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(71) Applicant: **Motorola Inc.**
Schaumburg, IL 60196 (US)

(72) Inventors:
- **Grossman, Ovadia**
  67899 Tel Aviv (IL)
- **Ben-Ayun, Moshe**
  67899 Tel Aviv (IL)
- **Rozental, Mark**
  67899 Tel Aviv (IL)

(74) Representative: **McCormack, Derek James**
Optimus
Grove House, Lutyens Close,
Chineham Court,
Basingstoke, Hampshire RG24 8AG (GB)

(54) A radio communication unit and an antenna arrangement therefor

(57) A radio unit comprises an antenna arrangement (200) capable of supporting multiple frequency bands. The antenna arrangement (200) comprises a first resonator (201) and a second resonator (207) tuned to different frequency bands. The second resonator (207) comprises a coupling section (209) which has a transformer coupling to the first resonator (201) and which effectively couples a signal between the first and second resonator (201,207) The second radiator may also in clude a radiating section (211) which effectively transmits or receives the radio signal and a coupling section (209). The first and second resonators (201,207) are galvanically isolated from each other. A radio frequency signal is fed to or taken from an antenna connector (205) connected to the first resonator (201). The coupling between the first resonator (201) and the second resonator (207) provides a transformer effect for transferring the signal between the resonators (201,207).

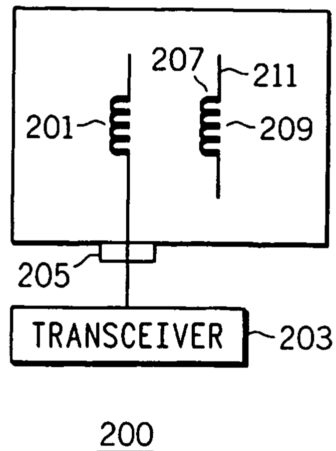

FIG. 2

EP 1 542 316 A1

Description

Field of the invention

[0001] The invention relates to a radio unit and an antenna arrangement therefor and in particular to an antenna arrangement suitable for two or more frequency ranges.

Background of the Invention

[0002] In the last century, radio transmission of modulated signals has become one of the must widespread means for communication over distance. In recent years, the use of radio communication has become even more ubiquitous with the advent of e.g. wireless local networks and mobile telephones.

[0003] A key parameter in radio communication systems is the design of the antennas which translate between electrical signals in wires and components and electromagnetic waves which propagate through space. The performance and efficiency of a radio communication system is heavily dependent on the performance of the antennas and therefore much research into optimal antenna structures have been carried out over the years.

[0004] In recent years, the increased use of radio communication for small portable radio units, such as mobile phones, has led to increased research into antenna structures suitable for this purpose. For example, in order to obtain a low form factor for mobile phones, significant research has been undertaking in order to develop small antenna structures that operate efficiently.

[0005] In addition, the complexity of radio units tends to increase and nowadays radio units typically serve multiple purposes. For example, mobile phones capable of operating on different frequency bands have become commonplace. As another example, many mobile phones are likely to in the near future have built in satellite location functionality based on the Global Positioning System (GPS).

[0006] Accordingly, it is currently desirable to develop practical and efficient multi band or frequency antennas which can operate in a plurality of different frequency ranges. For example, for a combined portable radio communication unit with a built in GPS receiver, it is desirable to have a multi band antenna capable of efficient reception at both around e.g. 400MHz and 1575 MHz.

[0007] Conventionally, multi band antennas for such purposes are formed by implementing two or more decoupled resonators within a single housing and connecting the antenna connector to both resonators. Typically, a substantially helical coil antenna element is combined with a straight quarterwave wire antenna element with the endpoints electrically connected to each other and the antenna connector. Thus, a transmit signal fed to the antenna will be galvanically fed to both antenna elements although radiation will predominantly be from the resonator tuned to the frequency of the transmit signal.

[0008] However, such a structure has a number of associated disadvantages.

[0009] Firstly, the resonators tend to be coupled due to the close proximity and the small size of the structure. Although the design process seeks to minimise this coupling, it cannot be avoided and it furthermore limits the design freedom of the antenna structure. Specifically, in order to maintain low coupling, the antenna structure typically comprises a substantially helical coil for the lowest frequency combined with a straight wire resonator for the higher frequency. A second substantially helical coil for the higher frequency would typically result in too strong a coupling.

