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- **Rahim, Abdul**
164 22 Kista (SE)
- **Arbin, Axel von**
183 63 Täby (SE)
- **Lindberg, Peter**
752 29 Uppsala (SE)
- **Braun, Christian**
113 21 Stockholm (SE)

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

(72) Inventors:
• **Kaikkonen, Andrei**
175 48 Järfälla (SE)

(74) Representative: **Fritzon, Rolf et al**
Kransell & Wennborg KB
P.O. Box 27834
115 93 Stockholm (SE)

(54) **An antenna device, an antenna system and a portable radio communication device comprising such an antenna device**

(57) The present invention relates to an antenna device for a portable radio communication device configured for simultaneous multi frequency band operation. The antenna device comprises a first elongated radiating element (1), a second elongated radiating element (2), a third elongated radiating element (3), first filtering means (4) arranged between the first and second elongated radiating elements, second filtering means (5) arranged between the second and third elongated radiating elements, and third filtering means (6) connecting the second elongated radiating element (2) to ground, wherein the first filtering means (4) is configured to block BT operating frequencies and to pass FM operating frequencies, the second filtering means (5) is configured to pass FM operating frequencies, and the third filtering means (6) is configured to ground GPS operating frequencies.

ranged between the second and third elongated radiating elements, and third filtering means (6) connecting the second elongated radiating element (2) to ground, wherein the first filtering means (4) is configured to block BT operating frequencies and to pass FM operating frequencies, the second filtering means (5) is configured to pass FM operating frequencies, and the third filtering means (6) is configured to ground GPS operating frequencies.

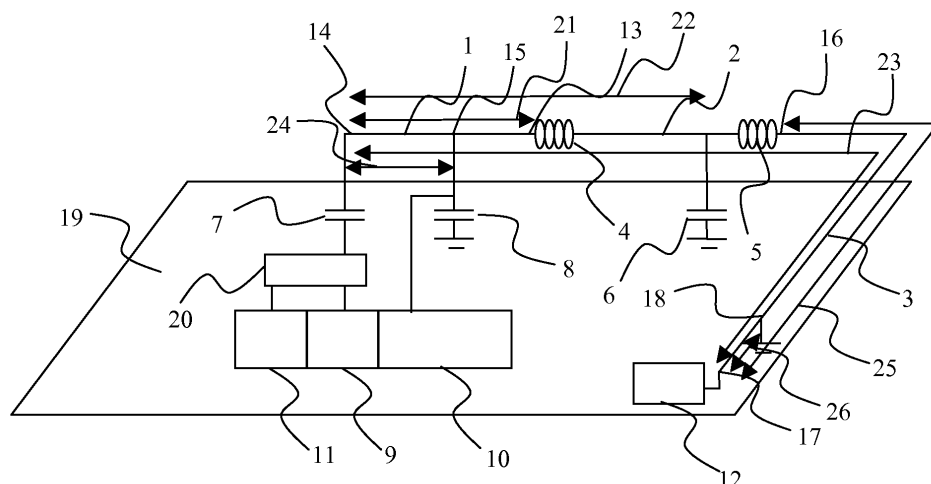


FIG. 1

Description

FIELD OF INVENTION

[0001] The present invention relates generally to antenna devices and more particularly to an antenna device for use in a portable radio communication device providing a plurality of simultaneously operating frequency band.

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 compared to protruding 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, PDA, portable computer or similar devices.

[0003] However, the application 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 device is limited. These constraints may make it difficult to find a configuration of the antenna device that provides for 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, GPS, BT, 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 device.

SUMMARY OF THE INVENTION

[0007] An object of the present invention is to provide an antenna device for a portable radio communication device, which efficiently utilizes available space of the portable radio communication device and provides for simultaneous multi frequency band operation.

[0008] This object, among others, is according to the present invention attained by an antenna device, an antenna system and a portable radio communication device, respectively, as defined by the appended claims.

[0009] By providing an antenna device for a portable radio communication device configured for simultaneous multi frequency band operation, wherein the antenna device comprises a first elongated radiating element, a second elongated radiating element, a third elongated radiating element, first filtering means arranged between the first and second elongated radiating elements, second filtering means arranged between the second and third elongated radiating elements, and third filtering means connecting the second elongated radiating element to ground, and wherein the first filtering means is configured to block BT operating frequencies and to pass FM operating frequencies, the second filtering means is configured to pass FM operating frequencies, and the third filtering means is configured to ground GPS operating frequencies, three different antennas are combined into one antenna providing simultaneous operation with good isolation between all antennas as well as good performance for all antennas.

