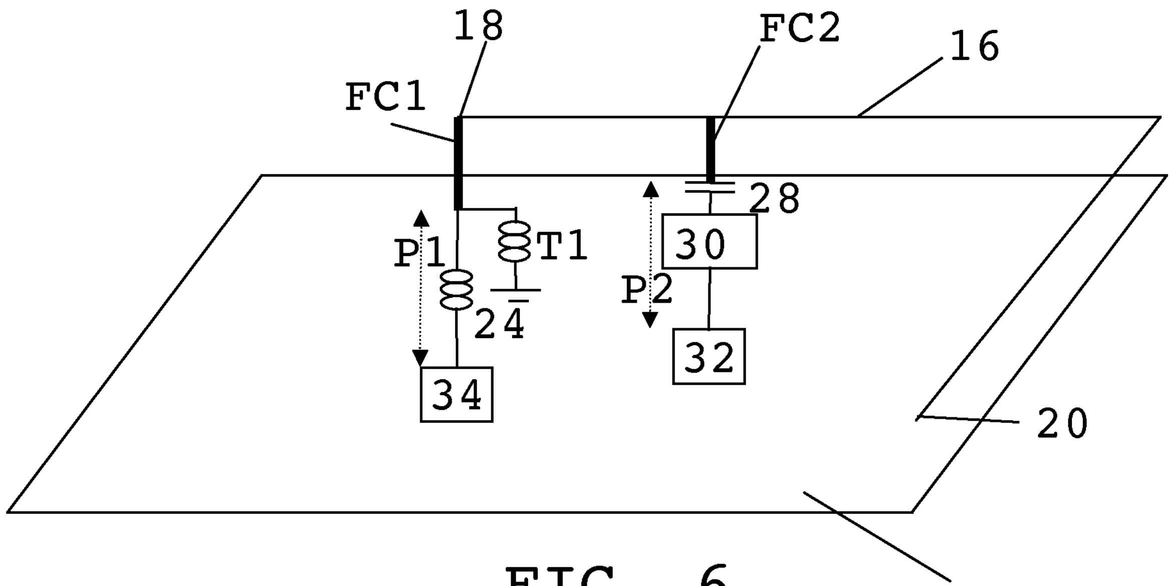

FIG. 6

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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 a first lower and a second higher frequency band. 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.

[0003] However, the use of internal antennas in a mobile phone puts some constraints on the configuration of the radiating element of the antenna. In particular, in a portable radio communication device the space for an internal antenna is limited. These constraints may make it difficult to find a configuration of the antenna that enables the desired use. This is especially true for antennas intended for use with radio signals of relatively low frequencies as the desired physical length of such antennas are large compared to antennas operating with relatively high frequencies.

[0004] One specific application operating in a relatively low frequency band is the FM radio application. The FM operating band is defined as frequencies between 88-108 MHz in most of the world and frequencies between 76-90 MHz in Japan. Prior art conventional antenna configurations, such as loop antennas or monopole antennas, fitted within the casing of a portable radio communication device will result in unsatisfactory operation in that the antenna either has too bad performance over a sufficiently wide frequency band or sufficient performance over a too narrow frequency band.

[0005] Instead, a conventional FM antenna for portable radio communication devices is usually provided in the headset wire connected to the communication device. This configuration with a relatively long wire permits an antenna length that is sufficient also for low frequency applications. However, if no external antenna is permitted this solution is obviously not feasible.

[0006] Further, a portable radio communication device is today many times provided with frequency operational coverage for other frequency bands than FM, such as GSM900, GSM1800, Bluetooth, WLAN, WCDMA and GPS. A portable radio communication device has limited space and it is thus desirable to, if possible, add multiple functionality to an antenna.

[0007] The radiating element is then to resonate in more than one frequency band. This is hard to accomplish in a small portable radio communication device.

[0008] US 6204819, US 2006/097918 and US 2004/041734 all disclose antennas being operable in different bands.

[0009] However these use switching arrangements for obtaining multiband operation. It would in view of this be of interest to provide an antenna device providing multiband functionality which does not require switches.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to provide a small-sized antenna device that provides improved multiband functionality.

[0011] Another object is to provide an antenna device that can provide simultaneous multiband functionality.

[0012] The invention is based on the realization that improved multiband functionality can be obtained in an antenna device by providing a single solid unbranched radiating element having a first and a second opposite end and being arranged to be placed in a plane parallel with and spaced from a ground plane. The antenna device also comprises a first feeding connection to the first end of the single solid unbranched radiating element, a first connection path between the single solid unbranched radiating element and a first frequency band signal handling unit as well as a tuning element connected to the single solid unbranched radiating element. This tuning element tunes the single solid unbranched radiating element for fundamental resonance in the first frequency band. The antenna device further includes a first signal passing and blocking arrangement that allows signals in the first frequency band to pass through the first connection path and blocks signals in the second frequency band from passing through the first connection path. The antenna device also includes a second connection path between the single solid unbranched radiating element and a second frequency band signal handling unit and a second signal passing and blocking arrangement that allows signals in the second frequency band to pass through the second connection path and blocks signals in the first frequency band from passing through the second connection path. At least one of the first and the second connection paths is connected to the first feeding connection.

[0013] According to a first aspect of the present invention there is provided an antenna device as defined in claim 1.

[0014] According to a second aspect of the present invention there is provided portable radio communication device as defined in claim 16.

