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(54) Compact RFID reader antenna

(57) The present invention relates to a compact Ultra High Frequency (UHF) Radio Frequency Identification (RFID) reader antenna for handheld devices. The reader antenna has a carrier frequency and defining a volume, and the reader antenna comprises a ground element having a height, a width and a length; at least one active antenna element defining a longitudinal extension axis; and a base material having a base height, a base width and a base length. The reader antenna has a bandwidth larger than approximately 13% of the carrier frequency (frequency of operation) and a realised gain larger than 6 dBi, wherein the width of the antenna is less than 70 mm and the volume of the antenna is less than 50000 mm^3. Furthermore, the invention relates to an RFID reader system and to use of the compact RFID reader antenna.

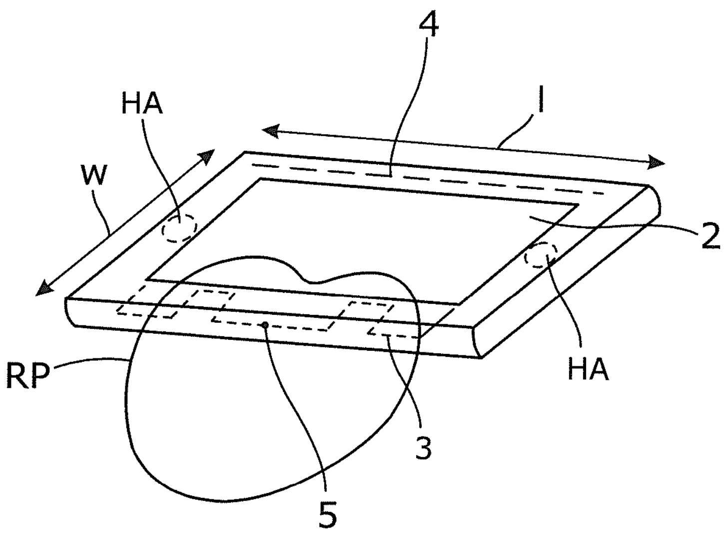

Fig. 1b

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Description

Field of the invention

[0001] The present invention relates to a compact Ultra High Frequency (UHF) Radio Frequency Identification (RFID) reader antenna for handheld devices. Furthermore, the invention relates to an RFID reader system and to use of the compact RFID reader antenna.

Background art

[0002] Antennas destined for radio frequency identification systems (RFID) require high gain in order to maximise the interrogation distance of tags. However, there is a fundamental trade-off between antenna gain and electric volume. The electrical volume relates to the operating frequency with the volume enclosing the physical part of an antenna that is used in the radiation mechanism.

[0003] A directive antenna occupies an electrically large area and volume (large compared with the operating wavelength λ). From a product design point of view, especially for portable devices, the shape and volume occupied by the physical antenna are of great interest. In addition, any antenna design is very much dependent on the intended application.

[0004] For an RFID reader, the antenna performance is directly related to the overall performance of the RFID reader system. Consequently, the traditional approach of sacrificing performance for a smaller system volume if such is required, i.e. a smaller antenna volume, is not an option simply because the reader system typically will no longer fulfill the specifications required. This is contrary to common practice concerning other wireless communication devices where the design is a key selling point, i.e. devices such as mobile phones.

[0005] For a handheld implementation of an RFID reader, the size and shape of the device are important criteria in the design of practical applications, but it has never been the deciding factor in the acquisition process. In traditional RFID applications, i.e. in package tracing for warehouses or for farm animal management systems, available commercial portable readers tend to have a bulky design in order to accommodate a high gain antenna.

[0006] Alternative applications, e.g. in cases where RFID tags are used e.g. for tracking stolen items, these applications typically require more integration with the potential solutions. In these types of applications, there is a great interest in adapting the antenna's shape and size to be easy to conceal and to be not obvious.

[0007] An example would be an antenna that can be attached to the back cover of ordinary smart phones without completely disturbing the aspect of the phone. In this case, traditional approaches to building RFID reader antennas are not valid because of the size requirements. An ideal design would require a low physical profile, i.e. a small physical electrically small antenna that can radiate efficiently in the presence of a conducting plane (e.g. the ground plane of the phone).

[0008] The way the user handles the device and the way the hands of the user interact with the antenna's near-field will determine the antenna performance. The antenna design has a set of constrains unique to this application. Nonetheless, the challenge of making an electrically small and directive antenna remains universally valid for any RFID or localisation applications in general.

[0009] The drawbacks of the known solutions are the big ground plane required to get decent directivity (at least 0.9 λ by 0.9 λ for patch antennas) due to the fringing field effects. Furthermore, for the traditional horn and helical designs, the height required to achieve an acceptable gain for a given bandwidth is considerable, and it dictates the largest dimension of the antenna. Finally, the fact that the peak gain is in a direction normal to the ground surface will lead to bulky readers.

[0010] A design that does not compromise between gain and bandwidth will need to have a considerable height. No less than 35 mm of height and a ground plane of 250 x 250 mm are required to achieve a good gain for an UHF RFID reader antenna using a classical patch antenna design.

Summary of the invention

[0011] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved directional antenna with small physical dimensions.

[0012] Furthermore, it is an aspect of the present invention that the near field of the antenna is less susceptible to disturbance from the user presence, e.g. a hand of a human being.

[0013] It is a further aspect of the invention to provide a handheld embodiment of the present invention that is immune to the perturbations introduced by the user's lossy tissue.

[0014] It is a further aspect of the invention to provide an antenna that is easy to manufacture.

[0015] It is a further aspect of the invention to provide a directional antenna.

[0016] It is a yet further aspect of the present invention to provide a handheld RFID reader antenna which can be easily integrated with handheld communication devices already on the market (e.g. phones, tablets or laptops).

[0017] The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by a compact Ultra High Frequency (UHF) Radio Frequency Identification (RFID) reader antenna for handheld devices, the reader antenna having a carrier frequency and defining a volume, and the reader antenna comprising:

- a ground element,
- at least one active antenna element (defining a longitudinal extension axis, and
- a base material having a base height, a base width and a base length,

  the reader antenna having a bandwidth larger than approximately 13% of the carrier frequency (frequency of operation) and a realised gain larger than 6 dBi wherein the width of the antenna is less than 70 mm and the volume of the antenna is less than 50000 mm^3.