[0010] By preferably configuring the second filtering means to block WCDMA Rx operating frequencies a fourth antenna is advantageously combined into the antenna device.

[0011] Connecting the first elongated radiating element to a BT transceiver through fourth filtering means, and to ground through fifth filtering means, wherein the fourth filtering means is configured to block FM operating frequencies and to match the BT transceiver, and the fifth filtering means is configured to pass BT operating frequencies and to tune an FM transceiver, facilitates matching and tuning.

[0012] The configuration of the antenna device is preferably such that it effectively works as an IFA type antenna for BT, GPS and WCDMA Rx operating frequencies, and as a loop type antenna for FM operating frequencies.

[0013] By preferably supporting the first, second and third elongated radiating elements on a dielectric carrier a cost efficient and robust installation of the antenna device is provided. Advantageously the dielectric carrier is part of the back cover of the portable radio communication device.

[0014] Preferably the first and second filtering means provided as RF chokes, whereby good quality blocking is achieved, and the third, fourth and fifth filtering means are preferably provided as capacitors, whereby low cost blocking is achieved. By alternatively providing the first

and the second filtering means as a simple inductance a low cost blocking is achieved.

[0015] By connecting the first elongated radiating element to the first filtering means in a first end to the fourth filtering means in a second end, opposite the first end, and connecting the fifth filtering means to a connection point on the first elongated radiating element close to the first end thereof, and connecting the third elongated radiating element to the second filtering means in a first end and to a WCDMA receiver in a second end, opposite the first end thereof, and grounding the third elongated radiating element in a connection point close to the second end thereof a combo transceiver can be used for BT and FM.

[0016] By preferably connecting the third filtering means to the second elongated radiating element close to the second filtering means and configuring the second and third filtering means together to block GPS operating frequencies, isolation is improved. Alternatively, the third filtering means is connected to the second elongated radiating element close to the first filtering means and the first and third filtering means are together configured to block GPS operating frequencies.

[0017] A first end of the third elongated radiating element is preferably connected to the second filtering means and a second end, opposite the first end, is connected to sixth filtering means configured for GPS matching.

[0018] Advantageously the third filtering means is connected to the second elongated radiating element close to the second filtering means, and the second and third filtering means are together configured to block GPS operating frequencies, in order to improve isolation between BT and GPS operation.

[0019] Further preferred embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF DRAWINGS

[0020] The present invention will become more fully understood from the detailed description of embodiments given below and the accompanying figures, which are given by way of illustration only, and thus, are not limitative of the present invention, wherein:

FIG. 1 is a schematic diagram showing a first embodiment of an antenna device according to the present invention.

FIG. 2 is a schematic diagram showing a second embodiment of an antenna device of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0021] In the following description, for purpose of explanation and not limitation, specific details are set forth, such as particular techniques and applications in order

to provide a thorough understanding of the present invention. However, it will be apparent for a person skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed description of well-known methods and apparatuses are omitted so as not to obscure the description of the present invention with unnecessary details.

[0022] In the following description and claims, the term radiating element is used. It is to be understood that this term is intended to cover electrically conductive elements arranged for receiving and/or transmitting radio signals. Further the term IFA type antenna is also used, which is to be understood as a radiating element comprising feeding and grounding points in one end thereof and the other end being open. Also, the term loop type antenna is used, which is to be understood as an antenna having an effective radiating structure of essentially a loop.

[0023] An antenna device for a portable radio communication device according to a first embodiment of the present invention will now be described with reference to Fig. 1.

[0024] The antenna device comprises a first elongated radiating element 1, having a first end 13 and a second end 14 opposite the first end 13, a second radiating element 2, and a third radiating element 3, having a first end 16 and a second end 17 opposite the first end 15. The antenna device further comprises first filtering means 4 connected between the second elongated radiating element 2 and the first end 13 of the first elongated radiating element 1, and second filtering means 5 connected between the second elongated radiating element 2 and the first end 16 of the third elongated radiating element 3. The second radiating element 3 is connected to ground through third filtering means 6.