[0015] Further preferred embodiments are defined in the dependent claims.

[0016] The invention has a number of advantages. The single solid unbranched radiating element that provides multiband operation is very small. Multiband operation is furthermore obtained simultaneously. There is no switching between operations in different bands. This has the advantage of providing a more rapid signal processing as well as energy savings. A solid and unbranched radiating element is also simple to produce.

BRIEF DESCRIPTION OF DRAWINGS

[0017] The invention is now described, by way of example, with reference to the accompanying drawings, in which:

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

Fig. 2 schematically shows a perspective view of an antenna device according to a first embodiment of the present invention;

Fig. 3 schematically shows a perspective view of the antenna device in the first embodiment being provided above a circuit board with frequency band signal handling units;

Fig. 4 schematically shows a perspective view of an antenna device according to a second embodiment of the present invention being provided above a circuit board with frequency band signal handling units;

Fig. 5 schematically shows a perspective view of an antenna device according to a third embodiment of the present invention being provided above a circuit board with frequency band signal handling units;

Fig. 6 schematically shows a perspective view of an antenna device according to a fourth embodiment of the present invention being provided above a circuit board with frequency band signal handling units; and

Fig. 7 schematically shows a perspective view of an antenna device according to a fifth embodiment of the present invention being provided above a circuit board with frequency band signal handling units.

DETAILED DESCRIPTION OF THE INVENTION

[0018] 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.

[0019] Fig. 1 shows a front view of the exterior or casing of a portable radio communication device 10, in the form of a mobile phone. A mobile phone is just an example of one type of portable radio communication device. Other examples are lap top computers, palm top computers, electronic organizers and electronic gaming machines. In the portable radio communication device 10 there is an antenna device as well as a circuit board on which frequency band signal handling units are provided. The antenna device is then connected to such frequency band signal handling units as well as to a ground plane. This ground plane is normally provided as a part of the circuit board. Signal handling units are typically implemented through radio circuits arranged to modulate and/or demodulate radio signals and process them. These may be arranged to only transmit, only receive or to both transmit and recive radio signals. These may be FM signal handling units, Bluetooth signal handling units, GPS signal handling units as well as cellular radio signal handling units such as WCDMA RX (diversity) signal handling units.

[0020] These types of portable radio communication devices are often small in size. It is furthermore often desirable that the antenna device is completely provided in the interior of the portable radio communication device, i.e. inside the casing of it. Consequently the space provided for radiating elements in antenna devices is limited. This means that in order to use the allocated space as efficiently as possible it may be necessary to use the same radiating element for handling signals of different types, i.e. signals that are modulated differently from each other and also occupy significantly different frequency bands. This is hard to do.

[0021] The present invention is directed towards providing simultaneous multiple use of a single radiating element, where the single radiating element is made to resonate in at least a first lower and a second higher frequency band. These bands may with advantage be separated from each other by more than 1 GHz.

[0022] This is furthermore done using a radiating element that is unbranched and therefore the space it occupies is limited. A solid radiating element is here an element where there are no tuning, matching and switching elements or units provided on the radiating element or between sections of the radiating element. An unbranched element is an element that has no branches. An unbranched radiating element can also be seen as a radiating element having a main radiating body but lacking radiating branches joined to this main body. The lower frequency band may with advantage be an FM frequency band (76 - 108 MHz) and the second a Bluetooth frequency band (2400 - 2482 MHz). However, the second frequency band may also be a GPS band (1575 MHz) or a WCDM RX (diversity) band (2110 - 2170 MHz).

[0023] An antenna device according to a first embodiment of the present invention will now be described with reference being made to fig. 2 which schematically shows a perspective view of the antenna device on its own and to fig. 3, which schematically shows the antenna device above a circuit board and on which frequency band signal handling units are provided. From the drawings it is evident that the antenna device according to the present invention is provided in the interior of the portable radio communication device.

[0024] The antenna device 12 includes a single solid unbranched radiating antenna element 16 above a circuit board 14 provided with a ground plane (not shown). The ground plane here typically is provided as one layer in the circuit board and occupies as much as possible of the area of the circuit board 14. The radiating element 16 has a first end 18 as well as a second opposite end 20. The radiating element 16 is here provided in a plane that is parallel to the plane of the circuit board 14 and typically stretches along at least two adjacent and here two orthogonal sides of the board that here coincide with corresponding sides of the ground plane. It does furthermore not stretch beyond these corresponding sides of the ground plane. It does not cross any of these sides but stays within a volume defined and bounded by the corresponding ground plane sides. This means that from the first end 18 the radiating element 16 in this embodiment stretches straight along a first side of the board 14, whereupon it makes a ninety degree turn at a corner between the first and an orthogonal second side of the board 14 and then stretches along this second side. In the embodiments of the invention to be described here the radiating element 16 is provided at a distance of 5 mm from the board and it is 100 mm long. It should however be noted that the invention is in no way limited to these dimensions, but these are mere examples of the dimensions of the radiating element. The second end 20 is in this embodiment electrically floating, i.e. it does not have a direct electrical connection to any other elements. The radiating element 16 may in all the embodiments to be described be provided as a wire or conductor and can also be provided on a carrier such as a flex film. The first end 18 here has a first feeding connection FC1 leading to other elements of the antenna device. This connection is typically provided as a conductor which can lead from the plane of the circuit board to the plane in which the radiating element is provided.