[0018] In this way, it is achieved that it is possible to fit the antenna with the desired bandwidth and frequency even on existing handheld portable devices, e.g. a Portable Digital Assistant (PDA), a smart phone, a mobile phone, a portable navigation system or similar. Of course, such devices are designed for a specific intended use, e.g. as a handheld communication device, and as such, the addition of large physical elements is unwanted. As mentioned above, the previously known RFID reader antennas would be too large to be fitted on e.g. a common mobile phone or smart phone. However, the antenna according to the present invention is so small that it may be fitted without disturbing the use of the device. Furthermore, in order to achieve properties, i.e. a realised gain, of the antenna that is necessary for a given purpose, the antenna may be a directional antenna. In this way, it is possible to adapt the antenna in a way that enhances the antenna properties in a direction that is biased in relation to the intended use of the portable device. Considering an antenna fitted onto a smart phone or mobile phone, the phone is typically positioned in the same manner both during and between use. This is due to the simple fact that the phone is fitted with a display that needs to be facing the user during use. Hence, when the orientation of the phone is predetermined, it is possible to adapt the RFID antenna to the phone in a preferred manner. Furthermore, when handling of the phone causes the phone to be oriented in a certain manner during use, the phone is usually put into a pocket, belt container or bag by the user in the same manner each time. The active element may be called a driving element.

[0019] In an embodiment, the ground element carries and connects electrical components. In this way, it is possible to have not only the antenna, but also to comprise a full RFID reader in the volume of the antenna.

[0020] In an embodiment, the electrical components of the RFID reader may include a display. In this way, it is possible to have a fully operational reader device with the possibility of presenting the information based on the data gathered from the antenna.

[0021] Due to the possibility of applying electronics inside the volume of the antenna, volume may comprise the full RFID reader and not only the antenna. Hence, an RFID reader is obtained that is easy for the user to handle without changing the performance of the antenna more than a 30% decrease in realised gain.

[0022] The antenna design of the present invention may be handled by the user in locations between the elements, e.g. by placing the thumbs of the user between the elements. In this way, it is possible to implement the antenna on various systems and handheld devices without affecting the realised gain of the antenna. It is possible for the user to directly touch and handle the antenna in areas between the elements. In an embodiment, the base material may be a dielectric material. In this way, it is achieved that it is possible to adjust the directivity of the antenna. Furthermore, it is possible to adjust the radiation pattern.

[0023] It is achieved that the antenna is a directive, low profile and easy to manufacture antenna with only two elements. The one element is a driving element and the other is a passive or active element. Furthermore, a reduction of the backwards radiation of an element with electrically small reflective surfaces or elements is achieved. The distance between the elements of the array may be significantly reduced from the traditional $\lambda/2$ to λ /10 or λ /15 depending on the bandwidth requirements of the antenna, thus minimising the occupied area.

[0024] Using a miniaturised dipole, the antenna may be kept as a directive and compact antenna. It is known that the dipole will maintain its radiation pattern even when its size is much smaller than $\lambda/2$ however, as stated above this is typically on the expense of the gain. Similarly, the antenna may have a distance of $\lambda/2$ between an external antenna and a conductive surface, e.g. a printed element integrated with an RFID reader chip and placed on an external cover for a smart phone.

[0025] The wavelength is given by the speed of propagation of electromagnetic wave in the certain medium. (David Pozar Microwave engineering, chapter 2) λ=c/f approximately 346 mmλ is the wavelength, c is the speed of propagation (speed of light) and f is frequency. In vacuum, the dimensions an embodiment of the invention provide the following sizes in wavelength:

Physical size (mm)	Electrical size at 865 MHz
120 (length of base material/antenna)	0.34 λ or λ /3
65 (width of base material/antenna)	0.18λ or λ/5.3
9 (distance from active element to ground)	0.02 λ or λ/38.5
10 (distance from second element to ground)	0.03 λ or λ/34.6
54 (distance from active to second element)	0.14λ or λ/7
8 (Width of meandering path)	0.02 λ or λ /43.3
30 (width of ground plate)	0.08 λ or λ/11.5
78 (length of ground plate)	0.22λ or λ/4.4

[0026] Hence, according to the physical size of the present invention, it is seen that the λ-factor is significantly smaller than hitherto known at the frequency of 865 MHz.

[0027] In a simple manner, traditional tunable impedance methods, i.e. tunable matching, can be applied to correct disturbances introduced by the user. This is due to the fact that the antenna performance depends only on one coupling, the coupling between the reflective element (ground or a conducting surface) and active element. Therefore, it is easy to adapt the antenna to a specific handheld device which it is connected to, or in general for a specific purpose.

[0028] The distance between the ground element and the at least one active element may be 2 mm-35 mm, 4 mm-30 mm, 6 mm-25 mm, 8 mm-20 mm or 10 mm-15 mm.

[0029] The compact design of the antenna makes it possible to implement the antenna in a number of handheld devices. Concerning e.g. mobile phones, the aesthetic appearance as well as the size of the phone is of great importance with respect to the daily use of the device. Hence, an implementation of the antenna according to the present invention on a phone requires that the overall size of the antenna is smaller than the phone. In another embodiment, the compact RFID reader antenna may have a distance between the ground element and the at least one reflector/passive element of 2 mm-35 mm, 4 mm-30 mm, 6 mm-25 mm, 8 mm-20 mm or 10 mm-15 mm. In an embodiment, the ground element may act as a passive element. In this way, it is possible to achieve a small and compact reader antenna. The insensitivity to the handling of the end-user makes it possible to use the antenna in a number of handheld devices without customising the antenna for the specific purpose.

[0030] Furthermore, the active element may be meandering along its axis of extension.

[0031] In this way, it is achieved that the antenna may have an increased gain. This is due to the fact that a longer active element in combination with the ground element increases the overall gain of the antenna. In case of an embodiment providing only limited space for the active element, a meandering path of the active element will make it possible to increase the overall length of the active element and thereby increase the gain properties.