[0010] Accordingly, the size of the antenna arrangement is relatively large which is particularly undesirable for portable applications.

[0011] Furthermore, such antenna structures must be designed very carefully in order to reduce coupling. Therefore, the addition of a new or different frequency range requires not only a new antenna element to be designed but also a redesign of the entire antenna structure with specific consideration to minimising coupling. Typically, a complete structural redesign is needed. Accordingly this is a very inflexible approach which requires dedicated antenna structures for radio units depending on the exact frequency bands that must be covered.

[0012] Also, due to the interdependence between the different antenna elements, a complicated design process is required. Specifically, any modifications to one antenna element may affect the performance of other antenna elements and this must be taken into account in the design.

[0013] Hence, an improved antenna arrangement for a radio unit would be advantageous and in particular an antenna arrangement allowing for increased flexibility, reduced size, facilitated redesign, simplified and reduced cost manufacturing, improved upgradeability and/or improved performance would be advantageous.

Summary of the Invention

[0014] Accordingly, the Invention seeks to preferably mitigate, alleviate or eliminate one or more of the above mentioned disadvantages singly or in any combination.

[0015] According to a first aspect of the invention there is provided an antenna arrangement comprising: a first resonator having an associated first resonance frequency; and a second resonator having an associated second resonance frequency and comprising a and a coupling section coupled to the first resonator for coupling a signal between the first and second resonator; and wherein the first and second resonators are galvanically isolated from each other and are coupled to each other by a transformer coupling.

The second resonator may include a radiating section additional to the coupling section.

[0016] Thus, the invention may provide a multi band antenna arrangement wherein the first resonator is suitable for receiving and/or transmitting radio signals in a frequency range around the first resonance frequency and the second resonator is suitable for receiving and/or transmitting radio signals in a frequency range around the second resonance frequency. The first resonator may thus provide a first antenna element for a first frequency range and the second resonator provides a second antenna element for a second frequency range.

[0017] The coupling section of the second resonator provides a relatively strong coupling to the first resonator but may provide only a relatively weak radiating effect whereas the radiating section may provide a relatively low coupling but a strong radiating effect. Specifically, the radiating effect of the second resonator may be substantially exclusively provided by the radiating section and the coupling may be substantially exclusively provided by the coupling section.

[0018] The term 'radiating' is used as a common term for both the receiving and transmitting antenna performance, i.e. the radiating section may be operable to generate an electromagnetic signal from an electrical current as well as generate an electrical current from a received electromagnetic signal. The coupling may thus be from the first resonator to the second resonator or from the second resonator to the first resonator.

[0019] The antenna arrangement uses a magnetic coupling between the first and second resonator to transfer signals to and from the second resonator similar to a transformer coupling. Accordingly, the antenna arrangement preferably has a strong magnetic coupling between the first resonator and the coupling section of the second resonator. Therefore, it is not necessary to minimise coupling between the first and second resonator and the antenna arrangement is much less sensitive to the effect of one resonator on the other resonator.

[0020] Specifically, the invention may allow increased design freedom and reduced interdependence between the design of the first and second resonator. Specifically, the second resonator may simply be located close to the first resonator to achieve the desired coupling while not significantly affecting the performance of the first resonator. Thus, the galvanic isolation and reduced interdependence between resonators allows an antenna arrangement wherein additional frequency bands may be covered by simply adding an additional resonator without redesigning the first resonator. Thus, all that is required is the physical proximity between the first and second resonator.

[0021] Hence, a simple, low cost antenna arrangement may be provided which is flexible and allows for easy upgradeability and/or facilitated re-design for new frequency bands.

[0022] Furthermore, the reduced interdependence between the first and second resonator provides increased design freedom which for example may be used to reduce the size of the antenna arrangement.

[0023] According to a feature of the invention, the antenna arrangement comprises a first antenna housing element comprising the first resonator and a second antenna housing element comprising the second resonator wherein the second antenna housing element is detachable from the first antenna housing element.