[0025] The antenna device 12 according to the present invention is provided with a first connection path P1 (shown as a dotted bidirectional arrow) that stretches between the radiating element 16 and a first frequency band signal handling unit 34. In the figures this path P1 is shown as stretching from the first feeding connection FC1 to the first frequency band signal handling unit 34. In this first path P1 there is here provided a first signal passing and blocking arrangement 22 (indicated with a dashed box). The antenna device 12 of the present invention is also provided with a second connection path P2 (also shown as a dotted bidirectional arrow) that stretches between the radiating element 16 and a second frequency band signal handling unit 32. The second path P2 is in the figures shown as stretching from the first feeding connection FC1 to the second frequency band signal handling unit 32. In this second path P2 there is provided a second signal passing and blocking arrangement 26 (also indicated with a dashed box).

[0026] The first signal passing and blocking arrangement 22 is here arranged to allow signals in the first frequency band to always pass through the first connection path P1 and to always block signals in the second frequency band from passing through the first connection path, while the second signal passing and blocking arrangement 26 is arranged to always allow signals in the second frequency band to pass through the second connection path P2 and to always block signals in the first frequency band from passing through the second connection path.

[0027] In this and the other embodiments described later the first signal passing and blocking arrangement 22 includes a first filter 24 connected between the radiating element 16 and the first frequency band signal handling unit 34. As the first frequency band is lower than the second frequency band this first filter may be a low pass filter. In the embodiments described here this first filter 24 is provided in the form of an inductor connected between the radiating element and the first frequency band signal handling unit 34, which inductor in these embodiments has, only as an example, a value of 56 nH. It should be realized that a low pass filter may be realized in other ways. It should also be realized that the first filter is not limited to a low pass filter but may also be a band pass filter with the pass band set to cover the first frequency band.

[0028] In a similar manner the second signal passing and blocking arrangement 26 includes a second filter 28 connected between the radiating element 16 and the second frequency band signal handling unit 32. As the second frequency band is higher than the first frequency band this second filter may be a high pass filter. In the embodiments described here this second filter is provided in the form of a capacitor 28 connected between the radiating element 16 and the second frequency band signal handling unit 32, which capacitor in these embodiments has, only as an example, a value of 1 pF. It should be realized that a high pass filter may be realized in other ways. It should also be realized that the second filter is not limited to a high pass filter but may also be a band pass filter with the pass band set to cover the second frequency band and any other frequency bands of signals that are to pass the second connection path.

[0029] The length of the radiating element 16 is according to the invention smaller than the quarter of a wavelength at which fundamental resonance occurs in the first frequency band. Therefore a tuning element T1 is connected to the radiating element 16 and in this embodiment also the first connection path. This tuning element T1 is arranged to tune the single solid unbranched radiating element 16 for fundamental resonance in the first frequency band.

[0030] Because the second end 20 of the radiating element is electrically floating, the radiating element is a monopole element and more particularly an ILA (Inverted L Antenna) element. This means that this radiating element 16 is capacitive in nature in the first frequency band. This also means that the tuning element T1 can be provided as an inductive element connected between the radiating element 16 and ground. In the present example it has a value of 470 nH. The tuning element T1 is here furthermore also connected to the first connection path P1 and then to the connection point between the first filter 24 and the radiating element 16. This also means that in this embodiment it assists in blocking signals in the second frequency band from reaching ground via the first feeding connection FC1.

[0031] As was mentioned earlier, the second filter 28 in the second signal passing and blocking arrangement 26 blocks signals in the first frequency band and allows signals in the second frequency band to pass.

[0032] This filter 28 may however also be put to further use. It may simultaneously act to match the radiating element 16 for obtaining resonance in the second frequency band. This matching may not be enough, in which case the path P2 may also include a matching network 30 for performing an even better match. In this sense the capacitive filter 28 may also be seen as a part of the matching network 30.

[0033] In this first embodiment of the present invention both the first and the second paths P1 and P2 are connected to the first feeding connection FC1 and thus both are connected to the first end 18 of the radiating element 16. This means that the tuning element T1 tunes the radiating element for fundamental resonance in the first frequency band, which in this example is the FM band. However, for the second frequency band, which in this example is the Bluetooth frequency band, the radiating element operates with harmonic resonance. In this first embodiment this resonance is obtained through the use of the matching network 30 and second filter 28 in the second signal passing and blocking arrangement 26 for matching the radiating element 16 to harmonic resonance. The whole length of the radiating element is here selected and used for obtaining resonance in both frequency bands.

[0034] It should here be realized that if the second frequency band is another band, like for instance a GPS frequency band, then the radiating element may also here operate with fundamental resonance in the second band.

[0035] Fig. 4 shows a perspective view of an antenna device according to a second embodiment of the present invention being provided above a circuit board in a similar way as in the first embodiment.

[0036] In this second embodiment many of the elements are the same as in the first embodiment, and therefore only the differences will be described in detail. The radiating element 16 is here provided in the same way in relation to the two connection paths P1 and P2 and the circuit board 14 as in the first embodiment. The second path P2 is furthermore identical as is the first filter 24 of the first path P1. However, here the second end 20 of the radiating element 16 is connected to a ground connection GC leading to the ground plane. This connection is typically provided as a conductor which can lead from the plane of the circuit board to the plane in which the radiating element is provided. This means that here the ILA antenna is a half loop antenna, which can be seen as half a magnetic dipole antenna. This means that in the first frequency band the radiating element 16 is inductive in nature. This also means that the tuning element T2 can be provided as a capacitance connected to ground instead of an inductor connected to ground. The tuning element T2 is here as an example a capacitance of 30 pF. However, the tuning element P2 when provided in this way will also provide a path to ground for operations in the second frequency band.