[0032] In addition, the active element and the ground element may be positioned in the same plane.

[0033] In this way, it is achieved that the direction of the peak gain projects substantially from the same plane, i.e. a plane parallel to the plane of the ground element. It is avoided that the peak gain is perpendicular to the ground element, which would lead to a bulky reader. Hence, in this way, it is possible to minimise the overall height of the antenna.

[0034] Also, the active element may have a total length of 50 mm-200 mm, 75 mm-175 mm or 100 mm-150 mm.

[0035] In this way, it is achieved that the active element obtains the physical properties needed to be fitted onto portable devices. The length of the active element is a design trade-off between the length of the active element, the dipoles and antenna peak gain and bandwidth. Hence, the longer active element is, the higher the peak gain may be.

[0036] Moreover, a passive element may be arranged to reflect radiation from the antenna.

[0037] In this way, it is achieved that the required phase difference between the excitation currents of the two elements may be obtained by adjusting the length difference between the two dipoles and offsetting their frequency resonance. In another embodiment, the ground element/plate may act as the passive element. In an embodiment the ground plate may have slotted outline. In this way the length of the ground element that faces the active element may be longer.

[0038] Additionally, the antenna may be adapted to be comprised in a cover for a handheld device, such as a mobile telephone.

[0039] In this way, it is achieved that it is simple to install the antenna on the phone. A cover for a mobile phone is a well-known physical device that most users of mobile phone know how to use, and hence, it is possible for the end-user easily to install the cover. The restraints when manufacturing a cover for a mobile phone may be different depending on the general purpose of the cover, and purposes as different as e.g. protection of the phone, credit card holder or simply a skin to keep up with the latest fashion tendencies may cause the cover to have different appearances. Therefore, the end-users are used to various covers, which suggests an easy entry on the market. A cover for a mobile phone comprising an antenna according to the invention. A mobile phone comprising a compact RFID reader antenna according to the invention. In this way, it is possible to achieve a dynamic RFID reader system comprising a number of portable devices where at least more than half of them are repositioned during a day. In this way, a large area may be examined, and a large number of RFID tags in the area may be located. The antenna may comprise handling areas for the user to hold and/or handle the antenna. Due to the build-up of the antenna, it is possible for the end-user to handle the antenna in certain areas without disturbing the efficiency, i.e. the realised gain of the antenna. The handling areas may be located between the active and the passive element.

[0040] Furthermore, the active element may be a dipole element.

[0041] In this way, a reliable and cheap antenna is provided.

[0042] In addition, the antenna may comprise two active elements.

[0043] In this way, it is possible to adjust the length of the two active elements, e.g. two dipoles, to be different. Thereby, it is possible to offset their frequency resonance. A high Q element will have the phase response rapidly varying over the frequency, and thus, the optimal directivity pattern is obtained for a small frequency interval. When the antenna comprises two active elements, it is possible to dynamically adjust the radiation pattern to the specific conditions. Such conditions may be interference of the user handling the antenna.

[0044] Further, the antenna may comprise a power source.

[0045] In this way, it is achieved that the transmitting and receiving part of the antenna may be kept separate from the power source. Hence, the physical space needed for the antenna is minimised. In an embodiment of the antenna, the base material may have a volume comprising the ground element and the electrical components in order to form a stand-along RFID reader unit.

[0046] Also, the power source may be an external power source of a portable device, e.g. a mobile telephone, a PDA or a similar handheld device.

[0047] In this way, it is possible to avoid individual charging of a power source of the antenna. The power supply for the antenna is the handheld device, and therefore, the indication of battery status and charging are carried out as if no RFID antenna was present. Concerning the power consumption, the end-user is most likely not to be aware that the RFID antenna is fitted.

[0048] Moreover, the ground element may comprise a slot and a capacitor. The dimensions of the base material may be defining the dimensions of the antenna. The base material may be extending beyond the active element and the ground plate.

[0049] In this way, it is achieved that the antenna ground may be tuned. Furthermore, it is possible to get forward radiation, i.e. to make the antenna directional. Hereby, it is possible to tune the antenna to the specific purpose, and if the antenna is connected to a portable device, it is possible to take the specific specifications of the phone into account when tuning the antenna.

[0050] Additionally, the antenna may be a patch antenna.

[0051] The present invention furthermore relates to an RFID reader system comprising:

- a compact RFID reader antenna as described above,
- an external power source,
- a handheld device comprising a geolocation unit, and
- a means for transmitting location data to an external location.

[0052] In a further embodiment, an RFID reader system comprises sensors for orientation. In this way, it is possible to determine not only the positioning of the reader, but also the orientation in the horizontal plane. In this way, it is possible to increase the positioning accuracy of an object comprising an RFID tag to be read by the reader. Furthermore, it is possible to keep track of the area scanned by the reader. In another embodiment, the RFID reader system may comprise a movement detection sensor.

[0053] Furthermore, the external location may be an external server or cloud server.

[0054] In this way, it is possible to share the data collected by the RFID antenna in a simple manner. At the external server or cloud, it is possible to translate the data collected into information of e.g. the position of an object.

[0055] Moreover, the means for transmitting data, e.g. GPS coordinates, may be comprised in the handheld device.

[0056] In this way, it is possible to use the features of the handheld/portable device, i.e. a host device, to the widest extent possible. The more features of the handheld device are possible to utilise, the fever features may be comprised in the RFID reader itself. Therefore, if the physical properties of the RFID reader antenna are as small as possible, it is easier to fit the antenna to the host device.

[0057] Finally, the present invention relates to use of the compact RFID reader antennas described above for performing location determination of RFID-carrying elements.

[0058] In an embodiment, the RFID-carrying elements may be e.g. furniture, paintings, hospital equipment, electronic equipment, cars or other high value movable objects. In hospitals, the staff often walks around a lot, and therefore, if each person of the staff could be fitted with an RFID reader, the staff could act as detection post for locating the equipment and reporting the position to a central place. In this way, it would be possible to easily find and access the equipment, e.g. beds, tools for surgery or any other object that is moved around the hospital, and relocate these to the desired location, either for storage or immediate use.