[0025] The second end 14 of the first elongated radiating element 1 is connected to fourth filtering means 7, which in turn is connected to a GPS (Global Positioning System) receiver 11 and a BT (Bluetooth) transceiver 9, preferably through a GPS/BT diplexer 20. The second end 17 of the third elongated radiating element 3 is connected to a WCDMA (Wideband Code Division Multiple Access) Rx receiver 12, preferably a diversity receiver. Additionally, a matching network is preferably provided between the second end 17 of the third radiating element 3 and the WCDMA receiver 12, for matching of the WCDMA receiver 12.

[0026] A FM transceiver 10 is connected to a connection point 15 of the first elongated radiating element 1 close to the second end 14 thereof. The connection point 15 is further connected to ground through fifth filtering means 8.

[0027] Ground is also connected to a connection point 18 close to the second end 17 of the third elongated radiating element 3. The length 26 between the connection point 18 and the second end 17 of the third elongated radiating element 3 is preferably used for matching of the WCDMA receiver 12, and is typically about 10 mm.

[0028] The first elongated radiating element 1 have a length 21 configured for BT operation, about 35 mm. The first and second elongated radiating elements 1 and 2 together with the first filtering means 4 have a length 22 configured for GPS operation, about 70 mm. The first, second and third elongated radiating elements 1, 2 and 3 together have a length 23 configured for FM operation, about 110 mm. The length 24 between the connection point 15 and the first end 14 of the first elongated radiating element 1 is configured for matching of the GPS receiver 11 and the BT transceiver 9, about 10 mm. The exemplary lengths given above are dependent on e.g. distance above a ground plane device 19, in this case based on the distance of about 6 mm and on filtering means values.

[0029] The first filtering means 4 is preferably provided as an RF choke, but could also be provided as a simple inductor, of about 20 nH, and could alternatively be provided as parallel resonant circuit. The first filtering means 4 is in such a way configured to pass FM and GPS operation and to block BT operation. The second filtering means 5 is preferably provided as an RF choke, but could also be provided as a simple inductor, of about 20 nH, and could alternatively be provided as parallel resonant circuit. The second filtering means 5 is in such a way configured to pass FM operation and block WCDMA operation. The third filtering means 6 is connected close, about 5 mm from the second filtering means 5, and is preferably provided as a capacitor of about 5 pF, and is in such a way configured together with the second filtering means 5 to block GPS operation.

[0030] The fourth filtering means 7 is preferably provided as a capacitor of about 1 pF. By providing the fourth filtering means 7 as a capacitor, a simple, low cost and efficient filtering means is achieved. The fourth filtering means 7 is in such a way configured to pass BT and GPS operation and to block FM operation. The fifth filtering means 8 is preferably provided as a capacitor of about 30 pF. The fifth filtering means 8 is in such a way configured to tune the FM transceiver 10 and to ground BT operation. The antenna device is in such a way configured to simultaneously with FM frequencies operate at BT, GPS and WCDMA operating frequencies, wherein the BT, GPS and WCDMA antennas effectively work as IFA type antennas, and the FM antenna effectively works as a loop type antenna.

[0031] The antenna device thus exhibits a ground and feed point near the second end of the first elongated radiating element and an open end in first end of the first elongated radiating element, for BT frequencies. The antenna device also exhibits a ground and feed point in the second end of the first elongated radiating element and an open end in the combined second and third filtering means, for GPS frequencies. The antenna device further exhibits a ground and feed point in the second end of the third elongated radiating element and an open end in the second filtering means, for WCDMA frequencies. The antenna device also exhibits a loop structure from the fifth filtering means to grounding point 18, for FM frequen-

cies. The antenna device needs no diplexer for implementing FM frequencies. The isolation between all antennas is good, as well as the performance of all antennas, for such an antenna device.

[0032] The first, second and third elongated radiating elements are preferably planar elements supported by a dielectric carrier, such as radiating portions on a dielectric flexible film supported by a carrier. The dielectric carrier is preferably a portion of the back cover of the portable radio communication device. Alternatively the dielectric carrier is e.g. a portion of the middle deck the portable radio communication device. With the first, second and third elongated radiating elements supported by a dielectric carrier the RF choke is preferably mounted thereon. Further, the first, second and third elongated radiating elements are alternatively self-supported, and the RF choke is in this case preferably mounted on a printed wiring board onto which the radiating elements are mounted on.