[0037] In order to avoid this a further filter 35 is provided between the tuning element T2 and the radiating element 16. In this embodiment the tuning element T2 and the first filter 24 share the same connection to the radiating element 16. This also means that the further filter may be considered as a part of the first signal passing and blocking arrangement. Because of this the further filter 35 is provided in the first path P1 and here between the radiating element 16 and the first filter 24. The tuning element T2 is then connected between ground and the junction between the first filter 24 and the further filter 35. The further filter may here be a low pass filter in the form of an inductor having an exemplifying value of 20 nH.

[0038] In operation resonance is obtained similarly to what has been described in relation to the first embodiment.

[0039] Fig. 5 shows a perspective view of an antenna device according to a third embodiment of the present invention being provided above a circuit board in a similar way to the second embodiment.

[0040] The main difference from the second embodiment is that the radiating element 16 includes a second feeding connection FC2. This second feeding connection FC2 is provided between the first and the second ends 18 and 20. This connection is typically provided as a conductor which can lead from the plane of the circuit board to the plane in which the radiating element is provided. As in the second embodiment the second connection path P2 is connected to the first feeding connection FC1. However in this third embodiment the first connection path P1 is connected to the second feeding connection FC2. The further filter provided in the second embodiment is here also omitted since it is no longer needed.

[0041] In operation the tuning element T2 tunes the radiating element 16 for fundamental resonance in the first frequency band. However, here this resonance is based on the length of the part of the single solid unbranched radiating element between the second feeding connection FC2 and the second end 20. This means that it is this length that is selected and used to provide resonance in the first frequency band. The rest of the radiating element, i.e. the part between the first and second feeding connections FC1 and FC2 has more limited influence on the resonance in the first frequency band.

[0042] For the second frequency band, the second feeding connection FC2 acts as a grounding connection and thus the radiating element acts as an IFA (Inverted F Antenna) in this band. Also here the whole of the length of the radiating element is used for obtaining harmonic or fundamental resonance depending on which band is the second frequency band.

[0043] Fig. 6 shows a perspective view of an antenna device according to a fourth embodiment of the present invention being provided above a circuit board in a similar way as the previous described embodiments.

[0044] In this fourth embodiment there is a second feeding connection FC2 as in the fourth embodiment of the invention and there is a first connection path P1 of the same type as in the first embodiment connected to the first feeding connection FC1. The second end 20 of the radiating element 16 is also floating just as in the first embodiment. The second connection path P2 is furthermore provided in the same way as in the previously described embodiments

[0045] However, in this fourth embodiment, the second connection path P2 connects the second frequency band signal handling unit 32 with the second feeding connection FC2.

[0046] In operation the whole length of the radiating element 16 is used for obtaining resonance in the first frequency band and the length of the part of the radiating element between the first and the second feeding connections FC1 and FC2 is used for obtaining resonance in the second frequency band. This means that the length of the whole radiating element 16 is selected for obtaining resonance in the first frequency band and the length of the part of the element between the first and the second feeding connections FC1 and FC2 is selected to provide resonance in the second frequency band. In this fourth embodiment, the radiating element operates at the fundamental resonance in both the first and the second frequency bands.

[0047] Fig. 7 shows a perspective view of an antenna device according to a fifth embodiment of the present invention being provided above a circuit board in a similar way to the previously described embodiments. The antenna device in this sixth embodiment is provided for operation in a third frequency band in addition to the first and second frequency bands. This third frequency band may furthermore be provided between the first and the second frequency bands.

[0048] The antenna device according to this fifth embodiment is in many ways similar to the antenna device according to the fourth embodiment. However, there are some differences. In this fifth embodiment the second end 20 of the radiating element 16 is connected to a grounding connection GC just as in the second and third embodiments of the invention. For this reason the first connection path is provided in essentially the same way as in the third embodiment. However, it is of course connected to the first feeding connection FC1. In this fifth embodiment the second connection path is also different.

[0049] The second connection path here includes a first branch connecting the radiating element 16 with the second frequency band signal handling unit 32 and a second branch connecting the radiating element 16 with a third frequency band signal handling unit 38. The third frequency band is in this embodiment a GPS frequency band and therefore the third frequency band signal handling unit 38 is a GPS signal handling unit. In order to provide the two branches of the second path, this second path includes a signal combining unit 36, here in the form of a diplexer, that allows the radiating element 16 to simultaneously handle signals in the second and the third frequency bands via the second feeding connection FC2. This diplexer 36 is connected between the matching network 30 and the two signal handing units 32 and 38. It is at one end connected to the matching network 30 and at another end separately connected to the second frequency band signal handling unit 32 and the third frequency band signal handling unit 38. Operation in the first and second frequency bands is essentially performed in the same way as in the fourth embodiment. However, here the length of the part of the single solid unbranched radiating element 16 between the second feeding connection FC2 and the second end 20 is also selected to provide operation in the third frequency band. This length is thus selected for providing resonance after matching using the matching network. The resonance may here be fundamental or harmonic resonance.