Brief description of the drawings

[0059] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

Fig. 1a is a schematic view of an RFID reader antenna mounted next to a display,

Fig. 1b shows the RFID reader antenna of Fig. 1a and its radiation pattern,

Fig. 2a is a schematic view of an embodiment of an RFID reader antenna comprising a capacitor,

Fig. 2b shows the radiation pattern of the RFID reader antenna of Fig. 2a integrated in a cover for a mobile phone,

Fig. 3a is a schematic view of an embodiment of an RFID reader antenna comprising a capacitor,

Fig. 3b shows the radiation pattern of the RFID reader antenna of Fig. 3a integrated in a cover for a mobile phone,

Fig. 4 shows the radiation pattern of an embodiment of a RFID reader antenna integrated in a cover for a mobile phone,

Fig. 5a is a schematic view of an RFID reader antenna comprising dipoles,

Fig. 5b shows the RFID reader antenna of Fig. 5a, and

Fig. 6 is a schematic view of another embodiment of and RFID reader antenna mounted in a mobile phone.

[0060] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

[0061] Figs. 1a and 1b show an embodiment of a very compact RFID reader antenna 1 that can operate in the UHF band. The antenna 1 is schematically shown located in a handheld device, indicated by dotted lines for the particular purpose of reading RFID tags (not shown). The limiting factors of this design are the distances d1, d2 between the ground plate 2 of the PCB and active element/dipole 3 and the passive reflector 4 due to the loss in radiation resistance. In the present embodiment, the base length / of a base material (not shown) and the ground plate 2 is 120 mm and the base width w is 55 mm. The base height h is measured in a direction perpendicular to the plane defined by the base width w and the base length / (shown in Fig. 5b). In this embodiment the ground plate 2 is approximately the same size as the base material. The distance between the active element/dipole 3 and the ground plate 2 is approximately 3 mm, and the distance d1 between the reflector 4 and the ground plate 2 is approximately 5 mm.

[0062] In this embodiment, the RFID reader antenna 1 comprises the active element 3 and the PCB ground plate 2 and the passive reflector 4. Further in this embodiment, the RFID reader is indicated by the fact that the ground plate 2 is a PCB that hold the components for the RFID reader. The information retrieved may be presented in a display (not shown) e.g. the size of the ground plate/ PCB 2.

[0063] The smaller the PCB ground plate 2 will be, the smaller the whole design can be until a limit imposed by the antenna element. It is obvious for person skilled in the art that if the dipoles 3 are shrunk to a certain limit, their radiation efficiency will suffer due to the increased quality factor (Q).

[0064] The feed point 5 for the dipole 3 is positioned centrally on the dipole 3. The electromagnetic coupling EM takes place from the dipole 3 to the passive reflector 4. Fig. 1b shows the antenna of Fig. 1a where the numerals 3 and 4 indicate the orientation of the antenna in relation to that in Fig. 1a. It is seen that the radiation pattern RP is directional due to the build-up of the antenna. Hence, the radiation pattern RP emits from the side of the RFID antenna where the active element 3 is located.

[0065] By manipulating the phase of the ground currents, i.e. the equivalent current source, it is possible to align the two radiated fields to interfere constructively, thereby effectively doubling the radiated field. In this embodiment, the forward gain of a radiating element can be increased by a maximum of 6 dBi.

[0066] Figs. 2a, 2b, 3a, 3b and 4 all show embodiments of an antenna 1 that can be integrated into a simple and easy to manufacture cover 10 for a handheld device e.g. a mobile phone 11 applicable to phones already on the market.

[0067] In Figs. 2a and 2b, a slot 12 with a capacitor is used to tune the antenna ground 2 in order to get forward radiation RP'. In Fig. 2b, the active element is positioned along the longer side of the mobile phone 10. Handling areas HA are indicated by dotted lines. In this embodiment where the ground plate 2 acts as a passive element, the actual antenna area is the end section of the ground plate 2 facing the active element 3. The handling areas HA may in this embodiment be positioned in an area outside the area between the active element 3 and the second/passive element. It should be mentioned the second element may be active as well.

[0068] Furthermore, Fig. 2 shows a design of an RFID reader antenna 1 that can easily be integrated into a cover 10 for smart phones. Fig. 2b further shows the radiating direction RP, and in this embodiment, the radiation projects from to the longer side of the phone. Fig. 2a shows a schematic view of the antenna design included in the cover of Fig. 2b. The active element 3 is positioned along the long side / of the phone 11. The ground plate 2 comprises a slot 12 and a capacitor 13 in order further to direct the radiation pattern and hence obtaining a higher gain in this direction. The distance *d2* is in this embodiment approximately 5 mm, i.e. the distance *d2* between the active element 3 and the ground plate 2. It is seen that the feeding point 5 for the active element is positioned substantially opposing each other.

[0069] In Fig. 3b, the radiation pattern RP is projecting from the shorter side of the mobile phone 11. The active element 3 is positioned crosswise in the cover 10 of the mobile phone 11, and hence, the radiation pattern will project from the shorter side of the mobile phone 11, e.g. the top part.

[0070] Fig. 3a shows the position of the active element 3 in relation to the ground plate 2. In order to make the RFID antenna 1 a directional antenna, and thereby achieving a higher gain, the ground plate comprises a slot 12 and a capacitor 13.

[0071] If necessary, such a localisation application, i.e. a system for detecting and reading RFIDs, will be hard to see and can be easily be disguised as part of an ordinary phone. The cover design can easily be made to resemble that of covers that users ordinarily have for protecting their phones from damage. This is due to the simple fact that it is possible to make the RFID reader antenna so small that it is possible to fit into or onto numerous devices.

[0072] The restraints when manufacturing a cover for a mobile phone may be different depending on the general purpose of the cover, and purposes as different as e.g. protection of the phone, credit card holder or simply a skin to keep up with the latest fashion tendencies may cause the cover to have different appearances. Therefore, the end-users are used to various covers, suggesting an easy entry on the market.