[0033] The antenna device preferably forms a half-loop radiating element for FM operation. A half-loop antenna is a virtual loop antenna, by being provided over a ground plane device 19 of the portable radio communication device. The lengths 24 and 26 in Fig. 1 are thus seen as open-ended stubs protruding from a loop, by the FM transceiver, which stubs affect FM operation very little.

[0034] The BT and GPS antennas utilize parts of the FM antenna, which antennas thus are added to an originally configured active FM antenna without essentially increasing utilization of available space in the portable radio communication device. All antennas are configured to operate on their respective ground tone, which thereby minimizes their sensitivity to the environment.

[0035] Due to that the GPS receiver, the BT transceiver and the FM transceiver have feed points closely located on the first elongated radiating element 1 they can be provided as a single module combo transceiver without long transmission lines.

[0036] The antenna device preferably comprises a BT/GPS diplex filter 20 between the fourth filtering means 7 and the BT transceiver and GPS receiver, respectively, which diplex filter 20 e.g. is implemented as a standard component or integrated on chips. Alternatively, the BT transceiver and GPS receiver are connected directly to the fourth filtering means 7.

[0037] For configuration of the antenna device the first filtering means 4 is preferably positioned at the voltage maxima for the BT antenna, the second filtering means 5 is preferably positioned at the voltage maxima for the WCDMA antenna, and the third filtering means 6 is preferably positioned at the current maxima for the GPS antenna, respectively. All antennas are configured to operate on their respective ground tone, which thereby minimizes their sensitivity to the environment.

[0038] An antenna system for the first embodiment of the antenna device comprises the antenna device, the filtering means and the receivers and transceivers.

[0039] A second embodiment of an antenna device for a portable radio communication device according to the present invention is illustrated in Fig. 2.

[0040] The antenna device comprises a first elongated radiating element 1, having a first end 13 and a second end 14 opposite the first end 13, a second radiating element 2, and a third radiating element 3, having a first end 16 and a second end 17 opposite the first end 16. The antenna device further comprises first filtering means 4 connected between the second elongated radiating element 2 and the first end 13 of the first radiating element 1. The antenna device also comprises second filtering means 5 connected between the first end 16 of the third elongated radiating element 3 and the second radiating element 2. Third filtering means 6 connects the second elongated radiating element 2 to ground.

[0041] The second end 14 of the first elongated radiating element 1 is connected to fourth filtering means 7, which in turn is connected to a BT transceiver 9. The second end 17 of the third elongated radiating element 3 is connected to a WCDMA (Wideband Code Division Multiple Access) Rx receiver 12, preferably a diversity receiver, and a GPS receiver 11. The WCDMA receiver 12 and GPS receiver 11 are preferably connected through a WCDMA/GPS diplexer 27, which diplex filter 27 e.g. is implemented as a standard component or integrated on chips. Additionally, a matching network 28 is preferably provided between the diplex filter 27 and the second end 27 of the third radiating element 3, for matching of the WCDMA receiver 12.

[0042] A ground connection is connected close to the second end 17 of the third elongated radiating element 3 at point 18, typically having a length 26 of about 10 mm for matching of the WCDMA receiver 12. A FM transceiver 10 is connected to a point 15 of the first elongated radiating element 1 close to the first end 14 thereof. The connection point 15 is further connected to ground through sixth filtering means 8. The connection point is close, about 5 mm from the first filtering means 4.

[0043] The first, second and third elongated radiating elements 1, 2 and 3 together have a length 23 configured for FM operation, about 110 mm. The first elongated radiating element 1 have a length 21 configured for BT operation, about 35 mm. The length 24 between the connection point 15 and the first end 14 of the first elongated radiating element 1 is configured for matching of the BT transceiver 9, about 10 mm. The third elongated radiating element 3 has a length 25 configured for WCDMA Rx operation, about 35 mm. The length 29 for GPS operation is preferably about 70 mm. The length 26 between the connection point 18 and the second end 17 of the third elongated radiating element 3 is configured for matching of the WCDMA Rx receiver 12. The exemplary lengths given above are dependent on e.g. distance above a ground plane device 19, in this case based on the distance of about 6 mm and filtering means values.