[0024] This provides for a particularly advantageous implementation. Specifically, this may provide for easy manufacturing and a high degree of flexibility. For example, different housing elements may be manufactured individually comprising resonators for different frequencies. A desired frequency performance of the antenna arrangement may be achieved simply by combining the appropriate housing elements. Thus, a desirable antenna arrangement may be implemented by simply selecting and joining the appropriate building blocks in the form of antenna housing elements comprising suitable resonators.

[0025] According to a different feature of the invention, the second antenna housing element is operable to be substantially friction mounted on the first antenna housing element.

[0026] This provides for a particularly simple and efficient way of implementing the antenna arrangement which provides a high degree of flexibility.

[0027] According to a different feature of the invention, the second housing element provides galvanic isolation of the second resonator.

[0028] Preferably the second housing element is made out of an isolating material and the second resonator is preferably completely contained in this material. For example, the resonator may be enclosed in a second antenna housing element by injection moulding. The same approach may be used for the first resonator and antenna housing element. This provides for an easy to manufacture, robust and/or efficient implementation providing the desired galvanic isolation.

[0029] According to a different feature of the invention, the first resonator comprises a substantially helical coil. This is a particularly suitable implementation of the first resonator which typically tends to reduce the size of the antenna arrangement. The resonator may for example be substantially formed by a helical coil or only part of the resonator may be in the form of a substantially helical coil.

[0030] According to a different feature of the invention, the radiating section comprises a substantially helical coil. This is a particularly suitable implementation of the second resonator which typically tends to reduce the size of the antenna arrangement. The radiating section may for example be substantially formed by a helical coil or only part of the radiating section may be in the form of a substantially helical coil. Preferably, both the first and second resonators comprise substantially helical coils resulting in an antenna arrangement of small dimensions which is particularly suitable for a portable radio unit.

[0031] According to a different feature of the invention, the second resonator is located inside the first resonator.

[0032] Specifically, the second antenna housing element may simply be placed inside the first antenna housing element. For example, if the first resonator is a substantially helical coil, the second resonator may be located within the substantially helical coil. This is a particularly practical implementation for many applications.

[0033] According to a different feature of the invention the second resonator is located outside the first resonator. Specifically, the second antenna housing element may simply be placed around the first antenna housing element. For example, if the second resonator is a substantially helical coil, the first resonator may be located within the substantially helical coil. This is a particularly practical implementation for many applications.

[0034] According to a different feature of the invention, the first resonance frequency is associated with a cellular communication system frequency and the second resonance frequency is associated with a Global Positioning System (GPS) frequency. The invention may provide a suitable antenna arrangement e.g. for a combined cellular communication unit and GPS unit.

[0035] According to a different feature of the invention, the antenna arrangement further comprises a third resonator having an associated third resonance frequency; wherein the first, second and third resonator are magnetically coupled and galvanically isolated from each other.

[0036] The antenna arrangement is suitable for multi band radio units and may easily be modified to provide efficient antenna performance on three or more different frequency bands.

[0037] According to a different feature of the invention, the antenna arrangement further comprises a magnetic element operable to increase the magnetic coupling between the first and second resonator.

[0038] This may allow increased coupling which improves performance and reduces losses associated with the coupling of the first and second resonator. The magnetic element may be particularly suitable for lower frequencies where losses in magnetic elements tend to be lower.

[0039] According to a different feature of the invention, the antenna arrangement comprises a single galvanic antenna connector connected only to the first resonator. Preferably only one galvanic connection exists for coupling the antenna to a receiver and/or transmitter.

[0040] According to a different feature of the invention, the coupling section is located towards an end of the first resonator connected to the antenna connector. This provides a particularly suitable implementation and improves the coupling of the signal between the first and second resonator.

[0041] According to a different feature of the invention, the coupling section and the radiating section is formed by a single conductive wire. This provides for a particularly simple, easy to manufacture and/or low cost implementation.

[0042] The antenna arrangement may preferably be comprised in a radio unit.

[0043] According to a different feature of the invention, the first resonator is galvanically coupled to a transmitter for feeding a signal to the antenna arrangement, and the antenna arrangement is operable predominantly radiate frequencies of the signal in a first frequency range around the first resonance frequency from the first resonator and to predominantly radiate frequencies of the signal in a second frequency range around the second resonance frequency from the second resonator.