[0073] If more gain is required, extra director elements can be added, and the cover can be extended, as illustrated in Fig. 4. The cover will then contain RF components and adc's to ensure communication with the tag. Communication from the cover to the phone may e.g. be carried out by cables or by using near-filed communication. The information retrieved by the RFID reader antenna can be displayed directly on the phone. Furthermore, by using the computing capabilities of the phone, smarter and more complex localisation algorithms can be run.

[0074] Fig. 5 shows an example of an embodiment of the antenna 1, e.g. for use as a handheld reader. This simple two element antenna 1 can be utilised for obtaining a very compact and efficient design. The occupied area of a dipole array for a fixed distance can be minimised by meandering the dipole arms 51, 52. Nonetheless, the length reduction will affect the radiating resistance and consequently the quality factor (Q) of the antenna. From an impedance bandwidth perspective, the UHF RFID allocated for Europe, i.e. the 865-868 MHz band, is not demanding and can be easily covered.

[0075] For the present embodiment which employs a passive element as a reflector 4, the required phase difference between the excitation currents of the two elements is obtained by adjusting the difference in length of the two elements and offsetting their frequency resonance. A high Q element will have the phase response rapidly varying over frequency, and thus, the optimal directivity pattern is obtained for a small frequency interval.

[0076] Finally, there is a design trade-off between the length of the dipole arms 51, 52 and antenna peak gain and bandwidth.

[0077] The numerical model of the structure presented in Fig. 5 has been simulated using the commercial software, CST Microwave Studio, based on the FDTD method. Based on these specifications, a prototype has been manufactured using copper printed on a double-sided 1 mm thick FR4 plate 54 with a relative permittivity of 4.3 and a loss tangent of 0.025. The FR4 plate 54 is placed on a base material 55, an approximately 6 mm thick Arlon CuClad 233LX substrate with relative electric permittivity of 2.33 and loss tangent of 0.0018. The active/driving dipole is simulated as if it would be fed with a coaxial cable. For the test, the ground of the coaxial feeding cable is connected to the second arm 52 of the dipole, whereas the inner conductor is connected to the first arm 51. The use of a balun is avoided by grounding the coaxial cable in the middle of the PCB ground plate 2 in order to minimise ground currents, and thereby the ground current is led away from the mock-up orthogonally to the main current oscillation plane in order to minimise the cable effect.

[0078] The distance between the excited dipole and the ground plane is only 9 mm, and therefore, the input resistance at the resonance frequency is lower than 50 ohm, requiring an impedance matching network. An L matching network with a parallel inductor of 5.6 nH and a series capacitor of 3 pF have been used for this antenna. The inductor has a Q of 60, and the capacitor has a Q equal to 200.

[0079] Considering that the theoretical maximum directivity for this array is 8.15 dBi, in free space the antenna has a good gain due to the excellent match and high radiation efficiency.

[0080] The presence of a user's hand has been simulated by a rough model of the hand phantom. The material used for the simulation of the hand has a relative permittivity of 36.2 and a conductivity of 0.79 S/m. The thumb has been approximated with a 15 mm x 15 mm x 60 mm block, and the index finger has been modelled with a cylinder having a radius of 15 mm and a height of 70 mm. The realised gain is the metric that takes into account all the sources of losses and represents the radiating performance realistically. It is the product of the directivity with the total efficiency. Considering that the theoretical gain for this array is 8.15 dBi, in free space, the antenna has a good realised gain of 5-6 dB due to the excellent match and high radiation efficiency (860-875 MHz).

[0081] Fig. 6 shows another embodiment of the RFID reader antenna 1 using the already existing antenna 60 of a phone as a reflector. Only a part of the phone body 61 is indicated (the phone itself is not shown). The cover 10" comprises the active element 3" and uses the phone as power source and the antenna 60 of the phone as a passive element. It will be realised that a system utilising such an existing antenna will be specific to each phone, as the specific properties will be affected by the losses associated with phone antennas. However, when a duplex filter offers sufficient rejection in the RFID operating frequency band, a good performance can be achieved, as simulation results of the simplified model show a dBi of approximately 6.5.

[0082] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

[0083] In addition the compact antenna can be applied to any compact handheld RFID reader design. We chose to illustrate the idea for an RFID applications because extensive use in practice however, the design and application can be for any generic localization applications, such as the tracking of active emitters. In addition, we based the embodiment of the design on an application serving the 865 MHz European UHF RFID band because the available license free spectrum, good propagation characteristics and the size of the antenna required. We underline the fact that this principle of designing antennas can be scaled and adapted for any frequency but we considered a practical localization device that can be easily designed, manufactured and made commercially available.

Claims

1. A compact Ultra High Frequency (UHF) Radio Frequency Identification (RFID) reader antenna (1) for handheld devices, the reader antenna having a carrier frequency and defining a volume, and the reader antenna comprising:

- a ground element (2),
- at least one active antenna element (3) defining a longitudinal extension axis, and
- a base material having a base height (h), a base width (w) and a base length (/),

the reader antenna having a bandwidth larger than approximately 13% of the carrier frequency (frequency of operation) and a realised gain larger than 6 dBi wherein the width of the antenna is less than 70 mm and the volume of the antenna is less than 50000 mm^3.

2. A compact UHF RFID reader antenna (1) according to claim 1, wherein the distance between the ground element (2) and the at least one active element (3) is 2 mm-35mm, 4 mm-30 mm, 6 mm-25 mm, 8 mm-20 mm or 10 mm-15 mm.

3. A compact RFID reader antenna (1) according to claim 1 or 2, wherein the active element (3) is meandering along its axis of extension.

4. A compact RFID reader antenna (1) according to claim 1, 2 or 3, wherein the active element (3) and the ground element (2) are positioned in the same plane.

5. A compact RFID reader antenna (1) according to any of the preceding claims, wherein the active element (3) has a total length of 50 mm-200 mm, 75 mm-175 mm or 100 mm-150 mm.

6. A compact RFID reader antenna (1) according to any of the preceding claims, wherein a passive element (4) is arranged to reflect radiation from the antenna.

7. A compact RFID reader antenna (1) according to any of the preceding claims, wherein the antenna (1) is adapted to be comprised in a cover for a handheld device (11), such as a mobile telephone.