[0044] The first filtering means 1 is preferably provided as an RF choke, but could also be provided as a simple

inductor, of about 20 nH, and could alternatively be provided as parallel resonant circuit. The first filtering means 4 is in such a way configured to pass FM operation and to block BT operation. The second filtering means 5 is preferably provided as an RF choke, but could also be provided as a simple inductor, of about 15 nH, and could alternatively be provided as parallel resonant circuit. The second filtering means 5 is in such a way configured to pass FM operation and to block WCDMA operation. The third filtering means is preferably provided as a capacitor of about 5 pF.

[0045] The fourth filtering means 7 is preferably provided as a capacitor of about 1 pF. The fourth filtering means 7 is in such a way configured to pass BT operation and to block FM operation. The fifth filtering means 8 is preferably provided as a capacitor of about 30 pF. The fifth filtering means 15 is in such a way configured to tune the FM transceiver 10 and to ground BT operation. The antenna device is in such a way configured to simultaneously with FM frequencies operate at BT, GPS and WCDMA Rx frequencies.

[0046] The antenna device thus exhibits a ground and feed point near the second end of the first elongated radiating element and an open end in first end of the first elongated radiating element, for BT frequencies. The antenna device also exhibits a ground and feed point in the second end of the third elongated radiating element and an open end in the combined first and third filtering means, for GPS frequencies. The antenna device further exhibits a ground and feed point in the second end of the third elongated radiating element and an open end in the second filtering means, for WCDMA frequencies. The antenna device also exhibits a loop structure from the fifth filtering means to grounding point 18, for FM frequencies. The antenna device needs no diplexer for implementing FM frequencies. The isolation between all antennas is good, as well as the performance of all antennas, for such an antenna device.

[0047] The first, second and third elongated radiating elements are preferably planar elements supported by a dielectric carrier, such as radiating portions on a dielectric flexible film supported by a carrier. The dielectric carrier is preferably a portion of the back cover of the portable radio communication device. Alternatively the dielectric carrier is e.g. a portion of the middle deck the portable radio communication device. With the first, second and third radiating elements supported by a dielectric carrier the RF chokes are preferably mounted thereon. Further, the first, second and third radiating elements are alternatively self-supported, and the RF chokes are in this case preferably mounted on a printed wiring board 19 onto which the radiating elements are mounted on.

[0048] The antenna device preferably forms a half-loop radiating element for FM operation. The antenna device thus effectively forms IFA type antennas for BT, GPS and WCDMA Rx operation, and effectively forms a loop type antenna for FM operation.

[0049] The BT, GPS and WCDMA RX antennas utilize

parts of the FM antenna, which antennas thus are added to an originally configured active FM antenna without essentially increasing utilization of available space in the portable radio communication device.

[0050] For configuration of the antenna device the first filtering means 4 is preferably positioned at the voltage maxima for the BT antenna, the second filtering means 5 is preferably positioned at the voltage maxima for the WCDMA antenna, and the third filtering means 6 is preferably positioned at the current maxima for the GPS antenna, respectively. All antennas are configured to operate on their respective ground tone, which thereby minimizes their sensitivity to the environment.

[0051] Due to that the BT transceiver and the FM transceiver have feed points closely located on the first radiating element 1 they can be provided as a single module combo transceiver without long transmission lines.

[0052] In a simplified implementation of the second embodiment of the present invention no WCDMA receiver is used. The main differences compared to the second embodiment described is that the WCDMA receiver 12 is removed, the GPS/WCDMA diplexer 27 is removed, and the GPS receiver 12 is connected to the matching network 28, which matching network typically is a capacitor of 2 pF for GPS matching.

[0053] An antenna system for the second embodiment of the antenna device comprises the antenna device, the filtering means and the receivers and transceivers.

[0054] It will be obvious that the present invention may be varied in a plurality of ways. Such variations are not to be regarded as departure from the scope of the present invention as defined by the appended claims. All such variations as would be obvious for a person skilled in the art are intended to be included within the scope of the present invention as defined by the appended claims.