[0044] The antenna arrangement is suitable for operating as a transmit antenna. The magnetic coupling provides the signal energy of the second frequency range to the second resonator from where it is effectively radiated.

[0045] The signal fed to the antenna arrangement does not necessarily contain energy in both the first and second frequency ranges simultaneously although it may do so. Specifically, the transmit signal may be a dual band signal having simultaneous dual band transmissions or non-simultaneous dual band transmissions.

[0046] According to a different feature of the invention, the first resonator is galvanically coupled to a receiver and the radio signals in a first frequency range around the first resonance frequency is predominantly received by the first resonator and radio signals in a second frequency range around the second resonance frequency is predominantly received by the second resonator.

[0047] The antenna arrangement is suitable for operating as a receive antenna. The magnetic coupling provides the signal energy of the second frequency range from the second resonator to the receiver.

[0048] According to a different feature of the invention, the radio unit comprises a radio unit housing and the first resonator is internal to the radio unit housing and the second resonator is comprised in an antenna housing element external to the radio unit housing.

[0049] This may provide for a simple way of upgrading a single band receiver being designed with an internal antenna. Specifically, the antenna functionality required for supporting a second frequency band may simply be achieved by adding an antenna housing element comprising the second resonator to the existing radio unit. Thus, no redesign of the radio unit is required.

[0050] Preferably the radio unit is a portable radio unit.

[0051] These and other aspects, features and advantages of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

Brief Description of the Drawings

[0052] An embodiment of the invention will be described, by way of example only, with reference to the drawings, in which

FIG. 1 illustrates an implementation of an antenna arrangement for a two band radio unit in accordance with prior art;

FIG. 2 illustrates an example of an antenna arrangement in accordance with an embodiment of the invention;

FIG. 3 illustrates an antenna arrangement comprising antenna housing elements in accordance with an embodiment of the invention; and

FIG. 4 illustrates a radio unit in accordance with an embodiment of the invention.

Detailed Description of an Embodiment of the Invention

[0053] The following description focuses on an embodiment of the invention applicable to a portable radio unit comprising a cellular communication system radio unit operating in the 400 MHz frequency band and a Global Positioning System (GPS) receiver operating in the 1575 MHz frequency band.
However, it will be appreciated that the invention is not limited to this application but may be applied to many other radio communication applications.

[0054] Antennas for multiple frequency radios are required to have more than one resonance in order to efficiently accommodate several frequency ranges. This is conventionally achieved by adding a second decoupled resonator within the antenna to provide coverage for the second frequency band.

[0055] FIG. 1 illustrates an implementation of an antenna arrangement for a two band radio unit in accordance with the prior art. The antenna arrangement uses two decoupled and connected resonators to provide frequency coverage of the two distinct frequency bands around 400MHz and 1575 MHz respectively.

[0056] The antenna arrangement 100 comprises a first resonator 101 for covering the 400 MHz frequency band. The first resonator is galvanically coupled to a transceiver 103 though a suitable connector 105 and transmission line. The first resonator is a helical coil in order to reduce the size of the antenna arrangement.

[0057] In order to cover the 1575MHz band, a second resonator 107 has been added. The second resonator 107 is also connected to the transceiver 103 through the connector 105. Thus, the first and second resonators 101, 107 are electrically connected at one end. In order to reduce the coupling between the antenna elements, the second resonator is typically designed as a straight quarter wave wire antenna since for example a helical coil would result in a strong coupling to the first resonator 101. Specifically, the second resonator should be orthogonal to the first resonator and therefore the design freedom for designing the second resonator is very limited.

[0058] Accordingly, a conventional multi band antenna arrangement is typically of an undesirable large size. For example, to cover the frequency bands of 400MHz and 1575 MHz an antenna arrangement having a length of 5 cm is typically required.

[0059] Also, the addition of the second resonator 107 affects the performance of the first resonator 101 and requires this to be retuned since both resonators are coupled directly to the same feed. Additional resonance with a third resonator would further require redesign and retuning of all three resonators and typically a complete structural redesign would be required.

[0060] FIG. 2 illustrates an example of an antenna arrangement 200 in accordance with an embodiment of the invention.