[0050] There has here been described a number of different embodiments of the present invention that all provide a very small single solid unbranched radiating element that provides operation in two or three bands. This operation is furthermore obtained simultaneously. There is no switching between operation in different bands. This has the advantage of providing a more rapid signal processing, since there is no switching between bands. This also saves energy that would be used for operating switches. A solid and unbranched radiating element is also easy to produce.

[0051] It should here be realized that it is possible to make several modifications to the present invention. It is for instance possible to also provide operation in the third frequency band in the device of the fourth embodiment using a signal combining unit. In the same way it is also possible to omit this signal combing unit from the fifth embodiment in case the third frequency band is not needed. The matching network may in some instances be omitted from the second connection path. The different bands used may furthermore be varied. The second frequency band may for instance be WCDMA RX (diversity) or GPS instead of Bluetooth. Where there are three frequency bands the second and third frequency band may be a combination of any of the above mentioned bands. Also the first band may be a different band, such as for instance a DVBH television band.

[0052] The signal handling units were here described as separate units. It should be realized that two or more of them may be combined into the same physical entity, such as in the same component. These signal handling units were here also described as excluded from the antenna device. It should be realized that they may as an alternative also be included in the antenna device.

[0053] 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. Therefore the present invention is only to be limited by the following claims.

Claims

1. An antenna device (12) for a portable radio communication device (10) operable in at least a first lower frequency band and a second higher frequency band, the antenna device comprising:

    - a single solid unbranched radiating element (16) having a first (18) and a second (20) opposite end and being arranged to be placed in a plane parallel with and spaced from a ground plane;
    - a first feeding connection (FC1) to the first end (18) of the single solid unbranched radiating element (16);
    - a first connection path (P1) between the single solid unbranched radiating element and a first frequency band signal handling unit (34);
    - a tuning element (T1; T2) connected to said single solid unbranched radiating element and being arranged to tune the single solid unbranched radiating element for fundamental resonance in the first frequency band;
    - a first signal passing and blocking arrangement (22) arranged to allow signals in the first frequency band to pass through the first connection path and to block signals in the second frequency band from passing through the first connection path;
    - a second connection path (P2) between the single, solid, unbranched radiating element and a second frequency band signal handling unit (32); and
    - a second signal passing and blocking arrangement (26) arranged to allow signals in the second frequency band to pass through the second connection path and to block signals in the first frequency band from passing through the second connection path;
    - wherein at least one of the first and the second connection path is connected to the first feeding connection.

2. The antenna device according to claim 1, wherein the first signal passing and blocking arrangement includes a first filter (24) in the first connection path (P1) set to let signals in the first frequency band to pass and to stop signals in the second frequency band from passing.

3. The antenna device according to claim 1 or 2, wherein the second signal passing and blocking arrangement includes a second filter (28) in the second connection path (P2) set to let signals in the second frequency band to pass and to stop signals in the first frequency band from passing.

4. The antenna device according to claim 3, wherein the second signal passing and blocking arrangement (26) includes a second frequency band matching network (30).

5. The antenna device according to any previous claim, further including a second feeding connection (FC2) to the single solid unbranched radiating element provided between said first and second ends (18, 20), where one of the connection paths (P2) is connected to the first feeding connection and the other to the second feeding connection (FC2).

6. The antenna device according to claim 5, wherein the first connection path (P1) is connected to the first feeding connection (FC1), the second connection path (P2) is connected to the second feeding connection (FC2), the length of the whole single solid unbranched radiating element is selected for obtaining resonance in the first frequency band and the length of the part of the single solid unbranched radiating element between the first and the second feeding connections is selected to provide resonance in the second frequency band.

7. The antenna device according to claim 6, wherein the second connection path includes a first branch connecting the single solid unbranched radiating element (16) with the second frequency band signal handling unit (32) and a second branch connecting the single solid unbranched radiating element (16) with a third frequency band signal handling unit (38) and the length of the part of the single solid unbranched radiating element between the second feeding connection and the second end is selected to provide operation in a third frequency band provided between the first and the second frequency bands.

8. The antenna device according to claim 7, wherein the second connection path (P2) includes a signal combining unit (36) for allowing the solid, unbranched radiating element to simultaneously handle signals in the second and the third frequency bands.

9. The antenna device according to claim 5, wherein the second connection path (P2) is connected to the first feeding connection (FC1), the first connection path (P1) is connected to the second feeding connection (FC2), the length of the whole single solid unbranched radiating element is selected for obtaining resonance in the second frequency band and the length of the part of the single solid unbranched radiating element between the second feeding connection and the second end is selected to provide fundamental resonance in the first frequency band.

10. The antenna device according to any of claims 1 -4, wherein the second connection path (P2) is connected to the first feeding connection and the length of the whole single solid unbranched radiating element is selected for obtaining resonance in the second frequency band.

11. The antenna device (10) according to claim 10, wherein the first connection path (P1) is also connected to the first feeding connection (FC1) and the length of the whole single solid unbranched radiating element is also selected for obtaining fundamental resonance in the first frequency band.

12. The antenna device according to claim 10, further comprising a second feeding connection (FC2) to the single solid unbranched radiating element provided between said first and second end (18, 20), wherein the first connection path (P2) is connected to the second feeding connection (FC2) and the length of the part of the single solid unbranched radiating element between the second feeding connection and the second end is selected to provide fundamental resonance in the first frequency band.