Claims

1. An antenna device for a portable radio communication device configured for simultaneous multi frequency band operation, **characterized in that** said antenna device comprises a first elongated radiating element (1), a second elongated radiating element (2), a third elongated radiating element (3), first filtering means (4) arranged between said first and second elongated radiating elements, second filtering means (5) arranged between said second and third elongated radiating elements, and third filtering means (6) connecting said second elongated radiating element (2) to ground, wherein said first filtering means (4) is configured to block BT operating frequencies and to pass FM operating frequencies, said second filtering means (5) is configured to pass FM operating frequencies, and said third filtering means (6) is configured to ground GPS operating frequencies.
2. The antenna device according to claim 1, wherein said second filtering means (2) is configured to block WCDMA Rx operating frequencies.
3. The antenna device according to claim 1 or 2, comprising fourth filtering means (7) connecting said first elongated radiating element (1) to a BT transceiver (9), and fifth filtering means (8) connecting said first elongated radiating element (1) to ground, wherein said fourth filtering means (7) is configured to block FM operating frequencies and to match said BT transceiver, and said fifth filtering means (8) is configured to pass BT operating frequencies and to tune an FM transceiver (10).
4. The antenna device according to claim 3, wherein said antenna device is configured to effectively work as an IFA type antenna for BT, GPS and WCDMA Rx operating frequencies, and to effectively work as a loop type antenna for FM operating frequencies.
5. The antenna device according to any of claims 1-4, comprising a dielectric carrier supporting said first, second and third elongated radiating elements.
6. The antenna device according to claim 5, wherein said dielectric carrier is part of the back cover of the portable radio communication device.
7. The antenna device according to any of claims 1-6, wherein said first and second filtering means (4, 5) each is a RF choke.
8. The antenna device according to any of claims 1-7, wherein said third filtering means (6) is a capacitor.
9. The antenna device according to claim 3, wherein said fourth and fifth filtering means (7, 8) each is a capacitor.
10. The antenna device according to any of claims 1-9, wherein said first elongated radiating element (1) is connected to said first filtering means (4) in a first end (13) and is connected to said fourth filtering means (7) in a second end (14), opposite said first end (13), said fifth filtering means (8) is connected to a connection point (15) on said first elongated radiating element (1) close to said first end (14) of said first elongated radiating element (1), said third elongated radiating element (3) is connected to said second filtering means (5) in a first end (16) and to a WCDMA receiver in a second end (17), opposite said first end (16) of said third elongated radiating element, said third elongated radiating element is grounded in a connection point (18) close to said second end (17) thereof.

11. The antenna device according to claim 10, wherein said third filtering means (6) is connected to said second elongated radiating element (2) close to said second filtering means (5) and said second and third filtering means (5, 6) are together configured to block GPS operating frequencies. 5
12. The antenna device according to claim 10, wherein said third filtering means (6) is connected to said second elongated radiating element (2) close to said first filtering means (5) and said first and third filtering means (5, 6) are together configured to block GPS operating frequencies. 10
13. The antenna device according to claim 2, wherein a first end of said third elongated radiating element (3) is connected to said second filtering means (5) and a second end, opposite said first end, is connected to sixth filtering means (6) configured for GPS matching. 15
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14. The antenna device according to claim 13, wherein said third filtering means (6) is connected to said second elongated radiating element (2) close to said second filtering means (5), and said second and third filtering means (5, 6) are together configured to block GPS operating frequencies. 25
15. An antenna system for a portable radio communication device **characterized in that** it comprises an antenna device according to any of previous claims and a BT transceiver, a FM transceiver and a GPS receiver. 30
16. The antenna system according to claim 15, comprising a WCDMA receiver. 35
17. A portable radio communication device, **characterized in that** it comprises an antenna system according to claim 15 or 16, and a ground plane device (19), wherein said first, second and third elongated radiating elements (1, 2, 3) are arranged over said ground plane device. 40