[0061] Similarly to the antenna arrangement 100 of FIG. 1, the antenna arrangement 200 of FIG. 2 comprises a first resonator 201 which is connected to a transceiver 203 through a connector 205. The first resonator 203 is in the specific embodiment a helical coil having a resonance frequency of around 400 MHz.

[0062] In addition, the antenna arrangement 200 comprises a second resonator 207 which is tuned to a second resonance frequency of 1575 MHz. However, in contrast to the antenna arrangement 100 of FIG. 1, the second resonator 207 of FIG. 2 is not electrically connected to the connector or to the transceiver 203. Rather the first and second resonators 201, 207 are galvanically isolated from each other.

[0063] Furthermore, in contrast to the arrangement of FIG. 1, the first and second resonators 201, 207 are not orthogonal but are rather magnetically coupled to each other. Specifically, the first and second resonators 201, 207 are magnetically coupled through a coupling section 209 of the second resonator. Accordingly, a current variant in one resonator will cause a magnetic field fluctuation that will result in a varying current being induced in the other resonator. Hence, the coupling between the first and second resonators 201, 207 provides a transformer effect allowing for signals to be coupled from one resonator to the other.

[0064] The second resonator 207 further comprises a radiating section 211. The radiating section 211 and coupling section is preferable made from a single wire. For example, the coupling section 209 may be formed by a tightly wound wire and the radiating section 211 may be formed by a straight section or a very loosely wound section of the same wire.

[0065] When a signal is coupled to the coupling section 209 of the second resonator 207, a current will be induced. As this current flows in the radiating section 211, a strong electromagnetic signal will be transmitted. Likewise, when receiving a signal, an electromagnetic current will flow in the radiating section 211 and thus in the coupling section 209 thereby resulting in the received signal being coupled to the first resonator.

[0066] The first and second resonators 201, 207 are in the embodiment of FIG. 2 comprised in the same housing and may for example be formed by injection moulding techniques as is well known in the art.

[0067] The antenna arrangement 200 of FIG. 2 provides for an efficient antenna arrangement that may conveniently be designed or modified for operation on different frequencies. Specifically, as the first and second resonator 201, 207 are strongly coupled, the resonators 201, 207 are not designed to be orthogonal and accordingly may be designed without this restriction.

[0068] Furthermore, as the first and second resonators 201, 207 are not galvanically connected to each other and the transceiver, the interdependence between the resonators is greatly reduced. Accordingly, the first and second resonator may be individually designed without consideration of the other resonator. Specifically, the embodiment provides for separate control over the resonance frequencies of the first and second resonators 201, 207. The separation of the second resonator into a coupling section and radiating section and the therewith associated separation of functionality provides an increased design freedom and reduced interdependence between the first and second resonator.

[0069] The first and second resonators 201, 207 may for example both be designed fully or partially as substantially helical coils thereby resulting in the length of the antenna arrangement 200 being substantially reduced. The antenna arrangement is therefore particularly suitable for portable radio units. Furthermore, the reduced interdependence results in modifications to one resonator not requiring modifications to the other resonator. Thus, the design and dimensioning is significantly facilitated and the flexibility is increased allowing for modifications to be introduced which only affect the resonator being modified.

[0070] Accordingly, in the antenna arrangement of FIG. 2, transformer coupling of the different resonators is utilised in order to achieve separate control over resonance frequencies (and thus the length) of the resonators thereby making shorter antenna possible. Furthermore, by utilising the transformer principle, no galvanic connection is required between resonators and an additional resonance may easily be added.

[0071] As a specific example, the first resonator 201 may be a substantially helical coil and the second resonator 207 may be comprise a half wave wire having approximately 1/3 wavelength of the wire formed as a substantially helical coil situated within the substantially helical coil of the first resonator 201. In this case, the substantially helical coil will form the coupling section and the remaining straight wire will form the radiating section.

[0072] The first and second resonators may be comprised in different antenna housing elements which preferably are detachable with respect to each other. FIG. 3 illustrates a cross section of an antenna arrangement 300 comprising antenna housing elements 301, 303 in accordance with an embodiment of the invention. The antenna arrangement 300 comprises a first antenna housing element 301 comprising the first resonator and a second antenna housing element 303 comprising the second resonator. FIG. 3 illustrates a helical coil of the first resonator and specifically shows the wire in cross section when going into the figure 305 and coming out of the figure 307.