13. The antenna device according to any of claims 1 - 12, wherein the second end (20) is electrically floating and the tuning element (T1) is realized as an inductive tuning element.

14. The antenna device according to any of claims 1 - 12, further comprising a grounding connection (GC), where the second end (20) is connected to this grounding connection and the tuning element (T2) is realized as a capacitive tuning element.

15. The antenna device according to claim 11 and 14, wherein the first signal passing and blocking arrangement includes a further filter (35) between the tuning element and the single solid, unbranched radiating element.

16. A portable radio communication device (10) comprising a first frequency band signal handling unit (34), a second frequency band signal handling unit (32), a ground plane and an antenna device (12) operable in at least a first lower frequency band and a second higher frequency band, said antenna device comprising:

- a single solid unbranched radiating element (16) having a first (18) and a second (20) opposite end and placed in a plane parallel with and spaced from the ground plane;
- a first feeding connection (FC1) to the first end (18) of the single solid unbranched radiating element (16);
- a first connection path (P1) between the single solid unbranched radiating element and the first frequency band signal handling unit;
- a tuning element (T1; T2) connected to said single solid unbranched radiating element and being arranged to tune the single solid unbranched radiating element for fundamental resonance in the first frequency band;
- a first signal passing and blocking arrangement (22) arranged to allow signals in the first frequency band to pass through the first connection path and to block signals in the second frequency band from passing through the first connection path;
- a second connection path (P2) between the single, solid, unbranched radiating element and the second frequency band signal handling unit; and
- a second signal passing and blocking arrangement (26) arranged to allow signals in the second frequency band to pass through the second connection path and to block signals in the first frequency band from passing through the second connection path:
- wherein at least one of the first and the second connection path is connected to the first feeding connection.