8. A compact RFID reader antenna (1) according to any of the preceding claims, wherein the active element (3) is a dipole element.

9. A compact RFID reader antenna (1) according to claim 8, wherein the antenna comprises two active elements.

10. A compact RFID reader antenna (1) according to any of the preceding claims, wherein the antenna comprises a power source.

11. A compact RFID reader antenna (1) according to claim 10, wherein the power source is an external power source of a portable device, e.g. a mobile telephone, a PDA or a similar handheld device.

12. A compact RFID reader antenna (1) according to any of the preceding claims, wherein the ground element (2) comprises a slot (12) and a capacitor (13).

13. An RFID reader system comprising:

- a compact RFID reader antenna according to claims 1-12,
- an external power source,
- a handheld device comprising a geolocation unit, and
- a means for transmitting location data to an external location.

14. An RFID activation and reading antenna system according to claim 13, wherein the external location is an external server or cloud server.

15. An RFID activation and reading antenna system according to claim 13 or 14, wherein the means for transmitting data, e.g. GPS coordinates, is comprised in the handheld device.

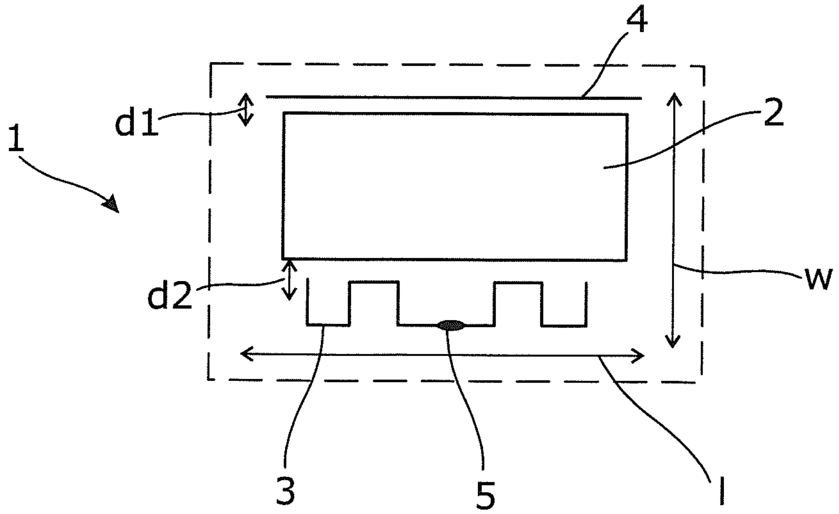

Fig. 1a

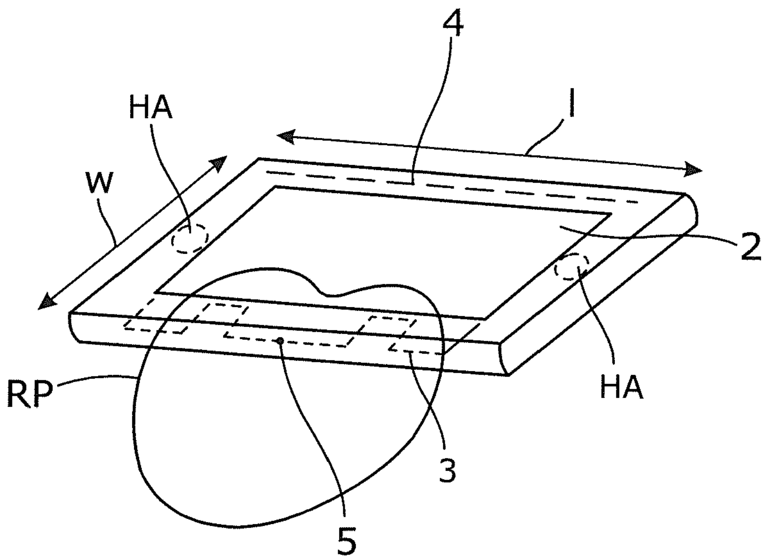