[0073] FIG. 3 furthermore illustrates a second resonator wire 309 having a length substantially equal to half a wavelength of the resonance frequency of the second resonator. Part of the second resonator wire 309 is formed as a helical coil to reduce the length of the antenna arrangement 300 and to provide the coupling section. In the example of FIG. 3, the first resonator is completely enclosed in the first antenna housing element 301 and the second resonator is completely enclosed in the second antenna housing element 303. The antenna housing elements 301, 303 are in the example made of an electrically isolating material and thereby provide galvanic isolation of the resonators. However, the first resonator is electrically connected to an antenna connector (not shown) for connection to a suitable radio unit.

[0074] In the antenna arrangement of FIG. 3, the first and second antenna housing element 301, 303 are separate elements that may be detached from each other. Specifically, the first housing element 301 comprises an inner bore 311 into which the second housing element 303 may be inserted. In some embodiments, the first and second antenna housing elements 301, 303 may be made from resilient materials allowing for a friction fit between the antenna housing elements 301, 303. However, in the illustrated embodiment, the bore 311 of the first housing element 301 comprises a thread and the external circumference of the second antenna housing element 303 comprises a complementary thread thereby allowing the second antenna housing element 303 to be screwed into the first antenna housing element 301.

[0075] The structure of FIG. 3 provides for a very flexible approach wherein an antenna arrangement may be easily customised or modified. For example, manufacturing of a range of different antennas may be simplified by manufacturing a number of antenna housing elements shaped as the first antenna housing element 301 and a number of antenna housing elements shaped as the second antenna housing element 303. A given two band antenna arrangement may then be implemented simply be selecting two antenna housing elements having the appropriate resonance frequencies and combining these. Furthermore, new frequency bands may easily be added to the range simply be manufacturing an antenna housing element comprising a resonator suitable for the new frequency band. This new antenna housing element may be used with all the existing antenna housing elements without requiring any redesign.

[0076] In the example of FIG. 3, the second resonator is located inside the first resonator, i.e. the second antenna housing element 303 is inserted into the first antenna housing element 301. However, in other embodiments, it may be advantageous to locate the second resonator outside the first resonator.

[0077] FIG. 4 illustrates a radio unit 400 in accordance with an embodiment of the invention. In the example of FIG. 4, the second resonator is located outside the first resonator.

[0078] The radio unit 400 comprises a housing 401 forming the outer shell of the functionality of the radio unit 400. A first antenna housing element 403 is attached to the housing 401 or may be formed as an integral part of the housing 401. The first antenna housing element 403 comprises a first resonator 405 tuned to a first resonance frequency. The first resonator 405 is connected to a transceiver 407 though a connector 409. A radio unit 400 comprising these parts may be arranged to operate on a first frequency band associated with the first resonance frequency.

[0079] However, in some cases it may be advantageous to modify a radio unit as described about to operate on an additional second frequency band. The radio unit 400 may accordingly be modified by placing a second antenna housing element 411 around the first antenna housing element 403 as illustrated in FIG. 4. The second antenna housing element 411 comprises a second resonator 413 in the example in the form of a partly substantially helical coil. The second resonator 413 is tuned to the second frequency band and is magnetically coupled to and galvanically isolated from the first resonator as described above. Preferably, the second antenna housing element 411 may be made from a resilient material, such as a rubber material, and have dimensions allowing it to tightly fit the first antenna housing element 403 thereby providing a friction fit of the second antenna housing element 411 on the first antenna housing element 403.

[0080] When transmitting in the first frequency band, the transmit signal will predominantly be radiated by the first resonator 405. However, when transmitting in the second frequency band, the transmit signal will be predominantly transmitted from the second resonator 413 due to the magnetic coupling and tuning of the first and second resonator. Likewise, when receiving in the first frequency band, the received signal will predominantly be from the first resonator 405. However, when receiving in the second frequency band, the received signal will be predominantly be from the second resonator 413 due to the magnetic coupling and tuning of the first and second resonator.