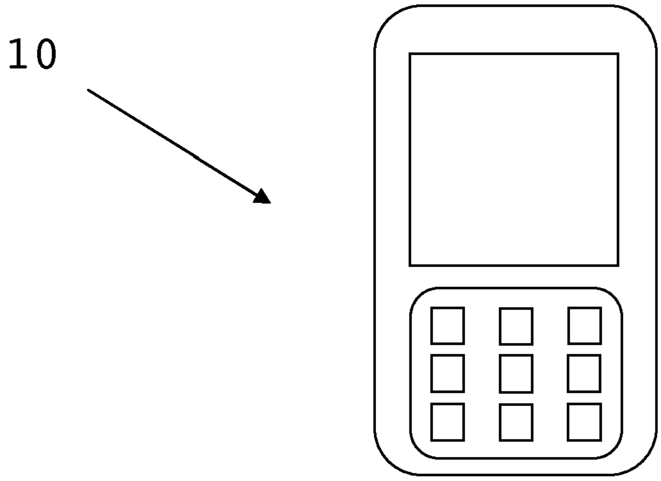


FIG. 1

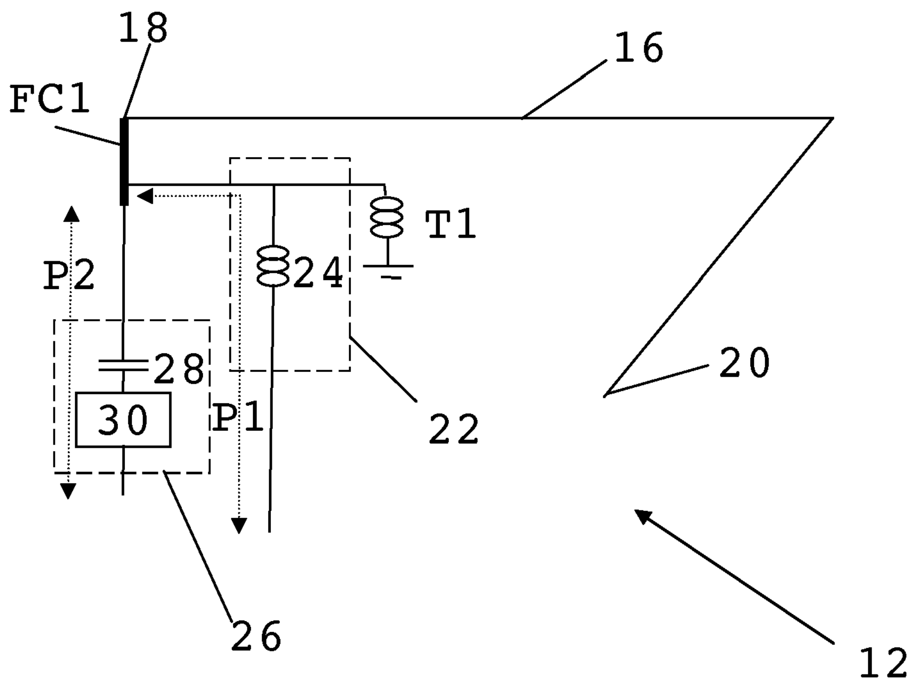


FIG. 2

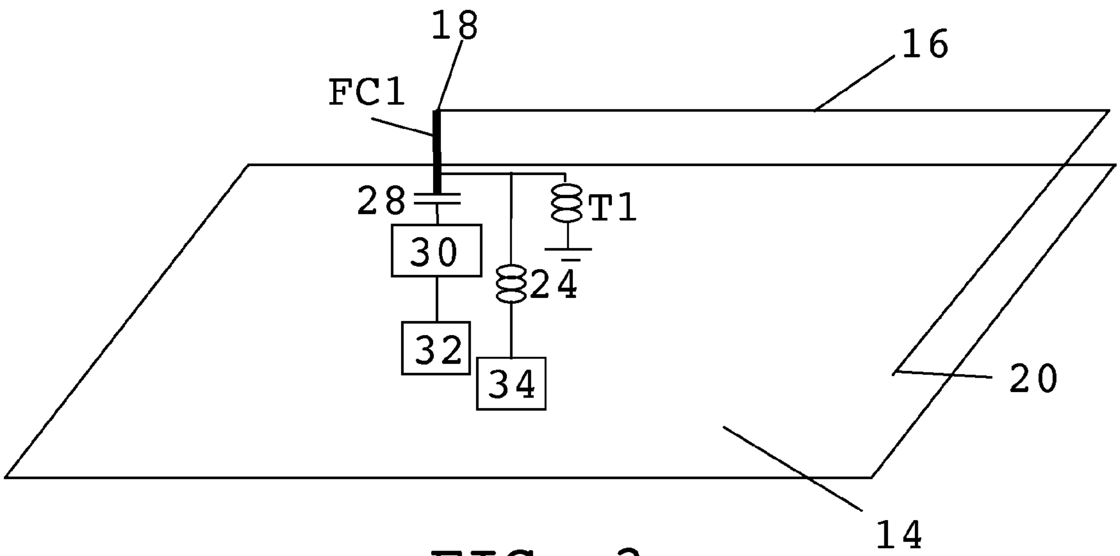

18
16
FC1
28
T1
30
24
32
34
20
14

FIG. 3

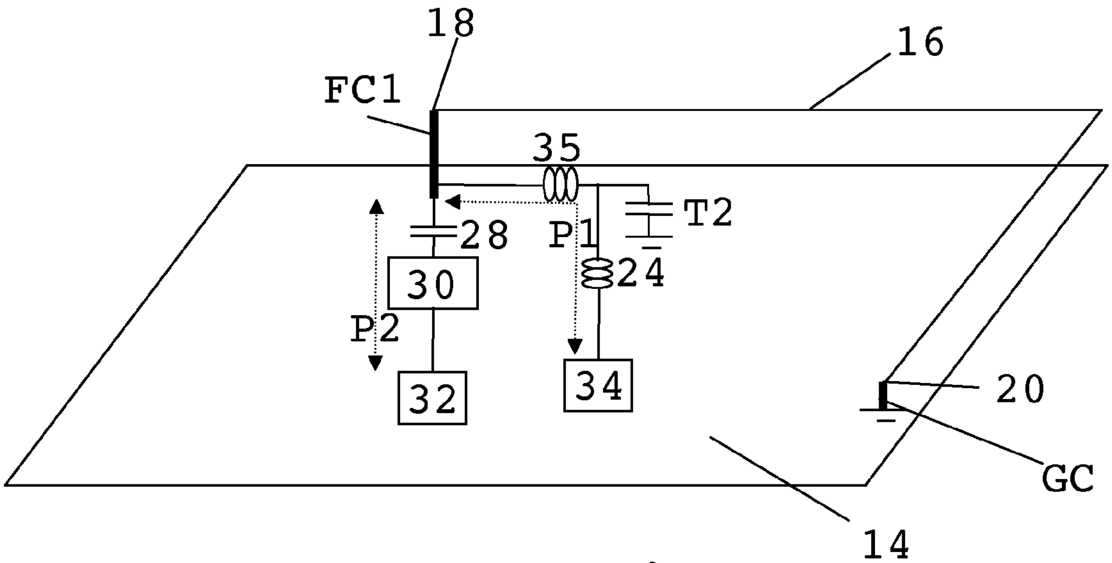
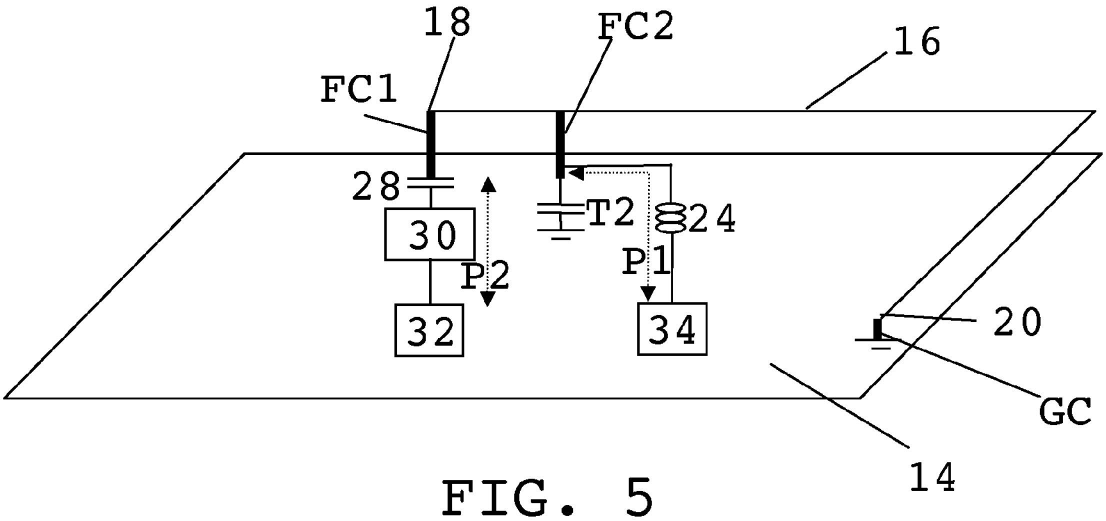