Fig. 1b

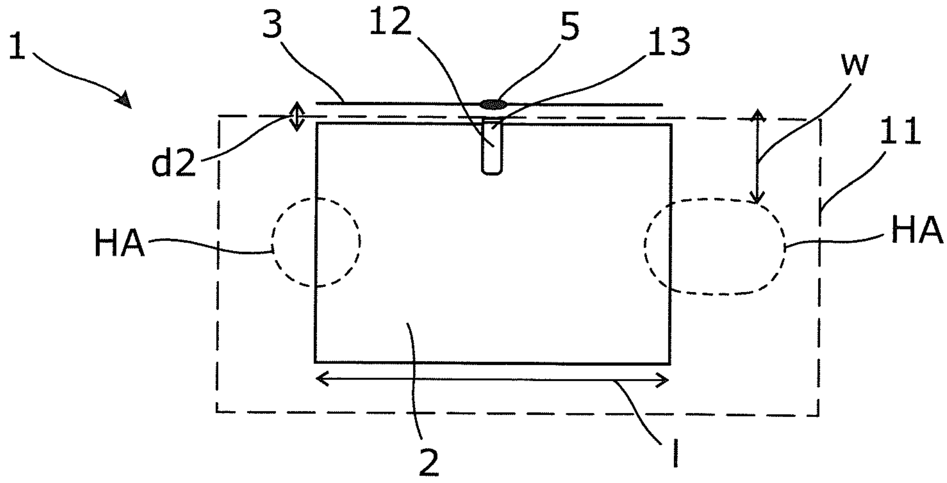

Fig. 2a

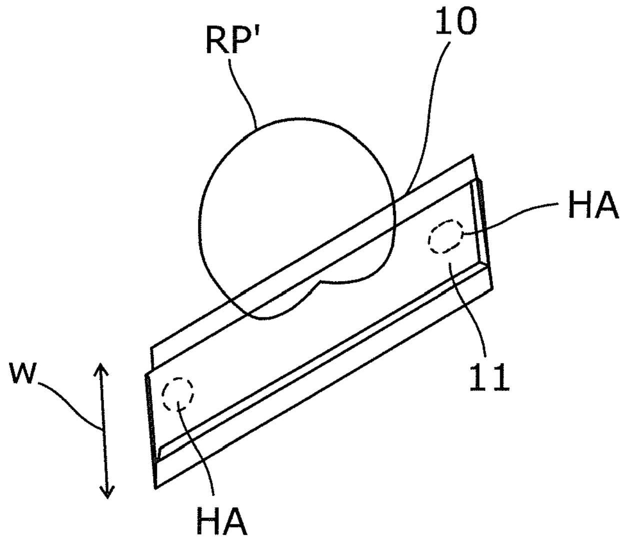

Fig. 2b

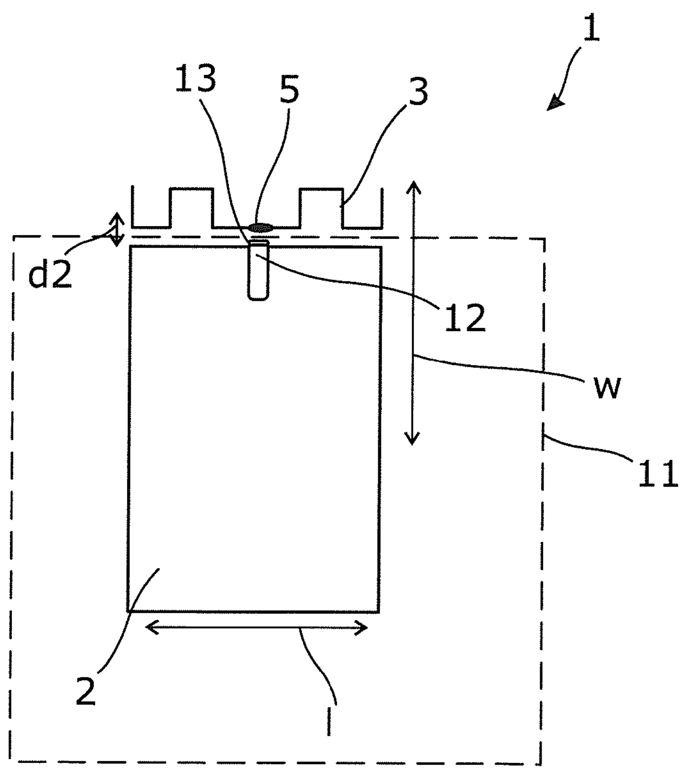

Fig. 3a

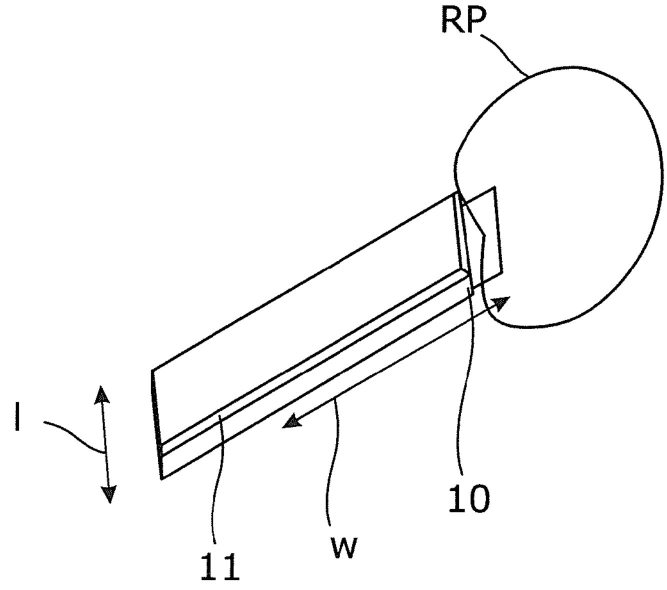

Fig. 3b

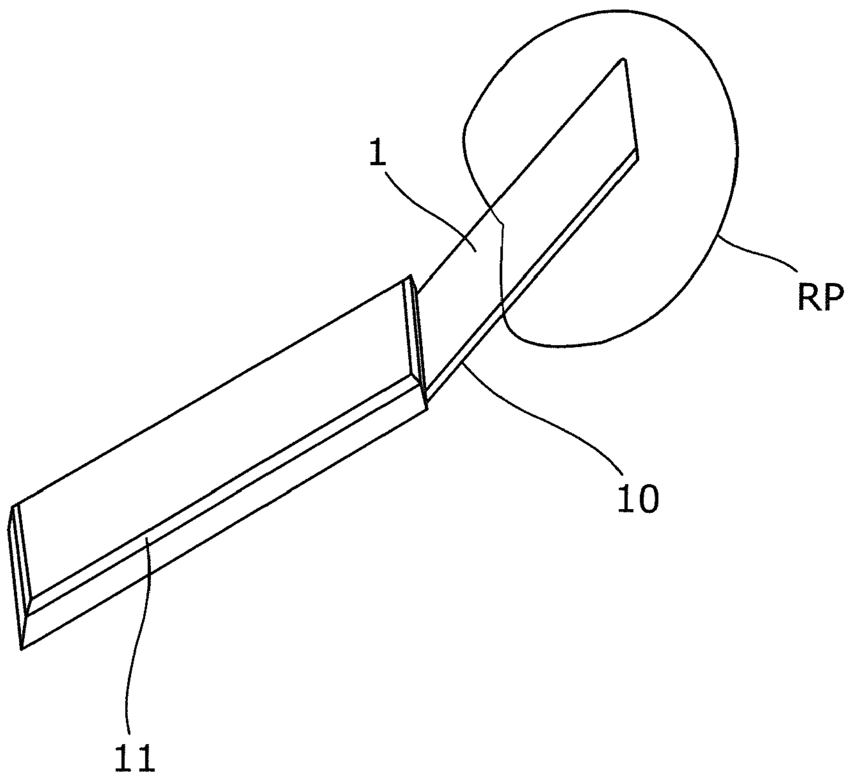

Fig. 4

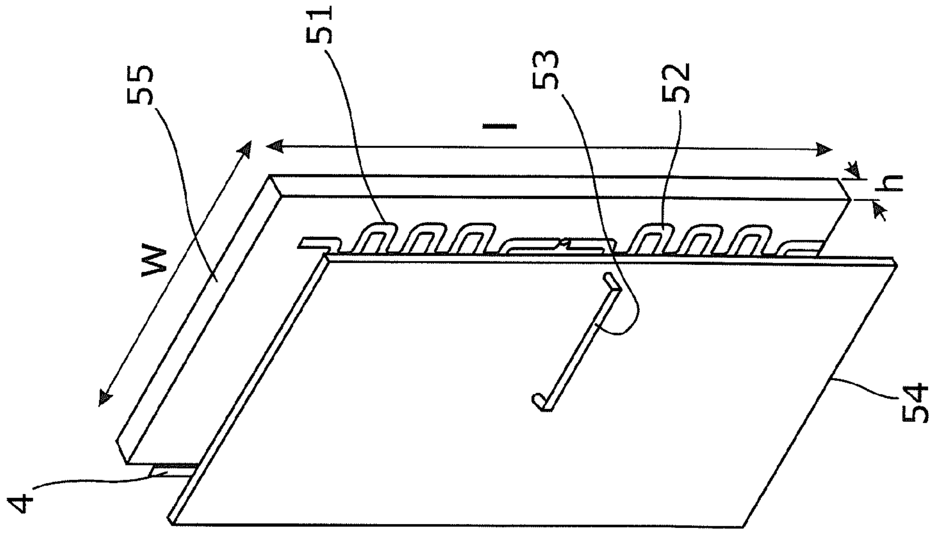

Fig. 5b

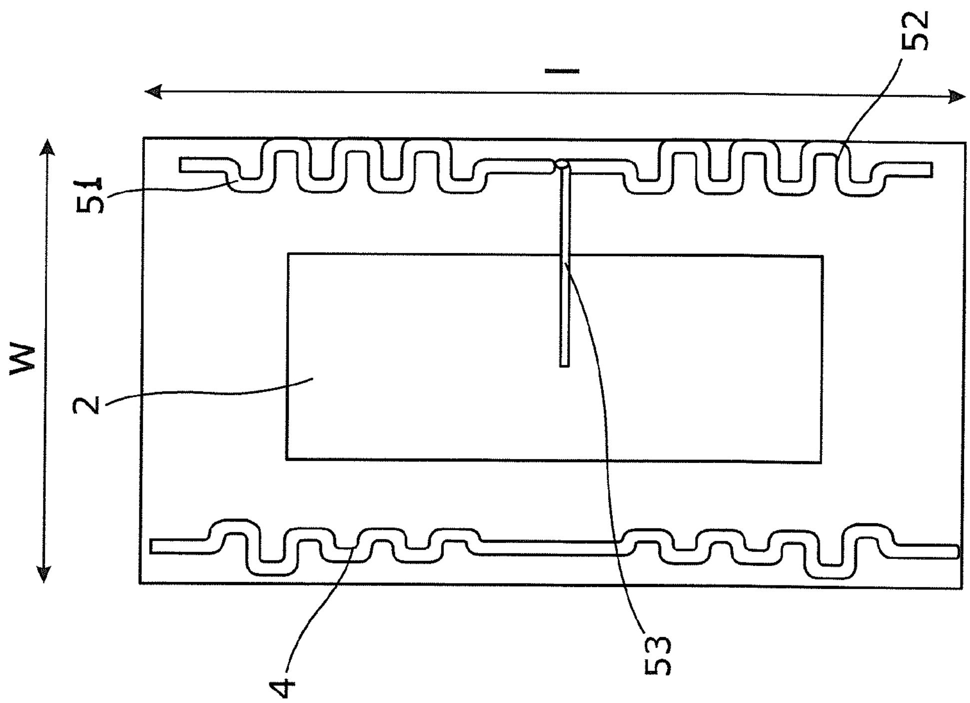

Fig. 5a

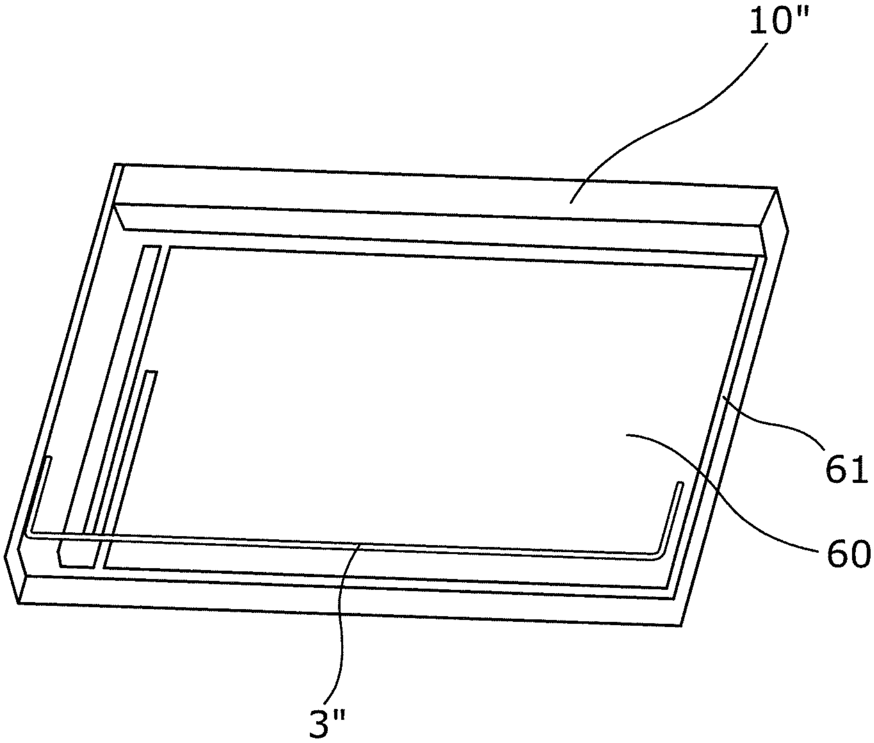

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 5567

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 November 2013	Wattiaux, Véronique

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CATEGORY OF CITED DOCUMENTS

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