[0081] Thus, in this embodiment, a radio unit may easily and simply be modified to operate on different frequency bands. This may provide for a simplified and reduced cost manufacturing process where the same radio unit housing 401 may be reused for both single band and multiple band radio units.

[0082] In some applications antenna resonators are located internal to a radio unit housing in order to reduce the form factor of the radio unit. The described antenna arrangement is very suitable for providing an additional frequency band to such a resonator as galvanic connection is not required. Thus, a second resonator having a second resonance frequency may be included in an antenna housing element which can be attached to the external of the radio unit housing thereby providing for efficient antenna performance at the second frequency.

[0083] In some applications, the magnetic coupling between the first and second resonator may be increased by including magnetic material that increases the magnetic coupling between the resonators. For example, if two helical coils are located coaxially, a magnetic element may be placed inside the inner helical coil. However, as losses in magnetic materials typically rise with increasing frequency, this approach is more advantageous at lower frequencies. The magnetic material may comprise a ferromagnetic material such as iron.

[0084] It will be appreciated that although the above description has focused on antenna arrangements comprising two resonators at different frequencies, the disclosed principles also apply to larger number of resonators. For example, a three band antenna arrangement may be implemented by implementing three galvanically isolated and magnetically coupled resonators having different resonance frequencies.

[0085] Although the present invention has been described in connection with the preferred embodiment, it is not intended to be limited to the specific form set forth herein. Rather, the scope of the present invention is limited only by the accompanying claims. In the claims, the term comprising does not exclude the presence of other elements or steps. Furthermore, although individually listed, a plurality of means, elements or method steps may be implemented by e.g. a single unit or processor. Additionally, although individual features may be included in different claims, these may possibly be advantageously combined, and the inclusion in different claims does not imply that a combination of features is not feasible and/or advantageous. In addition, singular references do not exclude a plurality. Thus references to "a", "an", "first", "second" etc do not preclude a plurality.

Claims

1. An antenna arrangement (200) comprising a first resonator (201) having an associated first resonance frequency and a second resonator (207) having an associated second resonance frequency, the second resonator having a coupling section (209) for coupling a signal between the first resonator and the second resonator, the first and second resonators being galvanically isolated from each other, wherein the coupling section of the second resonator is coupled to the first resonator by a transformer coupling.

2. An antenna arrangement according to claim 1 wherein the transformer coupling includes a magnetic core material to increase coupling between the first and second resonators.

3. An antenna arrangement according to claim 1 or claim 2 wherein the second resonator includes a radiating section additional to the coupling section.

4. An antenna arrangement as claimed in any one preceding claim, wherein the antenna arrangement comprises a first antenna housing element comprising the first resonator and a second antenna housing element comprising the second resonator and wherein the second housing element is detachable from the first antenna housing element.

5. An antenna arrangement as claimed in claim 4 wherein the second antenna housing element is operable to be substantially friction mounted on the first antenna housing element.

6. An antenna arrangement as claimed in claim 4 or claim 5 wherein the second housing element provides galvanic isolation of the second resonator.

7. An antenna arrangement as claimed in any one preceding claim wherein the first resonator comprises a substantially helical coil.

8. An antenna arrangement as claimed in any one preceding claim wherein the second resonator includes a radiating section which comprises a substantially straight or loosely wound wire.

9. An antenna arrangement as claimed in any one preceding claim wherein the second resonator is located inside the first resonator.

10. An antenna arrangement as claimed in any one preceding claims 1 to 8 wherein the second resonator is located outside the first resonator.

11. An antenna arrangement as claimed in any one preceding claim wherein the first resonance frequency is a frequency associated with a cellular communication system frequency and the second resonance frequency is associated with a Global Positioning System (GPS) frequency.

12. An antenna arrangement as claimed in any one preceding claim and further comprising a third resonator having an associated third resonance frequency; wherein the first, second and third resonators are magnetically coupled and galvanically isolated from each other.

13. An antenna arrangement as claimed in any previous claim comprising a single galvanic antenna connector connected only to the first resonator.

14. An antenna arrangement as claimed in claim 13 wherein the coupling section is located toward an end of the first resonator connected to the antenna connector.