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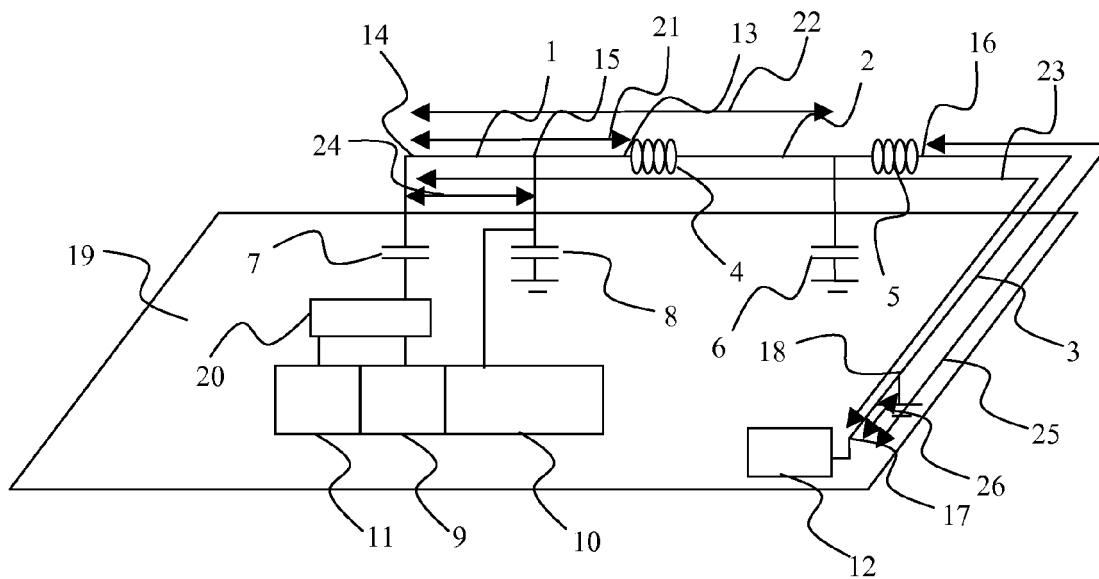


FIG. 1

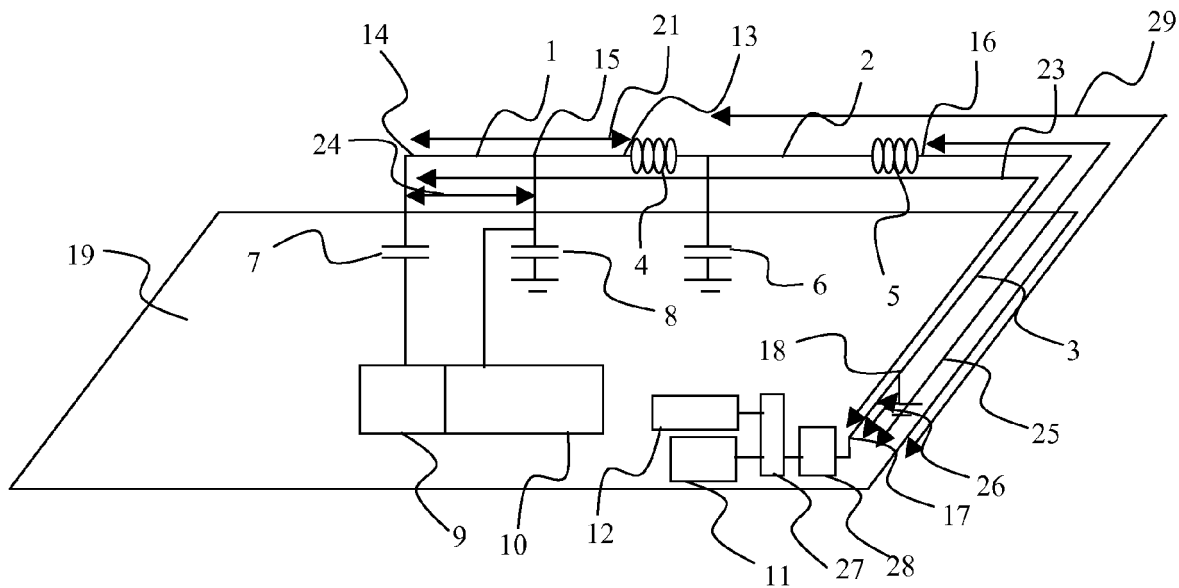


FIG. 2



EUROPEAN SEARCH REPORT

Application Number
EP 09 15 0765

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Place of search Munich		Date of completion of the search 9 March 2009	Examiner 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	

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 09 15 0765

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