18
16
FC1
35
T2
28
P1
24
30
P2
34
32
20
GC
14

FIG. 4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FC1
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T2
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P1
P2
34
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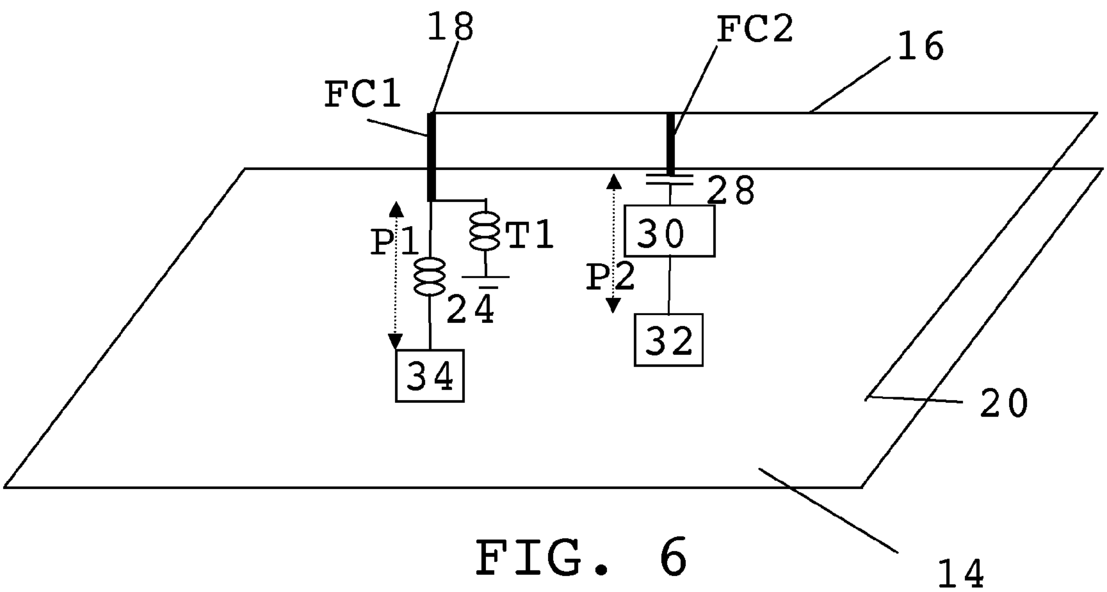
GC
14

FIG. 5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FC1
28
T1
P1
30
24
P2
32
34
20
14

FIG. 6

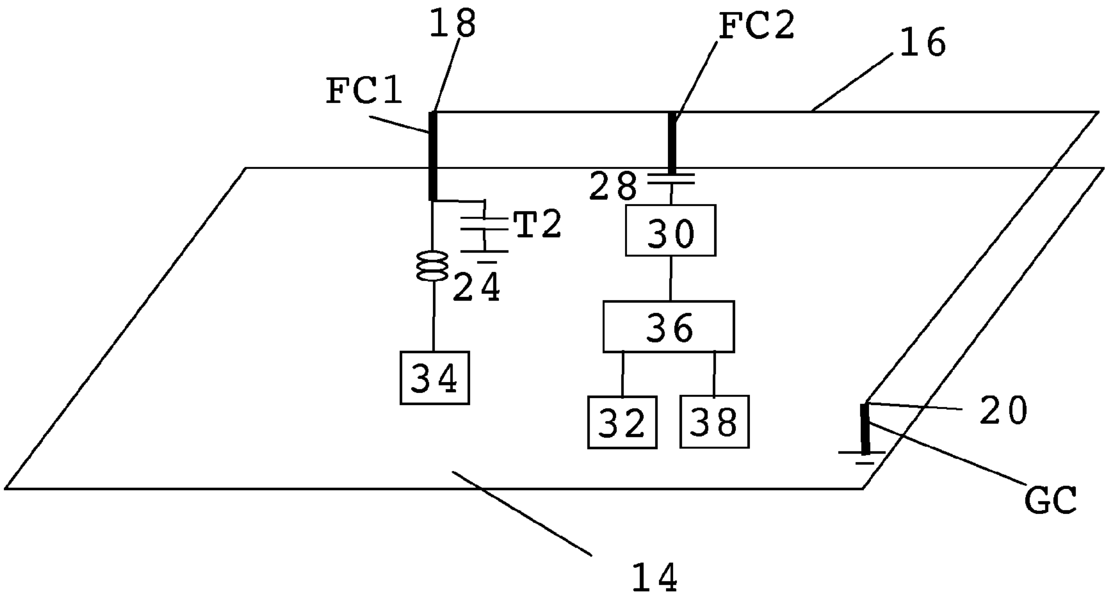

FIG. 7

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Place of search	Date of completion of the search	Examiner
Munich	27 April 2009	Unterberger, Michael

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