15. An antenna arrangement as claimed in claim 14 wherein the second resonator includes a coupling section and a radiating section formed from a single conductive wire.

16. A radio communication unit comprising an antenna arrangement as claimed in any previous claim.

17. A radio communication unit as claimed in claim 16 wherein the first resonator is galvanically coupled to a transmitter for feeding a signal to the antenna arrangement, and the antenna arrangement is operable to predominantly radiate frequencies of the signal in a first frequency range around the first resonance frequency from the first resonator and to predominantly radiate frequencies of the signal in a second frequency range around the second resonance frequency from the second resonator.

18. A radio communication unit as claimed in claim 16 or claim 17 wherein the first resonator is galvanically coupled to a receiver and wherein radio signals in a first frequency range around the first resonance frequency is predominantly received by the first resonator, and radio signals in a second frequency range around the second resonance frequency is predominantly received by the second resonator

19. A radio communication unit as claimed in claim 16 or claim 17 wherein the radio communication unit includes a radio unit housing and the first resonator is internal to the radio unit housing, and the second resonator is included in an antenna housing element external to the radio unit housing.

20. A radio communication unit as claimed in any one of claims 15 to 19 wherein the radio unit is a portable radio unit.

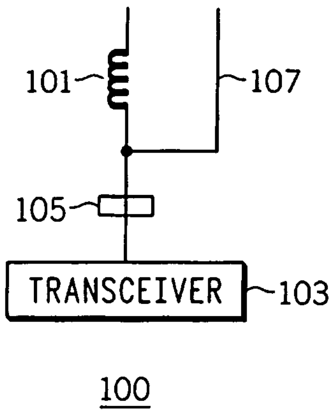

FIG. 1

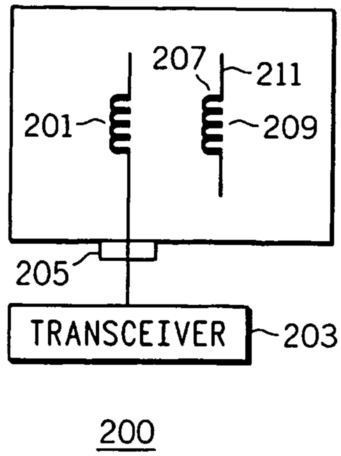

FIG. 2

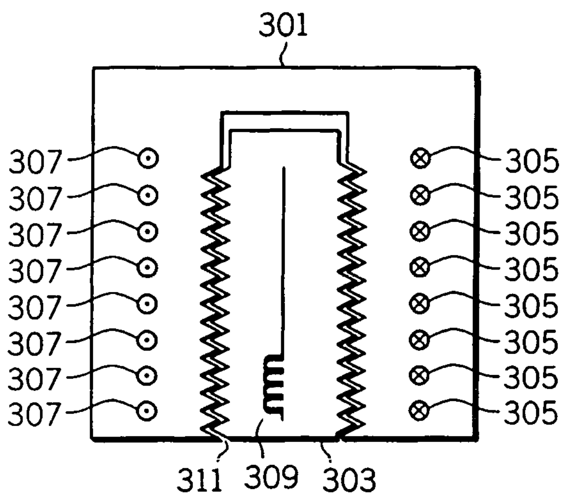

FIG. 3

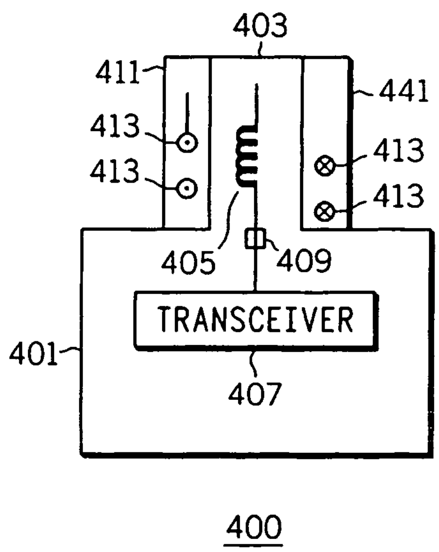

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 04 10 6528

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Place of search	Date of completion of the search	Examiner
Munich	17 March 2005	von Walter, S-U

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2

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